User's Manual

32

Renesas RA6T1 Group

User's Manual: Hardware

32-Bit MCU
Renesas Advanced (RA) Family
Renesas RA6 Series

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瑞萨电子高级(RA)系列32位MCU
Renesas RA6 Series

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General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

处理微处理单元和微控制器的一般注意事项单位产品

以下使用说明适用于瑞萨的所有微处理单元和微控制器单元产品。有关详细的使用说明本文档所涵盖的产品，请参阅文档的相关部分以及为产品发布的任何技术更新。

1. 防止静电放电(ESD)
   当暴露于CMOS器件时，强电场会导致栅极氧化物的破坏并最终降低器件的运行性能。脚步必须采取措施，尽可能停止静电的产生，并在出现时迅速消散。环境控制必须足够的。干燥时，应使用加湿器。建议避免使用容易产生静电的绝缘体。半导体器件必须在防静电容器、静电屏蔽袋或导电材料中储存和运输。所有测试和包括工作台和地板在内的测量工具必须接地。操作员还必须使用腕带接地。半导体不得赤手触摸设备。对于安装有半导体器件的印刷电路板，必须采取类似的预防措施。
2. 上电处理
   通电时产品的状态是不确定的。LSI内部电路的状态是不确定的，通电时寄存器设置和引脚未定义。在将复位信号施加到外部复位的成品中管脚，从通电到复位过程完成，管脚的状态不能保证。以类似的方式，引脚的状态在通过片内上电复位功能复位的产品中，从供电时间到供电达到指定重置的级别。
3. 断电状态下的信号输入
   请勿在设备断电时输入信号或IO上拉电源。输入此类信号或IO导致的电流注入上拉电源可能会导致故障，此时通过设备的异常电流可能会导致内部退化元素。请按照产品文档中所述的电源关闭状态下的输入信号指南进行操作。
4. 处理未使用的引脚
   按照手册中未使用引脚处理中给出的说明处理未使用的引脚。CMOS产品的输入引脚是一般处于高阻状态。在开路状态下使用未使用的引脚操作时，会在附近感应出额外的电磁噪声LSI，相关的直通电流在内部流动，并且由于将引脚状态错误识别为输入信号而发生故障成为可能。
5. 时钟信号
   应用复位后，只有在工作时钟信号稳定后才释放复位线。在程序中切换时钟信号时执行，等待目标时钟信号稳定。当时钟信号由外部谐振器或外部振荡器产生时在复位期间，确保只有在时钟信号完全稳定后才释放复位线。此外，当切换到时钟信号时在程序执行过程中由外部谐振器或外部振荡器产生，等待目标时钟信号稳定。
6. 输入引脚的电压施加波形
   由于输入噪声或反射波导致的波形失真可能会导致故障。如果CMOS器件的输入保持在VIL之间的区域(Max.)和VIH(Min.)由于噪音，例如，设备可能发生故障。小心，以防止颤动的噪音进入设备时，输入电平是固定的，并且在输入电平通过VIL(Max.)和VIH(Min.)之间的区域时的过渡期间也是如此。
7. 禁止访问保留地址
   禁止访问保留地址。保留地址是为将来可能的功能扩展提供的。不要访问这些不能保证LSI的正确操作。
8. 产品之间的差异
   在从一种产品更改为另一种产品之前，例如更改为具有不同部件号的产品，请确认更改不会导致问题。同一组中的微处理单元或微控制器单元产品的特性，但具有不同的部件号，其特性可能会有所不同内部存储器容量，布局模式和其他因素，这些因素会影响电气特性的范围，例如特性值，工作裕度、抗噪声能力和辐射噪声量。当更改为具有不同部件号的产品时，实施系统-给定产品的评估测试

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Preface

1. About this Document

This manual is generally organized into an overview of the product, descriptions of the CPU, system control functions, peripheral functions, electrical characteristics, and usage notes. This manual describes the product specification of the microcontroller (MCU) superset. Depending on your product, some pins, registers, or functions might not exist. Address space that store unavailable registers are reserved.

2. Audience

This manual is written for system designers who are designing and programming applications using this MCU. The user is expected to have basic knowledge of electrical circuits, logic circuits, and the MCU.

3. Related documents

Renesas provides the following documents for this MCU.

Document type	Description
Datasheet	Features, overview, and electrical characteristics of the MCU
User's Manual: Hardware	MCU specifications such as pin assignments, memory maps, peripheral functions, electrical characteristics, timing diagrams, and operation descriptions
Application Notes	Technical notes, board design guidelines, and software migration information
Technical Update (TU)	Preliminary reports on product specifications such as restriction and errata

4. Numbering Notation

The following numbering notation is used throughout this manual:

Example	Description
011b	Binary number. For example, the binary equivalent of the number 3 is 011b.
1Fh	Hexadecimal number. For example, the hexadecimal equivalent of the number 31 is described 1Fh. In some cases, a hexadecimal number is shown with the prefix 0x, based on C/C++ formatting.
1234	Decimal number. Decimal numbers are generally shown without a suffix.

Preface

1. 关于本文档

本手册一般由产品概述、CPU说明、系统控制功能、外围功能、电气特性和使用说明组成。本手册描述了微控制器(MCU)超集的产品规格。根据您的产品，某些引脚、寄存器或功能可能不存在。保留存储不可用寄存器的地址空间。

2. Audience

本手册是为使用该MCU设计和编程应用程序的系统设计人员编写的。要求用户具备电路、逻辑电路和MCU的基本知识。

3. 相关文件

瑞萨为此MCU提供了以下文档。

文件类型	Description
Datasheet	MCU的特性、概述和电气特性
User's Manual: Hardware	MCU规范，例如引脚分配、存储器映射、外设功能、电气特性、时序图和操作描述
应用笔记	技术说明、电路板设计指南和软件迁移信息
技术更新(TU)	限制、勘误等产品规格的初步报告

4. 编号符号

本手册通篇使用以下编号符号：

Example	Description
011b	二进制数。例如，数字3的二进制等价物是011b。
1Fh	十六进制数。例如，数字31的十六进制等值表示为1Fh。在某些情况下，根据CC++格式，显示带有前缀0x的十六进制数。
1234	十进制数。十进制数字通常不带后缀。

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5. Typographic Notation

The following typographic notation is used throughout this manual:

Example	Description
ICU.NMICR.NMIMD	Periods separate a function module symbol (ICU), register symbol (NMICR), and bit field symbol (NMIMD)
ICU.NMICR	A period separates a function module symbol (ICU) and register symbol (NMICR)
NMICR.NMIMD	A period separates a register symbol (NMICR) and bit field symbol (NMIMD)
NFCLKSEL[1:0]	In a register bit name, the bit range enclosed in square brackets indicates the number of bits in the field at this location. In this example, NFCLKSEL[1:0] represents a 2-bit field at the specified location in the NMI Pin Interrupt Control Register (NMICR).

6. Unit Prefix

The following unit prefixes are sometimes misleading. Those unit prefixes are described throughout this manual with the following meaning:

Prefix	Description
b	Bit
B	Byte. This unit prefix is generally used for memory specification of the MCU and address space.
k	1000 = 10^3. k is also used to denote 1024 (2^{10}) but this unit prefix is used to denote 1000 (10^3) throughout this manual.
K	1024 = 2^{10}. This unit prefix is used to denote 1024 (2^{10}) not 1000 (10^3) throughout this manual.

7. Special Terms

The following terms have special meanings:

Term	Description
NC	Not connected pin. NC means the pin is not connected to the MCU.
Hi-Z	High impedance

5. 排版符号

本手册通篇使用以下印刷符号：

Example	Description
ICU.NMICR.NMIMD	句点分隔功能模块符号(ICU)、寄存器符号(NMICR)和位域符号(NMIMD)
ICU.NMICR	句点分隔功能模块符号(ICU)和寄存器符号(NMICR)
NMICR.NMIMD	句点分隔寄存器符号(NMICR)和位域符号(NMIMD)
NFCLKSEL[1:0]	在寄存器位名称中，方括号中的位范围表示该位置的字段中的位数。在本例中，NFCLKSEL[1:0]表示NMI引脚中断控制寄存器(NMICR)中指定位置的2位字段。

6. 单位前缀

以下单位前缀有时会产生误导。这些单位前缀在本手册中进行了描述，含义如下：

Prefix	Description
b	Bit
B	字节。该单元前缀一般用于MCU的内存规范和地址空间。
k	1000=103。k也用于表示1024(210)，但在本手册中，此单位前缀用于表示1000(103)。
K	1024=210。在本手册中，该单位前缀用于表示1024(210)而不是1000(103)。

7. 特别条款

以下术语具有特殊含义：

Term	Description
NC	未连接引脚。NC表示该引脚未连接到MCU。
Hi-Z	高阻抗

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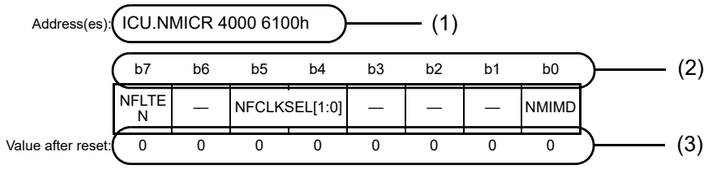
8. Register Description

Each register description includes both a register diagram that shows the bit assignments and a register bit table that describes the content of each bit. The example of symbols used in these tables are described in the sections that follow. The following is an example of a register description and associated bit field definition.

X.X.X NMI Pin Interrupt Control Register (NMICR)



(6)

(4) (5)

Bit	Symbol	Bit name	Description	R/W
b0	NMIMD	NMI Detection Set	0: Falling edge 1: Rising edge.	R/W
b3 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b5, b4	NFCLKSEL[1:0]	NMI Digital Filter Sampling Clock Select	b5 b4 0 0: PCLKB 0 1: PCLKB/8 1 0: PCLKB/32 1 1: PCLKB/64.	R/W
b6	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7	NFLTEN	NMI Digital Filter Enable	0: Disable the digital filter 1: Enable the digital filter.	R/W

(1) Function module symbol, register symbol, and address assignment

Function module symbol, register symbol, and address assignment of this register are generally expressed. ICU.NMICR 4000 6100h means NMI Pin Interrupt Control Register (NMICR) of Interrupt Controller Unit (ICU) is assigned to address 4000 6100h.

(2) Bit number

This number indicates the bit number. These bits are shown in order from b31 to b0 for a 32-bit register, from b15 to b0 for a 16-bit register, and from b7 to b0 for an 8-bit register.

(3) Value after reset

This symbol or number indicates the value of each bit after a reset. The value is shown in binary unless specified otherwise.
0: Indicates that the value is 0 after a reset.
1: Indicates that the value is 1 after a reset.
x: Indicates that the value is undefined after a reset.

(4) Bit symbol

Bit symbol indicates the short name of the bit field. Reserved bit is expressed with a —.

(5) Bit name

Bit name indicates the full name of the bit field.

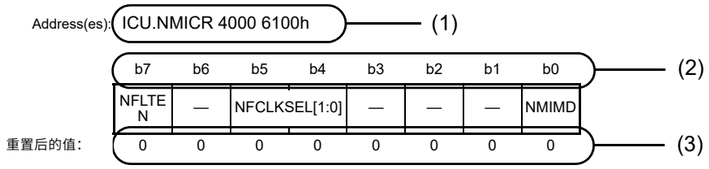
(6) R/W

The R/W column indicates access type: whether the bit field is read or write.
R/W: The bit field is read and write.
R/(W): The bit field is read and write. But writing to this bit field has some limitations. For details on the limitations, see the description or notes of respective registers.
R: The bit field is read-only. Writing to this bit field has no effect.
W: The bit field is write-only. The read value is undefined.

8. 注册说明

每个寄存器描述都包括一个显示位分配的寄存器图和一个描述每个位内容的寄存器位表。这些表中使用的符号示例将在以下部分中描述。以下是寄存器描述和相关位字段定义的示例。

X.X.X NMI引脚中断控制寄存器(NMICR)



(6)

(4) (5)

Bit	Symbol	位名称	Description	R/W
b0	NMIMD	NMI检测集	0：下降沿1： 上升沿。	R/W
b3 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b5, b4	NFCLKSEL[1:0]	NMI数字滤波器采样时钟 Select	b5 b4 0 0: PCLKB 0 1: PCLKB/8 1 0: PCLKB/32 1 1: PCLKB/64.	R/W
b6	—	Reserved	该位读取为0。写入值应为0。	R/W
b7	NFLTEN	NMI数字滤波器启用	0：禁用数字滤波器1：启 用数字滤波器。	R/W

(1) 功能模块符号、寄存器符号、地址分配

一般表示该寄存器的功能模块符号、寄存器符号、地址分配。ICU.NMICR40006100h表示中断控制器单元(ICU)的NMI引脚中断控制寄存器(NMICR)分配到地址40006100h。

(2) 位号

该数字表示位数。对于32位寄存器，这些位按照从b31到b0的顺序显示，对于16位寄存器，这些位从b15到b0，对于8位寄存器，按照从b7到b0的顺序显示。

(3) 重置后的值

该符号或数字表示复位后每个位的值。除非另有说明，否则该值以二进制显示。0：表示复位后值为0。
1：表示复位后值为1。x：表示复位后该值未定义。

(4) 位符号

位符号表示位域的简称。保留位用—表示。

(5) 位名称

位名表示位域的全称。

(6) R/W

RW列表示访问类型：位域是读还是写。
RW：位域可读写。
R(W)：位域可读写。但是写入这个位域有一些限制。有关限制的详细信息，请参见各个寄存器的说明或注释。R：位域是只读的。写入该位域无效。

W：位域是只写的。读取值未定义。

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9. Abbreviations

Abbreviations used in this manual are shown in the following table:

Abbreviation	Description
AES	Advanced Encryption Standard
AHB	Advanced High-Performance Bus
AHB-AP	AHB Access Port
APB	Advanced Peripheral Bus
ARC	Alleged RC
ATB	Advanced Trace Bus
BCD	Binary Coded Decimal
BSDL	Boundary Scan Description Language
DES	Data Encryption Standard
DSA	Digital Signature Algorithm
ECC	Elliptic Curve Cryptography
ETB	Embedded Trace Buffer
ETM	Embedded Trace Macrocell
FLL	Frequency Locked Loop
FPU	Floating-Point Unit
GSM	Global System for Mobile communications
HMI	Human Machine Interface
IrDA	Infrared Data Association
LSB	Least Significant Bit
MSB	Most Significant Bit
NVIC	Nested Vector Interrupt Controller
PC	Program Counter
PFS	Port Function Select
PLL	Phase Locked Loop
POR	Power-On Reset
PWM	Pulse Width Modulation
RSA	Rivest Shamir Adleman
SHA	Secure Hash Algorithm
S/H	Sample and Hold
SP	Stack Pointer
SWD	Serial Wire Debug
SW-DP	Serial Wire-Debug Port
TRNG	True Random Number Generator
UART	Universal Asynchronous Receiver/Transmitter

9. Abbreviations

本手册中使用的缩写如下表所示：

Abbreviation	Description
AES	高级加密标准
AHB	先进的高性能总线
AHB-AP	AHB访问端口
APB	先进的外围总线
ARC	Alleged RC
ATB	高级跟踪总线
BCD	二进制编码的十进制
BSDL	边界扫描描述语言
DES	数据加密标准
DSA	数字签名算法
ECC	椭圆曲线密码学
ETB	嵌入式跟踪缓冲区
ETM	嵌入式跟踪宏单元
FLL	锁频环
FPU	Floating-Point Unit
GSM	全球移动通信系统
HMI	人机接口
IrDA	红外数据协会
LSB	最低有效位
MSB	最高有效位
NVIC	嵌套向量中断控制器
PC	程序计数器
PFS	端口功能选择
PLL	锁相环
POR	Power-On Reset
PWM	脉冲宽度调制
RSA	Rivest Shamir Adleman
SHA	安全哈希算法
S/H	采样和保持
SP	堆栈指针
SWD	串口线调试
SW-DP	串行线调试端口
TRNG	真随机数发生器
UART	通用异步收发器

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RA生态工作室

Contents

Features 38

1. Overview 39
   - 1.1 Function Outline 39
   - 1.2 Block Diagram 43
   - 1.3 Part Numbering 44
   - 1.4 Function Comparison 45
   - 1.5 Pin Functions 46
   - 1.6 Pin Assignments 49
   - 1.7 Pin Lists 51

2. CPU 53
   - 2.1 Overview 53
     - 2.1.1 CPU 53
     - 2.1.2 Debug 53
     - 2.1.3 Operating Frequency 54
   - 2.2 MCU Implementation Options 55
   - 2.3 Trace Interface 55
   - 2.4 JTAG/SWD Interface 55
   - 2.5 Debug Mode 56
     - 2.5.1 Debug Mode Definition 56
     - 2.5.2 Debug Mode Effects 56
   - 2.6 Programmers Model 57
     - 2.6.1 Address Spaces 57
     - 2.6.2 Cortex-M4 Peripheral Address Map 57
     - 2.6.3 CoreSight ROM Table 58
     - 2.6.4 DBGREG Module 59
     - 2.6.5 OCDREG Module 61
   - 2.7 CoreSight ATB Funnel 63
   - 2.8 Flash Patch and Break Unit 64
   - 2.9 SysTick System Timer 64
   - 2.10 CoreSight Time Stamp Generator 64
   - 2.11 OCD Emulator Connection 64
     - 2.11.1 DBGEN 65
     - 2.11.2 Unlock ID Code 65
     - 2.11.3 Restrictions on Connecting an OCD Emulator 65
   - 2.12 References 67

3. Operating Modes 68
   - 3.1 Overview 68
   - 3.2 Details of Operating Modes 68
     - 3.2.1 Single-Chip Mode 68

Contents

Features 38

1. Overview 39
   - 1.1 功能概要 39
   - 1.2 框图 43
   - 1.3 零件编号 44
   - 1.4 功能比较 45
   - 1.5 引脚功能 46
   - 1.6 引脚分配 49
   - 1.7 引脚列表 51

2. CPU 53
   - 2.1 Overview 53
     - 2.1.1 CPU 53
     - 2.1.2 Debug 53
     - 2.1.3 工作频率 54
   - 2.2 MCU实施选项 55
   - 2.3 跟踪接口 55
   - 2.4 JTAG/SWD Interface 55
   - 2.5 调试模式 56
     - 2.5.1 调试模式定义 56
     - 2.5.2 调试模式效果 56
   - 2.6 程序员模型 57
     - 2.6.1 地址空间 57
     - 2.6.2 Cortex-M4外设地址映射 57
     - 2.6.3 CoreSightROM表 58
     - 2.6.4 DBGREG Module 59
     - 2.6.5 OCDREG Module 61
   - 2.7 CoreSight ATB Funnel 63
   - 2.8 闪存补丁和中断单元 64
   - 2.9 SysTick系统定时器 64
   - 2.10 CoreSight时间戳生成器 64
   - 2.11 OCD仿真器连接 64
     - 2.11.1 DBGEN 65
     - 2.11.2 解锁ID码 65
     - 2.11.3 连接OCD模拟器的限制 65
   - 2.12 References 67

3. 操作模式 68
   - 3.1 Overview 68
   - 3.2 操作模式的详细信息 68
     - 3.2.1 Single-Chip Mode 68

RA生态工作室

3.2.2 SCI Boot Mode 68
3.3 Operating Mode Transitions 68
3.3.1 Operating Mode Transitions as Determined by the Mode-Setting Pin 68
4. Address Space 69
4.1 Overview 69
5. Memory Mirror Function (MMF) 70
5.1 Overview 70
5.2 Register Descriptions 70
5.2.1 MemMirror Special Function Register (MMSFR) 70
5.2.2 MemMirror Enable Register (MMEN) 71
5.3 Operation 71
5.3.1 MMF Operation 71
5.3.2 Setting Example 74
6. Resets 76
6.1 Overview 76
6.2 Register Descriptions 80
6.2.1 Reset Status Register 0 (RSTSR0) 80
6.2.2 Reset Status Register 1 (RSTSR1) 81
6.2.3 Reset Status Register 2 (RSTSR2) 83
6.2.4 Reset Control Register 1 (RCR1) 84
6.2.5 Reset Control Register 2 (RCR2) 84
6.2.6 Reset Control Register 4 (RCR4) 84
6.3 Operation 85
6.3.1 RES Pin Reset 85
6.3.2 Power-On Reset 85
6.3.3 Voltage Monitor Reset 86
6.3.4 Deep Software Standby Reset 87
6.3.5 Independent Watchdog Timer Reset 87
6.3.6 Watchdog Timer Reset 88
6.3.7 Software Reset 88
6.3.8 Determination of Cold/Warm Start 88
6.3.9 Determination of Reset Generation Source 88
6.4 Initialization Procedure Required after Reset 89
7. Option-Setting Memory 91
7.1 Overview 91
7.2 Register Descriptions 91
7.2.1 Option Function Select Register 0 (OFS0) 91
7.2.2 Option Function Select Register 1 (OFS1) 94
7.2.3 Access Window Setting Register (AWS) 95
7.2.4 OCD/Serial Programmer ID Setting Register (OSIS) 97
7.3 Setting the Option-Setting Memory 98

3.2.2 SCI启动模式 68
3.3 操作模式转换 68
3.3.1 由模式设置引脚决定的工作模式转换 68
4. 地址空间 69
4.1 Overview 69
5. 内存镜像功能(MMF) 70
5.1 Overview 70
5.2 寄存器说明 70
5.2.1 MemMirror特殊功能寄存器(MMSFR) 70
5.2.2 MemMirror使能寄存器(MMEN) 71
5.3 Operation 71
5.3.1 MMF Operation 71
5.3.2 设置示例 74
6. Resets 76
6.1 Overview 76
6.2 寄存器说明 80
6.2.1 复位状态寄存器0(RSTSR0) 80
6.2.2 复位状态寄存器1(RSTSR1) 81
6.2.3 复位状态寄存器2(RSTSR2) 83
6.2.4 复位控制寄存器1(RCR1) 84
6.2.5 复位控制寄存器2(RCR2) 84
6.2.6 复位控制寄存器4(RCR4) 84
6.3 Operation 85
6.3.1 RES引脚复位 85
6.3.2 Power-On Reset 85
6.3.3 电压监控器复位 86
6.3.4 深度软件待机复位 87
6.3.5 独立看门狗定时器复位 87
6.3.6 看门狗定时器复位 88
6.3.7 软件复位 88
6.3.8 冷暖启动的确定 88
6.3.9 复位产生源的确定 88
6.4 复位后所需的初始化过程 89
7. Option-Setting Memory 91
7.1 Overview 91
7.2 寄存器说明 91
7.2.1 选项功能选择寄存器0(OFS0) 91
7.2.2 选项功能选择寄存器1(OFS1) 94
7.2.3 访问窗口设置寄存器(AWS) 95
7.2.4 OCD串行编程器ID设置寄存器(OSIS) 97
7.3 设置选项设置记忆 98

7.3.1 Allocation of Data in the Option-Setting Memory 98
7.3.2 Setting Data for Programming the Option-Setting Memory 98
7.4 Usage Notes 98
7.4.1 Data for Programming Reserved Areas and Reserved Bits in the Option-Setting Memory 98
8. Low Voltage Detection (LVD) 99
8.1 Overview 99
8.2 Register Descriptions 101
8.2.1 Voltage Monitor 1 Circuit Control Register 1 (LVD1CR1) 101
8.2.2 Voltage Monitor 1 Circuit Status Register (LVD1SR) 102
8.2.3 Voltage Monitor 2 Circuit Control Register 1 (LVD2CR1) 102
8.2.4 Voltage Monitor 2 Circuit Status Register (LVD2SR) 103
8.2.5 Voltage Monitor Circuit Control Register (LVCMPCR) 103
8.2.6 Voltage Detection Level Select Register (LVDLVLR) 104
8.2.7 Voltage Monitor 1 Circuit Control Register 0 (LVD1CR0) 104
8.2.8 Voltage Monitor 2 Circuit Control Register 0 (LVD2CR0) 105
8.3 VCC Input Voltage Monitor 106
8.3.1 Monitoring Vdet0 106
8.3.2 Monitoring Vdet1 106
8.3.3 Monitoring Vdet2 107
8.4 Reset from Voltage Monitor 0 107
8.5 Interrupt and Reset from Voltage Monitor 1 108
8.6 Interrupt and Reset from Voltage Monitor 2 111
8.7 Event Link Output 113
8.7.1 Interrupt Handling and Event Linking 114
9. Clock Generation Circuit 115
9.1 Overview 115
9.2 Register Descriptions 118
9.2.1 System Clock Division Control Register (SCKDIVCR) 118
9.2.2 System Clock Source Control Register (SCKSCR) 122
9.2.3 PLL Clock Control Register (PLLCCR) 124
9.2.4 PLL Control Register (PLLCR) 125
9.2.5 Main Clock Oscillator Control Register (MOSCCR) 125
9.2.6 Subclock Oscillator Control Register (SOSCCR) 126
9.2.7 Low-Speed On-Chip Oscillator Control Register (LOCOCR) 127
9.2.8 High-Speed On-Chip Oscillator Control Register (HOCOCR) 128
9.2.9 High-Speed On-Chip Oscillator Wait Control Register (HOCOWTCR) 128
9.2.10 Middle-Speed On-Chip Oscillator Control Register (MOCOCR) 129
9.2.11 FLL Control Register 1 (FLLCR1) 130
9.2.12 FLL Control Register 2 (FLLCR2) 131
9.2.13 Oscillation Stabilization Flag Register (OSCSF) 132

7.3.1 选项设置内存中的数据分配.....98
7.3.2 用于编程选项设置存储器的设置数据.....98
7.4 使用说明.....98
7.4.1 用于编程选项设置存储器中的保留区域和保留位的数据98
8. 低电压检测(LVD).....99
8.1 Overview 99
8.2 寄存器说明.....101
8.2.1 电压监视器1电路控制寄存器1(LVD1CR1).....101
8.2.2 电压监视器1电路状态寄存器(LVD1SR).....102
8.2.3 电压监控器2电路控制寄存器1(LVD2CR1).....102
8.2.4 电压监视器2电路状态寄存器(LVD2SR).....103
8.2.5 电压监控电路控制寄存器(LVCMPCR).....103
8.2.6 电压检测电平选择寄存器(LVDLVLR).....104
8.2.7 电压监控器1电路控制寄存器0(LVD1CR0).....104
8.2.8 电压监控器2电路控制寄存器0(LVD2CR0).....105
8.3 VCC输入电压监视器.....106
8.3.1 Monitoring Vdet0 106
8.3.2 Monitoring Vdet1 106
8.3.3 Monitoring Vdet2 107
8.4 从电压监视器0复位.....107
8.5 电压监视器1的中断和复位.....108
8.6 电压监视器2的中断和复位.....111
8.7 事件链接输出.....113
8.7.1 中断处理和事件链接.....114
9. 时钟产生电路.....115
9.1 Overview 115
9.2 寄存器说明.....118
9.2.1 系统时钟分频控制寄存器(SCKDIVCR).....118
9.2.2 系统时钟源控制寄存器(SCKSCR).....122
9.2.3 PLL时钟控制寄存器(PLLCCR).....124
9.2.4 PLL控制寄存器(PLLCR).....125
9.2.5 主时钟振荡器控制寄存器（MOSCCR）.....125
9.2.6 副时钟振荡器控制寄存器(SOSCCR).....126
9.2.7 低速片上振荡器控制寄存器(LOCOCR).....127
9.2.8 高速片上振荡器控制寄存器(HOCOCR).....128
9.2.9 高速片上振荡器等待控制寄存器（HOCOWTCR）.....128
9.2.10 中速片上振荡器控制寄存器(MOCOCR).....129
9.2.11 FLL控制寄存器1(FLLCR1).....130
9.2.12 FLL控制寄存器2(FLLCR2).....131
9.2.13 振荡稳定标志寄存器(OSCSF).....132

RA生态工作室

9.2.14 Oscillation Stop Detection Control Register (OSTDCR) 133
9.2.15 Oscillation Stop Detection Status Register (OSTDSR) 134
9.2.16 Main Clock Oscillator Wait Control Register (MOSCWTCR) 135
9.2.17 Main Clock Oscillator Mode Oscillation Control Register (MOMCR) 136
9.2.18 Subclock Oscillator Mode Control Register (SOMCR) 136
9.2.19 Clock Out Control Register (CKOCR) 137
9.2.20 LOCO User Trimming Control Register (LOCOUTCR) 138
9.2.21 MOCO User Trimming Control Register (MOCOUTCR) 138
9.2.22 HOCO User Trimming Control Register (HOCOUTCR) 139
9.2.23 Trace Clock Control Register (TRCKCR) 139
9.3 Main Clock Oscillator 139
9.3.1 Connecting the Crystal Resonator 140
9.3.2 External Clock Input 140
9.3.3 Notes on External Clock Input 140
9.4 Sub-Clock Oscillator 141
9.4.1 Connecting a 32.768-kHz Crystal Resonator 141
9.4.2 Handling of Pins when the Sub-Clock Oscillator Is Not Used 141
9.5 Oscillation Stop Detection Function 142
9.5.1 Oscillation Stop Detection and Operation after Detection 142
9.5.2 Oscillation Stop Detection Interrupts 143
9.6 PLL Circuit 144
9.7 Internal Clock 144
9.7.1 System Clock (ICLK) 144
9.7.2 Peripheral Module Clock (PCLKA, PCLKB, PCLKC, PCLKD) 145
9.7.3 Flash Interface Clock (FCLK) 146
9.7.4 CAN Clock (CANMCLK) 146
9.7.5 CAC Clock (CACCLK) 146
9.7.6 IWDT-Dedicated Clock (IWDTCLK) 146
9.7.7 AGT-Dedicated Clock (AGTSCLK, AGTLCLK) 146
9.7.8 SysTick Timer-Dedicated Clock (SYSTICCLK) 146
9.7.9 Clock/Buzzer Output Clock (CLKOUT) 146
9.7.10 JTAG Clock (JTAGTCK) 146
9.8 Usage Notes 147
9.8.1 Notes on Clock Generation Circuit 147
9.8.2 Notes on Resonator 147
9.8.3 Notes on Board Design 147
9.8.4 Notes on the Resonator Connect Pin 147
9.8.5 Notes on the Main Clock Oscillator Drive Capability Auto Switching Function 147
10. Clock Frequency Accuracy Measurement Circuit (CAC) 149
10.1 Overview 149
10.2 Register Descriptions 150

9.2.14 振荡停止检测控制寄存器（OSTDCR）.....133
9.2.15 振荡停止检测状态寄存器(OSTDSR).....134
9.2.16 主时钟振荡器等待控制寄存器（MOSCWTCR）.....135
9.2.17 主时钟振荡器模式振荡控制寄存器(MOMCR).....136
9.2.18 副时钟振荡器模式控制寄存器(SOMCR).....136
9.2.19 时钟输出控制寄存器(CKOCR).....137
9.2.20 LOCO用户微调控制寄存器(LOCOUTCR).....138
9.2.21 MOCO用户微调控制寄存器(MOCOUTCR).....138
9.2.22 HOCO用户微调控制寄存器(HOCOUTCR).....139
9.2.23 跟踪时钟控制寄存器(TRCKCR).....139
9.3 主时钟振荡器.....139
9.3.1 连接晶体谐振器.....140
9.3.2 外部时钟输入.....140
9.3.3 外部时钟输入注意事项.....140
9.4 Sub-Clock Oscillator 141
9.4.1 连接32.768-kHz晶体谐振器.....141
9.4.2 不使用副时钟振荡器时的引脚处理.....141
9.5 振荡停止检测功能.....142
9.5.1 振荡停止检测和检测后的操作.....142
9.5.2 振荡停止检测中断.....143
9.6 PLL Circuit 144
9.7 内部时钟.....144
9.7.1 系统时钟(ICLK).....144
9.7.2 外设模块时钟（PCLKA、PCLKB、PCLKC、PCLKD）.....145
9.7.3 闪存接口时钟(FCLK).....146
9.7.4 CAN时钟(CANMCLK).....146
9.7.5 CAC时钟(CACCLK).....146
9.7.6 IWDT-Dedicated Clock (IWDTCLK) 146
9.7.7 AGT-Dedicated Clock (AGTSCLK, AGTLCLK) 146
9.7.8 SysTick Timer-Dedicated Clock (SYSTICCLK) 146
9.7.9 时钟蜂鸣器输出时钟(CLKOUT).....146
9.7.10 JTAG Clock (JTAGTCK) 146
9.8 使用说明.....147
9.8.1 时钟产生电路的注意事项.....147
9.8.2 谐振器注意事项.....147
9.8.3 电路板设计注意事项.....147
9.8.4 谐振器连接引脚注意事项.....147
9.8.5 关于主时钟振荡器驱动能力自动切换功能的注意事项.....147
10. 时钟频率精度测量电路(CAC).....149
10.1 Overview 149
10.2 寄存器说明.....150

RA生态工作室

10.2.1 CAC Control Register 0 (CACR0) 150
10.2.2 CAC Control Register 1 (CACR1) 151
10.2.3 CAC Control Register 2 (CACR2) 152
10.2.4 CAC Interrupt Control Register (CAICR) 153
10.2.5 CAC Status Register (CASTR) 154
10.2.6 CAC Upper-Limit Value Setting Register (CAULVR) 155
10.2.7 CAC Lower-Limit Value Setting Register (CALLVR) 155
10.2.8 CAC Counter Buffer Register (CACNTBR) 155
10.3 Operation 155
10.3.1 Measuring Clock Frequency 155
10.3.2 Digital Filtering of Signals on CACREF Pin 156
10.4 Interrupt Requests 157
10.5 Usage Notes 157
10.5.1 Settings for the Module-Stop Function 157
11. Low Power Modes 158
11.1 Overview 158
11.2 Register Descriptions 161
11.2.1 Standby Control Register (SBYCR) 161
11.2.2 Module Stop Control Register A (MSTPCRA) 162
11.2.3 Module Stop Control Register B (MSTPCRB) 163
11.2.4 Module Stop Control Register C (MSTPCRC) 164
11.2.5 Module Stop Control Register D (MSTPCRD) 165
11.2.6 Operating Power Control Register (OPCCR) 166
11.2.7 Sub Operating Power Control Register (SOPCCR) 167
11.2.8 Snooze Control Register (SNZCR) 168
11.2.9 Snooze End Control Register (SNZEDCR) 169
11.2.10 Snooze Request Control Register (SNZREQCR) 170
11.2.11 Deep Software Standby Control Register (DPSBYCR) 172
11.2.12 Deep Software Standby Interrupt Enable Register 0 (DPSIER0) 173
11.2.13 Deep Software Standby Interrupt Enable Register 1 (DPSIER1) 173
11.2.14 Deep Software Standby Interrupt Enable Register 2 (DPSIER2) 174
11.2.15 Deep Software Standby Interrupt Enable Register 3 (DPSIER3) 175
11.2.16 Deep Software Standby Interrupt Flag Register 0 (DPSIFR0) 175
11.2.17 Deep Software Standby Interrupt Flag Register 1 (DPSIFR1) 176
11.2.18 Deep Software Standby Interrupt Flag Register 2 (DPSIFR2) 177
11.2.19 Deep Software Standby Interrupt Flag Register 3 (DPSIFR3) 178
11.2.20 Deep Software Standby Interrupt Edge Register 0 (DPSIEGR0) 179
11.2.21 Deep Software Standby Interrupt Edge Register 1 (DPSIEGR1) 179
11.2.22 Deep Software Standby Interrupt Edge Register 2 (DPSIEGR2) 180
11.2.23 System Control OCD Control Register (SYOCDCR) 180
11.2.24 Standby Condition Register (STCONR) 181

10.2.1 CAC控制寄存器0(CACR0)..... 150
10.2.2 CAC控制寄存器1(CACR1)..... 151
10.2.3 CAC控制寄存器2(CACR2)..... 152
10.2.4 CAC中断控制寄存器(CAICR)..... 153
10.2.5 CAC状态寄存器(CASTR)..... 154
10.2.6 CAC上限值设置寄存器(CAULVR)..... 155
10.2.7 CAC下限值设置寄存器(CALLVR)..... 155
10.2.8 CAC计数器缓冲寄存器(CACNTBR)..... 155
10.3 Operation 155
10.3.1 测量时钟频率..... 155
10.3.2 CACREF引脚上的信号数字滤波..... 156
10.4 中断请求..... 157
10.5 使用说明..... 157
10.5.1 模块停止功能的设置..... 157
11. 低功耗模式..... 158
11.1 Overview 158
11.2 寄存器说明..... 161
11.2.1 待机控制寄存器(SBYCR)..... 161
11.2.2 模块停止控制寄存器A(MSTPCRA)..... 162
11.2.3 模块停止控制寄存器B(MSTPCRB)..... 163
11.2.4 模块停止控制寄存器C(MSTPCRC)..... 164
11.2.5 模块停止控制寄存器D(MSTPCRD)..... 165
11.2.6 工作电源控制寄存器(OPCCR)..... 166
11.2.7 副操作功率控制寄存器(SOPCCR)..... 167
11.2.8 贪睡控制寄存器(SNZCR)..... 168
11.2.9 贪睡结束控制寄存器(SNZEDCR)..... 169
11.2.10 贪睡请求控制寄存器(SNZREQCR)..... 170
11.2.11 深度软件待机控制寄存器(DPSBYCR)..... 172
11.2.12 深度软件待机中断使能寄存器0(DPSIER0)..... 173
11.2.13 深度软件待机中断使能寄存器1(DPSIER1)..... 173
11.2.14 深度软件待机中断使能寄存器2(DPSIER2)..... 174
11.2.15 深度软件待机中断使能寄存器3(DPSIER3)..... 175
11.2.16 深度软件待机中断标志寄存器0(DPSIFR0)..... 175
11.2.17 深度软件待机中断标志寄存器1(DPSIFR1)..... 176
11.2.18 深度软件待机中断标志寄存器2(DPSIFR2)..... 177
11.2.19 深度软件待机中断标志寄存器3(DPSIFR3)..... 178
11.2.20 深度软件待机中断边沿寄存器0(DPSIEGR0)..... 179
11.2.21 深度软件待机中断边沿寄存器1(DPSIEGR1)..... 179
11.2.22 深度软件待机中断边沿寄存器2(DPSIEGR2)..... 180
11.2.23 系统控制OCD控制寄存器(SYOCDCR)..... 180
11.2.24 待机条件寄存器(STCONR)..... 181

RA生态工作室

11.3 Reducing Power Consumption by Switching Clock Signals 181
11.4 Module-Stop Function 182
11.5 Function for Lower Operating Power Consumption 182
11.5.1 Setting the Operating Power Control Mode 182
11.6 Sleep Mode 183
11.6.1 Transitioning to Sleep Mode 183
11.6.2 Canceling Sleep Mode 184
11.7 Software Standby Mode 184
11.7.1 Transitioning to Software Standby Mode 184
11.7.2 Canceling Software Standby Mode 187
11.7.3 Example of Software Standby Mode Application 188
11.8 Snooze Mode 189
11.8.1 Transitioning to Snooze Mode 189
11.8.2 Canceling Snooze Mode 190
11.8.3 Returning to Software Standby Mode 190
11.8.4 Snooze Operation Example 192
11.9 Deep Software Standby Mode 196
11.9.1 Transitioning to Deep Software Standby Mode 196
11.9.2 Canceling Deep Software Standby Mode 196
11.9.3 Pin States when Deep Software Standby Mode is Canceled 197
11.9.4 Example of Deep Software Standby Mode Application 197
11.9.5 Usage Flow for Deep Software Standby Mode 198
11.10 Usage Notes 199
11.10.1 Register Access 199
11.10.2 I/O Port States 201
11.10.3 Module-Stop State of DMAC and DTC 201
11.10.4 Internal Interrupt Sources 201
11.10.5 Input Buffer Control by the DIRQnE Bit (n = 0, 1, 4 to 12) 201
11.10.6 Transitioning to Low Power Modes 201
11.10.7 Timing of WFI Instruction 201
11.10.8 Writing to the WDT and IWDT Registers by the DMAC or DTC in Sleep Mode or Snooze Mode 201
11.10.9 Oscillators in Snooze Mode 202
11.10.10 Snooze Mode Entry by RXD0 Falling Edge 202
11.10.11 Using SCI0 in Snooze Mode 202
11.10.12 Conditions of A/D Conversion Start in Snooze Mode 202
11.10.13 ELC Events in Snooze Mode 202
12. Register Write Protection 203
12.1 Overview 203
12.2 Register Descriptions 203
12.2.1 Protect Register (PRCR) 203

11.3 通过切换时钟信号降低功耗.....181
11.4 Module-Stop Function 182
11.5 降低运行功耗的功能.....182
11.5.1 设置工作电源控制模式.....182
11.6 睡眠模式.....183
11.6.1 转换到睡眠模式.....183
11.6.2 取消睡眠模式.....184
11.7 软件待机模式.....184
11.7.1 转换到软件待机模式.....184
11.7.2 取消软件待机模式.....187
11.7.3 软件待机模式应用示例.....188
11.8 贪睡模式.....189
11.8.1 过渡到贪睡模式.....189
11.8.2 取消贪睡模式.....190
11.8.3 返回到软件待机模式.....190
11.8.4 贪睡操作示例.....192
11.9 深度软件待机模式.....196
11.9.1 过渡到深度软件待机模式.....196
11.9.2 取消深度软件待机模式.....196
11.9.3 取消深度软件待机模式时的引脚状态.....197
11.9.4 深度软件待机模式应用示例.....197
11.9.5 深度软件待机模式的使用流程.....198
11.10 使用说明.....199
11.10.1 注册访问.....199
11.10.2 IO端口状态.....201
11.10.3 DMAC和DTC的模块停止状态.....201
11.10.4 内部中断源.....201
11.10.5 DIRQnE位的输入缓冲器控制（n=0、1、4到12）.....201
11.10.6 过渡到低功耗模式.....201
11.10.7 WFI指令的时序.....201
11.10.8 在睡眠模式或贪睡模式下由DMAC或DTC写入WDT和IWDT寄存器.....201
11.10.9 处于贪睡模式的振荡器.....202
11.10.10 通过RXD0下降沿进入贪睡模式.....202
11.10.11 在贪睡模式下使用SCI0.....202
11.10.12 贪睡模式下AD转换开始的条件.....202
11.10.13 贪睡模式下的ELC事件.....202
12. 寄存器写保护.....203
12.1 Overview 203
12.2 寄存器说明.....203
12.2.1 保护寄存器(PRCR).....203

RA生态工作室

13. Interrupt Controller Unit (ICU) 204
13.1 Overview 204
13.2 Register Descriptions 206
13.2.1 IRQ Control Register i (IRQCRi) (i = 0 to 13) 206
13.2.2 Non-Maskable Interrupt Status Register (NMISR) 207
13.2.3 Non-Maskable Interrupt Enable Register (NMIER) 209
13.2.4 Non-Maskable Interrupt Status Clear Register (NMICLR) 210
13.2.5 NMI Pin Interrupt Control Register (NMICR) 212
13.2.6 ICU Event Link Setting Register n (IELSRn) (n = 0 to 95) 213
13.2.7 DMAC Event Link Setting Register n (DELSRn) (n = 0 to 7) 214
13.2.8 SYS Event Link Setting Register (SELSR0) 215
13.2.9 Wake Up Interrupt Enable Register (WUPEN) 215
13.3 Vector Table 216
13.3.1 Interrupt Vector Table 217
13.3.2 Event Numbers 219
13.4 Interrupt Operation 226
13.4.1 Detecting Interrupts 226
13.4.2 Selecting Interrupt Request Destinations 227
13.4.3 Digital Filter 229
13.4.4 External Pin Interrupts 229
13.5 Non-Maskable Interrupt Operation 230
13.6 Return from Low Power Modes 230
13.6.1 Return from Sleep Mode 230
13.6.2 Return from Software Standby Mode 230
13.6.3 Return from Snooze Mode 231
13.7 Using the WFI Instruction with Non-Maskable Interrupts 231
13.8 Reference 231
14. Buses 232
14.1 Overview 232
14.2 Description of Buses 233
14.2.1 Main Buses 233
14.2.2 Slave Interface 233
14.2.3 Parallel Operations 234
14.2.4 Restrictions on Endianness 234
14.3 Register Descriptions 234
14.3.1 Master Bus Control Register (BUSMCNT<master>) 234
14.3.2 Slave Bus Control Register (BUSSCNT<slave>) 235
14.3.3 Bus Error Address Register (BUSnERRADD) (n = 1 to 4) 236
14.3.4 Bus Error Status Register (BUSnERRSTAT) (n = 1 to 4) 237
14.4 Bus Error Monitoring 237
14.4.1 Bus Error Types 237

13. 中断控制器单元(ICU)..... 204
13.1 Overview 204
13.2 寄存器说明..... 206
13.2.1 IRQ控制寄存器i(IRQCRi)(i=0到13)..... 206
13.2.2 不可屏蔽中断状态寄存器(NMISR)..... 207
13.2.3 不可屏蔽中断使能寄存器(NMIER)..... 209
13.2.4 不可屏蔽中断状态清除寄存器(NMICLR)..... 210
13.2.5 NMI引脚中断控制寄存器(NMICR)..... 212
13.2.6 ICU事件链接设置寄存器n(IELSRn)(n=0到95)..... 213
13.2.7 DMAC事件链接设置寄存器n(DELSRn)(n=0到7)..... 214
13.2.8 SYS事件链接设置寄存器（SELSR0）..... 215
13.2.9 唤醒中断使能寄存器(WUPEN)..... 215
13.3 向量表..... 216
13.3.1 中断向量表..... 217
13.3.2 事件编号..... 219
13.4 中断操作..... 226
13.4.1 检测中断..... 226
13.4.2 选择中断请求目标..... 227
13.4.3 数字滤波器..... 229
13.4.4 外部引脚中断..... 229
13.5 不可屏蔽中断操作..... 230
13.6 从低功耗模式返回..... 230
13.6.1 从睡眠模式返回..... 230
13.6.2 从软件待机模式返回..... 230
13.6.3 从贪睡模式返回..... 231
13.7 将WFI指令与不可屏蔽中断一起使用..... 231
13.8 Reference 231
14. Buses 232
14.1 Overview 232
14.2 巴士说明..... 233
14.2.1 主要巴士..... 233
14.2.2 从接口..... 233
14.2.3 并行操作..... 234
14.2.4 字节序限制..... 234
14.3 寄存器说明..... 234
14.3.1 主总线控制寄存器(BUSMCNT<master>)..... 234
14.3.2 从总线控制寄存器(BUSSCNT<slave>)..... 235
14.3.3 总线错误地址寄存器(BUSnERRADD)(n=1到4)..... 236
14.3.4 总线错误状态寄存器(BUSnERRSTAT)(n=1到4)..... 237
14.4 总线错误监控..... 237
14.4.1 总线错误类型..... 237

14.4.2 Operation when a Bus Error Occurs 238
14.4.3 Conditions Leading to Illegal Address Access Errors 238
14.4.4 Timeout 239
14.5 Notes on using Flash Cache 239
14.6 References 239
15. Memory Protection Unit (MPU) 240
15.1 Overview 240
15.2 CPU Stack Pointer Monitor 240
15.2.1 Register Descriptions 243
15.2.2 Operation 247
15.3 Arm MPU 248
15.4 Bus Master MPU 248
15.4.1 Register Descriptions 249
15.4.2 Operation 254
15.5 Bus Slave MPU 256
15.5.1 Register Descriptions 257
15.5.2 Operation 261
15.6 Security MPU 262
15.6.1 Register Descriptions (Option-Setting memory) 262
15.6.2 Memory Protection 269
15.6.3 Usage Notes 270
15.7 References 270
16. DMA Controller (DMAC) 271
16.1 Overview 271
16.2 Register Descriptions 273
16.2.1 DMA Source Address Register (DMSAR) 273
16.2.2 DMA Destination Address Register (DMDAR) 273
16.2.3 DMA Transfer Count Register (DMCRA) 274
16.2.4 DMA Block Transfer Count Register (DMCRB) 275
16.2.5 DMA Transfer Mode Register (DMTMD) 275
16.2.6 DMA Interrupt Setting Register (DMINT) 276
16.2.7 DMA Address Mode Register (DMAMD) 277
16.2.8 DMA Offset Register (DMOFR) 279
16.2.9 DMA Transfer Enable Register (DMCNT) 279
16.2.10 DMA Software Start Register (DMREQ) 280
16.2.11 DMA Status Register (DMSTS) 281
16.2.12 DMAC Module Activation Register (DMAST) 282
16.3 Operation 282
16.3.1 Transfer Mode 282
16.3.2 Extended Repeat Area Function 285
16.3.3 Address Update Function Using Offset 287

14.4.2 发生总线错误时的操作 238
14.4.3 导致非法地址访问错误的条件 238
14.4.4 Timeout 239
14.5 使用FlashCache的注意事项 239
14.6 References 239
15. 内存保护单元(MPU) 240
15.1 Overview 240
15.2 CPU堆栈指针监视器 240
15.2.1 寄存器说明 243
15.2.2 Operation 247
15.3 Arm MPU 248
15.4 总线主控MPU 248
15.4.1 寄存器说明 249
15.4.2 Operation 254
15.5 总线从MPU 256
15.5.1 寄存器说明 257
15.5.2 Operation 261
15.6 Security MPU 262
15.6.1 寄存器说明（选项设置存储器） 262
15.6.2 内存保护 269
15.6.3 使用说明 270
15.7 References 270
16. DMA Controller (DMAC) 271
16.1 Overview 271
16.2 寄存器说明 273
16.2.1 DMA源地址寄存器(DMSAR) 273
16.2.2 DMA目标地址寄存器(DMDAR) 273
16.2.3 DMA传输计数寄存器(DMCRA) 274
16.2.4 DMA块传输计数寄存器(DMRCB) 275
16.2.5 DMA传输模式寄存器(DMTMD) 275
16.2.6 DMA中断设置寄存器(DMINT) 276
16.2.7 DMA地址模式寄存器(DMAMD) 277
16.2.8 DMA偏移寄存器(DMOFR) 279
16.2.9 DMA传输使能寄存器(DMCNT) 279
16.2.10 DMA软件启动寄存器(DMREQ) 280
16.2.11 DMA状态寄存器(DMSTS) 281
16.2.12 DMAC模块激活寄存器(DMAST) 282
16.3 Operation 282
16.3.1 传输模式 282
16.3.2 扩展的重复区域功能 285
16.3.3 使用偏移的地址更新功能 287

RA生态工作室

16.3.4 Activation Sources 291
16.3.5 Operation Timing 291
16.3.6 Execution Cycles of DMAC 292
16.3.7 Activating the DMAC 293
16.3.8 Starting DMA Transfer 295
16.3.9 Registers during DMA Transfer 295
16.3.10 Channel Priority 296
16.4 Ending DMA Transfer 296
16.4.1 Transfer End by Completion of Specified Total Number of Transfer Operations 296
16.4.2 Transfer End by Repeat Size End Interrupt 296
16.4.3 Transfer End by Interrupt on Extended Repeat Area Overflow 296
16.4.4 Precautions for the End of DMA Transfer 297
16.5 Interrupts 297
16.6 Event Link 298
16.7 Low Power Consumption Function 298
16.8 Usage Notes 299
16.8.1 Access to Registers during DMA Transfer 299
16.8.2 DMA Transfer to Reserved Areas 299
16.8.3 Setting the DMAC Event Link Setting Register of the Interrupt Controller Unit (ICU.DELSRn) 299
16.8.4 Suspending or Restarting DMA Activation 299
17. Data Transfer Controller (DTC) 300
17.1 Overview 300
17.2 Register Descriptions 302
17.2.1 DTC Mode Register A (MRA) 302
17.2.2 DTC Mode Register B (MRB) 303
17.2.3 DTC Transfer Source Register (SAR) 304
17.2.4 DTC Transfer Destination Register (DAR) 304
17.2.5 DTC Transfer Count Register A (CRA) 305
17.2.6 DTC Transfer Count Register B (CRB) 306
17.2.7 DTC Control Register (DTCCR) 306
17.2.8 DTC Vector Base Register (DTCVBR) 307
17.2.9 DTC Module Start Register (DTCST) 307
17.2.10 DTC Status Register (DTCSTS) 308
17.3 Activation Sources 308
17.3.1 Allocating Transfer Information and the DTC Vector Table 309
17.4 Operation 310
17.4.1 Transfer Information Read Skip Function 313
17.4.2 Transfer Information Write-Back Skip Function 314
17.4.3 Normal Transfer Mode 314
17.4.4 Repeat Transfer Mode 315
17.4.5 Block Transfer Mode 316

16.3.4 激活源 291
16.3.5 操作时间 291
16.3.6 DMAC的执行周期 292
16.3.7 激活DMAC 293
16.3.8 开始DMA传输 295
16.3.9 DMA传输期间的寄存器 295
16.3.10 频道优先级 296
16.4 结束DMA传输 296
16.4.1 完成指定的转移操作总数后转移结束 296
16.4.2 按重复大小结束中断传输结束 296
16.4.3 扩展重复区域溢出时通过中断传输结束 296
16.4.4 DMA传输结束的注意事项 297
16.5 Interrupts 297
16.6 活动链接 298
16.7 低功耗功能 298
16.8 使用说明 299
16.8.1 在DMA传输期间访问寄存器 299
16.8.2 DMA传输到保留区域 299
16.8.3 设置中断控制器单元(ICU.DELSRn)的DMAC事件链接设置寄存器 299
16.8.4 挂起或重新启动DMA激活 299
17. 数据传输控制器(DTC) 300
17.1 Overview 300
17.2 寄存器说明 302
17.2.1 DTC模式寄存器A(MRA) 302
17.2.2 DTC模式寄存器B(MRB) 303
17.2.3 DTC传输源寄存器(SAR) 304
17.2.4 DTC传输目的地寄存器(DAR) 304
17.2.5 DTC传输计数寄存器A(CRA) 305
17.2.6 DTC传输计数寄存器B(CRB) 306
17.2.7 DTC控制寄存器(DTCCR) 306
17.2.8 DTC向量基址寄存器(DTCVBR) 307
17.2.9 DTC模块启动寄存器(DTCST) 307
17.2.10 DTC状态寄存器(DTCSTS) 308
17.3 激活源 308
17.3.1 分配传输信息和DTC向量表 309
17.4 Operation 310
17.4.1 传输信息读取跳过功能 313
17.4.2 传输信息回写跳过功能 314
17.4.3 正常传输模式 314
17.4.4 重复传输模式 315
17.4.5 块传输模式 316

17.4.6 Chain Transfer 317
17.4.7 Operation Timing 318
17.4.8 Execution Cycles of DTC 320
17.4.9 DTC Bus Mastership Release Timing 320
17.5 DTC Setting Procedure 320
17.6 Examples of DTC Usage 321
17.6.1 Normal Transfer 322
17.6.2 Chain Transfer 322
17.6.3 Chain Transfer when Counter = 0 324
17.7 Interrupt Sources 325
17.8 Event Link 325
17.9 Snooze Control Interface 325
17.10 Module-Stop Function 325
17.11 Usage Notes 326
17.11.1 Transfer Information Start Address 326
18. Event Link Controller (ELC) 327
18.1 Overview 327
18.2 Register Descriptions 328
18.2.1 Event Link Controller Register (ELCR) 328
18.2.2 Event Link Software Event Generation Register n (ELSEGRn) (n = 0, 1) 328
18.2.3 Event Link Setting Register n (ELSRn) (n = 0 to 17) 329
18.3 Operation 335
18.3.1 Relation between Interrupt Handling and Event Linking 335
18.3.2 Linking Events 335
18.3.3 Example Procedure for Linking Events 336
18.4 Usage Notes 336
18.4.1 Linking DMAC or DTC Transfer End Signals as Events 336
18.4.2 Setting the Clocks 336
18.4.3 Setting the Module-Stop Function 336
18.4.4 ELC delay time 336
19. I/O Ports 338
19.1 Overview 338
19.2 Register Descriptions 340
19.2.1 Port Control Register 1 (PCNTR1/PODR/PDR) 340
19.2.2 Port Control Register 2 (PCNTR2/EIDR/PIDR) 341
19.2.3 Port Control Register 3 (PCNTR3/PORR/POSR) 342
19.2.4 Port Control Register 4 (PCNTR4/EORR/EOSR) 343
19.2.5 Port mn Pin Function Select Register (PmnPFS/PmnPFS_HA/PmnPFS_BY) (m = 0 to 7; n = 00 to 15) 344
19.2.6 Write-Protect Register (PWPR) 346
19.2.7 AGT Input Control Register (VBTICTLR) 346
19.3 Operation 346

17.4.6 链转移.....317
17.4.7 操作时间.....318
17.4.8 DTC的执行周期.....320
17.4.9 DTC总线主控释放时序.....320
17.5 DTC设置程序.....320
17.6 DTC使用示例.....321
17.6.1 正常传输.....322
17.6.2 链转移.....322
17.6.3 计数器=0时的链转移.....324
17.7 中断源.....325
17.8 活动链接.....325
17.9 贪睡控制界面.....325
17.10 Module-Stop Function 325
17.11 使用说明.....326
17.11.1 传输信息起始地址.....326
18. 事件链接控制器(ELC).....327
18.1 Overview 327
18.2 寄存器说明.....328
18.2.1 事件链接控制器寄存器(ELCR).....328
18.2.2 事件链接软件事件生成寄存器n(ELSEGRn)(n=0 1).....328
18.2.3 事件链接设置寄存器n(ELSRn)(n=0到17).....329
18.3 Operation 335
18.3.1 中断处理和事件链接之间的关系.....335
18.3.2 链接事件.....335
18.3.3 链接事件的示例过程.....336
18.4 使用说明.....336
18.4.1 将DMAC或DTC传输结束信号作为事件链接.....336
18.4.2 设置时钟.....336
18.4.3 设置模块停止功能.....336
18.4.4 ELC延迟时间.....336
19. I/O Ports 338
19.1 Overview 338
19.2 寄存器说明.....340
19.2.1 端口控制寄存器1(PCNTR1PODRPDR).....340
19.2.2 端口控制寄存器2(PCNTR2EIDRPIDR).....341
19.2.3 端口控制寄存器3(PCNTR3PORRPOSR).....342
19.2.4 端口控制寄存器4(PCNTR4EORREOSR).....343
19.2.5 端口mn引脚功能选择寄存器（PmnPFSPmnPFS_HAPmnPFS_BY）（m=0至7；n=00至15）.....344
19.2.6 Write-Protect Register (PWPR) 346
19.2.7 AGT输入控制寄存器(VBTICTLR).....346
19.3 Operation 346

19.3.1 General I/O Ports 346
19.3.2 Port Function Select 347
19.3.3 Port Group Function for the ELC 347
19.4 Handling of Unused Pins 349
19.5 Usage Notes 350
19.5.1 Procedure for Specifying the Pin Functions 350
19.5.2 Procedure for Using Port Group Input 350
19.5.3 Port Output Data Register (PODR) Summary 350
19.5.4 Notes on Using Analog Functions 350
19.5.5 I/O Buffer Specification 350
19.6 Peripheral Select Settings for each Product 352
19.7 Notes on the PmnPFS Register Setting 352
20. Key Interrupt Function (KINT) 363
20.1 Overview 363
20.2 Register Descriptions 365
20.2.1 Key Return Control Register (KRCTL) 365
20.2.2 Key Return Flag Register (KRF) 365
20.2.3 Key Return Mode Register (KRM) 365
20.3 Operation 366
20.3.1 Operation When Not Using Key Interrupt Flag (KRMD = 0) 366
20.3.2 Operation When Using the Key Interrupt Flags (KRMD = 1) 366
20.4 Usage Notes 368
21. Port Output Enable for GPT (POEG) 369
21.1 Overview 369
21.2 Register Descriptions 371
21.2.1 POEG Group n Setting Register (POEGGn) (n = A to D) 371
21.3 Output-Disable Control Operation 372
21.3.1 Pin Input Level Detection Operation 372
21.3.2 Output-Disable Requests from the GPT 373
21.3.3 Comparator Interrupt Detection 373
21.3.4 Output-Disable Control Using Detection of Stopped Oscillation 373
21.3.5 Output-Disable Control Using Registers 373
21.3.6 Release from Output-Disable 373
21.4 Interrupt Sources 374
21.5 External Trigger Output to the GPT 375
21.6 Usage Notes 375
21.6.1 Transition to Software Standby Mode 375
21.6.2 Specifying Pins Associated with the GPT 375
22. General PWM Timer (GPT) 376
22.1 Overview 376
22.2 Register Descriptions 380

19.3.1 通用IO端口……346
19.3.2 端口功能选择……347
19.3.3 ELC的端口组功能……347
19.4 未使用引脚的处理……349
19.5 使用说明……350
19.5.1 指定引脚功能的步骤……350
19.5.2 使用端口组输入的过程……350
19.5.3 端口输出数据寄存器(PODR)汇总……350
19.5.4 使用模拟功能的注意事项……350
19.5.5 IO缓冲器规范……350
19.6 每个产品的外设选择设置……352
19.7 PmnPFS寄存器设置的注意事项……352
20. 按键中断功能(KINT)……363
20.1 Overview 363
20.2 寄存器说明……365
20.2.1 密钥返回控制寄存器(KRCTL)……365
20.2.2 密钥返回标志寄存器(KRF)……365
20.2.3 密钥返回模式寄存器(KRM)……365
20.3 Operation 366
20.3.1 不使用按键中断标志(KRMD=0)时的操作……366
20.3.2 使用按键中断标志(KRMD=1)时的操作……366
20.4 使用说明……368
21. GPT(POEG)的端口输出使能……369
21.1 Overview 369
21.2 寄存器说明……371
21.2.1 POEG组n设置寄存器(POEGGn)(n=A到D)……371
21.3 输出禁用控制操作……372
21.3.1 引脚输入电平检测操作……372
21.3.2 来自GPT的输出禁用请求……373
21.3.3 比较器中断检测……373
21.3.4 使用停止振荡检测的输出禁用控制……373
21.3.5 使用寄存器的输出禁用控制……373
21.3.6 从输出禁用释放……373
21.4 中断源……374
21.5 到GPT的外部触发输出……375
21.6 使用说明……375
21.6.1 过渡到软件待机模式……375
21.6.2 指定与GPT关联的引脚……375
22. 通用PWM定时器(GPT)……376
22.1 Overview 376
22.2 寄存器说明……380

RA生态工作室

22.2.1 General PWM Timer Write Protection Register (GTWP) 382
22.2.2 General PWM Timer Software Start Register (GTSTR) 382
22.2.3 General PWM Timer Software Stop Register (GTSTP) 383
22.2.4 General PWM Timer Software Clear Register (GTCLR) 383
22.2.5 General PWM Timer Start Source Select Register (GTSSR) 384
22.2.6 General PWM Timer Stop Source Select Register (GTPSR) 387
22.2.7 General PWM Timer Clear Source Select Register (GTCSR) 390
22.2.8 General PWM Timer Up Count Source Select Register (GTUPSR) 393
22.2.9 General PWM Timer Down Count Source Select Register (GTDNSR) 396
22.2.10 General PWM Timer Input Capture Source Select Register A (GTICASR) 399
22.2.11 General PWM Timer Input Capture Source Select Register B (GTICBSR) 402
22.2.12 General PWM Timer Control Register (GTCR) 405
22.2.13 General PWM Timer Count Direction and Duty Setting Register (GTUDDTYC) 407
22.2.14 General PWM Timer I/O Control Register (GTIOR) 409
22.2.15 General PWM Timer Interrupt Output Setting Register (GTINTAD) 413
22.2.16 General PWM Timer Status Register (GTST) 415
22.2.17 General PWM Timer Buffer Enable Register (GTBER) 420
22.2.18 General PWM Timer Interrupt and A/D Converter Start Request Skipping Setting Register (GTITC) 423
22.2.19 General PWM Timer Counter (GTCNT) 425
22.2.20 General PWM Timer Compare Capture Register n (GTCCRn) (n = A to F) 425
22.2.21 General PWM Timer Cycle Setting Register (GTPR) 426
22.2.22 General PWM Timer Cycle Setting Buffer Register (GTPBR) 426
22.2.23 General PWM Timer Cycle Setting Double-Buffer Register (GTPDBR) 426
22.2.24 A/D Converter Start Request Timing Register n (GTADTRn) (n = A, B) 427
22.2.25 A/D Converter Start Request Timing Buffer Register n (GTADTBRn) (n = A, B) 427
22.2.26 A/D Converter Start Request Timing Double-Buffer Register n (GTADTDBRn) (n = A, B) 428
22.2.27 General PWM Timer Dead Time Control Register (GTDTCR) 428
22.2.28 General PWM Timer Dead Time Value Register n (GTDVn) (n = U, D) 430
22.2.29 General PWM Timer Dead Time Buffer Register n (GTDBn) (n = U, D) 430
22.2.30 General PWM Timer Output Protection Function Status Register (GTSOS) 431
22.2.31 General PWM Timer Output Protection Function Temporary Release Register (GTSOTR) 431
22.2.32 Output Phase Switching Control Register (OPSCR) 432
22.3 Operation 434
22.3.1 Basic Operation 434
22.3.2 Buffer Operation 444
22.3.3 PWM Output Operating Mode 455
22.3.4 Automatic Dead Time Setting Function 468
22.3.5 Count Direction Changing Function 473

22.2.1 通用PWM定时器写保护寄存器(GTWP)..... 382
22.2.2 通用PWM定时器软件启动寄存器(GTSTR)..... 382
22.2.3 通用PWM定时器软件停止寄存器(GTSTP)..... 383
22.2.4 通用PWM定时器软件清零寄存器(GTCLR)..... 383
22.2.5 通用PWM定时器启动源选择寄存器(GTSSR)..... 384
22.2.6 通用PWM定时器停止源选择寄存器(GTPSR)..... 387
22.2.7 通用PWM定时器清零源选择寄存器(GTCSR)..... 390
22.2.8 通用PWM定时器向上计数源选择寄存器(GTUPSR)..... 393
22.2.9 通用PWM定时器递减计数源选择寄存器(GTDNSR)..... 396
22.2.10 通用PWM定时器输入捕捉源选择寄存器A(GTICASR)..... 399
22.2.11 通用PWM定时器输入捕捉源选择寄存器B(GTICBSR)..... 402
22.2.12 通用PWM定时器控制寄存器(GTCR)..... 405
22.2.13 通用PWM定时器计数方向和占空比设置寄存器（GTUDDTYC）..... 407
22.2.14 通用PWM定时器IO控制寄存器(GTIOR)..... 409
22.2.15 通用PWM定时器中断输出设置寄存器(GTINTAD)..... 413
22.2.16 通用PWM定时器状态寄存器(GTST)..... 415
22.2.17 通用PWM定时器缓冲器使能寄存器(GTBER)..... 420
22.2.18 通用PWM定时器中断和AD转换器启动请求跳过设置寄存器(GTITC)..... 423
22.2.19 通用PWM定时器计数器(GTCNT)..... 425
22.2.20 通用PWM定时器比较捕捉寄存器n(GTCCRn)(n=A到F)..... 425
22.2.21 通用PWM定时器周期设置寄存器(GTPR)..... 426
22.2.22 通用PWM定时器周期设置缓冲寄存器(GTPBR)..... 426
22.2.23 通用PWM定时器周期设置双缓冲寄存器(GTPDBR)..... 426
22.2.24 AD转换器启动请求时序寄存器n(GTADTRn)(n=A B)..... 427
22.2.25 AD转换器启动请求时序缓冲寄存器n(GTADTBRn)(n=A B)..... 427
22.2.26 AD转换器启动请求时序双缓冲寄存器n(GTADTDBRn)(n=A B)..... 428
22.2.27 通用PWM定时器死区时间控制寄存器(GTDTCR)..... 428
22.2.28 通用PWM定时器死区值寄存器n(GTDVn)(n=U D)..... 430
22.2.29 通用PWM定时器死区缓冲寄存器n(GTDBn)(n=U D)..... 430
22.2.30 通用PWM定时器输出保护功能状态寄存器（GTSOS）..... 431
22.2.31 通用PWM定时器输出保护功能临时释放寄存器(GT SOTR) 431
22.2.32 输出相位切换控制寄存器(OPSCR)..... 432
22.3 Operation 434
22.3.1 基本操作..... 434
22.3.2 缓冲操作..... ……444
22.3.3 PWM输出工作模式..... 455
22.3.4 自动死区时间设置功能..... 468
22.3.5 计数方向改变功能..... 473

22.3.6 Function of Output Duty 0% and 100% 474
22.3.7 Hardware Count Start/Count Stop and Clear Operation 475
22.3.8 Synchronized Operation 482
22.3.9 PWM Output Operation Examples 486
22.3.10 Phase Counting Function 492
22.3.11 Output Phase Switching (GPT_OPS) 499
22.4 Interrupt Sources 506
22.4.1 DMAC/DTC Activation 512
22.4.2 Interrupt and A/D Conversion Request Skipping Function 512
22.5 A/D Converter Start Request 516
22.6 Operations Linked by the ELC 519
22.6.1 Event Signal Output to the ELC 519
22.6.2 Event Signal Inputs from the ELC 519
22.7 Noise Filter Function 519
22.8 Protection Function 520
22.8.1 Write-Protection for Registers 520
22.8.2 Disabling of Buffer Operation 520
22.8.3 GTIOC Pin Output Negate Control 521
22.8.4 Output Protection Function for GTIOC Pin Output 522
22.9 Initialization Method of Output Pins 529
22.9.1 Pin Settings after Reset 529
22.9.2 Pin Initialization Caused by Error during Operation 530
22.10 Usage Notes 530
22.10.1 Module-Stop Function Setting 530
22.10.2 GTCCRn Settings during Compare Match Operation (n = A to F) 530
22.10.3 Setting Range for the GTCNT Counter 531
22.10.4 Starting and Stopping the GTCNT Counter 531
22.10.5 Priority Order of Each Event 532
23. PWM Delay Generation Circuit 533
23.1 Overview 533
23.2 Register Descriptions 534
23.2.1 PWM Output Delay Control Register (GTDLYCR) 534
23.2.2 PWM Output Delay Control Register 2 (GTDLYCR2) 534
23.2.3 GTIOCnA Rising Output Delay Register (GTDLYRnA) (n = 0 to 3) 536
23.2.4 GTIOCnA Falling Output Delay Register (GTDLYFnA) (n = 0 to 3) 537
23.2.5 GTIOCnB Rising Output Delay Register (GTDLYRnB) (n = 0 to 3) 538
23.2.6 GTIOCnB Falling Output Delay Register (GTDLYFnB) (n = 0 to 3) 539
23.3 Operation 539
23.3.1 Adjustments to the Timing of Rising and Falling Edges in PWM Waveforms 539
23.3.2 Timing for Transfer of GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB Register Settings 541
23.4 Usage Notes 542

22.3.6 输出占空比0%和100%的功能 474
22.3.7 硬件计数开始计数停止和清除操作 475
22.3.8 同步操作 482
22.3.9 PWM输出操作示例 486
22.3.10 相位计数功能 492
22.3.11 输出相位切换(GPT_OPS) 499
22.4 中断源 506
22.4.1 DMAC/DTC Activation 512
22.4.2 中断和AD转换请求跳过功能 512
22.5 AD转换器启动请求 516
22.6 由ELC链接的操作 519
22.6.1 事件信号输出到ELC 519
22.6.2 来自ELC的事件信号输入 519
22.7 噪声过滤功能 519
22.8 保护功能 520
22.8.1 寄存器的写保护 520
22.8.2 禁用缓冲区操作 520
22.8.3 GTIOC引脚输出负控制 521
22.8.4 GTIOC引脚输出的输出保护功能 522
22.9 输出管脚的初始化方法 529
22.9.1 复位后的引脚设置 529
22.9.2 操作过程中错误导致的引脚初始化 530
22.10 使用说明 530
22.10.1 模块停止功能设置 530
22.10.2 比较匹配操作期间的GTCCRn设置（n=A到F） 530
22.10.3 GTCNT计数器的设置范围 531
22.10.4 启动和停止GTCNT计数器 531
22.10.5 每个事件的优先顺序 532
23. PWM延迟产生电路 533
23.1 Overview 533
23.2 寄存器说明 534
23.2.1 PWM输出延迟控制寄存器(GTDLYCR) 534
23.2.2 PWM输出延迟控制寄存器2(GTDLYCR2) 534
23.2.3 GTIOCnA上升沿输出延迟寄存器(GTDLYRnA)(n=0至3) 536
23.2.4 GTIOCnA下降输出延迟寄存器(GTDLYFnA)(n=0至3) 537
23.2.5 GTIOCnB上升沿输出延迟寄存器(GTDLYRnB)(n=0至3) 538
23.2.6 GTIOCnB下降输出延迟寄存器(GTDLYFnB)(n=0到3) 539
23.3 Operation 539
23.3.1 PWM波形上升沿和下降沿时序的调整 539
23.3.2 传送GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB寄存器设置的时序 541
23.4 使用说明 542

23.4.1 Module-Stop Function Settings 542
23.4.2 Notes on Delay Settings for PWM Delay Generation Circuit 542
24. Low Power Asynchronous General-Purpose Timer (AGT) 544
24.1 Overview 544
24.2 Register Descriptions 546
24.2.1 AGT Counter Register (AGT) 546
24.2.2 AGT Compare Match A Register (AGTCMA) 546
24.2.3 AGT Compare Match B Register (AGTCMB) 547
24.2.4 AGT Control Register (AGTCR) 547
24.2.5 AGT Mode Register 1 (AGTMR1) 549
24.2.6 AGT Mode Register 2 (AGTMR2) 550
24.2.7 AGT I/O Control Register (AGTIOC) 550
24.2.8 AGT Event Pin Select Register (AGTISR) 551
24.2.9 AGT Compare Match Function Select Register (AGTCMSR) 552
24.2.10 AGT Pin Select Register (AGTIOSEL) 552
24.3 Operation 553
24.3.1 Reload Register and Counter Rewrite Operation 553
24.3.2 Reload Register and Compare Register A/B Rewrite Operation 555
24.3.3 Timer Mode 556
24.3.4 Pulse Output Mode 557
24.3.5 Event Counter Mode 558
24.3.6 Pulse Width Measurement Mode 560
24.3.7 Pulse Period Measurement Mode 560
24.3.8 Compare Match Function 561
24.3.9 Output Settings for Each Mode 563
24.3.10 Standby Mode 564
24.3.11 Interrupt Sources 565
24.3.12 Event Signal Output to ELC 565
24.4 Usage Notes 565
24.4.1 Count Operation Start and Stop Control 565
24.4.2 Access to Counter Register 566
24.4.3 When Changing Mode 566
24.4.4 Digital Filter 566
24.4.5 How to Calculate Event Number, Pulse Width, and Pulse Period 566
24.4.6 When Count Is Forcibly Stopped by TSTOP Bit 566
24.4.7 When Selecting AGT0 Underflow as the Count Source 566
24.4.8 Reset of I/O Register 567
24.4.9 When Selecting PCLKB, PCLKB/8, or PCLKB/2 as the Count Source 567
24.4.10 When Selecting AGTSCLK or AGTLCLK as the Count Source 567
24.4.11 When Switching Source Clock 567

23.4.1 模块停止功能设置.....542
23.4.2 关于PWM延迟生成电路的延迟设置的注意事项.....542
24. 低功耗异步通用定时器(AGT).....544
24.1 Overview 544
24.2 寄存器说明.....546
24.2.1 AGT计数器寄存器(AGT).....546
24.2.2 AGT比较匹配A寄存器(AGTCMA).....546
24.2.3 AGT比较匹配B寄存器(AGTCMB).....547
24.2.4 AGT控制寄存器(AGTCR).....547
24.2.5 AGT模式寄存器1(AGTMR1).....549
24.2.6 AGT模式寄存器2(AGTMR2).....550
24.2.7 AGTIO控制寄存器(AGTIOC).....550
24.2.8 AGT事件引脚选择寄存器(AGTISR).....551
24.2.9 AGT比较匹配功能选择寄存器(AGCTMSR).....552
24.2.10 AGT引脚选择寄存器(AGTIOSEL).....552
24.3 Operation 553
24.3.1 重载寄存器和计数器重写操作.....553
24.3.2 重新加载寄存器和比较寄存器AB重写操作.....555
24.3.3 定时器模式.....556
24.3.4 脉冲输出模式.....557
24.3.5 事件计数器模式.....558
24.3.6 脉冲宽度测量模式.....560
24.3.7 脉冲周期测量模式.....560
24.3.8 比较匹配函数.....561
24.3.9 每种模式的输出设置.....563
24.3.10 待机模式.....564
24.3.11 中断源.....565
24.3.12 事件信号输出到ELC.....565
24.4 使用说明.....565
24.4.1 计数操作的开始和停止控制.....565
24.4.2 访问计数器寄存器.....566
24.4.3 更改模式时.....566
24.4.4 数字滤波器.....566
24.4.5 如何计算事件编号、脉冲宽度和脉冲周期.....566
24.4.6 当计数被TSTOP位强制停止时.....566
24.4.7 选择AGT0下溢作为计数源时.....566
24.4.8 IO寄存器的复位.....567
24.4.9 选择PCLKB、PCLKB8或PCLKB2作为计数源时.....567
24.4.10 选择AGTSCLK或AGTLCLK作为计数源时.....567
24.4.11 切换源时钟时.....567

25. Watchdog Timer (WDT) 568
25.1 Overview 568
25.2 Register Descriptions 569
25.2.1 WDT Refresh Register (WDTRR) 569
25.2.2 WDT Control Register (WDTCR) 570
25.2.3 WDT Status Register (WDTSR) 572
25.2.4 WDT Reset Control Register (WDTRCR) 573
25.2.5 WDT Count Stop Control Register (WDTCSTPR) 574
25.2.6 Option Function Select Register 0 (OFS0) 574
25.3 Operation 574
25.3.1 Count Operation in each Start Mode 574
25.3.2 Controlling Writes to the WDTCR, WDTRCR, and WDTCSTPR Registers 577
25.3.3 Refresh Operation 578
25.3.4 Reset Output 579
25.3.5 Interrupt Sources 579
25.3.6 Reading the Down-Counter Value 579
25.3.7 Association between Option Function Select Register 0 (OFS0) and WDT Registers 580
25.4 Link Operation by ELC 580
25.5 Usage Notes 580
25.5.1 ICU Event Link Setting Register n (IELSRn) Setting 580
26. Independent Watchdog Timer (IWDT) 581
26.1 Overview 581
26.2 Register Descriptions 582
26.2.1 IWDT Refresh Register (IWDTRR) 582
26.2.2 IWDT Status Register (IWDTSR) 583
26.2.3 Option Function Select Register 0 (OFS0) 584
26.3 Operation 586
26.3.1 Auto Start Mode 586
26.3.2 Refresh Operation 587
26.3.3 Status Flags 588
26.3.4 Reset Output 589
26.3.5 Interrupt Sources 589
26.3.6 Reading the Down-Counter Value 589
26.4 Link Operation by the ELC 590
26.5 Usage Notes 590
26.5.1 Refresh Operations 590
26.5.2 Restrictions on the Clock Division Ratio Setting 590
27. Serial Communications Interface (SCI) 591
27.1 Overview 591
27.2 Register Descriptions 595
27.2.1 Receive Shift Register (RSR) 595

25. 看门狗定时器(WDT)..... 568
25.1 Overview 568
25.2 寄存器说明..... 569
25.2.1 WDT刷新寄存器(WDTRR)..... 569
25.2.2 WDT控制寄存器(WDTCR)..... 570
25.2.3 WDT状态寄存器(WDTSR)..... 572
25.2.4 WDT复位控制寄存器(WDTRCR)..... 573
25.2.5 WDT计数停止控制寄存器(WDTCSTPR)..... 574
25.2.6 选项功能选择寄存器0(OFS0)..... 574
25.3 Operation 574
25.3.1 每种启动模式下的计数操作..... 574
25.3.2 控制对WDTCR、WDTRCR和WDTCSTPR寄存器的写入..... 577
25.3.3 刷新操作..... 578
25.3.4 复位输出..... 579
25.3.5 中断源..... 579
25.3.6 读取递减计数器值..... 579
25.3.7 选项功能选择寄存器0(OFS0)和WDT寄存器之间的关联..... 580
25.4 ELC的链接操作..... 580
25.5 使用说明..... 580
25.5.1 ICU事件链接设置寄存器n(IELSRn)设置..... 580
26. 独立看门狗定时器(IWDT)..... 581
26.1 Overview 581
26.2 寄存器说明..... 582
26.2.1 IWDT刷新寄存器(IWDTRR)..... 582
26.2.2 IWDT状态寄存器(IWDTSR)..... 583
26.2.3 选项功能选择寄存器0(OFS0)..... 584
26.3 Operation 586
26.3.1 自动启动模式..... 586
26.3.2 刷新操作..... 587
26.3.3 状态标志..... 588
26.3.4 复位输出..... 589
26.3.5 中断源..... 589
26.3.6 读取递减计数器值..... 589
26.4 ELC的链接操作..... 590
26.5 使用说明..... 590
26.5.1 刷新操作..... 590
26.5.2 时钟分频比设置的限制..... 590
27. 串行通信接口(SCI)..... 591
27.1 Overview 591
27.2 寄存器说明..... 595
27.2.1 接收移位寄存器(RSR)..... 595

RA生态工作室

27.2.2 Receive Data Register (RDR) 595
27.2.3 Receive 9-Bit Data Register (RDRHL) 595
27.2.4 Receive FIFO Data Register H, L, HL (FRDRH, FRDRL, FRDRHL) 596
27.2.5 Transmit Data Register (TDR) 597
27.2.6 Transmit 9-Bit Data Register (TDRHL) 597
27.2.7 Transmit FIFO Data Register H, L, HL (FTDRH, FTDRL, FTDRHL) 598
27.2.8 Transmit Shift Register (TSR) 599
27.2.9 Serial Mode Register (SMR) for Non-Smart Card Interface Mode (SCMR.SMIF = 0) 599
27.2.10 Serial Mode Register for Smart Card Interface Mode (SMR_SMCI) (SCMR.SMIF = 1) . 600
27.2.11 Serial Control Register (SCR) for Non-Smart Card Interface Mode (SCMR.SMIF = 0) .. 602
27.2.12 Serial Control Register for Smart Card Interface Mode (SCR_SMCI) (SCMR.SMIF = 1) 604
27.2.13 Serial Status Register (SSR) for Non-Smart Card Interface and Non-FIFO Mode (SCMR.SMIF = 0 and FCR.FM = 0) 605
27.2.14 Serial Status Register for Non-Smart Card Interface and FIFO Mode (SSR_FIFO) (SCMR.SMIF = 0 and FCR.FM = 1) 608
27.2.15 Serial Status Register for Smart Card Interface Mode (SSR_SMCI) (SCMR.SMIF = 1) . 611
27.2.16 Smart Card Mode Register (SCMR) 613
27.2.17 Bit Rate Register (BRR) 614
27.2.18 Modulation Duty Register (MDDR) 623
27.2.19 Serial Extended Mode Register (SEMR) 625
27.2.20 Noise Filter Setting Register (SNFR) 627
27.2.21 I²C Mode Register 1 (SIMR1) 627
27.2.22 I²C Mode Register 2 (SIMR2) 628
27.2.23 I²C Mode Register 3 (SIMR3) 629
27.2.24 I²C Status Register (SISR) 631
27.2.25 SPI Mode Register (SPMR) 631
27.2.26 FIFO Control Register (FCR) 632
27.2.27 FIFO Data Count Register (FDR) 634
27.2.28 Line Status Register (LSR) 634
27.2.29 Compare Match Data Register (CDR) 635
27.2.30 Data Compare Match Control Register (DCCR) 636
27.2.31 Serial Port Register (SPTR) 637
27.3 Operation in Asynchronous Mode 638
27.3.1 Serial Data Transfer Format 638
27.3.2 Receive Data Sampling Timing and Reception Margin in Asynchronous Mode 640
27.3.3 Clock 641
27.3.4 Double-Speed Operation and Frequency of 6 Times the Bit Rate 641
27.3.5 CTS and RTS Functions 641

27.2.2 接收数据寄存器(RDR)..... 595
27.2.3 接收9位数据寄存器(RDRHL)..... 595
27.2.4 接收FIFO数据寄存器H、L、HL（FRRDH、FRDRL、FRDRHL）..... 596
27.2.5 发送数据寄存器(TDR)..... 597
27.2.6 发送9位数据寄存器(TDRHL)..... 597
27.2.7 发送FIFO数据寄存器H L HL(FTDRH FTDRL FTDRHL)..... 598
27.2.8 发送移位寄存器(TSR)..... 599
27.2.9 非智能卡接口模式的串行模式寄存器(SMR)(SCMR.SMIF=0)..... 599
27.2.10 智能卡接口模式的串行模式寄存器(SMR_SMCI)(SCMR.SMIF=1)。 600
27.2.11 非智能卡接口模式的串行控制寄存器(SCR)(SCMR.SMIF=0)..602
27.2.12 智能卡接口模式的串行控制寄存器(SCR_SMCI)(SCMR.SMIF=1)604
27.2.13 用于非智能卡接口和非FIFO模式(SC)的串行状态寄存器(SSR) MR.SMIF = 0 and FCR.FM = 0) 605
27.2.14 非智能卡接口和FIFO模式的串行状态寄存器(SSR_FIFO)（SCMR.SMIF=0和FCR.FM=1）..... 608
27.2.15 智能卡接口模式的串行状态寄存器(SSR_SMCI)(SCMR.SMIF=1)。 611
27.2.16 智能卡模式寄存器(SCMR)..... 613
27.2.17 比特率寄存器(BRR)..... 614
27.2.18 调制占空比寄存器(MDDR)..... 623
27.2.19 串行扩展模式寄存器(SEMR)..... 625
27.2.20 噪声滤波器设置寄存器(SNFR)..... 627
27.2.21 I2C模式寄存器1(SIMR1)..... 627
27.2.22 I2C模式寄存器2(SIMR2)..... 628
27.2.23 I2C模式寄存器3(SIMR3)..... 629
27.2.24 我2C状态寄存器(SISR)..... 631
27.2.25 SPI模式寄存器(SPMR)..... 631
27.2.26 FIFO控制寄存器(FCR)..... 632
27.2.27 FIFO数据计数寄存器(FDR)..... 634
27.2.28 线路状态寄存器(LSR)..... 634
27.2.29 比较匹配数据寄存器(CDR)..... 635
27.2.30 数据比较匹配控制寄存器(DCCR)..... 636
27.2.31 串行端口寄存器(SPTR)..... 637
27.3 异步模式下的操作..... 638
27.3.1 串行数据传输格式..... 638
27.3.2 异步模式下接收数据采样时序和接收余量..... 640
27.3.3 Clock 641
27.3.4 双速操作和6倍比特率的频率..... 641
27.3.5 CTS和RTS功能..... 641

27.3.6 Address Match (Receive Data Match Detection) Function 642
27.3.7 SCI Initialization in Asynchronous Mode 645
27.3.8 Serial Data Transmission in Asynchronous Mode 647
27.3.9 Serial Data Reception in Asynchronous Mode 651
27.4 Multi-Processor Communication Function 658
27.4.1 Multi-Processor Serial Data Transmission 659
27.4.2 Multi-Processor Serial Data Reception 662
27.5 Operation in Clock Synchronous Mode 667
27.5.1 Clock 667
27.5.2 CTS and RTS Functions 668
27.5.3 SCI Initialization in Clock Synchronous Mode 668
27.5.4 Serial Data Transmission in Clock Synchronous Mode 670
27.5.5 Serial Data Reception in Clock Synchronous Mode 674
27.5.6 Simultaneous Serial Data Transmission and Reception in Clock Synchronous Mode 679
27.6 Operation in Smart Card Interface Mode 681
27.6.1 Example Connection 681
27.6.2 Data Format (Except in Block Transfer Mode) 682
27.6.3 Block Transfer Mode 683
27.6.4 Receive Data Sampling Timing and Reception Margin 683
27.6.5 SCI Initialization 684
27.6.6 Serial Data Transmission (Except in Block Transfer Mode) 686
27.6.7 Serial Data Reception (Except in Block Transfer Mode) 688
27.6.8 Clock Output Control 690
27.7 Operation in Simple IIC Mode 690
27.7.1 Generation of Start, Restart, and Stop Conditions 691
27.7.2 Clock Synchronization 692
27.7.3 SDA Output Delay 693
27.7.4 SCI Initialization in Simple IIC Mode 694
27.7.5 Operation in Master Transmission in Simple IIC Mode 695
27.7.6 Master Reception in Simple IIC Mode 697
27.8 Operation in Simple SPI Mode 699
27.8.1 States of Pins in Master and Slave Modes 699
27.8.2 SS Function in Master Mode 700
27.8.3 SS Function in Slave Mode 700
27.8.4 Relationship between Clock and Transmit/Receive Data 700
27.8.5 SCI Initialization in Simple SPI Mode 701
27.8.6 Transmission and Reception of Serial Data in Simple SPI Mode 701
27.9 Bit Rate Modulation Function 701
27.10 Interrupt Sources 702
27.10.1 Buffer Operation for SCIn_TXI and SCIn_RXI Interrupts (non-FIFO selected) 702
27.10.2 Buffer Operation for SCIn_TXI and SCIn_RXI Interrupts (FIFO selected) 702

27.3.6 地址匹配（接收数据匹配检测）功能.....642
27.3.7 异步模式下的SCI初始化.....645
27.3.8 异步模式下的串行数据传输.....647
27.3.9 异步模式下的串行数据接收.....651
27.4 多处理器通信功能.....658
27.4.1 多处理器串行数据传输.....659
27.4.2 多处理器串行数据接收.....662
27.5 时钟同步模式下的操作.....667
27.5.1 Clock 667
27.5.2 CTS和RTS功能.....668
27.5.3 时钟同步模式下的SCI初始化.....668
27.5.4 时钟同步模式下的串行数据传输.....670
27.5.5 时钟同步模式下的串行数据接收.....674
27.5.6 时钟同步模式下的同时串行数据传输和接收....679
27.6 智能卡接口模式下的操作.....681
27.6.1 示例连接.....681
27.6.2 数据格式（块传输模式除外）.....682
27.6.3 块传输模式.....683
27.6.4 接收数据采样时序和接收裕量.....683
27.6.5 SCI初始化.....684
27.6.6 串行数据传输（块传输模式除外）.....686
27.6.7 串行数据接收（块传输模式除外）.....688
27.6.8 时钟输出控制.....690
27.7 简单IIC模式下的操作.....690
27.7.1 启动、重新启动和停止条件的生成.....691
27.7.2 时钟同步.....692
27.7.3 SDA输出延迟.....693
27.7.4 简单IIC模式下的SCI初始化.....694
27.7.5 简单IIC模式下的主传输操作.....695
27.7.6 简单IIC模式下的主接收.....697
27.8 简单SPI模式下的操作.....699
27.8.1 主模式和从模式下的引脚状态.....699
27.8.2 主模式下的SS功能.....700
27.8.3 从模式下的SS功能.....700
27.8.4 时钟和发送接收数据之间的关系.....700
27.8.5 简单SPI模式下的SCI初始化.....701
27.8.6 简单SPI模式下串行数据的发送和接收.....701
27.9 比特率调制功能.....701
27.10 中断源.....702
27.10.1 SCIn_TXI和SCIn_RXI中断的缓冲区操作（选择非FIFO）.....702
27.10.2 SCIn_TXI和SCIn_RXI中断的缓冲区操作（选择FIFO）.....702

27.10.3 Interrupts in Asynchronous, Clock Synchronous, and Simple SPI Modes 702
27.10.4 Interrupts in Smart Card Interface Mode 704
27.10.5 Interrupts in Simple IIC Mode 704
27.11 Event Linking 705
27.12 Address Mismatch Event Output (SCI0_DCUF) 706
27.13 Noise Cancellation Function 706
27.14 Usage Notes 707
27.14.1 Settings for the Module-Stop State 707
27.14.2 SCI Operation during Low Power State 707
27.14.3 Break Detection and Processing 711
27.14.4 Mark State and Production of Breaks 712
27.14.5 Receive Error Flags and Transmit Operation in Clock Synchronous and Simple SPI Modes 712
27.14.6 Restrictions on Clock Synchronous Transmission in Clock Synchronous Mode and Simple SPI Mode 712
27.14.7 Restrictions on Using DMAC or DTC 713
27.14.8 Notes on Starting Transfer 714
27.14.9 External Clock Input in Clock Synchronous Mode and Simple SPI Mode 714
27.14.10 Limitations on Simple SPI Mode 714
28. IrDA Interface 716
28.1 Overview 716
28.2 Register Descriptions 717
28.2.1 IrDA Control Register (IRCR) 717
28.3 Operation 717
28.3.1 IrDA Interface Setup Procedure 717
28.3.2 Transmission 717
28.3.3 Reception 718
28.4 Usage Notes 718
28.4.1 Settings for the Module-Stop State 718
28.4.2 Asynchronous Reference Clock for SCI1 718
29. I2C Bus Interface (IIC) 719
29.1 Overview 719
29.2 Register Descriptions 721
29.2.1 I2C Bus Control Register 1 (ICCR1) 721
29.2.2 I2C Bus Control Register 2 (ICCR2) 723
29.2.3 I2C Bus Mode Register 1 (ICMR1) 726
29.2.4 I2C Bus Mode Register 2 (ICMR2) 727
29.2.5 I2C Bus Mode Register 3 (ICMR3) 728
29.2.6 I2C Bus Function Enable Register (ICFER) 730
29.2.7 I2C Bus Status Enable Register (ICSER) 732
29.2.8 I2C Bus Interrupt Enable Register (ICIER) 733
29.2.9 I2C Bus Status Register 1 (ICSR1) 734

27.10.3 异步、时钟同步和简单SPI模式下的中断 702
27.10.4 智能卡接口模式中的中断 704
27.10.5 简单IIC模式下的中断 704
27.11 事件链接 705
27.12 地址不匹配事件输出(SCI0_DCUF) 706
27.13 降噪功能 706
27.14 使用说明 707
27.14.1 模块停止状态的设置 707
27.14.2 低功耗状态下的SCI操作 707
27.14.3 断点检测和处理 711
27.14.4 标记状态和产生的中断 712
27.14.5 时钟同步和简单SPI中的接收错误标志和发送操作 Modes 712
27.14.6 时钟同步模式和简单SPI模式下时钟同步传输的限制 712
27.14.7 使用DMAC或DTC的限制 713
27.14.8 开始传输的注意事项 714
27.14.9 时钟同步模式和简单SPI模式下的外部时钟输入 714
27.14.10 简单SPI模式的限制 714
28. IrDA Interface 716
28.1 Overview 716
28.2 寄存器说明 717
28.2.1 IrDA控制寄存器(IRCR) 717
28.3 Operation 717
28.3.1 IrDA接口设置程序 717
28.3.2 Transmission 717
28.3.3 Reception 718
28.4 使用说明 718
28.4.1 模块停止状态的设置 718
28.4.2 SCI1的异步参考时钟 718
29. I2C总线接口(IIC) 719
29.1 Overview 719
29.2 寄存器说明 721
29.2.1 I2C总线控制寄存器1(ICCR1) 721
29.2.2 I2C总线控制寄存器2(ICCR2) 723
29.2.3 I2C总线模式寄存器1(ICMR1) 726
29.2.4 I2C总线模式寄存器2(ICMR2) 727
29.2.5 I2C总线模式寄存器3(ICMR3) 728
29.2.6 I2C总线功能使能寄存器(ICFER) 730
29.2.7 I2C总线状态使能寄存器(ICSER) 732
29.2.8 I2C总线中断使能寄存器(ICIER) 733
29.2.9 I2C总线状态寄存器1(ICSR1) 734

29.2.10 I²C Bus Status Register 2 (ICSR2) 736
29.2.11 I²C Bus Wakeup Unit Register (ICWUR) 739
29.2.12 I²C-Bus Wakeup Unit Register 2 (ICWUR2) 740
29.2.13 Slave Address Register L y (SARLy) (y = 0 to 2) 741
29.2.14 Slave Address Register U y (SARUy) (y = 0 to 2) 742
29.2.15 I²C Bus Bit Rate Low-Level Register (ICBRL) 742
29.2.16 I²C Bus Bit Rate High-Level Register (ICBRH) 743
29.2.17 I²C Bus Transmit Data Register (ICDRT) 744
29.2.18 I²C Bus Receive Data Register (ICDRR) 744
29.2.19 I2C Bus Shift Register (ICDRS) 745
29.3 Operation 745
29.3.1 Communication Data Format 745
29.3.2 Initial Settings 746
29.3.3 Master Transmit Operation 747
29.3.4 Master Receive Operation 750
29.3.5 Slave Transmit Operation 755
29.3.6 Slave Receive Operation 758
29.4 SCL Synchronization Circuit 760
29.5 SDA Output Delay Function 761
29.6 Digital Noise Filter Circuits 762
29.7 Address Match Detection 762
29.7.1 Slave-Address Match Detection 762
29.7.2 Detection of General Call Address 764
29.7.3 Device ID Address Detection 765
29.7.4 Host Address Detection 766
29.8 Wakeup Function 766
29.8.1 Normal Wakeup Mode 1 767
29.8.2 Normal Wakeup Mode 2 770
29.8.3 Command Recovery Mode and EEP Response Mode (Special Wakeup Modes) 772
29.8.4 Precautions for WFI Instruction Execution 775
29.9 Automatic Low-Hold Function for SCL 775
29.9.1 Function to Prevent Wrong Transmission of Transmit Data 775
29.9.2 NACK Reception Transfer Suspension Function 776
29.9.3 Function to Prevent Failure to Receive Data 777
29.10 Arbitration-Lost Detection Functions 778
29.10.1 Master Arbitration-Lost Detection (MALE Bit) 778
29.10.2 Function to Detect Loss of Arbitration during NACK Transmission (NALE Bit) 780
29.10.3 Slave Arbitration-Lost Detection (SALE Bit) 781
29.11 Start, Restart, and Stop Condition Issuing Function 782
29.11.1 Issuing a Start Condition 782
29.11.2 Issuing a Restart Condition 782

29.2.10 I2C总线状态寄存器2(ICSR2)..... 736
29.2.11 I2C总线唤醒单元寄存器（ICWUR）..... 739
29.2.12 I2C-Bus唤醒单元寄存器2(ICWUR2)..... 740
29.2.13 从地址寄存器Ly(SARLy)(y=0to2)..... 741
29.2.14 从地址寄存器Uy(SARUy)(y=0to2)..... 742
29.2.15 I2C总线比特率低电平寄存器(ICBRL)..... 742
29.2.16 I2C总线比特率高级寄存器(ICBRH)..... 743
29.2.17 I2C总线发送数据寄存器(ICDRT)..... 744
29.2.18 I2C总线接收数据寄存器(ICDRR)..... 744
29.2.19 I2C总线移位寄存器(ICDRS)..... 745
29.3 Operation 745
29.3.1 通讯数据格式..... 745
29.3.2 初始设置..... 746
29.3.3 主发送操作..... 747
29.3.4 主接收操作..... 750
29.3.5 从机发送操作..... 755
29.3.6 从机接收操作..... 758
29.4 SCL同步电路..... 760
29.5 SDA输出延迟功能..... 761
29.6 数字噪声滤波器电路..... 762
29.7 地址匹配检测..... 762
29.7.1 从地址匹配检测..... 762
29.7.2 广播呼叫地址的检测..... 764
29.7.3 设备ID地址检测..... 765
29.7.4 主机地址检测..... 766
29.8 唤醒功能..... 766
29.8.1 正常唤醒模式1..... 767
29.8.2 正常唤醒模式2..... 770
29.8.3 命令恢复模式和EEP响应模式（特殊唤醒模式）..... 772
29.8.4 WFI指令执行注意事项..... 775
29.9 SCL的自动低保持功能..... 775
29.9.1 防止传送数据错误传送的功能..... 775
29.9.2 NACK接收传输暂停功能..... 776
29.9.3 防止数据接收失败的功能..... 777
29.10 仲裁丢失检测功能..... 778
29.10.1 主仲裁丢失检测（MALE位）..... 778
29.10.2 在NACK传输期间检测仲裁丢失的功能（NALE位）..... 780
29.10.3 从设备仲裁丢失检测（SALE位）..... 781
29.11 启动、重启和停止条件发出函数..... 782
29.11.1 发出开始条件..... 782
29.11.2 发出重启条件..... 782

29.11.3 Issuing a Stop Condition 784
29.12 Bus Hanging 784
29.12.1 Timeout Function 784
29.12.2 Extra SCL Clock Cycle Output Function 785
29.12.3 IIC Reset and Internal Reset 786
29.13 SMBus Operation 786
29.13.1 SMBus Timeout Measurement 787
29.13.2 Packet Error Code (PEC) 788
29.13.3 SMBus Host Notification Protocol (Notify ARP Master Command) 788
29.14 Interrupt Sources 788
29.14.1 Buffer Operation for IICn_TXI and IICn_RXI Interrupts 789
29.15 State of Registers when Issuing each Condition 789
29.16 Event Link Output 790
29.16.1 Interrupt Handling and Event Linking 790
29.17 Usage Notes 791
29.17.1 Settings for the Module-Stop State 791
29.17.2 Notes on Starting Transfer 791
30. Controller Area Network (CAN) Module 792
30.1 Overview 792
30.2 Register Descriptions 794
30.2.1 Control Register (CTLR) 794
30.2.2 Bit Configuration Register (BCR) 797
30.2.3 Mask Register k (MKRk) (k = 0 to 7) 799
30.2.4 FIFO Received ID Compare Registers 0 and 1 (FIDCR0 and FIDCR1) 799
30.2.5 Mask Invalid Register (MKIVLR) 800
30.2.6 Mailbox Register j (MBj_ID, MBj_DL, MBj_Dm, MBj_TS) (j = 0 to 31; m = 0 to 7) 801
30.2.7 Mailbox Interrupt Enable Register (MIER) 805
30.2.8 Mailbox Interrupt Enable Register for FIFO Mailbox Mode (MIER_FIFO) 805
30.2.9 Message Control Register for Transmit (MCTL_TXj) (j = 0 to 31) 806
30.2.10 Message Control Register for Receive (MCTL_RXj) (j = 0 to 31) 808
30.2.11 Receive FIFO Control Register (RFCR) 810
30.2.12 Receive FIFO Pointer Control Register (RFPCR) 812
30.2.13 Transmit FIFO Control Register (TFCR) 812
30.2.14 Transmit FIFO Pointer Control Register (TFPCR) 814
30.2.15 Status Register (STR) 814
30.2.16 Mailbox Search Mode Register (MSMR) 816
30.2.17 Mailbox Search Status Register (MSSR) 817
30.2.18 Channel Search Support Register (CSSR) 818
30.2.19 Acceptance Filter Support Register (AFSR) 818
30.2.20 Error Interrupt Enable Register (EIER) 819
30.2.21 Error Interrupt Factor Judge Register (EIFR) 820

29.11.3 发出停止条件 784
29.12 巴士挂 784
29.12.1 超时功能 784
29.12.2 额外的SCL时钟周期输出功能 785
29.12.3 IIC复位和内部复位 786
29.13 SMBus Operation 786
29.13.1 SMBus超时测量 787
29.13.2 数据包错误代码(PEC) 788
29.13.3 SMBus主机通知协议（通知ARP主控命令） 788
29.14 中断源 788
29.14.1 IICn_TXI和IICn_RXI中断的缓冲区操作 789
29.15 发布每个条件时的寄存器状态 789
29.16 事件链接输出 790
29.16.1 中断处理和事件链接 790
29.17 使用说明 791
29.17.1 模块停止状态的设置 791
29.17.2 开始传输的注意事项 791
30. 控制器局域网(CAN)模块 792
30.1 Overview 792
30.2 寄存器说明 794
30.2.1 控制寄存器(CTLR) 794
30.2.2 位配置寄存器(BCR) 797
30.2.3 屏蔽寄存器k(MKRk)(k=0到7) 799
30.2.4 FIFO接收到的ID比较寄存器0和1（FIDCR0和FIDCR1） 799
30.2.5 屏蔽无效寄存器(MKIVLR) 800
30.2.6 邮箱寄存器j(MBj_ID MBj_DL MBj_Dm MBj_TS)(j=0to31;m=0to7) 801
30.2.7 邮箱中断使能寄存器(MIER) 805
30.2.8 FIFO邮箱模式的邮箱中断使能寄存器(MIER_FIFO) 805
30.2.9 用于发送的消息控制寄存器(MCTL_TXj)(j=0到31) 806
30.2.10 用于接收的消息控制寄存器(MCTL_RXj)(j=0到31) 808
30.2.11 接收FIFO控制寄存器(RFCR) 810
30.2.12 接收FIFO指针控制寄存器(RFPCR) 812
30.2.13 发送FIFO控制寄存器(TFCR) 812
30.2.14 发送FIFO指针控制寄存器(TFPCR) 814
30.2.15 状态寄存器(STR) 814
30.2.16 邮箱搜索模式寄存器(MSMR) 816
30.2.17 邮箱搜索状态寄存器(MSSR) 817
30.2.18 频道搜索支持寄存器(CSSR) 818
30.2.19 接受过滤器支持寄存器(AFSR) 818
30.2.20 错误中断使能寄存器(EIER) 819
30.2.21 错误中断因素判断寄存器(EIFR) 820

RA生态工作室

30.2.22 Receive Error Count Register (RECR) 822
30.2.23 Transmit Error Count Register (TECR) 823
30.2.24 Error Code Store Register (ECSR) 823
30.2.25 Time Stamp Register (TSR) 824
30.2.26 Test Control Register (TCR) 825
30.3 Operation Modes 826
30.3.1 CAN Reset Mode 827
30.3.2 CAN Halt Mode 828
30.3.3 CAN Sleep Mode 829
30.3.4 CAN Operation Mode (Excluding Bus-Off State) 829
30.3.5 CAN Operation Mode (Bus-Off State) 829
30.4 Data Transfer Rate Configuration 830
30.4.1 Clock Setting 830
30.4.2 Bit Timing Setting 830
30.4.3 Data Transfer Rate 831
30.5 Mailbox and Mask Register Structure 831
30.6 Acceptance Filtering and Masking Functions 832
30.7 Reception and Transmission 835
30.7.1 Reception 835
30.7.2 Transmission 837
30.8 Interrupts 838
30.9 Usage Notes 839
30.9.1 Settings for the Module-Stop State 839
30.9.2 Settings for the Operating Clock 839
31. Serial Peripheral Interface (SPI) 840
31.1 Overview 840
31.2 Register Descriptions 843
31.2.1 SPI Control Register (SPCR) 843
31.2.2 SPI Slave Select Polarity Register (SSLP) 845
31.2.3 SPI Pin Control Register (SPPCR) 845
31.2.4 SPI Status Register (SPSR) 846
31.2.5 SPI Data Register (SPDR/SPDR_HA) 848
31.2.6 SPI Sequence Control Register (SPSCR) 851
31.2.7 SPI Sequence Status Register (SPSSR) 851
31.2.8 SPI Bit Rate Register (SPBR) 852
31.2.9 SPI Data Control Register (SPDCR) 853
31.2.10 SPI Clock Delay Register (SPCKD) 855
31.2.11 SPI Slave Select Negation Delay Register (SSLND) 855
31.2.12 SPI Next-Access Delay Register (SPND) 856
31.2.13 SPI Control Register 2 (SPCR2) 856
31.2.14 SPI Command Registers 0 to 7 (SPCMD0 to SPCMD7) 857

30.2.22 接收错误计数寄存器(RECR)……822
30.2.23 发送错误计数寄存器(TECR)……823
30.2.24 错误代码存储寄存器(ECSR)……823
30.2.25 时间戳寄存器(TSR)……824
30.2.26 测试控制寄存器(TCR)……825
30.3 操作模式……826
30.3.1 CAN复位模式……827
30.3.2 CAN暂停模式……828
30.3.3 CAN睡眠模式……829
30.3.4 CAN操作模式（不包括总线关闭状态）……829
30.3.5 CAN操作模式（总线关闭状态）……829
30.4 数据传输速率配置……830
30.4.1 时钟设置……830
30.4.2 位时序设置……830
30.4.3 数据传输率……831
30.5 邮箱和掩码寄存器结构……831
30.6 接受过滤和屏蔽功能……832
30.7 接收和发送……835
30.7.1 Reception 835
30.7.2 Transmission 837
30.8 Interrupts 838
30.9 使用说明……839
30.9.1 模块停止状态的设置……839
30.9.2 工作时钟设置……839
31. 串行外设接口(SPI)……840
31.1 Overview 840
31.2 寄存器说明……843
31.2.1 SPI控制寄存器(SPCR)……843
31.2.2 SPI从机选择极性寄存器(SSLP)……845
31.2.3 SPI引脚控制寄存器(SPPCR)……845
31.2.4 SPI状态寄存器(SPSR)……846
31.2.5 SPI数据寄存器(SPDRSPDR_HA)……848
31.2.6 SPI序列控制寄存器(SPSCR)……851
31.2.7 SPI序列状态寄存器(SPSSR)……851
31.2.8 SPI比特率寄存器(SPBR)……852
31.2.9 SPI数据控制寄存器(SPDCR)……853
31.2.10 SPI时钟延迟寄存器(SPCKD)……855
31.2.11 SPI从机选择取反延迟寄存器(SSLND)……855
31.2.12 SPI下一次访问延迟寄存器(SPND)……856
31.2.13 SPI控制寄存器2(SPCR2)……856
31.2.14 SPI命令寄存器0到7(SPCMD0到SPCMD7)……第857章

RA生态工作室

31.2.15 SPI Data Control Register 2 (SPDCR2) 859
31.3 Operation 860
31.3.1 Overview of SPI Operation 860
31.3.2 Controlling the SPI Pins 861
31.3.3 SPI System Configuration Examples 862
31.3.4 Data Format 867
31.3.5 Transfer Format 875
31.3.6 Data Transfer Modes 877
31.3.7 Transmit Buffer Empty and Receive Buffer Full Interrupts 878
31.3.8 Error Detection 880
31.3.9 Initializing the SPI 884
31.3.10 SPI Operation 884
31.3.11 Clock Synchronous Operation 896
31.3.12 Loopback Mode 902
31.3.13 Self-Diagnosis of Parity Bit Function 902
31.3.14 Interrupt Sources 903
31.4 Output to the Event Link Controller (ELC) 904
31.4.1 Receive Buffer Full Event Output 904
31.4.2 Transmit Buffer Empty Event Output 904
31.4.3 Mode-Fault, Underrun, Overrun, or Parity Error Event Output 905
31.4.4 SPI Idle Event Output 905
31.4.5 Transmission-Completed Event Output 905
31.5 Usage Notes 905
31.5.1 Settings for the Module-Stop State 905
31.5.2 Constraints on Low Power Functions 906
31.5.3 Constraints on Starting Transfer 906
31.5.4 Constraints on Mode-Fault, Underrun, Overrun, or Parity Error Event Output 906
31.5.5 Constraints on SPRF/SPTEF Flags 906
32. Cyclic Redundancy Check (CRC) Calculator 907
32.1 Overview 907
32.2 Register Descriptions 908
32.2.1 CRC Control Register 0 (CRCCR0) 908
32.2.2 CRC Control Register 1 (CRCCR1) 908
32.2.3 CRC Data Input Register (CRCDIR/CRCDIR_BY) 909
32.2.4 CRC Data Output Register (CRCDOR/CRCDOR_HA/CRCDOR_BY) 909
32.2.5 Snoop Address Register (CRCSAR) 910
32.3 Operation 910
32.3.1 Basic Operation 910
32.3.2 CRC Snoop 913
32.4 Usage Notes 914
32.4.1 Settings for the Module-Stop State 914

31.2.15 SPI数据控制寄存器2(SPDCR2)..... 859
31.3 Operation 860
31.3.1 SPI操作概述..... 860
31.3.2 控制SPI引脚..... 861
31.3.3 SPI系统配置示例..... 862
31.3.4 数据格式..... 867
31.3.5 传输格式..... 875
31.3.6 数据传输模式..... 877
31.3.7 发送缓冲区空和接收缓冲区满中断..... 878
31.3.8 错误检测..... 880
31.3.9 初始化SPI..... 884
31.3.10 SPI操作..... 884
31.3.11 时钟同步操作..... 896
31.3.12 Loopback Mode 902
31.3.13 奇偶校验位功能的自诊断..... 902
31.3.14 中断源..... 903
31.4 输出到事件链接控制器(ELC)..... 904
31.4.1 接收缓冲器满事件输出..... 904
31.4.2 发送缓冲区空事件输出..... 904
31.4.3 模式故障、欠载、溢出或奇偶校验错误事件输出..... 905
31.4.4 SPI空闲事件输出..... 905
31.4.5 传输完成事件输出..... 905
31.5 使用说明..... 905
31.5.1 模块停止状态的设置..... 905
31.5.2 对低功耗功能的限制..... 906
31.5.3 开始传输的限制..... 906
31.5.4 模式故障、欠载、溢出或奇偶校验错误事件输出的约束..... 906
31.5.5 SPRFSPTEF标志的约束..... 906
32. 循环冗余校验(CRC)计算器..... 907
32.1 Overview 907
32.2 寄存器说明..... 908
32.2.1 CRC控制寄存器0(CRCCR0)..... 908
32.2.2 CRC控制寄存器1(CRCCR1)..... 908
32.2.3 CRC数据输入寄存器(CRCDIRCRCDIR_BY)..... 909
32.2.4 CRC数据输出寄存器（CRCDORCRCDOR_HACRCDOR_BY）..... 909
32.2.5 窥探地址寄存器(CRCSAR)..... 910
32.3 Operation 910
32.3.1 基本操作..... 910
32.3.2 CRC Snoop 913
32.4 使用说明..... 914
32.4.1 模块停止状态的设置..... 914

32.4.2 Note on Transmission 914
33. Boundary Scan 915
33.1 Overview 915
33.2 Register Descriptions 916
33.2.1 Instruction Register (JTIR) 916
33.2.2 ID Code Register (JTIDR) 917
33.2.3 Bypass Register (JTBPR) 917
33.2.4 Boundary Scan Register (JTBSR) 917
33.3 Operation 917
33.3.1 TAP Controller 917
33.3.2 Commands 918
33.4 Usage Notes 919
34. Secure Cryptographic Engine (SCE7) 921
34.1 Overview 921
34.2 Operation 923
34.2.1 Encryption Engine 923
34.2.2 Encryption and Decryption 924
34.3 Usage Notes 924
34.3.1 Software Standby Mode 924
34.3.2 Settings for the Module-Stop Function 924
35. 12-Bit A/D Converter (ADC12) 925
35.1 Overview 925
35.2 Register Descriptions 930
35.2.1 A/D Data Registers y (ADDRy), A/D Data Duplexing Register (ADDBLDR), A/D Data Duplexing Register A (ADDBLDRA), A/D Data Duplexing Register B (ADDBLDRB), A/D Temperature Sensor Data Register (ADTSDR), A/D Internal Reference Voltage Data Register (ADOCDR) 930
35.2.2 A/D Self-Diagnosis Data Register (ADRD) 934
35.2.3 A/D Control Register (ADCSR) 937
35.2.4 A/D Channel Select Register A0 (ADANSA0) 941
35.2.5 A/D Channel Select Register A1 (ADANSA1) 941
35.2.6 A/D Channel Select Register B0 (ADANSB0) 942
35.2.7 A/D Channel Select Register B1 (ADANSB1) 942
35.2.8 A/D-Converted Value Addition/Average Channel Select Register 0 (ADADS0) 943
35.2.9 A/D-Converted Value Addition/Average Channel Select Register 1 (ADADS1) 943
35.2.10 A/D-Converted Value Addition/Average Count Select Register (ADADC) 944
35.2.11 A/D Control Extended Register (ADCER) 945
35.2.12 A/D Conversion Start Trigger Select Register (ADSTRGR) 947
35.2.13 A/D Conversion Extended Input Control Register (ADEXICR) 948
35.2.14 A/D Sampling State Register n (ADSSTRn) (n = 00 to 03, 05 to 07, L, T, O) 950
35.2.15 A/D Sample and Hold Circuit Control Register (ADSHCR) 951
35.2.16 A/D Sample and Hold Operation Mode Selection Register (ADSHMSR) 951

32.4.2 传输注意事项 914
33. 边界扫描 915
33.1 Overview 915
33.2 寄存器说明 916
33.2.1 指令寄存器(JTIR) 916
33.2.2 ID代码寄存器(JTIDR) 917
33.2.3 旁路寄存器(JTBPR) 917
33.2.4 边界扫描寄存器(JTBSR) 917
33.3 Operation 917
33.3.1 TAP控制器 917
33.3.2 Commands 918
33.4 使用说明 919
34. 安全加密引擎(SCE7) 921
34.1 Overview 921
34.2 Operation 923
34.2.1 加密引擎 923
34.2.2 加密和解密 924
34.3 使用说明 924
34.3.1 软件待机模式 924
34.3.2 模块停止功能的设置 924
35. 12-Bit A/D Converter (ADC12) 925
35.1 Overview 925
35.2 寄存器说明 930
35.2.1 AD数据寄存器y(ADDRy)、AD数据双工寄存器(ADDBLDR)、AD数据双工寄存器A(ADDBLDRA) AD数据双工寄存器B(ADDBLDRB) AD温度传感器数据寄存器(ADTSDR) AD内部参考电压数据寄存器(ADOCDR) 930
35.2.2 AD自诊断数据寄存器(ADRD) 934
35.2.3 AD控制寄存器(ADCSR) 937
35.2.4 AD通道选择寄存器A0(ADANSA0) 941
35.2.5 AD通道选择寄存器A1(ADANSA1) 941
35.2.6 AD通道选择寄存器B0(ADANSB0) 942
35.2.7 AD通道选择寄存器B1(ADANSB1) 942
35.2.8 D转换值加法平均通道选择寄存器0(ADADS0) 943
35.2.9 D转换值加法平均通道选择寄存器1(ADADS1) 943
35.2.10 一个D转换值加法平均计数选择寄存器(ADADC) 944
35.2.11 AD控制扩展寄存器(ADCER) 945
35.2.12 AD转换开始触发选择寄存器(ADSTRGR) 947
35.2.13 AD转换扩展输入控制寄存器(ADEXICR) 948
35.2.14 AD采样状态寄存器n(ADSSTRn)（n=00至03、05至07、L、T、O） 950
35.2.15 AD采样和保持电路控制寄存器（ADSHCR） 951
35.2.16 AD采样和保持操作模式选择寄存器(ADSHMSR) 951

RA生态技术工作室

35.2.17 A/D Disconnection Detection Control Register (ADDISCR) 952
35.2.18 A/D Group Scan Priority Control Register (ADGSPCR) 953
35.2.19 A/D Compare Function Control Register (ADCMPCR) 954
35.2.20 A/D Compare Function Window A Channel Select Register 0 (ADCMPANSR0) 955
35.2.21 A/D Compare Function Window A Channel Select Register 1 (ADCMPANSR1) 956
35.2.22 A/D Compare Function Window A Extended Input Select Register (ADCMPANSER) 956
35.2.23 A/D Compare Function Window A Comparison Condition Setting Register 0 (ADCMPLR0) 957
35.2.24 A/D Compare Function Window A Comparison Condition Setting Register 1 (ADCMPLR1) 959
35.2.25 A/D Compare Function Window A Extended Input Comparison Condition Setting Register (ADCMPLER) 960
35.2.26 A/D Compare Function Window A Lower-Side Level Setting Register (ADCMPDR0), A/D Compare Function Window A Upper-Side Level Setting Register (ADCMPDR1), A/D Compare Function Window B Lower-Side Level Setting Register (ADWINLLB), A/D Compare Function Window B Upper-Side Level Setting Register (ADWINULB) 961
35.2.27 A/D Compare Function Window A Channel Status Register 0 (ADCMPSR0) 962
35.2.28 A/D Compare Function Window A Channel Status Register1 (ADCMPSR1) 963
35.2.29 A/D Compare Function Window A Extended Input Channel Status Register (ADCMPSER) 964
35.2.30 A/D Compare Function Window B Channel Select Register (ADCMPBNSR) 965
35.2.31 A/D Compare Function Window B Status Register (ADCMPBSR) 967
35.2.32 A/D Compare Function Window A/B Status Monitor Register (ADWINMON) 967
35.2.33 A/D Programmable Gain Amplifier Control Register (ADPGACR) 968
35.2.34 A/D Programmable Gain Amplifier Gain Setting Register 0 (ADPGAGS0) 970
35.2.35 A/D Programmable Gain Amplifier Pseudo-Differential Input Control Register (ADPGADCR0) 971
35.3 Operation 972
35.3.1 Scanning Operation 972
35.3.2 Single Scan Mode 972
35.3.3 Continuous Scan Mode 981
35.3.4 Group Scan Mode 988
35.3.5 Compare Function for Windows A and B 997
35.3.6 Analog Input Sampling and Scan Conversion Time 1001
35.3.7 Usage Example of A/D Data Register Automatic Clearing Function 1003
35.3.8 A/D-Converted Value Addition/Average Mode 1004
35.3.9 Disconnection Detection Assist Function 1004
35.3.10 Starting A/D Conversion with an Asynchronous Trigger 1006
35.3.11 Starting A/D Conversion with a Synchronous Trigger from a Peripheral Module 1006
35.3.12 Programmable Gain Amplifiers 1006
35.4 Vs: PGAVSS00, PGAVSS001Interrupt Sources and DTC/DMAC Transfer Requests 1007
35.4.1 Interrupt Requests 1007
35.5 Event Link Function 1010

35.2.17 AD断线检测控制寄存器(ADDISCR).....952
35.2.18 AD组扫描优先级控制寄存器(ADGSPCR).....953
35.2.19 AD比较功能控制寄存器(ADCMPCR).....954
35.2.20 AD比较功能窗口A通道选择寄存器0(ADCMPANSR0).....955
35.2.21 AD比较功能窗口A通道选择寄存器1(ADCMPANSR1).....956
35.2.22 AD比较功能窗口A扩展输入选择寄存器(ADCMPANSER)....956
35.2.23 AD比较功能窗口A比较条件设置寄存器0(ADCMPLR0) 957
35.2.24 AD比较功能窗口A比较条件设置寄存器1(ADCMPLR1) 959
35.2.25 AD比较功能窗口A扩展输入比较条件设置寄存器(ADCMPLER).....960
35.2.26 AD比较功能窗口A低端电平设置寄存器(ADCMPDR0) AD比较功能窗口A上层电平设置寄存器(ADCMPDR1) AD比较功能窗口B下层电平设置寄存器(ADWINLLB) AD比较功能窗口B上层电平设置寄存器 （ADWINULB）.....961
35.2.27 AD比较功能窗口A通道状态寄存器0(ADCMPSR0).....962
35.2.28 AD比较功能窗口A通道状态寄存器1(ADCMPSR1).....963
35.2.29 AD比较功能窗口A扩展输入通道状态寄存器(ADCMPSER).....964
35.2.30 AD比较功能窗口B通道选择寄存器(ADCMPBNSR).....965
35.2.31 AD比较功能窗口B状态寄存器(ADCMPBSR).....967
35.2.32 AD比较功能窗口AB状态监控寄存器 （ADWINMON）.....967
35.2.33 AD可编程增益放大器控制寄存器 （ADPGACR）.....968
35.2.34 AD可编程增益放大器增益设置寄存器0(ADPGAGS0).....970
35.2.35 AD可编程增益放大器伪差分输入控制寄存器(ADPGADCR0).....971
35.3 Operation 972
35.3.1 扫描操作.....972
35.3.2 单次扫描模式.....972
35.3.3 连续扫描模式.....981
35.3.4 组扫描模式.....988
35.3.5 比较WindowsA和B的功能.....997
35.3.6 模拟输入采样和扫描转换时间.....1001
35.3.7 AD数据寄存器自动清除功能的使用示例.....1003
35.3.8 一个D转换的增值平均模式.....1004
35.3.9 断线检测辅助功能.....1004
35.3.10 使用异步触发启动AD转换.....1006
35.3.11 使用外设模块的同步触发启动AD转换....1006
35.3.12 可编程增益放大器.....1006
35.4 对比：PGAVSS00、PGAVSS001中断源和DTCDMAC传输请求....1007
35.4.1 中断请求.....1007
35.5 事件链接功能.....1010

RA生态

35.5.1 Event Output to the ELC ... 1010
35.5.2 ADC12 Operation through an Event from the ELC ... 1010
35.6 Usage Notes ... 1010
35.6.1 Constraints on Reading the Data Registers ... 1010
35.6.2 Constraints on Stopping A/D Conversion ... 1010
35.6.3 A/D Conversion Restart and Termination Timing ... 1011
35.6.4 Constraints on Scan End Interrupt Handling ... 1011
35.6.5 Settings for the Module-Stop Function ... 1011
35.6.6 Notes on Entering the Low Power States ... 1012
35.6.7 Error in Absolute Accuracy when Disconnection Detection Assistance Is in Use ... 1012
35.6.8 Available functions and register settings of AN000 to AN002, AN007, AN100 to AN102, and AN107 ... 1012
35.6.9 Notes on Operating Modes and Status Bits ... 1013
35.6.10 Notes on Board Design ... 1013
35.6.11 Constraints on Noise Prevention ... 1014
35.6.12 Port Settings when Using the ADC12 Input ... 1014
35.6.13 Relationship between ADC12 Units 0 and 1 and the ACMPHS ... 1014
36. 12-Bit D/A Converter (DAC12) ... 1016
36.1 Overview ... 1016
36.2 Register Descriptions ... 1017
36.2.1 D/A Data Register m (DADRm) (m = 0, 1) ... 1017
36.2.2 D/A Control Register (DACR) ... 1017
36.2.3 DADRm Format Select Register (DADPR) ... 1019
36.2.4 D/A A/D Synchronous Start Control Register (DAADSCR) ... 1019
36.2.5 D/A Output Amplifier Control Register (DAAMPCR) ... 1020
36.2.6 D/A Amplifier Stabilization Wait Control Register (DAASWCR) ... 1020
36.2.7 D/A A/D Synchronous Unit Select Register (DAADUSR) ... 1021
36.3 Operation ... 1021
36.3.1 Reducing Interference between D/A and A/D Conversion ... 1022
36.4 Event Link Operation Setting Procedure ... 1024
36.4.1 DA0 Event Link Operation Setting Procedure ... 1024
36.4.2 DA1 Event Link Operation Setting Procedure ... 1024
36.5 Usage Notes on Event Link Operation ... 1024
36.6 Usage Notes ... 1024
36.6.1 Settings for the Module-Stop Function ... 1024
36.6.2 DAC12 Operation in the Module-Stop State ... 1024
36.6.3 DAC12 Operation in Software Standby Mode ... 1025
36.6.4 Restriction on Entering Deep Software Standby Mode ... 1025
36.6.5 Initialization Procedure with the Output Amplifier ... 1025
36.6.6 Restriction on Usage when Interference Reduction between D/A and A/D Conversion is Enabled ... 1025

35.5.1 事件输出到ELC ... 1010
35.5.2 ADC12通过来自ELC的事件进行操作 ... 1010
35.6 使用说明 ... 1010
35.6.1 读取数据寄存器的限制 ... 1010
35.6.2 停止AD转换的限制 ... 1010
35.6.3 AD转换重启和终止时序 ... 1011
35.6.4 扫描结束中断处理的限制 ... 1011
35.6.5 模块停止功能的设置 ... 1011
35.6.6 进入低功耗状态的注意事项 ... 1012
35.6.7 使用断开检测辅助时的绝对精度错误 ... 1012
35.6.8 AN000至AN002、AN007、AN100至AN102和AN107的可用功能和寄存器设置 ... 1012
35.6.9 关于操作模式和状态位的注意事项 ... 1013
35.6.10 电路板设计注意事项 ... 1013
35.6.11 噪音预防的限制 ... 1014
35.6.12 使用ADC12输入时的端口设置 ... 1014
35.6.13 ADC12单元0和1与ACMPHS之间的关系 ... 1014
36. 12-Bit D/A Converter (DAC12) ... 1016
36.1 Overview ... 1016
36.2 寄存器说明 ... 1017
36.2.1 DA数据寄存器m(DADRm)(m=0 1) ... 1017
36.2.2 DA控制寄存器(DACR) ... 1017
36.2.3 DADRm格式选择寄存器(DADPR) ... 1019
36.2.4 DAAD同步启动控制寄存器(DAADSCR) ... 1019
36.2.5 DA输出放大器控制寄存器(DAAMPCR) ... 1020
36.2.6 DA放大器稳定等待控制寄存器(DAASWCR) ... 1020
36.2.7 DAAD同步单元选择寄存器(DAADUSR) ... 1021
36.3 Operation ... 1021
36.3.1 减少DA和AD转换之间的干扰 ... 1022
36.4 事件链接操作设置程序 ... 1024
36.4.1 DA0事件链接操作设置步骤 ... 1024
36.4.2 DA1事件链接操作设置步骤 ... 1024
36.5 事件链接操作的使用说明 ... 1024
36.6 使用说明 ... 1024
36.6.1 模块停止功能的设置 ... 1024
36.6.2 DAC12在模块停止状态下的操作 ... 1024
36.6.3 DAC12在软件待机模式下的操作 ... 1025
36.6.4 进入深度软件待机模式的限制 ... 1025
36.6.5 使用输出放大器的初始化程序 ... 1025
36.6.6 启用DA和AD转换之间的干扰减少时的使用限制 ... 1025

37. Temperature Sensor (TSN) 1026
37.1 Overview 1026
37.2 Register Descriptions 1027
37.2.1 Temperature Sensor Control Register (TSCR) 1027
37.2.2 Temperature Sensor Calibration Data Register (TSCDR) 1027
37.3 Using the Temperature Sensor 1027
37.3.1 Preparation for Using the Temperature Sensor 1027
37.3.2 Procedure for Using the Temperature Sensor 1028
37.4 Usage Notes 1030
37.4.1 Settings for the Module-Stop Function 1030
37.4.2 Constraints 1030
38. High-Speed Analog Comparator (ACMPHS) 1031
38.1 Overview 1031
38.2 Register Descriptions 1032
38.2.1 Comparator Control Register (CMPCTL) 1032
38.2.2 Comparator Input Select Register (CMPSEL0) 1033
38.2.3 Comparator Reference Voltage Select Register (CMPSEL1) 1033
38.2.4 Comparator Output Monitor Register (CMPMON) 1034
38.2.5 Comparator Output Control Register (CPIOC) 1034
38.3 Operation 1034
38.4 Noise Filter 1036
38.5 ACMPHS Interrupts 1037
38.6 ACMPHS Output to the Event Link Controller (ELC) 1037
38.7 ACMPHS Pin Output 1037
38.8 Usage Notes 1037
38.8.1 Settings for the Module-Stop Function 1037
38.8.2 Relationship with the ADC12 1037
39. Data Operation Circuit (DOC) 1038
39.1 Overview 1038
39.2 Register Descriptions 1039
39.2.1 DOC Control Register (DOCR) 1039
39.2.2 DOC Data Input Register (DODIR) 1040
39.2.3 DOC Data Setting Register (DODSR) 1040
39.3 Operation 1040
39.3.1 Data Comparison Mode 1040
39.3.2 Data Addition Mode 1041
39.3.3 Data Subtraction Mode 1041
39.4 Interrupt Request and Output to the Event Link Controller (ELC) 1042
39.5 Usage Notes 1042
39.5.1 Settings for the Module-Stop State 1042

37. 温度传感器(TSN)..... 1026
37.1 Overview 1026
37.2 寄存器说明..... 1027
37.2.1 温度传感器控制寄存器(TSCR)..... 1027
37.2.2 温度传感器校准数据寄存器（TSCDR）..... 1027
37.3 使用温度传感器..... 1027
37.3.1 使用温度传感器的准备工作..... 1027
37.3.2 使用温度传感器的步骤..... 1028
37.4 使用说明..... 1030
37.4.1 模块停止功能的设置..... 1030
37.4.2 Constraints 1030
38. 高速模拟比较器(ACMPHS)..... 1031
38.1 Overview 1031
38.2 寄存器说明..... 1032
38.2.1 比较器控制寄存器(CMPCTL)..... 1032
38.2.2 比较器输入选择寄存器(CMPSEL0)..... 1033
38.2.3 比较器参考电压选择寄存器(CMPSEL1)..... 1033
38.2.4 比较器输出监控寄存器(CMPMON)..... 1034
38.2.5 比较器输出控制寄存器(CPIOC)..... 1034
38.3 Operation 1034
38.4 噪声过滤器..... 1036
38.5 ACMPHS Interrupts 1037
38.6 ACMPHS输出到事件链接控制器(ELC)..... 1037
38.7 ACMPHS引脚输出..... ……1037
38.8 使用说明..... 1037
38.8.1 模块停止功能的设置..... 1037
38.8.2 与ADC12的关系..... 1037
39. 数据运算电路(DOC)..... ……1038
39.1 Overview 1038
39.2 寄存器说明..... 1039
39.2.1 DOC控制寄存器(DOCR)..... 1039
39.2.2 DOC数据输入寄存器(DODIR)..... 1040
39.2.3 DOC数据设置寄存器(DODSR)..... 1040
39.3 Operation 1040
39.3.1 数据比较模式..... 1040
39.3.2 数据添加模式..... 1041
39.3.3 数据减法模式..... 1041
39.4 中断请求和输出到事件链接控制器(ELC)..... 1042
39.5 使用说明..... 1042
39.5.1 模块停止状态的设置..... 1042

RA生态工作室

40. SRAM 1043
40.1 Overview 1043
40.2 Register Descriptions 1043
40.2.1 SRAM Parity Error Operation After Detection Register (PARIOAD) 1043
40.2.2 SRAM Protection Register (SRAMPRCR) 1044
40.3 Operation 1044
40.3.1 Low-Power Functions 1044
40.3.2 Parity Calculation Function 1044
40.3.3 SRAM Error Sources 1046
40.3.4 Access Cycles 1046
40.4 Usage Notes 1047
40.4.1 Instruction Fetch from SRAM Area 1047
40.4.2 Store Buffer of SRAM 1047
41. Flash Memory 1048
41.1 Overview 1048
41.2 Memory Structure 1049
41.3 Flash Cache 1050
41.3.1 Overview 1050
41.3.2 Register Descriptions 1051
41.4 Operation 1052
41.4.1 Notice to use Flash Cache 1053
41.5 Operating Modes Associated with the Flash Memory 1053
41.5.1 ID Code Protection 1053
41.6 Overview of Functions 1054
41.6.1 Configuration Area Bit Map 1056
41.6.2 Startup Area Select 1056
41.6.3 Protection by Access Window 1057
41.7 Programming Commands 1059
41.8 Suspend Operation 1059
41.9 Protection 1060
41.10 Serial Programming Mode 1060
41.10.1 SCI Boot Mode 1060
41.11 Using a Serial Programmer 1060
41.11.1 Serial Programming 1061
41.11.2 Programming Environments 1061
41.12 Self-Programming 1061
41.12.1 Overview 1061
41.12.2 Background Operation 1061
41.13 Reading the Flash Memory 1062
41.13.1 Reading the Code Flash Memory 1062
41.13.2 Reading the Data Flash Memory 1062
41.14 Usage Notes 1062

40. SRAM 1043
40.1 Overview 1043
40.2 寄存器说明 1043
40.2.1 SRAM奇偶校验错误操作后检测寄存器（PARIOAD） 1043
40.2.2 SRAM保护寄存器(SRAMPRCR) 1044
40.3 Operation 1044
40.3.1 Low-Power Functions 1044
40.3.2 奇偶校验计算函数 1044
40.3.3 SRAM错误源 1046
40.3.4 访问周期 1046
40.4 使用说明 1047
40.4.1 从SRAM区域取指令 1047
40.4.2 SRAM的存储缓冲区 1047
41. 闪存 1048
41.1 Overview 1048
41.2 内存结构 1049
41.3 闪存 1050
41.3.1 Overview 1050
41.3.2 寄存器说明 1051
41.4 Operation 1052
41.4.1 使用FlashCache的注意事项 1053
41.5 与闪存相关的操作模式 1053
41.5.1 ID代码保护 1053
41.6 功能概述 第1054章
41.6.1 配置区位图 1056
41.6.2 启动区域选择 1056
41.6.3 访问窗口的保护 1057
41.7 编程命令 1059
41.8 暂停操作 1059
41.9 Protection 1060
41.10 串行编程模式 1060
41.10.1 SCI启动模式 1060
41.11 使用串行编程器 1060
41.11.1 串行编程 1061
41.11.2 编程环境 1061
41.12 Self-Programming 1061
41.12.1 Overview 1061
41.12.2 后台操作 1061
41.13 读取闪存 1062
41.13.1 读取代码闪存 1062
41.13.2 读取数据闪存 1062
41.14 使用说明 1062

RA生态工作室

41.14.1 Reading Areas where Programming or Erasure was Interrupted 1062
41.14.2 Restrictions on Additional Writes 1062
41.14.3 Reset during Programming and Erasure 1062
41.14.4 Allocation of Vectors for Interrupts and Other Exceptions during Programming and Erasure 1062
41.14.5 Restrictions during Programming and Erasure 1062
41.14.6 Abnormal Termination of Programming and Erasure 1062
42. Internal Voltage Regulator 1063
42.1 Overview 1063
42.2 Operation 1063
43. Electrical Characteristics 1064
43.1 Absolute Maximum Ratings 1064
43.2 DC Characteristics 1065
43.2.1 T_j/T_a Definition 1065
43.2.2 I/O V_{IH}, V_{IL} 1065
43.2.3 I/O I_{OH}, I_{OL} 1066
43.2.4 I/O V_{OH}, V_{OL}, and Other Characteristics 1067
43.2.5 Operating and Standby Current 1068
43.2.6 VCC Rise and Fall Gradient and Ripple Frequency 1071
43.3 AC Characteristics 1071
43.3.1 Frequency 1071
43.3.2 Clock Timing 1072
43.3.3 Reset Timing 1075
43.3.4 Wakeup Timing 1076
43.3.5 NMI and IRQ Noise Filter 1078
43.3.6 I/O Ports, POEG, GPT32, AGT, KINT, and ADC12 Trigger Timing 1079
43.3.7 PWM Delay Generation Circuit Timing 1081
43.3.8 CAC Timing 1081
43.3.9 SCI Timing 1082
43.3.10 SPI Timing 1087
43.3.11 IIC Timing 1091
43.4 ADC12 Characteristics 1094
43.5 DAC12 Characteristics 1098
43.6 TSN Characteristics 1098
43.7 OSC Stop Detect Characteristics 1098
43.8 POR and LVD Characteristics 1099
43.9 ACMPHS Characteristics 1102
43.10 PGA Characteristics 1102
43.11 Flash Memory Characteristics 1103
43.11.1 Code Flash Memory Characteristics 1103
43.11.2 Data Flash Memory Characteristics 1105
43.12 Boundary Scan 1105

41.14.1 读取编程或擦除被中断的区域 1062
41.14.2 对附加写入的限制 1062
41.14.3 编程和擦除期间的复位 1062
41.14.4 在编程和擦除过程中为中断和其他异常分配向量 1062
41.14.5 编程和擦除期间的限制 1062
41.14.6 编程和擦除异常终止 1062
42. 内部稳压器 1063
42.1 Overview 1063
42.2 Operation 1063
43. 电气特性 1064
43.1 绝对最大额定值 1064
43.2 DC Characteristics 1065
43.2.1 T_j/T_a Definition 1065
43.2.2 IOVIH VIL 1065
43.2.3 我哦我哦 我哦 1066
43.2.4 IOVOH、VOL和其他特性 1067
43.2.5 工作和待机电流 1068
43.2.6 VCC上升和下降梯度和纹波频率 1071
43.3 交流特性 1071
43.3.1 Frequency 1071
43.3.2 时钟时序 1072
43.3.3 重置时间 1075
43.3.4 唤醒时间 1076
43.3.5 NMI和IRQ噪声滤波器 1078
43.3.6 IO端口、POEG、GPT32、AGT、KINT和ADC12触发时序 1079
43.3.7 PWM延迟产生电路时序 1081
43.3.8 CAC时间 1081
43.3.9 SCI时序 1082
43.3.10 SPI时序 1087
43.3.11 IIC Timing 1091
43.4 ADC12 Characteristics 1094
43.5 DAC12 Characteristics 1098
43.6 TSN Characteristics 1098
43.7 OSC停止检测特性 1098
43.8 POR和LVD特性 1099
43.9 ACMPHS Characteristics 1102
43.10 PGA特性 1102
43.11 闪存特性 1103
43.11.1 代码闪存特性 1103
43.11.2 数据闪存特性 1105
43.12 边界扫描 1105

43.13 Joint Test Action Group (JTAG) 1107
43.14 Serial Wire Debug (SWD) 1108
43.15 Embedded Trace Macro Interface (ETM) 1109
Appendix 1. Port States in Each Processing Mode 1110
Appendix 2. Package Dimensions 1113
Appendix 3. I/O Registers 1115
3.1 Peripheral Base Addresses 1115
3.2 Access Cycles 1117
3.3 Register Descriptions 1118
Revision History 1144

43.13 联合测试行动组(JTAG)..... 1107
43.14 串行线调试(SWD)..... 1108
43.15 嵌入式跟踪宏接口(ETM)..... 1109
附录1.每种处理模式下的端口状态..... 1110
附录2.封装尺寸..... 1113
附录3.IO寄存器..... 1115
3.1 外设基地址..... 1115
3.2 访问周期..... 1117
3.3 寄存器说明..... 1118
修订记录..... 1144

RA生态工作室

Leading performance 120-MHz Arm® Cortex®-M4 core, up to 512 KB of code flash memory, 64-KB SRAM, security and safety features, and advanced analog.

Features

■ **Arm Cortex-M4 Core with Floating Point Unit (FPU)**
- Armv7E-M architecture with DSP instruction set
- Maximum operating frequency: 120 MHz
- Support for 4-GB address space
- On-chip debugging system: JTAG, SWD, and ETM
- Boundary scan and Arm Memory Protection Unit (Arm MPU)

■ **Memory**
- Up to 512-KB code flash memory (40 MHz zero wait states)
- 8-KB data flash memory (125,000 erase/write cycles)
- 64-KB SRAM
- Flash Cache (FCACHE)
- Memory Protection Units (MPU)
- Memory Mirror Function (MMF)
- 128-bit unique ID

■ **Connectivity**
- Serial Communications Interface (SCI) with FIFO × 7
- Serial Peripheral Interface (SPI) × 2
- I^2C bus interface (IIC) × 2
- CAN module (CAN) × 1
- IrDA interface

■ **Analog**
- 12-bit A/D Converter (ADC12) with 3 sample-and-hold circuits each × 2
- 12-bit D/A Converter (DAC12) × 2
- High-Speed Analog Comparator (ACMPHS) × 6
- Programmable Gain Amplifier (PGA) × 6
- Temperature Sensor (TSN)

■ **Timers**
- General PWM Timer 32-bit Enhanced High Resolution (GPT32EH) × 4
- General PWM Timer 32-bit Enhanced (GPT32E) × 4
- General PWM Timer 32-bit (GPT32) × 5
- Asynchronous General-Purpose Timer (AGT) × 2
- Watchdog Timer (WDT)

■ **Safety**
- SRAM parity error check
- Flash area protection
- ADC self-diagnosis function
- Clock Frequency Accuracy Measurement Circuit (CAC)
- Cyclic Redundancy Check (CRC) calculator
- Data Operation Circuit (DOC)
- Port Output Enable for GPT (POEG)
- Independent Watchdog Timer (IWDT)
- GPIO readback level detection
- Register write protection
- Main oscillator stop detection
- Illegal memory access

■ **System and Power Management**
- Low power modes
- Event Link Controller (ELC)
- DMA Controller (DMAC) × 8
- Data Transfer Controller (DTC)
- Key Interrupt Function (KINT)
- Power-on reset
- Low Voltage Detection (LVD) with voltage settings

■ **Security and Encryption**
- AES128/192/256
- 3DES/ARC4
- SHA1/SHA224/SHA256/MD5
- GHASH
- RSA/DSA/ECC
- True Random Number Generator (TRNG)

■ **Multiple Clock Sources**
- Main clock oscillator (MOSC) (8 to 24 MHz)
- Sub-clock oscillator (SOSC) (32.768 kHz)
- High-speed on-chip oscillator (HOCO) (16/18/20 MHz)
- Middle-speed on-chip oscillator (MOCO) (8 MHz)
- Low-speed on-chip oscillator (LOCO) (32.768 kHz)
- IWDT-dedicated on-chip oscillator (15 kHz)
- Clock trim function for HOCO/MOCO/LOCO
- Clock out support

■ **General-Purpose I/O Ports**
- Up to 76 input/output pins
  - Up to 9 CMOS input
  - Up to 67 CMOS input/output
    - Up to 14 input/output 5 V tolerant
    - Up to 13 high current (20 mA)

■ **Operating Voltage**
- VCC: 2.7 to 3.6 V

■ **Operating Temperature and Packages**
- Ta = -40°C to +105°C
  - 100-pin LQFP (14 mm × 14 mm, 0.5 mm pitch)
  - 64-pin LQFP (10 mm × 10 mm, 0.5 mm pitch)

RENESAS
RA6T1 Group
User's Manual

性能领先的120-MHzArm®Cortex®-M4内核、高达512KB的代码闪存、64-KBSRAM、安全和安全功能以及高级模拟。

Features

■带浮点单元(FPU)的ArmCortex-M4内核带DSP指令集的Armv7E-M架构最大工作频率：120MHz支持4GB地址空间片上调试系统：JTAG、SWD和ETM　边界扫描和Arm内存保护单元(ArmMPU)

■ **Memory**
高达512KB代码闪存（40MHz零等待状态）　8KB数据闪存（125 000个擦除写入周期）　64KBSRAM　闪存缓存(FCACHE)　内存保护单元(MPU)　内存镜像功能(MMF)　128位唯一ID

■ **Connectivity**
带FIFO的串行通信接口(SCI)×7　串行外设接口(SPI)×2　I2C总线接口(IIC)×2　CAN模块(CAN)×1　IrDA接口

■ **Analog**
12位模数转换器(ADC12)，每个带有3个采样保持电路×2　12位模数转换器(DAC12)×2　高速模拟比较器(ACMPHS)×6　可编程增益放大器(PGA)×6　温度传感器(TSN)

■ **Timers**
通用PWM定时器32位增强型高分辨率(GPT32EH)×4　通用PWM定时器32位增强型(GPT32E)×4　通用PWM定时器32位(GPT32)×5　异步通用定时器(AGT)×2　看门狗定时器(WDT)

■ **Safety**
SRAM奇偶校验错误检查　闪存区域保护　ADC自诊断功能　时钟频率精度测量电路(CAC)　循环冗余校验(CRC)计算器　数据操作电路(DOC)　GPT端口输出启用(POEG)　独立看门狗定时器(IWDT)　GPIO回读电平检测　寄存器写保护　主振荡器停止检测　非法内存访问

■系统和电源管理　低功耗模式　事件链接控制器(ELC)　DMA控制器(DMAC)×8　数据传输控制器(DTC)　按键中断功能(KINT)　上电复位　低电压检测(LVD)带电压设置

■安全和加密　AES128192256　3DESARC4　SHA1SHA224SHA256MD5　GHASH　RSADSAECC　真随机数生成器(TRNG)

■ **多个时钟源**
主时钟振荡器(MOSC)(8to24MHz)　副时钟振荡器(SOSC)(32.768kHz)　高速片上振荡器(HOCO)(161820MHz)　中速片上振荡器(MOCO)(8MHz)　低速片上振荡器(LOCO)(32.768kHz)　IWDT专用片上振荡器(15kHz)　HOCOMOCOLOCO的时钟微调功能　时钟输出支持

■通用IO端口　多达76个输入输出引脚　多达9个CMOS输入多达67个CMOS输入输出多达14个输入输出5V耐受多达13个大电流(20mA)

■工作电压　VCC：2.7至3.6V

■ **工作温度和封装　Ta=−40°C至+105°C**
- 100-pin LQFP (14 mm × 14 mm, 0.5 mm pitch)
- 64-pin LQFP (10 mm × 10 mm, 0.5 mm pitch)

RA生态工作室

1. Overview

The MCU integrates multiple series of software- and pin-compatible Arm®-based 32-bit cores that share a common set of Renesas peripherals to facilitate design scalability and efficient platform-based product development.

The MCU in this series incorporates a high-performance Arm Cortex®-M4 core running up to 120 MHz with the following features:

- Up to 512-KB code flash memory
- 64-KB SRAM
- Security and safety features
- 12-bit A/D Converter (ADC12)
- 12-bit D/A Converter (DAC12)
- Analog peripherals.

1.1 Function Outline

Table 1.1 Arm core

Feature	Functional description
Arm Cortex-M4 core	• Maximum operating frequency: up to 120 MHz • Arm Cortex-M4 core: - Revision: r0p1-01rel0 - Armv7E-M architecture profile - Single precision floating-point unit compliant with the ANSI/IEEE Std 754-2008. • Arm Memory Protection Unit (Arm MPU): - Armv7 Protected Memory System Architecture - 8 protect regions. • SysTick timer: - Driven by SYSTICCLK (LOCO) or ICLK.

Table 1.2 Memory

Feature	Functional description
Code flash memory	Up to 512-KB code flash memory. See section 41, Flash Memory.
Data flash memory	8-KB data flash memory. See section 41, Flash Memory.
Memory Mirror Function (MMF)	The Memory Mirror Function (MMF) can be configured to mirror the target application image load address in code flash memory to the application image link address in the 23-bit unused memory space (memory mirror space addresses). Your application code is developed and linked to run from this MMF destination address. Your application code does not need to know the load location where it is stored in code flash memory. See section 5, Memory Mirror Function (MMF).
Option-setting memory	The option-setting memory determines the state of the MCU after a reset. See section 7, Option-Setting Memory.
SRAM	On-chip high-speed SRAM. See section 40, SRAM.

Table 1.3 System (1 of 2)

Feature	Functional description
Operating modes	Two operating modes: • Single-chip mode • SCI boot mode. See section 3, Operating Modes.

1. Overview

MCU集成了多个系列软件和基于Arm®引脚兼容的32位内核，这些内核共享一组通用的瑞萨外设，以促进设计可扩展性和基于平台的高效产品开发。

该系列中的MCU包含一个运行频率高达120MHz的高性能ArmCortex®-M4内核，具有以下特性：

- 高达512KB的代码闪存
- 64-KB SRAM
- 安全和安全功能
- 12-bit A/D Converter (ADC12)
- 12-bit D/A Converter (DAC12)
- 模拟外设。

1.1 功能概要

Table 1.1 臂芯

Feature	功能说明
ArmCortex-M4内核	最大工作频率：高达120MHz ArmCortex-M4内核：修订版：r0p1-01rel0Armv7E-M架构配置文件符合ANSIIEEEStd754-2008的单精度浮点单元。 Arm内存保护单元（ArmMPU）： Armv7ProtectedMemorySystemArchitecture8保护区域。 SysTick计时器： 由SYSTICCLK(LOCO)或ICLK驱动。

Table 1.2 Memory

Feature	功能说明
代码闪存	高达512KB的代码闪存。请参见第41节，闪存。
数据闪存	8KB数据闪存。请参见第41节，闪存。
内存镜像功能(MMF)	内存镜像功能(MMF)可配置为将代码闪存中的目标应用程序映像加载地址镜像到23位未使用的内存空间（内存镜像空间地址）中的应用程序映像链接地址。您的应用程序代码已开发并链接到从该MMF目标地址运行。您的应用程序代码不需要知道它存储在代码闪存中的加载位置。请参阅第5节，内存镜像功能(MMF)。
Option-setting memory	选项设置存储器确定复位后MCU的状态。见第7节，Option-Setting Memory.
SRAM	片上高速SRAM。参见第40节，SRAM。

Table 1.3 系统(1of2)

Feature	功能说明
操作模式	两种工作模式： 单芯片模式 SCI启动模式。请参阅第3节，操作模式 。

RA生态工作室

Table 1.3 System (2 of 2)

Feature	Functional description
Resets	14 resets: • RES pin reset • Power-on reset • Voltage monitor 0 reset • Voltage monitor 1 reset • Voltage monitor 2 reset • Independent watchdog timer reset • Watchdog timer reset • Deep Software Standby reset • SRAM parity error reset • Bus master MPU error reset • Bus slave MPU error reset • Stack pointer error reset • Software reset. See section 6, Resets.
Low Voltage Detection (LVD)	The Low Voltage Detection (LVD) function monitors the voltage level input to the VCC pin, and the detection level can be selected using a software program. See section 8, Low Voltage Detection (LVD).
Clocks	• Main clock oscillator (MOSC) • Sub-clock oscillator (SOSC) • High-speed on-chip oscillator (HOCO) • Middle-speed on-chip oscillator (MOCO) • Low-speed on-chip oscillator (LOCO) • PLL frequency synthesizer • IDWT-dedicated on-chip oscillator • Clock out support. See section 9, Clock Generation Circuit.
Clock Frequency Accuracy Measurement Circuit (CAC)	The Clock Frequency Accuracy Measurement Circuit (CAC) counts pulses of the clock to be measured (measurement target clock) within the time generated by the clock to be used as a measurement reference (measurement reference clock), and determines the accuracy depending on whether the number of pulses is within the allowable range. When measurement is complete or the number of pulses within the time generated by the measurement reference clock is not within the allowable range, an interrupt request is generated. See section 10, Clock Frequency Accuracy Measurement Circuit (CAC).
Interrupt Controller Unit (ICU)	The Interrupt Controller Unit (ICU) controls which event signals are linked to the NVIC/DTC module and DMAC module. The ICU also controls NMI interrupts. See section 13, Interrupt Controller Unit (ICU).
Key Interrupt Function (KINT)	A key interrupt can be generated by setting the Key Return Mode Register (KRM) and inputting a rising or falling edge to the key interrupt input pins. See section 20, Key Interrupt Function (KINT).
Low power modes	Power consumption can be reduced in multiple ways, such as by setting clock dividers, stopping modules, selecting power control mode in normal operation, and transitioning to low power modes. See section 11, Low Power Modes.
Register write protection	The register write protection function protects important registers from being overwritten because of software errors. See section 12, Register Write Protection.
Memory Protection Unit (MPU)	Four Memory Protection Units (MPUs) and a CPU stack pointer monitor function are provided for memory protection. See section 15, Memory Protection Unit (MPU).
Watchdog Timer (WDT)	The Watchdog Timer (WDT) is a 14-bit down-counter that can be used to reset the MCU when the counter underflows because the system has run out of control and is unable to refresh the WDT. In addition, a non-maskable interrupt or interrupt can be generated by an underflow. A refresh-permitted period can be set to refresh the counter and used as the condition for detecting when the system runs out of control. See section 25, Watchdog Timer (WDT).
Independent Watchdog Timer (IWDT)	The Independent Watchdog Timer (IWDT) consists of a 14-bit down-counter that must be serviced periodically to prevent counter underflow. The IWDT provides functionality to reset the MCU or to generate a non-maskable interrupt or interrupt for a timer underflow. Because the timer operates with an independent, dedicated clock source, it is particularly useful in returning the MCU to a known state as a fail-safe mechanism when the system runs out of control. The IWDT can be triggered automatically on a reset, underflow, or refresh error, or by a refresh of the count value in the registers. See section 26, Independent Watchdog Timer (IWDT).

Table 1.3 系统(2之2)

Feature	功能说明
Resets	14次复位： RES引脚复位 上电复位 电压监控器0复位 电压监控器1复位 电压监控器2复位 独立看门狗定时器复位 看门狗定时器复位 深度软件待机复位 SRAM奇偶校验错误复位 总线主控MPU错误复位 总线从机MPU错误复位 堆栈指针错误复位 软件复位。请参阅第6节，重置。
低电压检测(LVD)	低电压检测(LVD)功能监控输入到VCC引脚的电压电平，并且可以使用软件程序选择检测电平。请参见第8节，低电压检测(LVD)。
Clocks	主时钟振荡器(MOSC) 子时钟振荡器(SOSC) 高速片上振荡器(HOCO) 中速片上振荡器(MOCO) 低速片上振荡器(LOCO) PLL频率合成器 IDWT专用的片上振荡器 时钟输出支持。请参见第9节，时钟生成电路。
时钟频率精度测量电路(CAC)	时钟频率精度测量电路(CAC)在用作测量基准的时钟（测量基准时钟）生成的时间内对要测量的时钟（测量目标时钟）的脉冲进行计数，并根据是否脉冲数在允许范围内。当测量完成或测量参考时钟在时间内产生的脉冲数不在允许范围内时，将产生中断请求。请参见第10节，时钟频率精度测量电路(CAC)。
中断控制器单元(ICU)	中断控制器单元(ICU)控制哪些事件信号链接到NVICDTC模块和DMAC模块。ICU还控制NMI中断。请参阅第13节，中断控制器单元(ICU)。
按键中断功能(KINT)	通过设置按键返回模式寄存器(KRM)并向按键中断输入引脚输入上升沿或下降沿，可以生成按键中断。请参见第20节，按键中断功能(KINT)。
低功耗模式	可以通过多种方式降低功耗，例如通过设置时钟分频器、停止模块、在正常操作中选择电源控制模式以及转换到低功耗模式。请参见第11节，低功耗模式。
寄存器写保护	寄存器写保护功能可保护重要寄存器不因软件错误而被覆盖。请参见第12节，寄存器写保护。
内存保护单元(MPU)	提供四个内存保护单元(MPU)和一个CPU堆栈指针监控功能用于内存保护。请参阅第15节，内存保护单元(MPU)。
看门狗定时器(WDT)	看门狗定时器(WDT)是一个14位递减计数器，可用于在计数器下溢时复位MCU，因为系统已失控且无法刷新WDT。此外，下溢可能会产生不可屏蔽的中断或中断。可以设置一个允许刷新周期来刷新计数器，作为检测系统何时失控的条件。请参见第25节，看门狗定时器(WDT)。
独立看门狗定时器(IWDT)	独立看门狗定时器(IWDT)包含一个14位递减计数器，必须定期对其进行服务以防止计数器下溢。IWDT提供复位MCU或生成不可屏蔽中断或定时器下溢中断的功能。由于定时器使用独立的专用时钟源运行，因此当系统失控时，它在将MCU作为故障安全机制返回到已知状态时特别有用。IWDT可以在复位、下溢或刷新错误时自动触发，或者通过刷新寄存器中的计数值来触发。请参见第26节，独立看门狗定时器(IWDT)。

RA生态工作室

Table 1.4 Event link

Feature	Functional description
Event Link Controller (ELC)	The Event Link Controller (ELC) uses the interrupt requests generated by various peripheral modules as event signals to connect them to different modules, enabling direct interaction between the modules without CPU intervention. See section 18, Event Link Controller (ELC).

Table 1.5 Direct memory access

Feature	Functional description
Data Transfer Controller (DTC)	A Data Transfer Controller (DTC) module is provided for transferring data when activated by an interrupt request. See section 17, Data Transfer Controller (DTC).
DMA Controller (DMAC)	An 8-channel DMA Controller (DMAC) module is provided for transferring data without the CPU. When a DMA transfer request is generated, the DMAC transfers data stored at the transfer source address to the transfer destination address. See section 16, DMA Controller (DMAC).

Table 1.6 Timers

Feature	Functional description
General PWM Timer (GPT)	The General PWM Timer (GPT) is a 32-bit timer with 13 channels. PWM waveforms can be generated by controlling the up-counter, down-counter, or up- and down-counter. In addition, PWM waveforms can be generated for controlling brushless DC motors. The GPT can also be used as a general-purpose timer. See section 22, General PWM Timer (GPT).
Port Output Enable for GPT (POEG)	Use the Port Output Enable for GPT (POEG) function to place the General PWM Timer (GPT) output pins in the output disable state. See section 21, Port Output Enable for GPT (POEG).
Low Power Asynchronous General-Purpose Timer (AGT)	The Low Power Asynchronous General-Purpose Timer (AGT) is a 16-bit timer that can be used for pulse output, external pulse width or period measurement, and counting of external events. This 16-bit timer consists of a reload register and a down-counter. The reload register and the down-counter are allocated to the same address, and can be accessed with the AGT register. See section 24, Low Power Asynchronous General-Purpose Timer (AGT).

Table 1.7 Communication interfaces (1 of 2)

Feature	Functional description
Serial Communications Interface (SCI)	The Serial Communications Interface (SCI) is configurable to five asynchronous and synchronous serial interfaces: • Asynchronous interfaces (UART and Asynchronous Communications Interface Adapter (ACIA)) • 8-bit clock synchronous interface • Simple IIC (master-only) • Simple SPI • Smart card interface. The smart card interface complies with the ISO/IEC 7816-3 standard for electronic signals and transmission protocol. Each SCI has FIFO buffers to enable continuous and full-duplex communication, and the data transfer speed can be configured independently using an on-chip baud rate generator. See section 27, Serial Communications Interface (SCI).
IrDA Interface (IrDA)	The IrDA interface sends and receives IrDA data communication waveforms in cooperation with the SCI1 based on the IrDA (Infrared Data Association) standard 1.0. See section 28, IrDA Interface.
I²C bus interface (IIC)	The 2-channel I²C bus interface (IIC) conforms with and provides a subset of the NXP I²C (Inter-Integrated Circuit) bus interface functions. See section 29, I²C Bus Interface (IIC).
Serial Peripheral Interface (SPI)	Two independent Serial Peripheral Interface (SPI) channels are capable of high-speed, full-duplex synchronous serial communications with multiple processors and peripheral devices. See section 31, Serial Peripheral Interface (SPI).

Table 1.4 活动链接

Feature	功能说明
事件链接控制器(ELC)	EventLinkController(ELC)使用各种外围模块产生的中断请求作为事件信号，将它们连接到不同的模块，实现模块之间的直接交互，无需CPU干预。请参阅第18节，事件链接控制器(ELC)。

Table 1.5 直接内存访问

Feature	功能说明
数据传输控制器(DTC)	数据传输控制器(DTC)模块用于在被中断请求激活时传输数据。请参阅第17节，数据传输控制器(DTC)。
DMA Controller (DMAC)	提供了一个8通道DMA控制器(DMAC)模块，用于在没有CPU的情况下传输数据。当产生DMA传输请求时，DMAC将存储在传输源地址的数据传输到传输目标地址。请参见第16节，DMA控制器(DMAC)。

Table 1.6 Timers

Feature	功能说明
通用PWM定时器(GPT)	通用PWM定时器(GPT)是一个具有13个通道的32位定时器。PWM波形可以通过控制递增计数器、递减计数器或递增递减计数器来生成。此外，可以生成PWM波形来控制无刷直流电机。GPT也可以用作通用定时器。请参见第22节，通用PWM定时器(GPT)。
GPT(POEG)的端口输出使能	使用PortOutputEnableforGPT(POEG)功能将通用PWM定时器(GPT)输出引脚置于输出禁用状态。请参阅第21节，GPT(POEG)的端口输出启用。
低功耗异步通用 目的定时器(AGT)	低功耗异步通用定时器(AGT)是一个16位定时器，可用于脉冲输出、外部脉冲宽度或周期测量以及外部事件计数。这个16位定时器由一个重载寄存器和一个递减计数器组成。重载寄存器和递减计数器分配到同一个地址，可以通过AGT寄存器访问。请参见第24节，低功耗异步通用定时器(AGT)。

Table 1.7 通信接口（2个中的1个）

Feature	功能说明
串行通信接口(SCI)	串行通信接口(SCI)可配置为五个异步和同步串行接口： 异步接口（UART和异步通信接口适配器(ACIA)） 8位时钟同步接口 简单IIC（仅限主机） 简单SPI 智能卡接口。智能卡接口符合ISOIEC7816-3电子信号和传输协议标准。每个SCI都有FIFO缓冲区以实现连续和全双工通信，并且可以使用片上波特率发生器独立配置数据传输速度。参见第27节，串行通信接口(SCI)。
IrDA Interface (IrDA)	IrDA接口与基于IrDA（InfraredDataAssociation）标准1.0的SCI1协同发送和接收IrDA数据通信波形。参见第28节，IrDA接口。
I2C总线接口(IIC)	2通道I2C总线接口(IIC)符合并提供NXPI2C（内部集成电路）总线接口功能的子集。请参阅第29节，I2C总线接口(IIC)。
串行外设接口(SPI)	两个独立的串行外围接口(SPI)通道能够与多个处理器和外围设备进行高速、全双工同步串行通信。请参阅第31节，串行外设接口(SPI)。

Table 1.7 Communication interfaces (2 of 2)

Feature	Functional description
Controller Area Network (CAN) module	The Controller Area Network (CAN) module provides functionality to receive and transmit data using a message-based protocol between multiple slaves and masters in electromagnetically-noisy applications. The CAN module complies with the ISO 11898-1 (CAN 2.0A/CAN 2.0B) standard and supports up to 32 mailboxes, which can be configured for transmission or reception in normal mailbox and FIFO modes. Both standard (11-bit) and extended (29-bit) messaging formats are supported. See section 30, Controller Area Network (CAN) Module.

Table 1.8 Analog

Feature	Functional description
12-bit A/D Converter (ADC12)	Up to two successive approximation 12-bit A/D Converters (ADC12) are provided. In unit 0, up to 11 analog input channels are selectable. In unit 1, up to eight analog input channels, the temperature sensor output, and an internal reference voltage are selectable for conversion. The A/D conversion accuracy is selectable from 12-bit, 10-bit, and 8-bit conversion, making it possible to optimize the tradeoff between speed and resolution in generating a digital value. See section 35, 12-Bit A/D Converter (ADC12).
12-bit D/A Converter (DAC12)	A 12-bit D/A Converter (DAC12) converts data and includes an output amplifier. See section 36, 12-Bit D/A Converter (DAC12).
Temperature Sensor (TSN)	The on-chip Temperature Sensor (TSN) can determine and monitor the die temperature for reliable operation of the device. The sensor outputs a voltage directly proportional to the die temperature, and the relationship between the die temperature and the output voltage is linear. The output voltage is provided to the ADC12 for conversion and can also be used by the end application. See section 37, Temperature Sensor (TSN).
High-Speed Analog Comparator (ACMPHS)	The High-Speed Analog Comparator (ACMPHS) compares a test voltage with a reference voltage and provides a digital output based on the conversion result. Both the test and reference voltages can be provided to the comparator from internal sources such as the DAC12 output and internal reference voltage, and an external source with or without an internal PGA. Such flexibility is useful in applications that require go/no-go comparisons to be performed between analog signals without necessarily requiring A/D conversion. See section 38, High-Speed Analog Comparator (ACMPHS).

Table 1.9 Data processing

Feature	Functional description
Cyclic Redundancy Check (CRC) calculator	The Cyclic Redundancy Check (CRC) calculator generates CRC codes to detect errors in the data. The bit order of CRC calculation results can be switched for LSB-first or MSB-first communication. Additionally, various CRC-generating polynomials are available. The snoop function allows monitoring reads from and writes to specific addresses. This function is useful in applications that require CRC code to be generated automatically in certain events, such as monitoring writes to the serial transmit buffer and reads from the serial receive buffer. See section 32, Cyclic Redundancy Check (CRC) Calculator.
Data Operation Circuit (DOC)	The Data Operation Circuit (DOC) compares, adds, and subtracts 16-bit data. See section 39, Data Operation Circuit (DOC).

Table 1.10 Security

Feature	Functional description
Secure Crypto Engine 7 (SCE7)	• Security algorithms: - Symmetric algorithms: AES, 3DES, and ARC4 - Asymmetric algorithms: RSA, DSA, and ECC. • Other support features: - TRNG (True Random Number Generator) - Hash-value generation: SHA1, SHA224, SHA256, GHASH, and MD5 - 128-bit unique ID.

Table 1.7 通信接口（2个中的2个）

Feature	功能说明
控制器局域网(CAN)模块	控制器局域网(CAN)模块提供了在电磁噪声应用中使用基于消息的协议在多个从机和主机之间接收和传输数据的功能。CAN模块符合ISO11898-1(CAN2.0ACAN2.0B)标准，最多支持32个邮箱，可配置为普通邮箱和FIFO模式下的发送或接收。支持标准（11位）和扩展（29位）消息格式。请参见第30节，控制器局域网(CAN)模块。

Table 1.8 Analog

Feature	功能说明
12-bit A/D Converter (ADC12)	最多提供两个逐次逼近型12位模数转换器(ADC12)。在单元0中，最多可选择11个模拟输入通道。在单元1中，可以选择多达8个模拟输入通道、温度传感器输出和内部参考电压进行转换。AD转换精度可从12位、10位和8位转换中选择，从而可以在生成数字值时优化速度和分辨率之间的折衷。请参阅第35节，12位AD转换器(ADC12)。
12-bit D/A Converter (DAC12)	一个12位DA转换器(DAC12)转换数据并包括一个输出放大器。请参阅第36节，12位DA转换器(DAC12)。
温度传感器(TSN)	片上温度传感器(TSN)可以确定和监控芯片温度，以确保器件可靠运行。传感器输出与管芯温度成正比的电压，管芯温度与输出电压呈线性关系。输出电压提供给ADC12进行转换，也可供最终应用使用。请参见第37节，温度传感器(TSN)。
高速模拟比较器(ACMPHS)	高速模拟比较器(ACMPHS)将测试电压与参考电压进行比较，并根据转换结果提供数字输出。测试电压和参考电压都可以从内部源（例如DAC12输出和内部参考电压）以及带有或不带有内部PGA的外部源提供给比较器。这种灵活性在需要在模拟信号之间执行go-no-go比较而不一定需要AD转换的应用中很有用。请参见第38节，高速模拟比较器(ACMPHS)。

Table 1.9 数据处理

Feature	功能说明
循环冗余校验(CRC)计算器	循环冗余校验(CRC)计算器生成CRC代码以检测数据中的错误。CRC计算结果的位顺序可以切换为LSB-first或MSB-first通信。此外，还可以使用各种生成CRC的多项式。snoop功能允许监视对特定地址的读取和写入。此功能在需要在某些事件中自动生成CRC代码的应用中很有用，例如监视对串行发送缓冲区的写入和从串行接收缓冲区的读取。请参见第32节，循环冗余校验(CRC)计算器。
数据运算电路(DOC)	数据运算电路(DOC)对16位数据进行比较、加法和减法。见第39节，数据运算电路（DOC）。

Table 1.10 Security

Feature	功能说明
安全加密引擎7(SCE7)	• Security algorithms: 对称算法：AES、3DES和ARC4非对称算法：RSA、DSA和ECC。 其他支持功能： TRNG（真随机数生成器）哈希值生成：SHA1、SHA224、SHA256、GHASH和MD5128位唯一ID。

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1.2 Block Diagram

Figure 1.1 shows a block diagram of the MCU superset, some individual devices within the group have a subset of the features.

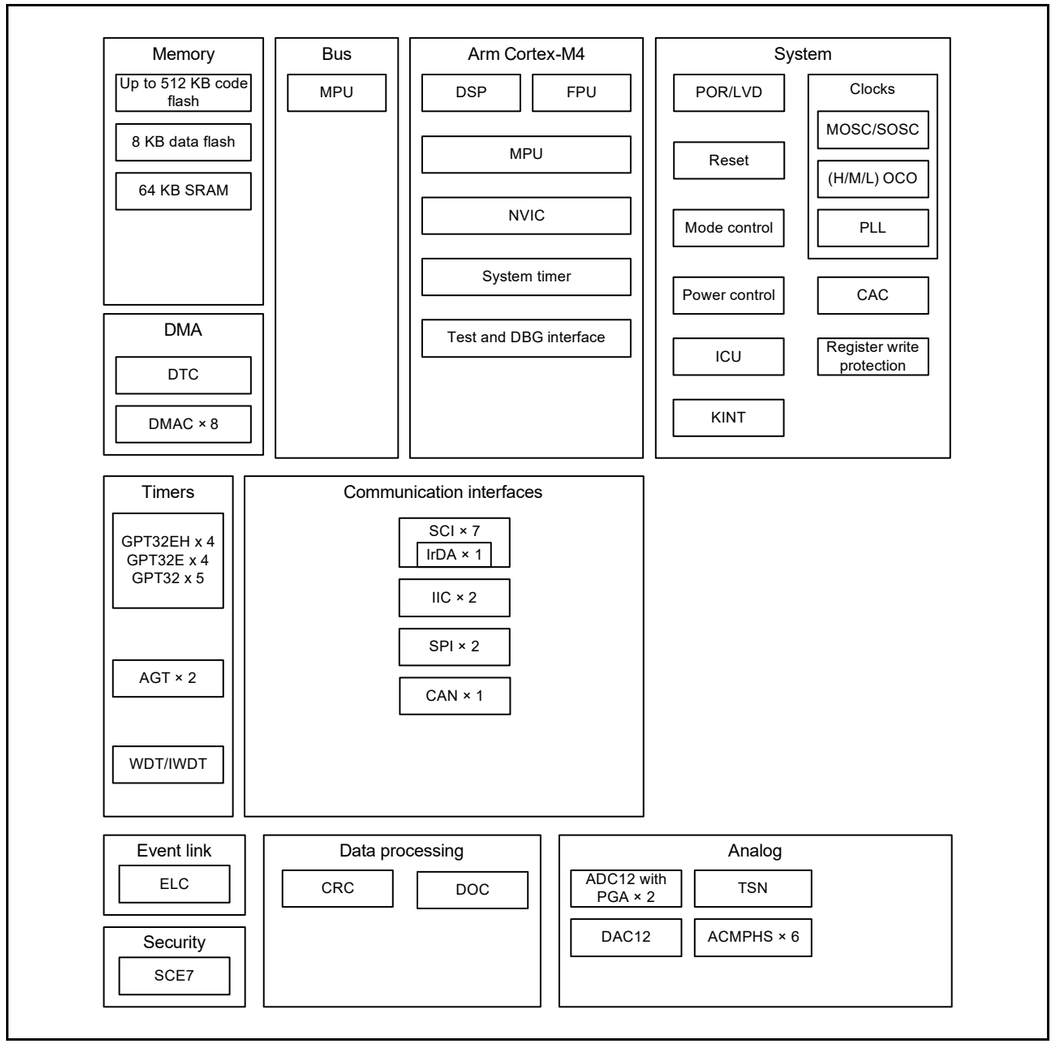

Figure 1.1 Block diagram

1.2 框图

图1.1显示了MCU超集的框图，该组中的一些单独的设备具有功能的子集。

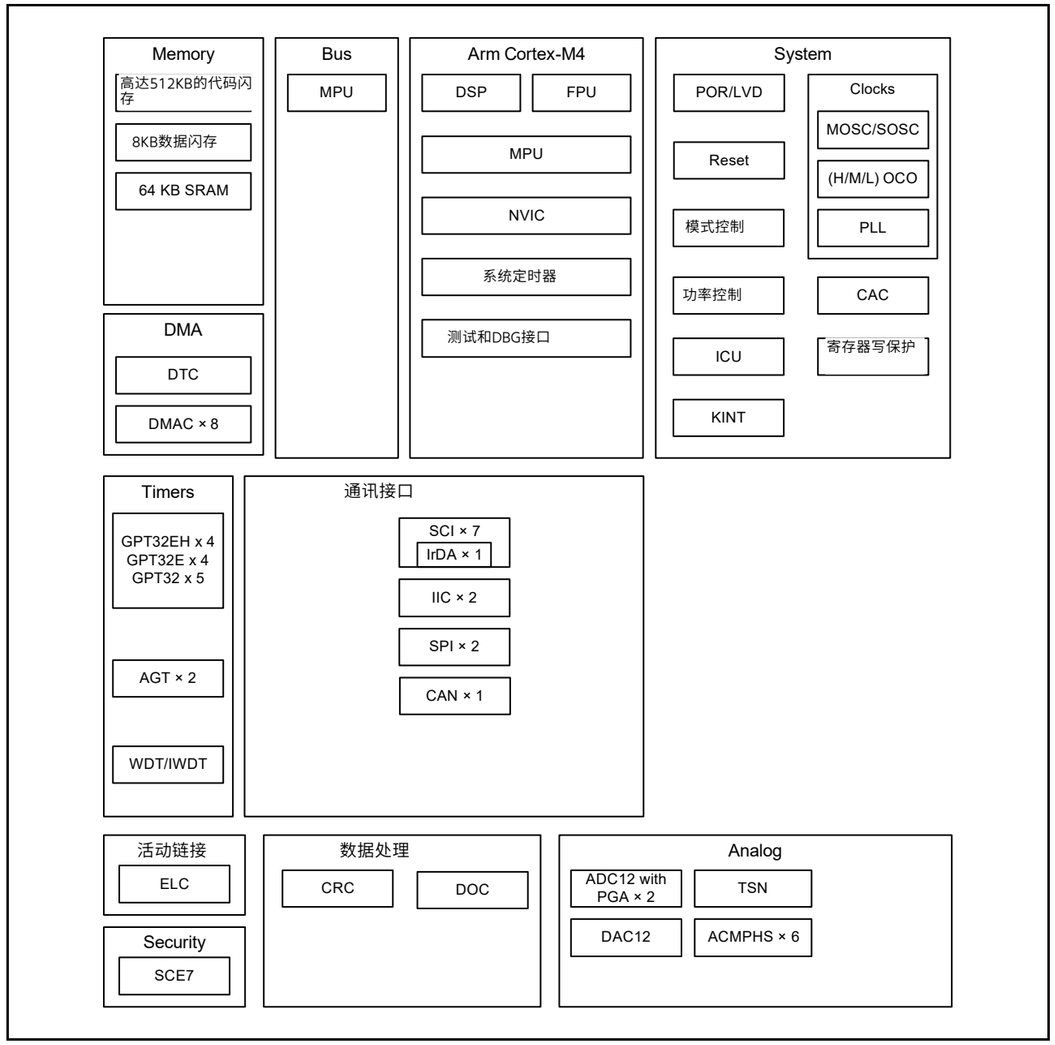

Figure 1.1 框图

1.3 Part Numbering

Figure 1.2 shows the product part number information, including memory capacity and package type. Table 1.11 shows a list of products.

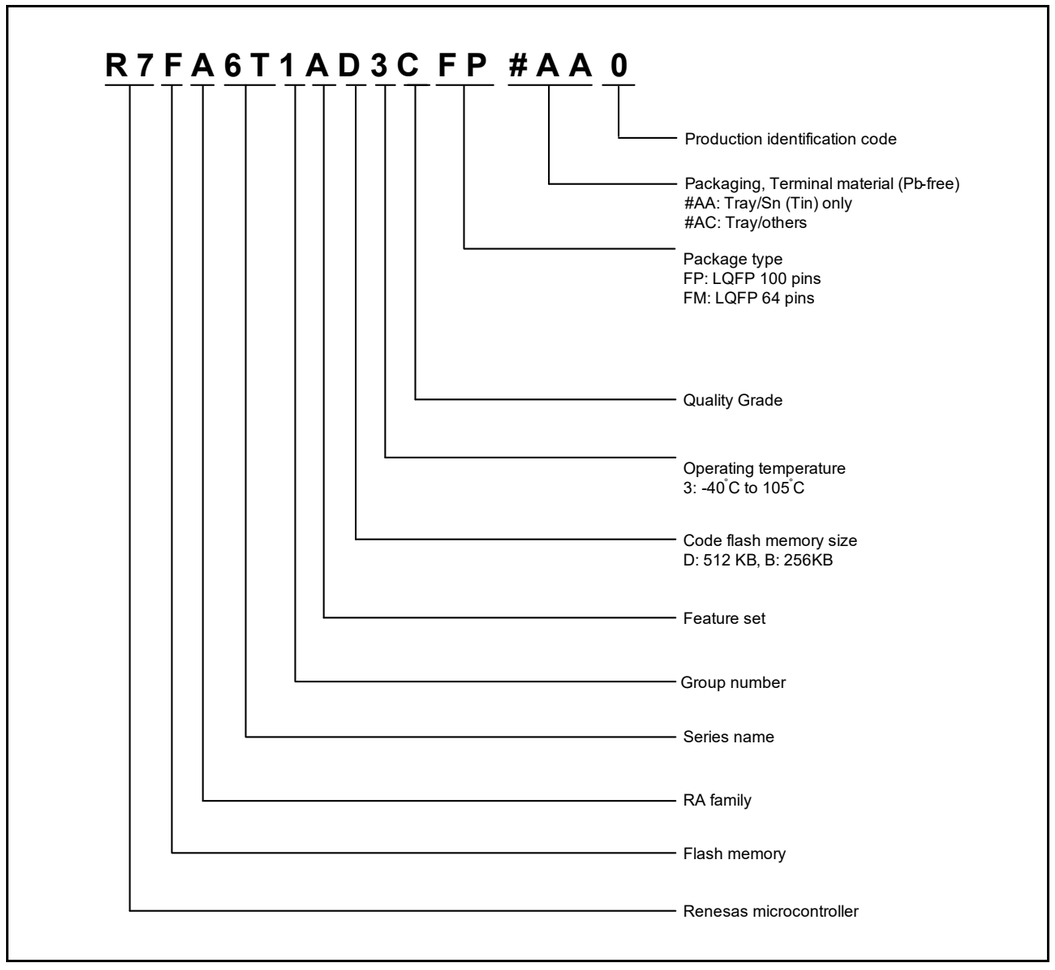

Figure 1.2 Part numbering scheme

Table 1.11 Product list

Product part number	Orderable part number	Package code	Code flash	Data flash	SRAM	Operating temperature
R7FA6T1AD3CFP	R7FA6T1AD3CFP#AA0	PLQP0100KB-B	512 KB	8 KB	64 KB	-40 to +105°C
R7FA6T1AB3CFP	R7FA6T1AB3CFP#AA0	PLQP0100KB-B	256 KB			-40 to +105°C
R7FA6T1AD3CFM	R7FA6T1AD3CFM#AA0	PLQP0064KB-C	512 KB			-40 to +105°C
R7FA6T1AB3CFM	R7FA6T1AB3CFM#AA0	PLQP0064KB-C	256 KB			-40 to +105°C

1.3 零件编号

图1.2显示了产品部件号信息，包括内存容量和封装类型。表1.11显示了产品列表。

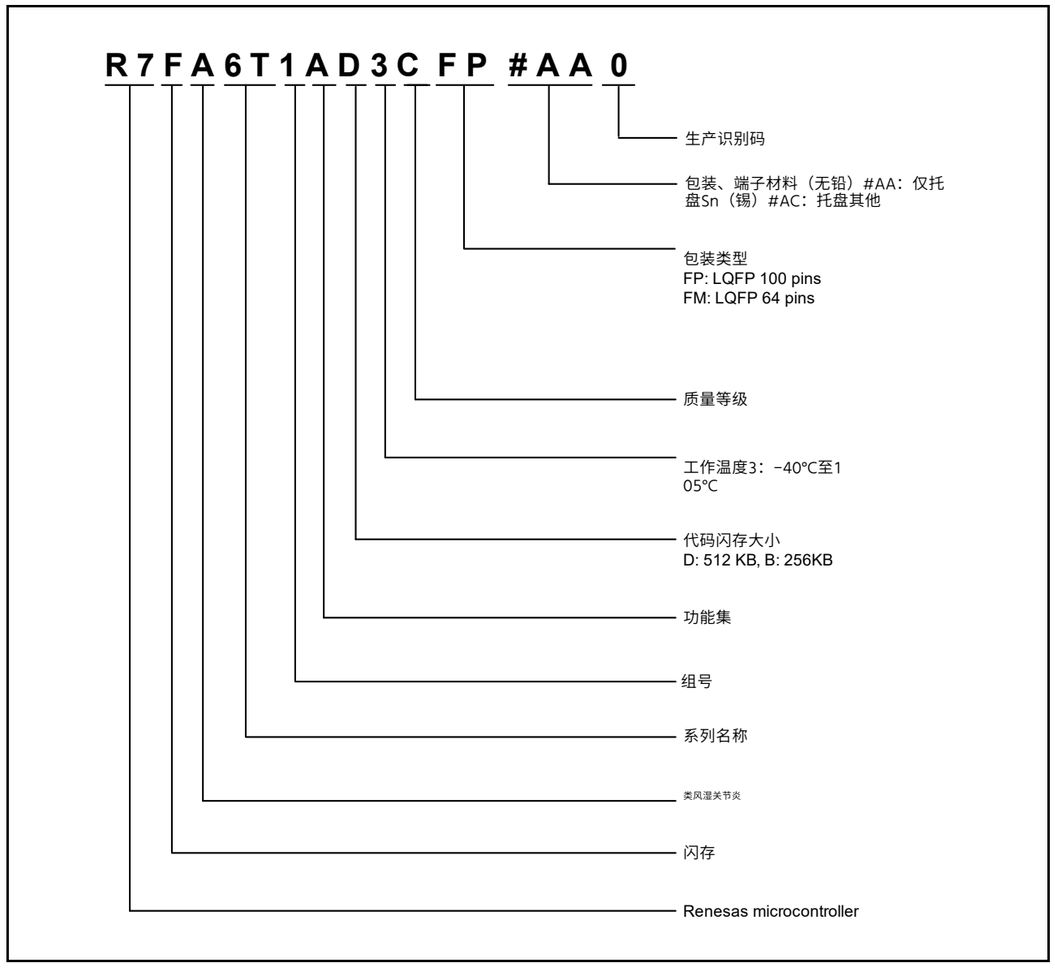

Figure 1.2 零件编号方案

Table 1.11 产品列表

产品部件号	可订购部件号	包装代码	代码闪存	数据闪存	SRAM	工作温度
R7FA6T1AD3CFP	R7FA6T1AD3CFP#AA0	PLQP0100KB-B	512 KB	8 KB	64 KB	-40 to +105°C
R7FA6T1AB3CFP	R7FA6T1AB3CFP#AA0	PLQP0100KB-B	256 KB			-40 to +105°C
R7FA6T1AD3CFM	R7FA6T1AD3CFM#AA0	PLQP0064KB-C	512 KB			-40 to +105°C
R7FA6T1AB3CFM	R7FA6T1AB3CFM#AA0	PLQP0064KB-C	256 KB			-40 to +105°C

1.4 Function Comparison

Table 1.12 Functional comparison

Function		Part numbers			
		R7FA6T1AD3CFP	R7FA6T1AB3CFP	R7FA6T1AD3CFM	R7FA6T1AB3CFM
Pin count		100		64	
Package		LQFP		LQFP	
Code flash memory		256 KB/512 KB			
Data flash memory		8 KB			
SRAM		64 KB			
	Parity	64 KB			
System	CPU clock	120 MHz			
	Backup registers	512 Bytes			
	ICU	Yes			
	KINT	8			
Event link	ELC	Yes			
DMA	DTC	Yes			
	DMAC	8			
Timers	GPT32EH	4			
	GPT32E	4		3	
	GPT32	5		4	
	AGT	2			
	WDT/IWDT	Yes			
Communication	SCI	7			
	IIC	2			
	SPI	2			
	CAN	1			
Analog	ADC12	19		10	
	DAC12	2			
	ACMPHS	6			
	TSN	Yes			
Data processing	CRC	Yes			
	DOC	Yes			
Security		SCE7			

1.4 功能比较

Table 1.12 功能比较

Function		零件号			
		R7FA6T1AD3CFP	R7FA6T1AB3CFP	R7FA6T1AD3CFM	R7FA6T1AB3CFM
针数		100		64	
Package		LQFP		LQFP	
代码闪存		256 KB/512 KB			
数据闪存		8 KB			
SRAM		64 KB			
	Parity	64 KB			
System	中央处理器时钟	120 MHz			
	备份寄存器	512 Bytes			
	ICU	Yes			
	KINT	8			
活动链接	ELC	Yes			
DMA	DTC	Yes			
	DMAC	8			
Timers	GPT32EH	4			
	GPT32E	4		3	
	GPT32	5		4	
	AGT	2			
	WDT/IWDT	Yes			
Communication	SCI	7			
	IIC	2			
	SPI	2			
	CAN	1			
Analog	ADC12	19		10	
	DAC12	2			
	ACMPHS	6			
	TSN	Yes			
数据处理	CRC	Yes			
	DOC	Yes			
Security		SCE7			

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1.5 Pin Functions

Table 1.13 Pin functions (1 of 3)

Function	Signal	I/O	Description
Power supply	VCC	Input	Power supply pin. This is used as the digital power supply for the respective modules and internal voltage regulator, and used to monitor the voltage of the POR/LVD. Connect this pin to the system power supply. Connect it to VSS by a 0.1-μF capacitor. Place the capacitor close to the pin.
	VCL0	Input	Connect this pin to VSS through a 0.1-μF smoothing capacitor used to stabilize the internal power supply. Place the capacitor close to the pin.
	VCL	Input	
	VSS	Input	Ground pin. Connect to the system power supply (0 V).
Clock	XTAL	Output	Pins for a crystal resonator. An external clock signal can be input through the EXTAL pin.
	EXTAL	Input	
	XCIN	Input	Input/output pins for the sub-clock oscillator. Connect a crystal resonator between XCOUT and XCIN.
	XCOUT	Output	
	CLKOUT	Output	Clock output pin
Operating mode control	MD	Input	Pin for setting the operating mode. The signal level on this pin must not be changed during operation mode transition on release from the reset state.
System control	RES	Input	Reset signal input pin. The MCU enters the reset state when this signal goes low.
CAC	CACREF	Input	Measurement reference clock input pin
Interrupt	NMI	Input	Non-maskable interrupt request pin
	IRQ0 to IRQ13	Input	Maskable interrupt request pins
KINT	KR00 to KR07	Input	A key interrupt can be generated by inputting a falling edge to the key interrupt input pins
On-chip emulator	TMS	I/O	On-chip emulator or boundary scan pins
	TDI	Input	
	TCK	Input	
	TDO	Output	
	TCLK	Output	This pin outputs the clock for synchronization with the trace data
	TDATA0 to TDATA3	Output	Trace data output
	SWDIO	I/O	Serial wire debug data input/output pin
	SWCLK	Input	Serial wire clock pin
	SWO	Output	Serial wire trace output pin
GPT	GTETRGA, GTETRGB, GTETRGC, GTETRGD	Input	External trigger input pins
	GTIOC0A to GTIOC12A, GTIOC0B to GTIOC12B	I/O	Input capture, output compare, or PWM output pins
	GTIU	Input	Hall sensor input pin U
	GTIV	Input	Hall sensor input pin V
	GTIW	Input	Hall sensor input pin W
	GTOUUP	Output	3-phase PWM output for BLDC motor control (positive U phase)
	GTOULO	Output	3-phase PWM output for BLDC motor control (negative U phase)
	GTOVUP	Output	3-phase PWM output for BLDC motor control (positive V phase)
	GTOVLO	Output	3-phase PWM output for BLDC motor control (negative V phase)
	GTOWUP	Output	3-phase PWM output for BLDC motor control (positive W phase)
	GTOWLO	Output	3-phase PWM output for BLDC motor control (negative W phase)
AGT	AGTEE0, AGTEE1	Input	External event input enable signals
	AGTIO0, AGTIO1	I/O	External event input and pulse output pins
	AGTO0, AGTO1	Output	Pulse output pins
	AGTOA0, AGTOA1	Output	Output compare match A output pins
	AGTOB0, AGTOB1	Output	Output compare match B output pins

1.5 引脚功能

Table 1.13 引脚功能(1of3)

Function	Signal	I/O	Description
电源	VCC	Input	电源引脚。这用作各个模块和内部稳压器的数字电源，并用于监控PORLVD的电压。将此引脚连接到系统电源。通过一个0.1μF电容将其连接到VSS。将电容器靠近引脚放置。
	VCL0	Input	通过一个用于稳定内部电源的0.1μF平滑电容器将此引脚连接到VSS。将电容器靠近引脚放置。
	VCL	Input	
	VSS	Input	接地引脚。连接到系统电源(0V)。
Clock	XTAL	Output	晶体谐振器的引脚。外部时钟信号可以通过输入 EXTAL pin.
	EXTAL	Input	
	XCIN	Input	副时钟振荡器的输入输出引脚。在XCOUT和XCIN之间连接一个晶体谐振器。
	XCOUT	Output	
	CLKOUT	Output	时钟输出引脚
操作模式控制	MD	Input	用于设置操作模式的引脚。在从复位状态释放的操作模式转换期间，不得更改此引脚上的信号电平。
系统控制	RES	Input	复位信号输入引脚。当该信号变低时，MCU进入复位状态。
CAC	CACREF	Input	测量参考时钟输入引脚
Interrupt	NMI	Input	不可屏蔽中断请求引脚
	IRQ0 to IRQ13	Input	可屏蔽中断请求引脚
KINT	KR00 to KR07	Input	通过向按键中断输入引脚输入下降沿可以产生按键中断
On-chip emulator	TMS	I/O	片上仿真器或边界扫描引脚
	TDI	Input	
	TCK	Input	
	TDO	Output	
	TCLK	Output	该引脚输出与跟踪数据同步的时钟
	TDATA0 to TDATA3	Output	跟踪数据输出
	SWDIO	I/O	串行线调试数据输入输出引脚
	SWCLK	Input	串行线时钟引脚
	SWO	Output	串行线迹输出引脚
GPT	GTETRGA, GTETRGB, GTETRGC, GTETRGD	Input	外部触发输入引脚
	GTIOC0A to GTIOC12A, GTIOC0B to GTIOC12B	I/O	输入捕捉、输出比较或PWM输出引脚
	GTIU	Input	霍尔传感器输入引脚U
	GTIV	Input	霍尔传感器输入引脚V
	GTIW	Input	霍尔传感器输入引脚W
	GTOUUP	Output	用于BLDC电机控制的3相PWM输出（正U相）
	GTOULO	Output	用于BLDC电机控制的3相PWM输出（负U相）
	GTOVUP	Output	用于BLDC电机控制的3相PWM输出（正V相）
	GTOVLO	Output	用于BLDC电机控制的3相PWM输出（负V相）
	GTOWUP	Output	用于BLDC电机控制的3相PWM输出（正W相）
	GTOWLO	Output	用于BLDC电机控制的3相PWM输出（负W相）
AGT	AGTEE0, AGTEE1	Input	外部事件输入使能信号
	AGTIO0, AGTIO1	I/O	外部事件输入和脉冲输出引脚
	AGTO0, AGTO1	Output	脉冲输出引脚
	AGTOA0, AGTOA1	Output	输出比较匹配A输出引脚
	AGTOB0, AGTOB1	Output	输出比较匹配B输出引脚

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Table 1.13 Pin functions (2 of 3)

Function	Signal	I/O	Description
SCI	SCK0 to SCK4, SCK8, SCK9	I/O	Input/output pins for the clock (clock synchronous mode)
	RXD0 to RXD4, RXD8, RXD9	Input	Input pins for received data (asynchronous mode/clock synchronous mode)
	TXD0 to TXD4, TXD8, TXD9	Output	Output pins for transmitted data (asynchronous mode/clock synchronous mode)
	CTS0_RTS0 to CTS4_RTS4, CTS8_RTS8, CTS9_RTS9	I/O	Input/output pins for controlling the start of transmission and reception (asynchronous mode/clock synchronous mode), active-low
	SCL0 to SCL4, SCL8, SCL9	I/O	Input/output pins for the IIC clock (simple IIC mode)
	SDA0 to SDA4, SDA8, SDA9	I/O	Input/output pins for the IIC data (simple IIC mode)
	SCK0 to SCK4, SCK8, SCK9	I/O	Input/output pins for the clock (simple SPI mode)
	MISO0 to MISO4, MISO8, MISO9	I/O	Input/output pins for slave transmission of data (simple SPI mode)
	MOSI0 to MOSI4, MOSI8, MOSI9	I/O	Input/output pins for master transmission of data (simple SPI mode)
	SS0 to SS4, SS8, SS9	Input	Chip-select input pins (simple SPI mode), active-low
IIC	SCL0, SCL1	I/O	Input/output pins for the clock
	SDA0, SDA1	I/O	Input/output pins for data
SPI	RSPCKA, RSPCKB	I/O	Clock input/output pin
	MOSIA, MOSIB	I/O	Input or output pins for data output from the master
	MISOA, MISOB	I/O	Input or output pins for data output from the slave
	SSLA0, SSLB0	I/O	Input or output pin for slave selection
	SSLA1 to SSLA3, SSLB1 to SSLB3	Output	Output pins for slave selection
CAN	CRX0	Input	Receive data
	CTX0	Output	Transmit data
Analog power supply	AVCC0	Input	Analog voltage supply pin. This is used as the analog power supply for the respective modules. Supply this pin with the same voltage as the VCC pin.
	AVSS0	Input	Analog ground pin. This is used as the analog ground for the respective modules. Supply this pin with the same voltage as the VSS pin.
	VREFH0	Input	Analog reference voltage supply pin for the ADC12 (unit 0). Connect this pin to VCC when not using the ADC12 (unit 0) and sample-and-hold circuit for AN000 to AN002.
	VREFL0	Input	Analog reference ground pin for the ADC12. Connect this pin to VSS when not using the ADC12 (unit 0) and sample-and-hold circuit for AN000 to AN002
	VREFH	Input	Analog reference voltage supply pin for the ADC12 (unit 1) and D/A Converter. Connect this pin to VCC when not using the ADC12 (unit 1), sample-and-hold circuit for AN100 to AN102, and D/A Converter.
	VREFL	Input	Analog reference ground pin for the ADC12 and D/A Converter. Connect this pin to VSS when not using the ADC12 (unit 1), sample-and-hold circuit for AN100 to AN102, and D/A Converter.
ADC12	AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020	Input	Input pins for the analog signals to be processed by the ADC12
	AN100 to AN102, AN105 to AN107, AN116, AN117	Input	
	ADTRG0	Input	Input pins for the external trigger signals that start the A/D conversion
	ADTRG1	Input	
	PGAVSS000, PGAVSS100	Input	Pseudo-differential input pins

Table 1.13 引脚功能（2个，共3个）

Function	Signal	I/O	Description
SCI	SCK0 to SCK4, SCK8, SCK9	I/O	时钟输入输出引脚（时钟同步模式）
	RXD0 to RXD4, RXD8, RXD9	Input	接收数据的输入引脚（异步模式时钟同步模式）
	TXD0 to TXD4, TXD8, TXD9	Output	传输数据的输出引脚（异步模式时钟同步模式）
	CTS0_RTS0 to CTS4_RTS4, CTS8_RTS8, CTS9_RTS9	I/O	输入输出引脚用于控制发送和接收的开始（异步模式时钟同步模式），低电平有效
	SCL0 to SCL4, SCL8, SCL9	I/O	IIC时钟的输入输出引脚（简单IIC模式）
	SDA0 to SDA4, SDA8, SDA9	I/O	IIC数据的输入输出引脚（简单IIC模式）
	SCK0 to SCK4, SCK8, SCK9	I/O	时钟输入输出引脚（简单SPI模式）
	MISO0 to MISO4, MISO8, MISO9	I/O	用于从机传输数据的输入输出引脚（简单SPI模式）
	MOSI0 to MOSI4, MOSI8, MOSI9	I/O	输入输出引脚用于主数据传输（简单SPI模式）
	SS0 to SS4, SS8, SS9	Input	片选输入引脚（简单SPI模式），低电平有效
IIC	SCL0, SCL1	I/O	时钟的输入输出引脚
	SDA0, SDA1	I/O	数据输入输出引脚
SPI	RSPCKA, RSPCKB	I/O	时钟输入输出引脚
	MOSIA, MOSIB	I/O	用于从主机输出数据的输入或输出引脚
	MISOA, MISOB	I/O	从机数据输出的输入或输出引脚
	SSLA0, SSLB0	I/O	从机选择的输入或输出引脚
	SSLA1 to SSLA3, SSLB1 to SSLB3	Output	从机选择的输出引脚
CAN	CRX0	Input	接收数据
	CTX0	Output	传输数据
模拟电源	AVCC0	Input	模拟电压电源引脚。这用作各个模块的模拟电源。为该引脚提供与VCC引脚相同的电压。
	AVSS0	Input	模拟接地引脚。这用作各个模块的模拟地。为该引脚提供与VSS引脚相同的电压。
	VREFH0	Input	ADC12（单元0）的模拟参考电压电源引脚。当不使用ADC12（单元0）和AN000到AN002的采样保持电路时，将此引脚连接到VCC。
	VREFL0	Input	ADC12的模拟参考接地引脚。不使用ADC12（单元0）和AN000至AN002的采样保持电路时，将此引脚连接到VSS
	VREFH	Input	ADC12（单元1）和DA的模拟参考电压电源引脚 转换器。不使用ADC12（单元1）、AN100至AN102的采样保持电路和DA转换器时，将此引脚连接到VCC。
	VREFL	Input	ADC12和DA转换器的模拟参考接地引脚。不使用ADC12（单元1）、AN100至AN102的采样保持电路和DA转换器时，将此引脚连接到VSS。
ADC12	AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020	Input	ADC12处理的模拟信号的输入引脚
	AN100 to AN102, AN105 to AN107, AN116, AN117	Input	
	ADTRG0	Input	用于启动AD转换的外部触发信号的输入引脚
	ADTRG1	Input	
	PGAVSS000, PGAVSS100	Input	伪差分输入引脚

Table 1.13 Pin functions (3 of 3)

Function	Signal	I/O	Description
DAC12	DA0, DA1	Output	Output pins for the analog signals processed by the D/A converter
ACMPHS	VCOUT	Output	Comparator output pin
	IVREF0 to IVREF3	Input	Reference voltage input pins for comparator
	IVCMP0 to IVCMP3	Input	Analog voltage input pins for comparator
I/O ports	P000 to P007	Input	General-purpose input pins
	P008, P014, P015	I/O	General-purpose input/output pins
	P100 to P115	I/O	General-purpose input/output pins
	P200	Input	General-purpose input pin
	P201, P205 to P214	I/O	General-purpose input/output pins
	P300 to P307	I/O	General-purpose input/output pins
	P400 to P415	I/O	General-purpose input/output pins
	P500 to P504, P508	I/O	General-purpose input/output pins
	P600 to P602, P608 to P610	I/O	General-purpose input/output pins
	P708	I/O	General-purpose input/output pin

Table 1.13 引脚功能（3个中的3个）

Function	Signal	I/O	Description
DAC12	DA0, DA1	Output	DA转换器处理的模拟信号的输出引脚
ACMPHS	VCOUT	Output	比较器输出引脚
	IVREF0 to IVREF3	Input	比较器的参考电压输入引脚
	IVCMP0 to IVCMP3	Input	比较器的模拟电压输入引脚
I/O ports	P000 to P007	Input	通用输入引脚
	P008, P014, P015	I/O	General-purpose input/output pins
	P100 to P115	I/O	General-purpose input/output pins
	P200	Input	通用输入引脚
	P201, P205 to P214	I/O	General-purpose input/output pins
	P300 to P307	I/O	General-purpose input/output pins
	P400 to P415	I/O	General-purpose input/output pins
	P500 to P504, P508	I/O	General-purpose input/output pins
	P600 to P602, P608 to P610	I/O	General-purpose input/output pins
	P708	I/O	General-purpose input/output pin

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1.6 Pin Assignments

Figure 1.3 and Figure 1.4 show the pin assignments.

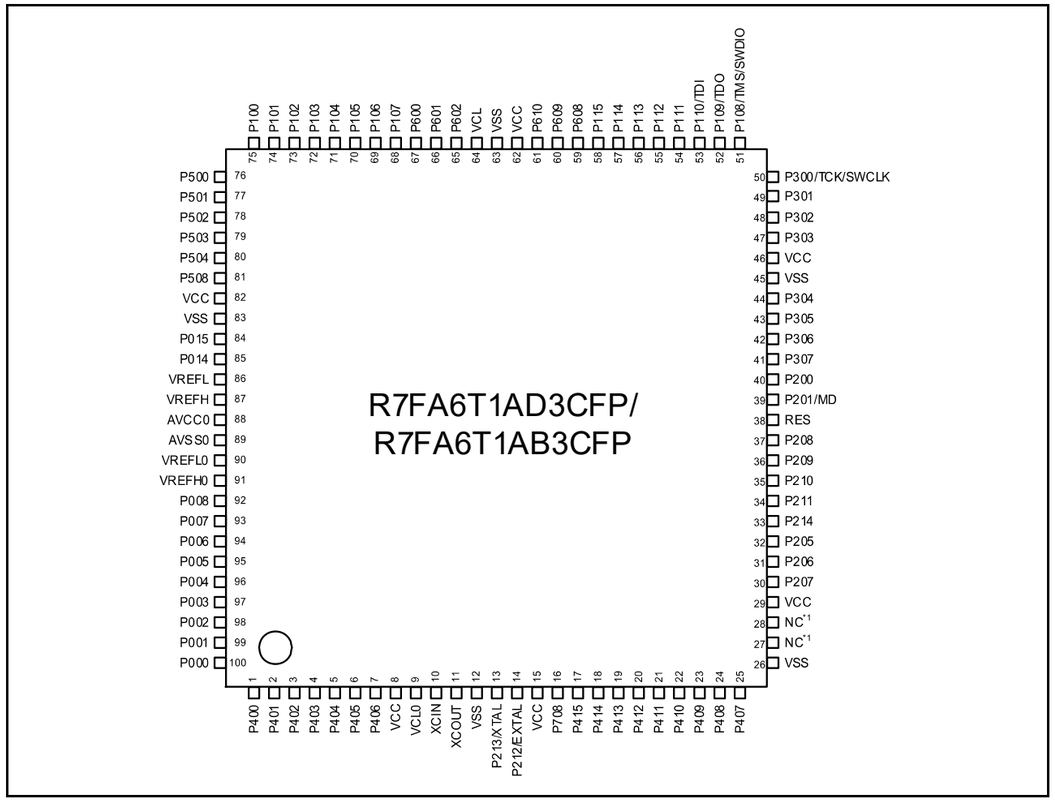

Figure 1.3 Pin assignment for 100-pin LQFP (top view)

Note 1. This pin should be left floating.

1.6 引脚分配

图1.3和图1.4显示了引脚分配。

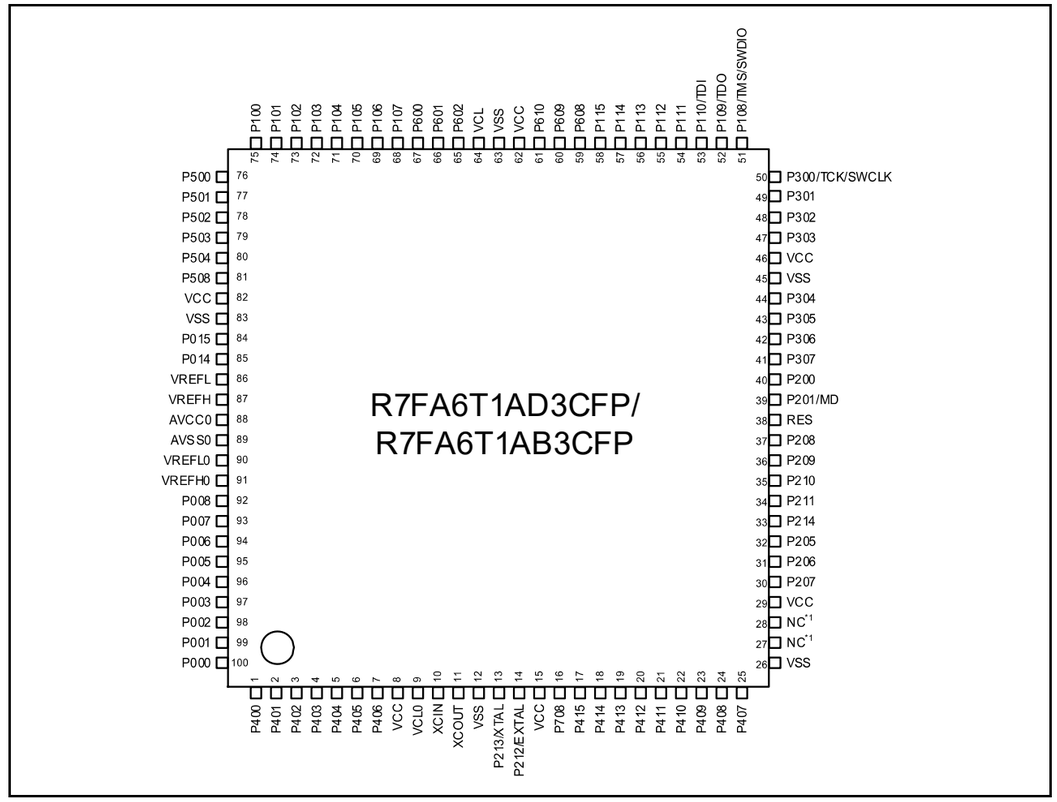

Figure 1.3 100引脚LQFP的引脚分配（顶视图）

注1.该引脚应悬空。

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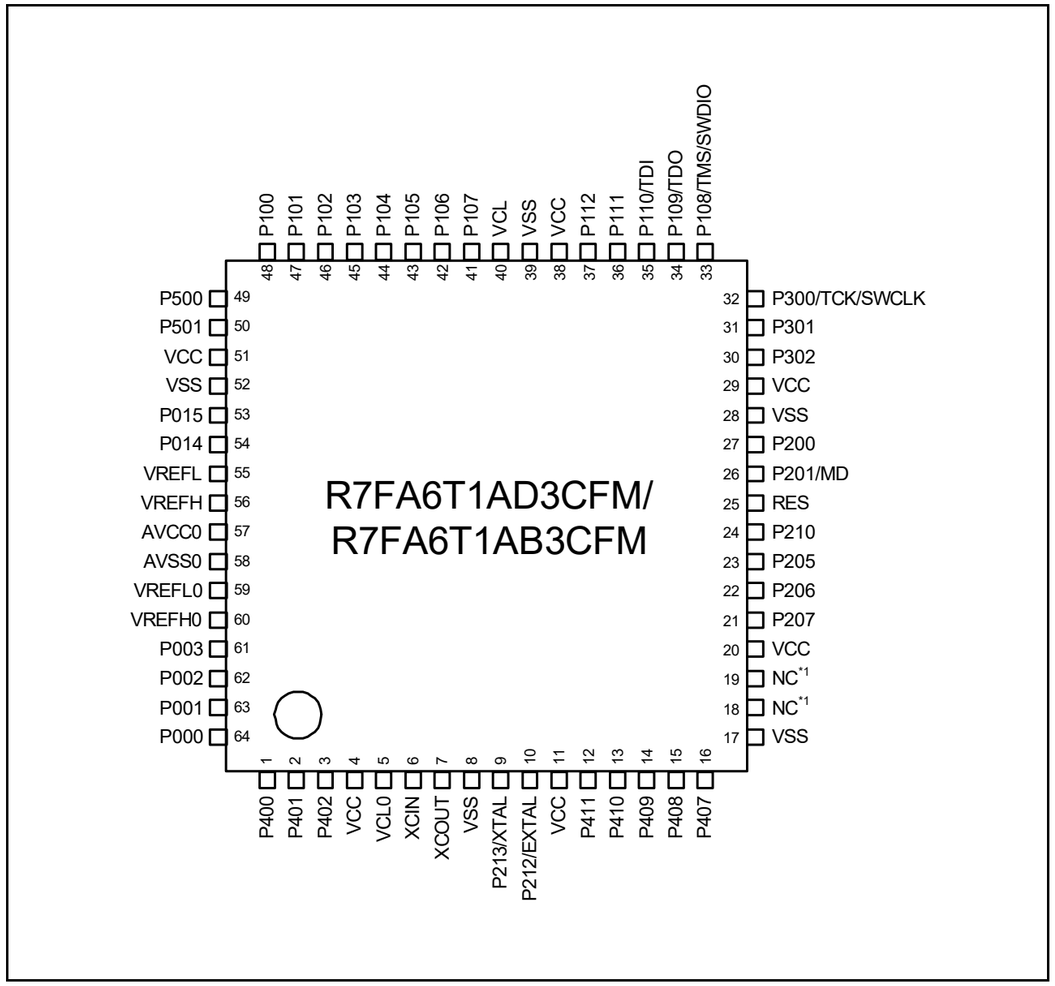

Figure 1.4 Pin assignment for 64-pin LQFP (top view)

Note 1. This pin should be left floating.

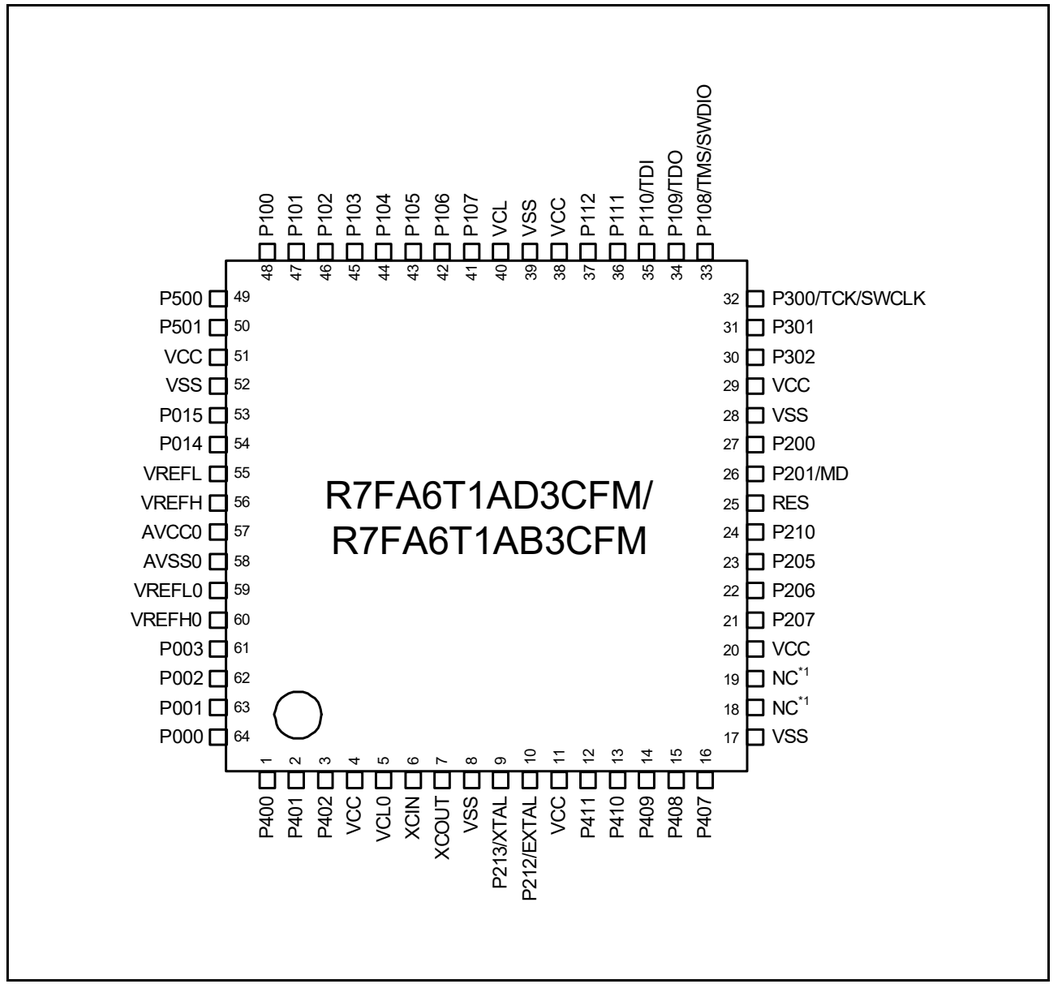

Figure 1.4 64引脚LQFP的引脚分配（顶视图）

注1.该引脚应悬空。

1.7 Pin Lists

Pin number					Timers			Communication interfaces					Analog	
LQFP100	LQFP64	Power, System, Clock, Debug, CAC	Interrupt	I/O port	AGT	GPT	GPT	CAN	SCI0,2,4,8 (30 MHz)	SCI1,3,9 (30 MHz)	IIC	SPI	ADC12	DAC12, ACMPHS
1	1	-	IRQ0	P400	AGTIO1	-	GTIOC6A	-	SCK4	-	SCL0_A	-	ADTRG1	-
2	2	-	IRQ5-DS	P401	-	GTETRGA	GTIOC6B	CTX0	CTS4_RTS4/SS4	-	SDA0_A	-	-	-
3	3	CACREF	IRQ4-DS	P402	AGTIO0/AGTIO1	-	-	CRX0	-	-	-	-	-	-
4	-	-	-	P403	AGTIO0/AGTIO1	-	GTIOC3A	-	-	-	-	-	-	-
5	-	-	-	P404	-	-	GTIOC3B	-	-	-	-	-	-	-
6	-	-	-	P405	-	-	GTIOC1A	-	-	-	-	-	-	-
7	-	-	-	P406	-	-	GTIOC1B	-	-	-	-	-	-	-
8	4	VCC	-	-	-	-	-	-	-	-	-	-	-	-
9	5	VCL0	-	-	-	-	-	-	-	-	-	-	-	-
10	6	XCIN	-	-	-	-	-	-	-	-	-	-	-	-
11	7	XCOUT	-	-	-	-	-	-	-	-	-	-	-	-
12	8	VSS	-	-	-	-	-	-	-	-	-	-	-	-
13	9	XTAL	IRQ2	P213	-	GTETRGC	GTIOC0A	-	-	TXD1/MOSI1/SDA1	-	-	ADTRG1	-
14	10	EXTAL	IRQ3	P212	AGTEE1	GTETRGD	GTIOC0B	-	-	RXD1/MISO1/SCL1	-	-	-	-
15	11	VCC	-	-	-	-	-	-	-	-	-	-	-	-
16	-	CACREF	IRQ11	P708	-	-	-	-	-	RXD1/MISO1/SCL1	-	SSLA3_B	-	-
17	-	-	IRQ8	P415	-	-	GTIOC0A	-	-	-	-	SSLA2_B	-	-
18	-	-	IRQ9	P414	-	-	GTIOC0B	-	-	-	-	SSLA1_B	-	-
19	-	-	-	P413	-	GTOUUP	-	-	CTS0_RTS0/SS0	-	-	SSLA0_B	-	-
20	-	-	-	P412	AGTEE1	GTOULO	-	-	SCK0	-	-	RSPCKA_B	-	-
21	12	-	IRQ4	P411	AGTOA1	GTOVUP	GTIOC9A	-	TXD0/MOSI0/SDA0	CTS3_RTS3/SS3	-	MOSIA_B	-	-
22	13	-	IRQ5	P410	AGTOB1	GTOVLO	GTIOC9B	-	RXD0/MISO0/SCL0	SCK3	-	MISOA_B	-	-
23	14	-	IRQ6	P409	-	GTOWUP	GTIOC10A	-	-	TXD3/MOSI3/SDA3	-	-	-	-
24	15	-	IRQ7	P408	-	GTOWLO	GTIOC10B	-	-	RXD3/MISO3/SCL3	SCL0_B	-	-	-
25	16	-	-	P407	AGTIO0	-	-	-	CTS4_RTS4/SS4	-	SDA0_B	-	ADTRG0	-
26	17	VSS	-	-	-	-	-	-	-	-	-	-	-	-
27	18	-	-	-	-	-	-	-	-	-	-	-	-	-
28	19	-	-	-	-	-	-	-	-	-	-	-	-	-
29	20	VCC	-	-	-	-	-	-	-	-	-	-	-	-
30	21	-	-	P207	-	-	-	-	-	-	-	-	-	-
31	22	-	IRQ0-DS	P206	-	GTIU	-	-	RXD4/MISO4/SCL4	-	SDA1_A	-	-	-
32	23	CLKOUT	IRQ1-DS	P205	AGTO1	GTIV	GTIOC4A	-	TXD4/MOSI4/SDA4	CTS9_RTS9/SS9	SCL1_A	-	-	-
33	-	TRCLK	-	P214	-	GTIU	-	-	-	-	-	-	-	-
34	-	TRDATA0	-	P211	-	GTIV	-	-	-	-	-	-	-	-
35	24	TRDATA1	-	P210	-	GTIW	-	-	-	-	-	-	-	-
36	-	TRDATA2	-	P209	-	GTOVUP	-	-	-	-	-	-	-	-
37	-	TRDATA3	-	P208	-	GTOVLO	-	-	-	-	-	-	-	-
38	25	RES	-	-	-	-	-	-	-	-	-	-	-	-
39	26	MD	-	P201	-	-	-	-	-	-	-	-	-	-
40	27	-	NMI	P200	-	-	-	-	-	-	-	-	-	-
41	-	-	-	P307	-	GTOUUP	-	-	-	-	-	-	-	-
42	-	-	-	P306	-	GTOULO	-	-	-	-	-	-	-	-
43	-	-	IRQ8	P305	-	GTOWUP	-	-	-	-	-	-	-	-
44	-	-	IRQ9	P304	-	GTOWLO	GTIOC7A	-	-	-	-	-	-	-
45	28	VSS	-	-	-	-	-	-	-	-	-	-	-	-
46	29	VCC	-	-	-	-	-	-	-	-	-	-	-	-
47	-	-	-	P303	-	-	GTIOC7B	-	-	-	-	-	-	-
48	30	-	IRQ5	P302	-	GTOUUP	GTIOC4A	-	TXD2/MOSI2/SDA2	-	-	SSLB3_B	-	-
49	31	-	IRQ6	P301	AGTIO0	GTOULO	GTIOC4B	-	RXD2/MISO2/SCL2	CTS9_RTS9/SS9	-	SSLB2_B	-	-
50	32	TCK/SWCLK	-	P300	-	GTOUUP	GTIOC0A_A	-	-	-	-	SSLB1_B	-	-
51	33	TMS/SWDIO	-	P108	-	GTOULO	GTIOC0B_A	-	-	CTS9_RTS9/SS9	-	SSLB0_B	-	-
52	34	CLKOUT/TDO/SWO	-	P109	-	GTOVUP	GTIOC1A_A	-	-	TXD9/MOSI9/SDA9	-	MOSIB_B	-	-
53	35	TDI	IRQ3	P110	-	GTOVLO	GTIOC1B_A	-	CTS2_RTS2/SS2	RXD9/MISO9/SCL9	-	MISOB_B	-	VCOUT
54	36	-	IRQ4	P111	-	-	GTIOC3A_A	-	SCK2	SCK9	-	RSPCKB_B	-	-
55	37	-	-	P112	-	-	GTIOC3B_A	-	TXD2/MOSI2/SDA2	SCK1	-	SSLB0_B	-	-
56	-	-	-	P113	-	-	GTIOC2A	-	RXD2/MISO2/SCL2	-	-	-	-	-
57	-	-	-	P114	-	-	GTIOC2B	-	-	-	-	-	-	-
58	-	-	-	P115	-	-	GTIOC4A	-	-	-	-	-	-	-
59	-	-	-	P608	-	-	GTIOC4B	-	-	-	-	-	-	-

1.7 引脚列表

针号		电源系统，时钟，调试，CAC			Timers			通讯接口					Analog	
LQFP100	LQFP64		Interrupt	I/O port	AGT	GPT	GPT	CAN	SCI0,2,4,8 (30 MHz)	SCI1,3,9 (30 MHz)	IIC	SPI	ADC12	DAC12, ACMPHS
1	1	-	IRQ0	P400	AGTIO1	-	GTIOC6A	-	SCK4	-	SCL0_A	-	ADTRG1	-
2	2	-	IRQ5-DS	P401	-	GTETRGA	GTIOC6B	CTX0	CTS4_RTS4/SS4	-	SDA0_A	-	-	-
3	3	CACREF	IRQ4-DS	P402	AGTIO0/AGTIO1	-	-	CRX0	-	-	-	-	-	-
4	-	-	-	P403	AGTIO0/AGTIO1	-	GTIOC3A	-	-	-	-	-	-	-
5	-	-	-	P404	-	-	GTIOC3B	-	-	-	-	-	-	-
6	-	-	-	P405	-	-	GTIOC1A	-	-	-	-	-	-	-
7	-	-	-	P406	-	-	GTIOC1B	-	-	-	-	-	-	-
8	4	VCC	-	-	-	-	-	-	-	-	-	-	-	-
9	5	VCL0	-	-	-	-	-	-	-	-	-	-	-	-
10	6	XCIN	-	-	-	-	-	-	-	-	-	-	-	-
11	7	XCOUT	-	-	-	-	-	-	-	-	-	-	-	-
12	8	VSS	-	-	-	-	-	-	-	-	-	-	-	-
13	9	XTAL	IRQ2	P213	-	GTETRGC	GTIOC0A	-	-	TXD1/MOSI1/SDA1	-	-	ADTRG1	-
14	10	EXTAL	IRQ3	P212	AGTEE1	GTETRGD	GTIOC0B	-	-	RXD1/MISO1/SCL1	-	-	-	-
15	11	VCC	-	-	-	-	-	-	-	-	-	-	-	-
16	-	CACREF	IRQ11	P708	-	-	-	-	-	RXD1/MISO1/SCL1	-	SSLA3_B	-	-
17	-	-	IRQ8	P415	-	-	GTIOC0A	-	-	-	-	SSLA2_B	-	-
18	-	-	IRQ9	P414	-	-	GTIOC0B	-	-	-	-	SSLA1_B	-	-
19	-	-	-	P413	-	GTOUUP	-	-	CTS0_RTS0/SS0	-	-	SSLA0_B	-	-
20	-	-	-	P412	AGTEE1	GTOULO	-	-	SCK0	-	-	RSPCKA_B	-	-
21	12	-	IRQ4	P411	AGTOA1	GTOVUP	GTIOC9A	-	TXD0/MOSI0/SDA0	CTS3_RTS3/SS3	-	MOSIA_B	-	-
22	13	-	IRQ5	P410	AGTOB1	GTOVLO	GTIOC9B	-	RXD0/MISO0/SCL0	SCK3	-	MISOA_B	-	-
23	14	-	IRQ6	P409	-	GTOWUP	GTIOC10A	-	-	TXD3/MOSI3/SDA3	-	-	-	-
24	15	-	IRQ7	P408	-	GTOWLO	GTIOC10B	-	-	RXD3/MISO3/SCL3	SCL0_B	-	-	-
25	16	-	-	P407	AGTIO0	-	-	-	CTS4_RTS4/SS4	-	SDA0_B	-	ADTRG0	-
26	17	VSS	-	-	-	-	-	-	-	-	-	-	-	-
27	18	-	-	-	-	-	-	-	-	-	-	-	-	-
28	19	-	-	-	-	-	-	-	-	-	-	-	-	-
29	20	VCC	-	-	-	-	-	-	-	-	-	-	-	-
30	21	-	-	P207	-	-	-	-	-	-	-	-	-	-
31	22	-	IRQ0-DS	P206	-	GTIU	-	-	RXD4/MISO4/SCL4	-	SDA1_A	-	-	-
32	23	CLKOUT	IRQ1-DS	P205	AGTO1	GTIV	GTIOC4A	-	TXD4/MOSI4/SDA4	CTS9_RTS9/SS9	SCL1_A	-	-	-
33	-	TRCLK	-	P214	-	GTIU	-	-	-	-	-	-	-	-
34	-	TRDATA0	-	P211	-	GTIV	-	-	-	-	-	-	-	-
35	24	TRDATA1	-	P210	-	GTIW	-	-	-	-	-	-	-	-
36	-	TRDATA2	-	P209	-	GTOVUP	-	-	-	-	-	-	-	-
37	-	TRDATA3	-	P208	-	GTOVLO	-	-	-	-	-	-	-	-
38	25	RES	-	-	-	-	-	-	-	-	-	-	-	-
39	26	MD	-	P201	-	-	-	-	-	-	-	-	-	-
40	27	-	NMI	P200	-	-	-	-	-	-	-	-	-	-
41	-	-	-	P307	-	GTOUUP	-	-	-	-	-	-	-	-
42	-	-	-	P306	-	GTOULO	-	-	-	-	-	-	-	-
43	-	-	IRQ8	P305	-	GTOWUP	-	-	-	-	-	-	-	-
44	-	-	IRQ9	P304	-	GTOWLO	GTIOC7A	-	-	-	-	-	-	-
45	28	VSS	-	-	-	-	-	-	-	-	-	-	-	-
46	29	VCC	-	-	-	-	-	-	-	-	-	-	-	-
47	-	-	-	P303	-	-	GTIOC7B	-	-	-	-	-	-	-
48	30	-	IRQ5	P302	-	GTOUUP	GTIOC4A	-	TXD2/MOSI2/SDA2	-	-	SSLB3_B	-	-
49	31	-	IRQ6	P301	AGTIO0	GTOULO	GTIOC4B	-	RXD2/MISO2/SCL2	CTS9_RTS9/SS9	-	SSLB2_B	-	-
50	32	TCK/SWCLK	-	P300	-	GTOUUP	GTIOC0A_A	-	-	-	-	SSLB1_B	-	-
51	33	TMS/SWDIO	-	P108	-	GTOULO	GTIOC0B_A	-	-	CTS9_RTS9/SS9	-	SSLB0_B	-	-
52	34	CLKOUT/TDO/SWO	-	P109	-	GTOVUP	GTIOC1A_A	-	-	TXD9/MOSI9/SDA9	-	MOSIB_B	-	-
53	35	TDI	IRQ3	P110	-	GTOVLO	GTIOC1B_A	-	CTS2_RTS2/SS2	RXD9/MISO9/SCL9	-	MISOB_B	-	VCOUT
54	36	-	IRQ4	P111	-	-	GTIOC3A_A	-	SCK2	SCK9	-	RSPCKB_B	-	-
55	37	-	-	P112	-	-	GTIOC3B_A	-	TXD2/MOSI2/SDA2	SCK1	-	SSLB0_B	-	-
56	-	-	-	P113	-	-	GTIOC2A	-	RXD2/MISO2/SCL2	-	-	-	-	-
57	-	-	-	P114	-	-	GTIOC2B	-	-	-	-	-	-	-
58	-	-	-	P115	-	-	GTIOC4A	-	-	-	-	-	-	-
59	-	-	-	P608	-	-	GTIOC4B	-	-	-	-	-	-	-

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Pin number		Power, System, Clock, Debug, CAC	Interrupt	I/O port	Timers			Communication interfaces					Analog	
LQFP100	LQFP64				AGT	GPT	GPT	CAN	SCI0,2,4,8 (30 MHz)	SCI1,3,9 (30 MHz)	IIC	SPI	ADC12	DAC12, ACMPHS
60	-	-	-	P609	-	-	GTIOC5A	-	-	-	-	-	-	-
61	-	-	-	P610	-	-	GTIOC5B	-	-	-	-	-	-	-
62	38	VCC	-	-	-	-	-	-	-	-	-	-	-	-
63	39	VSS	-	-	-	-	-	-	-	-	-	-	-	-
64	40	VCL	-	-	-	-	-	-	-	-	-	-	-	-
65	-	-	-	P602	-	-	GTIOC7B	-	-	TXD9	-	-	-	-
66	-	-	-	P601	-	-	GTIOC6A	-	-	RXD9	-	-	-	-
67	-	CLKOUT/CAC REF	-	P600	-	-	GTIOC6B	-	-	SCK9	-	-	-	-
68	41	-	KR07	P107	AGTOA0	-	GTIOC8A	-	CTS8_RTS8/SS8	-	-	-	-	-
69	42	-	KR06	P106	AGTOB0	-	GTIOC8B	-	SCK8	-	-	SSLA3_A	-	-
70	43	-	IRQ0/KR05	P105	-	GTETRGA	GTIOC1A	-	TXD8/MOSI8/SDA8	-	-	SSLA2_A	-	-
71	44	-	IRQ1/KR04	P104	-	GTETRGB	GTIOC1B	-	RXD8/MISO8/SCL8	-	-	SSLA1_A	-	-
72	45	-	KR03	P103	-	GTOWUP	GTIOC2A_A	CTX0	CTS0_RTS0/SS0	-	-	SSLA0_A	-	-
73	46	-	KR02	P102	AGTO0	GTOWLO	GTIOC2B_A	CRX0	SCK0	-	-	RSPCKA_A	ADTRG0	-
74	47	-	IRQ1/KR01	P101	AGTEE0	GTETRGB	GTIOC5A	-	TXD0/MOSI0/SDA0	CTS1_RTS1/SS1	SDA1_B	MOSIA_A	-	-
75	48	-	IRQ2/KR00	P100	AGTIO0	GTETRGA	GTIOC5B	-	RXD0/MISO0/SCL0	SCK1	SCL1_B	MISOA_A	-	-
76	49	-	-	P500	AGTOA0	GTIU	GTIOC11A	-	-	-	-	-	AN016	IVREF0
77	50	-	IRQ11	P501	AGTOB0	GTIV	GTIOC11B	-	-	-	-	-	AN116	IVREF1
78	-	-	IRQ12	P502	-	GTIW	GTIOC12A	-	-	-	-	-	AN017	IVCMP0
79	-	-	-	P503	-	GTETRGC	GTIOC12B	-	-	-	-	-	AN117	-
80	-	-	-	P504	-	GTETRGD	-	-	-	-	-	-	AN018	-
81	-	-	-	P508	-	-	-	-	-	-	-	-	AN020	-
82	51	VCC	-	-	-	-	-	-	-	-	-	-	-	-
83	52	VSS	-	-	-	-	-	-	-	-	-	-	-	-
84	53	-	IRQ13	P015	-	-	-	-	-	-	-	-	AN006/AN106	DA1/IVCMP1
85	54	-	-	P014	-	-	-	-	-	-	-	-	AN005/AN105	DA0/IVREF3
86	55	VREFL	-	-	-	-	-	-	-	-	-	-	-	-
87	56	VREFH	-	-	-	-	-	-	-	-	-	-	-	-
88	57	AVCC0	-	-	-	-	-	-	-	-	-	-	-	-
89	58	AVSS0	-	-	-	-	-	-	-	-	-	-	-	-
90	59	VREFL0	-	-	-	-	-	-	-	-	-	-	-	-
91	60	VREFH0	-	-	-	-	-	-	-	-	-	-	-	-
92	-	-	IRQ12-DS	P008	-	-	-	-	-	-	-	-	AN003	-
93	-	-	-	P007	-	-	-	-	-	-	-	-	PGAVSS100/AN107	-
94	-	-	IRQ11-DS	P006	-	-	-	-	-	-	-	-	AN102	IVCMP2
95	-	-	IRQ10-DS	P005	-	-	-	-	-	-	-	-	AN101	IVCMP2
96	-	-	IRQ9-DS	P004	-	-	-	-	-	-	-	-	AN100	IVCMP2
97	61	-	-	P003	-	-	-	-	-	-	-	-	PGAVSS000/AN007	-
98	62	-	IRQ8-DS	P002	-	-	-	-	-	-	-	-	AN002	IVCMP2
99	63	-	IRQ7-DS	P001	-	-	-	-	-	-	-	-	AN001	IVCMP2
100	64	-	IRQ6-DS	P000	-	-	-	-	-	-	-	-	AN000	IVCMP2

Note: Some pin names have the added suffix of _A and _B. When assigning the GPT, IIC, and SPI functionality, select the functional pins with the same suffix.

针号		电源系统，时钟，调试，CAC	Interrupt	I/O port	Timers			通讯接口					Analog	
LQFP100	LQFP64				AGT	GPT	GPT	CAN	SCI0,2,4,8 (30 MHz)	SCI1,3,9 (30 MHz)	IIC	SPI	ADC12	DAC12, ACMPHS
60	-	-	-	P609	-	-	GTIOC5A	-	-	-	-	-	-	-
61	-	-	-	P610	-	-	GTIOC5B	-	-	-	-	-	-	-
62	38	VCC	-	-	-	-	-	-	-	-	-	-	-	-
63	39	VSS	-	-	-	-	-	-	-	-	-	-	-	-
64	40	VCL	-	-	-	-	-	-	-	-	-	-	-	-
65	-	-	-	P602	-	-	GTIOC7B	-	-	TXD9	-	-	-	-
66	-	-	-	P601	-	-	GTIOC6A	-	-	RXD9	-	-	-	-
67	-	CLKOUT/CAC REF	-	P600	-	-	GTIOC6B	-	-	SCK9	-	-	-	-
68	41	-	KR07	P107	AGTOA0	-	GTIOC8A	-	CTS8_RTS8/SS8	-	-	-	-	-
69	42	-	KR06	P106	AGTOB0	-	GTIOC8B	-	SCK8	-	-	SSLA3_A	-	-
70	43	-	IRQ0/KR05	P105	-	GTETRGA	GTIOC1A	-	TXD8/MOSI8/SDA8	-	-	SSLA2_A	-	-
71	44	-	IRQ1/KR04	P104	-	GTETRGB	GTIOC1B	-	RXD8/MISO8/SCL8	-	-	SSLA1_A	-	-
72	45	-	KR03	P103	-	GTOWUP	GTIOC2A_A	CTX0	CTS0_RTS0/SS0	-	-	SSLA0_A	-	-
73	46	-	KR02	P102	AGTO0	GTOWLO	GTIOC2B_A	CRX0	SCK0	-	-	RSPCKA_A	ADTRG0	-
74	47	-	IRQ1/KR01	P101	AGTEE0	GTETRGB	GTIOC5A	-	TXD0/MOSI0/SDA0	CTS1_RTS1/SS1	SDA1_B	MOSIA_A	-	-
75	48	-	IRQ2/KR00	P100	AGTIO0	GTETRGA	GTIOC5B	-	RXD0/MISO0/SCL0	SCK1	SCL1_B	MISOA_A	-	-
76	49	-	-	P500	AGTOA0	GTIU	GTIOC11A	-	-	-	-	-	AN016	IVREF0
77	50	-	IRQ11	P501	AGTOB0	GTIV	GTIOC11B	-	-	-	-	-	AN116	IVREF1
78	-	-	IRQ12	P502	-	GTIW	GTIOC12A	-	-	-	-	-	AN017	IVCMP0
79	-	-	-	P503	-	GTETRGC	GTIOC12B	-	-	-	-	-	AN117	-
80	-	-	-	P504	-	GTETRGD	-	-	-	-	-	-	AN018	-
81	-	-	-	P508	-	-	-	-	-	-	-	-	AN020	-
82	51	VCC	-	-	-	-	-	-	-	-	-	-	-	-
83	52	VSS	-	-	-	-	-	-	-	-	-	-	-	-
84	53	-	IRQ13	P015	-	-	-	-	-	-	-	-	AN006/AN106	DA1/IVCMP1
85	54	-	-	P014	-	-	-	-	-	-	-	-	AN005/AN105	DA0/IVREF3
86	55	VREFL	-	-	-	-	-	-	-	-	-	-	-	-
87	56	VREFH	-	-	-	-	-	-	-	-	-	-	-	-
88	57	AVCC0	-	-	-	-	-	-	-	-	-	-	-	-
89	58	AVSS0	-	-	-	-	-	-	-	-	-	-	-	-
90	59	VREFL0	-	-	-	-	-	-	-	-	-	-	-	-
91	60	VREFH0	-	-	-	-	-	-	-	-	-	-	-	-
92	-	-	IRQ12-DS	P008	-	-	-	-	-	-	-	-	AN003	-
93	-	-	-	P007	-	-	-	-	-	-	-	-	PGAVSS100/AN107	-
94	-	-	IRQ11-DS	P006	-	-	-	-	-	-	-	-	AN102	IVCMP2
95	-	-	IRQ10-DS	P005	-	-	-	-	-	-	-	-	AN101	IVCMP2
96	-	-	IRQ9-DS	P004	-	-	-	-	-	-	-	-	AN100	IVCMP2
97	61	-	-	P003	-	-	-	-	-	-	-	-	PGAVSS000/AN007	-
98	62	-	IRQ8-DS	P002	-	-	-	-	-	-	-	-	AN002	IVCMP2
99	63	-	IRQ7-DS	P001	-	-	-	-	-	-	-	-	AN001	IVCMP2
100	64	-	IRQ6-DS	P000	-	-	-	-	-	-	-	-	AN000	IVCMP2

Note: 一些引脚名称添加了_A和_B的后缀。分配GPT、IIC和SPI功能时，选择具有相同后缀的功能管脚。

RA生态工作室

2. CPU

The MCU is based on the Arm® Cortex®-M4 core.

2.1 Overview

2.1.1 CPU

- Arm Cortex-M4
  - Revision: r0p1-01rel0
  - Armv7E-M architecture profile
  - Single Precision Floating-Point Unit compliant with the ANSI/IEEE Std 754-2008.
- Memory Protection Unit (MPU)
  - Armv7 Protected Memory System Architecture
  - 8 protected regions.
- SysTick timer
  - Driven by SYSTICCLK (LOCO) or ICLK.

See reference 1. and reference 2. for details.

2.1.2 Debug

- Arm CoreSight™ ETM-M4
  - Revision: r0p1-00rel0
  - Arm ETM architecture version 3.5.
- CoreSight Instrumentation Trace Macrocell (ITM)
- Data Watchpoint and Trace Unit (DWT)
  - 4 comparators for watchpoints and triggers.
- Flash Patch and Breakpoint Unit (FPB)
  - Flash Patch (remap) function is not available, only Breakpoint function is available.
  - 6 instruction comparators
  - 2 literal comparators.
- CoreSight Time Stamp Generator (TSG)
  - Time stamp for ETM and ITM
  - Driven by CPU clock.
- Debug Register Module (DBGREG)
  - Reset control
  - Halt control.
- CoreSight Debug Access Port (DAP)
  - JTAG Debug Port (JTAG-DP)
  - Serial Wire Debug Port (SW-DP).
- Cortex-M4 Trace Port Interface Unit (TPIU)
  - 4-bit TPIU formatter output
  - Serial Wire Output.

2. CPU

MCU基于Arm®Cortex®-M4内核。

2.1 Overview

2.1.1 CPU

- Arm Cortex-M4
  - Revision: r0p1-01rel0
  - Armv7E-M架构简介
  - 符合ANSIIEEEStd754-2008的单精度浮点单元。
- 内存保护单元(MPU)
  - Armv7受保护的内存系统架构
  - 8个保护区。
- SysTick timer
  - 由SYSTICCLK(LOCO)或ICLK驱动。

有关详细信息，请参阅参考1.和参考2.。

2.1.2 Debug

- Arm CoreSight™ ETM-M4
  - Revision: r0p1-00rel0
  - ArmETM架构版本3.5。
- CoreSight仪表跟踪宏单元(ITM)
- 数据观察点和跟踪单元(DWT)
  - 4个用于观察点和触发器的比较器。
- 闪存补丁和断点单元(FPB)
  - FlashPatch（重映射）功能不可用，只有断点功能可用。
  - 6 instruction comparators
  - 2 literal comparators.
- CoreSight时间戳生成器(TSG)
  - ETM和ITM的时间戳
  - 由CPU时钟驱动。
- 调试寄存器模块(DBGREG)
  - 重置控制
  - 停止控制。
- CoreSight调试访问端口(DAP)
  - JTAG调试端口(JTAG-DP)
  - 串行线调试端口(SW-DP)。
- Cortex-M4跟踪端口接口单元(TPIU)
  - 4-bit TPIU formatter output
  - 串行线输出。

- CoreSight Embedded Trace Buffer (ETB)
  - CoreSight Trace Memory Controller with ETB configuration
  - Buffer size: 2 KB.

See reference 1. and reference 2. for details.

2.1.3 Operating Frequency

The operating frequencies for the MCU are as follows:

- CPU: maximum 120 MHz
- 4-bit TPIU trace interface: maximum 60 MHz
- Serial Write Output (SWO) trace interface: maximum 60 MHz
- Joint Test Action Group (JTAG) interface: maximum 25 MHz
- Serial Wire Data (SWD) interface: maximum 25 MHz.

Figure 2.1 shows a block diagram of the Cortex-M4 core.

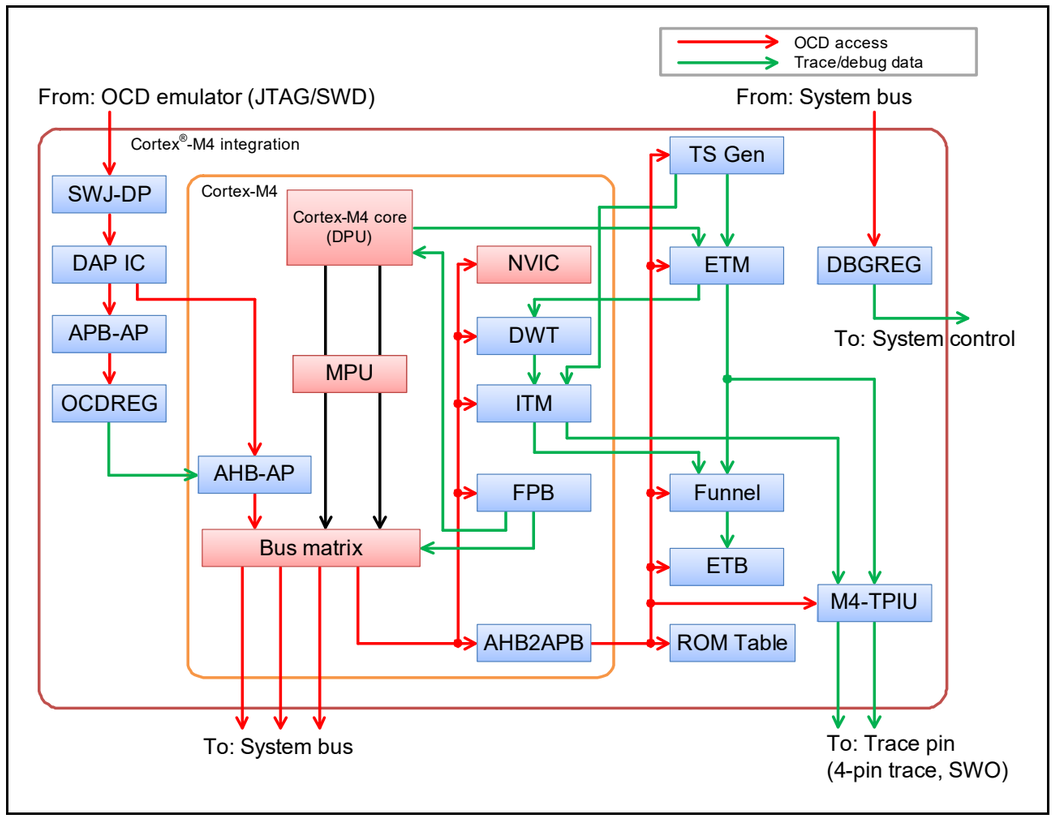

Figure 2.1 Cortex-M4 block diagram

- CoreSight嵌入式跟踪缓冲区(ETB)
  - 具有ETB配置的CoreSight跟踪内存控制器
  - Buffer size: 2 KB.

有关详细信息，请参阅参考1.和参考2.。

2.1.3 工作频率

MCU的工作频率如下：

- CPU: maximum 120 MHz
- 4位TPIU跟踪接口：最大60MHz
- 串行写输出(SWO)跟踪接口：最大60MHz
- 联合测试行动组(JTAG)接口：最大25MHz
- 串行线数据(SWD)接口：最大25MHz。

图2.1显示了Cortex-M4内核的框图。

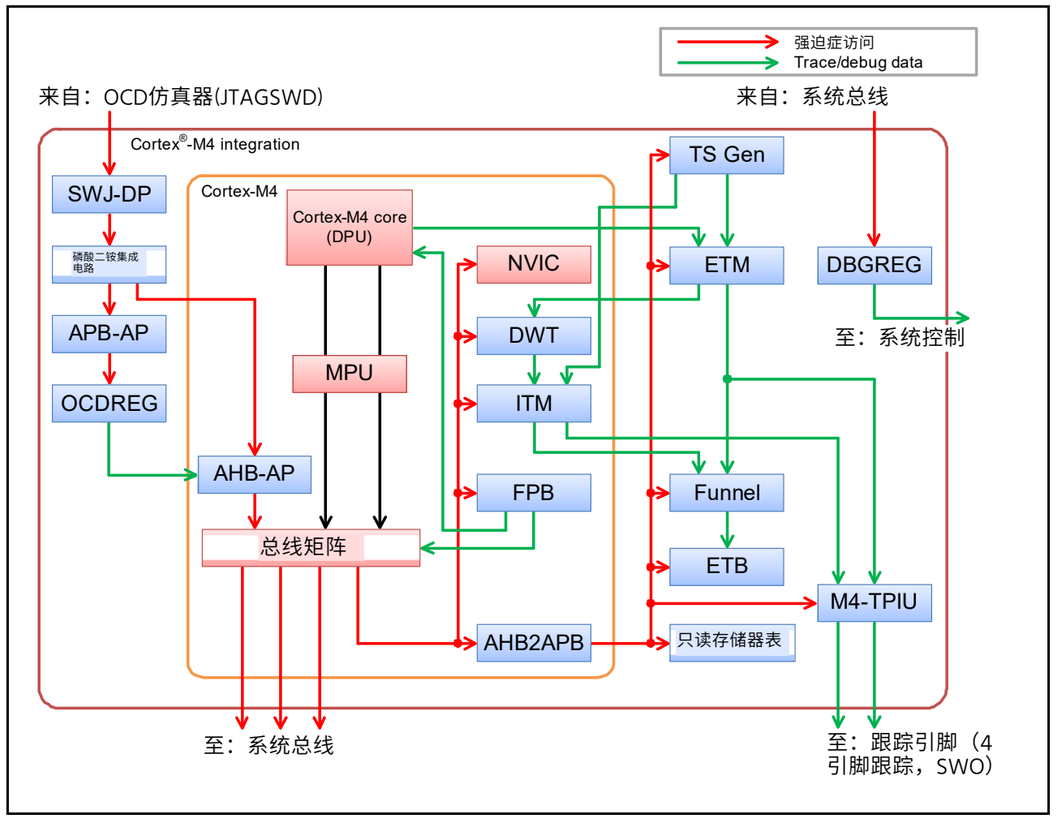

Figure 2.1 Cortex-M4框图

2.2 MCU Implementation Options

Table 2.1 shows the implementation options of the MCU and is based on the configurable options in reference 2.

Table 2.1 Implementation options

Option	Implementation
MPU	Included, 8 protect regions
FPB	Flash Patch (remap) function is not available, only Breakpoint function is available
Breakpoint function	Included
FPU	Included
Number of interrupts	96
Number of priority bits	4
Number of Wakeup Interrupt Controllers (WIC*1)	Not included
Sleep mode power saving	Sleep mode and other low power modes are supported. For more details, see section 11, Low Power Modes. SCB.SCR.SLEEPDEEP is ignored.
Endianness	Little-endian
SysTick SYST_CALIB register	SYST_CALIB = 4000 0147h Bit [31] = 0 Reference clock provided Bit [30] = 1 TERMS value is inexact Bits [29:24] = 00h Reserved Bits [23:0] = 000147h TERM: (32768 × 10 ms) - 1 / 32.768 kHz = 326.66 decimal = 327 with skew = 000147h
Event input/output	Not implemented
System reset request output	The SYSRESETREQ bit in the Application Interrupt and Reset Control Register causes a CPU reset
Auxiliary fault inputs (AUXFAULT)	Not implemented

Note 1. The ICU can wake up the CPU instead of the Wakeup Interrupt Controller (WIC). For details, see section 13, Interrupt Controller Unit (ICU).

2.3 Trace Interface

A Trace Port Interface Unit (TPIU) and Serial Wire Output (SWO) provide trace output. Table 2.2 shows the MCU pins for the function. These pins are multiplexed with other functions.

Table 2.2 Trace function pins

Name	I/O	Width	Function
TCLK	Output	1 bit	Trace clock
TDATA0	Output	1 bit	Trace data output 0
TDATA1	Output	1 bit	Trace data output 1
TDATA2	Output	1 bit	Trace data output 2
TDATA3	Output	1 bit	Trace data output 3
TDO/SWO	Output	1 bit	Serial wire output multiplexed with JTAG TDO pin

2.4 JTAG/SWD Interface

Table 2.3 shows the JTAG/SWD pins.

2.2 MCU实施选项

表2.1显示了MCU的实现选项，基于参考2中的可配置选项。

Table 2.1 实施选项

Option	Implementation
MPU	包括，8个保护区
FPB	FlashPatch（remap）功能不可用，只有Breakpoint功能可用
Breakpoint function	Included
FPU	Included
中断数	96
优先级位数	4
唤醒中断控制器数量(WIC*1)	不包含
睡眠模式省电	支持睡眠模式和其他低功耗模式。有关详细信息，请参阅第11节，低功耗模式。SCB.SCR.SLEEPDEEP被忽略。
Endianness	Little-endian
SysTick SYST_CALIB register	SYST_CALIB = 4000 0147h 位[31]=0提供参考时钟 位[30]=1TERMS值不准确 位[29:24]=00h保留 位[23:0]=000147hTERM：(32768×10ms)132.768kHz=326.66十进制=327，偏斜=000147h
Event input/output	未实现
系统复位请求输出	应用程序中断和复位控制寄存器中的SYSRESETREQ位导致CPU复位
辅助故障输入(AUXFAULT)	未实现

Note 1. ICU可以唤醒CPU而不是唤醒中断控制器(WIC)。有关详细信息，请参阅第13节，中断控制器单元（ICU）。

2.3 跟踪接口

跟踪端口接口单元(TPIU)和串行线输出(SWO)提供跟踪输出。表2.2显示了该功能的MCU引脚。这些引脚与其他功能复用。

Table 2.2 跟踪功能引脚

Name	I/O	Width	Function
TCLK	Output	1 bit	跟踪时钟
TDATA0	Output	1 bit	跟踪数据输出0
TDATA1	Output	1 bit	跟踪数据输出1
TDATA2	Output	1 bit	跟踪数据输出2
TDATA3	Output	1 bit	跟踪数据输出3
TDO/SWO	Output	1 bit	串行线输出与JTAGTDO引脚复用

2.4 JTAG/SWD Interface

表2.3显示了JTAGSWD引脚。

Table 2.3 JTAG/SWD pins

Name	I/O	P/N	Width	Function	When not in use
TCK/SWCLK	Input	Positive	1 bit	JTAG clock pin	Pull-up
TMS/SWDIO	I/O	Negative	1 bit	JTAG TMS pin SWD I/O pin	Pull-up
TDI	Input	Positive	1 bit	JTAG TDI pin	Pull-up
TDO/SWO	Output	Negative	1 bit	JTAG TDO pin multiplexed with serial wire output	Open

2.5 Debug Mode

2.5.1 Debug Mode Definition

In single chip mode, the debugger connection state is defined as On-Chip Debugger (OCD) mode, and the non-connected debugger state is defined as User mode. Table 2.4 shows the CPU debug modes and usage conditions.

Table 2.4 CPU debug mode and conditions

Conditions		Mode	
OCD connect	**JTAG/SWD authentication**	**Debug mode**	**Debug authentication**
Not connected	—	User mode	Disabled
Connected	Failed	User mode	Disabled
Connected	Passed	OCD mode	Enabled

Note 1. OCD connect is determined by the CDBGPWRUPREQ bit output in the SWJ-DP register. The bit can only be written by the OCD. However, the level of the bit can be confirmed by reading the DBGSTR.CDBGPWRUPREQ bit.

Note 2. Debug authentication is defined by the Armv7-M architecture. Enabled means that both invasive and non-invasive CPU debugging are permitted. Disabled means that both are not permitted.

2.5.2 Debug Mode Effects

This section describes the effects of debug mode, which occur both internally and externally to the CPU.

2.5.2.1 Low power mode

All CoreSight debug components can store the register settings even when the CPU enters Software Standby, Snooze, or Deep Software Standby mode. However, AHB-AP cannot respond to On-Chip Debug (OCD) access in these low power modes. The OCD must wait for cancellation of the low power mode to access the CoreSight debug components. To request low power mode cancellation, the OCD can set the DBIRQ bit in the MCUCTRL register. For details, see section 2.6.5.3, MCU Control Register (MCUCTRL).

2.5.2.2 Reset

In OCD mode, some resets depend on the CPU status and the DBGSTOPCR setting.

Table 2.5 Reset or interrupt and mode setting (1 of 2)

	Control in On-Chip Debug (OCD) mode	
Reset or interrupt name	**OCD break mode**	**OCD run mode**
RES pin reset	Same as user mode	
Power-on reset	Same as user mode	
Independent watchdog timer reset/interrupt	Does not occur*1	Depends on DBGSTOPCR setting*2
Watchdog timer reset/interrupt	Does not occur*1	Depends on DBGSTOPCR setting*2
Voltage monitor 0 reset	Depends on DBGSTOPCR setting*3	
Voltage monitor 1 reset/interrupt	Depends on DBGSTOPCR setting*3	
Voltage monitor 2 reset/interrupt	Depends on DBGSTOPCR setting*3	

Table 2.3 JTAG/SWD pins

Name	I/O	P/N	Width	Function	不使用时
TCK/SWCLK	Input	Positive	1 bit	JTAG时钟引脚	Pull-up
TMS/SWDIO	I/O	Negative	1 bit	JTAG TMS pin SWD I/O pin	Pull-up
TDI	Input	Positive	1 bit	JTAG TDI pin	Pull-up
TDO/SWO	Output	Negative	1 bit	JTAGTDO引脚与串行线输出复用	Open

2.5 调试模式

2.5.1 调试模式定义

在单芯片模式下，调试器连接状态定义为片上调试器（OCD）模式，未连接调试器状态定义为用户模式。表2.4显示了CPU调试模式和使用条件。

Table 2.4 CPU调试模式和条件

Conditions		Mode	
强迫症连接	**JTAG/SWD authentication**	**调试模式**	**调试认证**
未连接	—	用户模式	Disabled
Connected	Failed	用户模式	Disabled
Connected	Passed	强迫症模式	Enabled

Note 1. OCD连接由SWJ-DP寄存器中的CDBGPWRUPREQ位输出决定。该位只能由强迫症。但是，可以通过读取DBGSTR.CDBGPWUPREQ位来确认该位的电平。

Note 2. 调试身份验证由Armv7-M架构定义。启用意味着允许侵入式和非侵入式CPU调试。禁用意味着两者都不允许。

2.5.2 调试模式效果

本节描述调试模式的影响，它在CPU内部和外部都发生。

2.5.2.1 低功耗模式

即使CPU进入软件待机、贪睡或深度软件待机模式，所有CoreSight调试组件都可以存储寄存器设置。但是，AHB-AP在这些低功耗模式下无法响应片上调试(OCD)访问。OCD必须等待取消低功耗模式才能访问CoreSight调试组件。要请求取消低功耗模式，OCD可以设置MCUCTRL寄存器中的DBIRQ位。有关详细信息，请参见第2.6.5.3节，MCU控制寄存器（MCUCTRL）。

2.5.2.2 Reset

在OCD模式下，一些复位取决于CPU状态和DBGSTOPCR设置。

Table 2.5 复位或中断和模式设置（1of2）

	片上调试(OCD)模式下的控制	
重置或中断名称	**强迫症休息模式**	**强迫症运行模式**
RES引脚复位	与用户模式相同	
Power-on reset	与用户模式相同	
独立看门狗定时器复位中断	不发生*1	取决于DBGSTOPCR设置*2
看门狗定时器复位中断	不发生*1	取决于DBGSTOPCR设置*2
电压监控器0复位	取决于DBGSTOPCR设置*3	
电压监视器1复位中断	取决于DBGSTOPCR设置*3	
电压监视器2复位中断	取决于DBGSTOPCR设置*3	

Table 2.5 Reset or interrupt and mode setting (2 of 2)

Reset or interrupt name	Control in On-Chip Debug (OCD) mode	
	OCD break mode	OCD run mode
SRAM parity error reset/interrupt	Depends on DBGSTOPCR setting*3	
MPU bus master reset/interrupt	Same as user mode	
MPU bus slave reset/interrupt	Same as user mode	
Stack pointer error reset/interrupt	Same as user mode	
Deep software standby reset	Same as user mode	
Software reset	Same as user mode	

Note: In OCD break mode, the CPU is halted. In OCD run mode, the CPU is in OCD mode and the CPU is not halted.
Note 1. The IWDT and WDT always stop in this mode.
Note 2. The IWDT and WDT operation depends on the DBGSTOPCR setting.
Note 3. Reset or interrupt masking depends on the DBGSTOPCR setting.

2.6 Programmers Model

2.6.1 Address Spaces

The MCU debug system includes two CoreSight Access Ports (AP):

- AHB-AP, which is connected to the CPU bus matrix and has the same access to the system address space as the CPU
- APB-AP, which has a dedicated address space (OCD address space) and is connected to the OCD register.

Figure 2.2 shows a block diagram of the AP connection and address spaces.

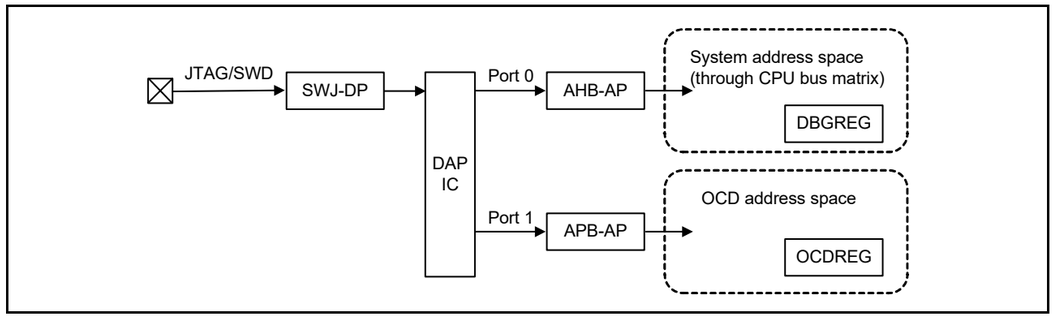

Figure 2.2 JTAG/SWD authentication block diagram

For debugging purposes, there are two register modules, DBGREG and OCDREG. DBGREG is located in the system address space and can be accessed from the OCD emulator, the CPU, and other bus masters in the MCU. OCDREG is located in the OCD address space and can only be accessed from the OCD tool. The CPU and other bus masters cannot access the OCD registers.

2.6.2 Cortex-M4 Peripheral Address Map

In the system address space, the Cortex-M4 core has a Private Peripheral Bus (PPB) that can only be accessed from the CPU and OCD emulator. The PPB is expanded from the Cortex-M4 original implementation for the MCU. Table 2.6 shows the address map of the MCU.

Table 2.6 Cortex-M4 peripheral address map (1 of 2)

Component name	Start address	End address	Note
ITM	E000 0000h	E000 0FFFh	See reference 2.
DWT	E000 1000h	E000 1FFFh	See reference 2.

Table 2.5 复位或中断和模式设置(2of2)

重置或中断名称	片上调试(OCD)模式下的控制	
	强迫症休息模式	强迫症运行模式
SRAM奇偶校验错误复位中断	取决于DBGSTOPCR设置*3	
MPU总线主机复位中断	与用户模式相同	
MPU总线从机复位中断	与用户模式相同	
堆栈指针错误复位中断	与用户模式相同	
深度软件待机复位	与用户模式相同	
软件复位	与用户模式相同	

Note: 在OCD中断模式下，CPU停止。在OCD运行模式下，CPU处于OCD模式并且CPU不会停止。
Note 1. IWDT和WDT始终在此模式下停止。
Note 2. IWDT和WDT操作取决于DBGSTOPCR设置。
Note 3. 复位或中断屏蔽取决于DBGSTOPCR设置。

2.6 程序员模型

2.6.1 地址空间

MCU调试系统包括两个CoreSight访问端口(AP)：

- AHB-AP，与CPU总线矩阵相连，与系统地址空间具有相同的访问权限CPU
- APB-AP，它有一个专用的地址空间（OCD地址空间），并与OCD寄存器相连。

图2.2显示了AP连接和地址空间的框图。

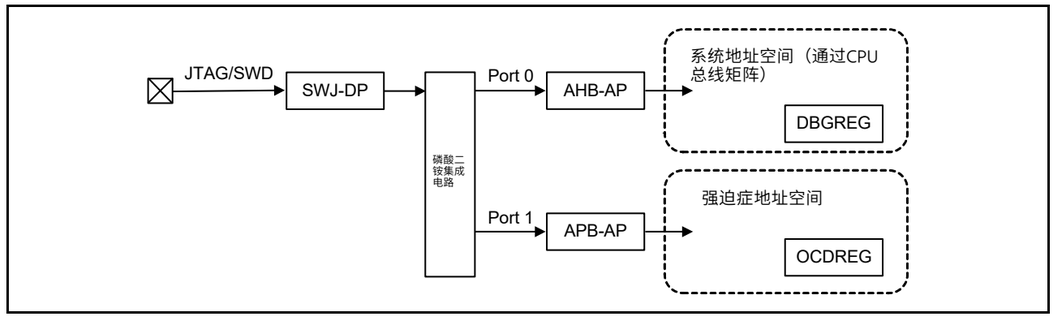

Figure 2.2 JTAGSWD认证框图

出于调试目的，有两个寄存器模块，DBGREG和OCDREG。DBGREG位于系统地址空间中，可以从OCD仿真器、CPU和MCU中的其他总线主控器访问。OCDREG位于OCD地址空间，只能从OCD工具访问。CPU和其他总线主机无法访问OCD寄存器。

2.6.2 Cortex-M4外设地址映射

在系统地址空间中，Cortex-M4内核有一个私有外设总线(PPB)，只能从CPU和强迫症模拟器。PPB从MCU的Cortex-M4原始实现扩展而来。表2.6显示了MCU的地址映射。

Table 2.6 Cortex-M4外设地址映射（1of2）

组件名称	起始地址	结束地址	Note
ITM	E000 0000h	E000 0FFFh	参见参考文献2。
DWT	E000 1000h	E000 1FFFh	参见参考文献2。

Table 2.6 Cortex-M4 peripheral address map (2 of 2)

Component name	Start address	End address	Note
FPB	E000 2000h	E000 2FFFh	See reference 2.
SCS	E000 E000h	E000 EFFFh	See reference 2.
TPIU	E004 0000h	E004 0FFFh	See reference 2.
ETM	E004 1000h	E004 1FFFh	See reference 5.
ATB funnel	E004 2000h	E004 2FFFh	See section 2.7 and reference 4.
ETB	E004 3000h	E004 3FFFh	See reference 6.
Time Stamp Generator	E004 4000h	E004 4FFFh	See section 2.10 and reference 4.
ROM Table	E00F F000h	E00F FFFFh	See section 2.6.3 and reference 7.

2.6.3 CoreSight ROM Table

The MCU contains one CoreSight ROM Table, which lists the Arm components.

2.6.3.1 ROM entries

Table 2.7 shows the ROM entries in the CoreSight ROM Table. The OCD emulator can use the ROM entries to determine which components are implemented in a system. See reference 7. for details.

Table 2.7 CoreSight ROM Table

#	Address	Access size	R/W	Value	Component
0	E00F F000h	32 bits	R	FFF0 F003h	NVIC
1	E00F F004h	32 bits	R	FFF0 2003h	SWT
2	E00F F008h	32 bits	R	FFF0 3003h	FPB
3	E00F F00Ch	32 bits	R	FFF0 1003h	ITM
4	E00F F010h	32 bits	R	FFF4 1003h	TPIU
5	E00F F014h	32 bits	R	FFF4 2003h	ETM
6	E00F F018h	32 bits	R	FFF4 3003h	Funnel
7	E00F F01Ch	32 bits	R	FFF4 4003h	ETB
8	E00F F020h	32 bits	R	FFF4 5003h	TSG
9	E00F F024h	32 bits	R	0000 0000h	End of entries

2.6.3.2 CoreSight component registers

The CoreSight ROM Table lists the CoreSight component registers defined in the Arm CoreSight architecture.

Table 2.8 shows the registers. See reference 7. for details of each register.

Table 2.8 CoreSight component registers in the CoreSight ROM Table (1 of 2)

Name	Address	Access size	R/W	Initial value
DEVTYPE	E00F FFCCh	32 bits	R	0000 0001h
PID4	E00F FFD0h	32 bits	R	0000 0004h
PID5	E00F FFD4h	32 bits	R	0000 0000h
PID6	E00F FFD8h	32 bits	R	0000 0000h
PID7	E00F FFDCh	32 bits	R	0000 0000h
PID0	E00F FFE0h	32 bits	R	0000 0027h
PID1	E00F FFE4h	32 bits	R	0000 0030h
PID2	E00F FFE8h	32 bits	R	0000 000Ah

Table 2.6 Cortex-M4外设地址映射（2个中的2个）

组件名称	起始地址	结束地址	Note
FPB	E000 2000h	E000 2FFFh	参见参考文献2。
SCS	E000 E000h	E000 EFFFh	参见参考文献2。
TPIU	E004 0000h	E004 0FFFh	参见参考文献2。
ETM	E004 1000h	E004 1FFFh	参见参考文献5。
ATB funnel	E004 2000h	E004 2FFFh	参见第2.7节和参考4。
ETB	E004 3000h	E004 3FFFh	参见参考文献6。
时间戳生成器	E004 4000h	E004 4FFFh	请参阅第2.10节和参考4。
只读存储器表	E00F F000h	E00F FFFFh	参见第2.6.3节和参考7。

2.6.3 CoreSightROM表

MCU包含一个CoreSightROM表，其中列出了Arm组件。

2.6.3.1 ROM条目

表2.7显示了CoreSightROM表中的ROM条目。OCD仿真器可以使用ROM条目来确定系统中实现了哪些组件。有关详细信息，请参见参考资料7。

Table 2.7 CoreSightROM表

#	Address	访问大小	R/W	Value	Component
0	E00F F000h	32 bits	R	FFF0 F003h	NVIC
1	E00F F004h	32 bits	R	FFF0 2003h	SWT
2	E00F F008h	32 bits	R	FFF0 3003h	FPB
3	E00F F00Ch	32 bits	R	FFF0 1003h	ITM
4	E00F F010h	32 bits	R	FFF4 1003h	TPIU
5	E00F F014h	32 bits	R	FFF4 2003h	ETM
6	E00F F018h	32 bits	R	FFF4 3003h	Funnel
7	E00F F01Ch	32 bits	R	FFF4 4003h	ETB
8	E00F F020h	32 bits	R	FFF4 5003h	TSG
9	E00F F024h	32 bits	R	0000 0000h	条目结束

2.6.3.2 CoreSight组件寄存器

CoreSightROM表列出了ArmCoreSight架构中定义的CoreSight组件寄存器。

表2.8显示了寄存器。有关每个寄存器的详细信息，请参见参考资料7。

Table 2.8 CoreSightROM表中的CoreSight组件寄存器(1of2)

Name	Address	访问大小	R/W	初始值
DEVTYPE	E00F FFCCh	32 bits	R	0000 0001h
PID4	E00F FFD0h	32 bits	R	0000 0004h
PID5	E00F FFD4h	32 bits	R	0000 0000h
PID6	E00F FFD8h	32 bits	R	0000 0000h
PID7	E00F FFDCh	32 bits	R	0000 0000h
PID0	E00F FFE0h	32 bits	R	0000 0027h
PID1	E00F FFE4h	32 bits	R	0000 0030h
PID2	E00F FFE8h	32 bits	R	0000 000Ah

Table 2.8 CoreSight component registers in the CoreSight ROM Table (2 of 2)

Name	Address	Access size	R/W	Initial value
PID3	E00F FFECh	32 bits	R	0000 0000h
CID0	E00F FFF0h	32 bits	R	0000 000Dh
CID1	E00F FFF4h	32 bits	R	0000 0010h
CID2	E00F FFF8h	32 bits	R	0000 0005h
CID3	E00F FFFCh	32 bits	R	0000 00B1h

2.6.4 DBGREG Module

The DBGREG module controls the debug functionalities and is implemented as a CoreSight-compliant component.

Table 2.9 shows the DBGREG registers other than the CoreSight component registers.

Table 2.9 Non-CoreSight DBGREG registers

Name		DAP port	Address	Access size	R/W
Debug Status Register	DBGSTR	Port 0	4001 B000h	32 bits	R
Debug Stop Control Register	DBGSTOPCR	Port 0	4001 B010h	32 bits	R/W
Trace Control Register	TRACECTR	Port 0	4001 B020h	32 bits	R/W

2.6.4.1 Debug Status Register (DBGSTR)

Address(es): DBG.DBGSTR 4001 B000h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	CDBGPWRUPACK	CDBGPWRUPREQ	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b27 to b0	—	Reserved	These bits are read as 0	R
b28	CDBGPWRUPREQ	Debug power-up request	0: OCD is not requesting debug power-up 1: OCD is requesting debug power-up.	R
b29	CDBGPWRUPACK	Debug power-up acknowledge	0: Debug power-up request is not acknowledged 1: Debug power-up request is acknowledged.	R
b31, b30	—	Reserved	These bits are read as 0	R

Table 2.8 CoreSightROM表中的CoreSight组件寄存器(2of2)

Name	Address	访问大小	R/W	初始值
PID3	E00F FFECh	32 bits	R	0000 0000h
CID0	E00F FFF0h	32 bits	R	0000 000Dh
CID1	E00F FFF4h	32 bits	R	0000 0010h
CID2	E00F FFF8h	32 bits	R	0000 0005h
CID3	E00F FFFCh	32 bits	R	0000 00B1h

2.6.4 DBGREG Module

DBGREG模块控制调试功能并被实现为符合CoreSight的组件。

表2.9显示了除CoreSight组件寄存器之外的DBGREG寄存器。

Table 2.9 Non-CoreSight DBGREG registers

Name		端口	Address	访问大小	R/W
调试状态寄存器	DBGSTR	Port 0	4001 B000h	32 bits	R
调试停止控制寄存器	DBGSTOPCR	Port 0	4001 B010h	32 bits	R/W
跟踪控制寄存器	TRACECTR	Port 0	4001 B020h	32 bits	R/W

2.6.4.1 调试状态寄存器(DBGSTR)

Address(es): DBG.DBGSTR 4001 B000h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	CDBGPWRUPACK	CDBGPWRUPREQ	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b27 to b0	—	Reserved	这些位被读为0	R
b28	CDBGPWRUPREQ	调试上电请求	0：OCD不请求调试上电1：OCD请求调试上电。	R
b29	CDBGPWRUPACK	调试上电确认	0：未确认调试上电请求1：确认调试上电请求。	R
b31, b30	—	Reserved	这些位被读为0	R

2.6.4.2 Debug Stop Control Register (DBGSTOPCR)

Address(es): DBG.DBGSTOPCR 4001 B010h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	DBGSTOP_RPER	—	—	—	—	—	DBGSTOP_LVD[2:0]		
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	DBGSTOP_WDT	DBGSTOP_IWDT
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Bit	Symbol	Bit name	Description	R/W
b0	DBGSTOP_IWDT	Mask bit for IWDT reset/interrupt	0: Enable IWDT reset/interrupt 1: Mask IWDT reset/interrupt and stop WDT count when CPU is in OCD break mode.	R/W
b1	DBGSTOP_WDT	Mask bit for WDT reset/interrupt	0: Enable WDT reset/interrupt 1: Mask WDT reset/interrupt and stop WDT count when CPU is in OCD break mode.	R/W
b15 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b16	DBGSTOP_LVD[2:0]	Mask bit for LVD0 reset	0: Enable LVD0 reset 1: Mask LVD0 reset.	R/W
b17		Mask bit for LVD1 reset/interrupt	0: Enable LVD1 reset/interrupt 1: Mask LVD1 reset/interrupt.	R/W
b18		Mask bit for LVD2 reset/interrupt	0: Enable LVD2 reset/interrupt 1: Mask LVD2 reset/interrupt.	R/W
b23 to b19	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b24	DBGSTOP_RPER	Mask bit for SRAM parity error reset/interrupt	0: Enable SRAM parity error reset/interrupt 1: Mask SRAM parity error reset/interrupt.	R/W
b31 to b25	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The Debug Stop Control Register (DBGSTOPCR) specifies the functional stop in OCD mode. All bits in the register are regarded as 0 when the MCU is not in OCD mode.

2.6.4.3 Trace Control Register (TRACECTR)

Address(es): DBG.TRACECTR 4001 B020h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	ENETBFULL	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b30 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b31	ENETBFULL	Enable bit for halt request on ETB full	0: ETB full does not cause a CPU halt 1: ETB full causes a CPU halt.	R/W

2.6.4.2 调试停止控制寄存器(DBGSTOPCR)

Address(es): DBG.DBGSTOPCR 4001 B010h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	DBGSTOP_RPER	—	—	—	—	—	DBGSTOP_LVD[2:0]		
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	DBGSTOP_WDT	DBGSTOP_IWDT
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Bit	Symbol	位名称	Description	R/W
b0	DBGSTOP_IWDT	IWDT复位中断屏蔽位	0：使能IWDT复位中断1：当CPU处于OCD中断模式时，屏蔽IWDT复位中断并停止WDT计数。	R/W
b1	DBGSTOP_WDT	WDT复位中断屏蔽位	0：使能WDT复位中断1：当CPU处于OCD中断模式时，屏蔽WDT复位中断并停止WDT计数。	R/W
b15 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b16	DBGSTOP_LVD[2:0]	LVD0复位屏蔽位	0：使能LVD0复位1 ：屏蔽LVD0复位。	R/W
b17		LVD1复位中断的屏蔽位	0：使能LVD1复位中断1：屏蔽LVD1复位中断。	R/W
b18		LVD2复位中断的屏蔽位	0：使能LVD2复位中断1：屏蔽LVD2复位中断。	R/W
b23 to b19	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b24	DBGSTOP_RPER	SRAM奇偶校验错误复位中断的屏蔽位	0：使能SRAM奇偶校验错误复位中断1：屏蔽SRAM奇偶校验错误复位中断。	R/W
b31 to b25	—	Reserved	这些位被读取为0。写入值应为0。	R/W

调试停止控制寄存器(DBGSTOPCR)指定OCD模式下的功能停止。当MCU不处于OCD模式时，寄存器中的所有位都被视为0。

2.6.4.3 跟踪控制寄存器(TRACECTR)

Address(es): DBG.TRACECTR 4001 B020h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	ENETBFULL	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b30 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b31	ENETBFULL	启用停止请求的位ETB full	0：ETB满不导致CPU停止1：ETB满导致CPU停止。	R/W

2.6.4.4 DBGREG CoreSight component registers

The DBGREG module provides the CoreSight component registers defined in the Arm CoreSight architecture.

Table 2.10 shows these registers. See reference 7. for details of each register.

Table 2.10 DBGREG CoreSight component registers

Name	Address	Access size	R/W	Initial value
PID4	4001 BFD0h	32 bits	R	0000 0004h
PID5	4001 BFD4h	32 bits	R	0000 0000h
PID6	4001 BFD8h	32 bits	R	0000 0000h
PID7	4001 BFDCh	32 bits	R	0000 0000h
PID0	4001 BFE0h	32 bits	R	0000 0005h
PID1	4001 BFE4h	32 bits	R	0000 0030h
PID2	4001 BFE8h	32 bits	R	0000 001Ah
PID3	4001 BFECh	32 bits	R	0000 0000h
CID0	4001 BFF0h	32 bits	R	0000 000Dh
CID1	4001 BFF4h	32 bits	R	0000 00F0h
CID2	4001 BFF8h	32 bits	R	0000 0005h
CID3	4001 BFFCh	32 bits	R	0000 00B1h

2.6.5 OCDREG Module

The OCDREG register module controls the On-Chip Debug (OCD) emulator functionalities and is implemented as a CoreSight-compliant component.

Table 2.11 shows the OCDREG registers other than the CoreSight component registers.

Table 2.11 Non-CoreSight OCDREG registers

Name		DAP port	Address	Access size	R/W
ID Authentication Code Register 0	IAUTH0	Port 1	8000 0000h	32 bits	W
ID Authentication Code Register 1	IAUTH1	Port 1	8000 0100h	32 bits	W
ID Authentication Code Register 2	IAUTH2	Port 1	8000 0200h	32 bits	W
ID Authentication Code Register 3	IAUTH3	Port 1	8000 0300h	32 bits	W
MCU Status Register	MCUSTAT	Port 1	8000 0400h	32 bits	R
MCU Control Register	MCUCTRL	Port 1	8000 0410h	32 bits	R/W

Note: OCDREG is located in the dedicated OCD address space. This address map is independent from the system address map. See section 2.6.2, Cortex-M4 Peripheral Address Map.

2.6.5.1 ID Authentication Code Register (IAUTH0 to 3)

Four authentication registers are provided for writing the 128-bit key. These registers must be written in sequential order from IAUTH0 to IAUTH3. If the set of register writes is not compliant with this order, the result is unpredictable.

Only 32-bit writes are permitted. The initial value of the registers is all 1s. This means that JTAG/SWD access is initially permitted when the ID code in the OSIS register has the initial value. See section 2.11.2, Unlock ID Code.

2.6.4.4 DBGREGCoreSight组件寄存器

DBGREG模块提供在ArmCoreSight架构中定义的CoreSight组件寄存器。

表2.10显示了这些寄存器。有关每个寄存器的详细信息，请参见参考资料7。

Table 2.10 DBGREGCoreSight组件寄存器

Name	Address	访问大小	R/W	初始值
PID4	4001 BFD0h	32 bits	R	0000 0004h
PID5	4001 BFD4h	32 bits	R	0000 0000h
PID6	4001 BFD8h	32 bits	R	0000 0000h
PID7	4001 BFDCh	32 bits	R	0000 0000h
PID0	4001 BFE0h	32 bits	R	0000 0005h
PID1	4001 BFE4h	32 bits	R	0000 0030h
PID2	4001 BFE8h	32 bits	R	0000 001Ah
PID3	4001 BFECh	32 bits	R	0000 0000h
CID0	4001 BFF0h	32 bits	R	0000 000Dh
CID1	4001 BFF4h	32 bits	R	0000 00F0h
CID2	4001 BFF8h	32 bits	R	0000 0005h
CID3	4001 BFFCh	32 bits	R	0000 00B1h

2.6.5 OCDREG Module

OCDREG寄存器模块控制片上调试(OCD)仿真器功能，并实现为CoreSight-compliant component.

表2.11显示了除CoreSight组件寄存器之外的OCDREG寄存器。

Table 2.11 Non-CoreSight OCDREG registers

Name		端口	Address	访问大小	R/W
ID验证码寄存器0	IAUTH0	Port 1	8000 0000h	32 bits	W
ID验证码寄存器1	IAUTH1	Port 1	8000 0100h	32 bits	W
ID验证码寄存器2	IAUTH2	Port 1	8000 0200h	32 bits	W
ID验证码寄存器3	IAUTH3	Port 1	8000 0300h	32 bits	W
MCU状态寄存器	MCUSTAT	Port 1	8000 0400h	32 bits	R
MCU控制寄存器	MCUCTRL	Port 1	8000 0410h	32 bits	R/W

Note: OCDREG位于专用的OCD地址空间中。该地址映射独立于系统地址映射。
请参阅第2.6.2节，Cortex-M4外设地址映射。

2.6.5.1 ID验证码寄存器（IAUTH0至3）

提供了四个认证寄存器用于写入128位密钥。这些寄存器必须按IAUTH0到IAUTH3的顺序写入。如果寄存器写入的集合不符合此顺序，则结果是不可预测的。

只允许32位写入。寄存器的初始值全为1。这意味着当OSIS寄存器中的ID代码具有初始值时，最初允许JTAGSWD访问。请参阅第2.11.2节，解锁ID代码。

Address(es): IAUTH0 8000 0000h

b31																													b0
IAUTH0: AID 31-0 bits																													
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Address(es): IAUTH1 8000 0100h

b31																													b0
IAUTH1: AID 63-32 bits																													
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Address(es): IAUTH2 8000 0200h

b31																													b0
IAUTH2: AID 95-64 bits																													
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Address(es): IAUTH3 8000 0300h

b31																													b0
IAUTH3: AID 127-96 bits																													
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

2.6.5.2 MCU Status Register (MCUSTAT)

Address(es): MCUSTAT 8000 0400h

b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
—	—	—	—	—	—	—	—	—	—	—	—	—	CPUSTOPCLK	CPUSLEEP	AUTH
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	1/0*1	1/0*1	0

Bit	Symbol	Bit name	Description	R/W
b0	AUTH	Authentication status	0: Authentication failed 1: Authentication succeeded.	R
b1	CPUSLEEP		0: CPU is not in Sleep mode 1: CPU is in Sleep mode.	R
b2	CPUSTOPCLK		0: CPU clock is not stopped. This indicates that the MCU is in Normal or Sleep mode 1: CPU clock is stopped. This indicates that the MCU is in Snooze or Software Standby mode.	R
b31 to b3	—	Reserved	These bits are read as 0.	R

Note 1. Depends on the MCU status.

Address(es): IAUTH0 8000 0000h

b31																													b0
IAUTH0：AID31-0位																													
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Address(es): IAUTH1 8000 0100h

b31																													b0
IAUTH1：AID63-32位																													
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Address(es): IAUTH2 8000 0200h

b31																													b0
IAUTH2：AID95-64位																													
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Address(es): IAUTH3 8000 0300h

b31																													b0
IAUTH3：AID127-96位																													
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

2.6.5.2 MCU状态寄存器(MCUSTAT)

Address(es): MCUSTAT 8000 0400h

b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
—	—	—	—	—	—	—	—	—	—	—	—	—	CPUSTOPCLK	CPUSLEEP	AUTH
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	1/0*1	1/0*1	0

Bit	Symbol	位名称	Description	R/W
b0	AUTH	认证状态	0：认证失败1：认证成功。	R
b1	CPUSLEEP		0：CPU不处于休眠模式1： CPU处于休眠模式。	R
b2	CPUSTOPCLK		0：CPU时钟不停止。这表明MCU处于正常或睡眠模式1：CPU时钟停止。这表明MCU处于贪睡或软件待机模式。	R
b31 to b3	—	Reserved	这些位读为0。	R

Note 1. 取决于MCU状态。

2.6.5.3 MCU Control Register (MCUCTRL)

Address(es): MCUCTRL 8000 0410h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DBIRQ	—	—	—	—	—	—	—	EDBGRQ
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	EDBGRQ	External Debug Request	Writing 1 to the bit causes a CPU halt or debug monitor exception: 0: Debug event not requested 1: Debug event requested. When the EDBGRQ bit is set to 0 or the CPU is halted, the EDBCRQ bit is cleared.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b8	DBIRQ	Debug Interrupt Request	Writing 1 to the bit wakes up the MCU from low power mode: 0: Debug interrupt not requested 1: Debug interrupt requested. The condition can be cleared by writing 0 to the DBIRQ bit.	R/W
b31 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: Set DBIRQ and EDBGRQ to the same value.

2.6.5.4 OCDREG CoreSight component registers

The OCDREG module provides the CoreSight component registers defined in the Arm CoreSight architecture.

Table 2.12 shows these registers. See reference 7. for details of each register.

Table 2.12 OCDREG CoreSight component registers

Name	Address	Access size	R/W	Initial value
PID4	8000 0FD0h	32 bits	R	0000 0004h
PID5	8000 0FD4h	32 bits	R	0000 0000h
PID6	8000 0FD8h	32 bits	R	0000 0000h
PID7	8000 0FDCh	32 bits	R	0000 0000h
PID0	8000 0FE0h	32 bits	R	0000 0004h
PID1	8000 0FE4h	32 bits	R	0000 0030h
PID2	8000 0FE8h	32 bits	R	0000 000Ah
PID3	8000 0FECh	32 bits	R	0000 0000h
CID0	8000 0FF0h	32 bits	R	0000 000Dh
CID1	8000 0FF4h	32 bits	R	0000 00F0h
CID2	8000 0FF8h	32 bits	R	0000 0005h
CID3	8000 0FFCh	32 bits	R	0000 00B1h

2.7 CoreSight ATB Funnel

There is one CoreSight ATB funnel in the MCU. The funnel has two ATB slaves and one ATB master, and it selects the debug trace source from ETM and ITM to ETB. Figure 2.3 shows the CoreSight ATB connection in the MCU.

2.6.5.3 MCU控制寄存器(MCUCTRL)

Address(es): MCUCTRL 8000 0410h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DBIRQ	—	—	—	—	—	—	—	EDBGRQ
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	EDBGRQ	外部调试 Request	向该位写入1会导致CPU停止或调试监视器异常：0：未请求调试事件1：已请求调试事件。当EDBGRQ位设置为0或CPU停止时， EDBCRQ位清零。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b8	DBIRQ	调试中断 Request	向该位写入1将MCU从低功耗模式唤醒：0：未请求调试中断1：请求调试中断。可以通过将0写入DBIRQ位来清除该条件。	R/W
b31 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 将DBIRQ和EDBGRQ设置为相同的值。

2.6.5.4 OCDREGCoreSight组件寄存器

OCDREG模块提供在ArmCoreSight架构中定义的CoreSight组件寄存器。

表2.12显示了这些寄存器。有关每个寄存器的详细信息，请参见参考资料7。

Table 2.12 OCDREGCoreSight组件寄存器

Name	Address	访问大小	R/W	初始值
PID4	8000 0FD0h	32 bits	R	0000 0004h
PID5	8000 0FD4h	32 bits	R	0000 0000h
PID6	8000 0FD8h	32 bits	R	0000 0000h
PID7	8000 0FDCh	32 bits	R	0000 0000h
PID0	8000 0FE0h	32 bits	R	0000 0004h
PID1	8000 0FE4h	32 bits	R	0000 0030h
PID2	8000 0FE8h	32 bits	R	0000 000Ah
PID3	8000 0FECh	32 bits	R	0000 0000h
CID0	8000 0FF0h	32 bits	R	0000 000Dh
CID1	8000 0FF4h	32 bits	R	0000 00F0h
CID2	8000 0FF8h	32 bits	R	0000 0005h
CID3	8000 0FFCh	32 bits	R	0000 00B1h

2.7 CoreSight ATB Funnel

MCU中有一个CoreSightATB漏斗。漏斗有两个ATB从站和一个ATB主站，它选择从ETM和ITM到ETB的调试跟踪源。图2.3显示了MCU中的CoreSightATB连接。

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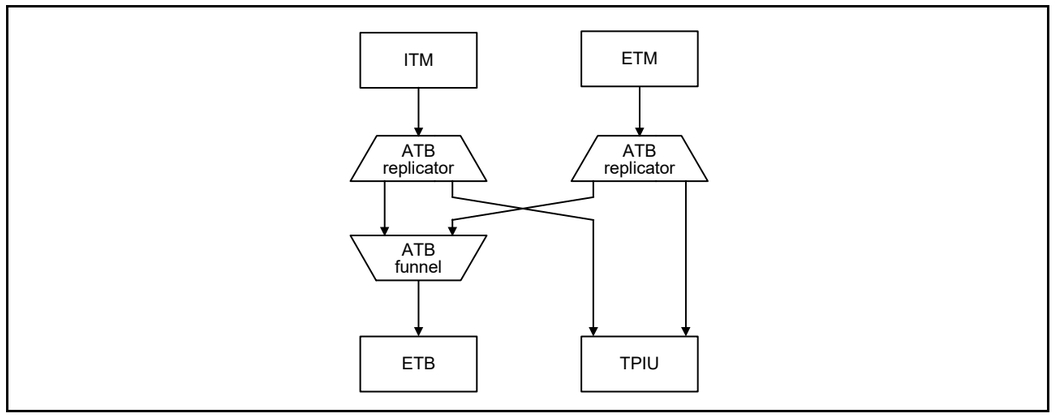


Figure 2.3 CoreSight ATB connection

Table 2.13 shows the ATB slave connection for the funnel.

Table 2.13 ATB slave connection

ATB slave number	Connected trace source
#0	ITM
#1	ETM

For details of the ATB and funnel, see reference 4.

2.8 Flash Patch and Break Unit

The MCU has a flash patch and break unit. Breakpoint function is available, but flash patch (remap) function is not available. Therefore, do not set the REPLACE bits [31:30] in the FP_COMPn register to 0. Bit [28] of FP_REMAP register is always set to 1. When writing to this register, write 1 to bit [28]. When reading this register, bit [28] is always read as 1. See reference 1.*2.9 for details.

2.9 SysTick System Timer

The SysTick system timer provides a simple 24-bit down counter. The reference clock for the timer can be selected as the CPU clock (ICLK) or SysTick Timer clock (SYSTICCLK). See section 9, Clock Generation Circuit and reference 1.*1 for details.

Note 1. In the reference, the IMPLEMENTATION DEFINED external reference clock is SYSTICCLK (LOCO) and the processor clock is ICLK.

2.10 CoreSight Time Stamp Generator

A CoreSight Time Stamp Generator provides a CPU clock-based timestamp to ITM and ETM. The 48 LSB bits of the 64-bit counter are used for the two components. See reference 4. for details.

2.11 OCD Emulator Connection

A JTAG/SWD authentication mechanism checks access permission for debug and MCU resources. To obtain full debug functionality, a pass result of the authentication mechanism is required.

Figure 2.4 shows a block diagram of the authentication mechanism.

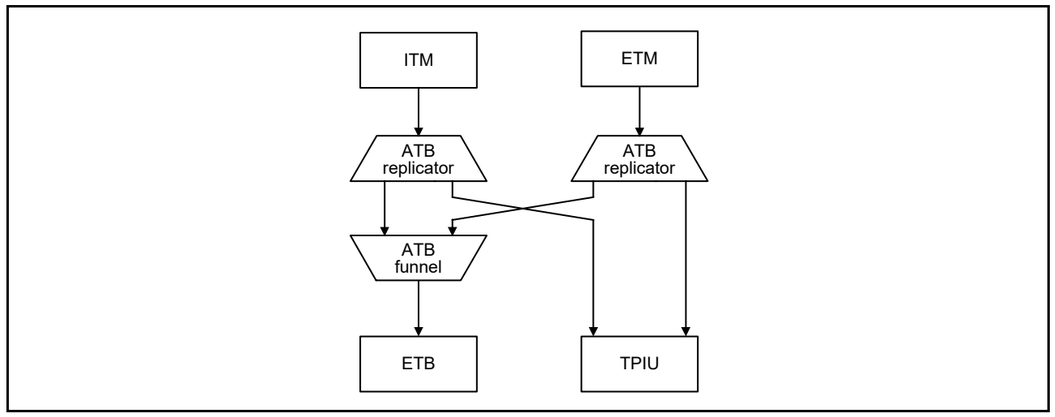


Figure 2.3 CoreSight ATB connection

表2.13显示了漏斗的ATB从属连接。

Table 2.13 ATB从机连接

ATB从机号	连接的跟踪源
#0	ITM
#1	ETM

有关ATB和漏斗的详细信息，请参阅参考4。

2.8 闪存补丁和中断单元

MCU有一个闪存补丁和中断单元。断点功能可用，但闪存补丁（重映射）功能不可用。因此，不要将FP_COMPn寄存器中的REPLACE位[31:30]设置为0。FP_REMAP寄存器的位[28]始终设置为1。写入该寄存器时，将1写入位[28]。读取此寄存器时，位[28]始终读取为1。请参阅参考1。*2.9了解详细信息。

2.9 SysTick系统定时器

SysTick系统定时器提供了一个简单的24位递减计数器。定时器的参考时钟可以选择为CPU时钟(ICLK)或SysTick定时器时钟(SYSTICCLK)。请参阅第9节，时钟生成电路和参考1。*1了解详细信息。

注1.在参考中，实现定义的外部参考时钟是SYSTICCLK(LOCO)，处理器时钟是ICLK。

2.10 CoreSight时间戳生成器

CoreSight时间戳生成器为ITM和ETM提供基于CPU时钟的时间戳。64位计数器的48个LSB位用于这两个组件。详见参考文献4。

2.11 OCD模拟器连接

JTAGSWD验证机制检查调试和MCU资源的访问权限。要获得完整的调试功能，需要验证机制的通过结果。

图2.4显示了认证机制的框图。

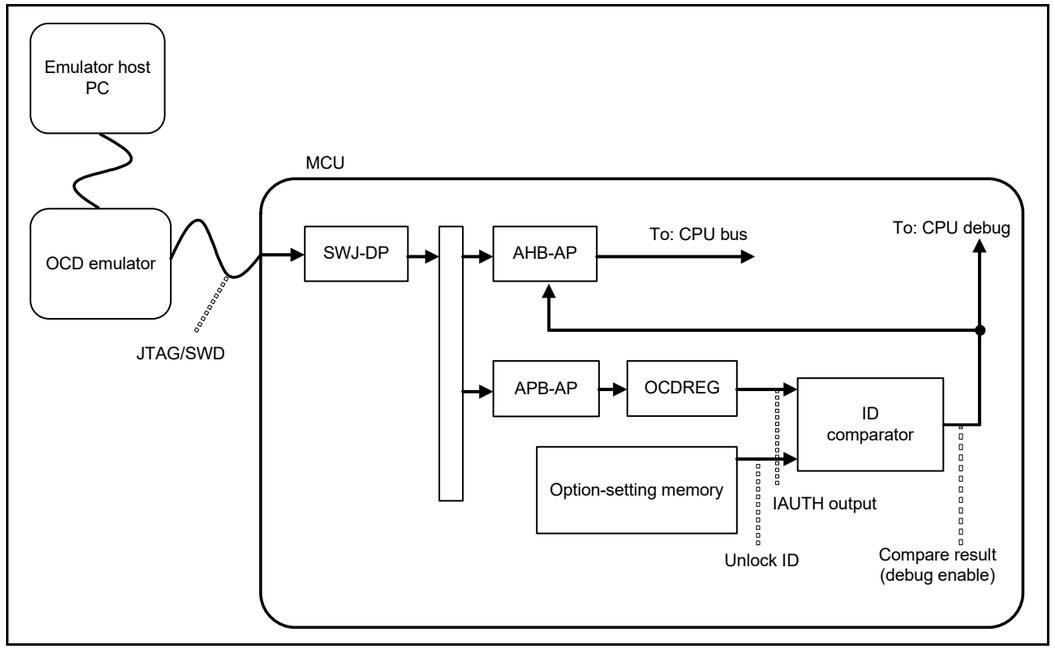


Figure 2.4 Authentication mechanism block diagram

An ID comparator is available in the MCU for authentication. The comparator compares the 128-bit IAUTH output from OCDREG and the 128-bit unlock ID code from the option-setting memory. When the two outputs are identical, the CPU debug functions and system bus access from the OCD emulator are permitted.

2.11.1 DBGEN

After the OCD emulator gets access permission, the OCD emulator must set the DBGEN bit in the System Control OCD Control Register (SYOCDCR). In addition, the OCD emulator must clear the DBGEN bit before disconnecting it. See section 11, Low Power Modes for details.

2.11.2 Unlock ID Code

The unlock ID code is used for checking permissions for debug and access to on-chip resources. If the unlock ID code matches the 128-bit data written in ID Authentication Registers 0 to 3, the JTAG/SWD debugger obtains access permission. Unlock ID code is written in the OCD/Serial Programmer ID Setting Register (OSIS) in the option-setting memory. The initial value of the unlock ID code is all 1s (FFFFFFFF_FFFFFFFF_FFFFFFFFh). See section 7, Option-Setting Memory for details.

2.11.3 Restrictions on Connecting an OCD Emulator

This section describes the restrictions on emulator access.

2.11.3.1 Starting connection while in low power mode

When starting a JTAG/SWD connection from an OCD emulator, the MCU must be in Normal or Sleep mode. If the MCU is in Software Standby, Snooze, or Deep Software Standby mode, the OCD emulator can cause the MCU to hang.

2.11.3.2 Changing low power mode while in OCD mode

When the MCU is in OCD mode, the low power mode can be changed. However, system bus access from AHB-AP is prohibited in Software Standby, Snooze, or Deep Software Standby mode. Only SWJ-DP, APB-AP, and OCDREG can be accessed from the OCD emulator in these modes. Table 2.14 shows the restrictions.

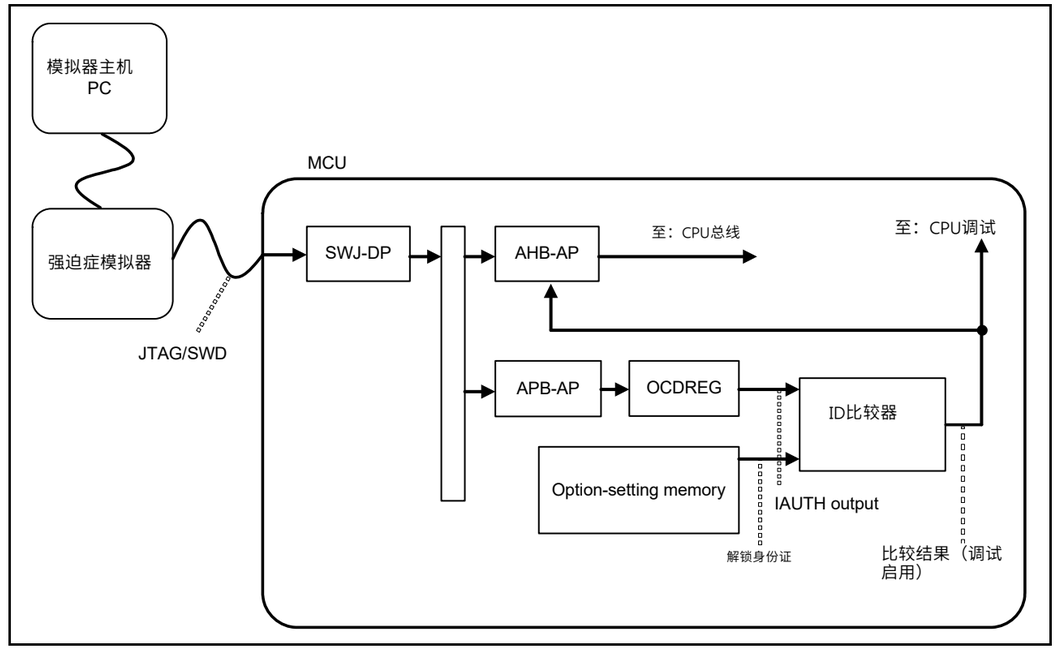


Figure 2.4 认证机制框图

MCU中有一个ID比较器用于身份验证。比较器比较来自OCDREG的128位IAUTH输出和来自选项设置存储器的128位解锁ID代码。当两个输出相同时，允许从OCD仿真器访问CPU调试功能和系统总线。

2.11.1 DBGEN

OCD模拟器获得访问权限后，OCD模拟器必须设置SystemControlOCD中的DBGEN位控制寄存器(SYOCDCR)。此外，OCD仿真器必须在断开连接之前清除DBGEN位。有关详细信息，请参见第11节，低功耗模式。

2.11.2 解锁ID码

解锁ID码用于检查调试权限和对片上资源的访问权限。如果解锁ID代码与ID验证寄存器0到3中写入的128位数据匹配，则JTAGSWD调试器获得访问权限。解锁ID代码写入选项设置存储器中的OCD串行编程器ID设置寄存器(OSIS)。解锁ID码初始值为全1（FFFFFFFF_FFFFFFFF_FFFFFFFFh）。有关详细信息，请参阅第7节，选项设置内存。

2.11.3 连接强迫症模拟器的限制

本节介绍对仿真器访问的限制。

2.11.3.1 在低功耗模式下开始连接

从OCD仿真器启动JTAGSWD连接时，MCU必须处于正常或睡眠模式。如果MCU处于软件待机、贪睡或深度软件待机模式，OCD仿真器会导致MCU挂起。

2.11.3.2 在OCD模式下更改低功耗模式

当MCU处于OCD模式时，可以更改低功耗模式。但是，在软件待机、贪睡或深度软件待机模式下，禁止从AHB-AP访问系统总线。在这些模式下，只能从OCD仿真器访问SWJ-DP、APB-AP和OCDREG。表2.14显示了这些限制。

Table 2.14 Restrictions by mode

Active mode	Start OCD emulator connection	Change low power mode	Access AHB-AP and system bus	Access APB-AP and OCDREG
Normal	Yes	Yes	Yes	Yes
Sleep	Yes	Yes	Yes	Yes
Software Standby	No	Yes	No	Yes
Snooze	No	Yes	No	Yes
Deep Software Standby	No	Yes	No	Yes

If system bus access is required in Software Standby, Snooze, or Deep Software Standby mode, set the OCUCTRL.DBIRG bit in OCDREG to wake up the MCU from the low power modes. Simultaneously, using the OCUCTRL.EDBGRQ bit in OCDREG, the OCD emulator can wake up the MCU without starting CPU execution by using a CPU break.

2.11.3.3 Modifying the unlock ID code in OSIS

After modifying the unlock ID code in the OSIS, the OCD emulator must reset the MCU by asserting the RES pin or setting the SYSRESETREQ bit of the Application Interrupt and Reset Control Register in the system control block to 1. The modified unlock ID code is reflected after reset.

2.11.3.4 Connecting sequence and JTAG/SWD authentication

Because the OCD emulator is protected by the JTAG/SWD authentication mechanism, the OCD might be required to input the ID code to the authentication registers. The OSIS value in the option-setting memory determines whether the code is required.

After the negation of the reset, a 5 µs wait time is required before comparing the OSIS value at cold start.

(1) When MSB of OSIS is 0 (bit [127] = 0)

The ID code is always mismatching and connection to the OCD is prohibited.

(2) When OSIS is all 1s (default)

OCD authentication is not required and the OCD can use the AHB-AP without authentication.

1. Connect the OCD emulator to the MCU through the JTAG or SWD interface.
2. Set up SWJ-DP to access the DAP bus. In the setup, the OCD emulator must assert CDBGPWRUPREQ in the SWJ-DP Control Status Register, then wait until CSDBGPWRUPACK in the same register is asserted.
3. Set up the AHB-AP to access the system address space. The AHB-AP is connected to the DAP bus port 0.
4. Start accessing the CPU debug resources using the AHB-AP.

(3) When OSIS[127:126] = 10b

OCD authentication is required and the OCD must write the unlock ID code to the IAUTH registers 0 to 3 in the OCDREG before using the AHB-AP.

1. Connect the OCD debugger to the MCU through the JTAG or SWD interface.
2. Set up SWJ-DP to access the DAP bus. In the setup, the OCD emulator must assert CDBGPWRUPREQ in the SWJ-DP Control Status Register, and wait until CSDBGPWRUPACK in the same register is asserted.
3. Set up the APB-AP to access OCDREG. The APB-AP is connected to the DAP bus port 1.
4. Write the 128-bit ID code to IAUTH registers 0 to 3 in the OCDREG using the APB-AP.
5. If the 128-bit ID code matches the OSIS value, the AHB-AP is authorized to issue an AHB transaction. The authorization result can be confirmed by the AUTH bit in the MCUSTAT Register or the DbgStatus bit in the AHB-AP Control Status Word Register.
   - When the DbgStatus bit is 1, the 128-bit ID code is a match with the OSIS value. AHB transfers are permitted.

Table 2.14 模式限制

主动模式	启动强迫症模拟器连接	更改低功耗模式	访问AHB-AP和系统总线	访问APB-AP和OCDREG
Normal	Yes	Yes	Yes	Yes
Sleep	Yes	Yes	Yes	Yes
软件待机	No	Yes	No	Yes
Snooze	No	Yes	No	Yes
深度软件待机	No	Yes	No	Yes

如果在软件待机、贪睡或深度软件待机模式下需要系统总线访问，请将OCDREG中的OCUCTRL.DBIRG位将MCU从低功耗模式唤醒。同时，使用OCDREG中的OCUCTRL.EDBGRQ位，OCD仿真器可以通过使用CPU中断来唤醒MCU而无需启动CPU执行。

2.11.3.3 修改OSIS中的解锁ID码

在OSIS中修改解锁ID代码后，OCD仿真器必须通过置位RES引脚或将系统控制块中的应用程序中断和复位控制寄存器的SYSRESETREQ位设置为1来复位MCU。修改后的解锁ID代码会反映复位后。

2.11.3.4 连接顺序和JTAGSWD认证

由于OCD仿真器受JTAGSWD身份验证机制的保护，因此可能需要OCD将ID代码输入到身份验证寄存器中。选项设置内存中的OSIS值决定是否需要该代码。

复位否定后，在冷启动时比较OSIS值之前需要5µs的等待时间。

(1) 当OSIS的MSB为0时（位[127]=0）

ID代码总是不匹配，并且禁止连接到OCD。

(2) 当OSIS全为1时（默认）

不需要OCD身份验证，OCD无需身份验证即可使用AHB-AP。

1. 通过JTAG或SWD接口将OCD仿真器连接到MCU。
2. 设置SWJ-DP以访问DAP总线。在设置中，OCD仿真器必须在SWJ中断言CDBGPWRUPREQ DP控制状态寄存器，然后等到同一寄存器中的CSDBGPWRUPACK置位。
3. 设置AHB-AP以访问系统地址空间。AHB-AP连接到DAP总线端口0。
4. 开始使用AHB-AP访问CPU调试资源。

(3) When OSIS[127:126] = 10b

需要OCD身份验证，并且OCD必须将解锁ID代码写入IAUTH寄存器中的0到3使用AHB-AP之前的OCDREG。

1. 通过JTAG或SWD接口将OCD调试器连接到MCU。
2. 设置SWJ-DP以访问DAP总线。在设置中，OCD仿真器必须在SWJ中断言CDBGPWRUPREQ DP控制状态寄存器，并等待同一寄存器中的CSDBGPWRUPACK置位。
3. 设置APB-AP以访问OCDREG。APB-AP连接到DAP总线端口1。
4. 使用APB-AP将128位ID代码写入OCDREG中的IAUTH寄存器0到3。
5. 如果128位ID代码与OSIS值匹配，则授权AHB-AP发出AHB事务。授权结果可以通过MCUSTAT寄存器中的AUTH位或AHBAP控制状态字寄存器中的DbgStatus位来确认。
   - 当DbgStatus位为1时，128位ID码与OSIS值匹配。允许AHB转移。

- When the DbgStatus bit is 0, the 128-bit ID code is not a match with the OSIS value. AHB transfers are not permitted.

6. Set up the AHB-AP to access the system address space. The AHB-AP is connected to the DAP bus port 0.
7. Start accessing the CPU debug resources using the AHB-AP.

(4) When OSIS[127:126] is 11b

OCD authentication is required and the OCD must write the unlock ID code to IAUTH registers 0 to 3 in the OCDREG. The connection sequence is the same when OSIS[127:126] is 10b except for "ALeRASE" capability.

When IATUH registers 0 to 3 are written with "ALeRASE" in ASCII code (414C_6552_4153_45FF_FFFF_FFFF_FFFF_FFFFh), the contents of the code flash, data flash, and configuration area are erased at once. See section 41, Flash Memory for details.

The ALeRASE sequence is as follows:

1. Connect the OCD debugger to the MCU through the JTAG or SWD interface.
2. Set up SWJ-DP to access DAP bus. In the setup, the OCD emulator must assert CDBGPWRUPREQ in the SWJDP Control Status Register, then wait until CSDBGPWRUPACK in the same register is asserted.
3. Set the APB-AP to access OCDREG. The APB-AP is connected to the DAP bus port 1.
4. Write the 128-bit ID code to IAUTH registers 0 to 3 in the OCDREG using the APB-AP.
5. If the 128-bit ID code is "ALeRASE" in ASCII code, the contents of the code flash, data flash, and configuration area are erased. Thereafter, the MCU transitions to Sleep mode.

2.12 References

1. *ARM® v7-M Architecture Reference Manual* (ARM DDI 0403D).
2. *ARM® Cortex®-M4 Processor Technical Reference Manual* (ARM DDI 0439D).
3. *ARM® Cortex®-M4 Devices Generic User Guide* (ARM DUI 0553A).
4. *ARM® CoreSight™ SoC-400 Technical Reference Manual* (ARM DDI 0480F).
5. *ARM® CoreSight™ ETM-M4 Technical Reference Manual* (ARM DDI 0440C).
6. *ARM® CoreSight™ Trace Memory Controller Technical Reference Manual* (ARM DDI 0461B).
7. *ARM® CoreSight™ Architecture Specification* (ARM IHI 0029D).

- 当DbgStatus位为0时，128位ID代码与OSIS值不匹配。不允许AHB转移。

6. 设置AHB-AP以访问系统地址空间。AHB-AP连接到DAP总线端口0。
7. 开始使用AHB-AP访问CPU调试资源。

(4) 当OSIS[127:126]为11b时

需要OCD身份验证，并且OCD必须将解锁ID代码写入OCDREG中的IAUTH寄存器0到3。
当OSIS[127:126]为10b时，连接顺序相同，但"ALeRASE"功能除外。

当IATUH寄存器0到3用ASCII码(414C_6552_4153_45FF_FFFF_FFFF_FFFF_FFFFh)写入"ALeRASE"时，代码闪存、数据闪存和配置区域的内容会立即被擦除。有关详细信息，请参见第41节，闪存。

ALeRASE序列如下：

1. 通过JTAG或SWD接口将OCD调试器连接到MCU。
2. 设置SWJ-DP以访问DAP总线。在设置中，OCD仿真器必须在SWJDP中断言CDBGPWRUPREQ控制状态寄存器，然后等到同一寄存器中的CSDBGPWRUPACK被断言。
3. 设置APB-AP以访问OCDREG。APB-AP连接到DAP总线端口1。
4. 使用APB-AP将128位ID代码写入OCDREG中的IAUTH寄存器0到3。
5. 如果128位ID代码是ASCII代码中的"ALeRASE"，则代码闪存、数据闪存和配置区域的内容被擦除。此后，MCU转换到休眠模式。

2.12 References

1. ARM®v7-M架构参考手册(ARMDDI0403D)。
2. ARM®Cortex®-M4处理器技术参考手册(ARMDDI0439D)。
3. ARM®Cortex®-M4设备通用用户指南(ARMDUI0553A)。
4. ARM®CoreSight SoC-400技术参考手册(ARMDDI0480F)。
5. ARM®CoreSight ETM-M4技术参考手册(ARMDDI0440C)。
6. ARM®CoreSight 跟踪内存控制器技术参考手册(ARMDDI0461B)。
7. ARM®CoreSight 架构规范(ARMIHI0029D)。

3. Operating Modes

3.1 Overview

Table 3.1 shows the selection of operating modes by the mode-setting pin. For details, see section 3.2, Details of Operating Modes. Operation starts with the on-chip flash memory enabled, regardless of the mode in which operation started.

Table 3.1 Selection of operating modes by the mode-setting pin

Mode-setting pin			
MD	**Operating mode**	**On-chip flash memory**	**External bus**
1	Single-chip mode	Enable	Disable
0	SCI boot mode	Enable	Disable

3.2 Details of Operating Modes

3.2.1 Single-Chip Mode

In single-chip mode, all I/O pins are available for use as input or output port, inputs or outputs for peripheral functions, or as interrupt inputs. When a reset is released while the MD pin is high, the MCU starts in single-chip mode and the on-chip flash is enabled.

3.2.2 SCI Boot Mode

In this mode, the on-chip flash memory programming routine (SCI boot program), stored in a dedicated area within the MCU, is used. The on-chip flash, including the code flash memory and data flash memory, can be modified from outside the MCU by using a universal asynchronous receiver/transmitter (UART) SCI. For details, see section 41, Flash Memory. The MCU starts in SCI boot mode if the MD pin is held low on release from the reset state.

3.3 Operating Mode Transitions

3.3.1 Operating Mode Transitions as Determined by the Mode-Setting Pin

Figure 3.1 shows operating mode transitions determined by the settings of the MD pin.

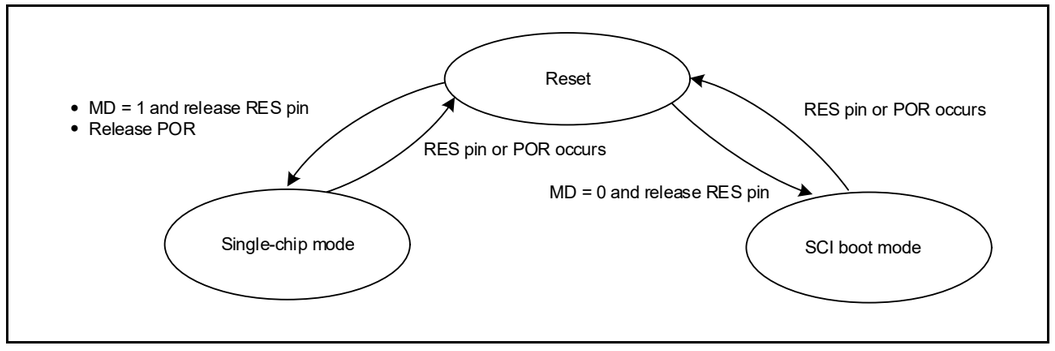


Figure 3.1 Mode-setting pin level and operating mode

3. 操作模式

3.1 Overview

表3.1显示了通过模式设置引脚选择的工作模式。有关详细信息，请参阅第3.2节，详细信息
操作模式。无论操作以何种模式开始，操作都会从启用片上闪存开始。

Table 3.1 通过模式设置引脚选择工作模式

Mode-setting pin			
MD	**操作模式**	**片上闪存**	**外部总线**
1	Single-chip mode	Enable	Disable
0	SCI开机模式	Enable	Disable

3.2 操作模式的详细信息

3.2.1 Single-Chip Mode

在单片机模式下，所有IO引脚都可用作输入或输出端口、外围功能的输入或输出，或用作中断输入。当MD引脚为高电平时释放复位时，MCU以单芯片模式启动，并启用片上闪存。

3.2.2 SCI启动模式

在这种模式下，使用存储在MCU内的专用区域中的片上闪存编程例程（SCI引导程序）。片上闪存，包括代码闪存和数据闪存，可以通过使用通用异步接收发送器(UART)SCI从MCU外部进行修改。有关详细信息，请参阅第41节，闪存。如果MD引脚在从复位状态释放时保持低电平，则MCU以SCI启动模式启动。

3.3 操作模式转换

3.3.1 由模式设置引脚确定的操作模式转换

图3.1显示了由MD引脚的设置决定的操作模式转换。

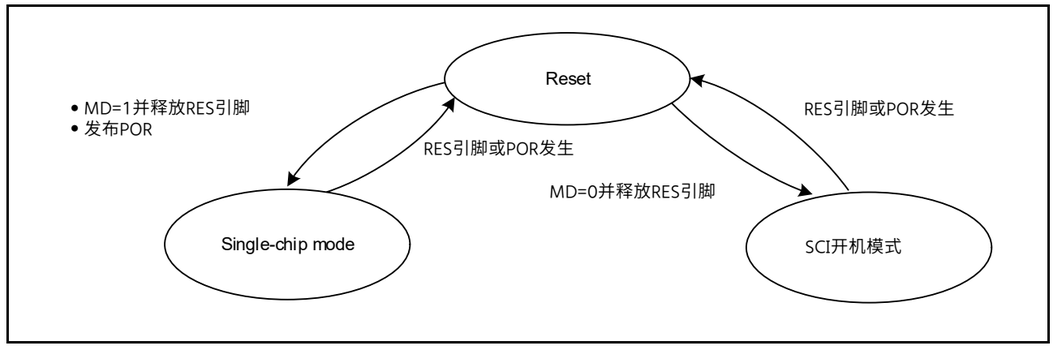
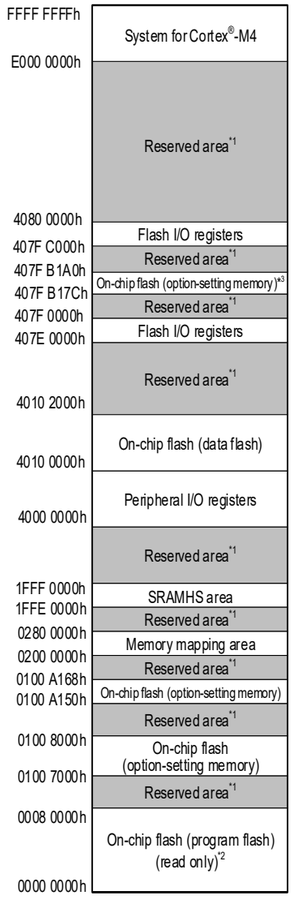


Figure 3.1 模式设置引脚电平和操作模式

4. Address Space

4.1 Overview

The MCU supports a 4-GB linear address space ranging from 0000 0000h to FFFF FFFFh that can contain both program and data. Figure 4.1 shows the memory map.



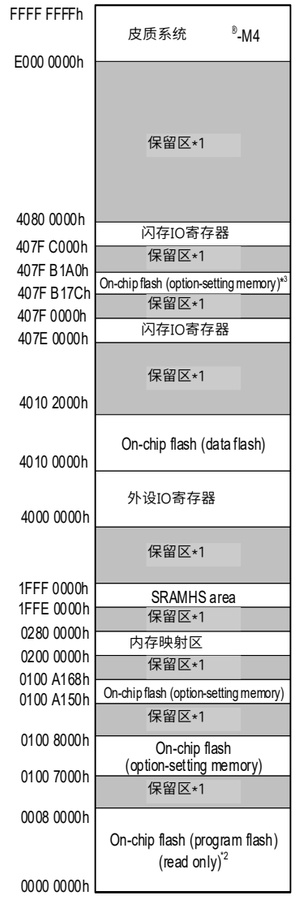
Note 1. Do not access reserved areas.
Note 2. Some regions are reserved for the option-setting memory. For details, see section 7, Option-Setting Memory.
Note 3. Do not access from 407F B180h to 407F B19Bh.

Figure 4.1 Memory map

4. 地址空间

4.1 Overview

MCU支持4-GB线性地址空间，范围从00000000h到FFFFFFFFh，可以同时包含程序和数据。图4.1显示了内存映射。



Note 1. 不要进入保留区域。
Note 2. 某些区域是为选项设置内存保留的。有关详细信息，请参阅第7节，选项设置内存。
Note 3. 请勿从407FB180h访问407FB19Bh。

Figure 4.1 内存映射

RA生态工作室

5. Memory Mirror Function (MMF)

5.1 Overview

The MCU provides a Memory Mirror Function (MMF). You can configure the MMF to map an application image load address in the code flash memory to the application image link address in the unused 23-bit memory mirror space addresses. Your application code must be developed and linked to run from this MMF destination address. The application code is not required to know the load location where it is stored in the code flash memory.

Table 5.1 lists the MMF specifications.

Table 5.1 MMF specifications

Parameter	Specifications
Memory mirror space	8 MB (0200 0000h to 027F FFFFh)
Memory mirror boundary	128 bytes

5.2 Register Descriptions

5.2.1 MemMirror Special Function Register (MMSFR)

Address(es): MMF.MMSFR 4000 1000h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	KEY[7:0]								—	MEMMIRADDR[15:9]						
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MEMMIRADDR[8:0]									—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	Symbol	Bit name	Description	R/W
b6 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b22 to b7	MEMMIRADDR[15:0]	Memory Mirror Address	0000h to FFFFh (8 MB)	R/W
b23	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b31 to b24	KEY[7:0]	MMSFR Key Code	These bits enable or disable rewriting of the MEMMIRADDR bits	R/W

MEMMIRADDR[15:0] bits (Memory Mirror Address)

The MEMMIRADDR[15:0] bits specify bits [22:7] of the memory mirror address. They define where the start address of the memory mirror space addresses (0200 0000h) is linked to. Writing to these bits is enabled only when this register is accessed in 32-bit words and the value DBh is written to the KEY[7:0] bits.

KEY[7:0] bits (MMSFR Key Code)

The KEY[7:0] bits enable or disable rewriting of the MEMMIRADDR[15:0] bits. Data written to the KEY bits is not saved. These bits are read as 0. The KEY code and MEMMIRADDR[15:0] bits must be written in the same cycle.

5. 内存镜像功能(MMF)

5.1 Overview

MCU提供内存镜像功能(MMF)。您可以配置MMF以将代码闪存中的应用程序映像加载地址映射到未使用的23位内存镜像空间地址中的应用程序映像链接地址。您的应用程序代码必须经过开发和链接才能从此MMF目标地址运行。应用程序代码不需要知道它存储在代码闪存中的加载位置。

表5.1列出了MMF规范。

Table 5.1 MMF specifications

Parameter	Specifications
内存镜像空间	8 MB (0200 0000h to 027F FFFFh)
内存镜像边界	128 bytes

5.2 注册说明

5.2.1 MemMirror特殊功能寄存器(MMSFR)

Address(es): MMF.MMSFR 4000 1000h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	KEY[7:0]								—	MEMMIRADDR[15:9]						
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MEMMIRADDR[8:0]									—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	Symbol	位名称	Description	R/W
b6 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b22 to b7	MEMMIRADDR[15:0]	内存镜像地址	0000h to FFFFh (8 MB)	R/W
b23	—	Reserved	该位读取为0。写入值应为0。	R/W
b31 to b24	KEY[7:0]	MMSFR密钥代码	这些位启用或禁用重写 MEMMIRADDR bits	R/W

MEMMIRADDR[15:0]位（内存镜像地址）

MEMMIRADDR[15:0]位指定内存镜像地址的位[22:7]。它们定义了内存镜像空间地址（02000000h）的起始地址链接到哪里。仅当以32位字访问该寄存器并将值DBh写入KEY[7:0]位时，才能写入这些位。

KEY[7:0]位（MMSFR密钥代码）

KEY[7:0]位启用或禁用MEMMIRADDR[15:0]位的重写。不保存写入KEY位的数据。这些位读为0。KEY代码和MEMMIRADDR[15:0]位必须在同一个周期内写入。

5.2.2 MemMirror Enable Register (MMEN)

Address(es): MMF.MMEN 4000 1004h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	KEY[7:0]								—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	EN
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	Symbol	Bit name	Description	R/W
b0	EN	Memory Mirror Function Enable	0: Disable MMF 1: Enable MMF.	R/W
b23 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b31 to b24	KEY[7:0]	MMEN Key Code	These bits enable or disable rewriting of the EN bit.	R/W

EN bit (Memory Mirror Function Enable)

Writing to the EN bit is enabled only when the MemMirror Enable Register is accessed in 32-bit words and the value DBh is written to the KEY[7:0] bits.

KEY[7:0] bits (MMEN Key Code)

The KEY[7:0] bits enable or disable rewriting of the EN bit. Data written to the KEY[7:0] bits is not saved. These bits are read as 0. The KEY code and the EN bit must be written in the same cycle.

5.3 Operation

5.3.1 MMF Operation

The MMF links the memory mirror space (0200 0000h to 027F FFFFh) to the code flash area. If MMEN.EN = 1, the CPU can access code flash using both normal addresses (starting at 0000 0000h) and memory mirror space addresses (starting at 0200 0000h). Figure 5.1 shows an overview of the MMF. The MMSFR.MEMMIRADDR[15:0] bits specify where the start address of the memory mirror space addresses (0200 0000h) is linked to. Figure 5.2, Figure 5.3, and Figure 5.4 show the MMF operation. Figure 5.5 shows the setting procedure of the MMF.

5.2.2 MemMirror启用寄存器(MMEN)

Address(es): MMF.MMEN 4000 1004h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	KEY[7:0]								—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	EN
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bits	Symbol	位名称	Description	R/W
b0	EN	内存镜像功能 Enable	0：禁用MMF1 ：启用MMF。	R/W
b23 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b31 to b24	KEY[7:0]	MMEN键码	这些位启用或禁用EN位的重写。	R/W

EN位（内存镜像功能使能）

仅当以32位字访问MemMirror使能寄存器并且值DBh被写入KEY[7:0]位。

KEY[7:0]位（MMEN键码）

KEY[7:0]位启用或禁用EN位的重写。写入KEY[7:0]位的数据不保存。这些位读为0。KEY代码和EN位必须在同一个周期内写入。

5.3 Operation

5.3.1 MMF Operation

MMF将内存镜像空间（02000000h到027FFFFFh）链接到代码闪存区域。如果MMEN.EN=1，CPU可以使用普通地址（从00000000h开始）和内存镜像空间地址（从02000000h开始）访问代码闪存。图5.1显示了MMF的概述。MMSFR.MEMMIRADDR[15:0]位指定存储器镜像空间地址(02000000h)的起始地址链接到的位置。图5.2、图5.3和图5.4显示了MMF操作。图5.5显示了MMF的设置过程。

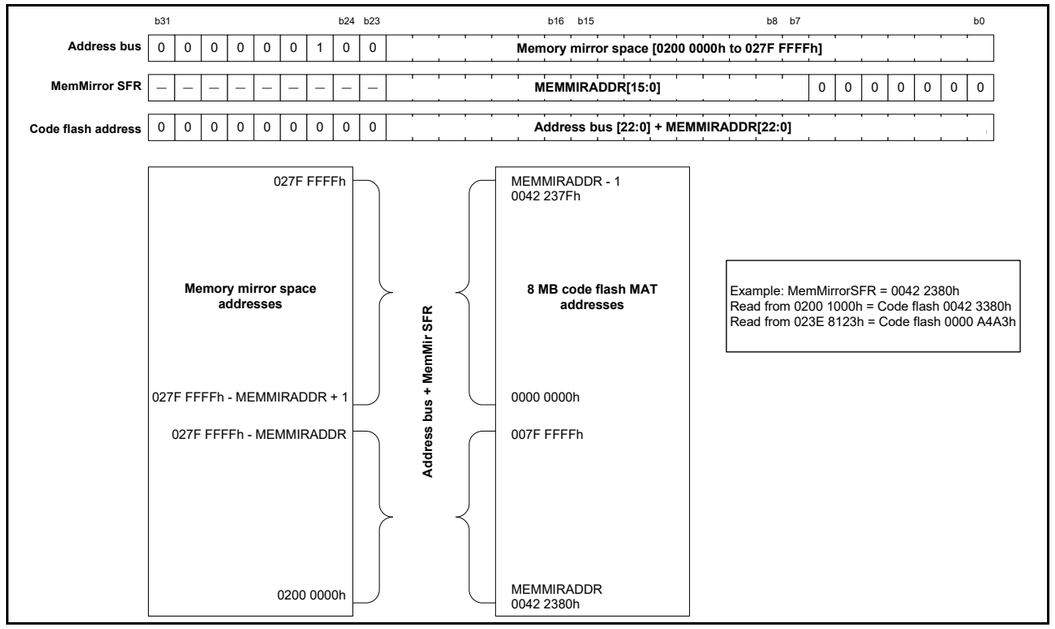
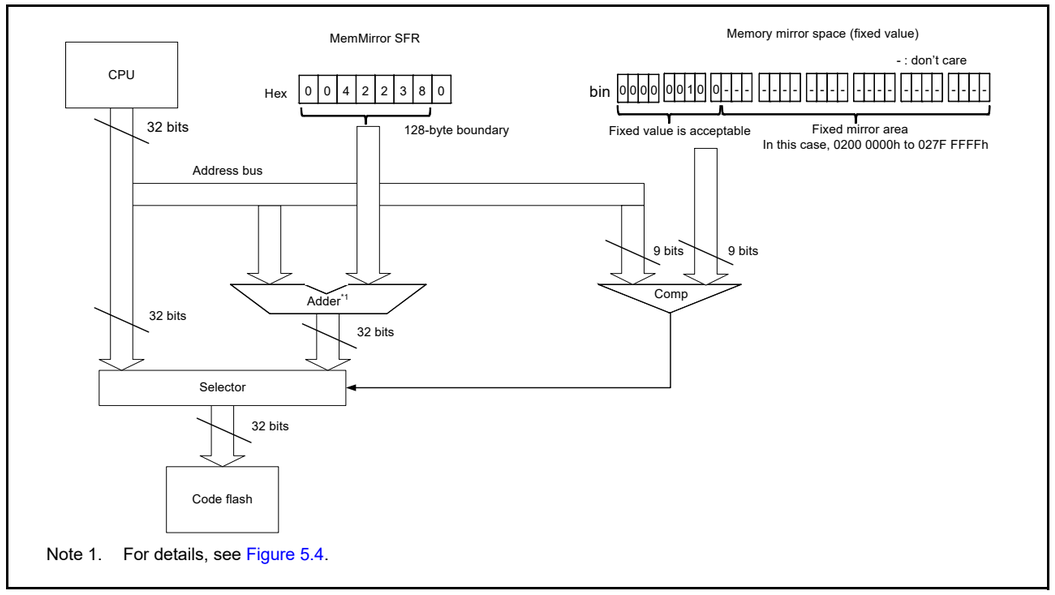


Figure 5.1 MMF operation



Note 1. For details, see Figure 5.4.

Figure 5.2 MMF block diagram

Figure 5.3 shows the addresses handled by each module. The Arm® MPU uses the original address of the CPU. The Security MPU and code flash memory each uses an address after conversion through the Memory Mirror Function.

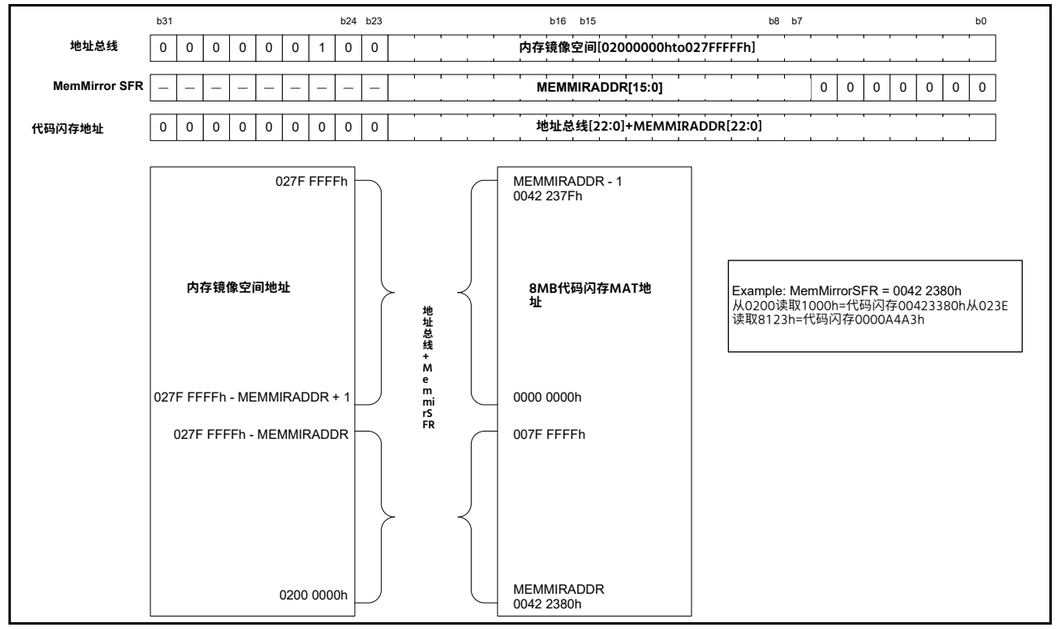
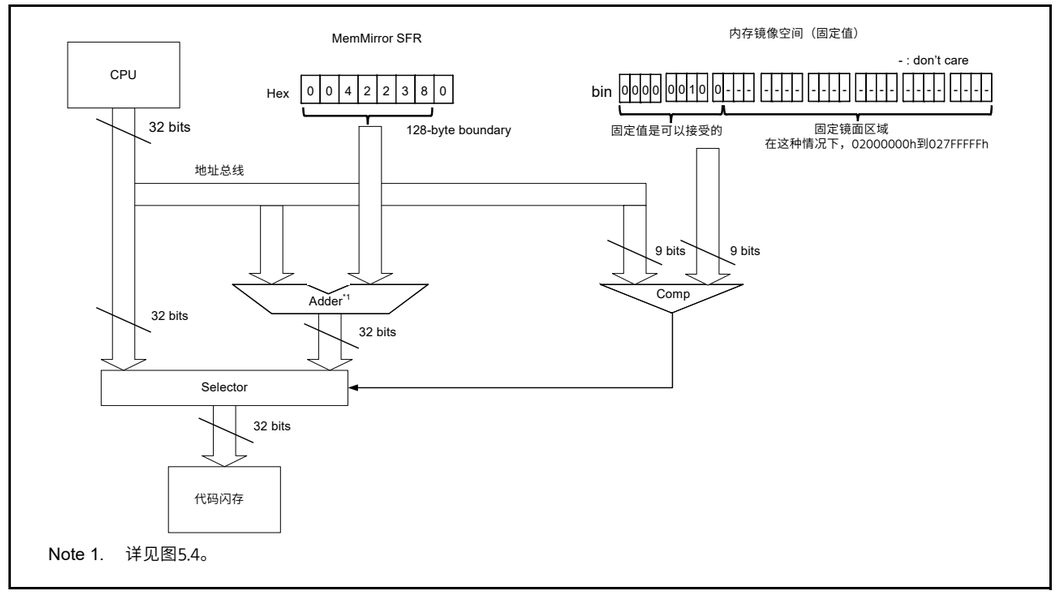


Figure 5.1 MMF operation



Note 1. 详见图5.4。

Figure 5.2 MMF框图

图5.3显示了每个模块处理的地址。Arm®MPU使用CPU的原始地址。这
安全MPU和代码闪存各使用一个通过MemoryMirrorFunction转换后的地址。

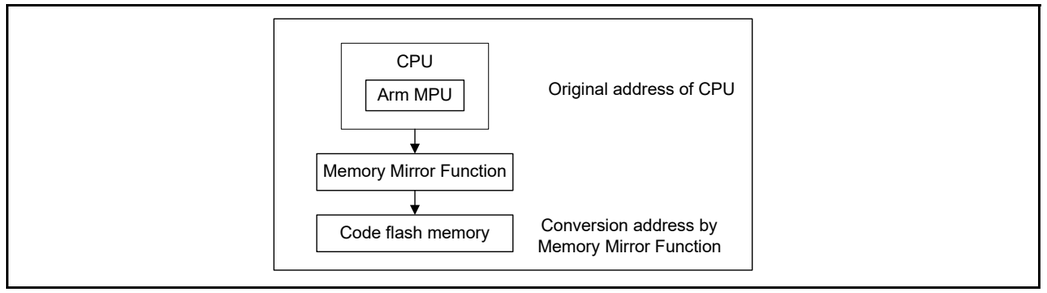


Figure 5.3 MMF address handling

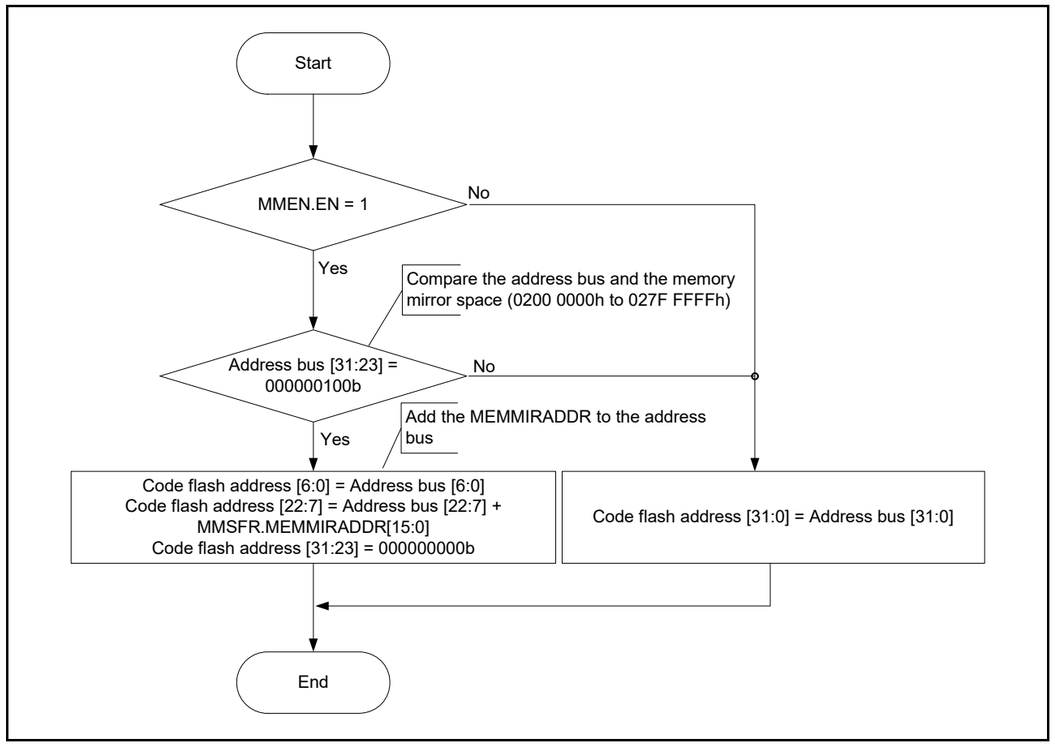


Figure 5.4 MMF operation flow

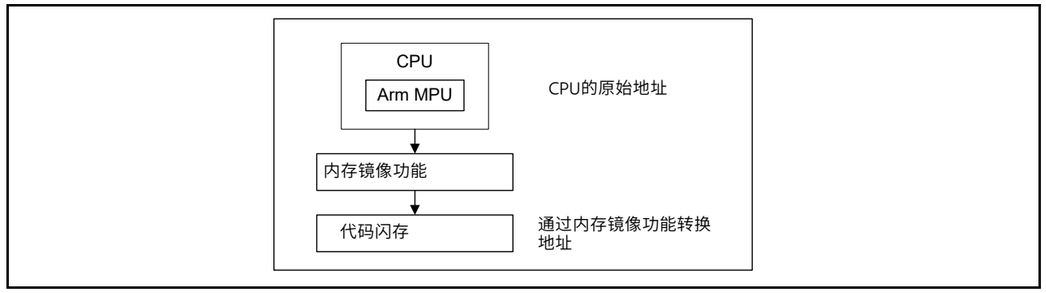


Figure 5.3 MMF地址处理

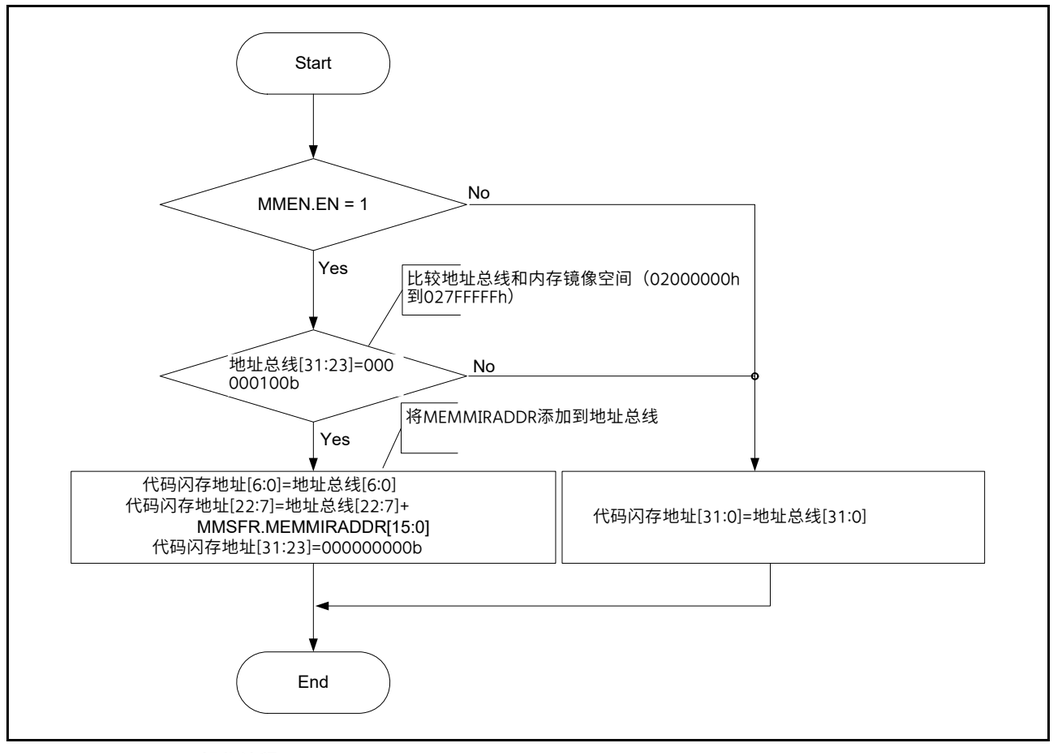


Figure 5.4 MMF操作流程

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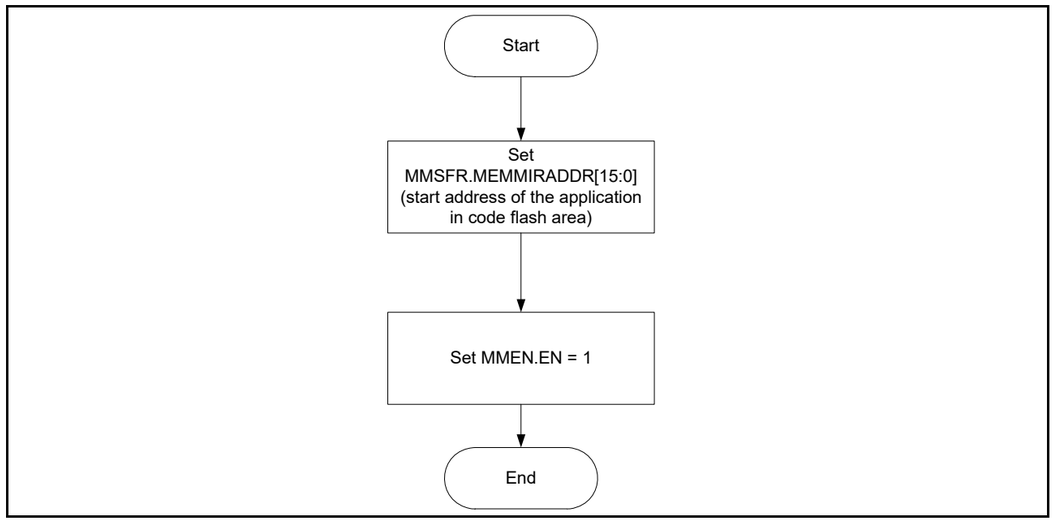

Figure 5.5 MMF setup flow

5.3.2 Setting Example

The target application code on the code flash can be accessed from the address 0200 0000h on the memory mirror space by setting up the code flash start address in MMSFR.MEMMIRADDR[15:0] and setting MMEN.EN = 1.

Figure 5.6 shows an example of how to use the MMF.

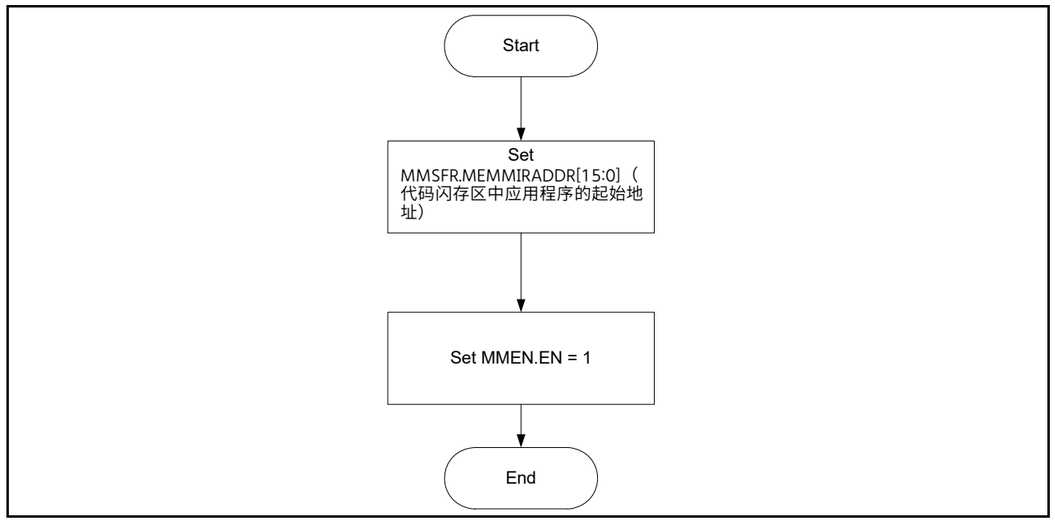

Figure 5.5 MMF设置流程

5.3.2 设置示例

通过在MMSFR.MEMMIRADDR[15:0]中设置代码闪存起始地址并设置MMEN.EN=1，可以从内存镜像空间的地址02000000h访问代码闪存上的目标应用程序代码。

图5.6显示了如何使用MMF的示例。

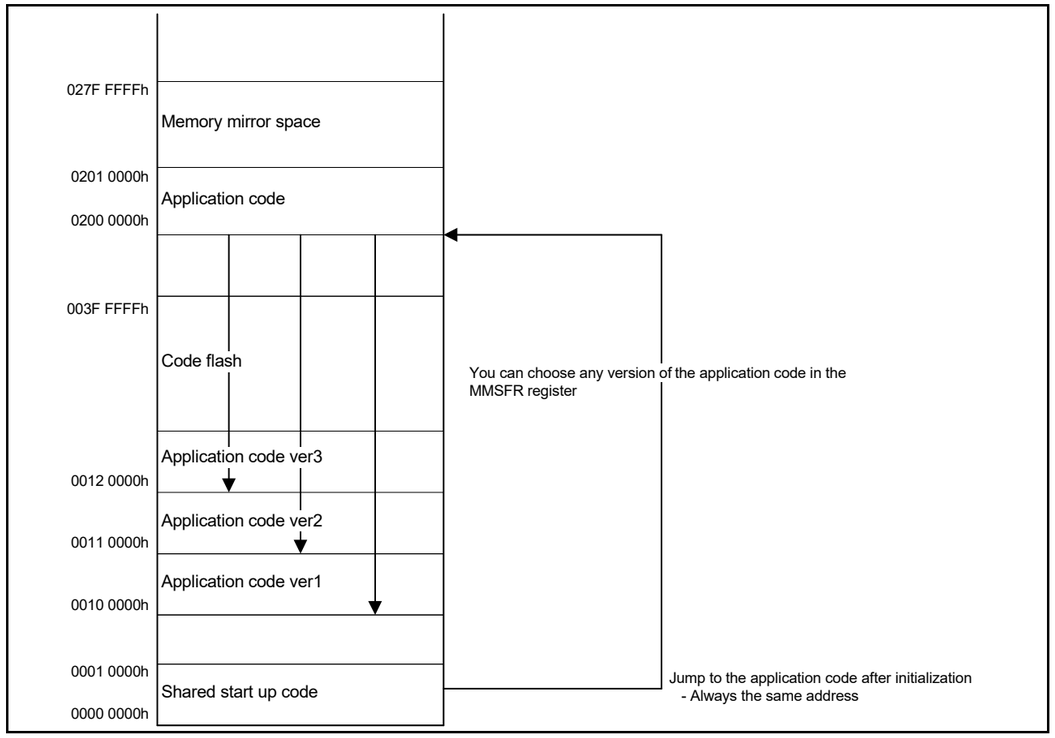

Figure 5.6 MMF setting example

Setting the MMSFR register to DB10 0000h to use the application code ver1.

Setting the MMSFR register to DB11 0000h to use the application code ver2.

Setting the MMSFR register to DB12 0000h to use the application code ver3.

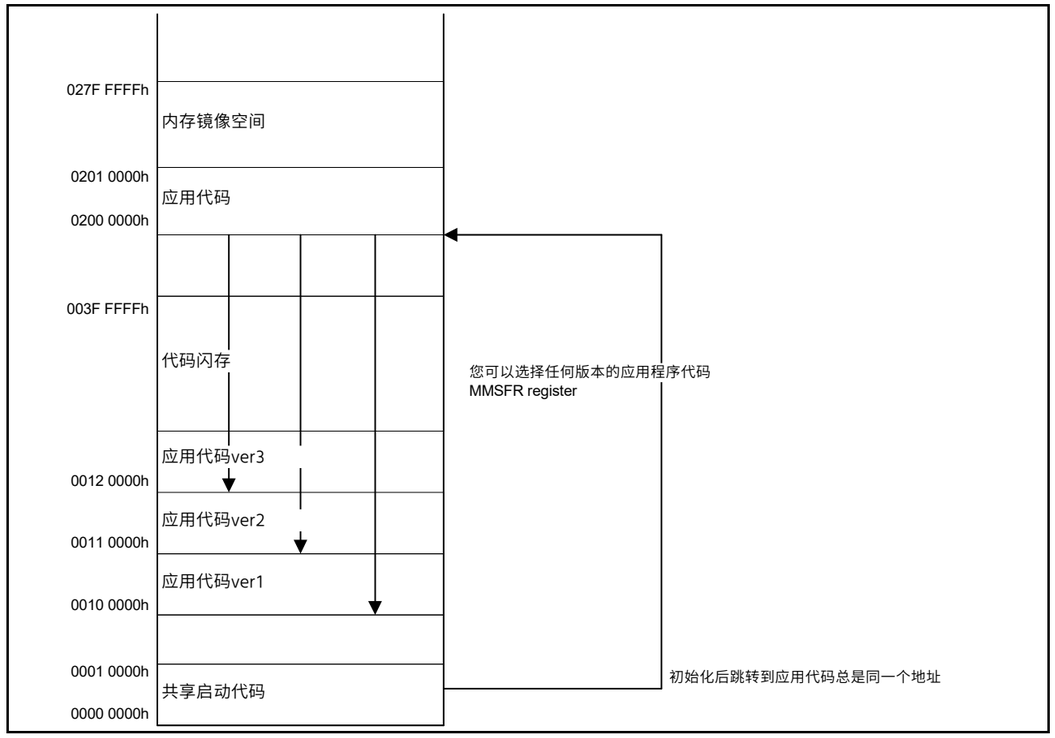

Figure 5.6 MMF设置示例

将MMSFR寄存器设置为DB100000h以使用应用程序代码ver1。

将MMSFR寄存器设置为DB110000h以使用应用程序代码ver2。

将MMSFR寄存器设置为DB120000h以使用应用程序代码ver3。

6. Resets

6.1 Overview

The MCU provides 13 resets:

- RES pin reset
- Power-on reset
- Independent watchdog timer reset
- Watchdog timer reset
- Voltage monitor 0 reset
- Voltage monitor 1 reset
- Voltage monitor 2 reset
- SRAM parity error reset
- Bus master MPU error reset
- Bus slave MPU error reset
- Stack pointer error reset
- Deep Software Standby reset
- Software reset.

Table 6.1 lists the reset names and sources.

Table 6.1 Reset names and sources

Reset name	Source
RES pin reset	Voltage input to the RES pin is driven low
Power-on reset	VCC rise (voltage detection V_{POR})*1
Independent watchdog timer reset	IWDT underflow or refresh error
Watchdog timer reset	WDT underflow or refresh error
Voltage monitor 0 reset	VCC fall (voltage detection V_{det0})*1
Voltage monitor 1 reset	VCC fall (voltage detection V_{det1})*1
Voltage monitor 2 reset	VCC fall (voltage detection V_{det2})*1
SRAM parity error reset	SRAM parity error detection
Bus master MPU error reset	Bus master MPU error detection
Bus slave MPU error reset	Bus slave MPU error detection
Stack pointer error reset	Stack pointer error detection
Deep software standby reset	Canceling of Deep Software Standby mode by an interrupt
Software reset	Register setting (use the Arm® software reset bit AIRCR.SYSRESETREQ)

Note 1. For details on the voltages to be monitored (V_{POR}, V_{det0}, V_{det1}, and V_{det2}), see section 8, Low Voltage Detection (LVD) and section 43, Electrical Characteristics.

The internal state and pins are initialized by a reset. Table 6.2 and Table 6.3 list the targets initialized by resets.

Table 6.2 Reset detect flags initialized by each reset source (1 of 2)

Flags to be initialized	Reset source							
	RES pin reset	Power-on reset	Voltage monitor 0 reset	Independent watchdog timer reset	Watchdog timer reset	Voltage monitor 1 reset	Voltage monitor 2 reset	Software reset
Power-On Reset Detect Flag (RSTSR0.PORF)	✓	×	×	×	×	×	×	×

6. Resets

6.1 Overview

MCU提供13次复位：

- RES引脚复位
- Power-on reset
- 独立看门狗定时器复位
- 看门狗定时器复位
- 电压监控器0复位
- 电压监视器1复位
- 电压监视器2复位
- SRAM奇偶校验错误复位
- 总线主控MPU错误复位
- 总线从机MPU错误复位
- 堆栈指针错误复位
- 深度软件待机复位
- 软件复位。

表6.1列出了复位名称和来源。

Table 6.1 重置名称和来源

重设名称	Source
RES引脚复位	输入到RES引脚的电压被驱动为低电平
Power-on reset	VCC上升（电压检测VPOR）*1
独立看门狗定时器复位	IWDT下溢或刷新错误
看门狗定时器复位	WDT下溢或刷新错误
电压监控器0复位	VCC下降（电压检测Vdet0）*1
电压监视器1复位	VCC下降（电压检测Vdet1）*1
电压监视器2复位	VCC下降（电压检测Vdet2）*1
SRAM奇偶校验错误复位	SRAM奇偶校验错误检测
总线主控MPU错误复位	总线主控MPU错误检测
总线从机MPU错误复位	总线从机MPU错误检测
堆栈指针错误复位	堆栈指针错误检测
深度软件待机复位	通过中断取消深度软件待机模式
软件复位	寄存器设置（使用Arm®软件复位位AIRCR.SYSRESETREQ）

Note 1. 有关要监控的电压（VPOR、Vdet0、Vdet1和Vdet2）的详细信息，请参见第8节，低电压检测(LVD)和第43节，电气特性。

内部状态和引脚由复位初始化。表6.2和表6.3列出了由复位初始化的目标。

Table 6.2 由每个复位源初始化的复位检测标志（2个中的1个）

要初始化的标志	重置源							
	RES引脚复位	Power-on reset	电压监控器0复位	独立看门狗定时器复位	看门狗定时器复位	电压监视器1复位	电压监视器2复位	软件复位
上电复位检测标志(RSTSR0.PORF)	✓	×	×	×	×	×	×	×

Table 6.2 Reset detect flags initialized by each reset source (2 of 2)

Flags to be initialized	Reset source							
	RES pin reset	Power-on reset	Voltage monitor 0 reset	Independent watchdog timer reset	Watchdog timer reset	Voltage monitor 1 reset	Voltage monitor 2 reset	Software reset
Voltage Monitor 0 Reset Detect Flag (RSTSR0.LVD0RF)	✓	✓	×	×	×	×	×	×
Independent Watchdog Timer Reset Detect Flag (RSTSR1.IWDTRF)	✓	✓	✓	×	×	×	×	×
Watchdog Timer Reset Detect Flag (RSTSR1.WDTRF)	✓	✓	✓	×	×	×	×	×
Voltage Monitor 1 Reset Detect Flag (RSTSR0.LVD1RF)	✓	✓	✓	×	×	×	×	×
Voltage Monitor 2 Reset Detect Flag (RSTSR0.LVD2RF)	✓	✓	✓	×	×	×	×	×
Software Reset Detect Flag (RSTSR1.SWRF)	✓	✓	✓	×	×	×	×	×
SRAM Parity Error Reset Detect Flag (RSTSR1.RPERF)	✓	✓	✓	×	×	×	×	×
Bus Slave MPU Error Reset Detect Flag (RSTSR1.BUSSRF)	✓	✓	✓	×	×	×	×	×
Bus Master MPU Error Reset Detect Flag (RSTSR1.BUSMRF)	✓	✓	✓	×	×	×	×	×
Stack Pointer Error Reset Detect Flag (RSTSR1.SPERF)	✓	✓	✓	×	×	×	×	×
Deep Software Standby Reset Detect Flag (RSTSR0.DPSRSTF)	✓	✓	✓	×	×	×	×	×
Cold Start/Warm Start Determination Flag (RSTSR2.CWSF)	×	✓	×	×	×	×	×	×

Flags to be initialized	Reset source					
	SRAM parity error reset	Bus master MPU error reset	Bus slave MPU error reset	Stack pointer error reset	Deep Software Standby reset	
					DEEPCUT[0] = 0	DEEPCUT[0] = 1
Power-On Reset Detect Flag (RSTSR0.PORF)	×	×	×	×	×	×
Voltage Monitor 0 Reset Detect Flag (RSTSR0.LVD0RF)	×	×	×	×	×	×
Independent Watchdog Timer Reset Detect Flag (RSTSR1.IWDTRF)	×	×	×	×	✓	✓
Watchdog Timer Reset Detect Flag (RSTSR1.WDTRF)	×	×	×	×	✓	✓
Voltage Monitor 1 Reset Detect Flag (RSTSR0.LVD1RF)	×	×	×	×	×	×
Voltage Monitor 2 Reset Detect Flag (RSTSR0.LVD2RF)	×	×	×	×	×	×
Software Reset Detect Flag (RSTSR1.SWRF)	×	×	×	×	✓	✓
SRAM Parity Error Reset Detect Flag (RSTSR1.RPERF)	×	×	×	×	✓	✓
Bus Slave MPU Error Reset Detect Flag (RSTSR1.BUSSRF)	×	×	×	×	✓	✓
Bus Master MPU Error Reset Detect Flag (RSTSR1.BUSMRF)	×	×	×	×	✓	✓
Stack Pointer Error Reset Detect Flag (RSTSR1.SPERF)	×	×	×	×	✓	✓
Deep Software Standby Reset Detect Flag (RSTSR0.DPSRSTF)	×	×	×	×	×	×
Cold Start/Warm Start Determination Flag (RSTSR2.CWSF)	×	×	×	×	×	×

✓: initialized to 0
×: Not initialized

Table 6.3 Module-related registers initialized by each reset source (1 of 2)

Registers to be initialized		Reset source							
		RES pin reset	Power-on reset	Voltage monitor 0 reset	Independent watchdog timer reset	Watchdog timer reset	Voltage monitor 1 reset	Voltage monitor 2 reset	Software reset
Watchdog timer registers	WDTRR, WDTCR, WDTSR, WDTRCR, WDTCSTPR	✓	✓	✓	✓	✓	✓	✓	✓
Voltage monitor function 1 registers	LVD1CR0, LVCMPCR.LVD1E, LVDLVLR.LVD1LVL	✓	✓	✓	✓	✓	×	×	×
	LVD1CR1/LVD1SR	✓	✓	✓	✓	✓	×	×	×

Table 6.2 由每个复位源初始化的复位检测标志（2个中的2个）

要初始化的标志	重置源							
	RES引脚复位	Power-on reset	电压监控器0复位	独立看门狗定时器复位	看门狗定时器复位	电压监视器1复位	电压监视器2复位	软件复位
电压监视器0复位检测标志(RSTSR0.LVD0RF)	✓	✓	×	×	×	×	×	×
独立看门狗定时器复位检测标志(RSTSR1.IWDTRF)	✓	✓	✓	×	×	×	×	×
看门狗定时器复位检测标志(RSTSR1.WDTRF)	✓	✓	✓	×	×	×	×	×
电压监视器1复位检测标志(RSTSR0.LVD1RF)	✓	✓	✓	×	×	×	×	×
电压监视器2复位检测标志(RSTSR0.LVD2RF)	✓	✓	✓	×	×	×	×	×
软件复位检测标志(RSTSR1.SWRF)	✓	✓	✓	×	×	×	×	×
SRAM奇偶校验错误复位检测标志（RSTSR1.RPERF）	✓	✓	✓	×	×	×	×	×
总线从机MPU错误复位检测标志(RSTSR1.BUSSRF)	✓	✓	✓	×	×	×	×	×
总线主控MPU错误复位检测标志(RSTSR1.BUSMRF)	✓	✓	✓	×	×	×	×	×
堆栈指针错误复位检测标志(RSTSR1.SPERF)	✓	✓	✓	×	×	×	×	×
深度软件待机复位检测标志(RSTSR0.DPRSTF)	✓	✓	✓	×	×	×	×	×
冷启动热启动确定标志(RSTSR2.CWSF)	×	✓	×	×	×	×	×	×

要初始化的标志	重置源					
	SRAM奇偶校验错误复位	总线主控MPU错误复位	总线从机MPU错误复位	堆栈指针错误复位	深度软件待机复位	
					DEEPCUT[0] = 0	DEEPCUT[0] = 1
上电复位检测标志(RSTSR0.PORF)	×	×	×	×	×	×
电压监视器0复位检测标志(RSTSR0.LVD0RF)	×	×	×	×	×	×
独立看门狗定时器复位检测标志(RSTSR1.IWDTRF)	×	×	×	×	✓	✓
看门狗定时器复位检测标志(RSTSR1.WDTRF)	×	×	×	×	✓	✓
电压监视器1复位检测标志(RSTSR0.LVD1RF)	×	×	×	×	×	×
电压监视器2复位检测标志(RSTSR0.LVD2RF)	×	×	×	×	×	×
软件复位检测标志(RSTSR1.SWRF)	×	×	×	×	✓	✓
SRAM奇偶校验错误复位检测标志（RSTSR1.RPERF）	×	×	×	×	✓	✓
总线从机MPU错误复位检测标志(RSTSR1.BUSSRF)	×	×	×	×	✓	✓
总线主控MPU错误复位检测标志(RSTSR1.BUSMRF)	×	×	×	×	✓	✓
堆栈指针错误复位检测标志(RSTSR1.SPERF)	×	×	×	×	✓	✓
深度软件待机复位检测标志(RSTSR0.DPRSTF)	×	×	×	×	×	×
冷启动热启动确定标志(RSTSR2.CWSF)	×	×	×	×	×	×

：初始化为0×：
未初始化

Table 6.3 由每个复位源初始化的模块相关寄存器（2个中的1个）

待初始化的寄存器		重置源							
		RES引脚复位	Power-on reset	电压监控器0复位	独立看门狗定时器复位	看门狗定时器复位	电压监视器1复位	电压监视器2复位	软件复位
看门狗定时器寄存器	WDTRR, WDTCR, WDTSR, WDTRCR, WDTCSTPR	✓	✓	✓	✓	✓	✓	✓	✓
电压监控功能1个寄存器	LVD1CR0, LVCMPCR.LVD1E, LVDLVLR.LVD1LVL	✓	✓	✓	✓	✓	×	×	×
	LVD1CR1/LVD1SR	✓	✓	✓	✓	✓	×	×	×

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Table 6.3 Module-related registers initialized by each reset source (2 of 2)

Registers to be initialized		Reset source							
		RES pin reset	Power-on reset	Voltage monitor 0 reset	Independent watchdog timer reset	Watchdog timer reset	Voltage monitor 1 reset	Voltage monitor 2 reset	Software reset
Voltage monitor function 2 registers	LVD2CR0, LVCMPCR.LVD2E, LVDLVLR.LVD2LVL	✓	✓	✓	✓	✓	×	×	×
	LVD2CR1/LVD2SR	✓	✓	✓	✓	✓	×	×	×
SOSC registers	SOSCCR	×	✓*1	×	×	×	×	×	×
	SOMCR	×	×	×	×	×	×	×	×
LOCO registers	LOCOCR	✓	✓	✓	✓	✓	✓	✓	✓
	LOCOUTCR	×	✓	✓	×	×	✓	✓	×
MOSC register	MOMCR	✓	✓	✓	✓	✓	✓	✓	✓
AGT register		×	✓	✓	×	×	✓	✓	×
MPU register		✓	✓	✓	✓	✓	✓	✓	✓
Pin state (except XCIN/XCOUT pin)		✓	✓	✓	✓	✓	✓	✓	✓
Pin state (XCIN/XCOUT pin)		×	×	×	×	×	×	×	×
Low-power function registers	DPSBYCR, DPSIER0 to DPSIER3, DPSIFR0 to DPSIFR3, DPSIEGR0 to DPSIEGR2	✓	✓	✓	✓	✓	✓	✓	✓
Registers other than those shown, CPU, and internal state		✓	✓	✓	✓	✓	✓	✓	✓

Registers to be initialized		Reset source					
		SRAM parity error reset	Bus master MPU error reset	Bus slave MPU error reset	Stack pointer error reset	Deep Software Standby reset	
						DEEPCUT[0] = 0	DEEPCUT[0] = 1
Watchdog timer registers	WDTRR, WDTCR, WDTSR, WDTRCR, WDTCSTPR	✓	✓	✓	✓	✓	✓
Voltage monitor function 1 registers	LVD1CR0, LVCMPCR.LVD1E, LVDLVLR.LVD1LVL	×	×	×	×	×	×
	LVD1CR1/LVD1SR	×	×	×	×	✓	✓
Voltage monitor function 2 registers	LVD2CR0, LVCMPCR.LVD2E, LVDLVLR.LVD2LVL	×	×	×	×	×	×
	LVD2CR1/LVD2SR	×	×	×	×	✓	✓
SOSC registers	SOSCCR	×	×	×	×	×	×
	SOMCR	×	×	×	×	×	×
LOCO registers	LOCOCR	✓	✓	✓	✓	✓	✓
	LOCOUTCR	×	×	×	×	×	✓
MOSC register	MOMCR	✓	✓	✓	✓	×	×
AGT register		×	×	×	×	×	✓
MPU register		✓	×	×	×	✓	✓
Pin states (except XCIN/XCOUT pin)		✓	✓	✓	✓	*2	*2
Pin states (XCIN/XCOUT pin)		×	×	×	×	×	×
Low-power function registers	DPSBYCR, DPSIER0 to DPSIER3, DPSIFR0 to DPSIFR3, DPSIEGR0 to DPSIEGR2	✓	✓	✓	✓	×	×
Registers other than those shown, CPU, and internal state		✓	✓	✓	✓	✓	✓

✓: Initialized
×: Not initialized

Note 1. For the initial value of each register, see section 9, Clock Generation Circuit.
Note 2. Depends on the setting of DPSBYCR.IOKEEP.

Table 6.4 and Table 6.5 show the states of SOSC and LOCO when a reset occurs.

Table 6.3 由每个复位源初始化的模块相关寄存器（2个中的2个）

待初始化的寄存器		重置源							
		RES引脚复位	Power-on reset	电压监控器0复位	独立看门狗定时器复位	看门狗定时器复位	电压监视器1复位	电压监视器2复位	软件复位
电压监控功能2个寄存器	LVD2CR0, LVCMPCR.LVD2E, LVDLVLR.LVD2LVL	✓	✓	✓	✓	✓	×	×	×
	LVD2CR1/LVD2SR	✓	✓	✓	✓	✓	×	×	×
SOSC registers	SOSCCR	×	✓*1	×	×	×	×	×	×
	SOMCR	×	×	×	×	×	×	×	×
LOCO寄存器	LOCOCR	✓	✓	✓	✓	✓	✓	✓	✓
	LOCOUTCR	×	✓	✓	×	×	✓	✓	×
MOSC register	MOMCR	✓	✓	✓	✓	✓	✓	✓	✓
AGT register		×	✓	✓	×	×	✓	✓	×
MPU register		✓	✓	✓	✓	✓	✓	✓	✓
引脚状态（XCINXCOUT引脚除外）		✓	✓	✓	✓	✓	✓	✓	✓
引脚状态（XCINXCOUT引脚）		×	×	×	×	×	×	×	×
低功耗功能寄存器	DPSBYCR, DPSIER0 to DPSIER3, DPSIFR0 to DPSIFR3, DPSIEGR0 to DPSIEGR2	✓	✓	✓	✓	✓	✓	✓	✓
未显示的寄存器、CPU和内部状态		✓	✓	✓	✓	✓	✓	✓	✓

待初始化的寄存器		重置源					
		SRAM奇偶校验错误复位	总线主控MPU错误复位	总线从机MPU错误复位	堆栈指针错误复位	深度软件待机复位	
						DEEPCUT[0] = 0	DEEPCUT[0] = 1
看门狗定时器寄存器	WDTRR, WDTCR, WDTSR, WDTRCR, WDTCSTPR	✓	✓	✓	✓	✓	✓
电压监控功能1个寄存器	LVD1CR0, LVCMPCR.LVD1E, LVDLVLR.LVD1LVL	×	×	×	×	×	×
	LVD1CR1/LVD1SR	×	×	×	×	✓	✓
电压监控功能2个寄存器	LVD2CR0, LVCMPCR.LVD2E, LVDLVLR.LVD2LVL	×	×	×	×	×	×
	LVD2CR1/LVD2SR	×	×	×	×	✓	✓
SOSC registers	SOSCCR	×	×	×	×	×	×
	SOMCR	×	×	×	×	×	×
LOCO寄存器	LOCOCR	✓	✓	✓	✓	✓	✓
	LOCOUTCR	×	×	×	×	×	✓
MOSC register	MOMCR	✓	✓	✓	✓	×	×
AGT register		×	×	×	×	×	✓
MPU register		✓	×	×	×	✓	✓
引脚状态（XCINXCOUT引脚除外）		✓	✓	✓	✓	*2	*2
引脚状态（XCINXCOUT引脚）		×	×	×	×	×	×
低功耗功能寄存器	DPSBYCR, DPSIER0 to DPSIER3, DPSIFR0 to DPSIFR3, DPSIEGR2	✓	✓	✓	✓	×	×
未显示的寄存器、CPU和内部状态		✓	✓	✓	✓	✓	✓

：已初始化×：
未初始化

Note 1. 对于每个寄存器的初始值，请参见第9节，时钟生成电路。
Note 2. 取决于DPSBYCR.IOKEEP的设置。

表6.4和表6.5显示了复位发生时SOSC和LOCO的状态。

Table 6.4 States of SOSC when a reset occurs

		Reset source	
		POR	**Other**
SOSC	Enable or disable	Initialized to enable	Continue with the state that was selected before the reset occurred
	Drive capability	Continue with the state that was selected before the reset occurred	

Table 6.5 States of LOCO when a reset occurs

		Reset source	
		POR, LVD0, LVD1, LVD2/ Deep Software Standby (DEEPCUT[0] = 1)	**Other**
LOCO	Enable or disable	Initialized to enable	
	Oscillation accuracy*1	Initialized to accuracy before trimming by LOCOUTCR (accuracy: ± 15%)	Continue with the accuracy that was trimmed by LOCOUTCR

Note 1. The LOCO User Trimming Control Register (LOCOUTCR) is reset by POR, LVD0, LVD1, LVD2, and Deep Software Standby (DEEPCUT[0] = 1) resets, returning the LOCO to the default oscillation accuracy. To restore the pre-reset LOCO oscillation accuracy, reload the required trimming value into LOCOUTCR after any of these resets.

Table 6.6 lists the pin related to the reset function.

Table 6.6 Reset I/O pin

Pin name	I/O	Function
RES	Input	Reset pin

Table 6.4 发生复位时SOSC的状态

		重置源	
		POR	**Other**
SOSC	启用或禁用	初始化为启用	继续使用重置发生之前选择的状态
	驱动能力	继续使用重置发生之前选择的状态	

Table 6.5 发生复位时的LOCO状态

		重置源	
		POR、LVD0、LVD1、LVD2深度软件待机（DEEPCUT[0]=1）	**Other**
LOCO	启用或禁用	初始化为启用	
	Oscillation accuracy*1	由LOCOUTCR微调前初始化为精度（精度：±15%）	继续使用被修剪的精度 LOCOUTCR

Note 1. LOCO用户微调控制寄存器(LOCOUTCR)通过POR、LVD0、LVD1、LVD2和深度软件待机(DEEPCUT[0]=1)复位，将LOCO返回到默认振荡精度。要恢复预复位的LOCO振荡精度，请在任何这些复位后将所需的微调值重新加载到LOCOUTCR。

表6.6列出了与复位功能相关的引脚。

Table 6.6 复位IO引脚

引脚名称	I/O	Function
RES	Input	复位引脚

RA生态工作室

6.2 Register Descriptions

6.2.1 Reset Status Register 0 (RSTSR0)

Address(es): SYSTEM.RSTSR0 4001 E410h

	b7	b6	b5	b4	b3	b2	b1	b0
	DPSRSTF	—	—	—	LVD2RF	LVD1RF	LVD0RF	PORF
Value after reset:	x*1	0	0	0	x*1	x*1	x*1	x*1

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	PORF	Power-On Reset Detect Flag	0: Power-on reset not detected 1: Power-on reset detected.	R(/W)*2
b1	LVD0RF	Voltage Monitor 0 Reset Detect Flag	0: Voltage monitor 0 reset not detected 1: Voltage monitor 0 reset detected.	R(/W)*2
b2	LVD1RF	Voltage Monitor 1 Reset Detect Flag	0: Voltage monitor 1 reset not detected 1: Voltage monitor 1 reset detected.	R(/W)*2
b3	LVD2RF	Voltage Monitor 2 Reset Detect Flag	0: Voltage monitor 2 reset not detected 1: Voltage monitor 2 reset detected.	R(/W)*2
b6 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	DPSRSTF	Deep Software Standby Reset Flag	0: Deep Software Standby mode cancellation not requested by an interrupt 1: Deep Software Standby mode cancellation requested by an interrupt.	R(/W)*2

Note 1. The value after reset depends on the reset source.
Note 2. Only 0 can be written to clear the flag. The flag must be cleared by writing 0 after 1 is read.

PORF flag (Power-On Reset Detect Flag)

The PORF flag indicates that a power-on reset occurred.

[Setting condition]

- When a power-on reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to PORF.

LVD0RF flag (Voltage Monitor 0 Reset Detect Flag)

The LVD0RF flag indicates that the VCC voltage fell below V_{det0}.

[Setting condition]

- When a voltage monitor 0 reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to LVD0RF.

LVD1RF flag (Voltage Monitor 1 Reset Detect Flag)

The LVD1RF flag indicates that the VCC voltage fell below V_{det1}.

[Setting condition]

- When a voltage monitor 1 reset occurs.

6.2 注册说明

6.2.1 复位状态寄存器0(RSTSR0)

Address(es): SYSTEM.RSTSR0 4001 E410h

	b7	b6	b5	b4	b3	b2	b1	b0
	DPSRSTF	—	—	—	LVD2RF	LVD1RF	LVD0RF	PORF
重置后的值:	x*1	0	0	0	x*1	x*1	x*1	x*1

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	PORF	上电复位检测标志	0：未检测到上电复位1：检测到上电复位。	R(/W)*2
b1	LVD0RF	电压监视器0复位检测标志	0：未检测到电压监控器0复位1：检测到电压监控器0复位。	R(/W)*2
b2	LVD1RF	电压监视器1复位检测标志	0：未检测到电压监控器1复位1：检测到电压监控器1复位。	R(/W)*2
b3	LVD2RF	电压监视器2复位检测标志	0：未检测到电压监控器2复位1：检测到电压监控器2复位。	R(/W)*2
b6 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	DPSRSTF	深度软件待机复位标志	0：中断未请求深度软件待机模式取消1：中断请求深度软件待机模式取消。	R(/W)*2

Note 1. 复位后的值取决于复位源。
Note 2. 只能写入0来清除标志。该标志必须在读取1后写入0来清除。

PORF标志（上电复位检测标志）

PORF标志表示发生了上电复位。

[Setting condition]

- 发生上电复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 当从PORF读取1然后将0写入PORF。

LVD0RF标志（电压监视器0复位检测标志）

LVD0RF标志表示VCC电压低于Vdet0。

[Setting condition]

- 发生电压监视器0复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 从LVD0RF读取1然后将0写入LVD0RF。

LVD1RF标志（电压监视器1复位检测标志）

LVD1RF标志表示VCC电压低于Vdet1。

[Setting condition]

- 当电压监视器1发生复位时。

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to LVD1RF.

LVD2RF flag (Voltage Monitor 2 Reset Detect Flag)

The LVD2RF flag indicates that the VCC voltage fell below V_{det2}.

[Setting condition]

- When a voltage monitor 2 reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to LVD2RF.

DPSRSTF flag (Deep Software Standby Reset Flag)

The DPSRSTF flag indicates that Deep Software Standby mode is canceled by an external or internal interrupt, and that an internal reset (Deep Software Standby reset) occurs when an exception from Deep Software Standby mode occurs.

[Setting condition]

- When Deep Software Standby mode is canceled by an external or internal interrupt. For details, see section 11, Low Power Modes.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to DPSRSTF.

6.2.2 Reset Status Register 1 (RSTSR1)

Address(es): SYSTEM.RSTSR1 4001 E0C0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SPERF	BUSMRF	BUSSRF	—	RPERF	—	—	—	—	—	SWRF	WDTRF	IWDTRF
Value after reset:	0	0	0	x*1	x*1	x*1	x*1	x*1	0	0	0	0	0	x*1	x*1	x*1

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	IWDTRF	Independent Watchdog Timer Reset Detect Flag	0: Independent watchdog timer reset not detected 1: Independent watchdog timer reset detected.	R(/W) *2
b1	WDTRF	Watchdog Timer Reset Detect Flag	0: Watchdog timer reset not detected 1: Watchdog timer reset detected.	R(/W) *2
b2	SWRF	Software Reset Detect Flag	0: Software reset not detected 1: Software reset detected.	R(/W) *2
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b8	RPERF	SRAM Parity Error Reset Detect Flag	0: SRAM parity error reset not detected 1: SRAM parity error reset detected.	R(/W) *2
b9	—	Reserved	The write value should be 0.	R/W
b10	BUSSRF	Bus Slave MPU Error Reset Detect Flag	0: Bus slave MPU error reset not detected 1: Bus slave MPU error reset detected.	R(/W) *2
b11	BUSMRF	Bus Master MPU Error Reset Detect Flag	0: Bus master MPU error reset not detected 1: Bus master MPU error reset detected.	R(/W) *2
b12	SPERF	SP Error Reset Detect Flag	0: SP error reset not detected 1: SP error reset detected.	R(/W) *2

[Clearing conditions]

- 发生表6.2中列出的复位时
- 从LVD1RF读取1然后将0写入LVD1RF。

LVD2RF标志（电压监视器2复位检测标志）

LVD2RF标志表示VCC电压低于Vdet2。

[Setting condition]

- 当电压监视器2发生复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 当从1读取然后0写入LVD2RF。

DPRSTF标志（深度软件待机复位标志）

DPSRSTF标志表示深度软件待机模式被外部或内部中断取消，并且当深度软件待机模式发生异常时发生内部复位（深度软件待机复位）。

[Setting condition]

- 当深度软件待机模式被外部或内部中断取消时。有关详细信息，请参阅第11节，低电源模式。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 当从1被读取，然后0被写入DPRSTF。

6.2.2 复位状态寄存器1(RSTSR1)

Address(es): SYSTEM.RSTSR1 4001 E0C0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SPERF	BUSMRF	BUSSRF	—	RPERF	—	—	—	—	—	SWRF	WDTRF	IWDTRF
重置后的值:	0	0	0	x*1	x*1	x*1	x*1	x*1	0	0	0	0	0	x*1	x*1	x*1

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	IWDTRF	独立看门狗定时器复位检测标志	0：未检测到独立看门狗定时器复位1：检测到独立看门狗定时器复位。	R(/W) *2
b1	WDTRF	看门狗定时器复位检测标志	0：未检测到看门狗定时器复位1：检测到看门狗定时器复位。	R(/W) *2
b2	SWRF	软件复位检测标志	0：未检测到软件复位1：检测到软件复位。	R(/W) *2
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b8	RPERF	SRAM奇偶校验错误复位检测标志	0：未检测到SRAM奇偶校验错误复位1：检测到SRAM奇偶校验错误复位。	R(/W) *2
b9	—	Reserved	写入值应为0。	R/W
b10	BUSSRF	总线从机MPU错误复位检测标志	0：未检测到总线从机MPU错误复位1：检测到总线从机MPU错误复位。	R(/W) *2
b11	BUSMRF	总线主控MPU错误复位检测标志	0：未检测到总线主控MPU错误复位1：检测到总线主控MPU错误复位。	R(/W) *2
b12	SPERF	SP错误复位检测标志	0：未检测到SP错误复位1：检测到SP错误复位。	R(/W) *2

Bit	Symbol	Bit name	Description	R/W
b15 to b13	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. The value after reset depends on the reset source.
Note 2. Only 0 can be written to clear the flag. The flag must be cleared by writing 0 after 1 is read.

IWDTRF flag (Independent Watchdog Timer Reset Detect Flag)

The IWDTRF flag indicates that an independent watchdog timer reset occurs.

[Setting condition]

- When an independent watchdog timer reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to IWDTRF.

WDTRF flag (Watchdog Timer Reset Detect Flag)

The WDTRF flag indicates that a watchdog timer reset occurs.

[Setting condition]

- When a watchdog timer reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to WDTRF.

SWRF flag (Software Reset Detect Flag)

The SWRF flag indicates that a software reset occurs.

[Setting condition]

- When a software reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to SWRF.

RPERF flag (SRAM Parity Error Reset Detect Flag)

The RPERF flag indicates that a SRAM parity error reset occurs.

[Setting condition]

- When a SRAM parity error reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to RPERF.

BUSSRF flag (Bus Slave MPU Error Reset Detect Flag)

The BUSSRF flag indicates that a bus slave MPU error reset occurs.

[Setting condition]

- When a bus slave MPU error reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs

Bit	Symbol	位名称	Description	R/W
b15 to b13	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 复位后的值取决于复位源。
Note 2. 只能写入0来清除标志。该标志必须在读取1后写入0来清除。

IWDTRF标志（独立看门狗定时器复位检测标志）

IWDTRF标志指示发生了独立的看门狗定时器复位。

[Setting condition]

- 当发生独立的看门狗定时器复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 从IWDTRF读取1然后将0写入IWDTRF。

WDTRF标志（看门狗定时器复位检测标志）

WDTRF标志指示发生了看门狗定时器复位。

[Setting condition]

- 当发生看门狗定时器复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 当从WDTRF读取1然后将0写入WDTRF。

SWRF标志（软件复位检测标志）

SWRF标志表示发生了软件复位。

[Setting condition]

- 当发生软件复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 从1读取然后0写入SWRF。

RPERF标志（SRAM奇偶校验错误复位检测标志）

RPERF标志表示发生SRAM奇偶校验错误复位。

[Setting condition]

- 当SRAM奇偶校验错误复位发生时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 当从RPERF读取1然后将0写入RPERF。

BUSSRF标志（总线从机MPU错误复位检测标志）

BUSSRF标志表示发生总线从MPU错误复位。

[Setting condition]

- 当发生总线从机MPU错误复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时

- When 1 is read from and then 0 is written to BUSSRF.

BUSMRF flag (Bus Master MPU Error Reset Detect Flag)

The BUSMRF flag indicates that a bus master MPU error reset occurs.

[Setting condition]

- When a bus master MPU error reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to BUSMRF.

SPERF flag (SP Error Reset Detect Flag)

The SPERF flag indicates that a stack pointer error reset occurs.

[Setting condition]

- When a stack pointer error reset occurs.

[Clearing conditions]

- When a reset listed in Table 6.2 occurs
- When 1 is read from and then 0 is written to SPERF.

6.2.3 Reset Status Register 2 (RSTSR2)

Address(es): SYSTEM.RSTSR2 4001 E411h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CWSF
Value after reset:	0	0	0	0	0	0	0	x*1

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	CWSF	Cold/Warm Start Determination Flag	0: Cold start 1: Warm start.	R(/W) *2
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. The value after reset depends on the reset source.
Note 2. Only 1 can be written to set the flag.

RSTSR2 determines whether a power-on reset caused the reset processing (cold start) or a reset signal input during operation caused the reset processing (warm start).

CWSF flag (Cold/Warm Start Determination Flag)

The CWSF flag indicates the type of reset processing, either cold start or warm start. The CWSF flag is initialized by a power-on reset. It is not initialized by a reset signal generated by the RES pin.

[Setting condition]

- When 1 is written by software. Writing 0 to CWSF does not set it to 0.

[Clearing condition]

- When a reset listed in Table 6.2 occurs.

- 当从1被读取然后0被写入BUSSRF。

BUSMRF标志（总线主控MPU错误复位检测标志）

BUSMRF标志指示发生总线主控MPU错误复位。

[Setting condition]

- 当发生总线主控MPU错误复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 读取1，然后将0写入BUSMRF。

SPERF标志（SP错误复位检测标志）

SPERF标志表示发生堆栈指针错误复位。

[Setting condition]

- 发生堆栈指针错误复位时。

[Clearing conditions]

- 发生表6.2中列出的复位时
- 当从SPERF读取1然后将0写入SPERF。

6.2.3 复位状态寄存器2(RSTSR2)

Address(es): SYSTEM.RSTSR2 4001 E411h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CWSF
重置后的值：	0	0	0	0	0	0	0	x*1

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	CWSF	冷暖启动确定标志	0：冷启动1： 热启动。	R(/W) *2
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 复位后的值取决于复位源。
Note 2. 只能写入1来设置标志。

RSTSR2判断是上电复位导致复位处理（冷启动）还是操作期间输入的复位信号导致复位处理（热启动）。

CWSF标志（冷暖启动确定标志）

CWSF标志指示复位处理的类型，冷启动或热启动。CWSF标志由上电复位初始化。它不会被RES引脚产生的复位信号初始化。

[Setting condition]

- 当1由软件写入时。将0写入CWSF不会将其设置为0。

[Clearing condition]

- 发生表6.2中列出的复位时。

6.2.4 Reset Control Register 1 (RCR1)

Address(es): RTC.RCR1 4004 4022h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—
Value after reset:	x	x	x	x	0	x	0	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	—	Reserved	The write value should be 0.	R/W
b1	—	Reserved	The write value should be 0.	R/W
b2	—	Reserved	The write value should be 0.	R/W
b3	—	Reserved	The write value should be 0.	R/W
b7 to b4	—	Reserved	The write value should be 0.	R/W

6.2.5 Reset Control Register 2 (RCR2)

Address(es): RTC.RCR2 4004 4024h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	RESET	—
Value after reset:	x	x	x	x	0	0	0	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	—	Reserved	The write value should be 0.	R/W
b1	RESET	Software Reset	• In writing 0: Invalid (writing 0 has no effect) 1: The target registers for software reset are initialized. • In reading 0: Software reset has completed 1: Software reset in progress.	R/W
b3 to b2	—	Reserved	The write value should be 0.	R/W
b7 to b4	—	Reserved	The write value should be 0.	R/W

6.2.6 Reset Control Register 4 (RCR4)

Address(es): RTC.RCR4 4004 4028h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	RCKSEL
Value after reset:	0	0	0	0	0	0	0	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	RCKSEL	Count Source Select	0: Sub-clock oscillator is not used 1: Sub-clock oscillator is used.	R/W
b7 to b1	—	Reserved	The write value should be 0.	R/W

6.2.4 复位控制寄存器1(RCR1)

Address(es): RTC.RCR1 4004 4022h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—
重置后的值:	x	x	x	x	0	x	0	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	—	Reserved	写入值应为0。	R/W
b1	—	Reserved	写入值应为0。	R/W
b2	—	Reserved	写入值应为0。	R/W
b3	—	Reserved	写入值应为0。	R/W
b7 to b4	—	Reserved	写入值应为0。	R/W

6.2.5 复位控制寄存器2(RCR2)

Address(es): RTC.RCR2 4004 4024h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	RESET	—
重置后的值:	x	x	x	x	0	0	0	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	—	Reserved	写入值应为0。	R/W
b1	RESET	软件复位	写入0：无效（写入0无效）1：初始化软件复位的目标寄存器。 读取中0：软件复位已完成1：软件复位正在进行中。	R/W
b3 to b2	—	Reserved	写入值应为0。	R/W
b7 to b4	—	Reserved	写入值应为0。	R/W

6.2.6 复位控制寄存器4(RCR4)

Address(es): RTC.RCR4 4004 4028h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	RCKSEL
重置后的值:	0	0	0	0	0	0	0	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	RCKSEL	计数源选择	0：不使用副时钟振荡器1：使用副时钟振荡器。	R/W
b7 to b1	—	Reserved	写入值应为0。	R/W

6.3 Operation

6.3.1 RES Pin Reset

The RES pin generates this reset. When the RES pin is driven low, all the processing in progress is aborted and the MCU enters a reset state. To successfully reset the MCU, the RES pin must be held low for the power supply stabilization time specified at power-on.

When the RES pin is driven high from low, the internal reset is canceled after the post-RES cancellation wait time (t_{RESWT}) elapses. The CPU then starts the reset exception handling.

For details, see section 43, Electrical Characteristics.

6.3.2 Power-On Reset

The power-on reset (POR) is an internal reset generated by the power-on reset circuit. If the RES pin is in a high-level state when power is supplied, a power-on reset is generated. After VCC exceeds V_{POR} and the specified power-on reset time elapses, the internal reset is canceled and the CPU starts the reset exception handling. The power-on reset time is the stabilization period for the external power supply and the MCU circuit. After a power-on reset is generated, the PORF flag in the RSTSR0 is set to 1. The PORF flag is initialized by the RES pin reset.

The voltage monitor 0 reset is an internal reset generated by the voltage monitor circuit. If the Voltage Detection 0 Circuit Start (LVDAS) bit in the Option Function Select Register 1 (OFS1) is 0 (voltage monitor 0 reset is enabled after a reset) and VCC falls below V_{det0}, the RSTSR.LVD0RF flag is set to 1 and the voltage detection circuit generates voltage monitor 0 reset. Clear the OFS1.LVDAS bit to 0 if the voltage monitor 0 reset is to be used.

After VCC exceeds V_{det0} and the voltage monitor 0 reset time (tLVD0) elapses, the internal reset is canceled and the CPU starts the reset exception handling. The V_{det0} voltage detection level can be changed by the setting in the VDSEL[1:0] bits in Option Function Select Register 1 (OFS1).

Figure 6.1 shows example of operations during a power-on reset and voltage monitor 0 reset.

6.3 Operation

6.3.1 RES引脚复位

RES引脚产生此复位。当RES引脚被驱动为低电平时，所有正在进行的处理都被中止，MCU进入复位状态。要成功复位MCU，RES引脚必须在上电时指定的电源稳定时间内保持低电平。

当RES引脚从低电平驱动为高电平时，内部复位会在RES取消后等待时间(tRESWT)过去后取消。CPU然后开始复位异常处理。

有关详细信息，请参阅第43节，电气特性。

6.3.2 Power-On Reset

上电复位（POR）是由上电复位电路产生的内部复位。如果上电时RES管脚处于高电平状态，则产生上电复位。VCC超过VPOR并经过规定的上电复位时间后，内部复位被取消，CPU开始复位异常处理。上电复位时间是外部电源和MCU电路的稳定期。上电复位产生后，RSTSR0中的PORF标志设置为1。PORF标志由RES引脚复位初始化。

电压监控器0复位是由电压监控器电路产生的内部复位。如果选项功能选择寄存器1(OFS1)中的电压检测0电路启动(LVDAS)位为0（复位后使能电压监视器0复位）并且VCC降至Vdet0以下，则RSTSR0.LVD0RF标志设置为1电压检测电路产生电压监测0复位。如果要使用电压监视器0复位，则将OFS1.LVDAS位清零。

在VCC超过Vdet0并且电压监视器0复位时间(tLVD0)过去后，内部复位被取消，并且CPU启动复位异常处理。Vdet0电压检测电平可以通过在选项功能选择寄存器1(OFS1)中的VDSEL[1:0]位。

图6.1显示了上电复位和电压监视器0复位期间的操作示例。

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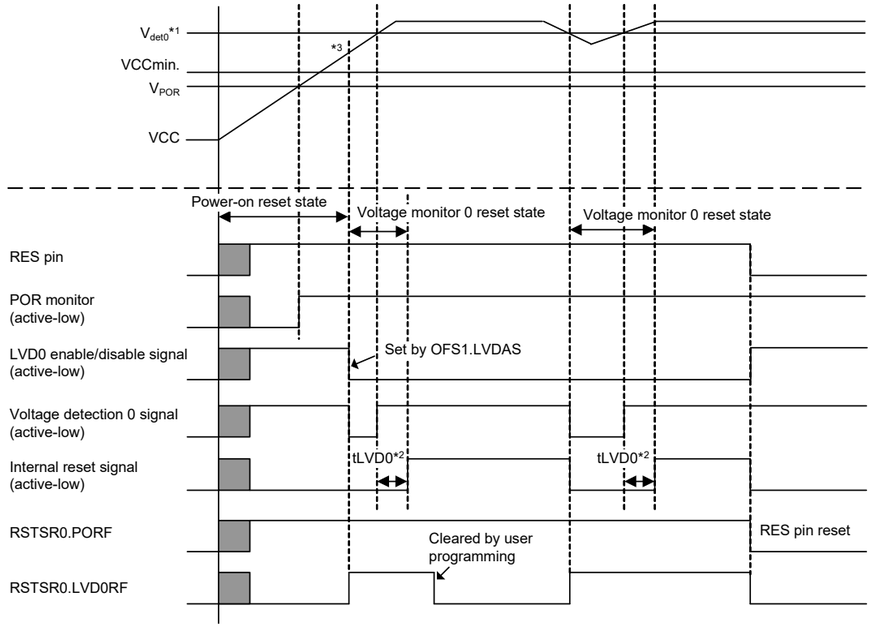


Note: For details on the electrical characteristics, see section 43, Electrical Characteristics.
Note 1. V_{det0} shows a voltage monitor 0 reset detection level, V_{POR} shows a power-on reset detection level, and VCCmin shows minimum guaranteed voltage of MCU.
Note 2. tLVD0 shows a time for voltage monitor 0 reset.
Note 3. At power-on, VCC should have risen to the minimum guaranteed voltage before the POR reset is released.

Figure 6.1 Example of operations during power-on and voltage monitor 0 resets

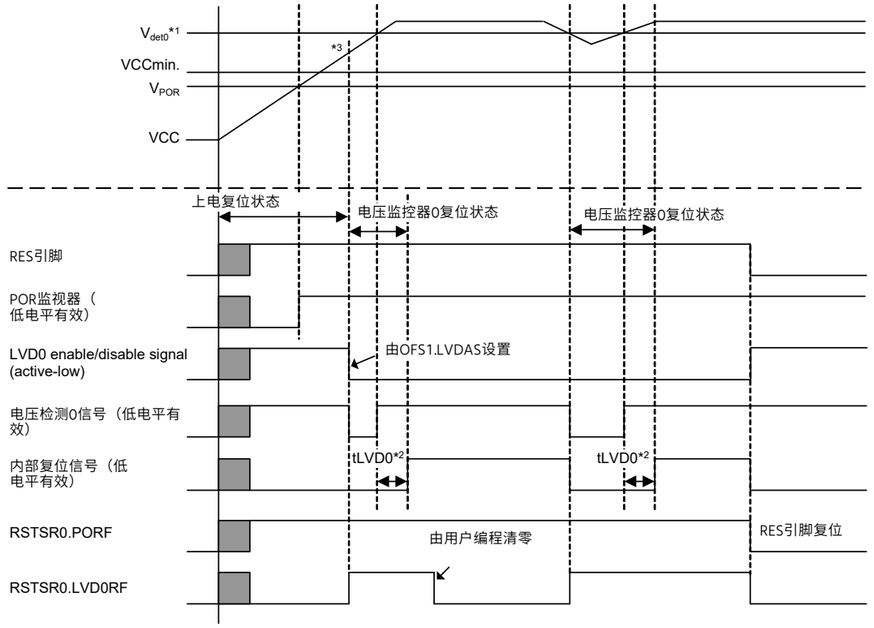
6.3.3 Voltage Monitor Reset

The voltage monitor 0 reset is an internal reset generated by the voltage monitor circuit. If the Voltage Detection 0 Circuit Start (LVDAS) bit in the Option Function Select Register 1 (OFS1) is 0 (voltage monitor 0 reset is enabled after a reset) and VCC falls below V_{det0}, the RSTSR0.LVD0RF flag becomes 1 and the voltage detection circuit generates a voltage monitor 0 reset. Clear the OFS1.LVDAS bit to 0 if the voltage monitor 0 reset is to be used. After VCC exceeds V_{det0} and the voltage monitor 0 reset time (tLVD0) elapses, the internal reset is canceled and the CPU starts the reset exception handling.

When the Voltage Monitor 1 Interrupt/Reset Enable bit (RIE) is set to 1 (enabling generation of a reset or interrupt by the voltage detection circuit) and the Voltage Monitor 1 Circuit Mode Select bit (LVD1CR0.RI) is set to 1 (selecting generation of a reset in response to detection of a low voltage) in the Voltage Monitor 1 Circuit Control Register 0 (LVD1CR0), the RSTSR0.LVD1RF flag is set to 1 and the voltage detection circuit generates a voltage monitor 1 reset if VCC falls to or below V_{det1}.

Likewise, when the Voltage Monitor 2 Interrupt/Reset Enable bit (RIE) is set to 1 (enabling generation of a reset or interrupt by the voltage detection circuit) and the Voltage Monitor 2 Circuit Mode Select bit (LVD2CR0.RI) is set to 1 (selecting generation of a reset in response to detection of a low voltage) in Voltage Monitor 2 Circuit Control Register 0 (LVD2CR0), the RSTSR0.LVD2RF flag is set to 1 and the voltage detection circuit generates a voltage monitor 2 reset if VCC falls to or below V_{det2}.

Similarly, timing for release from the voltage monitor 1 reset state is selectable in the Voltage Monitor 1 Reset Negate Select bit (RN) in the LVD1CR0 register. When the LVD1CR0.RN bit is 0 and VCC falls to or below V_{det1}, the CPU is released from the internal reset state and starts reset exception handling when the LVD1 reset time (tLVD1) elapses after VCC rises above V_{det1}. When the LVD1CR0.RN bit is 1 and VCC falls to or below V_{det1}, the CPU is released from the



Note: 有关电气特性的详细信息，请参见第43节，电气特性。
Note 1. Vdet0表示电压监视器0复位检测电平，VPOR表示上电复位检测电平，VCCmin表示MCU的最低保证电压。
Note 2. tLVD0显示电压监视器0复位的时间。
Note 3. 上电时，VCC应该在POR复位释放之前上升到最低保证电压。

Figure 6.1 上电和电压监控0复位期间的操作示例

6.3.3 电压监视器复位

电压监控器0复位是由电压监控器电路产生的内部复位。如果电压检测0选项功能选择寄存器1(OFS1)中的电路启动(LVDAS)位为0（复位后使能电压监控器0复位）且VCC低于Vdet0，RSTSR0.LVD0RF标志变为1，电压检测电路产生一个电压监视器0复位。如果要使用电压监视器0复位，则将OFS1.LVDAS位清零。在VCC超过Vdet0并且电压监视器0复位时间(tLVD0)过去后，内部复位被取消，CPU开始复位异常处理。

当电压监视器1中断复位使能位(RIE)设置为1（允许电压检测电路产生复位或中断）并且电压监视器1电路模式选择位(LVD1CR0.RI)设置为1（选择电压监控器1电路控制寄存器0(LVD1CR0)中的低电压检测产生复位），RSTSR0.LVD1RF标志设置为1，如果VCC下降到电压检测电路产生电压监控器1复位或低于Vdet1。

同样，当电压监控器2中断复位允许位(RIE)设置为1（允许电压检测电路产生复位或中断）并且电压监控器2电路模式选择位(LVD2CR0.RI)设置为1时（响应检测到低电压选择产生复位）在电压监控器2电路控制寄存器0(LVD2CR0)中，RSTSR0.LVD2RF标志设置为1，如果VCC下降，电压检测电路产生电压监控器2复位到或低于Vdet2。

类似地，从电压监视器1复位状态释放的时间可在电压监视器1复位否定中选择LVD1CR0寄存器中的选择位(RN)。当LVD1CR0.RN位为0且VCC下降到或低于Vdet1时，CPU会从内部复位状态中释放并在VCC上升到Vdet1以上后经过LVD1复位时间(tLVD1)时开始复位异常处理。当LVD1CR0.RN位为1且VCC下降到或低于Vdet1时，CPU从

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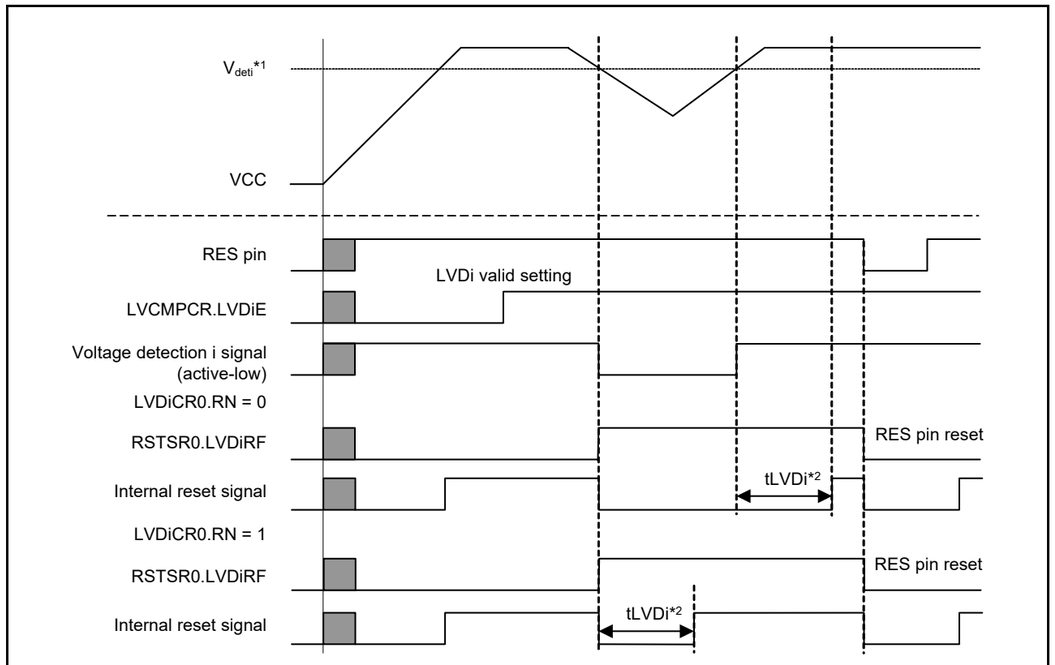
internal reset state and starts reset exception handling when the LVD1 reset time (tLVD1) elapses.

Likewise, timing for release from the voltage monitor 2 reset state is selectable in the Voltage Monitor 2 Reset Negate Select bit (RN) in the LDV2CR0 register.

Detection levels V_{det1} and V_{det2} can be changed in the Voltage Detection Level Select Register (LDVLVLR).

Figure 6.2 shows an example of operations during voltage monitor 1 and 2 resets. For details on the voltage monitor 1 reset and voltage monitor 2 reset, see section 8, Low Voltage Detection (LVD).



Note: For details on the electrical characteristics, see section 43, Electrical Characteristics.
Note 1. V_{deti} indicates the detection level of a voltage monitor 1 reset and voltage monitor 2 reset (i = 1, 2).
Note 2. tLVDi indicates the time for a voltage monitor 1 reset and voltage monitor 2 reset (i = 1, 2).

Figure 6.2 Example of operations during voltage monitor 1 and voltage monitor 2 resets

6.3.4 Deep Software Standby Reset

The deep software standby reset is an internal reset generated when Deep Software Standby mode is canceled by an associated interrupt. The deep software standby reset is canceled after tDSBY (return time after Deep Software Standby mode cancellation) elapses.

When tDSBYWT (wait time after Deep Software Standby mode cancellation) elapses after Deep Software Standby mode is canceled, the internal reset is canceled and the CPU starts the reset exception handling.

For details on the deep software standby reset, see section 11, Low Power Modes.

6.3.5 Independent Watchdog Timer Reset

The independent watchdog timer reset is an internal reset generated from the Independent Watchdog Timer (IWDT). Output of the reset from the IWDT can be selected in the Option Function Select Register 0 (OFS0).

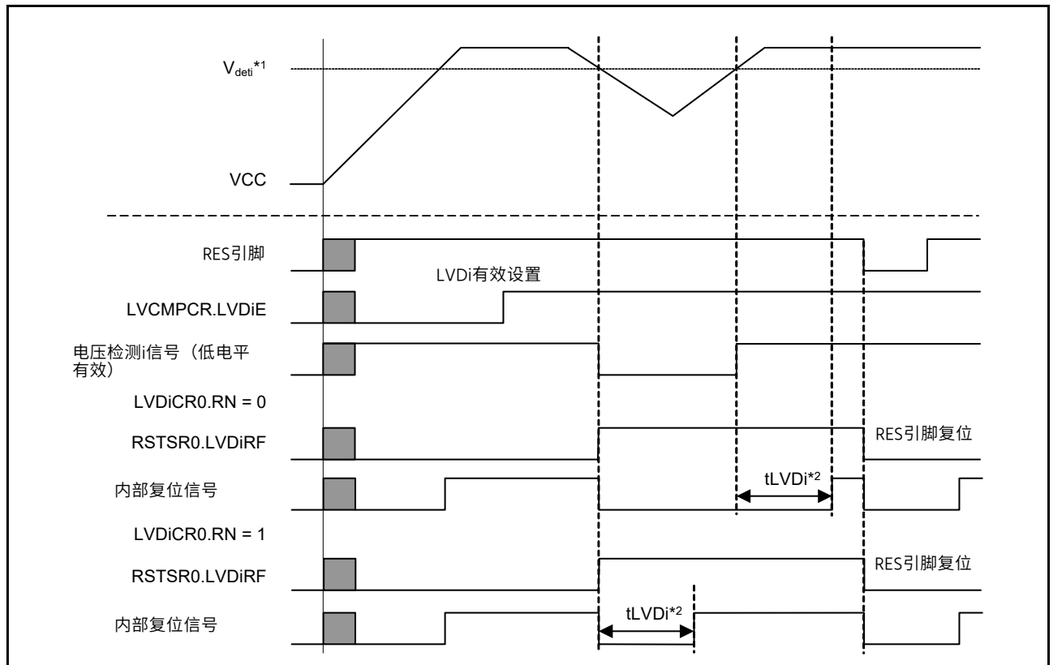
When output of the independent watchdog timer reset is selected, the reset is generated if the IWDT underflows, or if data is written when refresh operation is disabled. When the internal reset time (tRESW2) elapses after the independent watchdog timer reset is generated, the internal reset is canceled and the CPU starts the reset exception handling.

内部复位状态，并在LVD1复位时间(tLVD1)结束时开始复位异常处理。

同样，从电压监视器2复位状态中释放的时间可在电压监视器2复位否定中选择LDV2CR0寄存器中的选择位(RN)。

检测电平Vdet1和Vdet2可以在电压检测电平选择寄存器(LDVLVLR)中更改。

图6.2显示了电压监视器1和2复位期间的操作示例。有关电压监视器1复位和电压监视器2复位的详细信息，请参阅第8节，低电压检测(LVD)。



Note: 有关电气特性的详细信息，请参见第43节，电气特性。
Note 1. Vdeti表示电压监视器1复位和电压监视器2复位(i=1 2)的检测电平。
Note 2. tLVDi表示电压监视器1复位和电压监视器2复位的时间(i=1 2)。

Figure 6.2 电压监控器1和电压监控器2复位期间的操作示例

6.3.4 深度软件待机复位

深度软件待机复位是在深度软件待机模式被相关中断取消时产生的内部复位。深度软件待机复位在tDSBY（深度软件待机模式取消后的返回时间）过去后取消。

当深度软件待机模式取消后经过tDSBYWT（深度软件待机模式取消后的等待时间）时，内部复位被取消并且CPU开始复位异常处理。

有关深度软件待机复位的详细信息，请参见第11节，低功耗模式。

6.3.5 独立看门狗定时器复位

独立看门狗定时器复位是由独立看门狗定时器（IWDT）产生的内部复位。
可以在选项功能选择寄存器0(OFS0)中选择IWDT的复位输出。

Whenoutputoftheindependentwatchdogtimerresetisselected theresetisgeneratediftheIWDTunderflows orifdataiswrittenwhenrefreshoperationisdisabled.当独立看门狗定时器复位产生后经过内部复位时间(tRESW2)时，内部复位被取消，CPU开始复位异常处理。

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For details on the independent watchdog timer reset, see section 26, Independent Watchdog Timer (IWDT).

6.3.6 Watchdog Timer Reset

The watchdog timer reset is an internal reset generated from the Watchdog Timer (WDT). Output of the reset from the WDT can be selected in the WDT Reset Control Register (WDTRCR) or Option Function Select Register 0 (OFS0).

When output of the watchdog timer reset is selected, the reset is generated if the WDT underflows, or if data is written when refresh operation is disabled. When the internal reset time (tRESW2) elapses after the watchdog timer reset is generated, the internal reset is canceled and the CPU starts the reset exception handling.

For details on the watchdog timer reset, see section 25, Watchdog Timer (WDT).

6.3.7 Software Reset

Software reset is an internal reset generated by a software setting of the SYSRESETREQ bit in the AIRCR register in the Arm core. When the SYSRESETREQ bit is set to 1, a software reset is generated. When the internal reset time (tRESW2) elapses after a software reset is generated, the internal reset is canceled and the CPU starts the reset exception handling.

For details on the SYSRESETREQ bit, see the *ARM® Cortex®-M4 Technical Reference Manual*.

6.3.8 Determination of Cold/Warm Start

Read the CWSF flag in RSTSR2 to determine the cause of reset processing. This flag indicates whether a power-on reset caused the reset processing (cold start) or a reset signal input during operation caused the reset processing (warm start).

The CWSF flag is set to 0 when a power-on reset occurs (cold start). Otherwise, the flag is not set to 0. The flag is set to 1 when 1 is written to it through software. It is not set to 0 even on writing 0 to it.

Figure 6.3 shows an example of a cold/warm start determination operation.

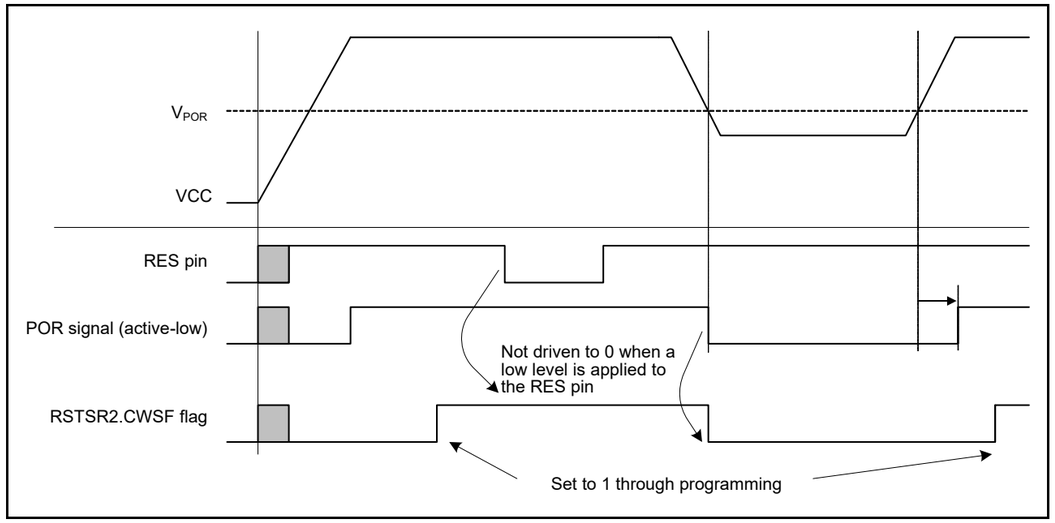


Figure 6.3 Example of a cold/warm start determination operation

6.3.9 Determination of Reset Generation Source

Read RSTSR0 and RSTSR1 to determine which reset executes the reset exception handling. Figure 6.4 shows an example of the flow to identify a reset generation source. The reset flag must be written with 0 after it is read as 1.

有关独立看门狗定时器复位的详细信息，请参见第26节，独立看门狗定时器(IWDT)。

6.3.6 看门狗定时器复位

看门狗定时器复位是由看门狗定时器(WDT)产生的内部复位。从复位输出可以在WDT复位控制寄存器(WDTRCR)或选项功能选择寄存器0(OFS0)中选择WDT。

选择看门狗定时器复位的输出时，如果WDT下溢，或者在禁止刷新操作时写入数据，则产生复位。当看门狗定时器复位产生后经过内部复位时间(tRESW2)时，内部复位被取消，CPU开始复位异常处理。

有关看门狗定时器复位的详细信息，请参见第25节，看门狗定时器(WDT)。

6.3.7 软件复位

软件复位是通过软件设置Arm内核的AIRCR寄存器中的SYSRESETREQ位产生的内部复位。当SYSRESETREQ位设置为1时，会产生软件复位。当软件复位产生后经过内部复位时间(tRESW2)时，内部复位被取消，CPU开始复位异常处理。

有关SYSRESETREQ位的详细信息，请参阅ARM®Cortex®-M4技术参考手册。

6.3.8 冷暖启动的测定

读取RSTSR2中的CWSF标志以确定复位处理的原因。该标志指示是上电复位导致复位处理（冷启动）还是操作期间输入的复位信号导致复位处理（热启动）。

发生上电复位（冷启动）时，CWSF标志设置为0。否则，该标志不设置为0。当通过软件向其写入1时，该标志设置为1。即使向其写入0，它也不会设置为0。

图6.3显示了冷暖启动确定操作的示例。

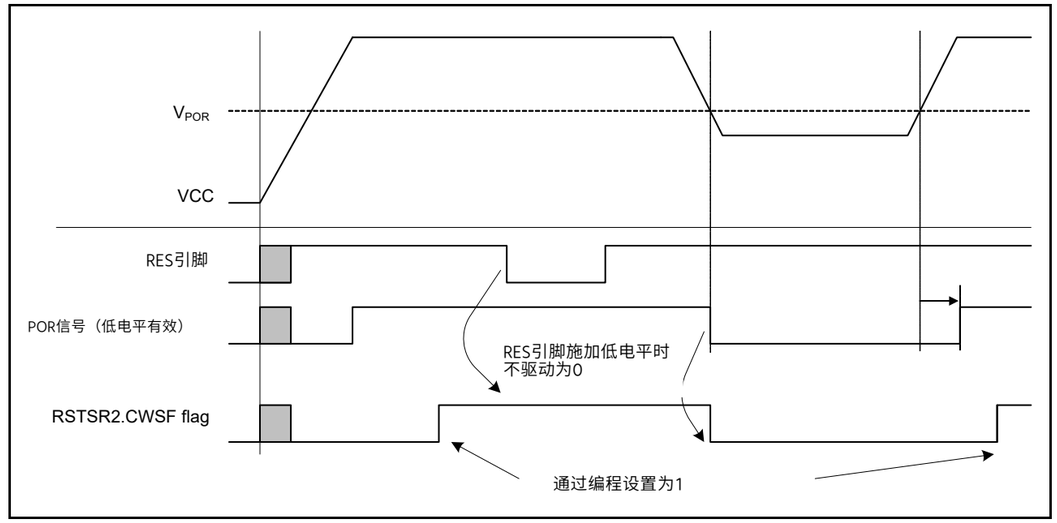
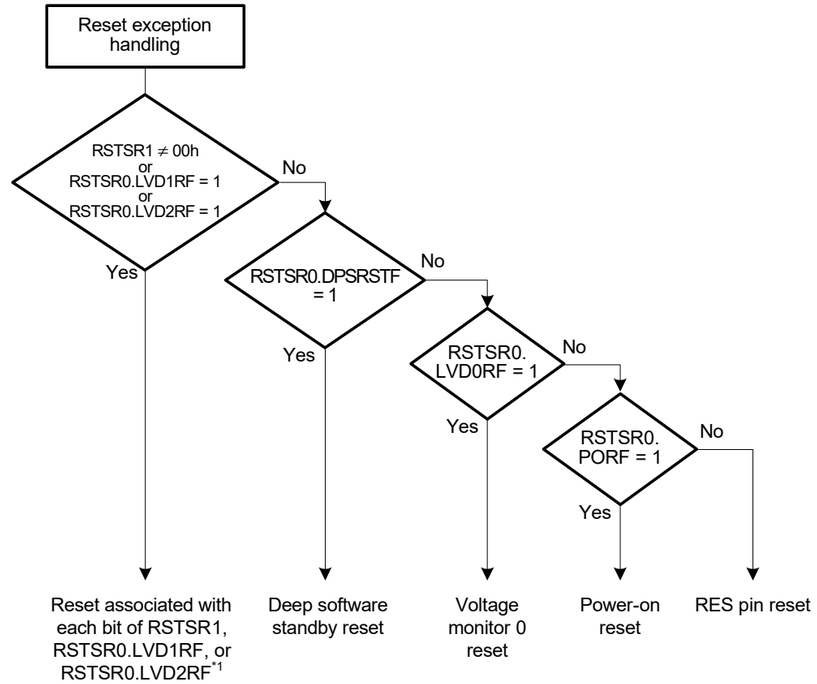


Figure 6.3 冷暖启动判定动作示例

6.3.9 复位产生源的确定

读取RSTSR0和RSTSR1以确定哪个复位执行复位异常处理。图6.4显示了识别复位产生源的流程示例。复位标志读为1后必须写为0。



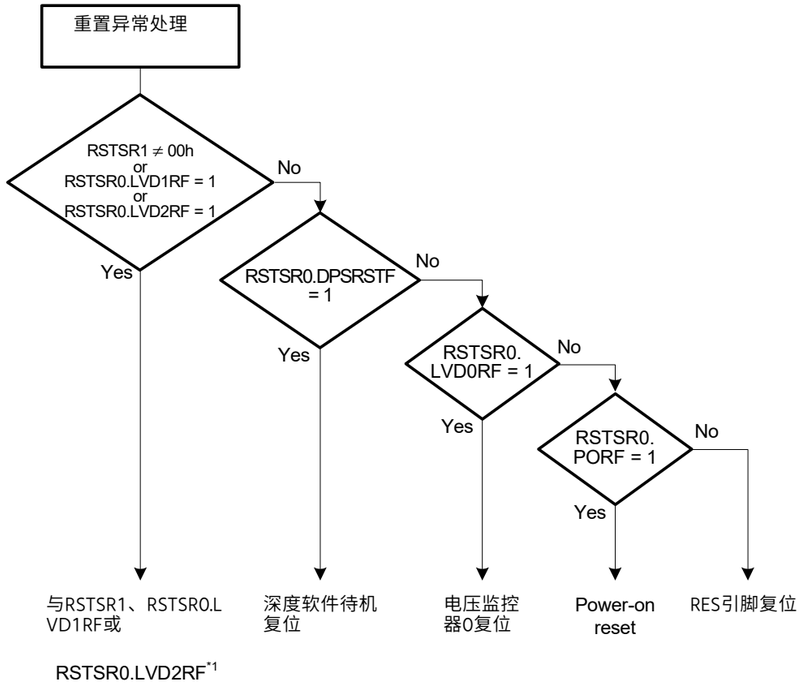
Note 1. If two or more resets associated with each bit of RSTSR1, RSTSR0.LVD1RF, or RSTSR0.LVD2RF occur at the same time, all reset flags are set to 1.

Figure 6.4 Example of reset generation source determination flow

6.4 Initialization Procedure Required after Reset

The MCU has registers that are not initialized after reset. In some cases, an unintended interrupt request may cause an increase in power consumption or malfunction. Therefore, initialize these registers after reset according to one of the procedures described in Figure 6.5 and Figure 6.6.

Figure 6.5 shows the initialization procedure in all cases and Figure 6.6 shows the initialization procedure that can be applied when the sub-clock oscillator is not used.



Note 1. 如果与RSTSR1、RSTSR0.LVD1RF或RSTSR0.LVD2RF的每一位相关的两个或多个复位同时发生，则所有复位标志都设置为1。

Figure 6.4 复位产生源确定流程示例

6.4 复位后需要的初始化程序

MCU具有复位后未初始化的寄存器。在某些情况下，意外中断请求可能会导致功耗增加或故障。因此，根据图6.5和图6.6中描述的程序之一在复位后初始化这些寄存器。

图6.5显示了所有情况下的初始化过程，图6.6显示了在不使用副时钟振荡器时可以应用的初始化过程。

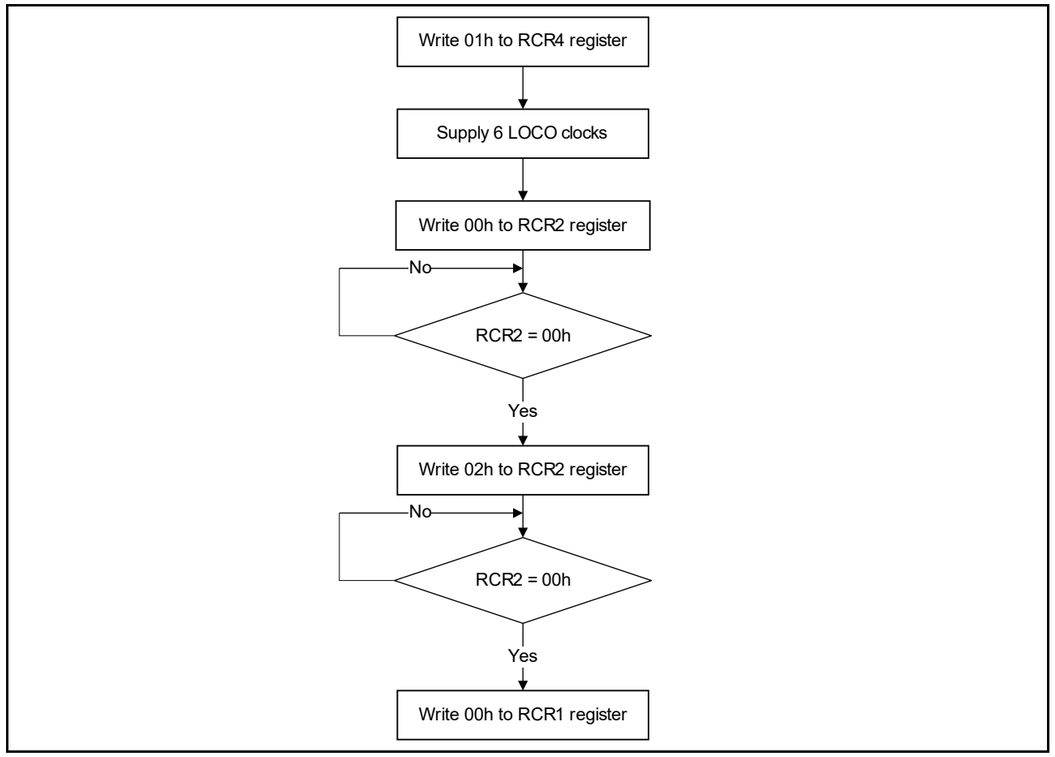


Figure 6.5 Initialization procedure for all cases

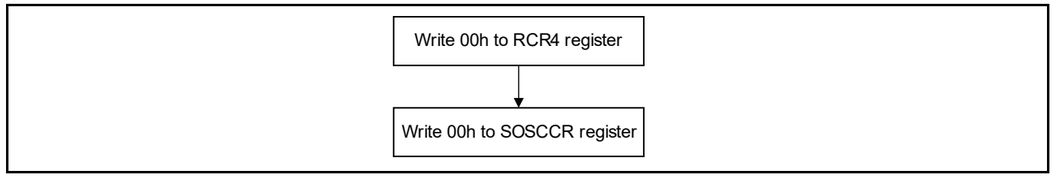


Figure 6.6 Initialization procedure when the sub-clock oscillator is not used

For more information on the SOSCCR register, see section 9, Clock Generation Circuit.

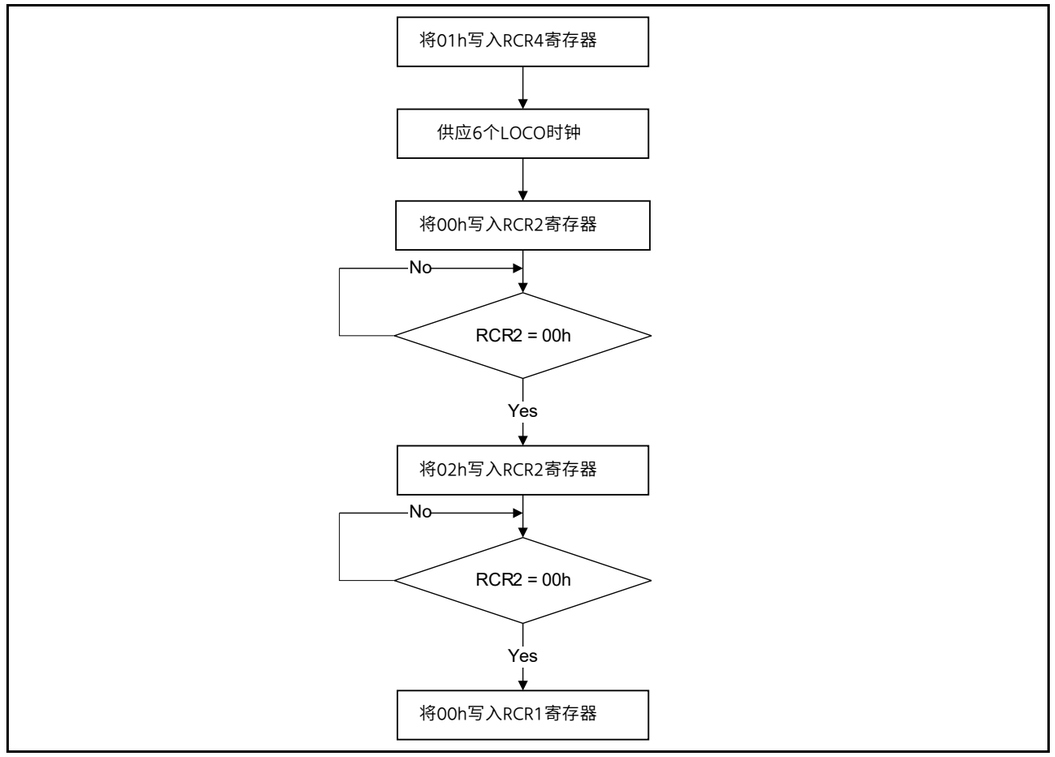


Figure 6.5 所有情况的初始化程序

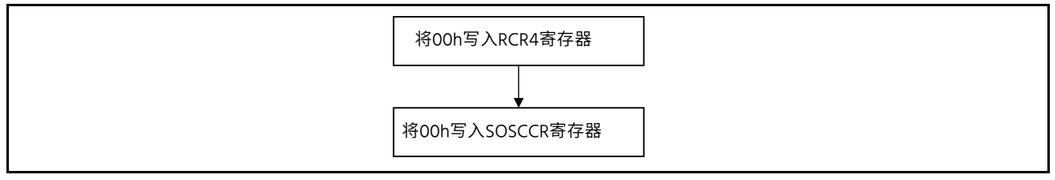


Figure 6.6 不使用副时钟振荡器时的初始化程序

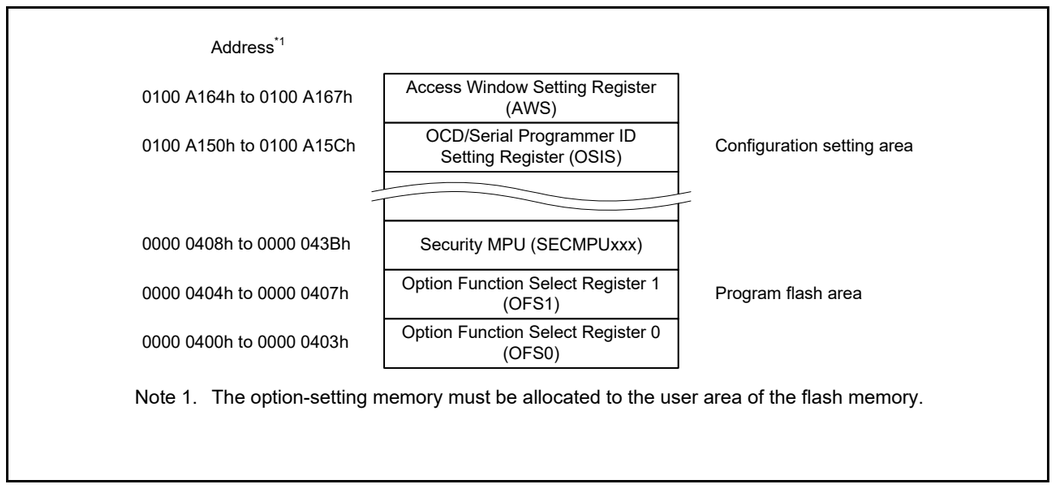
有关SOSCCR寄存器的更多信息，请参见第9节，时钟生成电路。

7. Option-Setting Memory

7.1 Overview

The option-setting memory determines the state of the MCU after a reset. The option-setting memory is allocated to the configuration setting area and the program flash area of the flash memory. The available methods of setting are different for the two areas.

Figure 7.1 shows the option-setting memory area.



Note 1. The option-setting memory must be allocated to the user area of the flash memory.

Figure 7.1 Option-setting memory area

7.2 Register Descriptions

7.2.1 Option Function Select Register 0 (OFS0)

Address(es): OFS0 0000 0400h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	WDTST PCTL	—	WDTRS TIRQS	WDTRPSS[1:0]		WDTRPES[1:0]		WDTCKS[3:0]				WDTTOPS[1:0]		WDTST RT	—
Value after reset:					User setting*1											

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	IWDTS TPCTL	—	IWDTRS TIRQS	IWDTRPSS[1:0]		IWDTRPES[1:0]		IWDTCKS[3:0]				IWDTTOPS[1:0]		IWDTS TRT	—
Value after reset:					User setting*1											

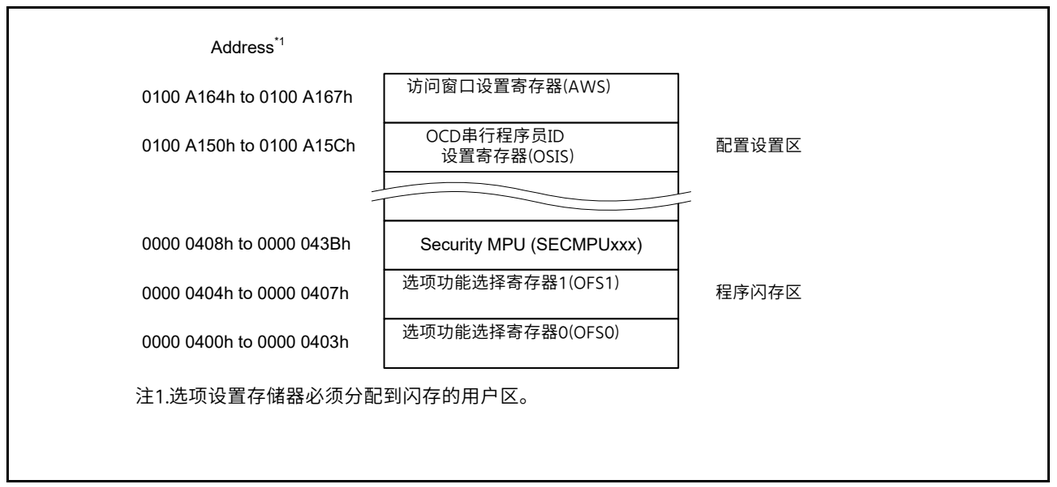
Bit	Symbol	Bit name	Description	R/W
b0	—	Reserved	When read, this bit returns the written value. The write value should be 1.	R
b1	IWDTSTRT	IWDT Start Mode Select	0: Automatically activate IWDT after a reset (auto start mode) 1: Disable IWDT.	R
b3, b2	IWDTTOPS[1:0]	IWDT Timeout Period Select	b3 b2 0 0: 128 cycles (007Fh) 0 1: 512 cycles (01FFh) 1 0: 1024 cycles (03FFh) 1 1: 2048 cycles (07FFh).	R

7. Option-Setting Memory

7.1 Overview

选项设置存储器确定复位后MCU的状态。选项设置存储器分配给闪存的配置设置区和程序闪存区。两个区域的可用设置方法不同。

图7.1显示了选项设置存储区。



注1.选项设置存储器必须分配到闪存的用户区。

Figure 7.1 选项设置存储区

7.2 注册说明

7.2.1 选项功能选择寄存器0(OFS0)

Address(es): OFS0 0000 0400h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	WDTST PCTL	—	WDTRS TIRQS	WDTRPSS[1:0]		WDTRPES[1:0]		WDTCKS[3:0]				WDTTOPS[1:0]		WDTST RT	—
重置后的值:					用户设置*1											

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	IWDTS TPCTL	—	IWDTRS TIRQS	IWDTRPSS[1:0]		IWDTRPES[1:0]		IWDTCKS[3:0]				IWDTTOPS[1:0]		IWDTS TRT	—
重置后的值:					用户设置*1											

Bit	Symbol	位名称	Description	R/W
b0	—	Reserved	读取时，该位返回写入的值。写入值应为1。	R
b1	IWDTSTRT	IWDT启动模式选择	0：复位后自动激活IWDT（自动启动模式）1：禁用IWDT。	R
b3, b2	IWDTTOPS[1:0]	IWDT超时周期选择	b3 b2 0 0: 128 cycles (007Fh) 0 1: 512 cycles (01FFh) 1 0: 1024 cycles (03FFh) 1 1: 2048 cycles (07FFh).	R

Bit	Symbol	Bit name	Description	R/W
b7 to b4	IWDTCKS[3:0]	IWDT-Dedicated Clock Frequency Division Ratio Select	b7 b4 0 0 0 0: × 1 0 0 1 0: × 1/16 0 0 1 1: × 1/32 0 1 0 0: × 1/64 1 1 1 1: × 1/128 0 1 0 1: × 1/256. Other settings are prohibited.	R
b9, b8	IWDTRPES[1:0]	IWDT Window End Position Select	b9 b8 0 0: 75% 0 1: 50% 1 0: 25% 1 1: 0% (no window end position setting).	R
b11, b10	IWDTRPSS[1:0]	IWDT Window Start Position Select	b11 b10 0 0: 25% 0 1: 50% 1 0: 75% 1 1: 100% (no window start position setting).	R
b12	IWDTRSTIRQS	IWDT Reset Interrupt Request Select	0: Enable non-maskable interrupt request or interrupt request 1: Enable reset.	R
b13	—	Reserved	When read, this bit returns the written value. The write value should be 1.	R
b14	IWDTSTPCTL	IWDT Stop Control	0: Continue counting 1: Stop counting when in Sleep, Snooze, or Software Standby mode.	R
b16, b15	—	Reserved	When read, these bits return the written value. The write value should be 1.	R
b17	WDTSTRT	WDT Start Mode Select	0: Automatically activate WDT after a reset (auto start mode) 1: Stop WDT after a reset (register start mode).	R
b19, b18	WDTTOPS[1:0]	WDT Timeout Period Select	b19 b18 0 0: 1024 cycles (03FFh) 0 1: 4096 cycles (0FFFh) 1 0: 8192 cycles (1FFFh) 1 1: 16384 cycles (3FFFh).	R
b23 to b20	WDTCKS[3:0]	WDT Clock Frequency Division Ratio Select	b23 b20 0 0 0 1: PCLKB divided by 4 0 1 0 0: PCLKB divided by 64 1 1 1 1: PCLKB divided by 128 0 1 1 0: PCLKB divided by 512 0 1 1 1: PCLKB divided by 2048 1 0 0 0: PCLKB divided by 8192. Other settings are prohibited.	R
b25, b24	WDTRPES[1:0]	WDT Window End Position Select	b25 b24 0 0: 75% 0 1: 50% 1 0: 25% 1 1: 0% (No window end position setting).	R
b27, b26	WDTRPSS[1:0]	WDT Window Start Position Select	b27 b26 0 0: 25% 0 1: 50% 1 0: 75% 1 1: 100% (No window start position setting).	R
b28	WDTRSTIRQS	WDT Reset Interrupt Request Select	WDT Behavior Select 0: Interrupt 1: Reset.	R
b29	—	Reserved	When read, this bit returns the written value. The write value should be 1.	R
b30	WDTSTPCTL	WDT Stop Control	0: Continue counting 1: Stop counting when entering Sleep mode.	R
b31	—	Reserved	When read, this bit returns the written value. The write value should be 1.	R

Bit	Symbol	位名称	Description	R/W
b7 to b4	IWDTCKS[3:0]	IWDT-Dedicated Clock 分频比 Select	b7b40000：×10010：×116 0011：×1320100：×16411 11：×11280101：×1256。 禁止其他设置。	R
b9, b8	IWDTRPES[1:0]	IWDT窗口结束位置 Select	b9b800：75%01：50%10：25%11：0% （无窗口结束位置设置）。	R
b11, b10	IWDTRPSS[1:0]	IWDT窗口起始位置 Select	b11b1000：25%01：50%10：75%11：100 %（无窗口起始位置设置）。	R
b12	IWDTRSTIRQS	IWDT复位中断 请求选择	0：使能不可屏蔽中断请求或中断请求1：使能复位。	R
b13	—	Reserved	读取时，该位返回写入的值。写入值应为1。	R
b14	IWDTSTPCTL	IWDT停止控制	0：继续计数1：在休眠、贪睡或软件待机模式下停止计数。	R
b16, b15	—	Reserved	读取时，这些位返回写入的值。写入值应为1。	R
b17	WDTSTRT	WDT启动模式选择	0：复位后自动激活WDT（自动启动模式）1：复位后停止WDT（寄存器启动模式）。	R
b19, b18	WDTTOPS[1:0]	WDT超时周期选择	b19 b18 0 0: 1024 cycles (03FFh) 0 1: 4096 cycles (0FFFh) 1 0: 8192 cycles (1FFFh) 1 1: 16384 cycles (3FFFh).	R
b23 to b20	WDTCKS[3:0]	WDT时钟频率 分频比选择	b23b200001：PCLKB除以40100： PCLKB除以641111：PCLKB除以12 80110：PCLKB除以5120111：PCL KB除以20481000：PCLKB除以819 2。禁止其他设置。	R
b25, b24	WDTRPES[1:0]	WDT窗口结束位置 Select	b25b2400：75%01：50%10：25%11：0 %（无窗口结束位置设置）。	R
b27, b26	WDTRPSS[1:0]	WDT窗口起始位置 Select	b27b2600：25%01：50%10：75%11：100 %（无窗口起始位置设置）。	R
b28	WDTRSTIRQS	WDT复位中断请求 Select	WDT行为选择0：中 断1：复位。	R
b29	—	Reserved	读取时，该位返回写入的值。写入值应为1。	R
b30	WDTSTPCTL	WDT停止控制	0：继续计数1：进入休眠模式时停止计数。	R
b31	—	Reserved	读取时，该位返回写入的值。写入值应为1。	R

Note 1. The value in a blank product is FFFF FFFFh. It is set to the value written by your application.

IWDTSTRT bit (IWDT Start Mode Select)

The IWDTSTRT bit selects the mode in which the IWDT is activated after a reset (stopped state or activated state).

IWDTTOPS[1:0] bits (IWDT Timeout Period Select)

The IWDTTOPS[1:0] bits select the timeout period, that is, the time it takes for the down counter to underflow, as 128, 512, 1024, or 2048 cycles of the frequency-divided clock set in the IWDTCKS[3:0] bits. The number of clock cycles that the counter takes to underflow after a refresh operation is determined by the combination of the IWDTCKS[3:0] and IWDTTOPS[1:0] bits.

For details, see section 26, Independent Watchdog Timer (IWDT).

IWDTCKS[3:0] bits (IWDT-Dedicated Clock Frequency Division Ratio Select)

The IWDTCKS[3:0] bits select the division ratio of the prescaler for dividing the frequency of the clock for the IWDT as 1/1, 1/16, 1/32, 1/64, 1/128, or 1/256. Using this setting combined with the IWDTTOPS[1:0] bit setting, the IWDT counting period can be set from 128 to 524288 IWDT clock cycles.

For details, see section 26, Independent Watchdog Timer (IWDT).

IWDTRPES[1:0] bits (IWDT Window End Position Select)

The IWDTRPES[1:0] bits select the position where the window for the down counter ends as 0%, 25%, 50%, or 75% of the count value. The value of the window end position must be smaller than the value of the window start position. Otherwise, only the value for the window start position is valid.

The counter values associated with the settings for the start and end positions of the window, in the IWDTRPSS[1:0] and IWDTRPES[1:0] bits vary with the setting in the IWDTTOPS[1:0] bits.

For details, see section 26, Independent Watchdog Timer (IWDT).

IWDTRPSS[1:0] bits (IWDT Window Start Position Select)

The IWDTRPSS[1:0] bits select the position where the window for the down counter starts as 25%, 50%, 75%, or 100% of the counted value. The point at which counting starts is 100% and the point at which an underflow occurs is 0%. The interval between the positions where the window starts and ends becomes the period in which a refresh is possible. However, refresh is not possible outside this period.

For details, see section 26, Independent Watchdog Timer (IWDT).

IWDTRSTIRQS bit (IWDT Reset Interrupt Request Select)

The IWDTRSTIRQS bit selects the operation on an underflow of the down counter or generation of a refresh error. The selected operation can be an independent watchdog timer reset, non-maskable interrupt request, or interrupt request.

For details, see section 26, Independent Watchdog Timer (IWDT).

IWDTSTPCTL bit (IWDT Stop Control)

The IWDTSTPCTL bit specifies whether to stop counting when entering Sleep, Snooze, or Software Standby mode.

For details, see section 26, Independent Watchdog Timer (IWDT).

WDTSTRT bit (WDT Start Mode Select)

The WDTSTRT bit selects the mode in which the WDT is activated after a reset (stopped state or activated state). When the WDT is activated in auto start mode, the OFS0 register setting for the WDT is valid.

WDTTOPS[1:0] bits (WDT Timeout Period Select)

The WDTTOPS[1:0] bits select the timeout period, that is, the time it takes for the down counter to underflow, as 1024, 4096, 8192, or 16384 cycles of the frequency-divided clock set in the WDTCKS[3:0] bits. The number of PCLKB cycles that the counter takes to underflow after a refresh operation is determined by the combination of the WDTCKS[3:0] and WDTTOPS[1:0] bits.

For details, see section 25, Watchdog Timer (WDT).

Note 1. 空白产品中的值为FFFFFFFFh。它设置为您的应用程序写入的值。

IWDTSTRT位（IWDT启动模式选择）

IWDTSTRT位选择复位后激活IWDT的模式（停止状态或激活状态）。

IWDTTOPS[1:0]位（IWDT超时周期选择）

IWDTTOPS[1:0]位选择超时周期，即递减计数器下溢所需的时间，为IWDTCKS[3中设置的分频时钟的128、512、1024或2048个周期：0]位。刷新操作后计数器下溢的时钟周期数由IWDTCKS[3:0]和IWDTTOPS[1:0]位的组合决定。

有关详细信息，请参见第26节，独立看门狗定时器(IWDT)。

IWDTCKS[3:0]位（IWDT专用时钟分频比选择）

IWDTCKS[3:0]位选择用于将IWDT的时钟频率分频为11、116、132、164、1128或1256的预分频器的分频比。将此设置与IWDTTOPS[1:0]位设置，IWDT计数周期可以设置为128到524288个IWDT时钟周期。

有关详细信息，请参见第26节，独立看门狗定时器(IWDT)。

IWDTRPES[1:0]位（IWDT窗口结束位置选择）

IWDTRPES[1:0]位选择递减计数器窗口结束的位置为计数值的0%、25%、50%或75%。窗口结束位置的值必须小于窗口开始位置的值。否则，只有窗口起始位置的值有效。

在IWDTRPSS[1:0]和窗口的开始和结束位置设置相关的计数器值
IWDTRPES[1:0]位随IWDTTOPS[1:0]位的设置而变化。

有关详细信息，请参见第26节，独立看门狗定时器(IWDT)。

IWDTRPSS[1:0]位（IWDT窗口起始位置选择）

IWDTRPSS[1:0]位选择递减计数器窗口开始的位置为计数值的25%、50%、75%或100%。计数开始点为100%，下溢发生点为0%。窗口开始和结束位置之间的间隔成为可以刷新的时间段。但是，在此期间之外无法刷新。

有关详细信息，请参见第26节，独立看门狗定时器(IWDT)。

IWDTRSTIRQS位（IWDT复位中断请求选择）

IWDTRSTIRQS位选择在递减计数器下溢或产生刷新错误时的操作。选择的操作可以是独立的看门狗定时器复位、不可屏蔽中断请求或中断请求。

有关详细信息，请参见第26节，独立看门狗定时器(IWDT)。

IWDTSTPCTL位（IWDT停止控制）

IWDTSTPCTL位指定在进入休眠、贪睡或软件待机模式时是否停止计数。

有关详细信息，请参见第26节，独立看门狗定时器(IWDT)。

WDTSTRT位（WDT启动模式选择）

WDTSTRT位选择复位后WDT激活的模式（停止状态或激活状态）。当WDT在自动启动模式下激活时，WDT的OFS0寄存器设置有效。

WDTOPS[1:0]位（WDT超时周期选择）

WDTTOPS[1:0]位选择超时周期，即递减计数器下溢所需的时间，为WDTCKS[3中设置的分频时钟的1024、4096、8192或16384个周期：0]位。刷新操作后计数器下溢的PCLKB周期数由WDTCKS[3:0]和WDTTOPS[1:0]位的组合决定。

有关详细信息，请参见第25节，看门狗定时器(WDT)。

WDTCKS[3:0] bits (WDT Clock Frequency Division Ratio Select)

The WDTCKS[3:0] bits select the division ratio of the prescaler to divide the PCLKB frequency as 1/4, 1/64, 1/128, 1/512, 1/2048, or 1/8192. Using this setting combined with the WDTTOPS[1:0] bit setting, the WDT counting period can be set from 4096 to 134217728 PCLKB cycles.

For details, see section 25, Watchdog Timer (WDT).

WDTRPES[1:0] bits (WDT Window End Position Select)

The WDTRPES[1:0] bits select the position where the window for the down counter ends as 0%, 25%, 50%, or 75% of the counted value. The value of the window end position must be smaller than the value of the window start position. Otherwise, only the value for the window start position is valid.

The counter values associated with the settings for the start and end positions of the window, in the WDTRPSS[1:0] and WDTRPES[1:0] bits, vary with the setting of the WDTTOPS[1:0] bits.

For details, see section 25, Watchdog Timer (WDT).

WDTRPSS[1:0] bits (WDT Window Start Position Select)

The WDTRPSS[1:0] bits select the position where the window for the down counter starts as 25%, 50%, 75%, or 100% of the counted value. The point at which counting starts is 100% and the point at which an underflow occurs is 0%. The interval between the positions where the window starts and ends becomes the period in which a refresh is possible. However, refresh is not possible outside this period.

For details, see section 25, Watchdog Timer (WDT).

WDTRSTIRQS bit (WDT Reset Interrupt Request Select)

The WDTRSTIRQS bit selects the operation on an underflow of the down counter or generation of a refresh error. The selected operation can be a watchdog timer reset, non-maskable interrupt request, or interrupt request.

For details, see section 25, Watchdog Timer (WDT).

WDTSTPCTL bit (WDT Stop Control)

The WDTSTPCTL bit specifies whether to stop counting when entering Sleep mode. For details, see section 25, Watchdog Timer (WDT).

7.2.2 Option Function Select Register 1 (OFS1)

Address(es): OFS1 0000 0404h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	User setting*1															

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	—	—	—	—	—	HOCOFRQ0[1:0]		HOCOEN	—	—	—	—	—	LVDAS	VDSEL0[1:0]	
	User setting*1															

Bit	Symbol	Bit name	Description	R/W
b1, b0	VDSEL0[1:0]	Voltage Detection 0 Level Select	b1 b0 0 0: Setting prohibited 0 1: Select 2.94 V 1 0: Select 2.87 V 1 1: Select 2.80 V.	R
b2	LVDAS	Voltage Detection 0 Circuit Start	0: Enable voltage monitor 0 reset after a reset 1: Disable voltage monitor 0 reset after a reset.	R
b7 to b3	—	Reserved	When read, these bits return the written value. The write value should be 1.	R

WDTCKS[3:0]位（WDT时钟分频比选择）

WDTCKS[3:0]位选择预分频器的分频比，以将PCLKB频率分频为14、164、1128、1512、12048或18192。将此设置与WDTTOPS[1结合使用：0]位设置，WDT计数周期可设置为4096到134217728个PCLKB周期。

有关详细信息，请参见第25节，看门狗定时器(WDT)。

WDTRPES[1:0]位（WDT窗口结束位置选择）

WDTRPES[1:0]位选择递减计数器窗口结束的位置为计数值的0%、25%、50%或75%。窗口结束位置的值必须小于窗口开始位置的值。否则，只有窗口起始位置的值有效。

与窗口的开始和结束位置的设置相关的计数器值，在WDTRPSS[1:0]和WDTRPES[1:0]位，随WDTTOPS[1:0]位的设置而变化。

有关详细信息，请参见第25节，看门狗定时器(WDT)。

WDTRPSS[1:0]位（WDT窗口起始位置选择）

WDTRPSS[1:0]位选择递减计数器窗口开始的位置为计数值的25%、50%、75%或100%。计数开始点为100%，下溢发生点为0%。窗口开始和结束位置之间的间隔成为可以刷新的时间段。但是，在此期间之外无法刷新。

有关详细信息，请参见第25节，看门狗定时器(WDT)。

WDTRSTIRQS位（WDT复位中断请求选择）

WDTRSTIRQS位选择在递减计数器下溢或产生刷新错误时的操作。所选操作可以是看门狗定时器复位、不可屏蔽中断请求或中断请求。

有关详细信息，请参见第25节，看门狗定时器(WDT)。

WDTSTPCTL位（WDT停止控制）

WDTSTPCTL位指定进入休眠模式时是否停止计数。有关详细信息，请参阅第25节，看门狗定时器（WDT）。

7.2.2 选项功能选择寄存器1(OFS1)

Address(es): OFS1 0000 0404h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	用户设置*1															

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	—	—	—	—	—	HOCOFRQ0[1:0]		HOCOEN	—	—	—	—	—	LVDAS	VDSEL0[1:0]	
	用户设置*1															

Bit	Symbol	位名称	Description	R/W
b1, b0	VDSEL0[1:0]	电压检测0级别选择	b1b000：禁止设置01：选择2.94V10：选择2.87V11：选择2.80V。	R
b2	LVDAS	电压检测0电路启动	0：启用电压监控器0复位后复位1：禁用电压监控器0复位后复位。	R
b7 to b3	—	Reserved	读取时，这些位返回写入的值。写入值应为1。	R

Bit	Symbol	Bit name	Description	R/W
b8	HOCOEN	HOCO Oscillation Enable	0: Enable HOCO oscillation after a reset 1: Disable HOCO oscillation after a reset.	R
b10, b9	HOCOFRQ0[1:0]	HOCO Frequency Setting 0	b10 b9 0 0: 16 MHz 0 1: 18 MHz 1 0: 20 MHz 1 1: Setting prohibited.	R
b31 to b11	—	Reserved	When read, these bits return the written value. The write value should be 1.	R

Note 1. The value in a blank product is FFFF FFFFh. It is set to the value written by your application.

VDSEL0[1:0] bits (Voltage Detection 0 Level Select)

The VDSEL0[1:0] bits select the voltage detection level of the voltage detection 0 circuit.

LVDAS bit (Voltage Detection 0 Circuit Start)

The LVDAS bit selects whether the voltage monitor 0 reset is enabled or disabled after a reset.

HOCOEN bit (HOCO Oscillation Enable)

The HOCOEN bit selects whether the HOCO oscillation is enabled or disabled after a reset. Setting this bit to 0 allows the HOCO oscillation to start before the CPU starts operation, which reduces the wait time for oscillation stabilization.

Note: When the HOCOEN bit is set to 0, the system clock source is not switched to HOCO. The system clock source is only switched to HOCO by setting the Clock Source Select bits (SCKSCR.CKSEL[2:0]). To use the HOCO clock, you must set the OFS1.HOCOFRQ0 bit to an optimum value.

HOCOFRQ0[1:0] bits (HOCO Frequency Setting 0)

The HOCOFRQ0[1:0] bits specify the HOCO frequency after a reset as 16, 18, or 20 MHz.

7.2.3 Access Window Setting Register (AWS)

Address(es): AWS 0100 A164h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	BTFLG	—	—	—	—	FAWE[10:0]										
Value after reset:						User setting										

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	FSPR	—	—	—	—	FAWS[10:0]										
Value after reset:						User setting										

Bit	Symbol	Bit name	Description	R/W
b10 to b0	FAWS[10:0]	Access Window Start Block Address	These bits specify the start block address for the access window. They do not represent the block number of the access window. The access window is only valid in the program flash area. The block address specifies the first address of the block and consists of address bits [23:13].	R
b14 to b11	—	Reserved	When read, these bits return the written value. The write value should be 1.	R

Bit	Symbol	位名称	Description	R/W
b8	HOCOEN	HOCO Oscillation Enable	0：复位后启用HOCO振荡1：复位后禁用HOCO振荡。	R
b10, b9	HOCOFRQ0[1:0]	HOCO Frequency Setting 0	b10b900：16MHz01：18MHz10：20MHz11：禁止设置。	R
b31 to b11	—	Reserved	读取时，这些位返回写入的值。写入值应为1。	R

Note 1. 空白产品中的值为FFFFFFFFh。它设置为您的应用程序写入的值。

VDSEL0[1:0]位（电压检测0电平选择）

VDSEL0[1:0]位选择电压检测0电路的电压检测电平。

LVDAS位（电压检测0电路启动）

LVDAS位选择在复位后是启用还是禁用电压监视器0复位。

HOCOEN位（HOCO振荡使能）

HOCOEN位选择在复位后是启用还是禁用HOCO振荡。将此位设置为0允许在CPU开始操作之前启动HOCO振荡，从而减少振荡稳定的等待时间。

Note: 当HOCOEN位设置为0时，系统时钟源不切换到HOCO。系统时钟源只能通过设置时钟源选择位(SCKSCR.CKSEL[2:0])切换到HOCO。要使用HOCO时钟，您必须将OFS1.HOCOFRQ0位设置为最佳值。

HOCOFRQ0[1:0]位（HOCO频率设置0）

HOCOFRQ0[1:0]位指定复位后的HOCO频率为16、18或20MHz。

7.2.3 访问窗口设置寄存器(AWS)

Address(es): AWS 0100 A164h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	BTFLG	—	—	—	—	FAWE[10:0]										
重置后的值：						用户设置										

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	FSPR	—	—	—	—	FAWS[10:0]										
重置后的值：						用户设置										

Bit	Symbol	位名称	Description	R/W
b10 to b0	FAWS[10:0]	访问窗口启动块 Address	这些位指定访问窗口的起始块地址。它们不代表访问窗口的块号。访问窗口仅在程序闪存区有效。块地址指定块的第一个地址，由地址位[23:13]组成。	R
b14 to b11	—	Reserved	读取时，这些位返回写入的值。写入值应为1。	R

Bit	Symbol	Bit name	Description	R/W
b15	FSPR	Protection of Access Window and Startup Area Select Function	This bit controls the programming of the write/erase protection for the access window, the Startup Area Select flag (AWS.BTFLG), and the temporary boot swap control. When this bit is set to 0, it cannot be changed to 1. 0: Executing the configuration setting command for programming the access window (FAWE[10:0], FAWS[10:0]) and the Startup Area Select flag (AWS.BTFLG) is invalid 1: Executing the configuration setting command for programming the access window (FAWE[10:0], FAWS[10:0]) and the Startup Area Select flag (AWS.BTFLG) is valid.	R
b26 to b16	FAWE[10:0]	Access Window End Block Address	These bits specify the end block address for the access window. They do not represent the block number of the access window. The access window is only valid in the program flash area. The end block address for the access window is the next block to the region acceptable for programming and erasure defined by the access window. The block address specifies the first address of the block and consists of the address bits [23:13].	R
b30 to b27	—	Reserved	When read, these bits return the written value. The write value should be 1.	R
b31	BTFLG	Startup Area Select Flag	This bit specifies whether the address of the startup area is exchanged for the boot swap function or not: 0: First 8-KB area (0000 0000h to 0000 1FFFh) and second 8-KB area (0000 2000h to 0000 3FFFh) are exchanged 1: First 8-KB area (0000 0000h to 0000 1FFFh) and second 8-KB area (0000 2000h to 0000 3FFFh) are not exchanged.	R

Issuing the program or erase (P/E) command to an area outside the access window causes a command-locked state. The access window is only valid in the program flash area. The access window provides protection in self-programming mode, serial programming mode, and on-chip debug mode. The access window can be locked by the FSPR bit.

The access window is specified in both the FAWS[10:0] and FAWE[10:0] bits: The settings for the bits are as follows:

- FAWE[10:0] = FAWS[10:0]: The P/E command is allowed to execute in the full program flash area
- FAWE[10:0] > FAWS[10:0]: The P/E command is only allowed to execute in the window from the block pointed to by the FAWS[10:0] bits to the block one lower than the block pointed to by the FAWE[10:0] bits
- FAWE[10:0] < FAWS[10:0]: The P/E command is not allowed to execute in the program flash area.

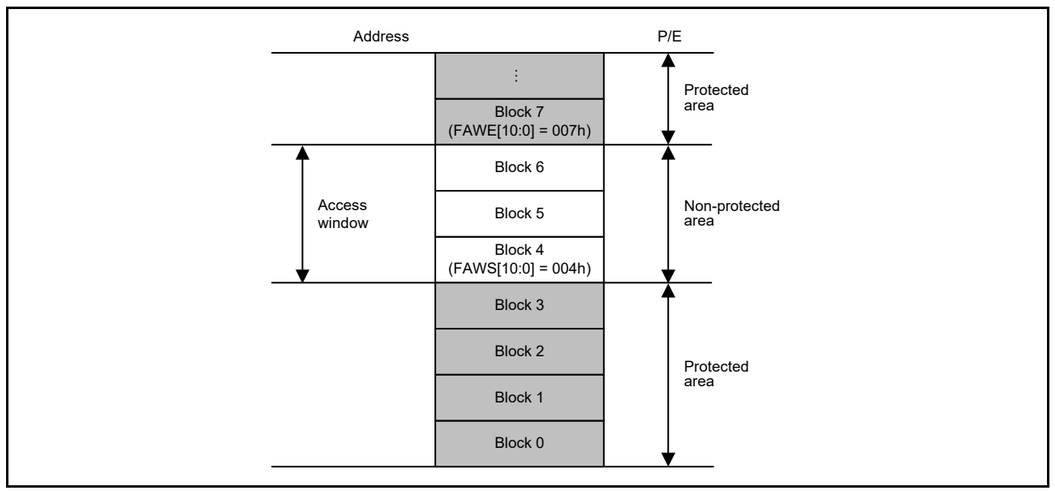


Figure 7.2 Access window overview

Bit	Symbol	位名称	Description	R/W
b15	FSPR	访问保护 窗口和启动区 选择功能	该位控制访问窗口的写擦除保护、启动区域选择标志(AWS.BTFLG)和临时引导交换控制的编程。当该位设置为0时，不能更改为1。 0：执行用于编程访问窗口（FAWE[10:0]、FAWS[10:0]）和启动区域选择标志（AWS）的配置设置命令.BTFLG)无效1：执行访问窗口编程的配置设置命令（FAWE[10:0]、FAWS[10:0]）和启动区域选择标志（AWS.BTFLG）有效。	R
b26 to b16	FAWE[10:0]	访问窗口结束块 Address	这些位指定访问窗口的结束块地址。它们不代表访问窗口的块号。访问窗口仅在程序闪存区有效。访问窗口的结束块地址是访问窗口定义的可用于编程和擦除的区域的下一个块。块地址指定块的第一个地址，由地址位[23:13]组成。	R
b30 to b27	—	Reserved	读取时，这些位返回写入的值。写入值应为1。	R
b31	BTFLG	启动区选择标志	该位指定启动区域的地址是否交换用于引导交换功能：0：交换第一个8-KB区域（00000000h到00001FFFh）和第二个8-KB区域（00002000h到00003FFFh）1:第一个8-KB区域（00000000h到00001FFFh）和第二个8-KB区域（00002000h到00003FFFh）不交换。	R

向访问窗口之外的区域发出编程或擦除(PE)命令会导致命令锁定状态。访问窗口仅在程序闪存区有效。访问窗口在自编程模式、串行编程模式和片上调试模式下提供保护。访问窗口可以通过FSPR位锁定。

访问窗口在FAWS[10:0]和FAWE[10:0]位中指定：位设置如下：

- FAWE[10:0]=FAWS[10:0]：允许PE命令在整个程序flash区执行
- FAWE[10:0]>FAWS[10:0]：PE命令只允许在窗口中从FAWS[10:0]位指向的块到比FAWS[10:0]指向的块低一级的块执行FAWE[10:0]位
- FAWE[10:0]<FAWS[10:0]：不允许在程序闪存区执行PE命令。

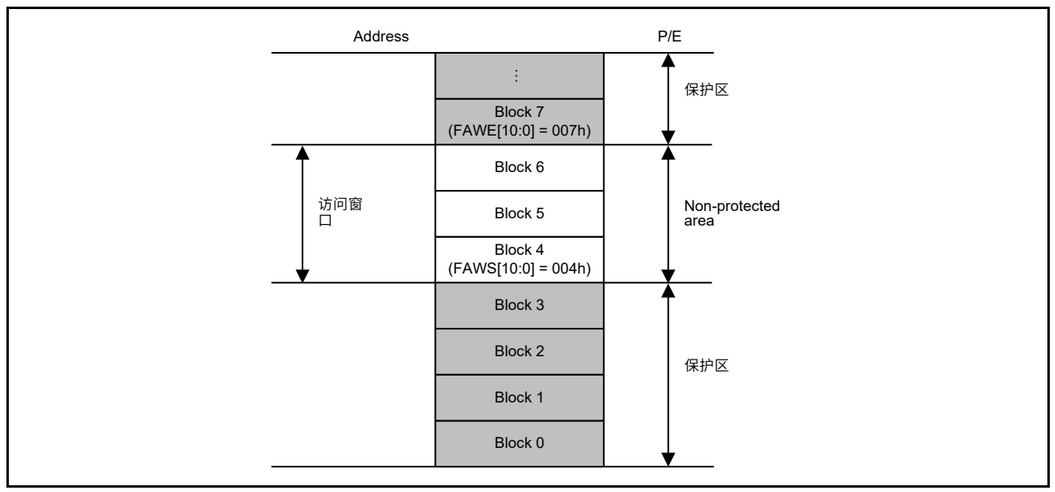


Figure 7.2 访问窗口概述

7.2.4 OCD/Serial Programmer ID Setting Register (OSIS)

The OSIS register stores the ID for ID code protection of the OCD/serial programmer. When connecting the OCD/serial programmer, write values so that the MCU can determine whether to permit the connection. Use this register to check whether a code transmitted from the OCD/serial programmer matches the ID code in the option-setting memory.

When the ID codes match, connection with the OCD/serial programmer is permitted, if not, connection with the OCD/serial programmer is not possible. The OSIS register must be set in 32-bit words.

Address(es): OSIS 0100 A150h, OSIS 0100 A154h, OSIS 0100 A158h, OSIS 0100 A15Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	User setting															

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	User setting															

These fields hold the ID for use in ID authentication for the OCD/serial programmer.

ID code bits [127] and [126] determine whether ID code protection is enabled, and the authentication method to use with the host. Table 7.1 shows how the ID code determines the authentication method.

Setting bit [127] to 0 prevents Renesas from accessing the test mode. Therefore, Renesas cannot perform failure analysis unless provided with bits [126:0]. To process any warranty claim, Renesas must be able to perform failure analysis.

Table 7.1 Specifications for ID code protection

Operating mode on boot up	ID code	State of protection	Operations on connection to programmer or on-chip debugger
Serial programming mode (SCI boot mode) On-chip debug mode (JTAG/SWD boot mode)	FFh, …, FFh (all bytes are FFh)	Protection disabled	The ID code is not checked, the ID code always matches, and the connection to programmer or on-chip debugger is permitted
	Bit [127] = 1, bit [126] = 1, and at least one of the 16 bytes is not FFh.	Protection enabled	Matching ID code indicates that authentication is complete and connection to the programmer or the on-chip debugger is permitted. Mismatching ID code indicates that transition to the ID code protection wait state. When the ID code sent from the programmer or the on-chip debugger is ALeRASE in ASCII code (414C_6552_4153_45FF_FFFF_FFFF_FFFF_FFFFh), the content of the user flash (code and data) area, and configuration area are erased. However, forced erasure is not executed when the FSPR bit is 0.
	Bit [127] = 1 and bit [126] = 0	Protection enabled	Matching ID code indicates that authentication is complete and connection to the programmer or the on-chip debugger is permitted. Mismatching ID code indicates transition to the ID code protection wait state.
	Bit [127] = 0	Protection enabled	The ID code is not checked, the ID code is always mismatching, the connection to the programmer or the on-chip debugger is prohibited, and Renesas cannot access the test mode.

7.2.4 OCD串行编程器ID设置寄存器(OSIS)

OSIS寄存器存储用于保护OCD串行编程器的ID代码的ID。连接OCD串口编程器时，写入数值，让MCU判断是否允许连接。使用该寄存器检查从OCD串行编程器发送的代码是否与选项设置存储器中的ID代码匹配。

当ID码匹配时，允许与OCD串行编程器连接，如果不匹配，则与强迫症串行编程器是不可能的。OSIS寄存器必须设置为32位字。

Address(es): OSIS 0100 A150h, OSIS 0100 A154h, OSIS 0100 A158h, OSIS 0100 A15Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	用户设置															

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	用户设置															

这些字段保存用于OCD串行编程器身份验证的ID。

ID代码位[127]和[126]确定是否启用ID代码保护，以及与主机一起使用的身份验证方法。表7.1显示了ID代码如何确定身份验证方法。

将位[127]设置为0可防止Renesas进入测试模式。因此，除非提供位[126:0]，否则瑞萨无法执行故障分析。要处理任何保修索赔，瑞萨电子必须能够执行故障分析。

Table 7.1 ID码保护规范

启动时的操作模式	身份证号码	保护状态	连接到编程器或片上调试器的操作
串行编程模式（SCI启动模式） 片上调试模式（JTAGSWD引导模式）	FFh … FFh（所有字节均为FFh）	保护已禁用	ID码不检查，ID码始终匹配，允许连接编程器或片上调试器
	位[127]=1，位[126]=1，16个字节中至少有一个不是FFh。	启用保护	匹配的ID代码表示验证已完成并且允许连接到编程器或片上调试器。不匹配的ID代码表示转换到ID代码保护等待状态。当编程器或片上调试器发送的ID码为ASCII码（414C_6552_4153_45FF_FFFF_FFFF_FFFF_FFFFh）的ALeRASE时，用户闪存（代码和数据）区和配置区的内容被擦除。然而，强制擦除不执行时 FSPR位为0。
	位[127]=1和位[126]=0	启用保护	匹配的ID代码表示验证已完成并且允许连接到编程器或片上调试器。ID代码不匹配表示转换到ID代码保护等待状态。
	Bit [127] = 0	启用保护	ID码不检查，ID码总是不匹配，禁止连接编程器或片上调试器，瑞萨无法进入测试模式。

7.3 Setting the Option-Setting Memory

7.3.1 Allocation of Data in the Option-Setting Memory

Programming data is allocated to the addresses in the option-setting memory shown in Figure 7.1. The allocated data is used by tools such as a flash programming software or an on-chip debugger.

Note: Programming formats vary depending on the compiler. See the compiler manual for details.

7.3.2 Setting Data for Programming the Option-Setting Memory

Allocating data according to the procedure described in section 7.3.1, Allocation of Data in the Option-Setting Memory, alone does not actually write the data to the option-setting memory. You must also follow one of the actions described in this section.

(1) Changing the option-setting memory by self-programming

To write data to the program flash area, use the programming command. To write data to the option-setting memory in the configuration setting area, use the configuration setting command. In addition, use the startup area select function to safely update the boot program that includes the option-setting memory.

For details on the programming command, the configuration setting command, and the startup area select function, see section 41, Flash Memory.

Note: While programming the configuration setting area, the following restrictions apply:

- The code must not access addresses that satisfy the ranges described by the expression defined in Expression 1 from all bus masters
- The code must not execute on addresses that satisfy the ranges described by the expression defined in Expression 1.

Expression 1

If (((address & 0x0101F800) = = 0x01010000) || ((address & 0x0101FC00) = = 0x01012000))

For example, the ranges of addresses 0x1FFF0000 to 0x1FFF07FF or 0x1FFF2000 to 0x1FFF23FF are associated with the SRAMHS area that is tagged as restricted. Also, interrupts are allowed, however, the ISR has these specified restrictions. Therefore, it is highly recommended that you disable all interrupts, and bus masters except the CPU while programming the configuration setting area because the interrupts and these modules might access prohibited area in Expression 1.

(2) Debugging through an OCD or programming by a flash writer

This procedure depends on the tool in use, see the tool manual for details.

The MCU provides two setting procedures as follows:

- Read the data allocated as described in section 7.3.1, Allocation of Data in the Option-Setting Memory, from an object file or Motorola S-format file generated by the compiler, and write the data to the MCU
- Use the GUI interface of the tool to program the same data allocated as described in section 7.3.1, Allocation of Data in the Option-Setting Memory.

Note: While programming the OSIS or AWS registers, the following restrictions apply:

- The code must not access addresses that satisfy the ranges described by the expression defined in Expression 1 from all bus masters
- The code must not execute on addresses that satisfy the ranges described by the expression defined in Expression 1.

7.4 Usage Notes

7.4.1 Data for Programming Reserved Areas and Reserved Bits in the Option-Setting Memory

When reserved areas and reserved bits in the option-setting memory are available for programming, write 1 to all bits in reserved areas and all reserved bits. If 0 is written to these bits, normal operation cannot be guaranteed.

7.3 设置选项设置内存

7.3.1 选项设置存储器中的数据分配

编程数据被分配到图7.1所示的选项设置存储器中的地址。分配的数据由闪存编程软件或片上调试器等工具使用。

Note: 编程格式因编译器而异。有关详细信息，请参阅编译器手册。

7.3.2 用于编程选项设置存储器的设置数据

根据第7.3.1节"在选项设置内存中分配数据"中描述的过程分配数据，单独实际上不会将数据写入选项设置内存。您还必须遵循本节中描述的操作之一。

(1) 通过自编程更改选项设置存储器

要将数据写入程序闪存区域，请使用编程命令。要将数据写入配置设置区域中的选项设置存储器，请使用配置设置命令。此外，使用启动区域选择功能可以安全地更新包含选项设置存储器的引导程序。

有关编程命令、配置设置命令和启动区域选择功能的详细信息，请参见第41节，闪存。

Note: 在对配置设置区域进行编程时，有以下限制：

- 代码不得从所有总线主机访问满足表达式1中定义的表达式所描述范围的地址
- 代码不得在满足表达式1中定义的表达式描述的范围的地址上执行。

Expression 1

If (((address & 0x0101F800) = = 0x01010000) || ((address & 0x0101FC00) = = 0x01012000))

例如，地址范围0x1FFF0000到0x1FFF07FF或0x1FFF2000到0x1FFF23FF与标记为受限的SRAMHS区域相关联。此外，允许中断，但是，ISR有这些指定的限制。因此，强烈建议您在对配置设置区域进行编程时禁用除CPU之外的所有中断和总线主控，因为中断和这些模块可能会访问表达式1中的禁止区域。

(2) 通过OCD进行调试或通过闪存写入器进行编程

此过程取决于所使用的工具，详细信息请参见工具手册。

MCU提供两种设置程序，如下所示：

- 从编译器生成的目标文件或摩托罗拉S格式文件中读取第7.3.1节"选项设置内存中的数据分配"中所述分配的数据，并将数据写入MCU
- 使用工具的GUI界面对分配的相同数据进行编程，如第7.3.1节所述，分配选项设置内存中的数据。

Note: 在对OSIS或AWS寄存器进行编程时，适用以下限制：

- 代码不得从所有总线主机访问满足表达式1中定义的表达式所描述范围的地址
- 代码不得在满足表达式1中定义的表达式描述的范围的地址上执行。

7.4 使用说明

7.4.1 用于编程选项设置中的保留区域和保留位的数据 Memory

当保留区域和保留的选项设置内存中可用于编程时，请在保留区域和所有保留位中为所有位写1。如果将0写入这些位，则无法保证正常操作。

RA生态工作室

8. Low Voltage Detection (LVD)

8.1 Overview

The Low Voltage Detection (LVD) module monitors the voltage level input to the VCC pin, and the detection level can be selected using a software program. The LVD module consists of three separate voltage level detectors, 0, 1, and 2, which measure the voltage level input to the VCC pin. LVD voltage detection registers allow your application to configure detection of VCC changes at various voltage thresholds.

Each voltage level detector has a voltage monitor associated with it, for example voltage monitors 0, 1, and 2. Voltage monitor registers are used to configure the LVD to trigger an interrupt, event link output, or reset when the thresholds are crossed.

Table 8.1 lists the LVD specifications. Figure 8.1 shows a block diagram of voltage detectors 0, 1, and 2, Figure 8.2 shows a block diagram of the voltage monitor 1 interrupt/reset circuit, and Figure 8.3 shows a block diagram of the voltage monitor 2 interrupt/reset circuit.

Table 8.1 LVD specifications

Parameter		Voltage monitor 0 specifications	Voltage monitor 1 specifications	Voltage monitor 2 specifications
VCC monitoring	Monitored voltage	V_{det0}	V_{det1}	V_{det2}
	Detected event	Voltage falls past V_{det0}	Voltage rises or falls past V_{det1}	Voltage rises or falls past V_{det2}
	Detected voltage	Selectable from three different levels in the OFS1.VDSEL0[1:0] bits	Selectable from three different levels in the LVDLVLR.LVD1LVL[4:0] bits	Selectable from three different levels in the LVDLVLR.LVD2LVL[2:0] bits
	Monitor flag	None	LVD1SR.MON flag: Monitors whether voltage is higher or lower than V_{det1}	LVD2SR.MON flag: Monitors whether voltage is higher or lower than V_{det2}
			LVD1SR.DET flag: V_{det1} passage detection	LVD2SR.DET flag: V_{det2} passage detection
Process on voltage detection	Reset	Voltage monitor 0 reset	Voltage monitor 1 reset	Voltage monitor 2 reset
		Reset when V_{det0} > VCC CPU restart after specified time with VCC > V_{det0}	Reset when V_{det1} > VCC CPU restart timing selectable: after specified time with VCC > V_{det1} or V_{det1} > VCC	Reset when V_{det2} > VCC CPU restart timing selectable: after specified time with VCC > V_{det2} or Vd_{det2} > VCC
	Interrupt	No interrupt	Voltage monitor 1 interrupt	Voltage monitor 2 interrupt
			Non-maskable or maskable interrupt selectable	Non-maskable or maskable interrupt selectable
			Interrupt request issued when V_{det1} > VCC or VCC > V_{det1}	Interrupt request issued when V_{det2} > VCC or VCC > V_{det2}
Digital filter	Enable/ Disable switching	Digital filter function not available	Available	Available
	Sampling time	—	1/n LOCO frequency × 2 (n: 2, 4, 8, 16)	1/n LOCO frequency × 2 (n: 2, 4, 8, 16)
Event linking		None	Available Output of event signals on detection of V_{det1} crossings	Available Output of event signals on detection of V_{det2} crossings

8. 低电压检测(LVD)

8.1 Overview

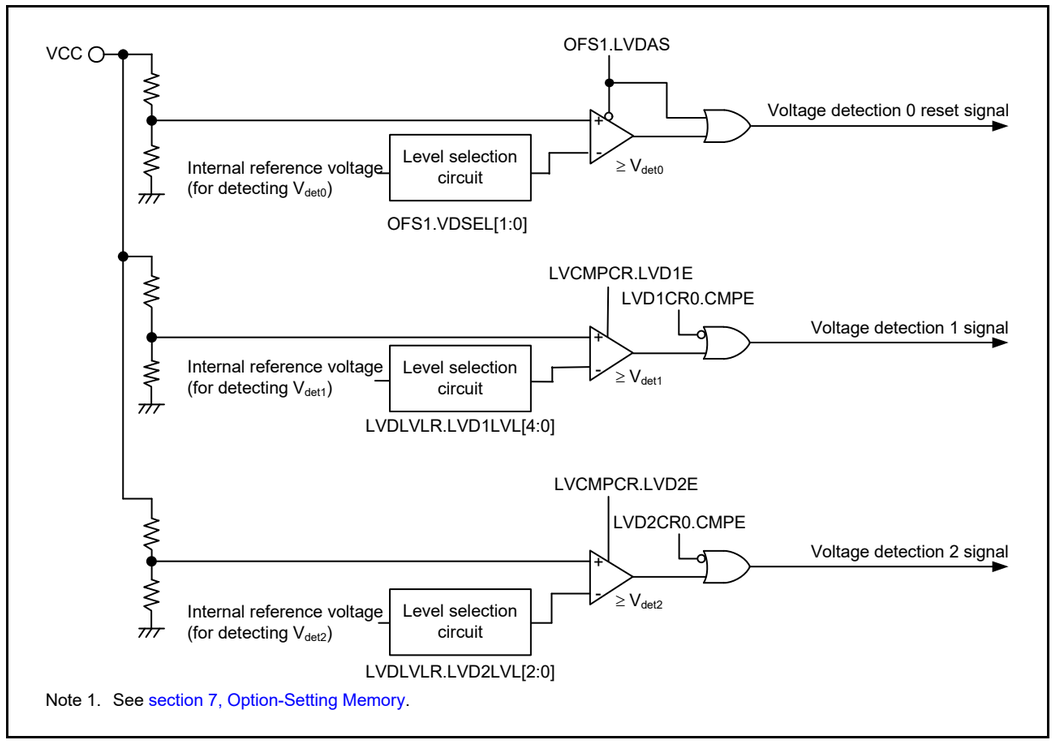
低电压检测(LVD)模块监控输入到VCC引脚的电压电平，并且可以使用软件程序选择检测电平。LVD模块由三个独立的电压电平检测器0、1和2组成，它们测量输入到VCC引脚的电压电平。LVD电压检测寄存器允许您的应用程序配置在各种电压阈值下检测VCC变化。

每个电压电平检测器都有一个与之关联的电压监视器，例如电压监视器0、1和2。电压监视器寄存器用于配置LVD，以在超过阈值时触发中断、事件链接输出或复位。

表8.1列出了LVD规格。图8.1显示了电压检测器0、1和2的框图，图8.2显示了电压监视器1中断复位电路的框图，图8.3显示了电压监视器2中断复位电路的框图。

Table 8.1 LVD specifications

Parameter		电压监视器0规格	电压监视器1规格	电压监视器2规格
VCC monitoring	监控电压	V_{det0}	V_{det1}	V_{det2}
	检测到的事件	电压下降超过Vdet0	电压上升或下降超过Vdet1	电压上升或下降超过Vdet2
	检测电压	可从OFS1.VDSEL0[1:0]位的三个不同级别中选择	可从LVDLVLR.LVD1LVL[4:0]位的三个不同级别中选择	可从LVDLVLR.LVD2LVL[2:0]位的三个不同级别中选择
	监控标志	None	LVD1SR.MON标志：监控电压是高于还是低于Vdet1	LVD2SR.MON标志：监控电压是高于还是低于Vdet2
			LVD1SR.DET标志：Vdet1通过检测	LVD2SR.DET标志：Vdet2通过检测
电压检测流程	Reset	电压监控器0复位	电压监视器1复位	电压监视器2复位
		当Vdet0>VCC时复位 CPU在VCC>Vdet0指定时间后重启	当Vdet1>VCC时复位 CPU重启时间可选：在VCC>Vdet1或Vdet1>VCC的指定时间后	当Vdet2>VCC时复位 CPU重启时间可选：在VCC>Vdet2或Vddet2>VCC的指定时间后
	Interrupt	无中断	电压监视器1中断	电压监视器2中断
			可选择不可屏蔽或可屏蔽中断	可选择不可屏蔽或可屏蔽中断
			中断请求发出时 V_{det1} > VCC or VCC > V_{det1}	中断请求发出时 V_{det2} > VCC or VCC > V_{det2}
数字滤波器	启用禁用切换	数字滤波器功能不可用	Available	Available
	采样时间	—	1nLOCO频率 2(n:2 4 8 16)	1nLOCO频率 2(n:2 4 8 16)
事件链接		None	Available 在检测到Vdet1交叉点时输出事件信号	Available 在检测到Vdet2交叉点时输出事件信号



Note 1. See section 7, Option-Setting Memory.

Figure 8.1 Voltage detection 0, 1, and 2 block diagram

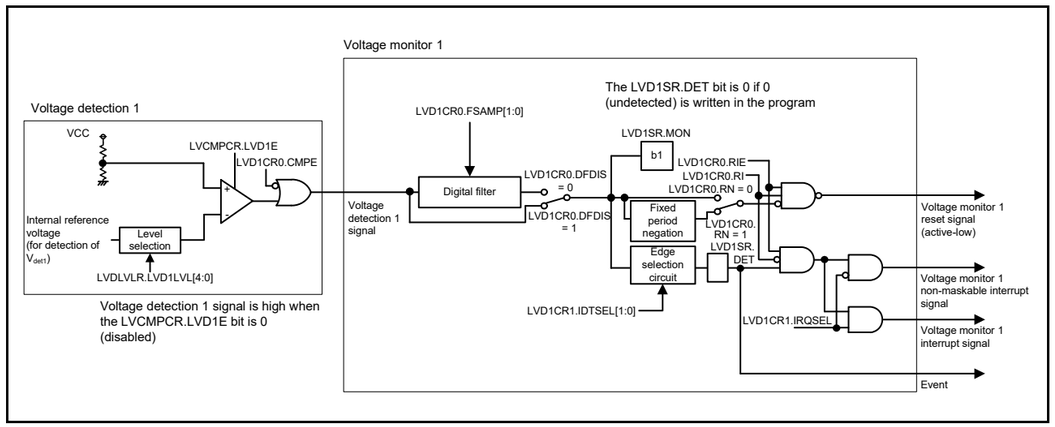
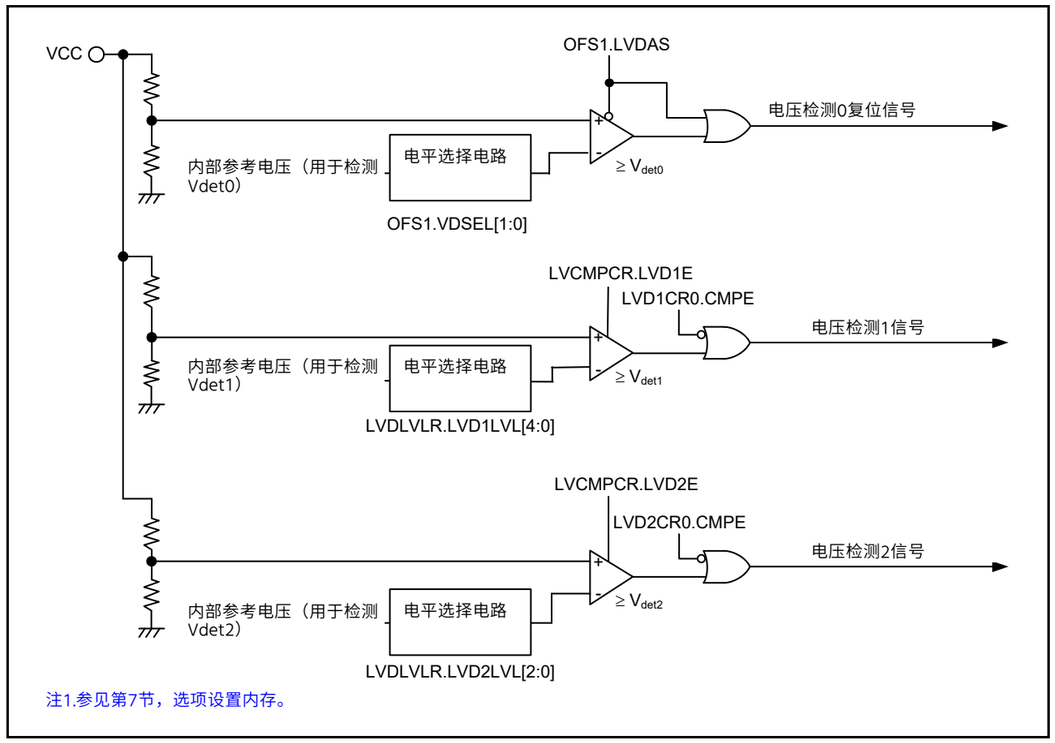


Figure 8.2 Voltage monitor 1 interrupt and reset circuit block diagram



注1.参见第7节，选项设置内存。

Figure 8.1 电压检测0、1和2框图

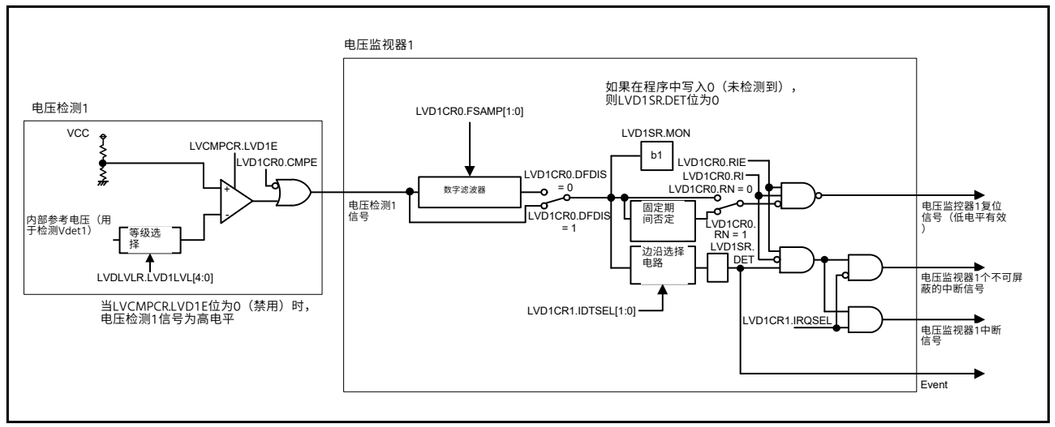


Figure 8.2 电压监视器1中断和复位电路框图

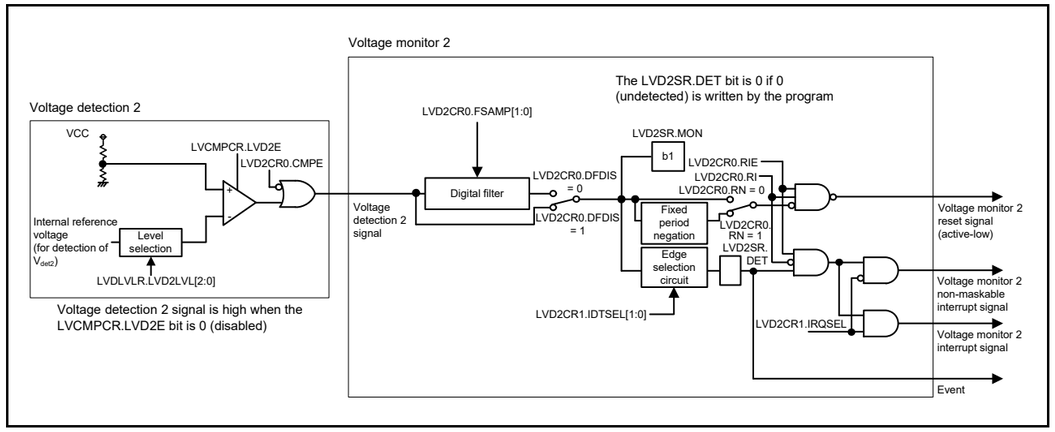


Figure 8.3 Voltage monitor 2 interrupt/reset circuit block diagram

8.2 Register Descriptions

8.2.1 Voltage Monitor 1 Circuit Control Register 1 (LVD1CR1)

Address(es): SYSTEM.LVD1CR1 4001 E0E0h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	IRQSEL	IDTSEL[1:0]	
Value after reset:	0	0	0	0	0	0	0	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	IDTSEL[1:0]	Voltage Monitor 1 Interrupt Generation Condition Select	b1 b0 0 0: When VCC ≥ V_{det1} (rise) is detected 0 1: When VCC < V_{det1} (fall) is detected 1 0: When fall and rise are detected 1 1: Settings prohibited.	R/W
b2	IRQSEL	Voltage Monitor 1 Interrupt Type Select	0: Non-maskable interrupt 1: Maskable interrupt.*1	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: Set the PRCR.PRC3 bit to 1 (write enabled) before rewriting this register.
Note 1. When enabling maskable interrupts, do not change the NMIER.LVD1EN bit value in the ICU from the reset state.

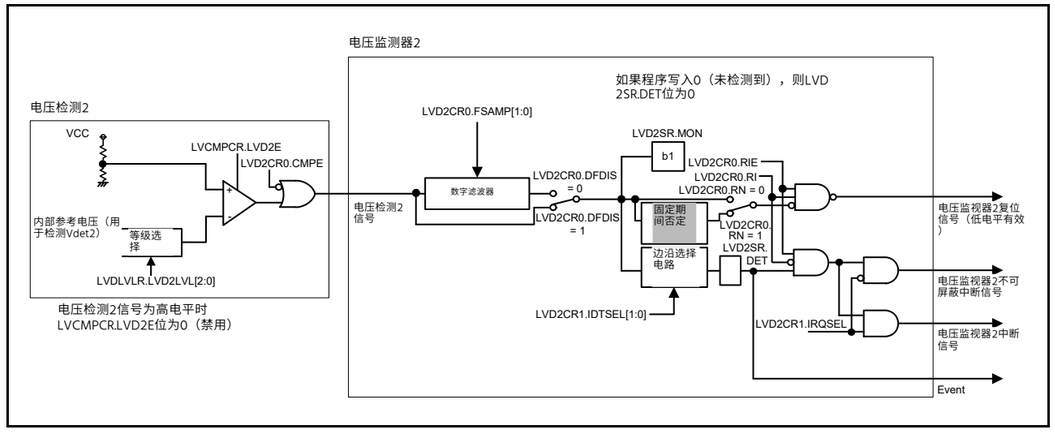


Figure 8.3 电压监测器2中断复位电路框图

8.2 注册说明

8.2.1 电压监视器1电路控制寄存器1(LVD1CR1)

Address(es): SYSTEM.LVD1CR1 4001 E0E0h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	IRQSEL	IDTSEL[1:0]	
重置后的值:	0	0	0	0	0	0	0	1

Bit	Symbol	位名称	Description	R/W
b1, b0	IDTSEL[1:0]	电压监视器1中断发生条件选择	b1b000：检测到VCC Vdet1（上升）时01：检测到VCC<Vdet1（下降）时10：检测到下降和上升时11：禁止设置。	R/W
b2	IRQSEL	电压监视器1中断类型 Select	0: Non-maskable interrupt 1: Maskable interrupt.*1	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 在重写该寄存器之前将PRCR.PRC3位设置为1（允许写入）。
Note 1. 启用可屏蔽中断时，不要从复位状态更改ICU中的NMIER.LVD1EN位值。

8.2.2 Voltage Monitor 1 Circuit Status Register (LVD1SR)

Address(es): SYSTEM.LVD1SR 4001 E0E1h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	MON	DET
Value after reset:	0	0	0	0	0	0	1	0

Bit	Symbol	Bit name	Description	R/W
b0	DET	Voltage Monitor 1 Voltage Change Detection Flag	0: Not detected 1: V_{det1} passage detected.	R(/W) *1
b1	MON	Voltage Monitor 1 Signal Monitor Flag	0: VCC < V_{det1} 1: VCC ≥ V_{det1} or MON is disabled.	R
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: Set the PRCR.PRC3 bit to 1 (write enabled) before rewriting this register.
Note 1. Only 0 can be written to this bit. After writing 0 to this bit, 2 system clock cycles are required for the bit to be read as 0.

DET flag (Voltage Monitor 1 Voltage Change Detection Flag)

The DET flag is enabled when the LVCMPCR.LVD1E bit is 1 (voltage detection 1 circuit enabled) and the LVD1CR0.CMPE bit is 1 (voltage monitor 1 circuit comparison result output enabled).

Set the DET flag to 0 after LVD1CR0.RIE is set to 0 (disabled). LVD1CR0.RIE can be set to 1 (enabled) after 2 or more PCLKB cycles elapse.

MON flag (Voltage Monitor 1 Signal Monitor Flag)

The MON flag is enabled when the LVCMPCR.LVD1E bit is 1 (voltage detection 1 circuit enabled) and the LVD1CR0.CMPE bit is 1 (voltage monitor 1 circuit comparison result output enabled).

8.2.3 Voltage Monitor 2 Circuit Control Register 1 (LVD2CR1)

Address(es): SYSTEM.LVD2CR1 4001 E0E2h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	IRQSEL	IDTSEL[1:0]	
Value after reset:	0	0	0	0	0	0	0	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	IDTSEL[1:0]	Voltage Monitor 2 Interrupt Generation Condition Select	b1 b0 0 0: When VCC ≥ V_{det2} (rise) is detected 0 1: When VCC < V_{det2} (fall) is detected 1 0: When fall and rise are detected 1 1: Settings prohibited.	R/W
b2	IRQSEL	Voltage Monitor 2 Interrupt Type Select	0: Non-maskable interrupt 1: Maskable interrupt.*1	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: Set the PRCR.PRC3 bit to 1 (write enabled) before rewriting this register.
Note 1. When enabling maskable interrupts, do not change the NMIER.LVD1EN bit value in the ICU from the reset state.

8.2.2 电压监视器1电路状态寄存器(LVD1SR)

Address(es): SYSTEM.LVD1SR 4001 E0E1h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	MON	DET
重置后的值:	0	0	0	0	0	0	1	0

Bit	Symbol	位名称	Description	R/W
b0	DET	电压监视器1电压变化检测标志	0：未检测到1：检测到Vdet1通过。	R(/W) *1
b1	MON	电压监视器1信号监视器标志	0：VCC<Vdet11：VCC Vdet1或MON被禁用。	R
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 在重写该寄存器之前将PRCR.PRC3位设置为1（允许写入）。
Note 1. 该位只能写入0。向该位写入0后，需要2个系统时钟周期才能将该位读为0。

DET标志（电压监视器1电压变化检测标志）

当LVCMPCR.LVD1E位为1（使能电压检测1电路）且
LVD1CR0.CMPE位为1（电压监视器1电路比较结果输出使能）。

在LVD1CR0.RIE设置为0（禁用）后，将DET标志设置为0。LVD1CR0.RIE可以在2或更多之后设置为1（启用）PCLKB周期过去了。

MON标志（电压监视器1信号监视器标志）

当LVCMPCR.LVD1E位为1（使能电压检测1电路）且
LVD1CR0.CMPE位为1（电压监视器1电路比较结果输出使能）。

8.2.3 电压监视器2电路控制寄存器1(LVD2CR1)

Address(es): SYSTEM.LVD2CR1 4001 E0E2h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	IRQSEL	IDTSEL[1:0]	
重置后的值:	0	0	0	0	0	0	0	1

Bit	Symbol	位名称	Description	R/W
b1, b0	IDTSEL[1:0]	电压监视器2中断发生条件选择	b1b000：检测到VCC Vdet2（上升）时01：检测到VCC<Vdet2（下降）时10：检测到下降和上升时11：禁止设置。	R/W
b2	IRQSEL	电压监视器2中断类型Select	0: Non-maskable interrupt 1: Maskable interrupt.*1	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 在重写该寄存器之前将PRCR.PRC3位设置为1（允许写入）。
Note 1. 启用可屏蔽中断时，不要从复位状态更改ICU中的NMIER.LVD1EN位值。

8.2.4 Voltage Monitor 2 Circuit Status Register (LVD2SR)

Address(es): SYSTEM.LVD2SR 4001 E0E3h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	MON	DET
Value after reset:	0	0	0	0	0	0	1	0

Bit	Symbol	Bit name	Description	R/W
b0	DET	Voltage Monitor 2 Voltage Change Detection Flag	0: Not detected 1: V_{det2} passage detected.	R(/W) *1
b1	MON	Voltage Monitor 2 Signal Monitor Flag	0: VCC < V_{det2} 1: VCC ≥ V_{det2} or MON is disabled.	R
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: Set the PRCR.PRC3 bit to 1 (write enabled) before rewriting this register.
Note 1. Only 0 can be written to this bit. After writing 0 to this bit, 2 system clock cycles are required for the bit to be read as 0.

DET flag (Voltage Monitor 2 Voltage Change Detection Flag)

The DET flag is enabled when the LVCMPCR.LVD2E bit is 1 (voltage detection 2 circuit enabled) and the LVD2CR0.CMPE bit is 1 (voltage monitor 2 circuit comparison result output enabled).

Set the DET flag to 0 after LVD2CR0.RIE is set to 0 (disabled). LVD2CR0.RIE can be set to 1 (enabled) after 2 or more PCLKB cycles have elapsed.

MON flag (Voltage Monitor 2 Signal Monitor Flag)

The MON flag is enabled when the LVCMPCR.LVD2E bit is 1 (voltage detection 2 circuit enabled) and the LVD2CR0.CMPE bit is 1 (voltage monitor 2 circuit comparison result output enabled).

8.2.5 Voltage Monitor Circuit Control Register (LVCMPCR)

Address(es): SYSTEM.LVCMPCR 4001 E417h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	LVD2E	LVD1E	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b5	LVD1E	Voltage Detection 1 Enable	0: Voltage detection 1 circuit disabled 1: Voltage detection 1 circuit enabled.	R/W
b6	LVD2E	Voltage Detection 2 Enable	0: Voltage detection 2 circuit disabled 1: Voltage detection 2 circuit enabled.	R/W
b7	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

Note: Set the PRCR.PRC3 bit to 1 (write enabled) before rewriting this register.

LVD1E bit (Voltage Detection 1 Enable)

When using voltage detection 1 interrupt/reset or the LVD1SR.MON bit, set the LVD1E bit to 1. The voltage detection 1 circuit starts when $t_{d(E-A)}$ elapses after the LVD1E bit value is changed from 0 to 1. When using the voltage detection 1 circuit in Deep Software Standby mode, do not set the DPSBYCR.DEEPCUT[1:0] bits to 11b.

8.2.4 电压监视器2电路状态寄存器(LVD2SR)

Address(es): SYSTEM.LVD2SR 4001 E0E3h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	MON	DET
重置后的值:	0	0	0	0	0	0	1	0

Bit	Symbol	位名称	Description	R/W
b0	DET	电压监视器2电压变化检测标志	0：未检测到1：检测到Vdet2通过。	R(/W) *1
b1	MON	电压监视器2信号监视器Flag	0：VCC<Vdet21：VCC Vdet2或MON被禁用。	R
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 在重写该寄存器之前将PRCR.PRC3位设置为1（允许写入）。
Note 1. 该位只能写入0。向该位写入0后，需要2个系统时钟周期才能将该位读为0。

DET标志（电压监视器2电压变化检测标志）

当LVCMPCR.LVD2E位为1（使能电压检测2电路）且LVD2CR0.CMPE位为1（电压监控器2电路比较结果输出使能）。

在LVD2CR0.RIE设置为0（禁用）后，将DET标志设置为0。LVD2CR0.RIE可以设置为1（启用）后2或更多PCLKB周期已经过去。

MON标志（电压监视器2信号监视器标志）

当LVCMPCR.LVD2E位为1（电压检测2电路使能）且LVD2CR0.CMPE位为1（电压监控器2电路比较结果输出使能）。

8.2.5 电压监控电路控制寄存器(LVCMPCR)

Address(es): SYSTEM.LVCMPCR 4001 E417h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	LVD2E	LVD1E	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b5	LVD1E	电压检测1使能	0：电压检测1电路无效1：电压检测1电路有效。	R/W
b6	LVD2E	电压检测2使能	0：电压检测2电路无效1：电压检测2电路有效。	R/W
b7	—	Reserved	该位读取为0。写入值应为0。	R/W

Note: 在重写该寄存器之前将PRCR.PRC3位设置为1（允许写入）。

LVD1E位（电压检测1使能）

使用电压检测1中断复位或LVD1SR.MON位时，将LVD1E位设置为1。LVD1E位值从0变为1后经过td(E-A)时，电压检测1电路启动。使用电压检测时1电路处于深度软件待机模式，请勿将DPSBYCR.DEEPCUT[1:0]位设置为11b。

LVD2E bit (Voltage Detection 2 Enable)

When using voltage detection 2 interrupt/reset or the LVD2SR.MON bit, set the LVD2E bit to 1. The voltage detection 2 circuit starts when $t_{d(E-A)}$ elapses after the LVD2E bit value is changed from 0 to 1. When using the voltage detection 2 circuit in Deep Software Standby mode, do not set the DPSBYCR.DEEPCUT[1:0] bits to 11b.

8.2.6 Voltage Detection Level Select Register (LVDLVLR)

Address(es): SYSTEM.LVDLVLR 4001 E418h

	b7	b6	b5	b4	b3	b2	b1	b0
	LVD2LVL[2:0]			LVD1LVL[4:0]				
Value after reset	1	1	1	1	0	0	1	1

Bit	Symbol	Bit name	Description	R/W
b4 to b0	LVD1LVL[4:0]	Voltage Detection 1 Level Select (standard voltage during fall in voltage)	b4 b0 1 0 0 0 1: 2.99 V (V_{det1_1}) 1 0 0 1 0: 2.92 V (V_{det1_2}) 1 0 0 1 1: 2.85 V (V_{det1_3}). Other settings are prohibited.	R/W
b7 to b5	LVD2LVL[2:0]	Voltage Detection 2 Level Select (standard voltage during fall in voltage)	b7 b5 1 0 1: 2.99 V (V_{det2_1}) 1 1 0: 2.92 V (V_{det2_2}) 1 1 1: 2.85 V (V_{det2_3}). Other settings are prohibited.	R/W

Note: Set the PRCR.PRC3 bit to 1 (write enabled) before rewriting this register.

The contents of the LVDLVLR register can only be changed if the LVCMPCR.LVD1E and LVCMPCR.LVD2E bits (voltage detection n circuit disable, n = 1, 2) are both 0. Do not set LVD detectors 1 and 2 to the same voltage detection level.

8.2.7 Voltage Monitor 1 Circuit Control Register 0 (LVD1CR0)

Address(es): SYSTEM.LVD1CR0 4001 E41Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	RN	RI	FSAMP[1:0]		—	CMPE	DFDIS	RIE
Value after reset:	1	0	0	0	x	0	1	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	RIE	Voltage Monitor 1 Interrupt/Reset Enable	0: Disable 1: Enable.	R/W
b1	DFDIS	Voltage Monitor 1 Digital Filter Disable Mode Select	0: Enable digital filter 1: Disable digital filter.	R/W
b2	CMPE	Voltage Monitor 1 Circuit Comparison Result Output Enable	0: Disable voltage monitor 1 circuit comparison result output 1: Enable voltage monitor 1 circuit comparison result output.	R/W
b3	—	Reserved	The read value is undefined. The write value should be 1.	R/W
b5, b4	FSAMP[1:0]	Sampling Clock Select	b5 b4 0 0: 1/2 LOCO frequency 0 1: 1/4 LOCO frequency 1 0: 1/8 LOCO frequency 1 1: 1/16 LOCO frequency.	R/W

LVD2E位（电压检测2使能）

使用电压检测2中断复位或LVD2SR.MON位时，将LVD2E位设置为1。LVD2E位值从0变为1后经过td(E-A)时，电压检测2电路启动。使用电压检测时2电路处于深度软件待机模式，请勿将DPSBYCR.DEEPCUT[1:0]位设置为11b。

8.2.6 电压检测电平选择寄存器(LVDLVLR)

Address(es): SYSTEM.LVDLVLR 4001 E418h

	b7	b6	b5	b4	b3	b2	b1	b0
	LVD2LVL[2:0]			LVD1LVL[4:0]				
重置后的值	1	1	1	1	0	0	1	1

Bit	Symbol	位名称	Description	R/W
b4 to b0	LVD1LVL[4:0]	电压检测1电平选择（电压下降时的标准电压）	b4b010001:2.99V(Vdet1_1)10010:2.92V(Vdet1_2)10011:2.85V(Vdet1_3)。禁止其他设置。	R/W
b7 to b5	LVD2LVL[2:0]	电压检测2电平选择（电压下降时的标准电压）	b7b5101：2.99V(Vdet2_1)110：2.92V(Vdet2_2)111：2.85V(Vdet2_3)。禁止其他设置。	R/W

Note: 在重写该寄存器之前将PRCR.PRC3位设置为1（允许写入）。

LVDLVLR寄存器的内容只有在LVCMPCR.LVD1E和LVCMPCR.LVD2E位（电压检测n电路禁用，n=1 2）都为0时才能更改。不要将LVD检测器1和2设置为相同的电压检测等级。

8.2.7 电压监视器1电路控制寄存器0(LVD1CR0)

Address(es): SYSTEM.LVD1CR0 4001 E41Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	RN	RI	FSAMP[1:0]		—	CMPE	DFDIS	RIE
重置后的值:	1	0	0	0	x	0	1	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	RIE	电压监视器1 Interrupt/Reset Enable	0：禁用1 ：启用。	R/W
b1	DFDIS	电压监视器1数字滤波器禁用模式选择	0：启用数字滤波器1 ：禁用数字滤波器。	R/W
b2	CMPE	电压监视器1电路比较结果输出 Enable	0：禁止电压监视1电路比较结果输出1：使能电压监视1电路比较结果输出。	R/W
b3	—	Reserved	读取值未定义。写入值应为1。	R/W
b5, b4	FSAMP[1:0]	采样时钟选择	b5b400：12LOCO频率01：14LOCO频率10：18LOCO频率11：116LOCO频率。	R/W

Bit	Symbol	Bit name	Description	R/W
b6	RI	Voltage Monitor 1 Circuit Mode Select	0: Generate voltage monitor 1 interrupt on V_{det1} passage 1: Enable voltage monitor 1 reset when the voltage falls to and below V_{det1}.	R/W
b7	RN	Voltage Monitor 1 Reset Negate Select	0: Negate after a stabilization time (t_{LVD1}) when VCC > V_{det1} is detected 1: Negate after a stabilization time (t_{LVD1}) on assertion of the LVD1 reset.	R/W

Note: Set the PRCR.PRC3 bit to 1 (write enabled) before rewriting this register.

RIE bit (Voltage Monitor 1 Interrupt/Reset Enable)

The RIE bit enables or disables the voltage monitor 1 interrupt/reset. Set this bit to ensure that neither a voltage monitor 1 interrupt nor a voltage monitor 1 reset is generated during programming or erasure of the flash memory.

DFDIS bit (Voltage Monitor 1 Digital Filter Disable Mode Select)

The DFDIS bit enables the digital filter circuit. Set the LOCOCR.LCSTP bit to 0 (the LOCO operates) if this bit is 0 (enabled). Set the bit to 1 (disabled) when using the voltage monitor 1 circuit in Software Standby or Deep Software Standby mode.

FSAMP[1:0] bits (Sampling Clock Select)

Only change the FSAMP[1:0] bits when the LVD1CR0.DFDIS bit is 1 (digital filter circuit disabled) but not when LVD1CR0.DFDIS is 0 (digital filter circuit enabled).

RI bit (Voltage Monitor 1 Circuit Mode Select)

When the RI bit is 1 (voltage monitor 1 reset selected) or when the LVD2CR0.RI bit is 1 (voltage monitor 2 reset selected), transition to Software Standby mode can be made but not to Deep Software Standby mode. To enter Deep Software Standby mode, set the RI bit to 0 (voltage monitor 1 interrupt selected) and the LVD2CR0.RI bit to 0 (voltage monitor 2 interrupt selected).

RN bit (Voltage Monitor 1 Reset Negate Select)

If the RN bit is to be set to 1 (negation follows a stabilization time on assertion of the LVD1 reset signal), set the LOCOCR.LCSTP bit to 0 (the LOCO operates). In addition, for a transition to Software Standby or Deep Software Standby, the only possible value for the RN bit is 0 (negation follows a stabilization time when VCC > V_{det1} is detected). Do not set the RN bit to 1 when this is the case.

8.2.8 Voltage Monitor 2 Circuit Control Register 0 (LVD2CR0)

Address(es): SYSTEM.LVD2CR0 4001 E41Bh

	b7	b6	b5	b4	b3	b2	b1	b0
	RN	RI	FSAMP[1:0]		—	CMPE	DFDIS	RIE
Value after reset:	1	0	0	0	x	0	1	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	RIE	Voltage Monitor 2 Interrupt/Reset Enable	0: Disable 1: Enable.	R/W
b1	DFDIS	Voltage Monitor 2 Digital Filter Disable Mode Select	0: Enable digital filter 1: Disable digital filter.	R/W
b2	CMPE	Voltage Monitor 2 Circuit Comparison Result Output Enable	0: Disable voltage monitor 2 circuit comparison result output 1: Enable voltage monitor 2 circuit comparison result output.	R/W
b3	—	Reserved	The read value is undefined. The write value should be 1.	R/W

Bit	Symbol	位名称	Description	R/W
b6	RI	电压监视器1电路模式选择	0：在Vdet1通过时产生电压监控1中断1：当电压下降到Vdet1或低于Vdet1时，使能电压监控1复位。	R/W
b7	RN	电压监视器1复位否定选择	0：当检测到VCC>Vdet1时，在稳定时间(tLVD1)后取反1：在断言LVD1复位时在稳定时间(tLVD1)后取反。	R/W

Note: 在重写该寄存器之前将PRCR.PRC3位设置为1（允许写入）。

RIE位（电压监视器1中断复位使能）

RIE位启用或禁用电压监视器1中断复位。设置该位以确保在闪存的编程或擦除期间不会产生电压监视器1中断或电压监视器1复位。

DFDIS位（电压监视器1数字滤波器禁用模式选择）

DFDIS位使能数字滤波器电路。如果该位为0（启用），则将LOCOCR.LCSTP位设置为0（LOCO运行）。当在软件待机或深度软件待机模式下使用电压监视器1电路时，将该位设置为1（禁用）。

FSAMP[1:0]位（采样时钟选择）

仅在LVD1CR0.DFDIS位为1（禁用数字滤波器电路）时更改FSAMP[1:0]位，但在以下情况下不更改LVD1CR0.DFDIS为0（启用数字滤波器电路）。

RI位（电压监视器1电路模式选择）

当RI位为1（选择电压监视器1复位）或LVD2CR0.RI位为1（选择电压监视器2复位）时，可以转换到软件待机模式，但不能转换到深度软件待机模式。要进入深度软件待机模式，请将RI位设置为0（选择电压监视器1中断）并将LVD2CR0.RI位设置为0（选择电压监视器2中断）。

RN位（电压监视器1复位否定选择）

如果RN位被设置为1（否定遵循LVD1复位信号置位的稳定时间），设置LOCOCR.LCSTP位为0（LOCO运行）。此外，为了过渡到软件待机或深度软件待机时，RN位唯一可能的值是0（当检测到VCC>Vdet1时，否定遵循稳定时间）。在这种情况下，请勿将RN位设置为1。

8.2.8 电压监视器2电路控制寄存器0(LVD2CR0)

Address(es): SYSTEM.LVD2CR0 4001 E41Bh

	b7	b6	b5	b4	b3	b2	b1	b0
	RN	RI	FSAMP[1:0]		—	CMPE	DFDIS	RIE
重置后的值:	1	0	0	0	x	0	1	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	RIE	电压监视器2中断复位Enable	0：禁用1 ：启用。	R/W
b1	DFDIS	电压监视器2数字滤波器禁用模式选择	0：启用数字滤波器1 ：禁用数字滤波器。	R/W
b2	CMPE	电压监视器2电路比较结果输出使能	0：禁止电压监视2电路比较结果输出1：使能电压监视2电路比较结果输出。	R/W
b3	—	Reserved	读取值未定义。写入值应为1。	R/W

Bit	Symbol	Bit name	Description	R/W
b5, b4	FSAMP[1:0]	Sampling Clock Select	b5 b4 0 0: 1/2 LOCO frequency 0 1: 1/4 LOCO frequency 1 0: 1/8 LOCO frequency 1 1: 1/16 LOCO frequency.	R/W
b6	RI	Voltage Monitor 2 Circuit Mode Select	0: Generate voltage monitor 2 interrupt on V_{det2} passage 1: Enable voltage monitor 2 reset when the voltage falls to and below V_{det2}.	R/W
b7	RN	Voltage Monitor 2 Reset Negate Select	0: Negate after a stabilization time (t_{LVD2}) when VCC > V_{det2} is detected 1: Negate after a stabilization time (t_{LVD2}) on assertion of the LVD2 reset.	R/W

Note: Set the PRCR.PRC3 bit to 1 (write enabled) before rewriting this register.

RIE bit (Voltage Monitor 2 Interrupt/Reset Enable)

The RIE bit enables or disables voltage monitor 2 interrupt/reset. Set this bit to ensure that neither a voltage monitor 2 interrupt nor a voltage monitor 2 reset is generated during programming or erasure of the flash memory.

DFDIS bit (Voltage Monitor 2 Digital Filter Disable Mode Select)

The DFDIS bit enables the digital filter circuit. Set the LOCOCR.LCSTP bit to 0 (the LOCO operates) if this bit is 0 (enabled). Set the bit to 1 (disabled) when using the voltage monitor 2 circuit in Software Standby or Deep Software Standby mode.

FSAMP[1:0] bits (Sampling Clock Select)

Only change the FSAMP[1:0] bits when the LVD2CR0.DFDIS bit is 1 (digital filter circuit disabled), but not when LVD2CR0.DFDIS is 0 (digital filter circuit enabled).

RI bit (Voltage Monitor 2 Circuit Mode Select)

When the RI bit is 1 (voltage monitor 2 reset selected) or when the LVD1CR0.RI bit is 1 (voltage monitor 1 reset selected), transition to Software Standby mode can be made but not to Deep Software Standby mode. To enter Deep Software Standby mode, set the RI bit to 0 (voltage monitor 2 interrupt selected) and the LVD1CR0.RI bit to 0 (voltage monitor 1 interrupt selected).

RN bit (Voltage Monitor 2 Reset Negate Select)

If the RN bit is set to 1 (negation follows a stabilization time on assertion of the LVD2 reset signal), set the LOCOCR.LCSTP bit to 0 (the LOCO operates). Additionally, for a transition to Software Standby or Deep Software Standby mode, the only possible value for the RN bit is 0 (negation follows a stabilization time when VCC > V_{det2} is detected). Do not set the RN bit to 1 (negation follows a stabilization time after assertion of the LVD2 reset signal) when this is the case.

8.3 VCC Input Voltage Monitor

8.3.1 Monitoring V_{det0}

The comparison results from voltage monitor 0 are not available for reading.

8.3.2 Monitoring V_{det1}

Table 8.2 shows the procedure to set up monitoring against V_{det1}. After the settings are complete, the comparison results from voltage monitor 1 can be monitored with the LVD1SR.MON flag.

Bit	Symbol	位名称	Description	R/W
b5, b4	FSAMP[1:0]	采样时钟选择	b5b400：12LOCO频率01：14LOCO频率10：18LOCO频率11：116LOCO频率。	R/W
b6	RI	电压监视器2电路模式Select	0：在Vdet2通道时产生电压监视器2中断1：当电压下降到Vdet2或低于Vdet2时，使能电压监视器2复位。	R/W
b7	RN	电压监视器2复位否定Select	0：在检测到VCC>Vdet2时在稳定时间(tLVD2)后取反1：在LVD2复位有效时在稳定时间(tLVD2)后取反。	R/W

Note: 在重写该寄存器之前将PRCR.PRC3位设置为1（允许写入）。

RIE位（电压监视器2中断复位使能）

RIE位启用或禁用电压监视器2中断复位。设置该位以确保在闪存的编程或擦除期间不会产生电压监视器2中断或电压监视器2复位。

DFDIS位（电压监视器2数字滤波器禁用模式选择）

DFDIS位使能数字滤波器电路。如果该位为0（启用），则将LOCOCR.LCSTP位设置为0（LOCO运行）。当在软件待机或深度软件待机模式下使用电压监视器2电路时，将该位设置为1（禁用）。

FSAMP[1:0]位（采样时钟选择）

仅在LVD2CR0.DFDIS位为1（禁用数字滤波器电路）时更改FSAMP[1:0]位，但在LVD2CR0.DFDIS为0（启用数字滤波器电路）。

RI位（电压监视器2电路模式选择）

当RI位为1（选择电压监视器2复位）或LVD1CR0.RI位为1（选择电压监视器1复位）时，可以转换到软件待机模式，但不能转换到深度软件待机模式。要进入深度软件待机模式，请将RI位设置为0（选择电压监视器2中断）并将LVD1CR0.RI位设置为0（选择电压监视器1中断）。

RN位（电压监视器2复位否定选择）

如果RN位设置为1（否定遵循LVD2复位信号置位的稳定时间），设置LOCOCR.LCSTP位为0（LOCO运行）。此外，为了转换到软件待机或深度软件待机模式，RN位的唯一可能值是0（当检测到VCC>Vdet2时，取反遵循稳定时间）。在这种情况下，请勿将RN位设置为1（在LVD2复位信号置位后的稳定时间之后取反）。

8.3 VCC输入电压监视器

8.3.1 Monitoring V_{det0}

电压监视器0的比较结果不可读取。

8.3.2 Monitoring V_{det1}

表8.2显示了针对Vdet1设置监控的过程。设置完成后，电压监视器1的比较结果可以通过LVD1SR.MON标志进行监视。

Table 8.2 Procedure to set up monitoring against V_{det1}

Step		Monitoring the comparison results from voltage monitor 1
Setting the voltage detection 1 circuit	1	Set LVCMPCR.LVD1E = 0 to disable voltage detection 1 before writing to the LVDLVLR register.
	2	Select the detection voltage in the LVDLVLR.LVD1LVL[4:0] bits.
	3	Set LVCMPCR.LVD1E = 1 to enable voltage detection 1.
	4	Wait for at least $t_{d(E-A)}$ for the LVD operation stabilization time after LVD is enabled.*1
Setting the digital filter*2	5	Select the sampling clock for the digital filter in the LVD1CR0.FSAMP[1:0] bits.
	6	Set LVD1CR0.DFDIS = 0 to enable the digital filter.
	7	Wait for at least 2n + 3 LOCO cycles, where n = 2, 4, 8, 16 and the sampling clock for the digital filter is the LOCO frequency divided by n.
Enabling output	8	Set LVD1CR0.CMPE = 1 to enable output of the comparison results from voltage monitor 1.

Note 1. Steps 5 to 7 can be performed during the wait time in step 4. For details on $t_{d(E-A)}$, see section 43, Electrical Characteristics.
Note 2. Steps 5 to 7 are not required if the digital filter is not in use.

8.3.3 Monitoring V_{det2}

Table 8.3 shows the procedure to set up monitoring against V_{det2}. After the settings are complete, the comparison results from voltage monitor 2 can be monitored with the LVD2SR.MON flag.

Table 8.3 Procedure to set up monitoring against V_{det2}

Step		Monitoring the comparison results by voltage monitor 2
Setting up the voltage detection 2 circuit	1	Set LVCMPCR.LVD2E = 0 to disable voltage detection 2 before writing to the LVDLVLR register.
	2	Select the detection voltage in the LVDLVLR.LVD2LVL[2:0] bits.
	3	Set LVCMPCR.LVD2E = 1 to enable the voltage detection 2 circuit.
	4	Wait for at least $t_{d(E-A)}$ for the LVD operation stabilization time after LVD is enabled.*1
Setting up the digital filter*2	5	Select the sampling clock for the digital filter in the LVD2CR0.FSAMP[1:0] bits.
	6	Set LVD2CR0.DFDIS = 0 to enable the digital filter.
	7	Wait for at least 2n + 3 LOCO cycles, where n = 2, 4, 8, 16 and the sampling clock for the digital filter is the LOCO frequency divided by n.
Enabling output	8	Set LVD2CR0.CMPE = 1 to enable output of the comparison results by voltage monitor 2.

Note 1. Steps 5 to 7 can be performed during the wait time in step 4. For details on $t_{d(E-A)}$, see section 43, Electrical Characteristics.
Note 2. Steps 5 to 7 are not required if the digital filter is not in use.

8.4 Reset from Voltage Monitor 0

When using the reset from voltage monitor 0, clear the OFS1.LVDAS bit to 0 to enable the voltage monitor 0 reset after a reset. However, at boot mode, the reset from voltage monitor 0 is disabled regardless of the value of the OFS1.LVDAS bit. Figure 8.4 shows an example of operations for a voltage monitor 0 reset.

Table 8.2 针对Vdet1设置监控的程序

Step		从电压监视器1监视比较结果
设置电压检测1电路	1	设置LVCMPCR.LVD1E=0以在写入LVDLVLR寄存器之前禁用电压检测1。
	2	在LVDLVLR.LVD1LVL[4:0]位中选择检测电压。
	3	设置LVCMPCR.LVD1E=1以启用电压检测1。
	4	启用LVD后，至少等待td(E-A)的LVD操作稳定时间。*1
设置数字滤波器*2	5	在LVD1CR0.FSAMP[1:0]位中选择数字滤波器的采样时钟。
	6	设置LVD1CR0.DFDIS=0以启用数字滤波器。
	7	等待至少2n+3个LOCO周期，其中n=2、4、8、16，数字滤波器的采样时钟是LOCO频率除以n。
启用输出	8	设置LVD1CR0.CMPE=1以使能电压监视器1的比较结果输出。

Note 1. 步骤5至7可以在步骤4的等待时间内执行。有关td(E-A)的详细信息，请参阅第43节，电气Characteristics.
Note 2. 如果不使用数字滤波器，则不需要步骤5到7。

8.3.3 Monitoring V_{det2}

表8.3显示了针对Vdet2设置监控的过程。设置完成后，电压监视器2的比较结果可以通过LVD2SR.MON标志进行监视。

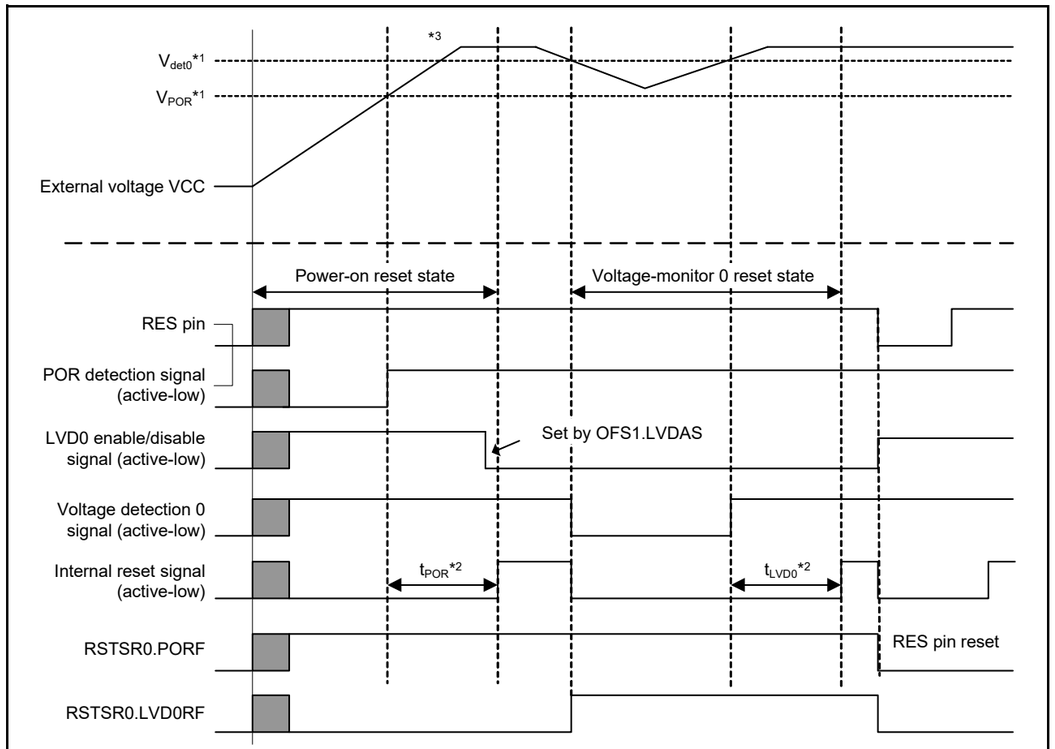
Table 8.3 针对Vdet2设置监控的程序

Step		通过电压监视器2监视比较结果
设置电压检测2电路	1	在写入LVDLVLR寄存器之前，设置LVCMPCR.LVD2E=0以禁用电压检测2。
	2	在LVDLVLR.LVD2LVL[2:0]位中选择检测电压。
	3	设置LVCMPCR.LVD2E=1以启用电压检测2电路。
	4	启用LVD后，至少等待td(E-A)的LVD操作稳定时间。*1
设置数字滤波器*2	5	在LVD2CR0.FSAMP[1:0]位中选择数字滤波器的采样时钟。
	6	设置LVD2CR0.DFDIS=0以启用数字滤波器。
	7	等待至少2n+3个LOCO周期，其中n=2、4、8、16，数字滤波器的采样时钟是LOCO频率除以n。
启用输出	8	设置LVD2CR0.CMPE=1以启用电压监视器2的比较结果输出。

Note 1. 步骤5至7可以在步骤4的等待时间内执行。有关td(E-A)的详细信息，请参阅第43节，电气Characteristics.
Note 2. 如果不使用数字滤波器，则不需要步骤5到7。

8.4 从电压监视器复位0

使用电压监控器0复位时，将OFS1.LVDAS位清零以在复位后启用电压监控器0复位。但是，在引导模式下，无论OFS1.LVDAS位的值如何，都禁止从电压监视器0进行的复位。图8.4显示了电压监视器0复位的操作示例。



Note: For details of the electrical characteristics, see section 43, Electrical Characteristics.
Note 1. V_{POR} indicates the detection level for a power-on reset and V_{det0} indicates the detection level for a voltage monitor 0 reset.
Note 2. t_{POR} indicates the period of a power-on reset and t_{LVD0} indicates the period of a voltage monitor 0 reset.
Note 3. At power-on, raise VCC to the minimum guaranteed voltage before releasing the POR reset.

Figure 8.4 Example of voltage monitor 0 reset operation

8.5 Interrupt and Reset from Voltage Monitor 1

An interrupt or reset can be generated in response to the comparison results from the voltage monitor 1 circuit.

Table 8.4 shows the procedure for setting bits related to the voltage monitor 1 interrupt/reset so that voltage monitoring operates. Table 8.5 shows the procedure for setting bits related to the voltage monitor 1 interrupt/reset so that voltage monitoring stops. Figure 8.5 shows an example of operations for a voltage monitor 1 interrupt. For the operation of the voltage monitor 1 reset, see Figure 6.2 in section 6, Resets.

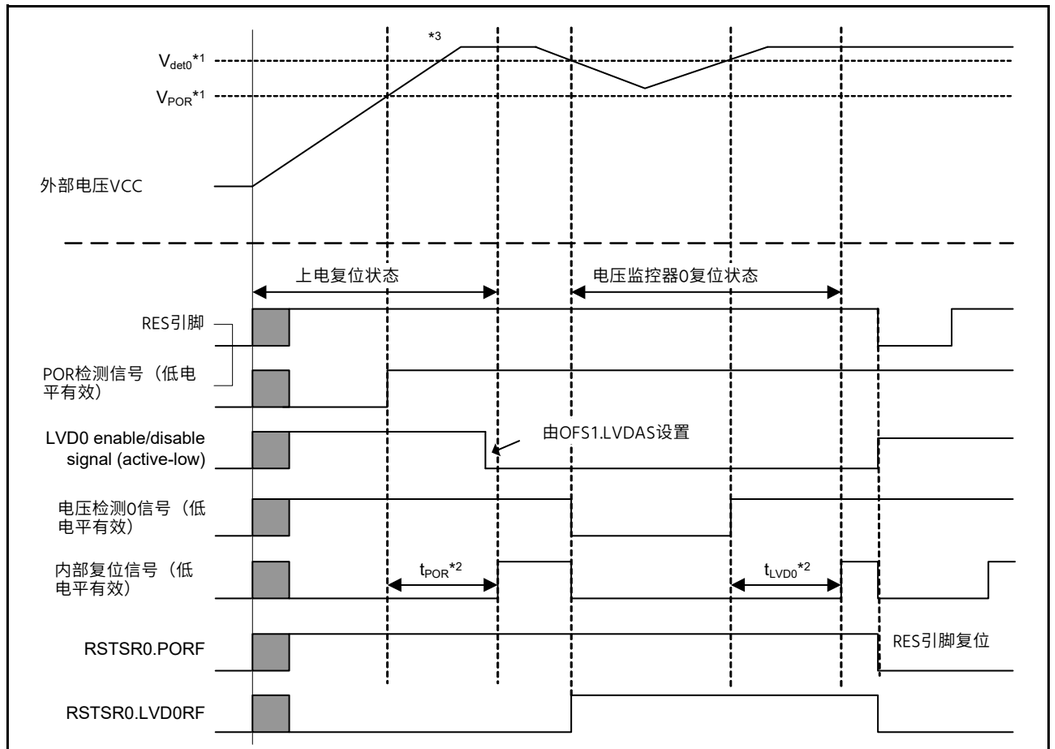
When using the voltage monitor 1 circuit in Software Standby or Deep Software Standby, set the circuit with the following procedures.

(1) Settings in Software Standby mode

- Disable the digital filter (LVD1CR0.DFDIS = 1)
- When VCC > V_{det1} is detected, negate the voltage monitor 1 reset signal (LVD1CR0.RN = 0) following a stabilization time.

(2) Settings in Deep Software Standby mode

- Disable the digital filter (LVD1CR0.DFDIS = 1)



Note: 有关电气特性的详细信息，请参阅第43节，电气特性。
Note 1. VPOR表示上电复位的检测电平，Vdet0表示电压监视器的检测电平0 reset.
Note 2. tPOR表示上电复位的周期，tLVD0表示电压监视器0复位的周期。
Note 3. 上电时，在释放POR复位之前将VCC提高到最低保证电压。

Figure 8.4 电压监视器0复位操作示例

8.5 电压监视器1的中断和复位

响应电压监视器1电路的比较结果，可以产生中断或复位。

表8.4显示了设置与电压监控1中断复位相关的位以使电压监控运行的过程。表8.5显示了设置与电压监控1中断复位相关的位以停止电压监控的过程。图8.5显示了电压监视器1中断的操作示例。有关电压监视器1复位的操作，请参见第6节"复位"中的图6.2。

在软件待机或深度软件待机中使用电压监视器1电路时，请按照以下步骤设置电路。

(1) 软件待机模式中的设置

- 禁用数字滤波器(LVD1CR0.DFDIS=1)
- 当检测到VCC>Vdet1时，在一段稳定时间后取消电压监视器1复位信号(LVD1CR0.RN=0)。

(2) 深度软件待机模式中的设置

- 禁用数字滤波器(LVD1CR0.DFDIS=1)

- Enable voltage monitor 1 interrupts (LVD1CR0.RI = 0). If the voltage monitor 1 reset is enabled (LVD1CR0.RI = 1), a transition to Deep Software Standby mode is not possible, and the operation transitions to Software Standby mode instead
- When the DPSBYCR.DEEPCUT[1:0] bits are 11b, the voltage monitor 1 circuit stops. To use the voltage monitor 1 circuit in Deep Software Standby mode, set the DPSBYCR.DEEPCUT[1:0] bits to a value other than 11b.

Table 8.4 Procedure for setting bits related to the voltage monitor 1 interrupt and voltage monitor 1 reset so that voltage monitoring operates

Step		Voltage monitor 1 interrupt (voltage monitor 1 ELC event output)	Voltage monitor 1 reset
Setting the voltage detection 1 circuit	1	Set LVCMPCR.LVD1E = 0 to disable voltage detection 1 before writing to the LVDLVLR register.	
	2	Select the detection voltage in the LVDLVLR.LVD1LVL[3:0] bits.	
	3	Set LVCMPCR.LVD1E = 1 to enable the voltage detection 1 circuit.	
	4	Wait for at least $t_{d(E-A)}$ for the LVD operation stabilization time after LVD is enabled.*1	
Setting the digital filter *2	5	Select the sampling clock for the digital filter in the LVD1CR0.FSAMP[1:0] bits.	
	6	Set LVD1CR0.DFDIS = 0 to enable the digital filter.	
	7	Wait for at least 2n + 3 LOCO cycles, where n = 2, 4, 8, 16 and the sampling clock for the digital filter is the LOCO frequency divided by n.*4	
Setting the voltage monitor 1 interrupt or reset	8	Set LVD1CR0.RI = 0 to select the voltage monitor 1 interrupt.	• Set LVD1CR0.RI = 1 to select the voltage monitor 1 reset • Select the type of reset negation in the LVD1CR0.RN bit.
	9	• Select the interrupt request timing in the LVD1CR1.IDTSEL[1:0] bits • Select the interrupt type in the LVD1CR1.IRQSEL bit.	—
Enabling output	10	Set LVD1SR.DET = 0.	
	11	Set LVD1CR0.RIE = 1 to enable the voltage monitor 1 interrupt or reset.*3	
	12	Set LVD1CR0.CMPE = 1 to enable output of the comparison results from voltage monitor 1.	

Note 1. Steps 5 to 11 can be performed during the wait time in step 4. For details on $t_{d(E-A)}$, see section 43, Electrical Characteristics.
Note 2. Steps 5 to 7 are not required if the digital filter is not in use.
Note 3. Step 11 is not required if only the ELC event signal is to be output.
Note 4. Steps 8 to 11 can be performed during the wait time in step 7.

Table 8.5 Procedure for setting bits related to the voltage monitor 1 interrupt and voltage monitor 1 reset so that voltage monitoring stops

Step		Voltage monitor 1 interrupt (voltage monitor 1 ELC event output), voltage monitor 1 reset
Stopping the enabling of output	1	Set LVD1CR0.CMPE = 0 to disable output of the comparison results by voltage monitor 1.
	2	Wait for at least 2n + 3 LOCO cycles, where n = 2, 4, 8, 16 and the sampling clock for the digital filter is the LOCO frequency divided by n.*1
	3	Set LVD1CR0.RIE = 0 to disable the voltage monitor 1 interrupt or reset.*2
Stopping the digital filter	4	Set LVD1CR0.DFDIS = 1 to disable the digital filter.*1, *3
Stopping the voltage detection 1 circuit	5	Set LVCMPCR.LVD1E = 0 to disable the voltage detection 1 circuit.

Note 1. Steps 2 and 4 are not required if the digital filter is not in use.
Note 2. Step 3 is not required if only the ELC event signal is to be output.
Note 3. To disable the digital filter from its enabled state and then re-enable it, disable it and wait for at least 2 LOCO clock cycles before re-enabling it.

- 启用电压监视器1中断(LVD1CR0.RI=0)。如果启用了电压监视器1复位(LVD1CR0.RI=1)，则无法转换到深度软件待机模式，而是将操作转换到软件待机模式
- 当DPSBYCR.DEEPCUT[1:0]位为11b时，电压监视器1电路停止。要在深度软件待机模式下使用电压监视器1电路，请将DPSBYCR.DEEPCUT[1:0]位设置为11b以外的值。

Table 8.4 设置与电压监控器1中断和电压监控器1复位相关的位以使电压监控器运行的步骤

Step		电压监视器1中断（电压监视器1ELC事件输出）	电压监视器1复位
设置电压检测1电路	1	设置LVCMPCR.LVD1E=0以在写入LVDLVLR寄存器之前禁用电压检测1。	
	2	在LVDLVLR.LVD1LVL[3:0]位中选择检测电压。	
	3	设置LVCMPCR.LVD1E=1以启用电压检测1电路。	
	4	启用LVD后，至少等待td(E-A)的LVD操作稳定时间。*1	
设置数字滤波器*2	5	在LVD1CR0.FSAMP[1:0]位中选择数字滤波器的采样时钟。	
	6	设置LVD1CR0.DFDIS=0以启用数字滤波器。	
	7	等待至少2n+3个LOCO周期，其中n=2、4、8、16，数字滤波器的采样时钟是LOCO频率除以n。*4	
设置电压监视器1中断或复位	8	设置LVD1CR0.RI=0以选择电压监视器1中断。	设置LVD1CR0.RI=1以选择电压监视器1复位在LVD1CR0.RN位中选择复位否定类型。
	9	在LVD1CR1.IDTSEL[1:0]位中选择中断请求时序 在LVD1CR1.IRQSEL位中选择中断类型。	—
启用输出	10	Set LVD1SR.DET = 0.	
	11	设置LVD1CR0.RIE=1以启用电压监视器1中断或复位。*3	
	12	设置LVD1CR0.CMPE=1以使能电压监视器1的比较结果输出。	

Note 1. 步骤5至11可以在步骤4的等待时间内执行。有关td(E-A)的详细信息，请参阅第43节，电气Characteristics.
Note 2. 如果不使用数字滤波器，则不需要步骤5到7。
Note 3. 如果只输出ELC事件信号，则不需要步骤11。
Note 4. 步骤8至11可以在步骤7的等待时间内执行。

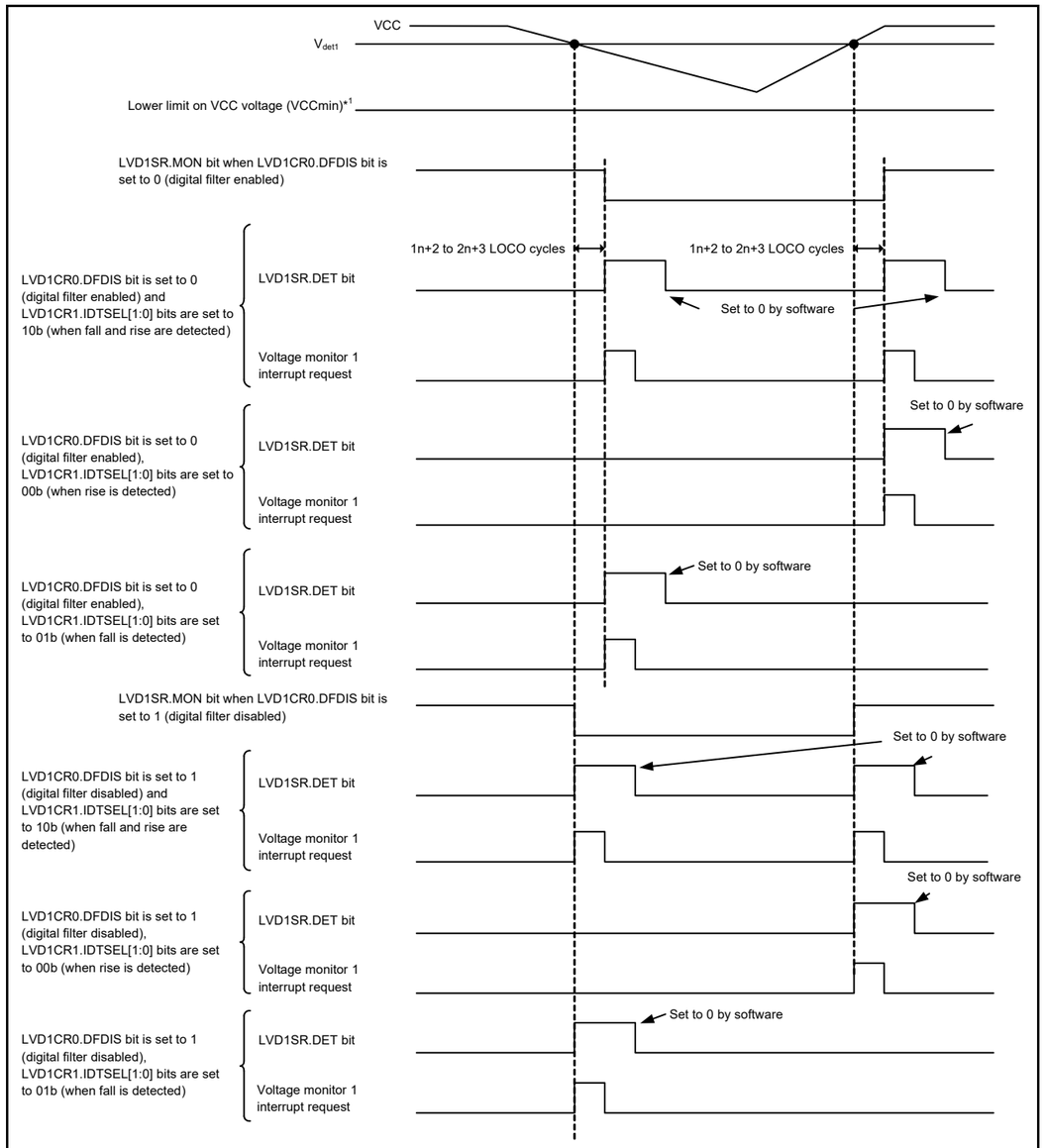
Table 8.5 设置与电压监控1中断和电压监控1复位相关的位以停止电压监控的步骤

Step		电压监视器1中断（电压监视器1ELC事件输出），电压监视器1复位
停止启用输出	1	设置LVD1CR0.CMPE=0以禁用电压监视器1的比较结果输出。
	2	等待至少2n+3个LOCO周期，其中n=2、4、8、16，数字滤波器的采样时钟是LOCO频率除以n。*1
	3	设置LVD1CR0.RIE=0以禁用电压监视器1中断或复位。*2
停止数字滤波器	4	设置LVD1CR0.DFDIS=1以禁用数字滤波器。*1 *3
停止电压检测1电路	5	设置LVCMPCR.LVD1E=0以禁用电压检测1电路。

Note 1. 如果不使用数字滤波器，则不需要步骤2和4。
Note 2. 如果只输出ELC事件信号，则不需要步骤3。
Note 3. 要从启用状态禁用数字滤波器然后重新启用它，请禁用它并等待至少2个LOCO时钟周期，然后再重新启用它。

If the voltage monitor 1 interrupt or reset setting is to be made again after it is used and stopped once, omit the following steps in the procedures for stopping and setting, depending on the conditions:

- Setting or stopping the voltage detection 1 circuit is not required if the settings for the circuit do not change
- Setting or stopping the digital filter is not required if the settings for the digital filter do not change
- Setting the voltage monitor 1 interrupt or reset is not required if the settings for the voltage monitor 1 interrupt or reset do not change.



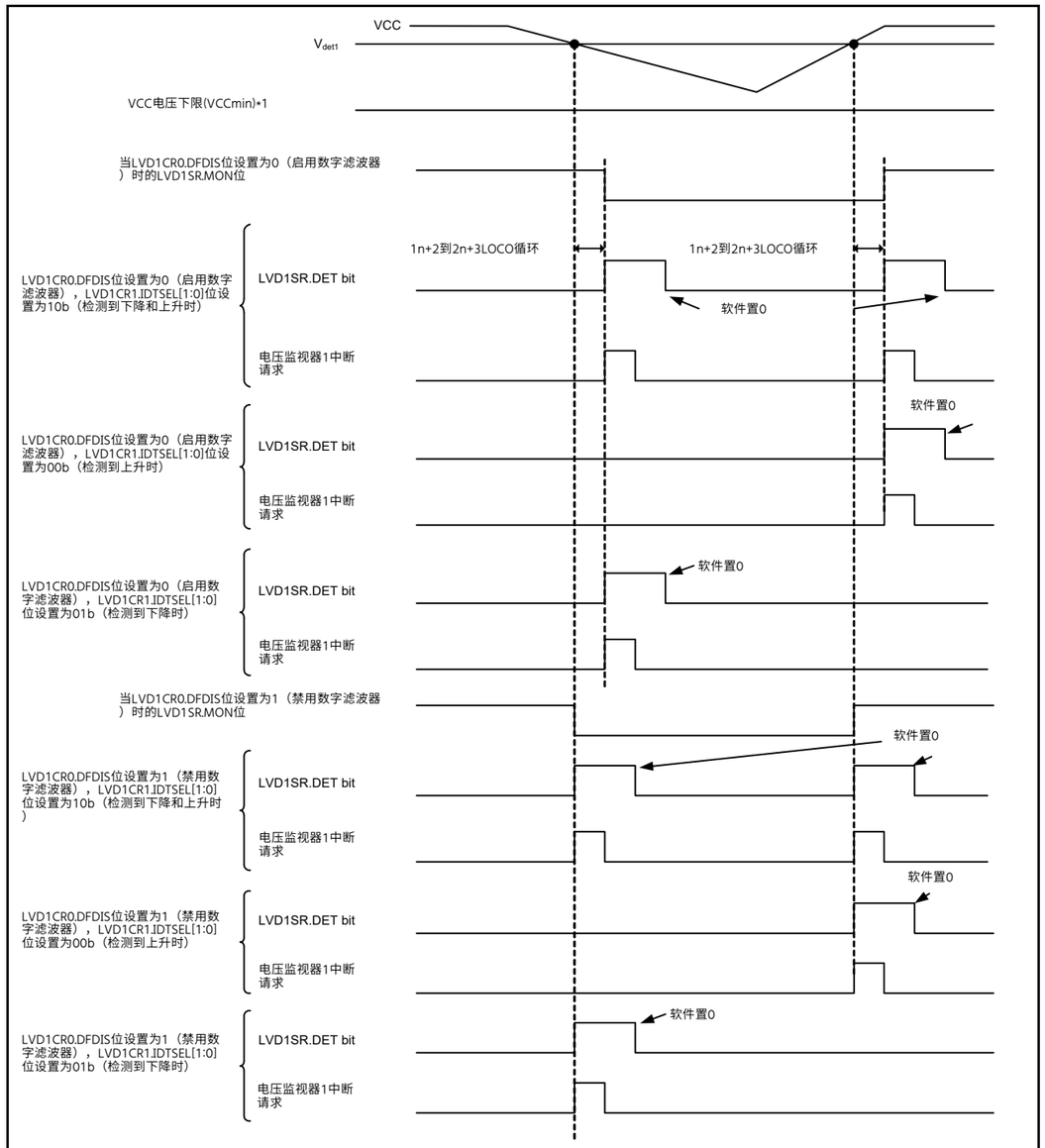
n: Frequency of the sampling clock for the digital filter is the LOCO frequency divided by n.

Note 1. When the voltage monitor 0 reset is not in use, VCC ≥ VCCmin.

Figure 8.5 Voltage monitor 1 interrupt operation example

如果电压监视器1在使用和停止一次后再次进行中断或复位设置，则在停止和设置过程中省略以下步骤，视情况而定：

- 如果电路的设置不改变，则不需要设置或停止电压检测1电路
- 如果数字滤波器的设置不变，则不需要设置或停止数字滤波器
- 如果电压监视器1中断或复位的设置没有改变，则不需要设置电压监视器1中断或复位。



n：数字滤波器的采样时钟频率是LOCO频率除以n。

Note 1. 不使用电压监视器0复位时，VCC VCCmin。

Figure 8.5 电压监视器1中断操作示例

8.6 Interrupt and Reset from Voltage Monitor 2

An interrupt or reset can be generated in response to the comparison results from the voltage monitor 2 circuit.

Table 8.6 shows the procedure for setting bits related to the voltage monitor 2 interrupt and reset so that voltage monitoring operates. Table 8.7 shows the procedure for setting bits related to the voltage monitor 2 interrupt and reset so that voltage monitoring stops. Figure 8.6 shows an example of operations for a voltage monitor 2 interrupt. For the operation of the voltage monitor 2 reset, see Figure 6.2 in section 6, Resets.

When using the voltage monitor 2 circuit in Software Standby or Deep Software Standby, set up the circuit with the following procedures.

(1) Setting in Software Standby mode

- Disable the digital filter (LVD2CR0.DFDIS = 1)
- When VCC > V_{det2} is detected, negate the voltage monitor 2 reset signal (LVD2CR0.RN = 0) following the stabilization time.

(2) Setting in Deep Software Standby mode

- Disable the digital filter (LVD2CR0.DFDIS = 1)
- Enable voltage monitor 2 interrupts (LVD2CR0.RI = 0). If the voltage monitor 2 reset is enabled (LVD2CR0.RI = 1), a transition to Deep Software Standby mode is not possible, and the operation transitions to Software Standby mode instead.
- When the DPSBYCR.DEEPCUT[1:0] bits are 11b, the voltage monitor 2 circuit stops. To use the voltage monitor 2 circuit in Deep Software Standby mode, set the DPSBYCR.DEEPCUT[1:0] bits to a value other than 11b.

Table 8.6 Procedure for setting bits related to voltage monitor 2 interrupt and voltage monitor 2 reset so that voltage monitoring operates

Step		Voltage monitor 2 interrupt (voltage monitor 2 ELC event output)	Voltage monitor 2 reset
Setting the voltage detection 2 circuit	1	Set LVCMPCR.LVD2E = 0 to disable voltage detection 2 before writing to the LVDLVLR register.	
	2	Select the detection voltage in the LVDLVLR.LVD2LVL[2:0] bits.	
	3	Set LVCMPCR.LVD2E = 1 to enable the voltage detection 2 circuit.	
	4	Wait for at least $t_{d(E-A)}$ for the LVD operation stabilization time after LVD is enabled.*1	
Setting the digital filter *2	5	Select the sampling clock for the digital filter in the LVD2CR0.FSAMP[1:0] bits.	
	6	Set LVD2CR0.DFDIS = 0 to enable the digital filter.	
	7	Wait for at least 2n + 3 LOCO cycles, where n = 2, 4, 8, 16, and the sampling clock for the digital filter is the LOCO frequency divided by n.*4	
Setting the voltage monitor 2 interrupt or reset	8	Set LVD2CR0.RI = 0 to select the voltage monitor 2 interrupt.	• Set LVD2CR0.RI = 1 to select the voltage monitor 2 reset • Select the type of reset negation in the LVD2CR0.RN bit.
	9	• Select the interrupt request timing in the LVD2CR1.IDTSEL[1:0] bits • Select the interrupt type in the LVD2CR1.IRQSEL bit.	—
Enabling output	10	Set LVD2SR.DET = 0.	
	11	Set LVD2CR0.RIE = 1 to enable the voltage monitor 2 interrupt or reset.*3	
	12	Set LVD2CR0.CMPE = 1 to enable output of the comparison results from voltage monitor 2.	

Note 1. Steps 5 to 11 can be performed during the wait time in step 4. For details on $t_{d(E-A)}$, see section 43, Electrical Characteristics.
Note 2. Steps 5 to 7 are not required if the digital filter is not in use.
Note 3. Step 11 is not required if only the ELC event signal is to be output.
Note 4. Steps 8 to 10 can be performed during the wait time in step 7.

8.6 电压监视器2的中断和复位

响应电压监视器2电路的比较结果，可以产生中断或复位。

表8.6显示了设置与电压监控器2中断和复位相关的位以使电压监控器工作的过程。表8.7显示了设置与电压监控2中断和复位相关的位以停止电压监控的过程。图8.6显示了电压监视器2中断的操作示例。有关电压监视器2复位的操作，请参见第6节"复位"中的图6.2。

在软件待机或深度软件待机中使用电压监视器2电路时，请按照以下步骤设置电路。

(1) 在软件待机模式下设置

- 禁用数字滤波器(LVD2CR0.DFDIS=1)
- 当检测到VCC>Vdet2时，在稳定时间之后取消电压监视器2复位信号(LVD2CR0.RN=0)。

(2) 在深度软件待机模式下设置

- 禁用数字滤波器(LVD2CR0.DFDIS=1)
- 启用电压监视器2中断(LVD2CR0.RI=0)。如果启用电压监视器2复位(LVD2CR0.RI=1)，则无法转换到深度软件待机模式，而是将操作转换到软件待机模式。
- 当DPSBYCR.DEEPCUT[1:0]位为11b时，电压监视器2电路停止。要在深度软件待机模式下使用电压监视器2电路，请将DPSBYCR.DEEPCUT[1:0]位设置为11b以外的值。

Table 8.6 设置与电压监控器2中断和电压监控器2相关的位以使电压监控器工作的步骤

Step		电压监视器2中断（电压监视器2ELC事件输出）	电压监视器2复位
设置电压检测2电路	1	在写入LVDLVLR寄存器之前，设置LVCMPCR.LVD2E=0以禁用电压检测2。	
	2	在LVDLVLR.LVD2LVL[2:0]位中选择检测电压。	
	3	设置LVCMPCR.LVD2E=1以启用电压检测2电路。	
	4	启用LVD后，至少等待td(E-A)的LVD操作稳定时间。*1	
设置数字滤波器*2	5	在LVD2CR0.FSAMP[1:0]位中选择数字滤波器的采样时钟。	
	6	设置LVD2CR0.DFDIS=0以启用数字滤波器。	
	7	等待至少2n+3个LOCO周期，其中n=2、4、8、16，数字滤波器的采样时钟是LOCO频率除以n。*4	
设置电压监视器2中断或复位	8	设置LVD2CR0.RI=0以选择电压监视器2中断。	设置LVD2CR0.RI=1以选择电压监视器2复位 在LVD2CR0.RN位中选择复位否定类型。
	9	在LVD2CR1.IDTSEL[1:0]位中选择中断请求时序 在LVD2CR1.IRQSEL位中选择中断类型。	—
启用输出	10	Set LVD2SR.DET = 0.	
	11	设置LVD2CR0.RIE=1以启用电压监视器2中断或复位。*3	
	12	设置LVD2CR0.CMPE=1以使能电压监视器2的比较结果输出。	

Note 1. 步骤5至11可以在步骤4的等待时间内执行。有关td(E-A)的详细信息，请参阅第43节，电气Characteristics.
Note 2. 如果不使用数字滤波器，则不需要步骤5到7。
Note 3. 如果只输出ELC事件信号，则不需要步骤11。
Note 4. 步骤8至10可以在步骤7的等待时间内执行。

Table 8.7 Procedure for setting bits related to voltage monitor 2 interrupt and voltage monitor 2 reset so that voltage monitoring stops

Step		Voltage monitor 2 interrupt (voltage monitor 2 ELC event output), voltage monitor 2 reset
Stopping the enabling output	1	Set LVD2CR0.CMPE = 0 to disable output of the comparison results by voltage monitor 2.
	2	Wait for at least 2n + 3 LOCO cycles, where n = 2, 4, 8, 16, and the sampling clock for the digital filter is the LOCO frequency divided by n.*1
	3	Set LVD2CR0.RIE = 0 to disable the voltage monitor 2 interrupt or reset.*2
Stopping the digital filter	4	Set LVD2CR0.DFDIS = 1 to disable the digital filter.*1, *3
Stopping the voltage detection 1 circuit	5	Set LVCMPCR.LVD2E = 0 to disable the voltage detection 2 circuit.

Note 1. Steps 2 and 4 are not required if the digital filter is not in use.
Note 2. Step 3 is not required if only the ELC event signal is to be output.
Note 3. To disable the digital filter from its enabled state and then re-enable it, disable it and wait for at least 2 LOCO cycles before re-enabling it.

If the voltage monitor 2 interrupt or reset setting is to be made again after it is used and stopped once, omit the following steps in the procedures for stopping and setting, depending on the conditions:

- Setting or stopping the voltage detection 2 circuit is not required if the settings for the circuit do not change
- Setting or stopping the digital filter is not required if the settings for the digital filter do not change
- Setting the voltage monitor 2 interrupt or reset is not required if the settings for the voltage monitor 2 interrupt or voltage monitor 2 reset do not change.

Table 8.7 设置与电压监控2中断和电压监控2复位相关的位以停止电压监控的步骤

Step		电压监控器2中断（电压监控器2ELC事件输出），电压监控器2复位
停止使能输出	1	设置LVD2CR0.CMPE=0以禁用电压监视器2的比较结果输出。
	2	等待至少2n+3个LOCO周期，其中n=2、4、8、16，数字滤波器的采样时钟是LOCO频率除以n。*1
	3	设置LVD2CR0.RIE=0以禁用电压监视器2中断或复位。*2
停止数字滤波器	4	设置LVD2CR0.DFDIS=1以禁用数字滤波器。*1 *3
停止电压检测1电路	5	设置LVCMPCR.LVD2E=0以禁用电压检测2电路。

Note 1. 如果不使用数字滤波器，则不需要步骤2和4。
Note 2. 如果只输出ELC事件信号，则不需要步骤3。
Note 3. 要从启用状态禁用数字滤波器然后重新启用它，请禁用它并等待至少2个LOCO周期，然后再重新启用它。

如果电压监视器2在使用和停止一次后再次进行中断或复位设置，则在停止和设置过程中省略以下步骤，视情况而定：

- 如果电路的设置不变，则不需要设置或停止电压检测2电路
- 如果数字滤波器的设置不变，则不需要设置或停止数字滤波器
- 如果电压监视器2中断或电压监视器2复位的设置没有改变，则不需要设置电压监视器2中断或复位。

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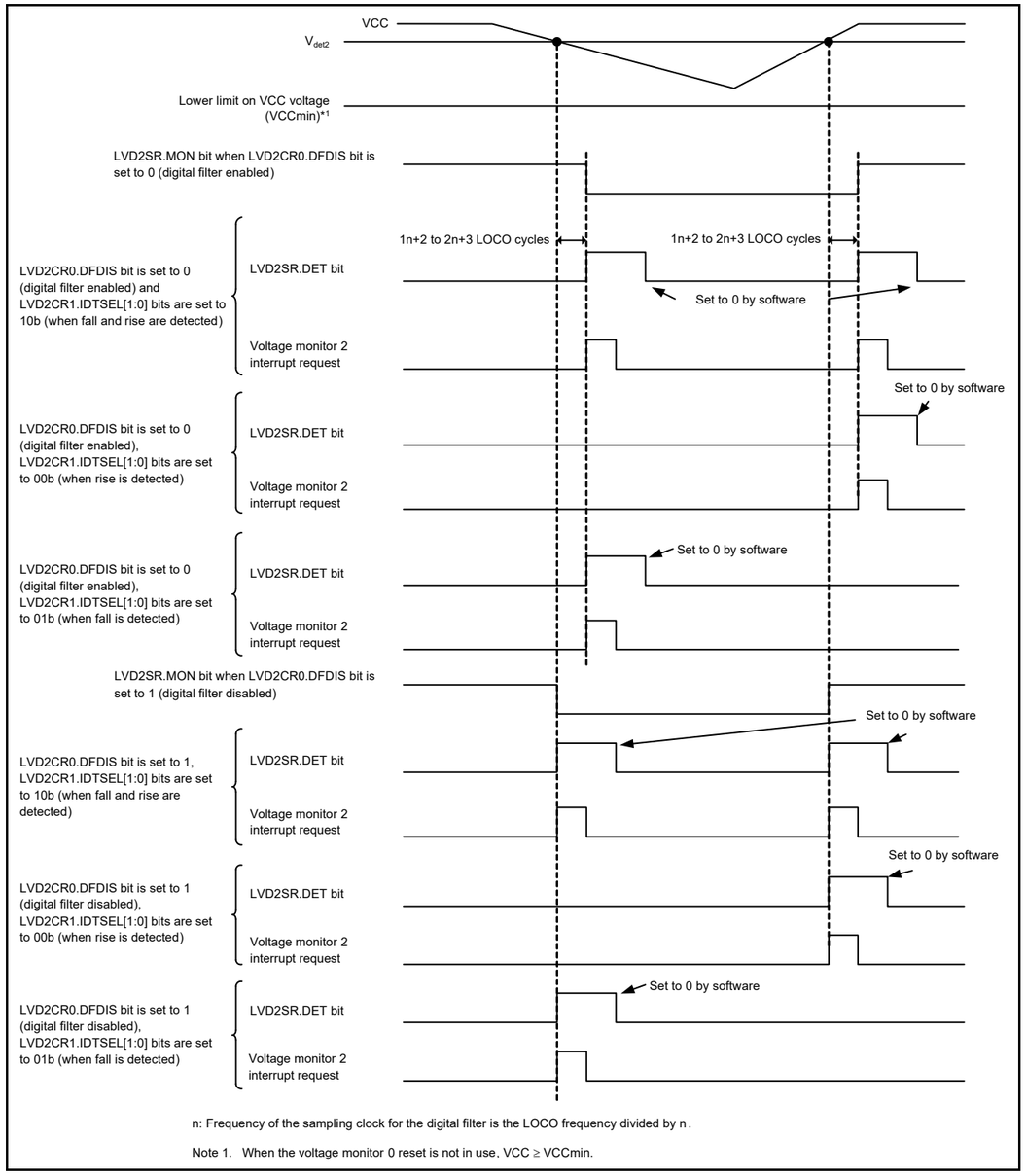

Figure 8.6 Example of voltage monitor 2 interrupt operation

8.7 Event Link Output

The LVD can output the event signals to the Event Link Controller (ELC).

(1) V_{det1} Crossing Detection Event

The LVD outputs the event signal when it detects that the voltage has passed the V_{det1} voltage while both the voltage detection 1 circuit and the voltage monitor 1 circuit comparison result output are enabled.

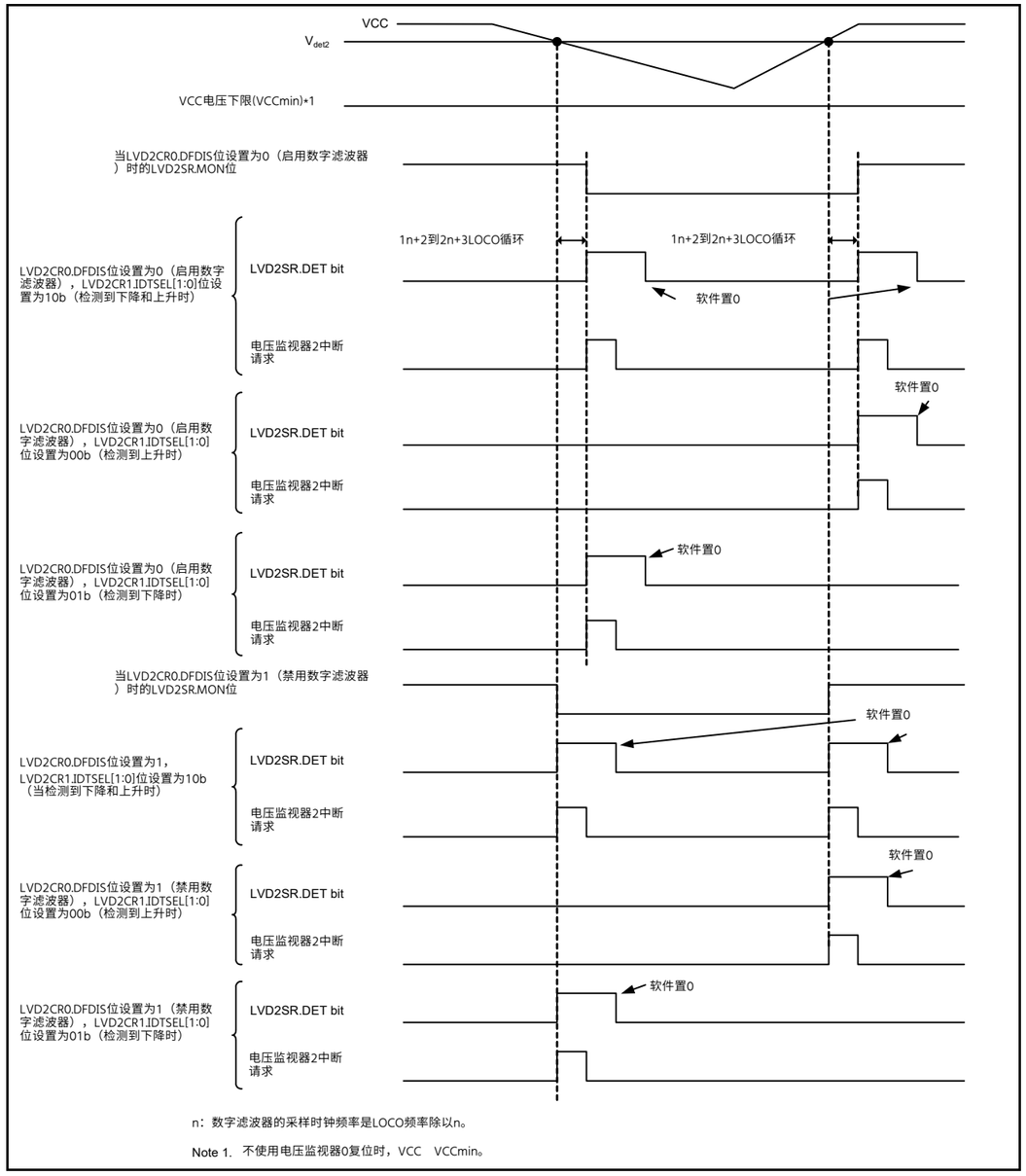

Figure 8.6 电压监视器2中断操作示例

8.7 事件链接输出

LVD可以将事件信号输出到事件链接控制器(ELC)。

(1) Vdet1交叉检测事件

当电压检测1电路和电压监视器1电路比较结果输出都启用时，LVD检测到电压已超过Vdet1电压时输出事件信号。

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(2) V_{det2} Crossing Detection Event

The LVD outputs the event signal when it detects that the voltage has passed the V_{det2} voltage while both the voltage detection 2 circuit and the voltage monitor 2 circuit comparison result output are enabled.

When enabling the event link output function of the LVD, you must enable the LVD before enabling the LVD event link function of the ELC. To stop the event link output function of the LVD, you must stop the LVD after disabling the LVD event link function of the ELC.

8.7.1 Interrupt Handling and Event Linking

The LVD provides bits to individually enable or disable the voltage monitor 1 and 2 interrupts. When an interrupt source is generated and the interrupt is enabled by the interrupt enable bit, the interrupt signal (LVD1CR0.RIE or LVD2CR0.RIE) is output to the CPU.

On the other hand, as soon as an interrupt source is generated, an event link signal is output as the event signal to the other module through the ELC, regardless of the state of the interrupt enable bit.

It is possible to output voltage monitor 1 and 2 interrupts in Software Standby and Deep Software Standby modes. The event signals for the ELC in Software Standby and Deep Software Standby modes are output as follows:

- When a V_{det1} or V_{det2} passage event is detected in Software Standby mode, event signals are not generated for the ELC because the clock is not supplied in Software Standby mode. Because the V_{det1} and V_{det2} passage detection flags are saved, when the clock supply resumes after returning from Software Standby mode, the event signals for the ELC are output based on the state of the V_{det1} and V_{det2} detection flags.
- When a V_{det1} or V_{det2} passage events is detected in Deep Software Standby mode, event signals are not generated for the ELC.

(2) Vdet2交叉检测事件

当电压检测2电路和电压监测器2电路比较结果输出都启用时，LVD检测到电压已超过Vdet2电压时输出事件信号。

使能LVD的事件链接输出功能时，必须先使能LVD，再使能ELC的LVD事件链接功能。要停止LVD的事件链接输出功能，必须在禁用ELC的LVD事件链接功能后停止LVD。

8.7.1 中断处理和事件链接

LVD提供位来单独启用或禁用电压监视器1和2中断。当产生中断源并通过中断使能位使能中断时，向CPU输出中断信号（LVD1CR0.RIE或LVD2CR0.RIE）。

另一方面，一旦产生中断源，无论中断使能位的状态如何，都会通过ELC将事件链接信号作为事件信号输出到其他模块。

在软件待机和深度软件待机模式下，可以输出电压监视器1和2中断。软件待机和深度软件待机模式下ELC的事件信号输出如下：

- 当在软件待机模式下检测到Vdet1或Vdet2通过事件时，不会为ELC生成事件信号，因为在软件待机模式下不提供时钟。因为保存了Vdet1和Vdet2通过检测标志，所以当从软件待机模式恢复后时钟供应恢复时，ELC的事件信号将根据Vdet1和Vdet2检测标志的状态输出。
- 当在深度软件待机模式下检测到Vdet1或Vdet2通过事件时，不会为ELC生成事件信号。

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9. Clock Generation Circuit

9.1 Overview

The MCU provides a clock generation circuit.

Table 9.1 and Table 9.2 list the clock generation circuit specifications. Figure 9.1 shows a block diagram, and Table 9.3 lists the I/O pins.

Table 9.1 Clock generation circuit specifications for the clock sources

Clock source	Description	Specifications
Main clock oscillator (MOSC)	Resonator frequency	8 MHz to 24 MHz
	External clock input frequency	Up to 24 MHz
	External resonator or additional circuit: ceramic resonator, crystal	Available
	Connection pins EXTAL, XTAL	
	Drive capability switching	
	Oscillation stop detection function	
Sub-clock oscillator (SOSC)	Resonator frequency	32.768 kHz
	External resonator or additional circuit: crystal resonator	Available
	Connection pins: XCIN, XCOUT	
	Drive capability switching	
PLL circuit	Input clock source	MOSC, HOCO
	Input pulse frequency division ratio	Selectable from 1, 2, and 3
	Input frequency	8 MHz to 24 MHz
	Frequency multiplication ratio	Selectable from 10 to 30 (0.5 steps)
	PLL output frequency	120 MHz to 240 MHz
High-speed on-chip oscillator (HOCO)	Oscillation frequency	16/18/20 MHz
	User trimming	Available
Middle-speed on-chip oscillator (MOCO)	Oscillation frequency	8 MHz
	User trimming	Available
Low-speed on-chip oscillator (LOCO)	Oscillation frequency	32.768 kHz
	User trimming	Available
IWDT-dedicated on-chip oscillator (IWDTLOCO)	Oscillation frequency	15 kHz
External clock input for JTAG (TCK)	Input clock frequency	Up to 25 MHz
External clock input for SWD (SWCLK)	Input clock frequency	Up to 25 MHz

Table 9.2 Clock generation circuit specifications for the internal clocks (1 of 2)

Parameter	Clock sources	Clock supply	Specifications
System clock (ICLK)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	CPU, DTC, DMAC, Flash, SRAM	Up to 120 MHz Division ratios: 1, 2, 4, 8, 16, 32, 64
Peripheral module clock A (PCLKA)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	Peripheral modules (SPI, SCI, SCE7, CRC, IrDA, GPT bus clock)	Up to 120 MHz Division ratios: 1, 2, 4, 8, 16, 32, 64

9. 时钟产生电路

9.1 Overview

MCU提供时钟生成电路。

表9.1和表9.2列出了时钟生成电路规格。图9.1显示了框图，表9.3列出了IO引脚。

Table 9.1 时钟源的时钟生成电路规格

时钟源	Description	Specifications
主时钟振荡器(MOSC)	谐振器频率	8 MHz to 24 MHz
	外部时钟输入频率	高达24MHz
	外部谐振器或附加电路：陶瓷谐振器、晶体	Available
	连接针EXTAL、XTAL	
	驱动能力切换	
	振荡停止检测功能	
Sub-clock oscillator (SOSC)	谐振器频率	32.768 kHz
	外部谐振器或附加电路：晶体谐振器	Available
	Connection pins: XCIN, XCOUT	
	驱动能力切换	
PLL circuit	输入时钟源	MOSC, HOCO
	输入脉冲分频比	可从1、2和3中选择
	输入频率	8 MHz to 24 MHz
	倍频比	可选择10至30（0.5步）
	锁相环输出频率	120 MHz to 240 MHz
High-speed on-chip oscillator (HOCO)	振荡频率	16/18/20 MHz
	用户修剪	Available
Middle-speed on-chip oscillator (MOCO)	振荡频率	8 MHz
	用户修剪	Available
Low-speed on-chip oscillator (LOCO)	振荡频率	32.768 kHz
	用户修剪	Available
IWDT-dedicated on-chip oscillator (IWDTLOCO)	振荡频率	15 kHz
JTAG(TCK)的外部时钟输入	输入时钟频率	高达25MHz
SWD的外部时钟输入(SWCLK)	输入时钟频率	高达25MHz

Table 9.2 内部时钟的时钟生成电路规格（1of2）

Parameter	时钟源	时钟电源	Specifications
系统时钟(ICLK)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	CPU、DTC、DMAC、闪存、SRAM	高达120MHz Division ratios: 1, 2, 4, 8, 16, 32, 64
外设模块时钟A(PCLKA)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	外围模块（SPI，SCI，SCE7, CRC, IrDA, GPT bus clock)	高达120MHz Division ratios: 1, 2, 4, 8, 16, 32, 64

Table 9.2 Clock generation circuit specifications for the internal clocks (2 of 2)

Parameter	Clock sources	Clock supply	Specifications
Peripheral module clock B (PCLKB)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	Peripheral modules (IIC, DOC, CAC, CAN, DAC12, POEG, AGT, ELC, I/O ports, WDT, IWDT, ADC12, KINT, ACMPHS, TSN)	Up to 60 MHz Division ratios: 1, 2, 4, 8, 16, 32, 64
Peripheral module clock C (PCLKC)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	Peripheral module (ADC12 conversion clock)	Up to 60 MHz Division ratios: 1, 2, 4, 8, 16, 32, 64
Peripheral module clock D (PCLKD)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	Peripheral module (GPT count clock)	Up to 120 MHz Division ratios: 1, 2, 4, 8, 16, 32, 64
Flash interface clock (FCLK)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	Flash interface	4 to 60 MHz (P/E) Up to 60 MHz (read) *1 Division ratios: 1, 2, 4, 8, 16, 32, 64
CAN clock (CANMCLK)	MOSC	CAN	8 to 24 MHz
AGT clock (AGTSCLK, AGTLCLK)	SOSC, LOCO	AGT	32.768 kHz
CAC main clock (CACMCLK)	MOSC	CAC	Up to 24 MHz
CAC sub-clock (CACSCLK)	SOSC	CAC	32.768 kHz
CAC LOCO clock (CACLCLK)	LOCO	CAC	32.768 kHz
CAC MOCO clock (CACMOCLK)	MOCO	CAC	8 MHz
CAC HOCO clock (CACHCLK)	HOCO	CAC	16, 18, 20 MHz
CAC IWDTLOCO clock (CACILCLK)	IWDTLOCO	CAC	15 kHz
IWDT clock (IWDTCLK)	IWDTLOCO	IWDT	15 kHz
SysTick timer clock (SYSTICCLK)	LOCO	SysTick timer	32.768 kHz
JTAG clock (JTAGTCK)	TCK pin	JTAG	Up to 25 MHz
Clock and buzzer output (CLKOUT)	MOSC, SOSC, LOCO, MOCO, HOCO	CLKOUT pin	Up to 24 MHz Division ratios: 1, 2, 4, 8, 16, 32, 64, 128
Serial wire clock (SWCLK)	SWCLK pin	OCD	Up to 25 MHz
Trace clock (TRCLK)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	CPU-OCD	Up to 60 MHz Division ratios: 1, 2, 4
TCLK pin output (TCLK)	1/2 TRCLK	TCLK pin	Up to 30 MHz

Note: Restrictions on setting the clock frequency: ICLK ≥ PCLKA ≥ PCLKB, PCLKD ≥ PCLKA ≥ PCLKB
Restrictions on the clock frequency ratio (N: integer, and up to 64):
ICLK:FCLK = N:1, ICLK:PCLKA = N:1, ICLK:PCLKB = N:1
ICLK:PCLKC = N:1 or 1:N, ICLK:PCLKD = N:1 or 1:N
If the A/D converter is enabled, the clock frequency ratio is constrained as follows:
PCLKB:PCLKC = 1:1 or 1:2 or 1:4 or 2:1 or 4:1 or 8:1.

Note: Clocks have a permissible frequency range. See Table 9.2.
Flash memory also has a permissible operating frequency range in each wait cycle setting. See section 41, Flash Memory.
Those clock frequency ranges must be satisfied even when the HOCO has its maximum or minimum frequency. See section 43, Electrical Characteristics.

Note: If the PLL reference clock source is HOCO, the PLL multiplication setting must be set to 120 MHz - 240 MHz in consideration of HOCO frequency (minimum/maximum).

Note 1. The minimum FCLK frequency is 4 MHz in Programming/Erasure (P/E) mode.

Table 9.2 内部时钟的时钟生成电路规格(2of2)

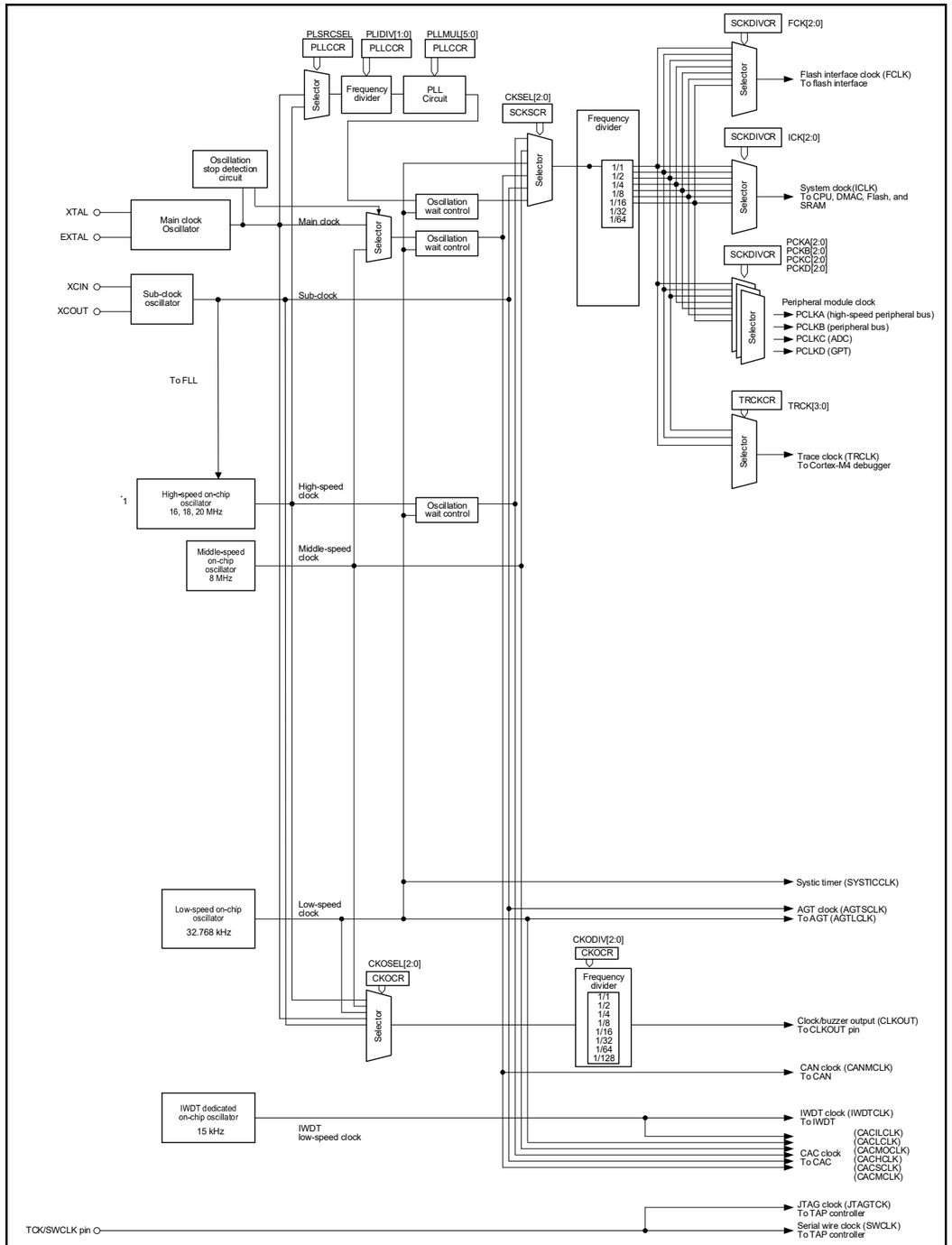
Parameter	时钟源	时钟电源	Specifications
外设模块时钟B(PCLKB)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	外围模块（IIC、DOC、CAC、CAN、DAC12、POEG、AGT、ELC、I/O ports, WDT, IWDT, ADC12, KINT, ACMPHS, TSN)	高达60MHz Division ratios: 1, 2, 4, 8, 16, 32, 64
外设模块时钟C(PCLKC)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	外设模块（ADC12转换时钟）	高达60MHz Division ratios: 1, 2, 4, 8, 16, 32, 64
外设模块时钟D(PCLKD)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	外围模块（GPT计数时钟）	高达120MHz Division ratios: 1, 2, 4, 8, 16, 32, 64
闪存接口时钟(FCLK)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	闪存接口	4至60MHz(PE)最高60 MHz（读取）*1 Division ratios: 1, 2, 4, 8, 16, 32, 64
CAN时钟(CANMCLK)	MOSC	CAN	8 to 24 MHz
AGT clock (AGTSCLK, AGTLCLK)	SOSC, LOCO	AGT	32.768 kHz
CAC主时钟(CACMCLK)	MOSC	CAC	高达24MHz
CAC sub-clock (CACSCLK)	SOSC	CAC	32.768 kHz
CACLOCO时钟(CACLCLK)	LOCO	CAC	32.768 kHz
CACMOCO时钟(CACMOCLK)	MOCO	CAC	8 MHz
CACHOCO时钟(CACHCLK)	HOCO	CAC	16, 18, 20 MHz
CACIWDTLOCO时钟(CACILCLK)	IWDTLOCO	CAC	15 kHz
IWDT clock (IWDTCLK)	IWDTLOCO	IWDT	15 kHz
SysTick定时器时钟(SYSTICCLK)	LOCO	SysTick timer	32.768 kHz
JTAG clock (JTAGTCK)	TCK pin	JTAG	高达25MHz
时钟和蜂鸣器输出(CLKOUT)	MOSC, SOSC, LOCO, MOCO, HOCO	CLKOUT pin	高达24MHz Division ratios: 1, 2, 4, 8, 16, 32, 64, 128
串行线时钟(SWCLK)	SWCLK pin	OCD	高达25MHz
跟踪时钟(TRCLK)	MOSC, SOSC, HOCO, MOCO, LOCO, PLL	CPU-OCD	高达60MHz Division ratios: 1, 2, 4
TCLK引脚输出(TCLK)	1/2 TRCLK	TCLK pin	高达30MHz

Note: 设置时钟频率的限制：ICLK≥PCLKA≥PCLKB，PCLKD≥PCLKA≥PCLKB
时钟频率比的限制（N：整数，最大为64）：
ICLK:FCLK = N:1, ICLK:PCLKA = N:1, ICLK:PCLKB = N:1
ICLK:PCLKC=N:1或1:N ICLK:PCLKD=N:1或1:N如果AD转换器使能，时钟频率比限制如下：
PCLKB:PCLKC = 1:1 or 1:2 or 1:4 or 2:1 or 4:1 or 8:1.

Note: 时钟具有允许的频率范围。见表9.2。
闪存在每个等待周期设置中也有一个允许的工作频率范围。请参见第41节，闪存。
即使HOCO具有其最大或最小频率，也必须满足这些时钟频率范围。参见第43节，电气特性。

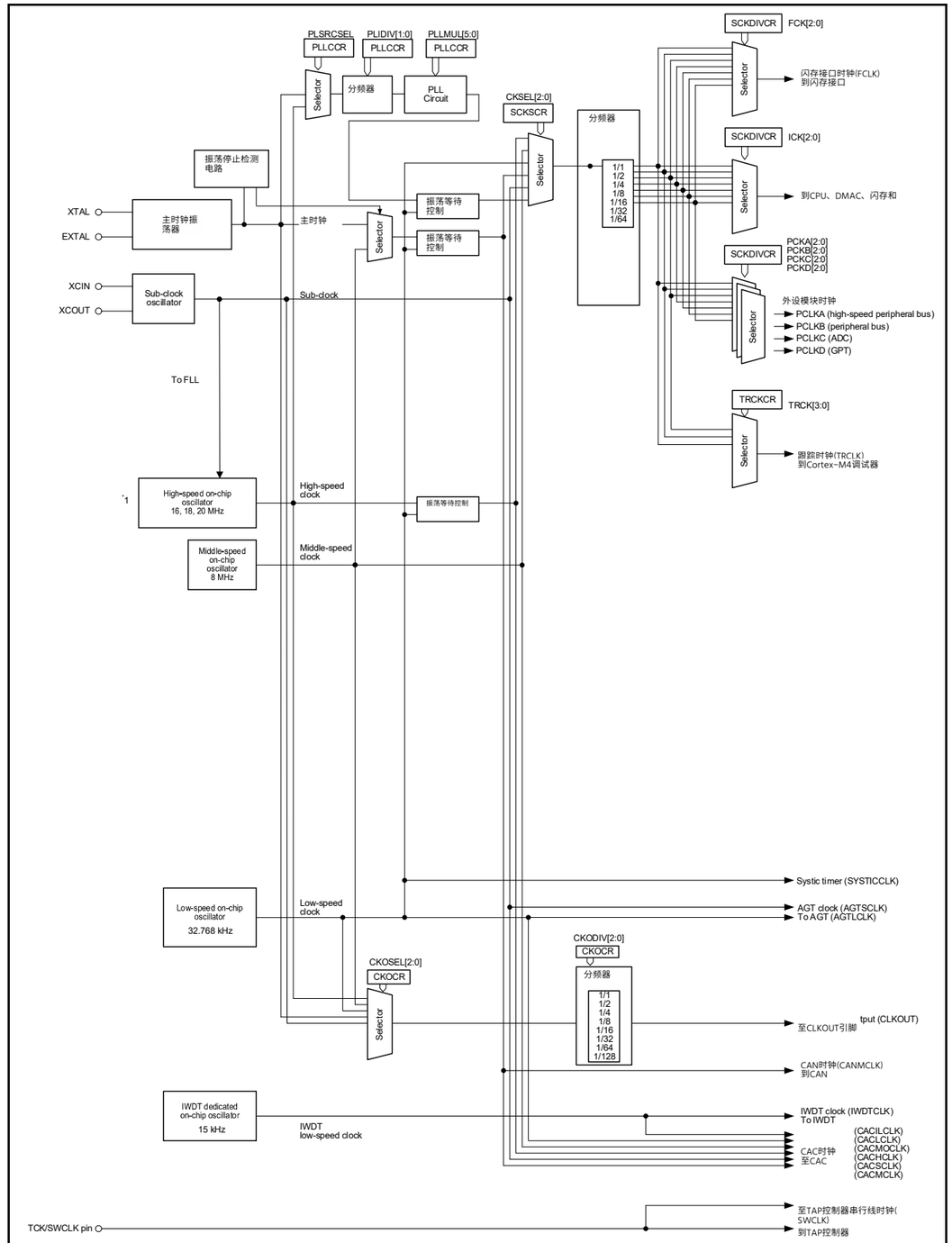
Note: 如果PLL参考时钟源是HOCO，则PLL倍频设置必须设置为120MHz240MHz考虑到HOCO frequency (minimum/maximum).

Note 1. 在编程擦除(PE)模式下，最小FCLK频率为4MHz。



Note 1. HOCO has FLL.

Figure 9.1 Clock generation circuit block diagram



注1.HOCO有FLL。

Figure 9.1 时钟产生电路框图

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Table 9.3 Clock Generation Circuit I/O pins

Pin name	I/O	Description
XTAL	Output	These pins are used to connect a crystal resonator. The EXTAL pin can also be used to input an external clock. For details, see section 9.3.2, External Clock Input.
EXTAL	Input	
XCIN	Input	These pins are used to connect to a 32.768-kHz crystal resonator
XCOUT	Output	
TCK/SWCLK	Input	This pin is used to input the clock for the JTAG
CLKOUT	Output	This pin is used to output the CLKOUT/BUZZER clock

9.2 Register Descriptions

9.2.1 System Clock Division Control Register (SCKDIVCR)

Address(es): SYSTEM.SCKDIVCR 4001 E020h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	FCK[2:0]			—	ICK[2:0]			—	—	—	—	—	—	—	—
Value after reset:	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	PCKA[2:0]			—	PCKB[2:0]			—	PCKC[2:0]			—	PCKD[2:0]		
Value after reset:	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	PCKD[2:0]	Peripheral Module Clock D (PCLKD) Select*3	b2 b0 0 0: ×1/1 0 0: ×1/2 0 1: ×1/4 0 1: ×1/8 1 0: ×1/16 1 0: ×1/32 1 1: ×1/64. Other settings are prohibited.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6 to b4	PCKC[2:0]	Peripheral Module Clock C (PCLKC) Select*3	b6 b4 0 0: ×1/1 0 0: ×1/2 0 1: ×1/4 0 1: ×1/8 1 0: ×1/16 1 0: ×1/32 1 1: ×1/64. Other settings are prohibited.	R/W
b7	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b10 to b8	PCKB[2:0]	Peripheral Module Clock B (PCLKB) Select*2	b10 b8 0 0: ×1/1 0 0: ×1/2 0 1: ×1/4 0 1: ×1/8 1 0: ×1/16 1 0: ×1/32 1 1: ×1/64. Other settings are prohibited.	R/W
b11	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

Table 9.3 时钟生成电路IO引脚

引脚名称	I/O	Description
XTAL	Output	这些引脚用于连接晶体谐振器。EXTAL引脚也可用于输入外部时钟。有关详细信息，请参见第9.3.2节，外部时钟输入。
EXTAL	Input	
XCIN	Input	这些引脚用于连接到32.768-kHz晶体谐振器
XCOUT	Output	
TCK/SWCLK	Input	该引脚用于输入JTAG的时钟
CLKOUT	Output	该引脚用于输出CLKOUTBUZZER时钟

9.2 注册说明

9.2.1 系统时钟分频控制寄存器(SCKDIVCR)

Address(es): SYSTEM.SCKDIVCR 4001 E020h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	FCK[2:0]			—	ICK[2:0]			—	—	—	—	—	—	—	—
重置后的值:	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	PCKA[2:0]			—	PCKB[2:0]			—	PCKC[2:0]			—	PCKD[2:0]		
重置后的值:	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	PCKD[2:0]	外设模块时钟D(PCLKD)选择*3	b2 b0 0 0: ×1/1 0 0: ×1/2 0 1: ×1/4 0 1: ×1/8 1 0: ×1/16 1 0: ×1/32 10：×164。禁止其他设置。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b6 to b4	PCKC[2:0]	外设模块时钟C(PCLKC)选择*3	b6 b4 0 0: ×1/1 0 0: ×1/2 0 1: ×1/4 0 1: ×1/8 1 0: ×1/16 1 0: ×1/32 10：×164。禁止其他设置。	R/W
b7	—	Reserved	该位读取为0。写入值应为0。	R/W
b10 to b8	PCKB[2:0]	外设模块时钟B(PCLKB)选择*2	b10 b8 0 0: ×1/1 0 0: ×1/2 0 1: ×1/4 0 1: ×1/8 1 0: ×1/16 1 0: ×1/32 10：×164。禁止其他设置。	R/W
b11	—	Reserved	该位读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b14 to b12	PCKA[2:0]	Peripheral Module Clock A (PCLKA) Select*2	b14 b12 0 0 0: ×1/1 0 0 1: ×1/2 0 1 0: ×1/4 0 1 1: ×1/8 1 0 0: ×1/16 1 0 1: ×1/32 1 1 0: ×1/64. Other settings are prohibited.	R/W
b16, b15	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b17	—	Reserved	This bit is read as 1. The write value should be 1.	R/W
b23 to b18	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b26 to b24	ICK[2:0]	System Clock (ICLK) Select*1*2*3*4	b26 b24 0 0 0: ×1/1 0 0 1: ×1/2 0 1 0: ×1/4 0 1 1: ×1/8 1 0 0: ×1/16 1 0 1: ×1/32 1 1 0: ×1/64. Other settings are prohibited.	R/W
b27	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b30 to b28	FCK[2:0]	Flash Interface Clock (FCLK) Select*1	b30 b28 0 0 0: ×1/1 0 0 1: ×1/2 0 1 0: ×1/4 0 1 1: ×1/8 1 0 0: ×1/16 1 0 1: ×1/32 1 1 0: ×1/64. Other settings are prohibited.	R/W
b31	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

Note 1. The association between the frequencies of the system clock (ICLK) and the flash interface clock (FCLK) should be ICLK:FCLK = N:1 (N: integer).
If a setting is made where ICLK < FCLK, then that setting is ignored.
Note 2. The association between the frequencies of the system clock (ICLK) and the peripheral module clocks (PCLKA, PCLKB) should be ICLK:PCLKA = N:1, ICLK:PCLKB = N:1 (N: integer).
If a setting is made where ICLK < PCLKA or ICLK < PCLKB, then that setting is ignored.
Note 3. The association between the frequencies of the system clock (ICLK) and the peripheral module clocks (PCLKC, PCLKD) should be ICLK:PCLKC, PCLKD = N:1 or 1:N (N: integer).
Note 4. The frequency of the system clock (ICLK) is limited to the Flash Wait Cycle register (FLWT). See section 41, Flash Memory.

The SCKDIVCR register selects the frequencies of the system clock (ICLK), the peripheral module clocks (PCLKA, PCLKB, PCLKC, PCLKD), and the flash interface clock (FCLK).

When the PLL is selected as the clock source, set the following modules to the module-stop state before changing the value of SCKDIVCR:

- SCE7
- GPT32EH
- GPT32E.

In addition, when changing a value in SCKDIVCR from a lower division ratio to a higher division ratio, wait at least 750 ns before changing the value. When changing a value from a higher division ratio to a lower division ratio, wait at least 250 ns after changing the value, before starting subsequent processing.

The recommended method to measure the wait time is through software. Be sure to consider the worst-case conditions to ensure that the required wait time elapses.

Figure 9.2 shows an example flow for changing the value of SCKDIVCR.

Bit	Symbol	位名称	Description	R/W
b14 to b12	PCKA[2:0]	外设模块时钟A(PCLKA)选择*2	b14 b12 0 0 0: ×1/1 0 0 1: ×1/2 0 1 0: ×1/4 0 1 1: ×1/8 1 0 0: ×1/16 1 0 1: ×1/32 10：×164。禁止其他设置。	R/W
b16, b15	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b17	—	Reserved	该位读取为1。写入值应为1。	R/W
b23 to b18	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b26 to b24	ICK[2:0]	系统时钟(ICLK) Select*1*2*3*4	b26 b24 0 0 0: ×1/1 0 0 1: ×1/2 0 1 0: ×1/4 0 1 1: ×1/8 1 0 0: ×1/16 1 0 1: ×1/32 10：×164。禁止其他设置。	R/W
b27	—	Reserved	该位读取为0。写入值应为0。	R/W
b30 to b28	FCK[2:0]	闪存接口时钟(FCLK) Select*1	b30 b28 0 0 0: ×1/1 0 0 1: ×1/2 0 1 0: ×1/4 0 1 1: ×1/8 1 0 0: ×1/16 1 0 1: ×1/32 10：×164。禁止其他设置。	R/W
b31	—	Reserved	该位读取为0。写入值应为0。	R/W

Note 1. 系统时钟(ICLK)和闪存接口时钟(FCLK)的频率之间的关联应该是
ICLK:FCLK = N:1 (N: integer).
如果进行了ICLK<FCLK的设置，则忽略该设置。
Note 2. 系统时钟（ICLK）和外围模块时钟（PCLKA、PCLKB）的频率之间的关联应该是ICLK:PCLKA=N:1，ICLK:PCLKB=N:1（N:整数）。如果进行了ICLK<PCLKA或ICLK<PCLKB的设置，则忽略该设置。
Note 3. 系统时钟（ICLK）和外设模块时钟（PCLKC、PCLKD）的频率之间的关联应该是ICLK:PCLKC，PCLKD=N:1或1:N（N：整数）。
Note 4. 系统时钟(ICLK)的频率受限于闪存等待周期寄存器(FLWT)。请参见第41节，闪存。

SCKDIVCR寄存器选择系统时钟(ICLK)、外设模块时钟(PCLKA、PCLKB、PCLKC、PCLKD）和闪存接口时钟（FCLK）。

WhenthePLLisselectedastheclocksource setthefollowingmodulestothemodule-stopstatebeforechangingthevalueofSCKDIVCR:

- SCE7
- GPT32EH
- GPT32E.

此外，将SCKDIVCR中的值从较低的分频比更改为较高的分频比时，在更改该值之前至少等待750ns。将值从高分频比更改为低分频比时，更改值后至少等待250ns，然后再开始后续处理。

测量等待时间的推荐方法是通过软件。请务必考虑最坏情况，以确保经过所需的等待时间。

图9.2显示了更改SCKDIVCR值的示例流程。

PCKD[2:0] bits (Peripheral Module Clock D (PCLKD) Select*3)

The PCKD[2:0] bits select the frequency of peripheral module clock D (PCLKD).

PCKC[2:0] bits (Peripheral Module Clock C (PCLKC) Select*3)

The PCKC[2:0] bits select the frequency of peripheral module clock C (PCLKC).

PCKB[2:0] bits (Peripheral Module Clock B (PCLKB) Select*2)

The PCKB[2:0] bits select the frequency of peripheral module clock B (PCLKB).

PCKA[2:0] bits (Peripheral Module Clock A (PCLKA) Select*2)

The PCKA[2:0] bits select the frequency of peripheral module clock A (PCLKA).

ICK[2:0] bits (System Clock (ICLK) Select*1*2*2*3*4)

The ICK[2:0] bits select the frequency of the system clock for the CPU, DMAC, and DTC.

FCK[2:0] bits (Flash Interface Clock (FCLK) Select*1)

The FCK[2:0] bits select the frequency of the flash interface clock (FCLK).

PCKD[2:0]位（外设模块时钟D(PCLKD)选择*3）

PCKD[2:0]位选择外设模块时钟D(PCLKD)的频率。

PCKC[2:0]位（外设模块时钟C(PCLKC)选择*3）

PCKC[2:0]位选择外围模块时钟C(PCLKC)的频率。

PCKB[2:0]位（外设模块时钟B(PCLKB)选择*2）

PCKB[2:0]位选择外设模块时钟B(PCLKB)的频率。

PCKA[2:0]位（外设模块时钟A(PCLKA)选择*2）

PCKA[2:0]位选择外设模块时钟A(PCLKA)的频率。

ICK[2:0]位（系统时钟(ICLK)选择*1*2*2*3*4）

ICK[2:0]位选择CPU、DMAC和DTC的系统时钟频率。

FCK[2:0]位（闪存接口时钟(FCLK)选择*1）

FCK[2:0]位选择闪存接口时钟(FCLK)的频率。

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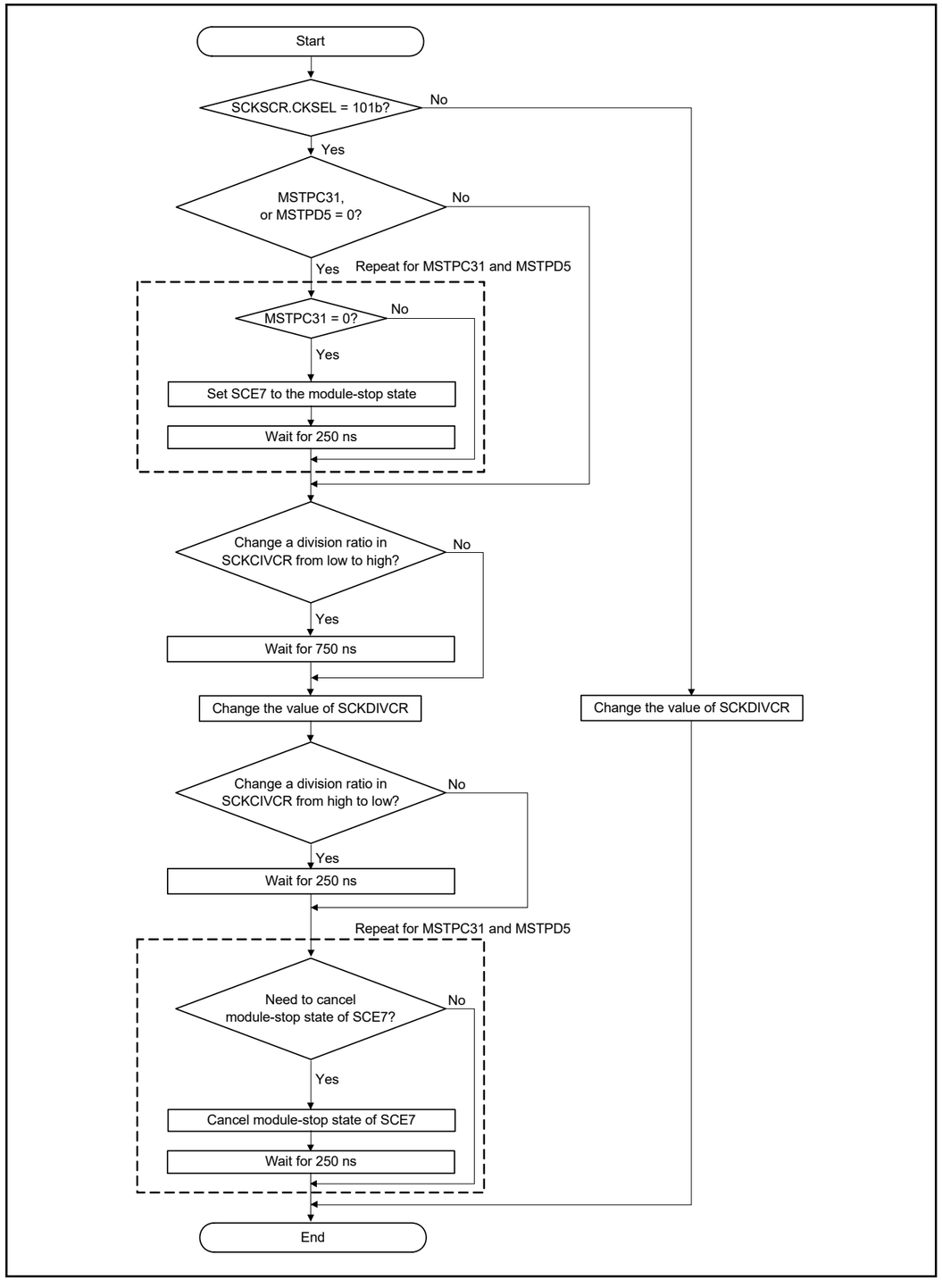


Figure 9.2 Example flow for changing the SCKDIVCR value

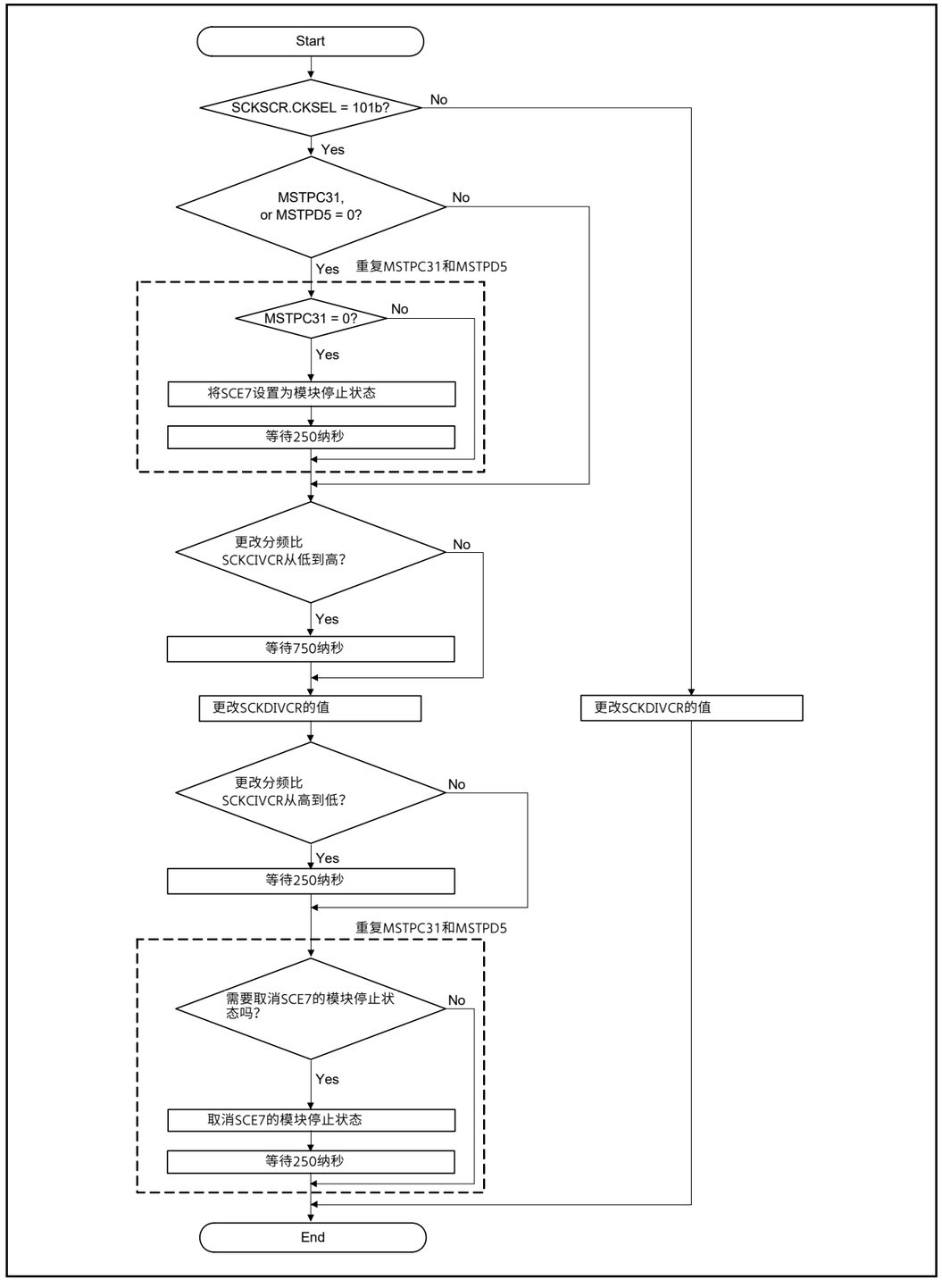


Figure 9.2 更改SCKDIVCR值的示例流程

9.2.2 System Clock Source Control Register (SCKSCR)

Address(es): SYSTEM.SCKSCR 4001 E026h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	CKSEL[2:0]		
Value after reset:	0	0	0	0	0	0	0	1

Bit	Symbol	Bit name	Description	R/W
b2 to b0	CKSEL[2:0]	Clock Source Select	b2 b0 0 0 0: HOCO 0 0 1: MOCO 0 1 0: LOCO 0 1 1: Main clock oscillator 1 0 0: Sub-clock oscillator 1 0 1: PLL. Other settings are prohibited.	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: Write to SCKSCR by 8-bit access.

The SCKSCR register selects the clock source for the system clock.

When changing the value of SCKSCR to either select or deselect the PLL, set the following modules to the module-stop state before changing the SCKSCR value:

- SCE7
- GPT32EH
- GPT32E.

In addition, when changing the value of SCKSCR from the PLL to a different clock source, wait at least 750 ns before changing the value. When changing the value from a non-PLL clock source to the PLL, wait at least 250 ns after changing the value, before starting subsequent processing.

The recommended method to measure the wait time is through software. Be sure to consider the worst-case conditions to ensure that the required wait time elapses.

Figure 9.3 shows an example flow for changing the value of SCKSCR.

CKSEL[2:0] bits (Clock Source Select)

The CKSEL[2:0] bits select the clock source for the following modules:

- System clock (ICLK)
- Peripheral module clocks (PCLKA, PCLKB, PCLKC, and PCLKD)
- Flash interface clock (FCLK).

The bits select from one of the following sources:

- Low-speed on-chip oscillator (LOCO)
- Middle-speed on-chip oscillator (MOCO)
- High-speed on-chip oscillator (HOCO)
- Main clock oscillator
- Sub-clock oscillator
- PLL circuit.

The clock sources should be switched when there are no occurring internal asynchronous interrupt. Transitions to clock sources that are not in operation are prohibited.

9.2.2 系统时钟源控制寄存器(SCKSCR)

Address(es): SYSTEM.SCKSCR 4001 E026h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	CKSEL[2:0]		
重置后的值:	0	0	0	0	0	0	0	1

Bit	Symbol	位名称	Description	R/W
b2 to b0	CKSEL[2:0]	时钟源选择	b2 b0 0 0 0: HOCO 0 0 1: MOCO 0 1 0: LOCO 0 1 1：主时钟振荡器 1 0 0: Sub-clock oscillator 01：锁相环。禁止其他设置 。	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 通过8位访问写入SCKSCR。

SCKSCR寄存器选择系统时钟的时钟源。

将SCKSCR的值更改为选择或取消选择PLL时，请在更改SCKSCR值之前将以下模块设置为模块停止状态：

- SCE7
- GPT32EH
- GPT32E.

此外，当将SCKSCR的值从PLL更改为不同的时钟源时，在更改值之前至少等待750ns。将值从非PLL时钟源更改为PLL时，更改值后至少等待250ns，然后再开始后续处理。

测量等待时间的推荐方法是通过软件。请务必考虑最坏情况，以确保经过所需的等待时间。

图9.3显示了更改SCKSCR值的示例流程。

CKSEL[2:0]位（时钟源选择）

CKSEL[2:0]位选择以下模块的时钟源：

- 系统时钟(ICLK)
- 外围模块时钟（PCLKA、PCLKB、PCLKC和PCLKD）
- 闪存接口时钟(FCLK)。

这些位从以下来源之一中选择：

- Low-speed on-chip oscillator (LOCO)
- Middle-speed on-chip oscillator (MOCO)
- High-speed on-chip oscillator (HOCO)
- 主时钟振荡器
- Sub-clock oscillator
- PLL circuit.

当没有发生内部异步中断时，应切换时钟源。禁止转换到未运行的时钟源。

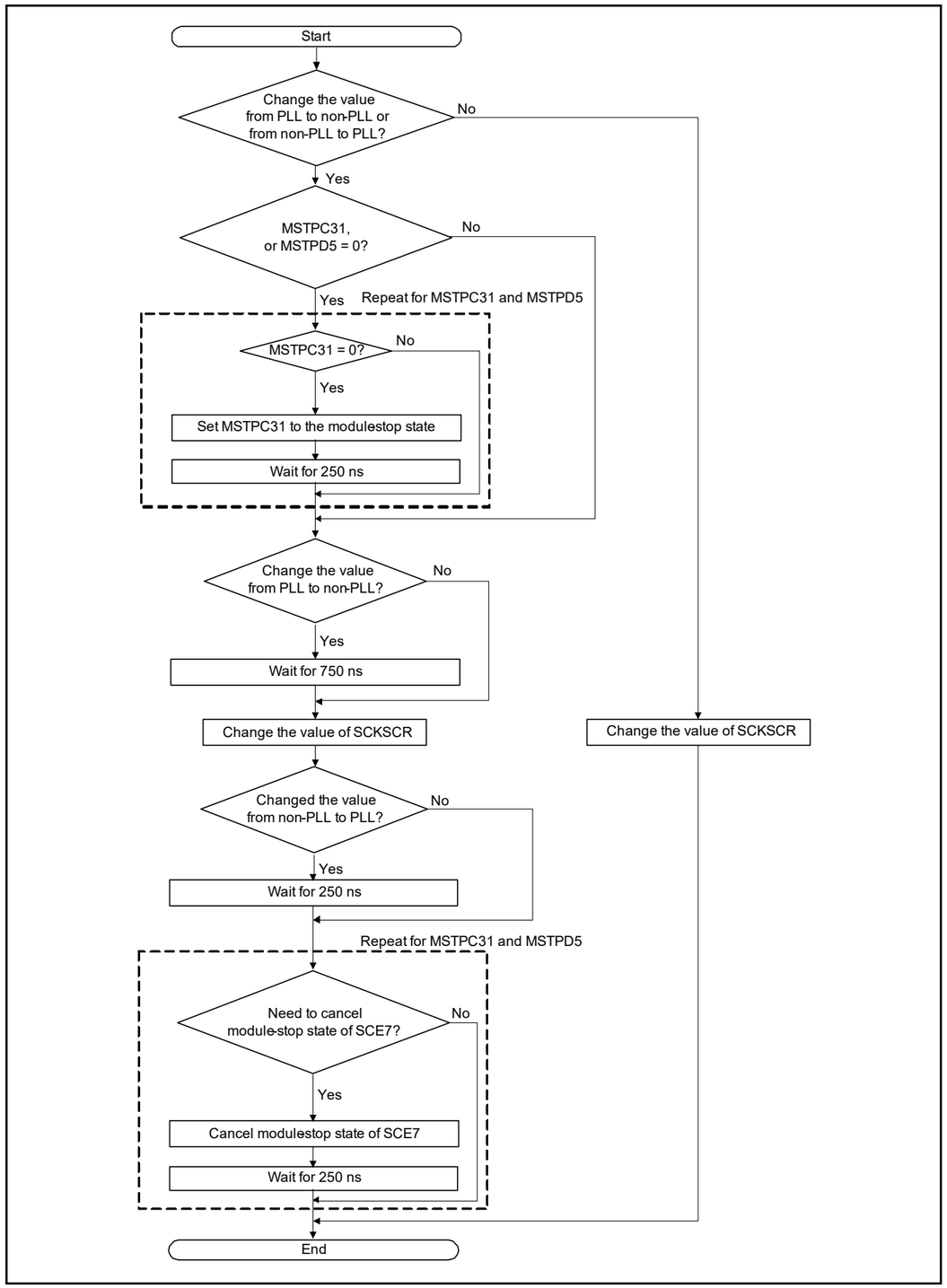


Figure 9.3 Example flow for changing the value of SCKSCR

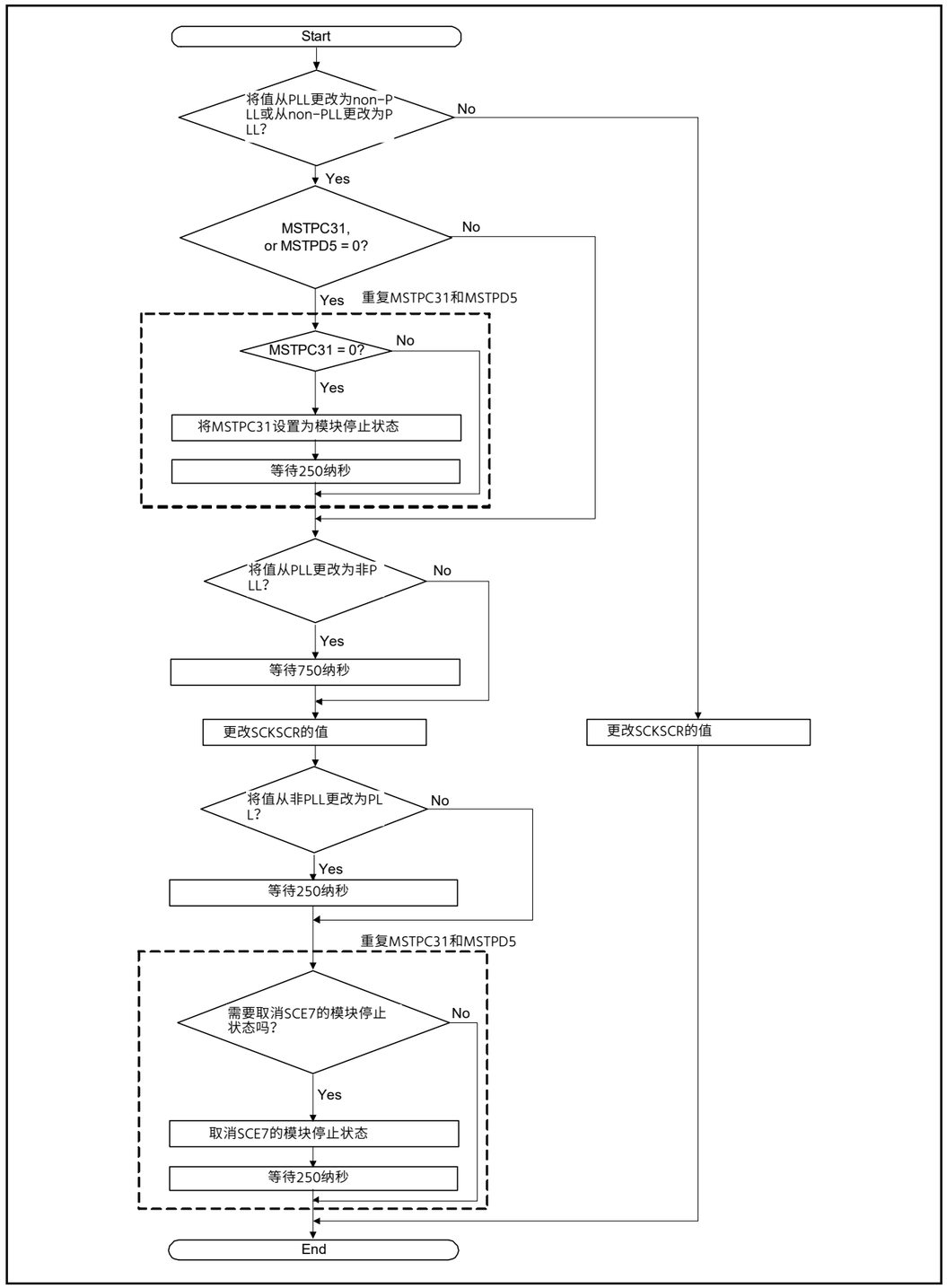


Figure 9.3 更改SCKSCR值的示例流程

9.2.3 PLL Clock Control Register (PLLCCR)

Address(es): SYSTEM.PLLCCR 4001 E028h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	PLLMUL[5:0]						—	—	—	PLSRC SEL	—	—	PLIDIV[1:0]	
Value after reset:	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	PLIDIV[1:0]	PLL Input Frequency Division Ratio Select*1	b1 b0 0 0: × 1 0 1: × 1/2 1 0: × 1/3 1 1: Setting prohibited.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	PLSRCSEL	PLL Clock Source Select	0: Main clock oscillator 1: HOCO.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b13 to b8	PLLMUL[5:0]	PLL Frequency Multiplication Factor Select*2	b13 b8 0 1 0 0 1 1: × 10.0 0 1 0 1 0 0: × 10.5 0 1 0 1 0 1: × 11.0 … 0 1 1 1 0 0: × 14.5 0 1 1 1 0 1: × 15.0 0 1 1 1 1 0: × 15.5 … 1 1 1 0 1 0: × 29.5 1 1 1 0 1 1: × 30.0. Other settings are prohibited.	R/W
b15, b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. PLIDIV[1:0] must be set so that the frequency of the PLL input signal is within the range listed in Table 9.1.
Note 2. PLLMUL[5:0] must be set so that the frequency of the PLL output signal is within the range listed in Table 9.1.

The PLLCCR register sets the operation of the PLL circuit. Writing to the PLLCCR is prohibited when the PLLCR.PLLSTP bit is 0, that is, when the PLL is operating.

PLIDIV[1:0] bits (PLL Input Frequency Division Ratio Select*1)

The PLIDIV[1:0] bits select the frequency division ratio for the PLL clock source.

PLSRCSEL bit (PLL Clock Source Select)

The PLSRCSEL bit selects the clock source for the PLL.

PLLMUL[5:0] bits (PLL Frequency Multiplication Factor Select*2)

The PLLMUL[5:0] bits select the frequency multiplication factor for the PLL circuit.

9.2.3 PLL时钟控制寄存器(PLLCCR)

Address(es): SYSTEM.PLLCCR 4001 E028h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	PLLMUL[5:0]						—	—	—	PLSRC SEL	—	—	PLIDIV[1:0]	
重置后的值:	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	PLIDIV[1:0]	PLL输入分频 Ratio Select*1	b1 b0 0 0: × 1 0 1: × 1/2 1 0: × 1/3 1 1：禁止设置。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	PLSRCSEL	PLL时钟源选择	0：主时钟振荡器1：HOCO。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b13 to b8	PLLMUL[5:0]	PLL倍频 Factor Select*2	b13 b8 0 1 0 0 1 1: × 10.0 0 1 0 1 0 0: × 10.5 0 1 0 1 0 1: × 11.0 … 0 1 1 1 0 0: × 14.5 0 1 1 1 0 1: × 15.0 0 1 1 1 1 0: × 15.5 … 1 1 1 0 1 0: × 29.5 11：×30.0。禁止其他设置。	R/W
b15, b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. PLIDIV[1:0]必须设置为使PLL输入信号的频率在表9.1中列出的范围内。
Note 2. 必须设置PLLMUL[5:0]，以使PLL输出信号的频率在表9.1中列出的范围内。

PLLCCR寄存器设置PLL电路的操作。禁止写入PLLCCR时
PLLCR.PLLSTP位为0，即当PLL工作时。

PLIDIV[1:0]位（PLL输入分频比选择*1）

PLIDIV[1:0]位选择PLL时钟源的分频比。

PLSRCSEL位（PLL时钟源选择）

PLSRCSEL位选择PLL的时钟源。

PLLMUL[5:0]位（PLL倍频因子选择*2）

PLLMUL[5:0]位选择PLL电路的倍频因子。

9.2.4 PLL Control Register (PLLCR)

Address(es): SYSTEM.PLLCR 4001 E02Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	PLLSTP
Value after reset:	0	0	0	0	0	0	0	1

Bit	Symbol	Bit name	Description	R/W
b0	PLLSTP	PLL Stop Control	0: Operate the PLL 1: Stop the PLL.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The PLLCR register controls the operation of the PLL circuit.

PLLSTP bit (PLL Stop Control)

The PLLSTP bit starts or stops the PLL circuit. When selecting the main clock oscillator as the clock source for the PLL in the PLLCCR.PLSRCSEL bit, you must also set the Main Clock Oscillator Wait Control Register (MOSCWTCR).

After setting the PLLSTP bit to 0, confirm that the OSCSF.PLLSF bit is set to 1 before using the PLL clock. A fixed stabilization wait is required after setting the PLL to start operation. A fixed wait time for the oscillation to stop is also required after stopping the PLL operation.

The following restrictions apply when starting and stopping the PLL operation:

- After stopping the PLL, confirm that the OSCSF.PLLSF bit is 0 before restarting the PLL
- Confirm that the PLL operates and that the OSCSF.PLLSF bit is 1 before stopping the PLL
- Regardless of whether the PLL clock is selected as the system clock, after setting the PLL to start operation, confirm that the OSCSF.PLLSF is set to 1 before executing a WFI instruction to place the MCU in Software Standby or Deep Software Standby mode
- When a transition to Software Standby or Deep Software Standby mode is to follow the setting to stop the PLL, confirm that the OSCSF.PLLSF bit is set to 0 before executing the WFI instruction.

Writing 1 to PLLSTP is prohibited under the following condition:

- SCKSCR.CKSEL[2:0] = 101b (system clock source = PLL).

Make sure the following conditions apply before writing 0 to PLLSTP:

- When PLL source clock = MOSC, OSCSF.MOSCSF bit is 1
- When PLL source clock = HOCO, OSCSF.HOCOSF bit is 1.

9.2.5 Main Clock Oscillator Control Register (MOSCCR)

Address(es): SYSTEM.MOSCCR 4001 E032h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	MOSTP
Value after reset:	0	0	0	0	0	0	0	1

Bit	Symbol	Bit name	Description	R/W
b0	MOSTP	Main Clock Oscillator Stop	0: Operate the main clock oscillator*1 1: Stop the main clock oscillator.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

9.2.4 PLL控制寄存器(PLLCR)

Address(es): SYSTEM.PLLCR 4001 E02Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	PLLSTP
重置后的值：	0	0	0	0	0	0	0	1

Bit	Symbol	位名称	Description	R/W
b0	PLLSTP	PLL停止控制	0：运行PLL1：停止PLL。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

PLLCR寄存器控制PLL电路的操作。

PLLSTP位（PLL停止控制）

PLLSTP位启动或停止PLL电路。在PLLCCR.PLSRCSEL位中选择主时钟振荡器作为PLL的时钟源时，您还必须设置主时钟振荡器等待控制寄存器(MOSCWTCR)。

将PLLSTP位设置为0后，在使用PLL时钟之前确认OSCSF.PLLSF位设置为1。将PLL设置为开始操作后，需要一个固定的稳定等待。停止PLL操作后，还需要固定的振荡停止等待时间。

启动和停止PLL操作时适用以下限制：

- 停止PLL后，在重启PLL之前确认OSCSF.PLLSF位为0
- 在停止PLL之前确认PLL运行并且OSCSF.PLLSF位为1
- 无论是否选择PLL时钟作为系统时钟，在设置PLL开始运行后，确认OSCSF.PLLSF设置为1，然后再执行WFI指令将MCU置于软件待机或深度软件待机模式
- 当按照设置转换到软件待机或深度软件待机模式以停止PLL时，请在执行WFI指令之前确认OSCSF.PLLSF位设置为0。

在以下情况下禁止向PLLSTP写入1：

- SCKSCR.CKSEL[2:0]=101b（系统时钟源=PLL）。

在将0写入PLLSTP之前，请确保满足以下条件：

- 当PLL源时钟=MOSC时，OSCSF.MOSCSF位为1
- 当PLL源时钟=HOCO时，OSCSF.HOCOSF位为1。

9.2.5 主时钟振荡器控制寄存器(MOSCCR)

Address(es): SYSTEM.MOSCCR 4001 E032h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	MOSTP
重置后的值：	0	0	0	0	0	0	0	1

Bit	Symbol	位名称	Description	R/W
b0	MOSTP	主时钟振荡器停止	0：运行主时钟振荡器*11：停止主时钟振荡器。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. The MOMCR register must be set before setting MOSTP to 0.

The MOSCCR register controls the main clock oscillator.

MOSTP bit (Main Clock Oscillator Stop)

The MOSTP bit starts or stops the main clock oscillator. To start the main clock oscillator, set this bit to 0. When changing the value of this bit, only execute subsequent instructions after reading the bit to check that its value is updated.

When using the main clock oscillator, you must set the Main Clock Oscillator Mode Oscillation Control Register (MOMCR) and the Main Clock Oscillator Wait Control Register (MOSCWTCR) before setting MOSTP to 0.

After setting the MOSTP bit to 0, confirm that the OSCSF.MOSCSF bit is set to 1 before using the main clock oscillator. A fixed stabilization wait is required after setting the main clock oscillator to start operation. A fixed wait time for the oscillation to stop is also required after stopping the main clock oscillator.

The following restrictions apply when starting and stopping the main clock oscillator operation:

- After stopping the main clock oscillator, confirm that the OSCSF.MOSCSF bit is 0 before restarting the main clock oscillator
- Confirm that the main clock oscillator operates and that the OSCSF.MOSCSF bit is 1 before stopping the main clock oscillator
- Regardless of whether the main clock oscillator is selected as the system clock, confirm that the OSCSF.MOSCSF bit is set to 1 before executing a WFI instruction to place the MCU in Software Standby or Deep Software Standby mode
- When a transition to Software Standby or Deep Software Standby mode is to follow the setting to stop the main clock oscillator, confirm that the OSCSF.MOSCSF bit is set to 0 before executing the WFI instruction.

Writing 1 to MOSTP is prohibited under the following conditions:

- SCKSCR.CKSEL[2:0] = 011b (system clock source = MOSC)
- PLLCCR.PLSRCSEL = 0 (PLL source clock = MOSC) and SCKSCR.CKSEL[2:0] = 101b (system clock source = PLL)
- PLLCCR.PLSRCSEL = 0 (PLL source clock = MOSC) and PLLCR.PLLSTP = 0 (PLL is operating).

9.2.6 Subclock Oscillator Control Register (SOSCCR)

Address(es): SYSTEM.SOSCCR 4001 E480h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	SOSTP
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SOSTP	Sub-Clock Oscillator Stop	0: Operate the sub-clock oscillator*1 1: Stop the sub-clock oscillator.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. The SOMCR register must be set before setting SOSTP to 0.

The SOSCCR register controls the sub-clock oscillator.

SOSTP bit (Sub-Clock Oscillator Stop)

The SOSTP bit starts or stops the sub-clock oscillator.

When changing the value of the SOSTP bit, only execute subsequent instructions after reading the bit and checking that its value is updated. Use the SOSTP bit when using the sub-clock oscillator as the source for a peripheral module.

Note 1. 在将MOSTP设置为0之前，必须设置MOMCR寄存器。

MOSCCR寄存器控制主时钟振荡器。

MOSTP位（主时钟振荡器停止）

MOSTP位启动或停止主时钟振荡器。要启动主时钟振荡器，将该位设置为0。当更改该位的值时，仅在读取该位后执行后续指令以检查其值是否已更新。

使用主时钟振荡器时，必须先设置主时钟振荡器模式振荡控制寄存器(MOMCR)和主时钟振荡器等待控制寄存器(MOSCWTCR)，然后再将MOSTP设置为0。

将MOSTP位设置为0后，在使用主时钟振荡器之前确认OSCSF.MOSCSF位设置为1。
将主时钟振荡器设置为开始运行后，需要一个固定的稳定等待时间。停止主时钟振荡器后，还需要一个固定的振荡停止等待时间。

以下限制适用于启动和停止主时钟振荡器操作：

- 停止主时钟振荡器后，在重新启动主时钟振荡器之前确认OSCSF.MOSCSF位为0
- 在停止主时钟振荡器之前，确认主时钟振荡器工作并且OSCSF.MOSCSF位为1
- 无论是否选择主时钟振荡器作为系统时钟，在执行WFI指令将MCU置于软件待机或深度软件待机模式之前，请确认OSCSF.MOSCSF位设置为1
- 当根据设置转换到软件待机或深度软件待机模式以停止主时钟振荡器时，请在执行WFI指令之前确认OSCSF.MOSCSF位设置为0。

在以下情况下禁止向MOSTP写入1：

- SCKSCR.CKSEL[2:0]=011b（系统时钟源=MOSC）
- PLLCCR.PLSRCSEL=0（PLL源时钟=MOSC）和SCKSCR.CKSEL[2:0]=101b（系统时钟源=PLL）
- PLLCCR.PLSRCSEL=0（PLL源时钟=MOSC）和PLLCR.PLLSTP=0（PLL正在运行）。

9.2.6 副时钟振荡器控制寄存器(SOSCCR)

Address(es): SYSTEM.SOSCCR 4001 E480h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	SOSTP
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SOSTP	副时钟振荡器停止	0：运行副时钟振荡器*11：停止副时钟振荡器。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 在将SOSTP设置为0之前，必须设置SOMCR寄存器。

SOSCCR寄存器控制副时钟振荡器。

SOSTP位（副时钟振荡器停止）

SONTP位启动或停止副时钟振荡器。

更改SONTP位的值时，仅在读取该位并检查其值是否已更新后执行后续指令。当使用副时钟振荡器作为外设模块的源时，使用SOTP位。

When using the sub-clock oscillator, you must set the Sub-Clock Oscillator Mode Control Register (SOMCR) before setting SOSTP to 0.

After setting SOSTP to 0, only use the sub-clock oscillator after the sub-clock oscillation stabilization wait time (tSUBOSCOWT) elapses. A fixed stabilization wait is required after setting the sub-clock oscillator to start operation. A fixed wait time for the oscillation to stop is also required after setting the SOSTP bit.

The following restrictions apply when starting and stopping operation:

- After stopping the sub-clock oscillator, allow a stop interval of at least 5 SOSC clock cycles before restarting it
- Confirm that sub-clock oscillation is stable before stopping the sub-clock oscillator
- Regardless of whether the sub-clock oscillator is selected as the system clock, confirm that the sub-clock oscillation is stable before executing a WFI instruction to place the MCU in Software Standby mode
- When a transition to Software Standby mode is to follow the setting to stop the sub-clock oscillator, wait for at least 3 SOSC clock cycles before executing the WFI instruction.

Writing 1 to SOSTP is prohibited under the following condition:

- SCKSCR.CKSEL[2:0] = 100b (system clock source = SOSC).

9.2.7 Low-Speed On-Chip Oscillator Control Register (LOCOCR)

Address(es): SYSTEM.LOCOCR 4001 E490h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	LCSTP
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	LCSTP	LOCO Stop	0: Operate the LOCO clock 1: Stop the LOCO clock.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The LOCOCR register controls the LOCO clock.

LCSTP bit (LOCO Stop)

The LCSTP bit starts or stops the LOCO clock.

After setting the LCSTP bit to 0 to start the LOCO clock, only use the clock after the LOCO clock oscillation stabilization wait time (tLOCOWT) elapses. A fixed stabilization wait is required after setting the LOCO clock to start operation. A fixed wait time for the oscillation to stop is also required.

The following restrictions apply when starting and stopping operation:

- After stopping the LOCO clock, allow a stop interval of at least 5 LOCO clock cycles before restarting it
- Confirm that LOCO oscillation is stable before stopping the LOCO clock
- Regardless of whether the LOCO clock is selected as the system clock, confirm that LOCO oscillation is stable before executing a WFI instruction to place the MCU in Software Standby or Deep Software Standby mode
- When a transition to Software Standby or Deep Software Standby mode is to follow the setting to stop the LOCO clock, wait for at least 3 LOCO clock cycles before executing the WFI instruction.

Writing 1 to LOSTP is prohibited under the following condition:

- SCKSCR.CKSEL[2:0] = 010b (system clock source = LOCO).

Because the LOCO clock measures the wait time for other oscillators, it continues to oscillate while measuring this time, regardless of the setting in LOCOCR.LCSTP. As a result, the LOCO clock might be unintentionally supplied even when the LCSTP is set to stop.

使用副时钟振荡器时，必须先设置副时钟振荡器模式控制寄存器(SOMCR)，然后再将SOSTP设置为0。

将SOSTP设置为0后，仅在副时钟振荡稳定等待时间(tSUBOSCOWT)过后才使用副时钟振荡器。设置副时钟振荡器开始运行后，需要一个固定的稳定等待。设置SOOSTP位后，还需要一个固定的振荡停止等待时间。

启动和停止操作时适用以下限制：

- 停止子时钟振荡器后，在重新启动之前允许至少5个SOSC时钟周期的停止间隔
- 在停止副时钟振荡器之前确认副时钟振荡稳定
- 无论是否选择副时钟振荡器作为系统时钟，在执行WFI指令之前确认副时钟振荡稳定，使MCU进入软件待机模式
- 当根据设置转换到软件待机模式以停止副时钟振荡器时，请等待至少3个SOSC时钟周期，然后再执行WFI指令。

在以下情况下禁止向SOTP写入1：

- SCKSCR.CKSEL[2:0]=100b（系统时钟源=SOSC）。

9.2.7 低速片上振荡器控制寄存器(LOCOCR)

Address(es): SYSTEM.LOCOCR 4001 E490h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	LCSTP
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	LCSTP	机车站	0：运行LOCO时钟1：停止LOCO时钟。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

LOCOCR寄存器控制LOCO时钟。

LCSTP位（LOCO停止）

LCSTP位启动或停止LOCO时钟。

将LCSTP位设置为0以启动LOCO时钟后，仅在LOCO时钟振荡稳定等待时间(tLOCOWT)过去后使用时钟。将LOCO时钟设置为开始操作后，需要进行固定的稳定等待。振荡停止的固定等待时间也是必需的。

启动和停止操作时适用以下限制：

- 停止LOCO时钟后，在重新启动之前允许至少5个LOCO时钟周期的停止间隔
- 在停止LOCO时钟之前确认LOCO振荡稳定
- 无论是否选择LOCO时钟作为系统时钟，在执行WFI指令将MCU置于软件待机或深度软件待机模式之前，请确认LOCO振荡稳定
- 当按照设置转换到软件待机或深度软件待机模式以停止LOCO时钟时，请等待至少3个LOCO时钟周期，然后再执行WFI指令。

在以下情况下禁止向LOSTP写入1：

- SCKSCR.CKSEL[2:0]=010b（系统时钟源=LOCO）。

因为LOCO时钟测量其他振荡器的等待时间，所以在测量该时间时它会继续振荡，而不管LOCOCR.LCSTP中的设置如何。因此，即使LCSTP设置为停止，也可能会无意中提供LOCO时钟。

9.2.8 High-Speed On-Chip Oscillator Control Register (HOCOCR)

Address(es): SYSTEM.HOCOCR 4001 E036h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	HCSTP
Value after reset:	0	0	0	0	0	0	0	0/1*1

Bit	Symbol	Bit name	Description	R/W
b0	HCSTP	HOCO Stop	0: Operate the HOCO clock*2 1: Stop the HOCO clock.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. The HCSTP bit value after a reset is 0 when the OFS1.HOCOEN bit is 0. It is 1 when the OFS1.HOCOEN bit is 1.
Note 2. If you use the HOCO (HCSTP = 0), you must set the OFS1.HOCOFRQ1 bit to an optimum value.

The HOCOCR register controls the HOCO clock.

HCSTP bit (HOCO Stop)

The HCSTP bit starts or stops the HOCO clock.

After setting the HCSTP bit to 0 to start the HOCO clock, confirm that the OSCSF.HOSCSF bit is set to 1 before using the clock. A fixed stabilization wait is required after setting the HOCO clock to start operation. A fixed wait time for oscillation to stop is also required. For the HOCO to operate, the HOCO Wait Control Register (HOCOWTCR) must also be set.

The following restrictions apply when starting and stopping operation:

- After stopping the HOCO, confirm that the OSCSF.HOCOSF bit is 0 before restarting the HOCO clock
- Confirm that the HOCO clock operates and that the OSCSF.HOCOSF bit is 1 before stopping the HOCO clock
- Regardless of whether the HOCO clock is selected as the system clock, confirm that the OSCSF.HOSCSF bit is set to 1 before executing a WFI instruction to place the MCU in Software Standby or Deep Software Standby mode
- When a transition to Software Standby or Deep Software Standby mode is to follow the setting to stop the HOCO clock, confirm that the OSCSF.MOSCSF bit is set to 0, before executing the WFI instruction.

Writing 1 to HCSTP is prohibited under the following conditions:

- SCKSCR.CKSEL[2:0] = 000b (system clock source = HOCO)
- PLLCCR.PLSRCSEL = 1 (PLL source clock = HOCO) and SCKSCR.CKSEL[2:0] = 101b (system clock source = PLL)
- PLLCCR.PLSRCSEL = 1 (PLL source clock = HOCO) and PLLCR.PLLSTP = 0 (PLL is operating).

9.2.9 High-Speed On-Chip Oscillator Wait Control Register (HOCOWTCR)

Address(es): SYSTEM.HOCOWTCR 4001 E0A5h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	HSTS[2:0]		
Value after reset:	0	0	0	0	0	0	1	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	HSTS[2:0]	HOCO Wait Time Setting	Wait time (s) = (HSTS[2:0] setting +3) / fLOCO	R/W

9.2.8 高速片上振荡器控制寄存器(HOCOCR)

Address(es): SYSTEM.HOCOCR 4001 E036h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	HCSTP
重置后的值:	0	0	0	0	0	0	0	0/1*1

Bit	Symbol	位名称	Description	R/W
b0	HCSTP	HOCO Stop	0：运行HOCO时钟*21：停止HOCO时钟。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 当OFS1.HOCOEN位为0时复位后的HCSTP位值为0。当OFS1.HOCOEN位为1时为1。
Note 2. 如果使用HOCO(HCSTP=0)，则必须将OFS1.HOCOFRQ1位设置为最佳值。

HOCOCR寄存器控制HOCO时钟。

HCSTP位（HOCO停止）

HCSTP位启动或停止HOCO时钟。

将HCSTP位设置为0以启动HOCO时钟后，在使用时钟之前确认OSCSF.HOSCSF位设置为1。在设置HOCO时钟开始操作后，需要一个固定的稳定等待。还需要固定的振荡停止等待时间。为了使HOCO运行，还必须设置HOCO等待控制寄存器（HOCOWTCR）。

启动和停止操作时适用以下限制：

- 停止HOCO后，确认OSCSF.HOCOSF位为0后再重启HOCO时钟
- 在停止HOCO时钟之前，确认HOCO时钟运行并且OSCSF.HOCOSF位为1
- 无论是否选择HOCO时钟作为系统时钟，在执行WFI指令将MCU置于软件待机或深度软件待机模式之前，请确认OSCSF.HOSCSF位设置为1
- 当转换到软件待机或深度软件待机模式是按照设置停止HOCO时钟时，在执行WFI指令之前确认OSCSF.MOSCSF位设置为0。

在以下情况下禁止向HCSTP写入1：

- SCKSCR.CKSEL[2:0]=000b（系统时钟源=HOCO）
- PLLCCR.PLSRCSEL=1（PLL源时钟=HOCO）和SCKSCR.CKSEL[2:0]=101b（系统时钟源=PLL)
- PLLCCR.PLSRCSEL=1（PLL源时钟=HOCO）和PLLCR.PLLSTP=0（PLL正在运行）。

9.2.9 高速片上振荡器等待控制寄存器(HOCOWTCR)

Address(es): SYSTEM.HOCOWTCR 4001 E0A5h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	HSTS[2:0]		
重置后的值:	0	0	0	0	0	0	1	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	HSTS[2:0]	HOCO等待时间设置	等待时间(s)=(HSTS[2:0]设置+3)fLOCO	R/W

Bit	Symbol	Bit name	Description	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R

HSTS[2:0] bits (HOCO Wait Time Setting)

The HSTS[2:0] bits must be set to 110b, except when using SCI0 in Snooze mode. When using SCI0 in Snooze mode, these bits must be set to 010b.

9.2.10 Middle-Speed On-Chip Oscillator Control Register (MOCOCR)

Address(es): SYSTEM.MOCOCR 4001 E038h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	MCSTP
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	MCSTP	MOCO Stop	0: Operate the MOCO clock 1: Stop the MOCO clock.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The MOCOCR register controls the MOCO clock.

MCSTP bit (MOCO Stop)

The MCSTP bit starts or stops the MOCO clock.

After setting the MCSTP bit to 0 to start the MOCO clock, only use the clock after the MOCO clock oscillation stabilization time (tMOCOWT) elapses. A fixed stabilization wait is required after setting the MOCO clock to start operation. A fixed wait time for oscillation to stop is also required after setting MCSTP to 1.

The following restrictions apply when starting and stopping operation:

- After stopping the MOCO clock, allow a stop interval of at least 5 MOCO clock cycles before restarting it
- Confirm that MOCO oscillation is stable before stopping the MOCO clock
- Regardless of whether the MOCO clock is selected as the system clock, confirm that MOCO oscillation is stable before executing a WFI instruction to place the MCU in Software Standby or Deep Software Standby mode
- When a transition to Software Standby or Deep Software Standby mode is to follow the setting to stop the MOCO clock, wait for at least 3 MOCO clock cycles before executing the WFI instruction.

Writing 1 to MCSTP is prohibited under the following condition:

- SCKSCR.CKSEL[2:0] = 001b (system clock source = MOCO).

Writing 1 to the MCSTP bit (stopping the MOCO) is prohibited if oscillation stop detection is enabled in the Oscillation Stop Detection Enable bit (OSTDCR.OSTDE) in the Oscillation Stop Detection Control Register.

Bit	Symbol	位名称	Description	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R

HSTS[2:0]位（HOCO等待时间设置）

HSTS[2:0]位必须设置为110b，除非在贪睡模式下使用SCI0。在贪睡模式下使用SCI0时，这些位必须设置为010b。

9.2.10 中速片上振荡器控制寄存器(MOCOCR)

Address(es): SYSTEM.MOCOCR 4001 E038h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	MCSTP
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	MCSTP	MOCO Stop	0：运行MOCO时钟1：停止MOCO时钟。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

MOCOCR寄存器控制MOCO时钟。

MCSTP位（MOCO停止）

MCSTP位启动或停止MOCO时钟。

将MCSTP位设置为0以启动MOCO时钟后，仅在MOCO时钟振荡稳定时间(tMOCOWT)过去后使用时钟。在设置MOCO时钟开始操作后，需要一个固定的稳定等待。将MCSTP设置为1后，还需要固定的振荡停止等待时间。

启动和停止操作时适用以下限制：

- 停止MOCO时钟后，在重新启动之前允许至少5个MOCO时钟周期的停止间隔
- 在停止MOCO时钟之前确认MOCO振荡稳定
- 无论是否选择MOCO时钟作为系统时钟，在执行WFI指令将MCU置于软件待机或深度软件待机模式之前，请确认MOCO振荡稳定
- 当按照设置转换到软件待机或深度软件待机模式以停止MOCO时钟时，请等待至少3个MOCO时钟周期，然后再执行WFI指令。

在以下情况下禁止向MCSTP写入1：

- SCKSCR.CKSEL[2:0]=001b（系统时钟源=MOCO）。

如果在Oscillation中使能了振荡停止检测，则禁止向MCSTP位写入1（停止MOCO）
振荡停止检测控制寄存器中的停止检测使能位(OSTDCR.OSTDE)。

9.2.11 FLL Control Register 1 (FLLCR1)

Address(es): SYSTEM.FLLCR1 4001 E039h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	FLLEN
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	FLLEN	FLL Enable	0: FLL function is disabled 1: FLL function is enabled.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: HOCO must be stopped (HOCOCR.HCSTP = 1) before FLLCR1.FLLEN is changed.
SOSC must operate with stabilization while FLL is enabled (FLLCR1.FLLEN = 1).

The FLLCR1 register controls the FLL function of the HOCO. The FLL function uses SOSC when available for better accuracy in HOCO.

FLLEN bit (FLL Enable)

The FLLEN bit enables or disables the FLL function of the HOCO.

If the FLL function is enabled, the frequency accuracy is guaranteed after the FLL is stabilized. The FLL stabilization can be checked by the frequency measurement of the Clock Frequency Accuracy Measurement Circuit (CAC) after the HOCO is stabilized.

The FLL function must be disabled by setting the FLLEN bit to 0 before transitioning to Software Standby mode.

Figure 9.4 and Figure 9.5 show an example flow of the FLL setting in each case.

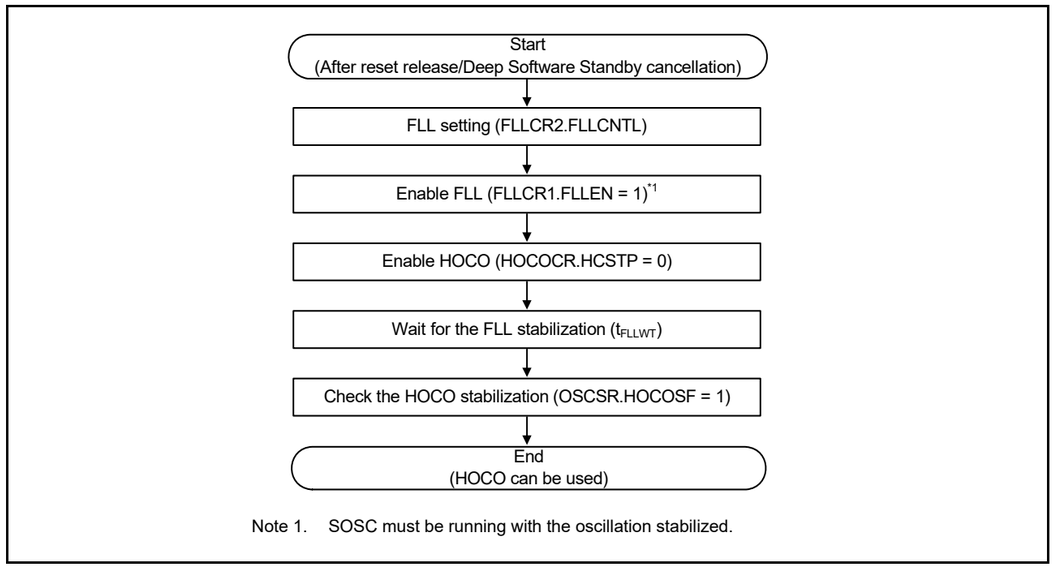


Figure 9.4 FLL setting flow after reset release/Deep Software Standby cancellation

9.2.11 FLL控制寄存器1(FLLCR1)

Address(es): SYSTEM.FLLCR1 4001 E039h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	FLLEN
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	FLLEN	FLL Enable	0：禁用FLL功能1：启用FLL功能。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 在更改FLLCR1.FLLEN之前，必须停止HOCO（HOCOCR.HCSTP=1）。
SOSC必须在启用FLL时稳定运行(FLLCR1.FLLEN=1)。

FLLCR1寄存器控制HOCO的FLL功能。FLL函数在可用时使用SOSC以在HOCO中获得更好的精度。

FLLEN位（FLL使能）

FLLEN位启用或禁用HOCO的FLL功能。

如果开启FLL功能，则在FLL稳定后，频率精度得到保证。在HOCO稳定后，可以通过时钟频率精度测量电路(CAC)的频率测量来检查FLL的稳定性。

在转换到软件待机模式之前，必须通过将FLLEN位设置为0来禁用FLL功能。

图9.4和图9.5显示了每种情况下FLL设置的示例流程。

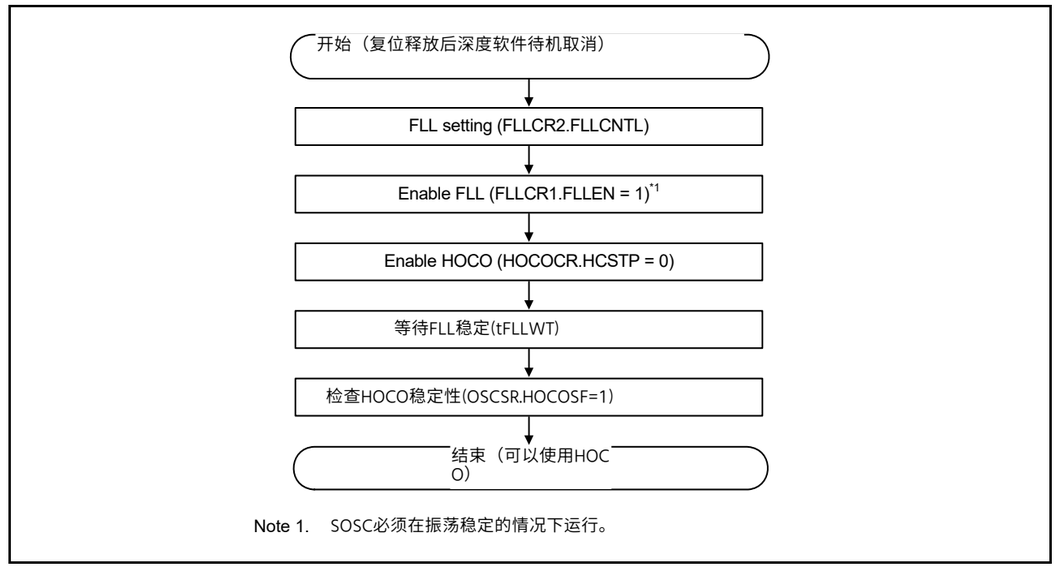
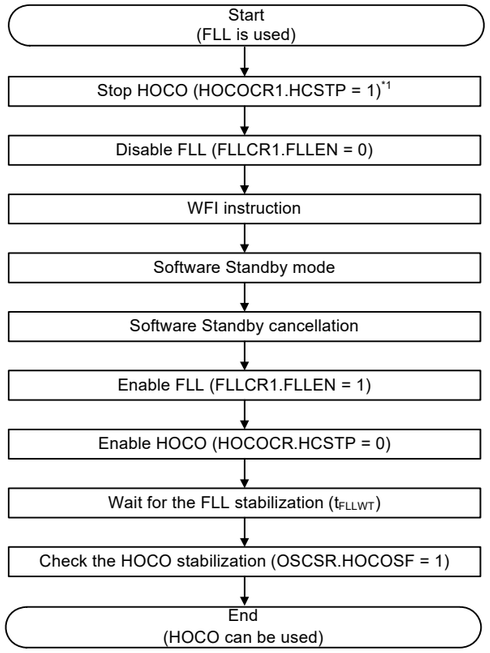


Figure 9.4 复位释放后的FLL设置流程DeepSoftwareStandby取消



Note 1. If HOCO is used as the system clock or the PLL reference clock, these clock sources must be changed to another clock before HOCO is stopped.

Figure 9.5 Software Standby transition/cancellation flow

9.2.12 FLL Control Register 2 (FLLCR2)

Address(es): SYSTEM.FLLCR2.4001 E03Ah

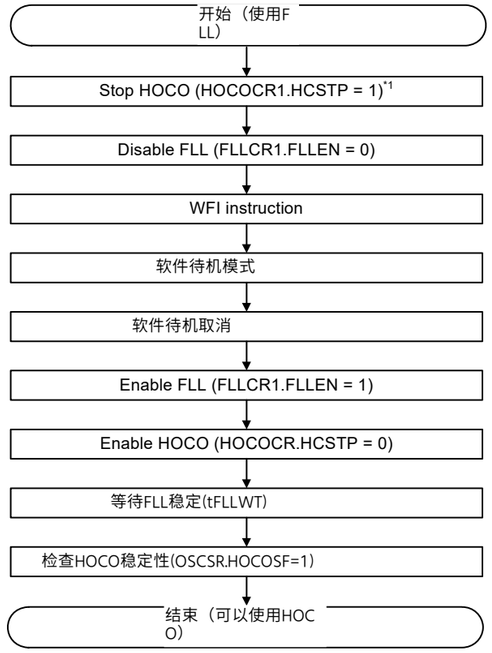
	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	FLLCNTL[10:0]										
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b10 to b0	FLLCNTL[10:0]	FLL Multiplication Control	• When OFS1.HOCOFRQ0[1:0] is 00b (16 MHz), these bits must be set to 1E9h • When OFS1.HOCOFRQ0[1:0] is 01b (18 MHz), these bits must be set to 226h • When OFS1.HOCOFRQ0[1:0] is 10b (20 MHz), these bits must be set to 263h. Other settings are prohibited.	R/W
b15 to b11	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The FLLCR2 register controls the FLL function of the HOCO.

FLLCNTL[10:0] bits (FLL Multiplication Control)

The FLLCNTL[10:0] bits select the multiplication ratio of the FLL reference clock. These bits must be set before FLL is enabled (FLLCR1.FLLEN = 1).



Note 1. 如果HOCO用作系统时钟或PLL参考时钟，则这些时钟源必须在HOCO停止之前更改为另一个时钟。

Figure 9.5 软件待机转换取消流程

9.2.12 FLL控制寄存器2(FLLCR2)

Address(es): SYSTEM.FLLCR2.4001 E03Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	FLLCNTL[10:0]										
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b10 to b0	FLLCNTL[10:0]	FLL乘法控制	当OFS1.HOCOFRQ0[1:0]为00b(16MHz)时，这些位必须设置为1E9h 当OFS1.HOCOFRQ0[1:0]为01b(18MHz)时，这些位必须设置为226h 当OFS1.HOCOFRQ0[1:0]为10b(20MHz)，这些位必须设置为263h。禁止其他设置。	R/W
b15 to b11	—	Reserved	这些位被读取为0。写入值应为0。	R/W

FLLCR2寄存器控制HOCO的FLL功能。

FLLCNTL[10:0]位（FLL乘法控制）

FLLCNTL[10:0]位选择FLL参考时钟的倍频比。这些位必须在启用FLL之前设置（FLLCR1.FLLEN=1）。

9.2.13 Oscillation Stabilization Flag Register (OSCSF)

Address(es): SYSTEM.OSCSF 4001 E03Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	PLLSF	—	MOSCSF	—	—	HOCOSF
Value after reset:	0	0	0	0	0	0	0	0/1*1

Bit	Symbol	Bit name	Description	R/W
b0	HOCOSF	HOCO Clock Oscillation Stabilization Flag	0: The HOCO clock is stopped or is not yet stable 1: The HOCO clock is stable, and is available for use as the system clock.	R
b2, b1	—	Reserved	These bits are read as 0.	R
b3	MOSCSF	Main Clock Oscillation Stabilization Flag	0: The main clock oscillator is stopped (MOSTP = 1) or is not yet stable*2 1: The main clock oscillator is stable, and is available for use as the system clock.	R
b4	—	Reserved	This bit is read as 0.	R
b5	PLLSF	PLL Clock Oscillation Stabilization Flag	0: The PLL clock is stopped or is not yet stable 1: The PLL clock is stable, and is available for use as the system clock.	R
b7, b6	—	Reserved	These bits are read as 0	R

Note 1. The value after reset depends on the OFS1.HOCOEN setting.
When OFS1.HOCOEN = 1, the HOCOSF value after reset is 0.
When OFS1.HOCOEN = 0, the HOCOSF value becomes 0 after reset is released, and HOCOSF is set to 1 after the HOCO oscillation stabilization wait time elapses.

Note 2. An appropriate value is set in the Wait Control Register for the given oscillator. If the wait time value is not sufficient, the oscillation stabilization flag is set to 1 and supply of the clock signal to the internal circuits starts before oscillation is stable.

The OSCSF register contains flags to indicate the operating status of the counters in the oscillation stabilization wait circuits for the individual oscillators.

After oscillation starts, these counters measure the wait time until each oscillator output clock is supplied to the internal circuits. An overflow of a counter indicates that the clock supply is stable and available for the associated circuit.

HOCOSF flag (HOCO Clock Oscillation Stabilization Flag)

The HOCOSF flag indicates the operating status of the counter that measures the wait time for the HOCO. Confirm that the OSCSF.HOCOSF is set to 1 before using the HOCO clock.

[Setting condition]

- After the HOCO clock stops and the HOCOCR.HCSTP bit is set to 0, supply of the MCU clock starts after the number of LOCO cycles associated with the HOCOWTCR register setting elapses.

[Clearing condition]

- When the HOCO clock is operating and then is deactivated because the HOCOCR.HCSTP bit is set to 1.

MOSCSF flag (Main Clock Oscillation Stabilization Flag)

The MOSCSF flag indicates the operating status of the counter that measures the wait time for the main clock oscillator.

[Setting condition]

- After the main clock oscillator stops and the MOSCCR.MOSTP bit is set to 0, supply of the MCU clock starts after the number of LOCO cycles associated with the MOSCWTCR register setting elapses.

[Clearing condition]

9.2.13 振荡稳定标志寄存器(OSCSF)

Address(es): SYSTEM.OSCSF 4001 E03Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	PLLSF	—	MOSCSF	—	—	HOCOSF
重置后的值:	0	0	0	0	0	0	0	0/1*1

Bit	Symbol	位名称	Description	R/W
b0	HOCOSF	HOCO时钟振荡稳定标志	0：HOCO时钟停止或尚未稳定1：HOCO时钟稳定，可用作系统时钟。	R
b2, b1	—	Reserved	这些位读为0。	R
b3	MOSCSF	主时钟振荡稳定标志	0：主时钟振荡器停止（MOSTP=1）或尚未稳定*21：主时钟振荡器稳定，可用作系统时钟。	R
b4	—	Reserved	该位读为0。	R
b5	PLLSF	PLL时钟振荡稳定Flag	0：PLL时钟停止或尚未稳定1：PLL时钟稳定，可用作系统时钟。	R
b7, b6	—	Reserved	这些位被读为0	R

Note 1. 复位后的值取决于OFS1.HOCOEN设置。当OFS1.HOCOEN=1时，复位后的HOCOSF值为0。
当OFS1.HOCOEN=0时，复位解除后HOCOSF值变为0，经过HOCO振荡稳定等待时间后HOCOSF设置为1。

Note 2. 给定振荡器的等待控制寄存器中设置了一个适当的值。如果等待时间值不够，则将振荡稳定标志设置为1，并在振荡稳定之前开始向内部电路提供时钟信号。

OSCSF寄存器包含用于指示各个振荡器的振荡稳定等待电路中的计数器的操作状态的标志。

振荡开始后，这些计数器测量等待时间，直到每个振荡器输出时钟被提供给内部电路。计数器溢出表明时钟供应稳定并可用于相关电路。

HOCOSF标志（HOCO时钟振荡稳定标志）

HOCOSF标志指示测量HOCO等待时间的计数器的操作状态。在使用HOCO时钟之前，请确认OSCSF.HOCOSF设置为1。

[Setting condition]

- 在HOCO时钟停止并且HOCOCR.HCSTP位设置为0后，在与HOCOWTCR寄存器设置相关的LOCO周期数过去后，MCU时钟的供应开始。

[Clearing condition]

- 当HOCO时钟运行，然后因为HOCOCR.HCSTP位设置为1而被停用时。

MOSCSF标志（主时钟振荡稳定标志）

MOSCSF标志指示测量主时钟振荡器等待时间的计数器的操作状态。

[Setting condition]

- 在主时钟振荡器停止且MOSCCR.MOSTP位设置为0后，在与MOSCWTCR寄存器设置相关的LOCO周期数过去后开始提供MCU时钟。

[Clearing condition]

- When the main clock oscillator is operating and then is deactivated because the MOSCCR.MOSTP bit is set to 1.

PLLSF flag (PLL Clock Oscillation Stabilization Flag)

The PLLSF flag indicates the operating status of the counter that measures the wait time for the PLL.

[Setting condition]

- After the PLL stops and the PLLCR.PLLSTP bit is set to 0, supply of the MCU clock starts after 31 LOCO cycles. If oscillation by the PLL clock source selected in the PLLCCR.PLSRCSEL bit is not stable when the PLLSTP bit is set to 0, counting of the LOCO cycles continues after the PLL clock source oscillation is stabilized. Wait time is calculated as:

  1 cycle = LOCO (32.768 kHz) x 8 (3.81 µs typical).

[Clearing condition]

- When the PLL is operating and then is deactivated because the PLLCCR.PLLSTP bit is set to 1.

9.2.14 Oscillation Stop Detection Control Register (OSTDCR)

Address(es): SYSTEM.OSTDCR 4001 E040h

	b7	b6	b5	b4	b3	b2	b1	b0
	OSTDE	—	—	—	—	—	—	OSTDIE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	OSTDIE	Oscillation Stop Detection Interrupt Enable	0: Disable oscillation stop detection interrupt (do not notify the POEG) 1: Enable oscillation stop detection interrupt (notify the POEG).	R/W
b6 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	OSTDE	Oscillation Stop Detection Function Enable	0: Disable oscillation stop detection function 1: Enable oscillation stop detection function.	R/W

The OSTDCR register controls the oscillation stop detection function.

OSTDIE bit (Oscillation Stop Detection Interrupt Enable)

The OSTDIE bit enables the oscillation stop detection function interrupt. This bit also controls whether oscillation stop detection is reported to the POEG.

If the Oscillation Stop Detection flag in the Oscillation Stop Detection Status Register (OSTDSR.OSTDF) requires clearing, set the OSTDIE bit to 0 before clearing OSTDF. Wait for at least 2 PCLKB cycles before setting the OSTDIE bit to 1. A longer PCLKB wait time might be required, depending on the number of cycles required to read a given I/O register.

OSTDE bit (Oscillation Stop Detection Function Enable)

The OSTDE bit enables the oscillation stop detection function.

When the OSTDE bit is 1 (enabled), the MOCO stop bit (MOCOCR.MCSTP) is set to 0 and MOCO operation starts. The MOCO clock cannot be stopped when the oscillation stop detection function is enabled. Writing 1 to the MOCOCR.MCSTP bit (MOCO stopped) is invalid.

When the Oscillation Stop Detection flag in the Oscillation Stop Detection Status Register (OSTDSR.OSTDF) is 1 (main clock oscillation stop detected), writing 0 to the OSTDE bit is invalid.

The OSTDE bit must be set to 0 before transitioning to Software Standby or Deep Software Standby mode. To transition to either of these modes, first set the OSTDE bit to 0, then execute the WFI instruction.

The following restrictions apply when using the oscillation stop detection function:

- 当主时钟振荡器正在运行，然后因为MOSCCR.MOSTP位设置为1而被停用时。

PLLSF标志（PLL时钟振荡稳定标志）

PLLSF标志指示测量PLL等待时间的计数器的操作状态。

[Setting condition]

- 在PLL停止并且PLLCR.PLLSTP位设置为0后，MCU时钟在31个LOCO周期后开始提供。当PLLSTP位设置为0时，如果在PLLCCR.PLSRCSEL位中选择的PLL时钟源的振荡不稳定，则在PLL时钟源振荡稳定后继续计数LOCO周期。等待时间计算如下：

1个周期=LOCO(32.768kHz)x8（典型值为3.81µs）
。【结算条件】

- 当PLL正在运行然后因为PLLCCR.PLLSTP位设置为1而被停用时。

9.2.14 振荡停止检测控制寄存器(OSTDCR)

Address(es): SYSTEM.OSTDCR 4001 E040h

	b7	b6	b5	b4	b3	b2	b1	b0
	OSTDE	—	—	—	—	—	—	OSTDIE
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	OSTDIE	振荡停止检测中断使能	0：禁止振荡停止检测中断（不通知POEG）1：使能振荡停止检测中断（通知POEG）。	R/W
b6 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	OSTDE	振荡停止检测功能启用	0：禁用振荡停止检测功能1：启用振荡停止检测功能。	R/W

OSTDCR寄存器控制振荡停止检测功能。

OSTDIE位（振荡停止检测中断使能）

OSTDIE位使能振荡停止检测功能中断。该位还控制是否将振荡停止检测报告给POEG。

如果振荡停止检测状态寄存器(OSTDSR.OSTDF)中的振荡停止检测标志需要清零，则在清零OSTDF之前将OSTDIE位设置为0。在将OSTDIE位设置为1之前等待至少2个PCLKB周期。可能需要更长的PCLKB等待时间，具体取决于读取给定IO寄存器所需的周期数。

OSTDE位（振荡停止检测功能使能）

OSTDE位使能振荡停止检测功能。

当OSTDE位为1（使能）时，MOCO停止位（MOCOCR.MCSTP）设置为0，MOCO操作开始。
使能振荡停止检测功能时，MOCO时钟不能停止。将1写入
MOCOCR.MCSTP位（MOCO停止）无效。

当振荡停止检测状态寄存器(OSTDSR.OSTDF)中的振荡停止检测标志为1（检测到主时钟振荡停止）时，向OSTDE位写入0无效。

在转换到软件待机或深度软件待机模式之前，必须将OSTDE位设置为0。要转换到这两种模式中的任何一种，首先将OSTDE位设置为0，然后执行WFI指令。

使用振荡停止检测功能时有以下限制：

- In low-speed mode, selecting division by 1, 2, 4, 8 for ICLK, FCLK, PCLKA, PCLKB, PCLKC, PCLKD is prohibited.

9.2.15 Oscillation Stop Detection Status Register (OSTDSR)

Address(es): SYSTEM.OSTDSR 4001 E041h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	OSTDF
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	OSTDF	Oscillation Stop Detection Flag	0: Main clock oscillation stop not detected 1: Main clock oscillation stop detected.	R(/W)*1
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. This bit can only be set to 0.

The OSTDSR register indicates the stop detection status of the main clock oscillator.

OSTDF flag (Oscillation Stop Detection Flag)

The OSTDF flag indicates the main clock oscillator status. When this flag is 1, it indicates that the main clock oscillation stop was detected. After this stop is detected, the OSTDF flag is not set to 0 even when the main clock oscillation is restarted. The OSTDF flag is set to 0 by writing 0 after reading it as 1.

At least 3 ICLK cycles of wait time are required between writing 0 to OSTDF and reading it as 0. If the OSTDF flag is set to 0 when the main clock oscillation is stopped, the OSTDF flag becomes 0 then returns to 1.

The OSTDF flag cannot be set to 0 under the following conditions:

- SCKSCR.CKSEL[2:0] = 011b (system clock source = MOSC)
- PLLCCR.PLSRCSEL = 0 (PLL source clock = MOSC) and SCKSCR.CKSEL[2:0] = 101b (system clock source = PLL).

The OSTDF flag must be set to 0 after switching the clock source to sources other than the main clock oscillator and PLL.

[Setting condition]

- The main clock oscillator is stopped when OSTDCR.OSTDE = 1 (oscillation stop detection function enabled).

[Clearing condition]

- 1 is read and then 0 is written when the SCKSCR.CKSEL[2:0] bits are neither 011b (system clock = MOSC) nor 101b (system clock = PLL), and the PLLCCR.PLSRCSEL bit is not 0 (PLL source clock = MOSC).

- 在低速模式下，禁止为ICLK、FCLK、PCLKA、PCLKB、PCLKC、PCLKD选择1、2、4、8分频。

9.2.15 振荡停止检测状态寄存器(OSTDSR)

Address(es): SYSTEM.OSTDSR 4001 E041h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	OSTDF
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	OSTDF	振荡停止检测标志	0：未检测到主时钟振荡停止1：检测到主时钟振荡停止。	R(/W)*1
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 该位只能设置为0。

OSTDSR寄存器指示主时钟振荡器的停止检测状态。

OSTDF标志（振荡停止检测标志）

OSTDF标志指示主时钟振荡器状态。该标志为1时，表示检测到主时钟振荡停止。检测到此停止后，即使重新启动主时钟振荡，OSTDF标志也不会设置为0。OSTDF标志在读取为1后通过写入0设置为0。

从向OSTDF写入0到将其读取为0之间至少需要3个ICLK周期的等待时间。如果在主时钟振荡停止时将OSTDF标志设置为0，则OSTDF标志变为0然后返回1。

在以下情况下，OSTDF标志不能设置为0：

- SCKSCR.CKSEL[2:0]=011b（系统时钟源=MOSC）
- PLLCCR.PLSRCSEL=0（PLL源时钟=MOSC）和SCKSCR.CKSEL[2:0]=101b（系统时钟源=PLL).

将时钟源切换到主时钟振荡器以外的源后，必须将OSTDF标志设置为0，并且
PLL.

[Setting condition]

- 当OSTDCR.OSTDE=1（使能振荡停止检测功能）时，主时钟振荡器停止。

[Clearing condition]

- 当SCKSCR.CKSEL[2:0]位既不是011b（系统时钟=MOSC）也不是101b（系统时钟=PLL）且PLLCCR.PLSRCSEL位不为0（PLL源时钟）时，读取1然后写入0=MOSC）。

9.2.16 Main Clock Oscillator Wait Control Register (MOSCWTCR)

Address(es): SYSTEM.MOSCWTCR 4001 E0A2h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	MSTS[3:0]			
Value after reset:	0	0	0	0	0	1	0	1

Bit	Symbol	Bit name	Description	R/W
b3 to b0	MSTS[3:0]	Main Clock Oscillator Wait Time Setting	When drive capability automatic switching function is disabled (MOMCR.AUTODRVEN = 0 [default]): b3 b0 0 0 0 1: Wait time = 35 cycles (133.5 µs) 0 0 1 0: Wait time = 67 cycles (255.6 µs) 0 0 1 1: Wait time = 131 cycles (499.7 µs) 0 1 0 0: Wait time = 259 cycles (988.0 µs) 0 1 0 1: Wait time = 547 cycles (2086.6 µs) (value after reset) 0 1 1 0: Wait time = 1059 cycles (4039.8 µs) 0 1 1 1: Wait time = 2147 cycles (8190.2 µs) 1 0 0 0: Wait time = 4291 cycles (16368.9 µs) 1 0 0 1: Wait time = 8163 cycles (31139.4 µs). When drive capability automatic switching function is enabled (MOMCR.AUTODRVEN = 1): b3 b0 0 0 0 1: Wait time = 36 cycles (137.3 µs) 0 0 1 0: Wait time = 68 cycles (259.4 µs) 0 0 1 1: Wait time = 132 cycles (503.5 µs) 0 1 0 0: Wait time = 260 cycles (991.8 µs) 0 1 0 1: Wait time = 548 cycles (2090.5 µs) (value after reset) 0 1 1 0: Wait time = 1060 cycles (4043.6 µs) 0 1 1 1: Wait time = 2148 cycles (8194.0 µs) 1 0 0 0: Wait time = 4292 cycles (16372.7 µs) 1 0 0 1: Wait time = 8164 cycles (31143.2 µs). Other settings are prohibited. Wait time is calculated as: 1 cycle (µs) = 1 / (f_LOCO [MHz] × 8) = 1 / (0.032768 × 8) = 3.81 µs	R/W
b7 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

MSTS[3:0] bits (Main Clock Oscillator Wait Time Setting)

The MSTS[3:0] bits specify the oscillation stabilization wait time for the main clock oscillator.

Set the main clock oscillation stabilization time to a period longer than or equal to the stabilization time recommended by the oscillator manufacturer. When the main clock is input externally, set these bits to 0001b, because the oscillation stabilization time is not required.

The wait time set in the MSTS[3:0] bits is counted using:

1 cycle (µs) = 1 / (f_ LOCO [MHz] × 8) = 1 / (0.032768 × 8) = 3.81 (µs).

The LOCO clock automatically oscillates when necessary, regardless of the LOCOCR.LOSTP bit value. After the specified wait time elapses, supply of the main clock oscillator starts internally in the MCU, and the OSCSF.MOSCSF flag is set to 1. If the specified wait time is short, supply of the main clock oscillator starts before oscillation of the clock becomes stable.

Only rewrite the MOSCWTCR register when the MOSCCR.MOSTP bit is 1 and the OSCSF.MOSCSF flag is 0. Do not rewrite this register under any other conditions.

9.2.16 主时钟振荡器等待控制寄存器(MOSCWTCR)

Address(es): SYSTEM.MOSCWTCR 4001 E0A2h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	MSTS[3:0]			
重置后的值:	0	0	0	0	0	1	0	1

Bit	Symbol	位名称	Description	R/W
b3 to b0	MSTS[3:0]	主时钟振荡器等待时间设定	禁用驱动能力自动切换功能时（MOMCR.AUTODRVEN=0[默认]）：b3 0 0 0 1：等待时间=35个周期(133.5µs) 0 0 1 0：等待时间=67个周期(255.6µs) 0 0 1 1：等待时间=131个周期(499.7µs) 0 1 0 0：等待时间=259个周期(988.0µs) 0 1 0 1：等待时间=547个周期（2086.6µs）（复位后的值） 0 1 1 0：等待时间=1059个周期（4039.8µs） 0 1 1 1：等待时间=2147个周期（8190.2µs） 1 0 0 0：等待时间=4291个周期（16368.9µs） 1 0 0 1：等待时间=8163个周期（31139.4µs）。 当驱动能力自动切换功能启用时（MOMCR.AUTODRVEN=1）：b3 0 0 0 1：等待时间=36个周期(137.3µs) 0 0 1 0：等待时间=68个周期(259.4µs) 0 0 1 1：等待时间=132个周期(503.5µs) 0 1 0 0：等待时间=260个周期(991.8µs) 0 1 0 1：等待时间=548个周期（2090.5µs）（复位后的值） 0 1 1 0：等待时间=1060个周期（4043.6µs） 0 1 1 1：等待时间=2148个周期（8194.0µs） 1 0 0 0：等待时间=4292个周期（16372.7µs） 01：等待时间=8164个周期（31143.2µs）。禁止 其他设置。 等待时间计算如下：1个周期(µs)=1(f_LOCO[MHz]×8)=1(0.032768×8)=3.81µs	R/W
b7 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W

MSTS[3:0]位（主时钟振荡器等待时间设置）

MSTS[3:0]位指定主时钟振荡器的振荡稳定等待时间。

将主时钟振荡稳定时间设置为大于或等于振荡器制造商推荐的稳定时间。当外部输入主时钟时，将这些位设置为0001b，因为不需要振荡稳定时间。

MSTS[3:0]位中设置的等待时间使用以下公式计算：

1个周期(µs)=1(f_LOCO[MHz]×8)=1(0.032768×8)=3.81(µs)。

无论LOCOCR.LOSTP位的值如何，LOCO时钟都会在必要时自动振荡。经过指定的等待时间后，MCU内部开始提供主时钟振荡器，并且OSCSF.MOSCSF标志设置为1。如果指定的等待时间短，则在时钟振荡之前开始提供主时钟振荡器变得稳定。

仅当MOSCCR.MOSTP位为1且OSCSF.MOSCSF标志为0时才重写MOSCWTCR寄存器。在任何其他情况下请勿重写此寄存器。

9.2.17 Main Clock Oscillator Mode Oscillation Control Register (MOMCR)

Address(es): SYSTEM.MOMCR 4001 E413h

	b7	b6	b5	b4	b3	b2	b1	b0
	AUTODRVEN	MOSEL	MODRV0[1:0]		—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b5, b4	MODRV0[1:0]	Main Clock Oscillator Drive Capability 0 Switching	b5 b4 0 0: 20 MHz to 24 MHz 0 1: 16 MHz to 20 MHz 1 0: 8 MHz to 16 MHz 1 1: 8 MHz.	R/W
b6	MOSEL	Main Clock Oscillator Switching	0: Resonator 1: External clock input.	R/W
b7	AUTODRVEN	Main Clock Oscillator Drive Capability Auto Switching Enable	0: Disable 1: Enable.	R/W

Note: The EXTAL/XTAL pin is also used as a port. In the initial state, the port function is selected.
Note: The MOSTP bit must be 1 (MOSC = stopped) before changing this register.

MODRV0[1:0] bits (Main Clock Oscillator Drive Capability 0 Switching)

The MODRV0[1:0] bits switch the drive capability of the main clock oscillator.

MOSEL bit (Main Clock Oscillator Switching)

The MOSEL bit switches the source for the main clock oscillator.

AUTODRVEN bit (Main Clock Oscillator Drive Capability Auto Switching Enable)

The AUTODRVEN bit controls the drive capability auto switching of the main clock oscillator.

When the AUTODRVEN bit is 1, after the time set in the MSTS bits in the Main Clock Oscillator Wait Control Register elapses, the drive capability of the main clock oscillator is automatically set to the lowest, regardless of the MOMCR.MODRV0[1:0] setting. The main clock oscillator restarts oscillation with MODRV0[1:0] bits set to switch the drive capability after oscillation stops by the MOSCCR.MOSTP setting or by entering Software Standby mode.

9.2.18 Subclock Oscillator Mode Control Register (SOMCR)

Address(es): SYSTEM.SOMCR 4001 E481h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	SODRV1	—
Value after reset:	0	0	0	0	0	0	x	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b1	SODRV1	Sub-Clock Oscillator Drive Capability Switching	0: Standard 1: Low.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: The SOSCCR.SOSTP bit must be 1 (SOSC = stopped) before changing this register.

9.2.17 主时钟振荡器模式振荡控制寄存器(MOMCR)

Address(es): SYSTEM.MOMCR 4001 E413h

	b7	b6	b5	b4	b3	b2	b1	b0
	AUTODRVEN	MOSEL	MODRV0[1:0]		—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b5, b4	MODRV0[1:0]	主时钟振荡器驱动能力0切换	b5 b4 0 0: 20 MHz to 24 MHz 0 1: 16 MHz to 20 MHz 1 0: 8 MHz to 16 MHz 1 1: 8 MHz.	R/W
b6	MOSEL	主时钟振荡器切换	0：谐振器1：外部时钟输入。	R/W
b7	AUTODRVEN	主时钟振荡器驱动能力自动切换启用	0：禁用1 ：启用。	R/W

Note: EXTALXTAL引脚也用作端口。在初始状态下，选择端口功能。
Note: 在更改此寄存器之前，MOSTP位必须为1（MOSC=停止）。

MODRV0[1:0]位（主时钟振荡器驱动能力0切换）

MODRV0[1:0]位切换主时钟振荡器的驱动能力。

MOSEL位（主时钟振荡器切换）

MOSEL位切换主时钟振荡器的源。

AUTODRVEN位（主时钟振荡器驱动能力自动切换使能）

AUTODRVEN位控制主时钟振荡器的驱动能力自动切换。

当AUTODRVEN位为1时，经过主时钟振荡器等待控制寄存器中MSTS位设置的时间后，主时钟振荡器的驱动能力自动设置为最低，与MOMCR.MODRV0[1:0无关]环境。主时钟振荡器在通过MOSCCR.MOSTP设置或进入软件待机模式停止振荡后，通过设置MODRV0[1:0]位重新开始振荡，以切换驱动能力。

9.2.18 副时钟振荡器模式控制寄存器(SOMCR)

Address(es): SYSTEM.SOMCR 4001 E481h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	SODRV1	—
重置后的值:	0	0	0	0	0	0	x	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	—	Reserved	该位读取为0。写入值应为0。	R/W
b1	SODRV1	副时钟振荡器驱动能力切换	0：标准1 ：低。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 在更改此寄存器之前，SOSCCR.SOSTP位必须为1（SOSC=停止）。

SODRV1 bit (Sub-Clock Oscillator Drive Capability Switching)

The SODRV1 bit switches the drive capability of the sub-clock oscillator. This bit is undefined at the first power on, but the value after reset of SOSCCR.SOSTP is 0 (SOSC = operating). Set up the SOSC as follows at the first power on:

1. Set the SOSCCR.SOSTP bit to 1 (SOSC = stopped).
2. Set the SODRV1 bit to the correct value for the current capacitor.
3. Set the SOSCCR.SOSTP bit to 0 (SOSC = operating).

9.2.19 Clock Out Control Register (CKOCR)

Address(es): SYSTEM.CKOCR 4001 E03Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	CKOEN	CKODIV[2:0]			—	CKOSEL[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	CKOSEL[2:0]	Clock Out Source Select	b2 b0 0 0 0: HOCO 0 0 1: MOCO 0 1 0: LOCO 0 1 1: MOSC 1 0 0: SOSC. Other settings are prohibited.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6 to b4	CKODIV[2:0]	Clock Out Input Frequency Division Select	b6 b4 0 0 0: ×1 0 0 1: /2 0 1 0: /4 0 1 1: /8 1 0 0: /16 1 0 1: /32 1 1 0: /64 1 1 1: /128.	R/W
b7	CKOEN	Clock Out Enable	0: Disable clock out 1: Enable clock out.	R/W

CKOSEL[2:0] bits (Clock Out Source Select)

The CKOSEL[2:0] bits specify the HOCO, MOCO, LOCO, MOSC, or SOSC clock as the source of the clock to be output from the CLKOUT pin. When changing the CLKOUT source clock, set the CKOEN bit to 0.

CKODIV[2:0] bits (Clock Out Input Frequency Division Select)

The CKODIV[2:0] bits specify the clock division ratio. Set the CKOEN bit to 0 when changing the division ratio. The division ratio of the output clock frequency must be set to a value no higher than the characteristics of the CLKOUT pin output frequency. For details on the characteristics of the CLKOUT pin, see section 43, Electrical Characteristics.

CKOEN bit (Clock Out Enable)

The CKOEN bit enables output from the CLKOUT pin. When CKOEN is set to 1, the selected clock is output. When CKOEN is set to 0, low is output. When changing this bit, confirm that the clock out source clock selected in the CKOSEL[2:0] bits is stable. Otherwise, a glitch might be generated in the output.

The CKOEN bit must be cleared before entering Software Standby or Deep Software Standby mode if the selected clock out source clock is stopped in that mode.

SODRV1位（副时钟振荡器驱动能力切换）

SODRV1位切换副时钟振荡器的驱动能力。该位在第一次上电时未定义，但SOSCCR.SOSTP复位后的值为0（SOSC=运行）。首次上电时按如下方式设置SOSC：

1. 将SOSCCR.SOSTP位设置为1（SOSC=停止）。
2. 将SODRV1位设置为当前电容的正确值。
3. 将SOSCCR.SOSTP位设置为0（SOSC=运行）。

9.2.19 时钟输出控制寄存器(CKOCR)

Address(es): SYSTEM.CKOCR 4001 E03Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	CKOEN	CKODIV[2:0]			—	CKOSEL[2:0]		
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	CKOSEL[2:0]	时钟输出源选择	b2 b0 0 0 0: HOCO 0 0 1: MOCO 0 1 0: LOCO 0 1 1: MOSC 00：SOSC。禁止其他设置。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b6 to b4	CKODIV[2:0]	时钟输出输入频率分区选择	b6 b4 0 0 0: ×1 0 0 1: /2 0 1 0: /4 0 1 1: /8 1 0 0: /16 1 0 1: /32 1 1 0: /64 1 1 1: /128.	R/W
b7	CKOEN	时钟输出使能	0：禁用时钟输出1 ：启用时钟输出。	R/W

CKOSEL[2:0]位（时钟输出源选择）

CKOSEL[2:0]位指定HOCO、MOCO、LOCO、MOSC或SOSC时钟作为从CLKOUT引脚输出的时钟源。更改CLKOUT源时钟时，将CKOEN位设置为0。

CKODIV[2:0]位（时钟输出输入分频选择）

CKODIV[2:0]位指定时钟分频比。更改分频比时将CKOEN位设置为0。输出时钟频率的分频比必须设置为不高于CLKOUT引脚输出频率特性的值。有关CLKOUT引脚特性的详细信息，请参见第43节，电气特性。

CKOEN位（时钟输出使能）

CKOEN位使能CLKOUT引脚的输出。当CKOEN设置为1时，输出选定的时钟。什么时候CKOEN设置为0，输出低电平。当改变该位时，确认时钟输出源时钟选择在CKOSEL[2:0]位是稳定的。否则，可能会在输出中产生故障。

如果所选时钟输出源时钟在该模式下停止，则必须在进入软件待机或深度软件待机模式之前清零CKOEN位。

9.2.20 LOCO User Trimming Control Register (LOCOUTCR)

Address(es): SYSTEM.LOCOUTCR 4001 E492h

	b7	b6	b5	b4	b3	b2	b1	b0
	LOCOUTRM[7:0]							
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	LOCOUTRM[7:0]	LOCO User Trimming	b7 b0 1 0 0 0 0 0 0 0: -128 1 0 0 0 0 0 0 1: -127 1 0 0 0 0 0 1 0: -126 … 1 1 1 1 1 1 1 1: -1 0 0 0 0 0 0 0 0: Center Code 0 0 0 0 0 0 0 1: +1 … 0 1 1 1 1 1 0 1: +125 0 1 1 1 1 1 1 0: +126 0 1 1 1 1 1 1 1: +127. These bits are added to the original LOCO trimming bits.	R/W

Note: MCU operation is not guaranteed when LOCOUTCR is set to a value that causes the LOCO frequency to be outside of the specification range.

Note: When LOCOUTCR is changed, the time that the frequency is stabilized corresponds to the frequency stabilization time at the start of the MCU operation.

9.2.21 MOCO User Trimming Control Register (MOCOUTCR)

Address(es): SYSTEM.MOCOUTCR 4001 E061h

	b7	b6	b5	b4	b3	b2	b1	b0
	MOCOUTRM[7:0]							
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	MOCOUTRM[7:0]	MOCO User Trimming	b7 b0 1 0 0 0 0 0 0 0: -128 1 0 0 0 0 0 0 1: -127 1 0 0 0 0 0 1 0: -126 … 1 1 1 1 1 1 1 1: -1 0 0 0 0 0 0 0 0: Center Code 0 0 0 0 0 0 0 1: +1 … 0 1 1 1 1 1 0 1: +125 0 1 1 1 1 1 1 0: +126 0 1 1 1 1 1 1 1: +127. These bits are added to the original MOCO trimming bits.	R/W

Note: MCU operation is not guaranteed when MOCOUTCR is set to a value that causes the MOCO frequency to be outside of the specification range.

Note: When MOCOUTCR is changed, the time that the frequency is stabilized corresponds to the frequency stabilization time at the start of the MCU operation.

9.2.20 LOCO用户微调控制寄存器(LOCOUTCR)

Address(es): SYSTEM.LOCOUTCR 4001 E492h

	b7	b6	b5	b4	b3	b2	b1	b0
	LOCOUTRM[7:0]							
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	LOCOUTRM[7:0]	LOCO用户修整	b7b010000000：-1281000 0001：-12710000010：-1 26…11111111：-10000000 0：中心代码00000001：+1 …01111101：+1250111111 0：+12601111111：+127。 这些位被添加到原始的LOCO修整位。	R/W

Note: 当LOCOUTCR设置为导致LOCO频率超出规范范围的值时，MCU操作无法保证。

Note: 当LOCOUTCR改变时，频率稳定的时间对应于MCU操作开始时的频率稳定时间。

9.2.21 MOCO用户微调控制寄存器(MOCOUTCR)

Address(es): SYSTEM.MOCOUTCR 4001 E061h

	b7	b6	b5	b4	b3	b2	b1	b0
	MOCOUTRM[7:0]							
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	MOCOUTRM[7:0]	MOCO用户修整	b7b010000000：-1281000 0001：-12710000010：-1 26…11111111：-10000000 0：中心代码00000001：+1 …01111101：+1250111111 0：+12601111111：+127。 这些位被添加到原始MOCO修整位中。	R/W

Note: 当MOCOUTCR设置为导致MOCO频率超出规格范围的值时，无法保证MCU操作。

Note: 当MOCOUTCR改变时，频率稳定的时间对应于MCU操作开始时的频率稳定时间。

9.2.22 HOCO User Trimming Control Register (HOCOUTCR)

Address(es): SYSTEM.HOCOUTCR 4001 E062h

	b7	b6	b5	b4	b3	b2	b1	b0
	HOCOUTRM[7:0]							
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	HOCOUTRM[7:0]	HOCO User Trimming	b7 b0 1 0 0 0 0 0 0 0: -128 1 0 0 0 0 0 0 1: -127 1 0 0 0 0 0 1 0: -126 … 1 1 1 1 1 1 1 1: -1 0 0 0 0 0 0 0 0: Center Code 0 0 0 0 0 0 0 1: +1 … 0 1 1 1 1 1 0 1: +125 0 1 1 1 1 1 1 0: +126 0 1 1 1 1 1 1 1: +127. These bits are added to the original HOCO trimming bits.	R/W

Note: MCU operation is not guaranteed when HOCOUTCR is set to a value that causes the HOCO frequency to be outside of the specification range.

Note: When HOCOUTCR is changed, the time that the frequency is stabilized corresponds to the frequency stabilization time at the start of the MCU operation.

Note: These bits must be 00000000b when FLL is enabled (FLLCR1.FLLEN = 1).

9.2.23 Trace Clock Control Register (TRCKCR)

Address(es): SYSTEM.TRCKCR 4001 E03Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	TRCKEN	—	—	—	TRCK[3:0]			
Value after reset:	0	0	0	0	0	0	0	1

Bit	Symbol	Bit name	Description	R/W
b3 to b0	TRCK[3:0]	Trace Clock Operating Frequency Select	b3 b0 0 0 0 0: /1 0 0 0 1: /2 (value after reset) 0 0 1 0: /4. Other settings are prohibited.	R/W
b6 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	TRCKEN	Trace Clock Operation Enable	0: Disable operation 1: Enable operation.	R/W

The Trace Clock Control Register controls the switching of the trace clock. Before changing the TRCLK frequency, set the TRCKEN bit to 0. The TRCKCR register is initialized by all reset sources.

9.3 Main Clock Oscillator

To supply the clock signal to the main clock oscillator, use one of the following ways:

- Connect an oscillator
- Connect the input of an external clock signal.

9.2.22 HOCO用户微调控制寄存器(HOCOUTCR)

Address(es): SYSTEM.HOCOUTCR 4001 E062h

	b7	b6	b5	b4	b3	b2	b1	b0
	HOCOUTRM[7:0]							
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	HOCOUTRM[7:0]	HOCO用户修整	b7b010000000：-1281000 0001：-12710000010：-1 26…11111111：-10000000 0：中心代码00000001：+1 …01111101：+1250111111 0：+12601111111：+127。 这些位被添加到原始HOCO修整位中。	R/W

Note: 当HOCOUTCR设置为导致HOCO频率超出规范范围的值时，MCU操作无法保证。

Note: 当HOCOUTCR改变时，频率稳定的时间对应于MCU操作开始时的频率稳定时间。

Note: 当FLL使能时（FLLCR1.FLLEN=1），这些位必须为00000000b。

9.2.23 跟踪时钟控制寄存器(TRCKCR)

Address(es): SYSTEM.TRCKCR 4001 E03Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	TRCKEN	—	—	—	TRCK[3:0]			
重置后的值:	0	0	0	0	0	0	0	1

Bit	Symbol	位名称	Description	R/W
b3 to b0	TRCK[3:0]	跟踪时钟运行频率选择	b3b00000：10001：2（复位后的值）0010：4。禁止其他设置。	R/W
b6 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	TRCKEN	跟踪时钟操作Enable	0：禁用操作1：启用操作。	R/W

跟踪时钟控制寄存器控制跟踪时钟的切换。在更改TRCLK频率之前，将TRCKEN位设置为0。TRCKCR寄存器由所有复位源初始化。

9.3 主时钟振荡器

要将时钟信号提供给主时钟振荡器，请使用以下方法之一：

- 连接振荡器
- 连接外部时钟信号的输入。

9.3.1 Connecting the Crystal Resonator

Figure 9.6 shows an example of connecting a crystal resonator. A damping resistor (R_d) can be added, if required. Because the resistor values vary according to the resonator and the oscillation drive capability, use values recommended by the resonator manufacturer. If the manufacturer recommends using an external feedback resistor (R_f), insert an R_f between EXTAL and XTAL by following the instructions.

When connecting a resonator to supply the clock, the frequency of the resonator must be in the frequency range of the resonator for the main clock oscillator as described in Table 9.1.

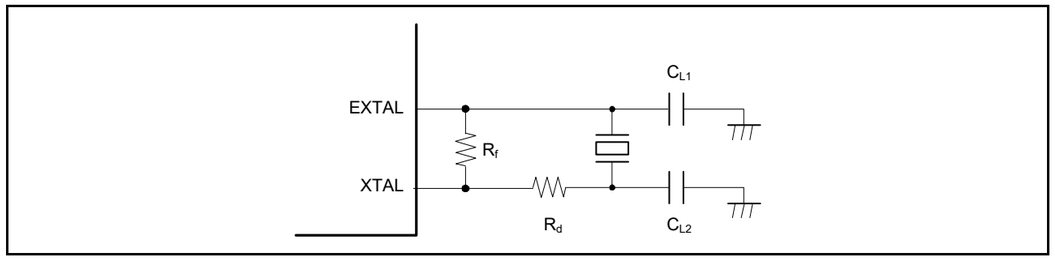


Figure 9.6 Example of crystal resonator connection

Figure 9.7 shows an equivalent circuit of the crystal resonator.

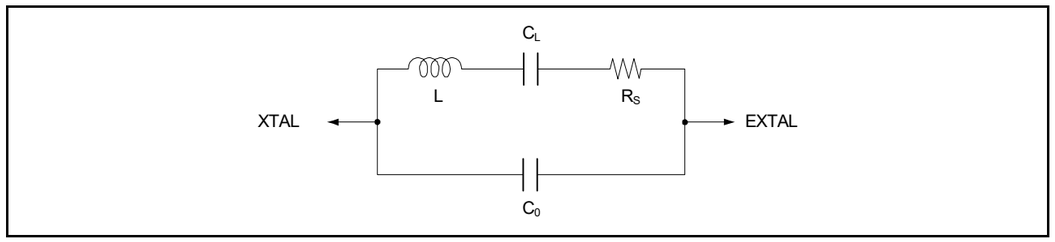


Figure 9.7 Equivalent circuit of the crystal resonator

9.3.2 External Clock Input

Figure 9.8 shows an example for connecting an external clock input. To operate the oscillator with an external clock signal, set the MOMCR.MOSEL bit to 1. The XTAL pin is the function that is set in PFS.P213PFS.

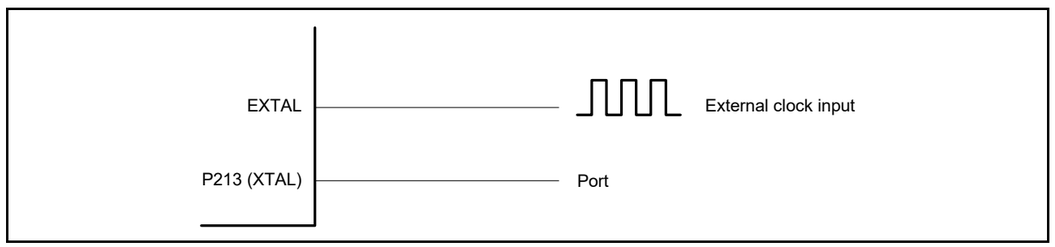


Figure 9.8 Equivalent circuit for external clock

9.3.3 Notes on External Clock Input

The frequency of the external clock input can only be changed when the main clock oscillator is stopped. Do not change the frequency of the external clock input when the Main Clock Oscillator Stop bit (MOSCCR.MOSTP) is 0.

9.3.1 连接晶体谐振器

图9.6显示了连接晶体谐振器的示例。如果需要，可以添加阻尼电阻器(Rd)。
由于电阻值因谐振器和振荡驱动能力而异，请使用谐振器制造商推荐的值。如果制造商建议使用外部反馈电阻器(Rf)，请按照说明在EXTAL和XTAL之间插入一个Rf。

连接谐振器以提供时钟时，谐振器的频率必须在表9.1中描述的主时钟振荡器的谐振器频率范围内。

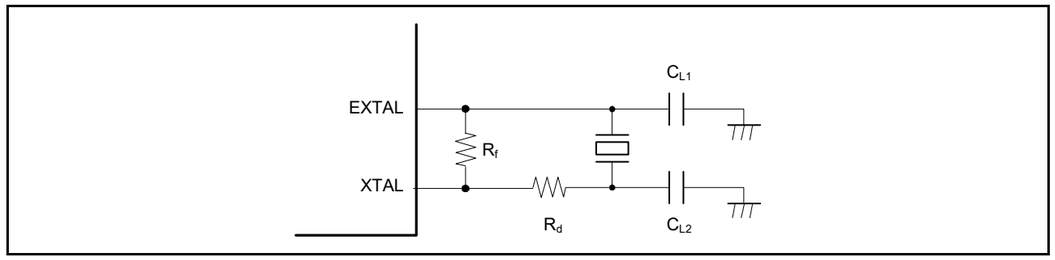


Figure 9.6 晶体谐振器连接示例

图9.7显示了晶体谐振器的等效电路。

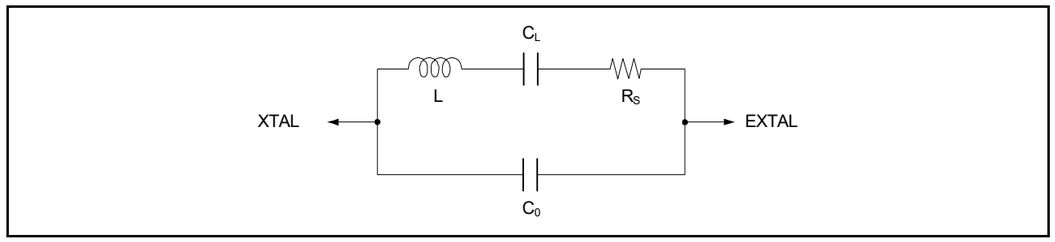


Figure 9.7 晶体谐振器的等效电路

9.3.2 外部时钟输入

图9.8显示了连接外部时钟输入的示例。要使用外部时钟信号操作振荡器，请将MOMCR.MOSEL位设置为1。XTAL引脚是在PFS.P213PFS中设置的功能。

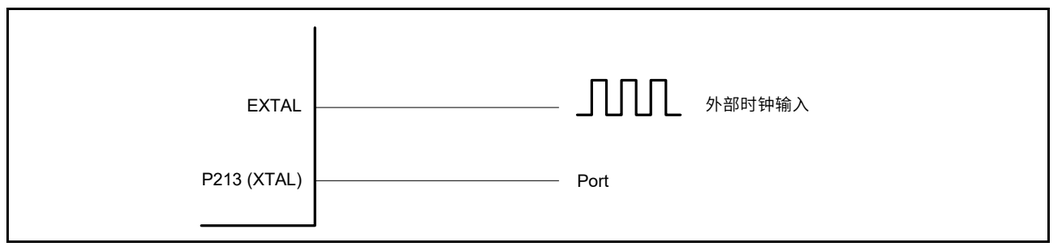


Figure 9.8 外部时钟等效电路

9.3.3 外部时钟输入注意事项

外部时钟输入的频率只有在主时钟振荡器停止时才能改变。当主时钟振荡器停止位(MOSCCR.MOSTP)为0时，请勿更改外部时钟输入的频率。

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9.4 Sub-Clock Oscillator

The only way of supplying a clock signal to the sub-clock oscillator is by connecting a crystal oscillator.

9.4.1 Connecting a 32.768-kHz Crystal Resonator

To supply a clock to the sub-clock oscillator, connect a 32.768-kHz crystal resonator as shown in Figure 9.9. A damping resistor (R_d) can be added, if required. Because the resistor values vary according to the resonator and the oscillation drive capability, use values recommended by the resonator manufacturer. If the manufacturer recommends using an external feedback resistor (R_f), insert an R_f between XCIN and XCOUT by following the instructions.

When connecting a resonator to supply the clock, the frequency of the resonator must be in the frequency range of the resonator for the sub-clock oscillator as described in Table 9.1.

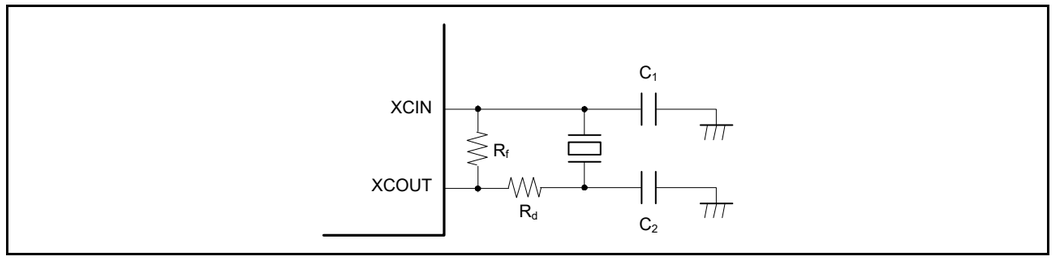

Figure 9.9 Connection example of 32.768-kHz crystal resonator

Figure 9.10 shows an equivalent circuit for the 32.768-kHz crystal resonator.

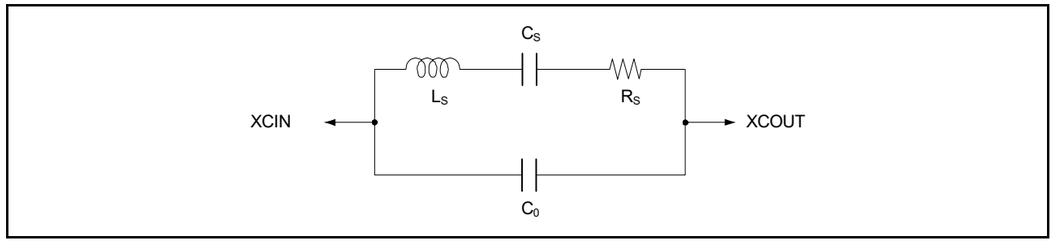

Figure 9.10 Equivalent circuit for the 32.768-kHz crystal resonator

9.4.2 Handling of Pins when the Sub-Clock Oscillator Is Not Used

When the sub-clock oscillator is not in use, connect the XCIN pin to VSS through a resistor (to pull VSS down) and leave the XCOUT pin open as shown in Figure 9.11. In addition, if an oscillator is not connected, set the Sub-clock Oscillator Stop bit (SOSCCR.SOSTP) to 1 to stop the oscillator.

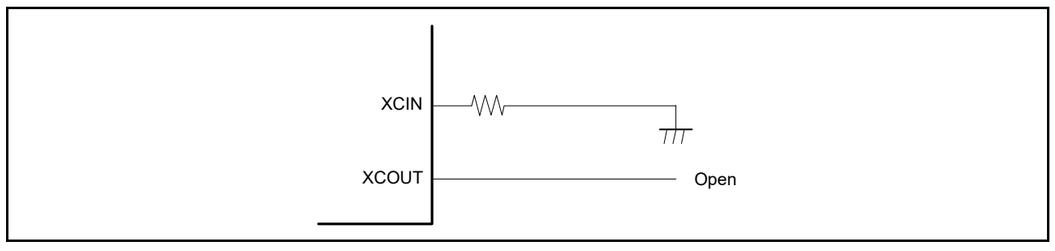

Figure 9.11 Pin handling when the sub-clock oscillator is not used

9.4 Sub-Clock Oscillator

向副时钟振荡器提供时钟信号的唯一方法是连接晶体振荡器。

9.4.1 连接32.768kHz晶体谐振器

要为副时钟振荡器提供时钟，请连接一个32.768-kHz晶体谐振器，如图9.9所示。如果需要，可以添加阻尼电阻器(Rd)。由于电阻值因谐振器和振荡驱动能力而异，请使用谐振器制造商推荐的值。如果制造商建议使用外部反馈电阻(Rf)，请按照说明在XCIN和XCOUT之间插入一个Rf。

连接谐振器以提供时钟时，谐振器的频率必须在表9.1中所述的副时钟振荡器的谐振器频率范围内。

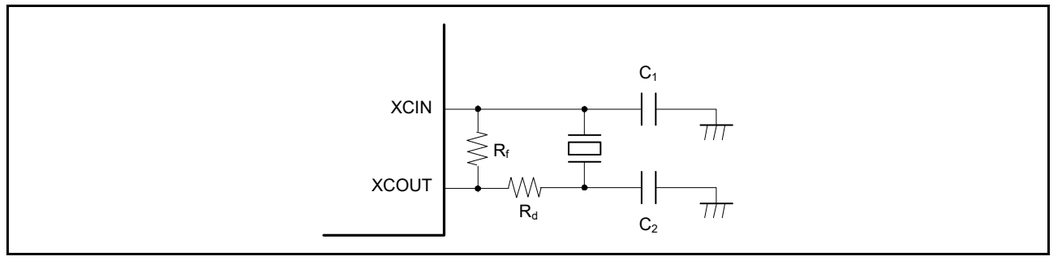

Figure 9.9 32.768-kHz晶体谐振器的连接示例

图9.10显示了32.768-kHz晶体谐振器的等效电路。

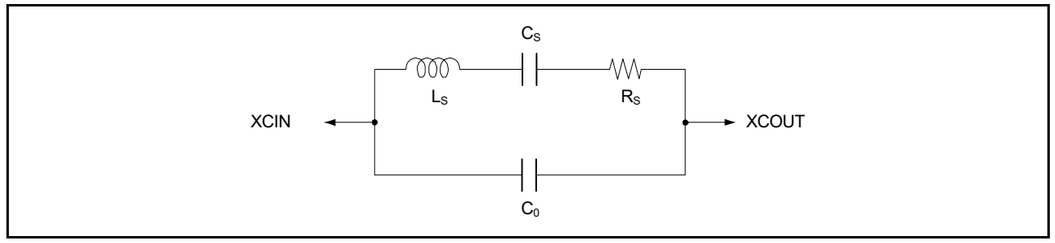

Figure 9.10 32.768kHz晶体谐振器的等效电路

9.4.2 不使用副时钟振荡器时的引脚处理

不使用副时钟振荡器时，通过一个电阻将XCIN引脚连接到VSS（将VSS下拉）并使XCOUT引脚保持开路，如图9.11所示。此外，如果未连接振荡器，请将副时钟振荡器停止位(SOSCCR.SOSTP)设置为1以停止振荡器。

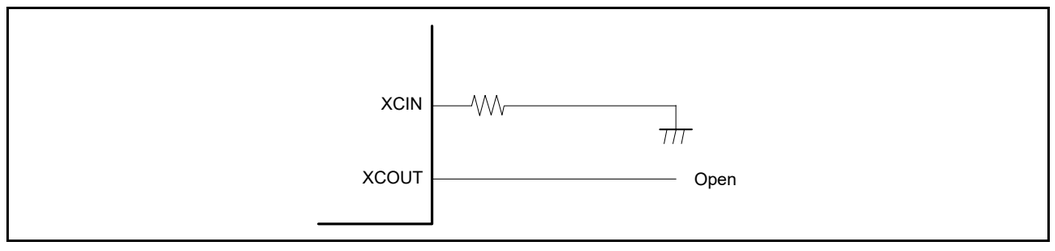

Figure 9.11 不使用副时钟振荡器时的引脚处理

9.5 Oscillation Stop Detection Function

9.5.1 Oscillation Stop Detection and Operation after Detection

The oscillation stop detection function detects the main clock oscillator stop. When an oscillation stop is detected, the system clock switches as follows:

- If an oscillation stop is detected with SCKSCR.CKSEL[2:0] = 011b (system clock source = MOSC), the system clock source switches to the MOCO clock
- If an oscillation stop is detected with PLLCCR.PLSRCSEL = 0 (PLL source clock = MOSC) and SCKSCR.CKSEL[2:0] = 101b (system clock source = PLL), the PLL clock remains as the system clock source. The frequency becomes a free-running oscillation frequency, and the setting of SCKSCR.CKSEL[2:0] bits does not change.

An oscillation stop detection interrupt request can be generated when an oscillation stop is detected. In addition, the General PWM Timer (GPT) output can be forced to a high-impedance state on detection.

The main clock oscillation stop is detected when the input clock remains at 0 or 1 for a certain period, for example, when a malfunction occurs in the main clock oscillator. See section 43, Electrical Characteristics.

Switching between the main clock oscillator and the MOCO clock or between the PLL clock and the PLL free-running clock is controlled by the Oscillation Stop Detection flag (OSTDSR.OSTDF).

The OSTDF flag controls the switched clock as follows:

- When SCKSCR.CKSEL[2:0] = 011b (system clock source = MOSC):
  - When OSTDF changes from 0 to 1, the clock source switches to the MOCO clock
  - When OSTDF changes from 1 to 0, the clock source switches to MOSC again.
- When PLLCCR.PLSRCSEL = 0 (PLL source clock = MOSC) and SCKSCR.CKSEL[2:0] = 101b (system clock source = PLL):
  - When OSTDF changes from 0 to 1, the clock source switches to the PLL free-running oscillation clock
  - When OSTDF changes from 1 to 0, the clock source switches to PLL again.

To switch the clock source to the main clock oscillator or PLL clock again after oscillation stop detection, set the CKSEL[2:0] bits to a clock source other than the main clock oscillator or PLL clock, and clear the OSTDF flag to 0. Also, check that the OSTDF flag is not 1, and then set the CKSEL[2:0] bits to the main clock oscillator or PLL clock after the specified oscillation stabilization time elapses.

After a reset release, the main clock oscillator is stopped and the oscillation stop detection function is disabled. To enable the oscillation stop detection function, activate the main clock oscillator and write 1 to the Oscillation Stop Detection Function Enable bit (OSTDCR.OSTDE) after the specified oscillation stabilization time elapses.

The oscillation stop detection function detects when the main clock oscillator is stopped by an external cause. This means that the oscillation stop detection function must be disabled before the main clock oscillator is stopped by software or before entering Software Standby or Deep Software Standby mode.

The oscillation stop detection function switches the following clocks to the MOCO clock (when the system clock is MOSC) or to the PLL free-running clock (when the system clock is PLL):

- All clocks that can be selected as the MOSC clock or PLL except CLKOUT
- The system clock (ICLK) frequency during MOCO operation (when the system clock is MOSC) or PLL free-running operation (when the system clock is PLL) is specified in the MOCO oscillation frequency and the division ratio set in the System Clock Select bits (SCKDIVCR.ICK[2:0]).

9.5 振荡停止检测功能

9.5.1 振荡停止检测和检测后操作

振荡停止检测功能检测主时钟振荡器停止。当检测到振荡停止时，系统时钟切换如下：

- 如果通过SCKSCR.CKSEL[2:0]=011b（系统时钟源=MOSC）检测到振荡停止，则系统时钟源切换到MOCO时钟
- 如果在PLLCCR.PLSRCSEL=0（PLL源时钟=MOSC）的情况下检测到振荡停止并且SCKSCR.CKSEL[2:0]=101b(系统时钟源=PLL)，PLL时钟保持为系统时钟源。频率变为自由振荡频率，SCKSCR.CKSEL[2:0]位的设置不变。

当检测到振荡停止时，可以产生一个振荡停止检测中断请求。除此之外
通用PWM定时器(GPT)输出可在检测时强制为高阻抗状态。

当输入时钟保持在0或1一段时间，例如，当主时钟振荡器发生故障时，检测到主时钟振荡停止。参见第43节，电气特性。

主时钟振荡器和MOCO时钟之间或PLL时钟和PLL自由运行时钟之间的切换由振荡停止检测标志(OSTDSR.OSTDF)控制。

OSTDF标志控制切换时钟如下：

- 当SCKSCR.CKSEL[2:0]=011b（系统时钟源=MOSC）时：
  - 当OSTDF由0变为1时，时钟源切换为MOCO时钟
  - 当OSTDF从1变为0时，时钟源再次切换到MOSC。
- 当PLLCCR.PLSRCSEL=0（PLL源时钟=MOSC）且SCKSCR.CKSEL[2:0]=101b（系统时钟源=PLL）时：
  - 当OSTDF由0变为1时，时钟源切换到PLL自由振荡时钟
  - 当OSTDF从1变为0时，时钟源再次切换到PLL。

要在检测到振荡停止后再次将时钟源切换到主时钟振荡器或PLL时钟，请设置
CKSEL[2:0]位到主时钟振荡器或PLL时钟以外的时钟源，并将OSTDF标志清除为0。另外，检查OSTDF标志不是1，然后设置CKSEL[2:0]在指定的振荡稳定时间过后，位到主时钟振荡器或PLL时钟。

复位释放后，主时钟振荡器停止，振荡停止检测功能被禁用。要启用振荡停止检测功能，请在指定的振荡稳定时间过后激活主时钟振荡器并将1写入振荡停止检测功能使能位(OSTDCR.OSTDE)。

振荡停止检测功能检测主时钟振荡器何时因外部原因停止。这意味着在软件停止主时钟振荡器之前或进入软件待机或深度软件待机模式之前，必须禁用振荡停止检测功能。

振荡停止检测功能将以下时钟切换到MOCO时钟（当系统时钟为
MOSC）或PLL自由运行时钟（当系统时钟为PLL时）：

- 除CLKOUT外，所有可选择作为MOSC时钟或PLL的时钟
- MOCO操作（系统时钟为MOSC时）或PLL自由运行操作（系统时钟为PLL时）期间的系统时钟(ICLK)频率在MOCO振荡频率和系统时钟选择位中设置的分频比中指定(SCKDIVCR.ICK[2:0])。

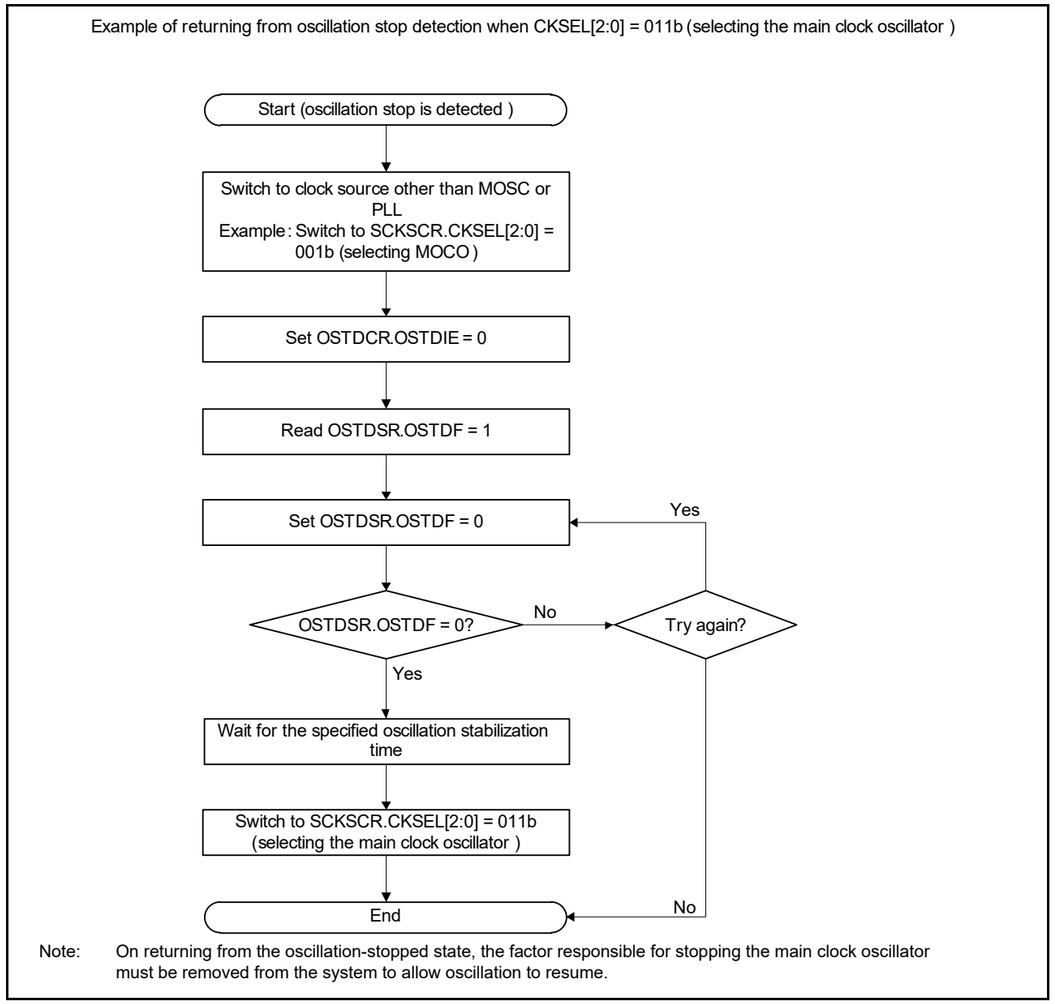

Figure 9.12 Flow of recovery on detection of oscillator stop

9.5.2 Oscillation Stop Detection Interrupts

An oscillation stop detection interrupt (MOSC_STOP) is generated when the Oscillation Stop Detection flag (OSTDSR.OSTDF) is 1 and the Oscillation Stop Detection Interrupt Enable bit in the Oscillation Stop Detection Control Register (OSTDCR.OSTDIE) is 1 (enabled). The Port Output Enable for GPT (POEG) is notified of the main clock oscillator stop. On receiving the notification, the POEG sets the Oscillation Stop Detection Flag in the POEG Group n Setting Register (POEGGn.OSTPF) to 1 (n = A, B).

After the oscillation stop is detected, wait at least 10 PCLKB cycles before writing to the POEGGn.OSTPF flag. When the OSTDSR.OSTDF flag requires clearing, do so after clearing the Oscillation Stop Detection Interrupt Enable bit in the Oscillation Stop Detection Control Register (OSTDCR.OSTDIE). Wait for at least 2 PCLKB clock cycles before setting the OSTDCR.OSTDIE bit to 1 again. A longer PCLKB wait time might be required, depending on the number of cycles required to read a given I/O register.

The oscillation stop detection interrupt is a non-maskable interrupt. Because non-maskable interrupts are disabled in the initial state after a reset release, enable non-maskable interrupts through software before using oscillation stop detection interrupts. For details, see section 13, Interrupt Controller Unit (ICU).

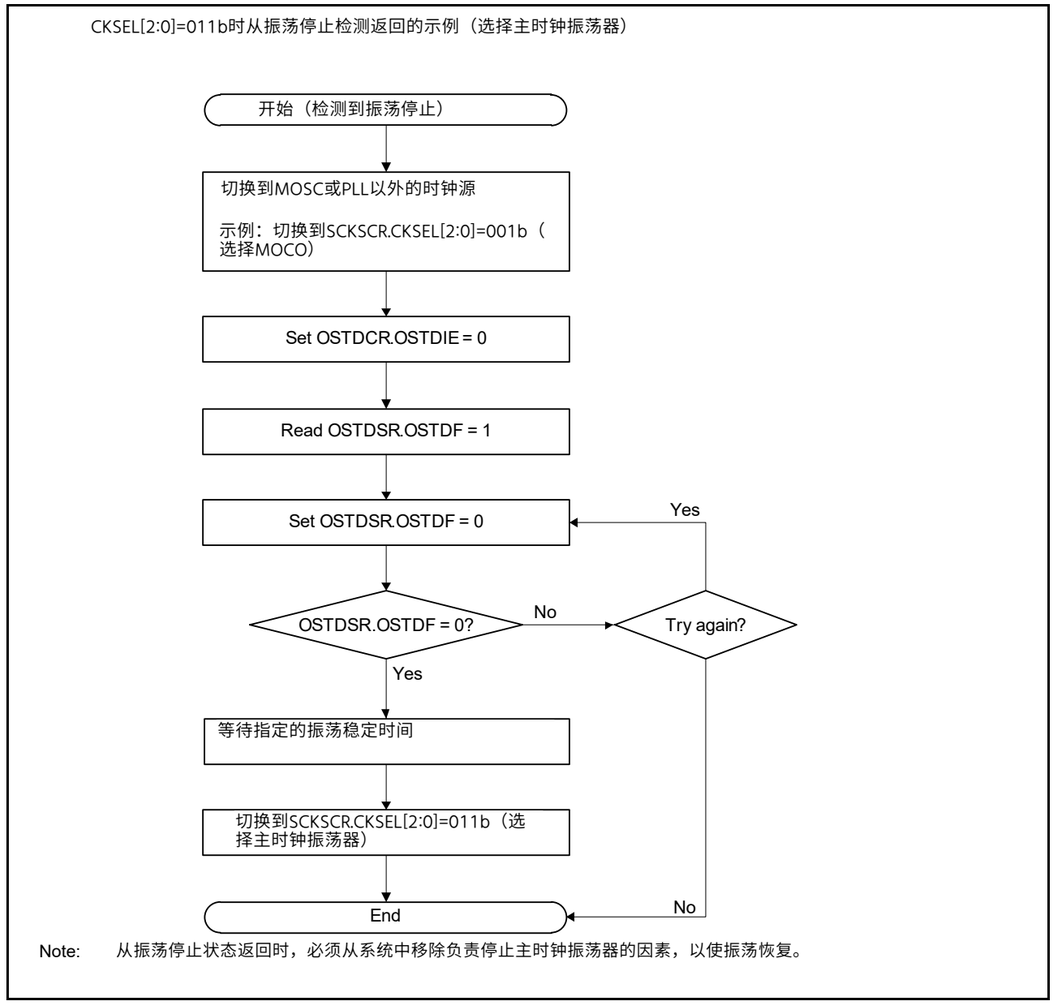

Figure 9.12 检测到振荡器停止时的恢复流程

9.5.2 振荡停止检测中断

当振荡停止检测标志(OSTDSR.OSTDF)为1且振荡停止检测控制寄存器(OSTDCR.OSTDIE)中的振荡停止检测中断使能位为1（使能）时，将产生一个振荡停止检测中断(MOSC_STOP)。GPT端口输出使能(POEG)被通知主时钟振荡器停止。收到通知后，POEG将POEG组n设置寄存器(POEGGn.OSTPF)中的振荡停止检测标志设置为1(n=A B)。

检测到振荡停止后，至少等待10个PCLKB周期，然后再写入POEGGn.OSTPF标志。当需要清除OSTDSR.OSTDF标志时，请在清除振荡停止检测控制寄存器(OSTDCR.OSTDIE)中的振荡停止检测中断使能位后执行此操作。等待至少2个PCLKB时钟周期，然后再将OSTDCR.OSTDIE位设置为1。可能需要更长的PCLKB等待时间，具体取决于读取给定IO寄存器所需的周期数。

振荡停止检测中断是一个不可屏蔽的中断。由于不可屏蔽中断在复位释放后的初始状态下被禁用，因此在使用振荡停止检测中断之前，请通过软件启用不可屏蔽中断。有关详细信息，请参阅第13节，中断控制器单元(ICU)。

9.6 PLL Circuit

The PLL circuit provides a function for multiplying the frequency from the oscillator.

9.7 Internal Clock

Clock sources for the internal clock signals include:

- Main clock oscillator
- Sub-clock oscillator
- HOCO clock
- MOCO clock
- LOCO clock
- PLL clock
- Dedicated clock for the IWDT
- External clock for JTAG.

The following internal clocks are produced from these sources:

- Operating clock for the CPU, DMAC, DTC, flash memory, and SRAM — system clock (ICLK)
- Operating clocks for peripheral modules — PCLKA, PCLKB, PCLKC, and PCLKD
- Operating clock for the flash interface — FCLK
- Operating clock for the CAN — CANMCLK
- Operating clock for the CAC — CACCLK
- Operating clock for the IWDT — IWDTCLK
- Operating clock for the AGT LOCO clock — AGTLCLK
- Operating clock for the AGT sub-clock — AGTSCLK
- Operating clock for the SysTick timer — SYSTICCLK
- Clock for external pin output — CLKOUT
- Operating clock for the JTAG — JTAGTCK.

For details on the registers used to set the frequencies of the internal clocks, see section 9.7.1, System Clock (ICLK) to section 9.7.10, JTAG Clock (JTAGTCK).

If the value of any of these bits is changed, subsequent operation is at the frequency determined by the new value.

9.7.1 System Clock (ICLK)

The system clock, ICLK, is the operating clock for the CPU, DMAC, DTC, flash memory, and SRAM.

The ICLK frequency is specified in the following bits:

- ICK[2:0] bits in SCKDIVCR
- CKSEL[2:0] bits in SCKSCR
- PLLMUL[5:0] and PLIDIV[1:0] bits in PLLCCR
- HOCOFRQ[1:0] bits in OFS1.

When the ICLK clock source is switched, the duration of the ICLK clock cycle becomes longer during the clock source transition period. See Figure 9.13 and Figure 9.14.

9.6 PLL Circuit

PLL电路提供了将振荡器的频率倍增的功能。

9.7 内部时钟

内部时钟信号的时钟源包括：

- 主时钟振荡器
- Sub-clock oscillator
- HOCO clock
- MOCO clock
- 机车时钟
- PLL clock
- IWDT的专用时钟
- JTAG的外部时钟。

以下内部时钟由这些源产生：

- CPU、DMAC、DTC、闪存和SRAM的工作时钟—系统时钟(ICLK)
- 外围模块的工作时钟—PCLKA、PCLKB、PCLKC和PCLKD
- 闪存接口的工作时钟——FCLK
- CAN的工作时钟—CANMCLK
- CAC的工作时钟—CACCLK
- IWDT的工作时钟—IWDTCLK
- AGTLOCO时钟的工作时钟—AGTLCLK
- AGT子时钟的工作时钟—AGTSCLK
- SysTick定时器的工作时钟—SYSTICCLK
- 外部引脚输出时钟—CLKOUT
- JTAG的工作时钟—JTAGTCK。

有关用于设置内部时钟频率的寄存器的详细信息，请参见第9.7.1节，系统时钟(ICLK)至第9.7.10节，JTAG时钟(JTAGTCK)。

如果这些位中的任何一个的值发生变化，则后续操作将以新值确定的频率进行。

9.7.1 系统时钟(ICLK)

系统时钟ICLK是CPU、DMAC、DTC、闪存和SRAM的工作时钟。

ICLK频率在以下位中指定：

- SCKDIVCR中的ICK[2:0]位
- SCKSCR中的CKSEL[2:0]位
- PLLCCR中的PLLMUL[5:0]和PLIDIV[1:0]位
- OFS1中的HOCOFRQ[1:0]位。

当ICLK时钟源切换时，ICLK时钟周期的持续时间在时钟源转换期间变长。请参见图9.13和图9.14。

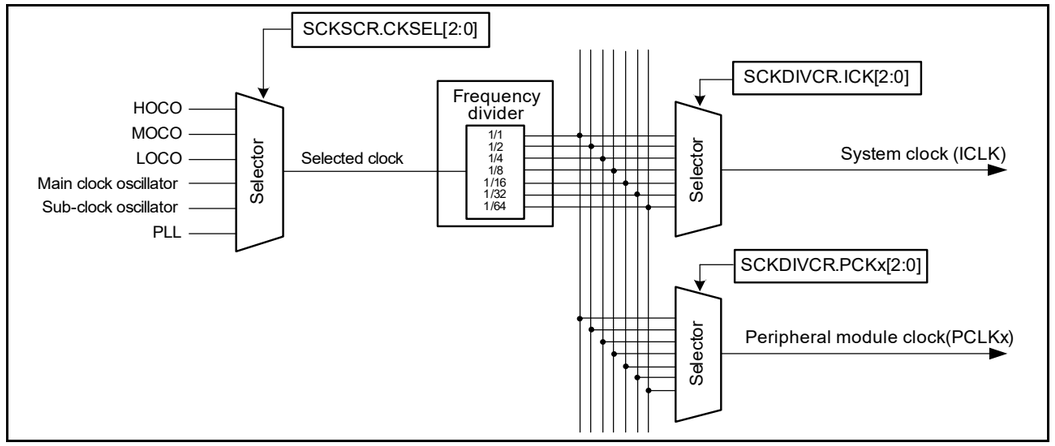

Figure 9.13 Clock source selector block diagram

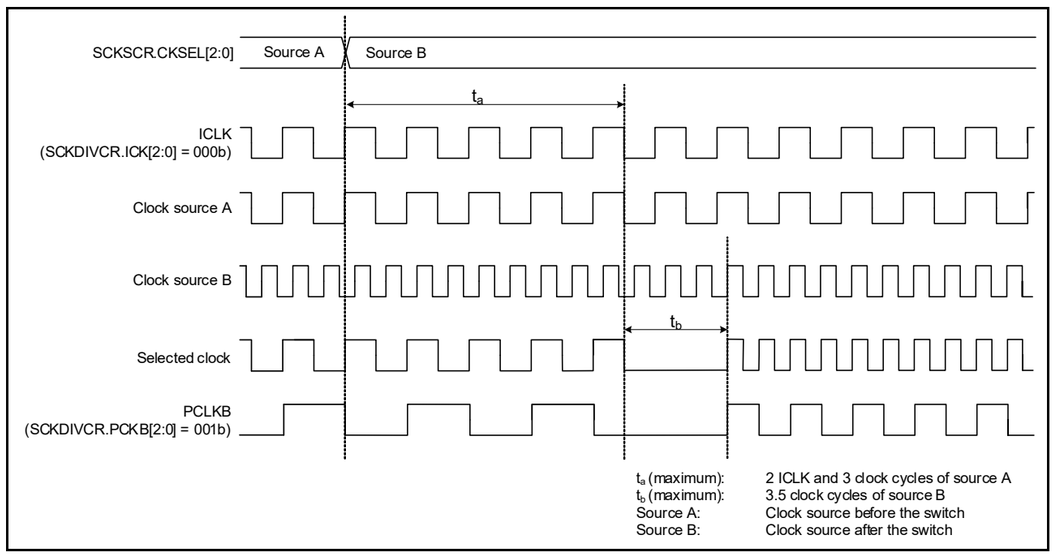

Figure 9.14 Clock source switching timing diagram

9.7.2 Peripheral Module Clock (PCLKA, PCLKB, PCLKC, PCLKD)

The peripheral module clocks, PCLKA, PCLKB, PCLKC, and PCLKD, are the operating clocks for the peripheral modules.

The frequency of the given clock is specified in the following bits:

- PCKA[2:0], PCKB[2:0], PCKC[2:0], and PCKD[2:0] bits in SCKDIVCR
- CKSEL[2:0] bits in SCKSCR
- PLLMUL[5:0] and PLIDIV[1:0] bits in PLLCCR
- HOCOFRQ[1:0] bits in OFS1.

When the clock source of the peripheral module clock is switched, the duration of the peripheral module clock cycle becomes longer during the clock source transition period. See Figure 9.13 and Figure 9.14.

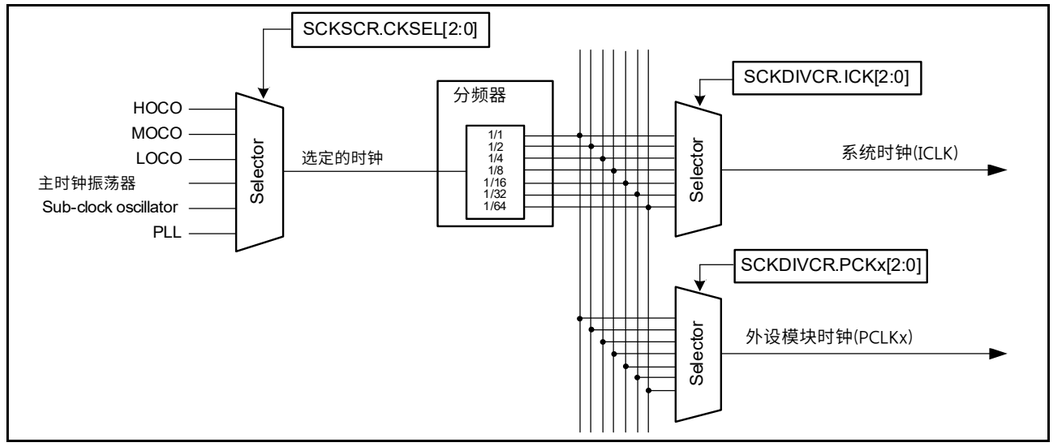

Figure 9.13 时钟源选择器框图

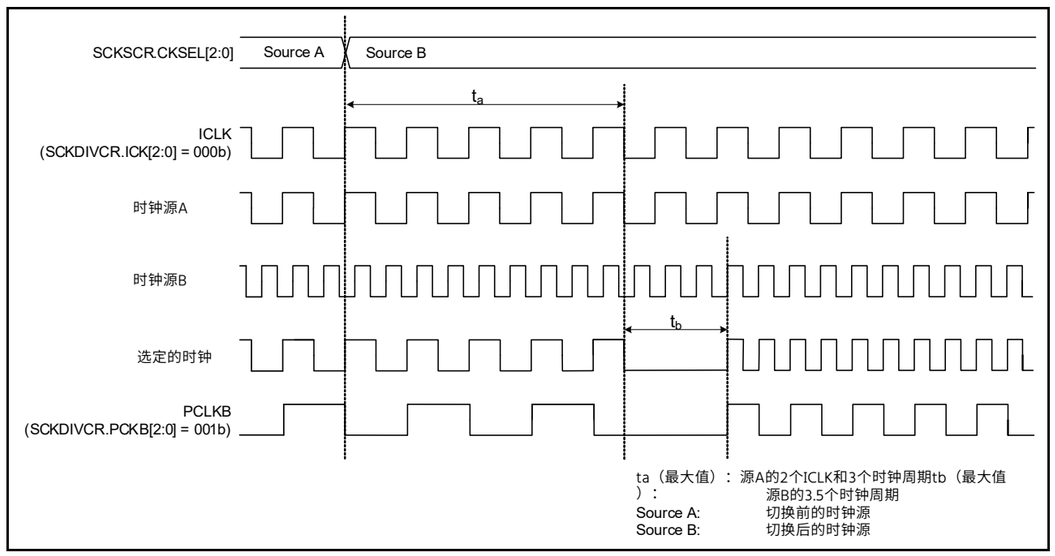

Figure 9.14 时钟源切换时序图

9.7.2 外设模块时钟（PCLKA、PCLKB、PCLKC、PCLKD）

外围模块时钟PCLKA、PCLKB、PCLKC和PCLKD是外围模块的工作时钟。

给定时钟的频率在以下位中指定：

- SCKDIVCR中的PCKA[2:0]、PCKB[2:0]、PCKC[2:0]和PCKD[2:0]位
- SCKSCR中的CKSEL[2:0]位
- PLLCCR中的PLLMUL[5:0]和PLIDIV[1:0]位
- OFS1中的HOCOFRQ[1:0]位。

当外围模块时钟的时钟源切换时，外围模块时钟周期的持续时间在时钟源转换期间会变长。请参见图9.13和图9.14。

9.7.3 Flash Interface Clock (FCLK)

The flash interface clock, FCLK, is the operating clock for the flash memory interface. In addition to reading from the data flash, FCLK is used for the programming and erasure of the code flash and data flash.

The FCLK frequency is specified in the following bits:

- FCK[2:0] bits in SCKDIVCR
- CKSEL[2:0] bits in SCKSCR
- PLLMUL[5:0] and PLIDIV[1:0] bits in PLLCCR
- HOCOFRQ[1:0] bits in OFS1.

9.7.4 CAN Clock (CANMCLK)

The CAN clock, CANMCLK, is the operating clock for the CAN module. CANMCLK is generated by the main clock oscillator.

9.7.5 CAC Clock (CACCLK)

The CAC clock, CACCLK, is the operating clock for the CAC. CACCLK is generated by the following oscillators:

- Main clock oscillator
- Sub-clock oscillator
- High-speed clock oscillator (HOCO)
- Middle-speed clock oscillator (MOCO)
- Low-speed on-chip oscillator (LOCO)
- IWDT-dedicated on-chip oscillator.

9.7.6 IWDT-Dedicated Clock (IWDTCLK)

The IWDT-dedicated clock, IWDTCLK, is the operating clock for the IWDT. IWDTCLK is internally generated by the IWDT-dedicated on-chip oscillator.

9.7.7 AGT-Dedicated Clock (AGTSCLK, AGTLCLK)

The AGT-dedicated clocks, AGTSCLK and AGTLCLK, are the operating clocks for the AGT. AGTSCLK is generated by the sub-clock oscillator and AGTLCLK is generated by the LOCO clock.

9.7.8 SysTick Timer-Dedicated Clock (SYSTICCLK)

The SysTick timer-dedicated clock, SYSTICCLK, is the operating clock for the SYSTICCLK. SYSTICCLK is generated by the LOCO clock.

9.7.9 Clock/Buzzer Output Clock (CLKOUT)

The CLKOUT is output externally from the CLKOUT pin for the clock or buzzer output. CLKOUT is output to the CLKOUT pin when CKOCR.CKOEN is set to 1. Only change the value in the CKODIV[2:0] or CKOSEL[2:0] bits in CKOCR when the CKOCR.CKOEN bit is 0.

The CLKOUT frequency is specified in the following bits:

- CKODIV[2:0] or CKOSEL[2:0] bits in CKOCR
- HOCOFRQ[1:0] bits in OFS1.

9.7.10 JTAG Clock (JTAGTCK)

The JTAG-dedicated clock, JTAGTCK, is the operating clock for the JTAG. JTAGTCK is generated by the external clock for JTAG (TCK).

9.7.3 闪存接口时钟(FCLK)

闪存接口时钟FCLK是闪存接口的工作时钟。除了从数据闪存读取外，FCLK还用于代码闪存和数据闪存的编程和擦除。

FCLK频率在以下位中指定：

- SCKDIVCR中的FCK[2:0]位
- SCKSCR中的CKSEL[2:0]位
- PLLCCR中的PLLMUL[5:0]和PLIDIV[1:0]位
- OFS1中的HOCOFRQ[1:0]位。

9.7.4 CAN时钟(CANMCLK)

CAN时钟CANMCLK是CAN模块的工作时钟。CANMCLK由主时钟振荡器产生。

9.7.5 CAC时钟(CACCLK)

CAC时钟CACCLK是CAC的工作时钟。CACCLK由以下振荡器产生：

- 主时钟振荡器
- Sub-clock oscillator
- 高速时钟振荡器(HOCO)
- 中速时钟振荡器(MOCO)
- Low-speed on-chip oscillator (LOCO)
- IWDT-dedicated on-chip oscillator.

9.7.6 IWDT-Dedicated Clock (IWDTCLK)

IWDT专用时钟IWDTCLK是IWDT的工作时钟。IWDTCLK由内部产生
IWDT-dedicated on-chip oscillator.

9.7.7 AGT-Dedicated Clock (AGTSCLK, AGTLCLK)

AGT专用时钟AGTSCLK和AGTLCLK是AGT的工作时钟。AGTSCLK由副时钟振荡器产生，AGTLCLK由LOCO时钟产生。

9.7.8 SysTick Timer-Dedicated Clock (SYSTICCLK)

SysTick定时器专用时钟SYSTICCLK是SYSTICCLK的工作时钟。SYSTICCLK由LOCO时钟生成。

9.7.9 时钟蜂鸣器输出时钟(CLKOUT)

CLKOUT从CLKOUT引脚外部输出，用于时钟或蜂鸣器输出。CLKOUT被输出到CKOCR.CKOEN设置为1时的CLKOUT引脚。仅更改CKODIV[2:0]或CKOSEL[2:0]位中的值CKOCR.CKOEN位为0时的CKOCR。

CLKOUT频率在以下位中指定：

- CKOCR中的CKODIV[2:0]或CKOSEL[2:0]位
- OFS1中的HOCOFRQ[1:0]位。

9.7.10 JTAG Clock (JTAGTCK)

JTAG专用时钟JTAGTCK是JTAG的工作时钟。JTAGTCK由JTAG的外部时钟(TCK)生成。

9.8 Usage Notes

9.8.1 Notes on Clock Generation Circuit

The frequencies of the system clock (ICLK), peripheral module clock (PCLKA to PCLKD), and flash interface clock (FCLK) supplied to each module change according to the settings in SCKDIVCR. Each frequency must meet the following conditions:

- Each frequency must be selected within the operation-guaranteed range of the clock cycle time (t_{cyc}) specified in the AC electrical characteristics, see section 43, Electrical Characteristics
- The frequencies must not exceed the ranges listed in Table 9.2
- The peripheral modules operate on PCLKB and PCLKA. The operating speed of modules such as the timer and SCI varies before and after the frequency is changed.
- The system clock (ICLK), peripheral module clock (PCLKA to PCLKD), and flash interface clock (FCLK) must be set according to Table 9.2.

To ensure correct processing after the clock frequency changes, first write to the relevant Clock Control Register to change the frequency, then read the value from the register, and finally perform the subsequent processing.

9.8.2 Notes on Resonator

Because various resonator characteristics relate closely to your board design, adequate evaluation is required before use. See the resonator connection example in Figure 9.9. The circuit constants for the resonator depend on the resonator to be used and the stray capacitance of the mounting circuit. Therefore, consult the resonator manufacturer when determining the circuit constants. The voltage to be applied between the resonator pins must be within the absolute maximum rating.

9.8.3 Notes on Board Design

When using a crystal resonator, place the resonator and its load capacitors as close to the XTAL and EXTAL pins as possible. Route other signal lines away from the oscillation circuit as shown in Figure 9.15, to prevent electromagnetic induction from interfering with correct oscillation.

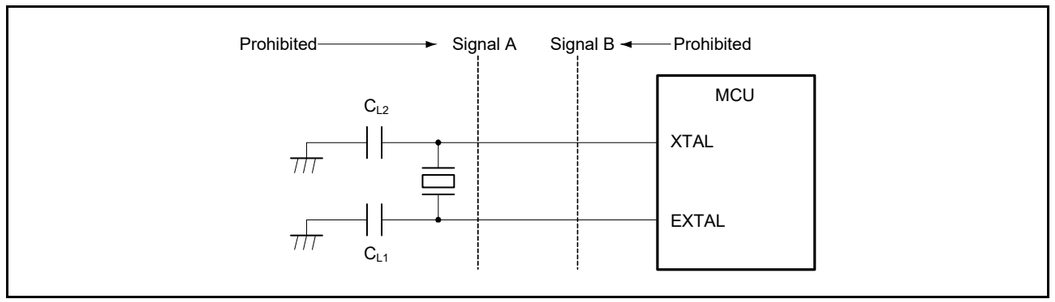

Figure 9.15 Signal routing in board design for oscillation circuit (applies to the sub-clock oscillator for the main clock oscillator)

9.8.4 Notes on the Resonator Connect Pin

When the main clock oscillator is not used, the EXTAL and XTAL pins can be used as general ports P212 and P213. When these pins are used as general ports, the main clock oscillator must be stopped (MOSCCR.MOSTP must be set to 1).

9.8.5 Notes on the Main Clock Oscillator Drive Capability Auto Switching Function

The drive capability of the auto switching function automatically lowers the drive capability of the main clock oscillator, after the main clock oscillator starts and suppresses the associated EMI.

To enable the drive capability of auto switching, set MOMCR.AUTODRVEN to 1 when the main clock oscillator is stopped (MOSCCR.MOSTP = 1). Regardless of the MOMCR.AUTODRVEN setting, the Drive Capability Switching

9.8 使用说明

9.8.1 时钟产生电路注意事项

提供给每个模块的系统时钟(ICLK)、外围模块时钟(PCLKA至PCLKD)和闪存接口时钟(FCLK)的频率根据SCKDIVCR中的设置而变化。每个频率必须满足以下条件：

- 每个频率必须在时钟周期时间(tcyc)中指定的操作保证范围内选择
  交流电气特性，参见第43节，电气特性
- 频率不得超过表9.2中列出的范围
- 外围模块在PCLKB和PCLKA上运行。定时器和SCI等模块的运行速度在频率改变前后会发生变化。
- 系统时钟（ICLK）、外设模块时钟（PCLKA到PCLKD）和闪存接口时钟（FCLK）必须按照表9.2进行设置。

为保证时钟频率改变后的正确处理，首先写入相关的时钟控制寄存器改变频率，然后从寄存器中读取值，最后进行后续处理。

9.8.2 谐振器注意事项

由于各种谐振器特性与您的电路板设计密切相关，因此在使用前需要进行充分评估。请参见图9.9中的谐振器连接示例。谐振器的电路常数取决于要使用的谐振器和安装电路的杂散电容。因此，在确定电路常数时，请咨询谐振器制造商。施加在谐振器引脚之间的电压必须在绝对最大额定值范围内。

9.8.3 电路板设计注意事项

使用晶体谐振器时，将谐振器及其负载电容尽可能靠近XTAL和EXTAL引脚。如图9.15所示，将其他信号线远离振荡电路，以防止电磁感应干扰正确的振荡。

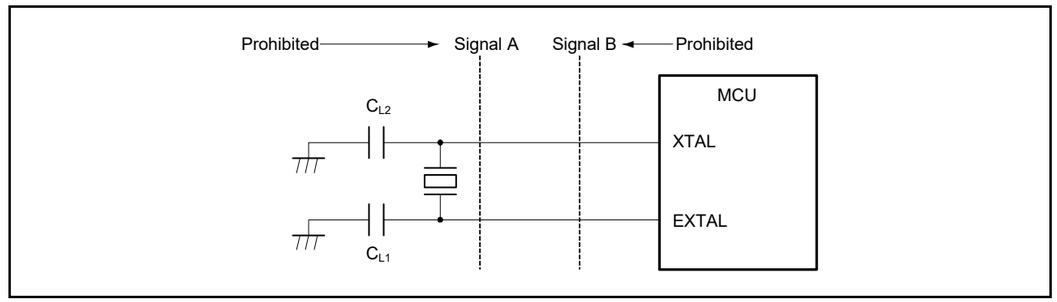

Figure 9.15 振荡电路板设计中的信号走线（适用于主时钟振荡器的副时钟振荡器）

9.8.4 谐振器连接引脚注意事项

当不使用主时钟振荡器时，EXTAL和XTAL引脚可用作通用端口P212和P213。
当这些引脚用作通用端口时，必须停止主时钟振荡器（MOSCCR.MOSTP必须设置为1）。

9.8.5 主时钟振荡器驱动能力自动切换功能注意事项

自动切换功能的驱动能力会在主时钟振荡器启动后自动降低主时钟振荡器的驱动能力并抑制相关的EMI。

要启用自动切换的驱动能力，当主时钟振荡器停止（MOSCCR.MOSTP=1）时，将MOMCR.AUTODRVEN设置为1。无论MOMCR.AUTODRVEN设置如何，驱动能力切换

Register (MOMCR.MODRV0[1:0]) must be set properly according to the selected oscillator. Next, enable the main clock oscillator (MOSCCR.MOSTP = 0). After the Oscillation Stabilization flag (OSCSF.MOSCSF) becomes 1, the main clock can be used.

EMI suppression is gained in return for an extension in the oscillation stabilization wait time. For more information, see section 9.2.16, Main Clock Oscillator Wait Control Register (MOSCWTCR).

必须根据所选振荡器正确设置寄存器(MOMCR.MODRV0[1:0])。接下来，启用主时钟振荡器(MOSCCR.MOSTP=0)。振荡稳定标志(OSCSF.MOSCSF)变为1后，可以使用主时钟。

获得EMI抑制以换取振荡稳定等待时间的延长。有关详细信息，请参阅第9.2.16节，主时钟振荡器等待控制寄存器(MOSCWTCR)。

RA生态工作室

10. Clock Frequency Accuracy Measurement Circuit (CAC)

10.1 Overview

The Clock Frequency Accuracy Measurement Circuit (CAC) counts pulses of the clock to be measured (measurement target clock) within the time generated by the clock selected as a measurement reference (measurement reference clock). It determines the accuracy depending on whether the number of pulses is within the allowable range.

The reference clock can be provided externally through an I/O port pin or internally from various on-chip oscillators. When measurement is complete or the number of pulses within the time generated by the measurement reference clock is not within the allowable range, an interrupt request is generated. This feature is useful in implementing a fail-safe mechanism for home and industrial automation applications.

Table 10.1 lists the CAC specifications, Figure 10.1 shows a block diagram, and Table 10.2 shows the I/O pins.

Table 10.1 CAC specifications

Parameter	Specifications
Measurement target clocks	Frequency can be measured for: • Main clock oscillator • Sub-clock oscillator • HOCO clock • MOCO clock • LOCO clock • IWDTCLK clock • Peripheral module clock B (PCLKB).
Measurement reference clocks	Frequency can be referenced to: • External clock input to the CACREF pin • Main clock oscillator • Sub-clock oscillator • HOCO clock • MOCO clock • LOCO clock • IWDTCLK clock • Peripheral module clock B (PCLKB).
Selectable function	Digital filter
Interrupt sources	• Measurement end • Frequency error • Overflow.
Module-stop function	Module-stop state can be set to reduce power consumption

10. 时钟频率精度测量电路(CAC)

10.1 Overview

时钟频率精度测量电路(CAC)在选择作为测量参考的时钟（测量参考时钟）生成的时间内对要测量的时钟（测量目标时钟）的脉冲进行计数。它根据脉冲数是否在允许范围内来确定精度。

参考时钟可以通过IO端口引脚从外部提供，也可以从各种片上振荡器内部提供。
当测量完成或测量参考时钟在时间内产生的脉冲数不在允许范围内时，将产生中断请求。此功能可用于为家庭和工业自动化应用实施故障安全机制。

表10.1列出了CAC规范，图10.1显示了框图，表10.2显示了IO引脚。

Table 10.1 CAC规格

Parameter	Specifications
测量目标时钟	可以测量以下频率的频率： 主时钟振荡器 副时钟振荡器 HOCO时钟 MOCO时钟 LOCO时钟 IWDTCLK时钟 外围模块时钟B(PCLKB)。
测量参考时钟	频率可以参考： CACREF引脚的外部时钟输入 主时钟振荡器 子时钟振荡器 HOCO时钟 MOCO时钟 LOCO时钟 IWDTCLK时钟 外设模块时钟B(PCLKB)。
可选择的功能	数字滤波器
中断源	测量结束 频率误差溢出。
Module-stop function	可设置模块停止状态以降低功耗

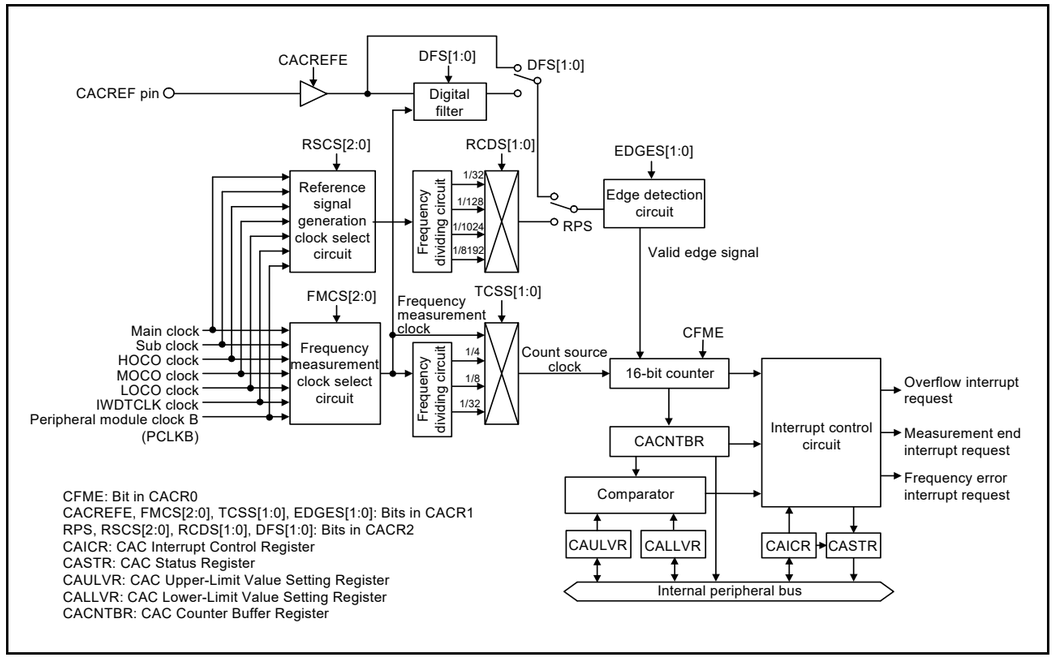

Figure 10.1 CAC block diagram

Table 10.2 CAC I/O pin

Pin name	I/O	Function
CACREF	Input	Measurement reference clock input pin

10.2 Register Descriptions

10.2.1 CAC Control Register 0 (CACR0)

Address(es): CAC.CACR0 4004 4600h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CFME
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CFME	Clock Frequency Measurement Enable	0: Disable 1: Enable.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CFME bit (Clock Frequency Measurement Enable)

The CFME bit enables the clock frequency measurement. Read the CFME bit to confirm that the bit value has changed. Additional write accesses are ignored before the change is complete.

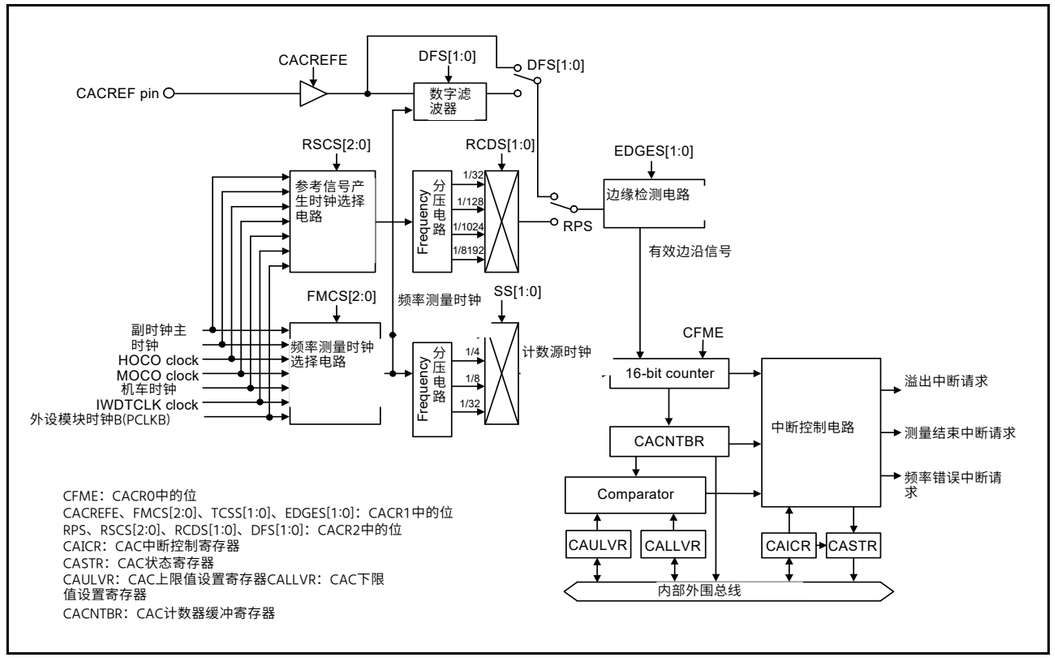

Figure 10.1 CAC框图

Table 10.2 CACIO引脚

引脚名称	I/O	Function
CACREF	Input	测量参考时钟输入引脚

10.2 注册说明

10.2.1 CAC控制寄存器0(CACR0)

Address(es): CAC.CACR0 4004 4600h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CFME
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CFME	时钟频率测量启用	0：禁用1 ：启用。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CFME位（时钟频率测量使能）

CFME位使能时钟频率测量。读取CFME位以确认该位值已更改。
在更改完成之前，将忽略其他写入访问。

10.2.2 CAC Control Register 1 (CACR1)

Address(es): CAC.CACR1 4004 4601h

	b7	b6	b5	b4	b3	b2	b1	b0
	EDGES[1:0]		TCSS[1:0]		FMCS[2:0]			CACREFE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CACREFE	CACREF Pin Input Enable	0: Disable 1: Enable.	R/W
b3 to b1	FMCS[2:0]	Measurement Target Clock Select	b3 b1 0 0 0: Main clock oscillator 0 0 1: Sub-clock oscillator 0 1 0: HOCO clock 0 1 1: MOCO clock 1 0 0: LOCO clock 1 0 1: Peripheral module clock (PCLKB) 1 1 0: IWDTCLK clock 1 1 1: Setting prohibited.	R/W
b5, b4	TCSS[1:0]	Measurement Target Clock Frequency Division Ratio Select	b5 b4 0 0: No division 0 1: ×1/4 clock 1 0: ×1/8 clock 1 1: ×1/32 clock.	R/W
b7, b6	EDGES[1:0]	Valid Edge Select	b7 b6 0 0: Rising edge 0 1: Falling edge 1 0: Both rising and falling edges 1 1: Setting prohibited.	R/W

Note: Set the CACR1 register when the CACR0.CFME bit is 0.

CACREFE bit (CACREF Pin Input Enable)

The CACREFE bit enables the CACREF pin input.

FMCS[2:0] bits (Measurement Target Clock Select)

The FMCS[2:0] bits select the measurement target clock whose frequency is to be measured.

TCSS[1:0] bits (Measurement Target Clock Frequency Division Ratio Select)

The TCSS[1:0] bits select the division ratio of the measurement target clock.

EDGES[1:0] bits (Valid Edge Select)

The EDGES[1:0] bits select the valid edge for the reference signal.

10.2.2 CAC控制寄存器1(CACR1)

Address(es): CAC.CACR1 4004 4601h

	b7	b6	b5	b4	b3	b2	b1	b0
	EDGES[1:0]		TCSS[1:0]		FMCS[2:0]			CACREFE
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CACREFE	CACREF引脚输入使能	0：禁用1 ：启用。	R/W
b3 to b1	FMCS[2:0]	测量目标时钟选择	b3b1000：主时钟振荡器001：副时钟振荡器010：HOCO时钟011：MOCO时钟100：LOCO时钟101：外围模块时钟（PCLKB）110：IWDTCLK时钟111：禁止设置。	R/W
b5, b4	TCSS[1:0]	测量目标时钟 分频比选择	b5b400：不分频 01：×14个时钟1 0：×18个时钟11 ：×132个时钟。	R/W
b7, b6	EDGES[1:0]	有效边选择	b7b600：上升沿01：下降沿10：上升沿和下降沿11：禁止设置。	R/W

Note: 当CACR0.CFME位为0时设置CACR1寄存器。

CACREFE位（CACREF引脚输入使能）

CACREFE位使能CACREF引脚输入。

FMCS[2:0]位（测量目标时钟选择）

FMCS[2:0]位选择要测量其频率的测量目标时钟。

TCSS[1:0]位（测量目标时钟分频比选择）

TCSS[1:0]位选择测量目标时钟的分频比。

EDGES[1:0]位（有效边沿选择）

EDGES[1:0]位选择参考信号的有效边沿。

10.2.3 CAC Control Register 2 (CACR2)

Address(es): CAC.CACR2 4004 4602h

	b7	b6	b5	b4	b3	b2	b1	b0
	DFS[1:0]		RCDS[1:0]		RSCS[2:0]			RPS
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	RPS	Reference Signal Select	0: CACREF pin input 1: Internal clock (internally generated signal).	R/W
b3 to b1	RSCS[2:0]	Measurement Reference Clock Select	b3 b1 0 0 0: Main clock oscillator 0 0 1: Sub-clock oscillator 0 1 0: HOCO clock 0 1 1: MOCO clock 1 0 0: LOCO clock 1 0 1: Peripheral module clock (PCLKB) 1 1 0: IWDTCLK clock 1 1 1: Setting prohibited.	R/W
b5, b4	RCDS[1:0]	Measurement Reference Clock Frequency Division Ratio Select	b5 b4 0 0: ×1/32 clock 0 1: ×1/128 clock 1 0: ×1/1024 clock 1 1: ×1/8192 clock.	R/W
b7, b6	DFS[1:0]	Digital Filter Select	b7 b6 0 0: Disable digital filtering 0 1: Use sampling clock for the digital filter as the frequency measuring clock 1 0: Use sampling clock for the digital filter as the frequency measuring clock divided by 4 1 1: Use sampling clock for the digital filter as the frequency measuring clock divided by 16.	R/W

Note: Set the CACR2 register when the CACR0.CFME bit is 0.

RPS bit (Reference Signal Select)

The RPS bit selects whether to use the CACREF pin input or an internal clock (internally generated signal) as the reference signal.

RSCS[2:0] bits (Measurement Reference Clock Select)

The RSCS[2:0] bits select the reference clock for measurement.

RCDS[1:0] bits (Measurement Reference Clock Frequency Division Ratio Select)

The RCDS[1:0] bits select the frequency division ratio of the measurement reference clock when an internal reference clock is selected (RPS = 1). When RPS = 0 (CACREF pin is used as the reference clock source), the reference clock is not divided.

DFS[1:0] bits (Digital Filter Select)

The DFS[1:0] bits enable or disable the digital filter and select its sampling clock.

10.2.3 CAC控制寄存器2(CACR2)

Address(es): CAC.CACR2 4004 4602h

	b7	b6	b5	b4	b3	b2	b1	b0
	DFS[1:0]		RCDS[1:0]		RSCS[2:0]			RPS
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	RPS	参考信号选择	0：CACREF引脚输入1：内部时钟（内部产生的信号）。	R/W
b3 to b1	RSCS[2:0]	测量参考时钟Select	b3b1000：主时钟振荡器001：副时钟振荡器010：HOCO时钟011：MOCO时钟100：LOCO时钟101：外围模块时钟（PCLKB）110：IWDTCLK时钟111：禁止设置。	R/W
b5, b4	RCDS[1:0]	测量参考时钟分频比选择	b5 b4 0 0: ×1/32 clock 0 1: ×1/128 clock 1 0: ×1/1024 clock 1 1: ×1/8192 clock.	R/W
b7, b6	DFS[1:0]	数字滤波器选择	b7b600：禁用数字滤波01：使用数字滤波器的采样时钟作为频率测量时钟10：使用数字滤波器的采样时钟作为频率测量时钟除以411：使用数字滤波器的采样时钟滤波器作为频率测量时钟除以16。	R/W

Note: 当CACR0.CFME位为0时设置CACR2寄存器。

RPS位（参考信号选择）

RPS位选择是使用CACREF引脚输入还是使用内部时钟（内部产生的信号）作为参考信号。

RSCS[2:0]位（测量参考时钟选择）

RSCS[2:0]位选择用于测量的参考时钟。

RCDS[1:0]位（测量参考时钟分频比选择）

TheRCDS[1:0]bitsselectthefrequencydivisionratioofthemeasurementreferenceclockwhenaninternalreferenceclockisselected(RPS=1).当RPS=0（CACREF引脚用作参考时钟源）时，参考时钟不分频。

DFS[1:0]位（数字滤波器选择）

DFS[1:0]位启用或禁用数字滤波器并选择其采样时钟。

10.2.4 CAC Interrupt Control Register (CAICR)

Address(es): CAC.CAICR 4004 4603h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	OVFFCL	MENDFCL	FERRFCL	—	OVFIE	MENDIE	FERRIE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	FERRIE	Frequency Error Interrupt Request Enable	0: Frequency error interrupt request is disabled 1: Frequency error interrupt request is enabled.	R/W
b1	MENDIE	Measurement End Interrupt Request Enable	0: Measurement end interrupt request is disabled 1: Measurement end interrupt request is enabled.	R/W
b2	OVFIE	Overflow Interrupt Request Enable	0: Overflow interrupt request is disabled 1: Overflow interrupt request is enabled.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	FERRFCL	FERRF Clear	When 1 is written to this bit, the FERRF flag is cleared. This bit is read as 0.	R/W
b5	MENDFCL	MENDF Clear	When 1 is written to this bit, the MENDF flag is cleared. This bit is read as 0.	R/W
b6	OVFFCL	OVFF Clear	When 1 is written to this bit, the OVFF flag is cleared. This bit is read as 0.	R/W
b7	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

FERRIE bit (Frequency Error Interrupt Request Enable)

The FERRIE bit enables the frequency error interrupt request.

MENDIE bit (Measurement End Interrupt Request Enable)

The MENDIE bit enables the measurement end interrupt request.

OVFIE bit (Overflow Interrupt Request Enable)

The OVFIE bit enables the overflow interrupt request.

FERRFCL bit (FERRF Clear)

Setting the FERRFCL bit to 1 clears the CASTR.FERRF flag.

MENDFCL bit (MENDF Clear)

Setting the MENDFCL bit to 1 clears the CASTR.MENDF flag.

OVFFCL bit (OVFF Clear)

Setting the OVFFCL bit to 1 clears the CASTR.OVFF flag.

10.2.4 CAC中断控制寄存器(CAICR)

Address(es): CAC.CAICR 4004 4603h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	OVFFCL	MENDFCL	FERRFCL	—	OVFIE	MENDIE	FERRIE
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	FERRIE	频率错误中断请求Enable	0：禁止频率错误中断请求1：允许频率错误中断请求。	R/W
b1	MENDIE	测量结束中断请求启用	0：禁止测量结束中断请求1：允许测量结束中断请求。	R/W
b2	OVFIE	溢出中断请求使能	0：禁止溢出中断请求1：使能溢出中断请求。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	FERRFCL	FERRF Clear	当向该位写入1时，FERRF标志被清除。该位读为0。	R/W
b5	MENDFCL	MENDF Clear	向该位写入1时，清除MENDF标志。该位读为0。	R/W
b6	OVFFCL	OVFF Clear	当向该位写入1时，OVFF标志被清除。该位读为0。	R/W
b7	—	Reserved	该位读取为0。写入值应为0。	R/W

FERRIE位（频率错误中断请求使能）

FERRIE位使能频率错误中断请求。

MENDIE位（测量结束中断请求使能）

MENDIE位使能测量结束中断请求。

OVFIE位（溢出中断请求使能）

OVFIE位使能溢出中断请求。

FERRFCL位（FERRF清除）

将FERRFCL位设置为1会清除CASTR.FERRF标志。

MENDFCL位（MENDF清除）

将MENDFCL位设置为1会清除CASTR。MENDF标志。

OVFFCL位（OVFF清除）

将OVFFCL位设置为1会清除CASTR。OVFF标志。

10.2.5 CAC Status Register (CASTR)

Address(es): CAC.CASTR 4004 4604h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	OVFF	MENDF	FERRF
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	FERRF	Frequency Error Flag	0: Clock frequency is within the allowable range 1: Clock frequency has deviated beyond the allowable range (frequency error).	R
b1	MENDF	Measurement End Flag	0: Measurement is in progress 1: Measurement ended.	R
b2	OVFF	Overflow Flag	0: Counter has not overflowed 1: Counter overflowed.	R
b7 to b3	—	Reserved	These bits are read as 0	R

FERRF flag (Frequency Error Flag)

The FERRF flag indicates a deviation of the clock frequency from the set value (frequency error).

[Setting condition]

- The clock frequency is outside the allowable range defined in the CAULVR and CALLVR registers.

[Clearing condition]

- 1 is written to the FERRFCL bit.

MENDF flag (Measurement End Flag)

The MENDF flag indicates the end of measurement.

[Setting condition]

- Measurement ends.

[Clearing condition]

- 1 is written to the MENDFCL bit.

OVFF flag (Overflow Flag)

The OVFF flag indicates that the counter overflowed.

[Setting condition]

- The counter overflows.

[Clearing condition]

- 1 is written to the OVFFCL bit.

10.2.5 CAC状态寄存器(CASTR)

Address(es): CAC.CASTR 4004 4604h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	OVFF	MENDF	FERRF
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	FERRF	频率错误标志	0：时钟频率在允许范围内1：时钟频率偏离允许范围（频率误差）。	R
b1	MENDF	测量结束标志	0：测量中1：测量结束。	R
b2	OVFF	溢出标志	0：计数器未溢出1：计数器溢出。	R
b7 to b3	—	Reserved	这些位被读为0	R

FERRF标志（频率误差标志）

FERRF标志表示时钟频率与设定值的偏差（频率误差）。

[Setting condition]

- 时钟频率超出CAULVR和CALLVR寄存器中定义的允许范围。

[Clearing condition]

- 1被写入FERRFCL位。

MENDF标志（测量结束标志）

MENDF标志表示测量结束。

[Setting condition]

- 测量结束。

[Clearing condition]

- 1被写入MENDFCL位。

OVFF标志（溢出标志）

OVFF标志表示计数器溢出。

[Setting condition]

- 计数器溢出。

[Clearing condition]

- 1写入OVFFCL位。

10.2.6 CAC Upper-Limit Value Setting Register (CAULVR)

Address(es): CAC.CAULVR 4004 4606h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CAULVR is a 16-bit read/write register that specifies the upper value of the allowable range. When the counter value exceeds the value specified in this register, a frequency error is detected. Write to this register when the CACR0.CFME bit is 0.

The counter value stored in CACNTBR can vary depending on the difference between the phases of the digital filter and edge-detection circuit, and the signal on the CACREF pin. Ensure that this setting allows an adequate margin.

10.2.7 CAC Lower-Limit Value Setting Register (CALLVR)

Address(es): CAC.CALLVR 4004 4608h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CALLVR is a 16-bit read/write register that specifies the lower value of the allowable range. When the counter value falls below the value specified in this register, a frequency error is detected. Write to this register when the CACR0.CFME bit is 0.

The counter value stored in CACNTBR can vary depending on the difference between the phases of the digital filter and edge-detection circuit, and the signal on the CACREF pin. Ensure that this setting allows an adequate margin.

10.2.8 CAC Counter Buffer Register (CACNTBR)

Address(es): CAC.CACNTBR 4004 460Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CACNTBR is a 16-bit read-only register that stores the measurement result.

10.3 Operation

10.3.1 Measuring Clock Frequency

The CAC measures the clock frequency using the CACREF pin input or the internal clock as a reference. Figure 10.2 shows an operating example of the CAC.

10.2.6 CAC上限值设置寄存器(CAULVR)

Address(es): CAC.CAULVR 4004 4606h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CAULVR是一个16位读写寄存器，用于指定允许范围的上限值。当计数器值超过此寄存器中指定的值时，检测到频率错误。当CACR0.CFME位为0时写入该寄存器。

存储在CACNTBR中的计数器值会根据数字滤波器和边沿检测电路的相位差以及CACREF引脚上的信号而变化。确保此设置允许有足够的余量。

10.2.7 CAC下限值设置寄存器(CALLVR)

Address(es): CAC.CALLVR 4004 4608h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CALLVR是一个16位读写寄存器，用于指定允许范围的下限值。当计数器值低于此寄存器中指定的值时，检测到频率错误。当CACR0.CFME位为0时写入该寄存器。

存储在CACNTBR中的计数器值会根据数字滤波器和边沿检测电路的相位差以及CACREF引脚上的信号而变化。确保此设置允许有足够的余量。

10.2.8 CAC计数器缓冲寄存器(CACNTBR)

Address(es): CAC.CACNTBR 4004 460Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CACNTBR是一个16位只读寄存器，用于存储测量结果。

10.3 Operation

10.3.1 测量时钟频率

CAC使用CACREF引脚输入或内部时钟作为参考来测量时钟频率。图10.2显示了CAC的操作示例。

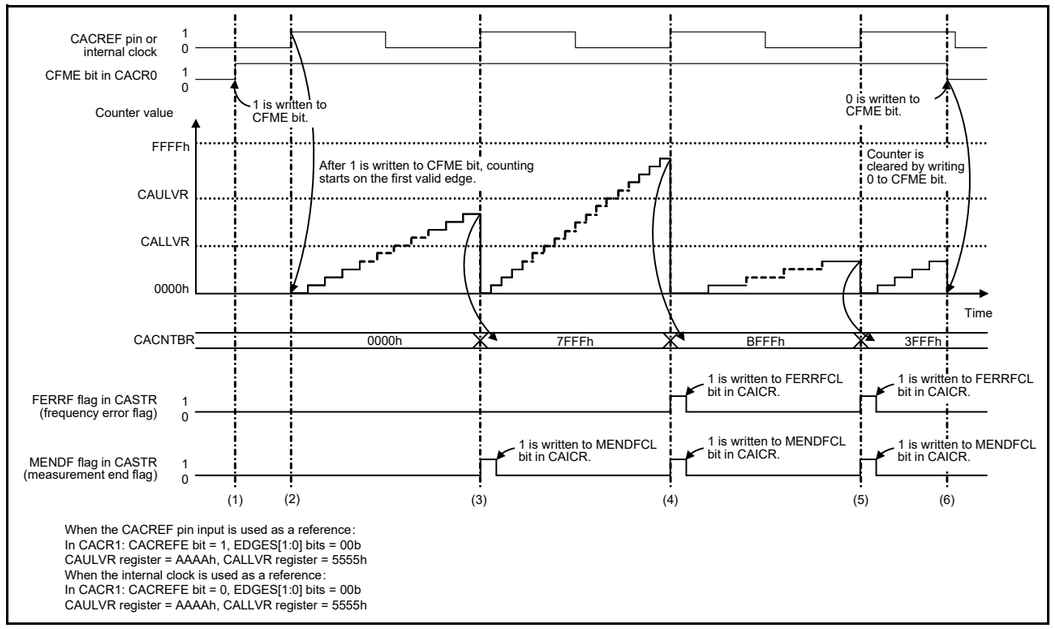

Figure 10.2 CAC operating example

In Figure 10.2:

1. Before writing 1 to CACR0.CFME, set CACR1 and CACR2 to define the measurement target clock and measurement reference clock. Writing 1 to the CACR0.CFME bit enables clock frequency measurement.
2. The timer starts counting up if the valid edge selected in the CACR1.EDGES[1:0] bits is input from the measurement reference clock. In Figure 10.2, the valid edge is a rising edge (CACR1.EDGES[1:0] = 00b).
3. When the next valid edge is input, the counter value is transferred to CACNTBR and compared with the values in CAULVR and CALLVR. If both CACNTBR ≤ CAULVR and CACNTBR ≥ CALLVR are true, only the MENDF flag in CASTR is set to 1, because the clock frequency is correct. If the MENDIE bit in CAICR is 1, a measurement end interrupt is generated.
4. When the next valid edge is input, the counter value is transferred to CACNTBR and compared with the values in CAULVR and CALLVR. If CACNTBR > CAULVR, the FERRF flag in CASTR is set to 1, because the clock frequency is erroneous. If the FERRIE bit in CAICR is 1, a frequency error interrupt is generated. The MENDF flag in CASTR is set to 1 at the end of measurement. If the MENDIE bit in CAICR is 1, a measurement end interrupt is generated.
5. When the next valid edge is input, the counter value is transferred to CACNTBR and compared with the values in CAULVR and CALLVR. If CACNTBR < CALLVR, the FERRF flag in CASTR is set to 1, because the clock frequency is erroneous. If the FERRIE bit in CAICR is 1, a frequency error interrupt is generated. The MENDF flag in CASTR is set to 1 at the end of measurement. If the MENDIE bit in CAICR is 1, a measurement end interrupt is generated.
6. When the CFME bit in CACR0 is 1, the counter value is transferred to CACNTBR and compared with the values in CAULVR and CALLVR every time a valid edge is input. Writing 0 to the CFME bit in CACR0 clears the counter and stops up-counting.

10.3.2 Digital Filtering of Signals on CACREF Pin

The CACREF pin has a digital filter, and levels on the CACREF pin are transmitted to the internal circuitry after three consecutive matches in the selected sampling interval. The same level continues to be transmitted internally until the level on the pin has three consecutive matches again. Enabling or disabling of the digital filter and its sampling clock are selectable.

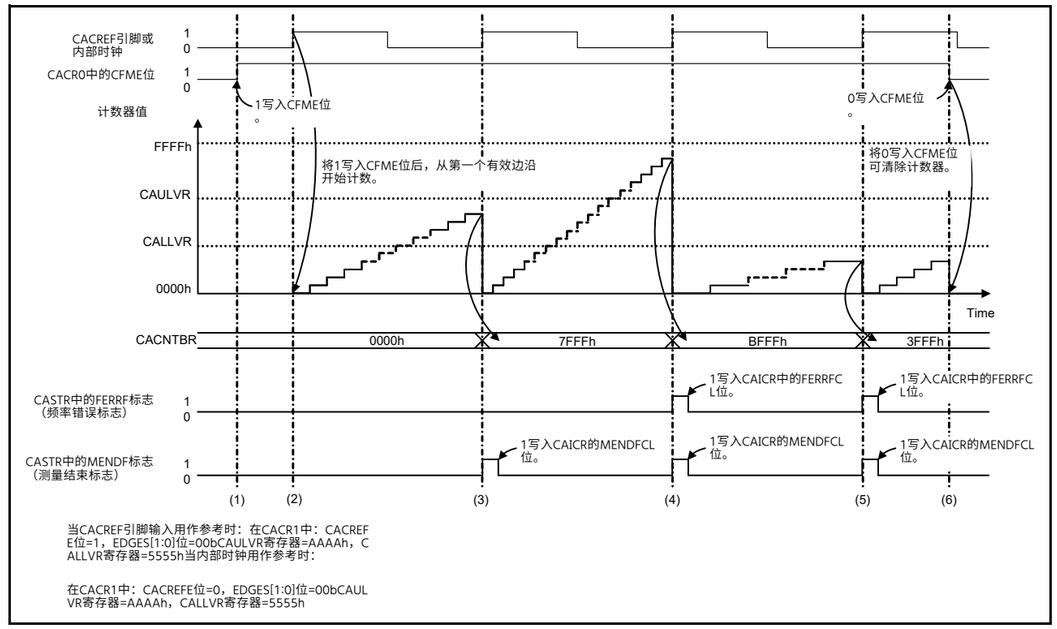

Figure 10.2 CAC操作示例

在图10.2中：

1. 在向CACR0.CFME写入1之前，设置CACR1和CACR2以定义测量目标时钟和测量参考时钟。向CACR0.CFME位写入1可启用时钟频率测量。
2. 如果在CACR1.EDGES[1:0]位中选择的有效边沿从测量参考时钟输入，则定时器开始计数。在图10.2中，有效边沿是上升沿(CACR1.EDGES[1:0]=00b)。
3. 当输入下一个有效边沿时，计数器值被传送到CACNTBR并与CAULVR和CALLVR中的值进行比较。如果CACNTBR≤CAULVR和CACNTBR≥CALLVR都为真，则只有CASTR中的MENDF标志设置为1，因为时钟频率是正确的。如果CAICR中的MENDIE位为1，则产生测量结束中断。
4. 当输入下一个有效边沿时，计数器值被传送到CACNTBR并与CAULVR和CALLVR中的值进行比较。如果CACNTBR>CAULVR，则CASTR中的FERRF标志设置为1，因为时钟频率错误。如果CAICR中的FERRIE位为1，则产生频率错误中断。CASTR中的MENDF标志在测量结束时设置为1。如果CAICR中的MENDIE位为1，则产生测量结束中断。
5. 当输入下一个有效边沿时，计数器值被传送到CACNTBR并与CAULVR和CALLVR中的值进行比较。如果CACNTBR<CALLVR，则CASTR中的FERRF标志设置为1，因为时钟频率错误。如果CAICR中的FERRIE位为1，则产生频率错误中断。CASTR中的MENDF标志在测量结束时设置为1。如果CAICR中的MENDIE位为1，则产生测量结束中断。
6. 当CACR0中的CFME位为1时，每次输入有效边沿时，计数器值被传送到CACNTBR并与CAULVR和CALLVR中的值进行比较。向CACR0中的CFME位写入0将清除计数器并停止向上计数。

10.3.2 CACREF引脚上的信号数字滤波

CACREF引脚有一个数字滤波器，CACREF引脚上的电平在选定的采样间隔内连续三个匹配后传输到内部电路。同一电平继续在内部传输，直到引脚上的电平再次连续匹配三个。可选择启用或禁用数字滤波器及其采样时钟。

The counter value transferred to CACNTBR might be in error by up to 1 cycle of the sampling clock because of the difference between the phases of the digital filter and the signal input to the CACREF pin. When a frequency dividing clock is selected as a count source clock, the counter value error is obtained using the following formula:

Counter value error = (1 cycle of the count source clock) / (1 cycle of the sampling clock)

10.4 Interrupt Requests

The CAC generates three types of interrupt requests:

- Frequency error interrupt
- Measurement end interrupt
- Overflow interrupt.

When an interrupt source is generated, the associated status flag becomes 1. Table 10.3 provides information on the CAC interrupt requests.

Table 10.3 CAC interrupt requests

Interrupt request	Interrupt enable bit	Status flag	Interrupt sources
Frequency error interrupt	CAICR.FERRIE	CASTR.FERRF	The result of comparing CACNTBR with CAULVR and CALLVR is either CACNTBR > CAULVR or CACNTBR < CALLVR
Measurement end interrupt	CAICR.MENDIE	CASTR.MENDF	• Valid edge is input from the CACREF pin or internal clock • Measurement end interrupt does not occur at the first valid edge after writing 1 to the CACR0.CFME bit.
Overflow interrupt	CAICR.OVFIE	CASTR.OVFF	The counter overflows

10.5 Usage Notes

10.5.1 Settings for the Module-Stop Function

The Module Stop Control Register C (MSTPCRC) can enable or disable CAC operation. The CAC module is initially stopped after reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

由于数字滤波器的相位和输入到CACREF引脚的信号之间的差异，传输到CACNTBR的计数器值可能会出现最多1个采样时钟周期的错误。Whenafrequencydividingclockisselectedasacountsourceclock thecountervaluee rrorisobtainedusingthefollowingformula:

计数器值误差=（计数源时钟的1个周期）（采样时钟的1个周期）

10.4 中断请求

CAC产生三种类型的中断请求：

- 频率错误中断
- 测量结束中断
- 溢出中断。

产生中断源时，相关的状态标志变为1。表10.3提供了有关CAC中断请求的信息。

Table 10.3 CAC中断请求

中断请求	中断使能位	状态标志	中断源
频率错误中断	CAICR.FERRIE	CASTR.FERRF	CACNTBR与CAULVR和CALLVR比较的结果是CACNTBR>CAULVR或CACNTBR<CALLVR
测量结束中断	CAICR.MENDIE	CASTR.MENDF	从CACREF引脚或内部时钟输入有效边沿 将1写入CACR0.CFME位后，在第一个有效边沿不会发生测量结束中断。
溢出中断	CAICR.OVFIE	CASTR.OVFF	计数器溢出

10.5 使用说明

10.5.1 模块停止功能的设置

模块停止控制寄存器C(MSTPCRC)可以启用或禁用CAC操作。CAC模块在复位后最初停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

11. Low Power Modes

11.1 Overview

The MCU provides several functions for reducing power consumption, such as setting clock dividers, stopping modules, selecting power control mode in normal mode, and transitioning to low power modes.

Table 11.1 lists the specifications of the low power mode functions. Table 11.2 lists the conditions to transition to low power modes, the states of the CPU and peripheral modules, and the method for canceling each mode. After a reset, the MCU enters the program execution state, but only the DMAC, DTC, and SRAM operate.

Table 11.1 Specifications of the low power mode functions

Parameter	Specifications
Reducing power consumption by switching clock signals	The frequency division ratio can be selected independently for the system clock (ICLK), peripheral module clocks (PCLKA, PCLKB, PCLKC, PCLKD), and flash interface clock (FCLK)*1
Module-stop state	Peripheral module functions can be stopped independently
Low power modes	• Sleep mode • Software Standby mode • Snooze mode • Deep Software Standby mode.
Power control modes	Power consumption can be reduced in Normal, Sleep, and Snooze modes by selecting an appropriate operating power control mode according to the operating frequency and voltage. Three operating power control modes are available: • High-speed mode • Low-speed mode • Subosc-speed mode.

Note 1. For details, see section 9, Clock Generation Circuit.

Table 11.2 Operating conditions of each low power mode (1 of 2)

Parameter	Sleep mode	Software Standby mode	Snooze mode*1	Deep Software Standby mode
Transition condition	WFI instruction while SBYCR.SSBY = 0	WFI instruction while SBYCR.SSBY = 1 and DPSBYCR.DPSBY = 0	Snooze request in Software Standby mode. SNZCR.SNZE = 1	WFI instruction while SBYCR.SSBY = 1 and DPSBYCR.DPSBY = 1
Canceling method	All interrupts. Any reset available in the mode.	Interrupts shown in Table 11.3. Any reset available in the mode.	Interrupts shown in Table 11.3. Any reset available in the mode.	Interrupts shown in Table 11.3. Any reset available in the mode.
State after cancellation by an interrupt	Program execution state (interrupt processing)	Program execution state (interrupt processing)	Program execution state (interrupt processing)	Reset state
State after cancellation by a reset	Reset state	Reset state	Reset state	Reset state
Main clock oscillator	Selectable	Stop	Selectable*2	Stop
Sub-clock oscillator	Selectable	Selectable	Selectable	Selectable
High-speed on-chip oscillator	Selectable	Stop	Selectable	Stop
Middle-speed on-chip oscillator	Selectable	Stop	Selectable	Stop
Low-speed on-chip oscillator	Selectable	Selectable	Selectable	Selectable*3
IWDT-dedicated on-chip oscillator	Selectable*5	Selectable*5	Selectable*5	Stop
PLL	Selectable	Stop	Selectable*2	Stop
Oscillation stop detection function	Selectable	Operation prohibited	Operation prohibited	Operation prohibited
Clock/buzzer output function	Selectable	Selectable*4	Selectable	Stop (Undefined)

11. 低功耗模式

11.1 Overview

MCU提供了多种降低功耗的功能，例如设置时钟分频器、停止模块、在正常模式下选择电源控制模式以及转换到低功耗模式。

表11.1列出了低功耗模式功能的规格。表11.2列出了转换到低功耗模式的条件、CPU和外围模块的状态以及取消每种模式的方法。复位后，MCU进入程序执行状态，但只有DMAC、DTC和SRAM运行。

Table 11.1 低功耗模式功能的规格

Parameter	Specifications
通过切换时钟信号降低功耗	分频比可以独立选择系统时钟（ICLK）、外围模块时钟（PCLKA、PCLKB、PCLKC、PCLKD）和闪存接口时钟（FCLK）*1
Module-stop state	外围模块功能可独立停止
低功耗模式	睡眠模式 软件待机模式 贪睡模式 深度软件待机模式。
电源控制模式	通过根据工作频率和电压选择合适的工作功率控制模式，可以降低Normal、Sleep和Snooze模式下的功耗。提供三种工作功率控制模式： 高速模式 低速模式 Subosc速度模式。

Note 1. 有关详细信息，请参见第9节，时钟生成电路。

Table 11.2 每种低功耗模式的运行条件（2个中的1个）

Parameter	睡眠模式	软件待机模式	Snooze mode*1	深度软件待机模式
过渡条件	WFI指令同时 SBYCR.SSBY = 0	WFI指令同时 SBYCR.SSBY = 1 and DPSBYCR.DPSBY = 0	软件待机模式下的贪睡请求。 SNZCR.SNZE = 1	WFI指令同时 SBYCR.SSBY = 1 and DPSBYCR.DPSBY = 1
取消方法	所有中断。 该模式下可用的任何复位。	中断如表11.3所示。该模式下可用的任何复位。	中断如表11.3所示。该模式下可用的任何复位。	中断如表11.3所示。该模式下可用的任何复位。
中断取消后的状态	程序执行状态（中断处理）	程序执行状态（中断处理）	程序执行状态（中断处理）	重置状态
通过复位取消后的状态	重置状态	重置状态	重置状态	重置状态
主时钟振荡器	Selectable	Stop	Selectable*2	Stop
Sub-clock oscillator	Selectable	Selectable	Selectable	Selectable
High-speed on-chip oscillator	Selectable	Stop	Selectable	Stop
Middle-speed on-chip oscillator	Selectable	Stop	Selectable	Stop
Low-speed on-chip oscillator	Selectable	Selectable	Selectable	Selectable*3
IWDT-dedicated on-chip oscillator	Selectable*5	Selectable*5	Selectable*5	Stop
PLL	Selectable	Stop	Selectable*2	Stop
振荡停止检测功能	Selectable	禁止操作	禁止操作	禁止操作
时钟蜂鸣器输出功能	Selectable	Selectable*4	Selectable	Stop (Undefined)

Table 11.2 Operating conditions of each low power mode (2 of 2)

Parameter	Sleep mode	Software Standby mode	Snooze mode*1	Deep Software Standby mode
CPU	Stop (Retained)	Stop (Retained)	Stop (Retained)	Stop (Undefined)
SRAMHS	Selectable	Stop (Retained)	Selectable	Stop (Undefined)
Flash memory	Operating	Stop (Retained)	Stop (Retained)	Stop (Retained)
DMA Controller (DMAC)	Selectable	Stop (Retained)	Operation prohibited	Stop (Undefined)
Data Transfer Controller (DTC)	Selectable	Stop (Retained)	Selectable	Stop (Undefined)
Watchdog Timer (WDT)	Selectable*5	Stop (Retained)	Stop (Retained)	Stop (Undefined)
Independent Watchdog Timer (IWDT)	Selectable*5	Selectable*5	Selectable *5	Stop (Undefined)
Low Power Asynchronous General Purpose Timer (AGTn, n = 0, 1)	Selectable	Selectable*6	Selectable*6	Selectable*6
12-bit A/D Converter (ADC12)	Selectable	Stop (Retained)	Selectable*15	Stop (Undefined)
Programmable Gain Amplifiers (PGAs)	Selectable*16	Selectable*16	Selectable*16	Stop (Undefined)
12-bit D/A Converter (DAC12)	Selectable	Stop (Retained)	Selectable	Stop (Undefined)
Data Operation Circuit (DOC)	Selectable	Stop (Retained)	Selectable	Stop (Undefined)
Serial Communications Interface (SCI0)	Selectable	Stop (Retained)	Selectable (RXD0 falling edge is available to enter Snooze mode) (only in asynchronous mode).*11	Stop (Undefined)
Serial Communications Interface (SCIn, n = 1 to 4, 8, 9)	Selectable	Stop (Retained)	Operation prohibited	Stop (Undefined)
I2C Bus Interface (IIC0)	Selectable	Selectable*10	Selectable*10	Stop (Undefined)
I2C Bus Interface (IIC1)	Selectable	Stop (Retained)	Operation prohibited	Stop (Undefined)
Event Link Controller (ELC)	Selectable	Stop (Retained)	Selectable*7	Stop (Undefined)
High-Speed Analog Comparator (ACMPHS0)	Selectable	Selectable*9	Selectable. VCOUT function only.*9	Stop (Undefined)
High-Speed Analog Comparator (ACMPHSn, n = 1 to 5)	Selectable	Selectable*8	Selectable. VCOUT function only.*8	Stop (Undefined)
IRQn (n = 0 to 13) pin interrupt	Selectable	Selectable	Selectable	Stop (Undefined)
NMI, IRQn-DS (n = 0, 1, 4 to 12) pin interrupt	Selectable	Selectable	Selectable	Selectable
Key Interrupt Function (KINT)	Selectable	Selectable	Selectable	Stop (Undefined)
Low voltage detection (LVD)	Selectable	Selectable	Selectable	Selectable*12
Power-on reset circuit	Operating	Operating	Operating	Operating*13
Other peripheral modules	Selectable	Stop (Retained)	Operation prohibited	Stop (Undefined)
I/O ports	Operating	Retained*14	Operating	Retained*14

Note: Selectable means that operating or not operating can be selected in the control registers.
Stop (Retained) means that the contents of the internal registers are retained but the operations are suspended.
Operation prohibited means that the function must be stopped before entering Software Standby mode.

Table 11.2 每种低功耗模式的操作条件（2个中的2个）

Parameter	睡眠模式	软件待机模式	Snooze mode*1	深度软件待机模式
CPU	Stop (Retained)	Stop (Retained)	Stop (Retained)	Stop (Undefined)
SRAMHS	Selectable	Stop (Retained)	Selectable	Stop (Undefined)
闪存	Operating	Stop (Retained)	Stop (Retained)	Stop (Retained)
DMA Controller (DMAC)	Selectable	Stop (Retained)	禁止操作	Stop (Undefined)
数据传输控制器(DTC)	Selectable	Stop (Retained)	Selectable	Stop (Undefined)
看门狗定时器(WDT)	Selectable*5	Stop (Retained)	Stop (Retained)	Stop (Undefined)
独立看门狗 Timer (IWDT)	Selectable*5	Selectable*5	Selectable *5	Stop (Undefined)
低电量 异步通用 用途定时器(AGTn n=0 1)	Selectable	Selectable*6	Selectable*6	Selectable*6
12-bit A/D Converter (ADC12)	Selectable	Stop (Retained)	Selectable*15	Stop (Undefined)
可编程增益 Amplifiers (PGAs)	Selectable*16	Selectable*16	Selectable*16	Stop (Undefined)
12-bit D/A Converter (DAC12)	Selectable	Stop (Retained)	Selectable	Stop (Undefined)
数据运算电路(DOC)	Selectable	Stop (Retained)	Selectable	Stop (Undefined)
串行通信 Interface (SCI0)	Selectable	Stop (Retained)	可选（RXD0下降沿可用于进入贪睡模式）（仅在异步模式下）。*11	Stop (Undefined)
串行通信接口（SCIn，n =1至4、8、9）	Selectable	Stop (Retained)	禁止操作	Stop (Undefined)
I2C总线接口(IIC0)	Selectable	Selectable*10	Selectable*10	Stop (Undefined)
I2C总线接口(IIC1)	Selectable	Stop (Retained)	禁止操作	Stop (Undefined)
事件链接控制器(ELC)	Selectable	Stop (Retained)	Selectable*7	Stop (Undefined)
High-Speed Analog Comparator (ACMPHS0)	Selectable	Selectable*9	Selectable. VCOUT function only.*9	Stop (Undefined)
High-Speed Analog 比较器（ACMPHSn，n= 1至5）	Selectable	Selectable*8	Selectable. VCOUT function only.*8	Stop (Undefined)
IRQn(n=0to13)引脚中断	Selectable	Selectable	Selectable	Stop (Undefined)
NMI IRQn-DS(n=0 1 4to 12)引脚中断	Selectable	Selectable	Selectable	Selectable
按键中断功能(KINT)	Selectable	Selectable	Selectable	Stop (Undefined)
低电压检测(LVD)	Selectable	Selectable	Selectable	Selectable*12
上电复位电路	Operating	Operating	Operating	Operating*13
其他外围模块	Selectable	Stop (Retained)	禁止操作	Stop (Undefined)
I/O ports	Operating	Retained*14	Operating	Retained*14

Note: 可选意味着可以在控制寄存器中选择操作或不操作。
停止（Retained）表示内部寄存器的内容被保留但操作被暂停。
禁止操作意味着在进入软件待机模式之前必须停止该功能。

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Stop (Undefined) means that the contents of the internal registers are undefined and power to the internal circuit is cut off.

Note 1. All modules whose module-stop bits are 0 start as soon as PCLKs are supplied after entering Snooze mode. To avoid an increase in power consumption in Snooze mode, set the module-stop bit of modules that are not required in Snooze mode to 1 before entering Software Standby mode.

Note 2. When using SCI0 in Snooze mode, MOSCCR.MOSTP and PLLCR.PLLSTP bits must be 1.

Note 3. If the DPSBYCR.DEEPCUT[1:0] bits are 00b, the oscillator status is the same as before entering Deep Software Standby mode. When the DPSBYCR.DEEPCUT[1:0] bits are not 00b, the oscillator stops when the MCU enters Deep Software Standby mode.

Note 4. Stopped when the Clock Output Source Select bits (CKOCR.CKOSEL[2:0]) are set to a value other than 010b (LOCO) and 100b (SOSC).

Note 5. In IWDT-dedicated on-chip oscillator and IWDT, operating or stopping is selected by setting the IWDT Stop Control bit (IWDTSTPCTL) in Option Function Select register 0 (OFS0) in IWDT auto start mode. In WDT, operating or stopping is selected by setting the WDT Stop Control bit (WDTSTPCTL) in Option Function Select Register 0 (OFS0) in WDT auto start mode.

Note 6. AGT0 operation is possible when 100b (AGTLCLK) or 110b (AGTSCLK) is selected in the AGT0.AGTMR1.TCK[2:0] bits.
AGT1 operation is possible when 100b (AGTLCLK), 110b (AGTSCLK), or 101b (underflow event signal from AGT0) is selected in the AGT1.AGTMR1.TCK[2:0] bits.
When 100b (AGTLCLK) is selected in AGTn.AGTMR1.TCK[2:0] bits (n = 0, 1), the DPSBYCR.DEEPCUT[1:0] bits must be set to 00b before entering Deep Software Standby mode.

Note 7. Event lists the restrictions described in section 11.10.13, ELC Events in Snooze Mode.

Note 8. Only VCOUT function is permitted. The VCOUT pin operates when ACMPHS uses no digital filter.
For details on digital filter, see section 38, High-Speed Analog Comparator (ACMPHS).

Note 9. When CMPCTL0.CSTEN bit is 1, canceling Software Standby Mode or entering Snooze mode by the comparator detection is available.

Note 10. IIC0 wakeup interrupt is available.

Note 11. Serial communication mode of SCI0 is asynchronous mode.

Note 12. When using LVD in Deep Software Standby mode, DPSBYCR.DEEPCUT[1:0] bits must be 00b or 01b before entering Deep Software Standby mode.

Note 13. When the MCU enters Deep Software Standby mode with the DPSBYCR.DEEPCUT[1:0] bits set to 11b, the LVD circuit stops and the low power function of the power-on reset circuit is enabled.

Note 14. For the address bus and bus control signals (for SRAM: CS0, CS1, CS4 to CS7, RD, WR0, and ALE), keeping the output state or changing to the high-impedance state can be selected in the SBYCR.OPE bit.

Note 15. When using the 12-bit A/D Converter in Snooze mode, the ADCMPCR.CMPAE and ADCMPCR.CMPBE bits must be 1.

Note 16. When using the Programmable Gain Amplifiers, MSTPDn (n = 15, 16) must be set to 0. For details, see section 35.3.12, Programmable Gain Amplifiers.

Table 11.3 Interrupt sources for canceling Snooze, Software Standby, and Deep Software Standby modes

Interrupt source	Name	Software Standby mode	Snooze mode	Deep Software Standby mode
NMI		Yes	Yes	Yes
Port	PORT_IRQn (n = 0 to 13)	Yes	Yes	No
	PORT_IRQn-DS (n = 0, 1, 4 to 12)	Yes	Yes	Yes
LVD	LVD_LVD1	Yes	Yes	Yes
	LVD_LVD2	Yes	Yes	Yes
IWDT	IWDT_NMIUNDF	Yes	Yes	No
KINT	KEY_INTKR	Yes	Yes	No
AGT1	AGT1_AGTI	Yes	Yes*3	Yes
	AGT1_AGTCMAI	Yes	Yes	No
	AGT1_AGTCMBI	Yes	Yes	No
ACMPHS	ACMP_HS0	Yes	Yes	No
IIC0	IIC0_WUI	Yes	Yes	No
ADC12n (n = 0, 1)	ADC12n_WCMPM	No	Yes with SELSR0*1,*3	No
	ADC12n_WCMPUM	No	Yes with SELSR0*1,*3	No
SCI0	SCI0_AM	No	Yes with SELSR0*1,*2	No
	SCI0_RXI_OR_ERI	No	Yes with SELSR0*1,*2	No
DTC	DTC_COMPLETE	No	Yes with SELSR0*1,*3	No
DOC	DOC_DOPCI	No	Yes with SELSR0*1	No

停止（未定义）表示内部寄存器的内容未定义，内部电路的电源被切断。

Note 1. 进入贪睡模式后，一旦提供PCLK，所有模块停止位为0的模块都会启动。为避免贪睡模式下的功耗增加，请在进入软件待机模式之前将贪睡模式下不需要的模块的模块停止位设置为1。

Note 2. 在贪睡模式下使用SCI0时，MOSCCR.MOSTP和PLLCR.PLLSTP位必须为1。

Note 3. 如果DPSBYCR.DEEPCUT[1:0]位为00b，则振荡器状态与进入深度软件待机模式之前相同。当DPSBYCR.DEEPCUT[1:0]位不为00b时，当MCU进入深度软件待机模式时振荡器停止。

Note 4. 当时钟输出源选择位(CKOCR.CKOSEL[2:0])设置为010b(LOCO)和100b(SOSC)以外的值时停止。

Note 5. 在IWDT专用内部振荡器和IWDT中，在IWDT自动启动模式下，通过设置选项功能选择寄存器0(OFS0)中的IWDT停止控制位(IWDTSTPCL)来选择操作或停止。在WDT中，通过在WDT自动启动模式下设置选项功能选择寄存器0(OFS0)中的WDT停止控制位(WDTSTPCTL)来选择操作或停止。

Note 6. 当在AGT0.AGTMR1.TCK[2:0]位中选择100b(AGTLCLK)或110b(AGTSCLK)时，可以进行AGT0操作。
当在AGT1.AGTMR1.TCK[2:0]位中选择100b(AGTLCLK)、110b(AGTSCLK)或101b（来自AGT0的下溢事件信号）时，可以进行AGT1操作。当在AGTn.AGTMR1.TCK[2:0]位(n=0 1)中选择100b(AGTLCLK)时，DPSBYCR.DEEPCUT[1:0]位必须在进入深度软件待机模式之前设置为00b。

Note 7. 事件列出了第11.10.13节"贪睡模式下的ELC事件"中描述的限制。

Note 8. 仅允许使用VCOUT功能。当ACMPHS不使用数字滤波器时，VCOUT引脚工作。
有关数字滤波器的详细信息，请参见第38节，高速模拟比较器(ACMPHS)。

注9.当CMPCTL0.CSTEN位为1时，可以通过比较器检测取消软件待机模式或进入贪睡模式。注10.IIC0唤醒中断可用。

注11.SCI0的串行通信模式为异步模式。

注12.在深度软件待机模式下使用LVD时，DPSBYCR.DEEPCUT[1:0]位必须为00b或01b，然后才能进入深度软件待机模式。

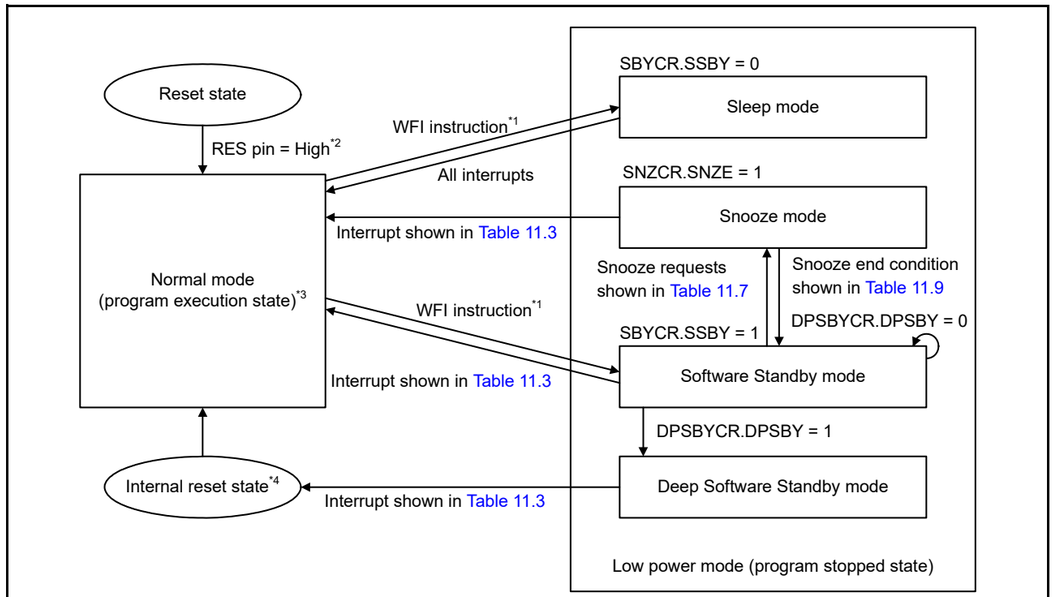
注13.当MCU进入深度软件待机模式且DPSBYCR.DEEPCUT[1:0]位设置为11b时，LVD电路停止并启用上电复位电路的低功耗功能。注14.对于地址总线和总线控制信号（对于SRAM：CS0、CS1、CS4到CS7、RD、WR0和ALE），可以在SBYCR中选择保持输出状态或变为高阻状态。OPE位。注15.在贪睡模式下使用12位AD转换器时，ADCMPCR.CMPAE和ADCMPCR.CMPBE位必须为1。注16.当使用可编程增益放大器时，MSTPDn(n=15 16)必须设置为0.详见35.3.12节，

可编程增益放大器。

Table 11.3 用于取消贪睡、软件待机和深度软件待机模式的中断源

中断源	Name	软件待机模式	贪睡模式	深度软件待机模式
NMI		Yes	Yes	Yes
Port	PORT_IRQn (n = 0 to 13)	Yes	Yes	No
	PORT_IRQn-DS (n = 0, 1, 4 to 12)	Yes	Yes	Yes
LVD	LVD_LVD1	Yes	Yes	Yes
	LVD_LVD2	Yes	Yes	Yes
IWDT	IWDT_NMIUNDF	Yes	Yes	No
KINT	KEY_INTKR	Yes	Yes	No
AGT1	AGT1_AGTI	Yes	Yes*3	Yes
	AGT1_AGTCMAI	Yes	Yes	No
	AGT1_AGTCMBI	Yes	Yes	No
ACMPHS	ACMP_HS0	Yes	Yes	No
IIC0	IIC0_WUI	Yes	Yes	No
ADC12n (n = 0, 1)	ADC12n_WCMPM	No	是SELSR0*1 *3	No
	ADC12n_WCMPUM	No	是SELSR0*1 *3	No
SCI0	SCI0_AM	No	是SELSR0*1 *2	No
	SCI0_RXI_OR_ERI	No	是SELSR0*1 *2	No
DTC	DTC_COMPLETE	No	是SELSR0*1 *3	No
DOC	DOC_DOPCI	No	是SELSR0*1	No

Note 1. To use the interrupt request as a trigger for exiting Snooze mode, the request must be selected in SELSR0. See section 13, Interrupt Controller Unit (ICU). When a trigger selected in SELSR0 occurs after executing a WFI instruction and during transition from Normal to Software Standby mode, whether the request can be accepted depends on the timing of the occurrence.
Note 2. Only one of either SCI0_AM or SCI0_RXI_OR_ERI can be selected.
Note 3. The event that is enabled by the SNZEDCR register must not be used.



Note 1. When an interrupt that acts as a trigger for cancel is received during a transition to the program-stopped state after the execution of a WFI instruction, the MCU executes interrupt exception handling instead of transitioning to low power mode.
Note 2. The MOCO clock is the source of the operating clock following a transition from the reset state to Normal mode.
Note 3. The transition to Normal mode is made from an interrupt in Sleep mode, Snooze mode, or Software Standby mode. The clock source is the same as before entering the low power mode.
Note 4. When an available interrupt request is generated, an internal reset (Deep Software Standby reset) is generated over a fixed period. Canceling of Deep Software Standby mode accompanies release from the internal reset state, and the MCU transitions to Normal mode and executes a reset exception processing with the MOCO clock as the source of the operating clock.

Figure 11.1 Mode transitions

11.2 Register Descriptions

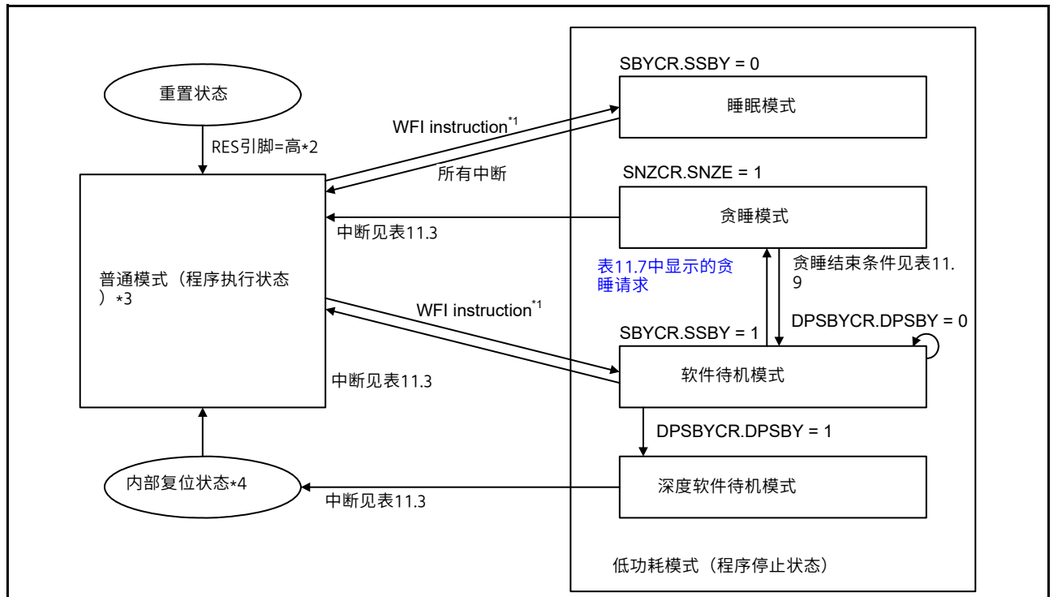
11.2.1 Standby Control Register (SBYCR)

Address(es): SYSTEM.SBYCR 4001 E00Ch

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SSBY	OPE	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b13 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. 要将中断请求用作退出贪睡模式的触发器，必须在SELSR0中选择该请求。见第13节，中断控制器单元（ICU）。当在SELSR0中选择的触发发生在执行WFI指令之后以及从正常模式到软件待机模式的转换期间，是否可以接受请求取决于发生的时间。
Note 2. 只能选择SCI0_AM或SCI0_RXI_OR_ERI之一。
Note 3. 不得使用由SNZEDCR寄存器启用的事件。



Note 1. 当在执行WFI指令后转换到程序停止状态期间接收到用作取消触发器的中断时，MCU执行中断异常处理，而不是转换到低功耗模式。
Note 2. MOCO时钟是从复位状态转换到正常模式后的工作时钟源。
Note 3. 通过休眠模式、贪睡模式或软件待机模式下的中断转换到正常模式。时钟源与进入低功耗模式前相同。
Note 4. 当产生可用中断请求时，会在固定周期内产生内部复位（深度软件待机复位）。深度软件待机模式的取消伴随着内部复位状态的释放，MCU转换到正常模式并以MOCO时钟作为工作时钟源执行复位异常处理。

Figure 11.1 模式转换

11.2 注册说明

11.2.1 待机控制寄存器(SBYCR)

Address(es): SYSTEM.SBYCR 4001 E00Ch

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SSBY	OPE	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b13 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b14	OPE	Output Port Enable	0: In Software Standby or Deep Software Standby mode, set the address bus and bus control signals to the high-impedance state. In Snooze mode, the status of the address bus and bus control signals are the same as before entering Software Standby mode. 1: In Software Standby or Deep Software Standby mode, retain the output state of the address bus and bus control signals.	R/W
b15	SSBY	Software Standby	0: Sleep mode 1: Software Standby mode when DPSBYCR.DPSBY = 0 and Deep Software Standby mode when DPSBYCR.DPSBY = 1.	R/W

OPE bit (Output Port Enable)

The OPE bit specifies whether to set to the high-impedance state or to retain the output of the address bus and bus control signals (for SRAM: CS0, CS1, CS4 to CS7, RD, WR0, and ALE) in Software Standby mode or Deep Software Standby mode.

SSBY bit (Software Standby)

The SSBY bit specifies the transition destination after a WFI instruction is executed.

When the SSBY bit is set to 1, the MCU enters Software Standby mode after executing a WFI instruction. When the MCU cancels Software Standby mode by an interrupt, the SSBY bit remains 1. The SSBY bit can be cleared by writing 0 to it.

When the OSTDCR.OSTDE bit is 1, the setting of SSBY bit is ignored. Even if the SSBY bit is 1, the MCU enters Sleep mode on execution of a WFI instruction.

When the FENTRYR.FENTRYi bit (i = 0 to 3) is 1 or the FENTRYR.FENTRYD bit is 1, the setting of SSBY bit is ignored. Even if the SSBY bit is 1, the MCU enters Sleep mode on execution of a WFI instruction. See Table 11.6 for details.

When using the HOCO clock to enter Software Standby mode, STCONR.STCON[1:0] must be set to 00b and HOCOWTCR.HSTS[2:0] must be set to 110b. However, when using SCI0 in Snooze mode, HOCOWTCR.HSTS[2:0] must be set to 010b.

11.2.2 Module Stop Control Register A (MSTPCRA)

Address(es): SYSTEM.MSTPCRA 4001 E01Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	MSTPA22	—	—	—	—	—	—
Value after reset:	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	MSTPA5	—	—	—	—	—
Value after reset:	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	0

Bit	Symbol	Bit name	Description	R/W
b0	—	Reserved	The write value should be 1.	R/W
b4 to b1	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b5	MSTPA5	High-Speed SRAM Module Stop	Target module: high-speed SRAM 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b7, b6	—	Reserved	The write value should be 1.	R/W
b21 to b8	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b22	MSTPA22	DMA Controller/Data Transfer Controller Module Stop*2	Target modules: DMAC, DTC 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W

Bit	Symbol	位名称	Description	R/W
b14	OPE	输出端口使能	0：在软件待机或深度软件待机模式下，设置 地址总线和总线控制信号为高阻状态。在贪睡模式下，地址总线和总线控制信号的状态与进入软件待机模式前相同。1：在软件待机或深度软件待机模式下，保持地址总线和总线控制信号的输出状态。	R/W
b15	SSBY	软件待机	0：休眠模式1：当DPSBYCR.DPSBY=0时为软件待机模式，当DPSBYCR.DPSBY=1时为深度软件待机模式。	R/W

OPE位（输出端口使能）

OPE位指定在软件待机模式下是设置为高阻状态还是保留地址总线和总线控制信号的输出（对于SRAM：CS0、CS1、CS4到CS7、RD、WR0和ALE）或深度软件待机模式。

SSBY位（软件待机）

SSBY位指定执行WFI指令后的转移目标。

当SSBY位设置为1时，MCU在执行WFI指令后进入软件待机模式。当。。。的时候
MCU通过中断取消软件待机模式，SSBY位保持为1。SSBY位可以通过向其写入0来清除。

当OSTDCR.OSTDE位为1时，忽略SSBY位的设置。即使SSBY位为1，MCU也会在执行WFI指令时进入休眠模式。

当FENTRYR.FENTRYi位（i=0到3）为1或FENTRYR.FENTRYD位为1时，忽略SSBY位的设置。即使SSBY位为1，MCU也会在执行WFI指令时进入休眠模式。详见表11.6。

当使用HOCO时钟进入软件待机模式时，STCONR.STCON[1:0]必须设置为00b并且HOCOWTCR.HSTS[2:0]必须设置为110b。但是，在贪睡模式下使用SCI0时，HOCOWTCR.HSTS[2:0]必须设置为010b。

11.2.2 模块停止控制寄存器A(MSTPCRA)

Address(es): SYSTEM.MSTPCRA 4001 E01Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	MSTPA22	—	—	—	—	—	—
重置后的值：	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	MSTPA5	—	—	—	—	—
重置后的值：	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	0

Bit	Symbol	位名称	Description	R/W
b0	—	Reserved	写入值应为1。	R/W
b4 to b1	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b5	MSTPA5	High-Speed SRAM Module Stop	目标模块：高速SRAM0：取消模块停止状态1：进入模块停止状态。	R/W
b7, b6	—	Reserved	写入值应为1。	R/W
b21 to b8	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b22	MSTPA22	DMA Controller/Data 传输控制器模块 Stop*2	目标模块：DMAC，DTC0：取消模块停止状态1：进入模块停止状态。	R/W

Bit	Symbol	Bit name	Description	R/W
b31 to b23	—	Reserved	These bits are read as 1. The write value should be 1.	R/W

Note 1. Bit [0] and bit [6] settings must be the same.
Note 2. When rewriting the MSTPA22 bit from 0 to 1, disable the DMAC and DTC before setting the MSTPA22 bit.

11.2.3 Module Stop Control Register B (MSTPCRB)

Address(es): MSTP.MSTPCRB 4004 7000h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MSTPB31	MSTPB30	MSTPB29	MSTPB28	MSTPB27	—	—	—	MSTPB23	MSTPB22	—	—	MSTPB19	MSTPB18	—	—
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	MSTPB9	MSTPB8	—	—	MSTPB5	—	—	MSTPB2	—	—
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b2	MSTPB2	Controller Area Network 0 Module Stop*1	Target module: CAN0 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b4, b3	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b5	MSTPB5	IrDA Module Stop	Target module: IrDA 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b7, b6	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b8	MSTPB8	I²C Bus Interface 1 Module Stop	Target module: IIC1 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b9	MSTPB9	I²C Bus Interface 0 Module Stop	Target module: IIC0 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b17 to b10	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b18	MSTPB18	Serial Peripheral Interface 1 Module Stop	Target module: SPI1 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b19	MSTPB19	Serial Peripheral Interface 0 Module Stop	Target module: SPI0 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b21, b20	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b22	MSTPB22	Serial Communication Interface 9 Module Stop	Target module: SCI9 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b23	MSTPB23	Serial Communication Interface 8 Module Stop	Target module: SCI8 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b26 to b24	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b27	MSTPB27	Serial Communication Interface 4 Module Stop	Target module: SCI4 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W

Bit	Symbol	位名称	Description	R/W
b31 to b23	—	Reserved	这些位被读取为1。写入值应为1。	R/W

Note 1. 位[0]和位[6]设置必须相同。
Note 2. 将MSTPA22位从0重写为1时，在设置MSTPA22位之前禁用DMAC和DTC。

11.2.3 模块停止控制寄存器B(MSTPCRB)

Address(es): MSTP.MSTPCRB 4004 7000h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MSTPB31	MSTPB30	MSTPB29	MSTPB28	MSTPB27	—	—	—	MSTPB23	MSTPB22	—	—	MSTPB19	MSTPB18	—	—
重置后的值:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	MSTPB9	MSTPB8	—	—	MSTPB5	—	—	MSTPB2	—	—
重置后的值:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b2	MSTPB2	控制器局域网0模块 Stop*1	目标模块：CAN00：取消模块停止状态1：进入模块停止状态。	R/W
b4, b3	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b5	MSTPB5	IrDA模块停止	目标模块：IrDA0：取消模块停止状态1：进入模块停止状态。	R/W
b7, b6	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b8	MSTPB8	I2C总线接口1模块停止	目标模块：IIC10：取消模块停止状态1：进入模块停止状态。	R/W
b9	MSTPB9	I2C总线接口0模块停止	目标模块：IIC00：取消模块停止状态1：进入模块停止状态。	R/W
b17 to b10	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b18	MSTPB18	串行外设接口1模块 Stop	目标模块：SPI10：取消模块停止状态1：进入模块停止状态。	R/W
b19	MSTPB19	串行外设接口0模块 Stop	目标模块：SPI00：取消模块停止状态1：进入模块停止状态。	R/W
b21, b20	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b22	MSTPB22	串行通讯接口9 模块停止	目标模块：SCI90：取消模块停止状态1：进入模块停止状态。	R/W
b23	MSTPB23	串行通讯接口8 模块停止	目标模块：SCI80：取消模块停止状态1：进入模块停止状态。	R/W
b26 to b24	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b27	MSTPB27	串行通讯接口4 模块停止	目标模块：SCI40：取消模块停止状态1：进入模块停止状态。	R/W

Bit	Symbol	Bit name	Description	R/W
b28	MSTPB28	Serial Communication Interface 3 Module Stop	Target module: SCI3 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b29	MSTPB29	Serial Communication Interface 2 Module Stop	Target module: SCI2 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b30	MSTPB30	Serial Communication Interface 1 Module Stop	Target module: SCI1 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b31	MSTPB31	Serial Communication Interface 0 Module Stop	Target module: SCI0 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W

Note 1. The MSTPBi bit must be written while the oscillation of the clock controlled by this bit is stable. To enter Software Standby mode after writing to this bit, wait for 2 CAN clock (CANMCLK) cycles after writing, then execute a WFI instruction (i = 1, 2).

11.2.4 Module Stop Control Register C (MSTPCRC)

Address(es): MSTP.MSTPCRC 4004 7004h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MSTPC 31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	MSTPC 14	MSTPC 13	—	—	—	—	—	—	—	—	—	—	—	MSTPC 1	MSTPC 0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Symbol	Bit name	Description	R/W
b0	MSTPC0*1	Clock Frequency Accuracy Measurement Circuit Module Stop	Target module: CAC 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b1	MSTPC1	Cyclic Redundancy Check Calculator Module Stop	Target module: CRC 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b12 to b2	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b13	MSTPC13	Data Operation Circuit Module Stop	Target module: DOC 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b14	MSTPC14	Event Link Controller Module Stop	Target module: ELC 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b30 to b15	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b31	MSTPC31	SCE7 Module Stop	Target module: SCE7 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W

Note 1. The MSTPC0 bit must be written while the oscillation of the clock controlled by this bit is stable. To enter Software Standby mode after writing to this bit, wait for 2 cycles of the slowest clock from the clocks output by the oscillators, then execute a WFI instruction.

Bit	Symbol	位名称	Description	R/W
b28	MSTPB28	串行通讯接口3 模块停止	目标模块：SCI30：取消模块停止状态1：进入模块停止状态。	R/W
b29	MSTPB29	串行通讯接口2 模块停止	目标模块：SCI20：取消模块停止状态1：进入模块停止状态。	R/W
b30	MSTPB30	串行通讯接口1 模块停止	目标模块：SCI10：取消模块停止状态1：进入模块停止状态。	R/W
b31	MSTPB31	串行通讯接口0 模块停止	目标模块：SCI00：取消模块停止状态1：进入模块停止状态。	R/W

Note 1. MSTPBi位必须在该位控制的时钟振荡稳定时写入。要在写入该位后进入软件待机模式，写入后等待2个CAN时钟(CANMCLK)周期，然后执行WFI指令(i=1 2)。

11.2.4 模块停止控制寄存器C(MSTPCRC)

Address(es): MSTP.MSTPCRC 4004 7004h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MSTPC 31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	MSTPC 14	MSTPC 13	—	—	—	—	—	—	—	—	—	—	—	MSTPC 1	MSTPC 0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Symbol	位名称	Description	R/W
b0	MSTPC0*1	时钟频率 精度测量 电路模块停止	目标模块：CAC0：取消模块停止状态1：进入模块停止状态。	R/W
b1	MSTPC1	循环冗余 检查计算器模块 Stop	目标模块：CRC0：取消模块停止状态1：进入模块停止状态。	R/W
b12 to b2	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b13	MSTPC13	数据运算电路 模块停止	目标模块：DOC0：取消模块停止状态1：进入模块停止状态。	R/W
b14	MSTPC14	事件链接控制器 模块停止	目标模块：ELC0：取消模块停止状态1：进入模块停止状态。	R/W
b30 to b15	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b31	MSTPC31	SCE7模块停止	目标模块：SCE70：取消模块停止状态1：进入模块停止状态。	R/W

Note 1. 必须在该位控制的时钟振荡稳定时写入MSTPC0位。要在写入该位后进入软件待机模式，请等待振荡器输出时钟中最慢时钟的2个周期，然后执行WFI指令。

11.2.5 Module Stop Control Register D (MSTPCRD)

Address(es): MSTP.MSTPCRD 4004 7008h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	MSTPD28	MSTPD27	MSTPD26	MSTPD25	MSTPD24	MSTPD23	MSTPD22	—	MSTPD20	—	—	—	MSTPD16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MSTPD15	MSTPD14	—	—	—	—	—	—	—	MSTPD6	MSTPD5	—	MSTPD3	MSTPD2	—	—
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b2	MSTPD2	Low Power Asynchronous General Purpose Timer 1 Module Stop*1	Target module: AGT1 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b3	MSTPD3	Low Power Asynchronous General Purpose Timer 0 Module Stop*2	Target module: AGT0 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b4	—	Reserved	This bit is read as 1. The write value should be 1.	R/W
b5	MSTPD5	General PWM Timer 32EH0 to 32EH3, 32E4 to 32E7, and PWM Delay Generation Circuit Module Stop	Target modules: GPT32EHx (x = 0 to 3), GPT32Ey (y = 4 to 7), and PWM Delay Generation Circuit 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b6	MSTPD6	General PWM Timer 328 to 3212 Module Stop	Target modules: GPT32x (x = 8 to 12) 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b13 to b7	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b14	MSTPD14	Port Output Enable for GPT Module Stop	Target module: POEG 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b15	MSTPD15	12-bit A/D Converter 1 Module Stop	Target module: ADC121 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b16	MSTPD16	12-bit A/D Converter 0 Module Stop	Target module: ADC120 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b19 to b17	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b20	MSTPD20	12-bit D/A Converter Module Stop	Target module: DAC12 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b21	—	Reserved	This bit is read as 1. The write value should be 1.	R/W
b22	MSTPD22	Temperature Sensor Module Stop	Target module: TSN 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b23	MSTPD23	High-Speed Analog Comparator 5 Module Stop	Target module: ACMPHS5 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b24	MSTPD24	High-Speed Analog Comparator 4 Module Stop	Target module: ACMPHS4 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b25	MSTPD25	High-Speed Analog Comparator 3 Module Stop	Target module: ACMPHS3 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W

11.2.5 模块停止控制寄存器D(MSTPCRD)

Address(es): MSTP.MSTPCRD 4004 7008h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	MSTPD28	MSTPD27	MSTPD26	MSTPD25	MSTPD24	MSTPD23	MSTPD22	—	MSTPD20	—	—	—	MSTPD16
重置后的值:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MSTPD15	MSTPD14	—	—	—	—	—	—	—	MSTPD6	MSTPD5	—	MSTPD3	MSTPD2	—	—
重置后的值:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b2	MSTPD2	低功耗异步通用定时器1 Module Stop*1	目标模块：AGT10：取消模块停止状态1：进入模块停止状态。	R/W
b3	MSTPD3	低功耗异步通用定时器0 Module Stop*2	目标模块：AGT00：取消模块停止状态1：进入模块停止状态。	R/W
b4	—	Reserved	该位读取为1。写入值应为1。	R/W
b5	MSTPD5	通用PWM定时器32EH0至32EH3、32E4至32E7和PWM延迟发生电路模块停止	目标模块：GPT32EHx(x=0to3) GPT32Ey(y=4to7) PWM延迟产生电路0：取消模块停止状态1：进入模块停止状态。	R/W
b6	MSTPD6	通用PWM定时器328至3212模块停止	目标模块：GPT32x(x=8to12)0：取消模块停止状态1：进入模块停止状态。	R/W
b13 to b7	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b14	MSTPD14	GPT的端口输出使能模块停止	目标模块：POEG0：取消模块停止状态1：进入模块停止状态。	R/W
b15	MSTPD15	12位AD转换器1模块停止	目标模块：ADC1210：取消模块停止状态1：进入模块停止状态。	R/W
b16	MSTPD16	12位AD转换器0模块停止	目标模块：ADC1200：取消模块停止状态1：进入模块停止状态。	R/W
b19 to b17	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b20	MSTPD20	12位DA转换器模块停止	目标模块：DAC120：取消模块停止状态1：进入模块停止状态。	R/W
b21	—	Reserved	该位读取为1。写入值应为1。	R/W
b22	MSTPD22	温度传感器模块Stop	目标模块：TSN0：取消模块停止状态1：进入模块停止状态。	R/W
b23	MSTPD23	High-Speed Analog比较器5模块停止	目标模块：ACMPHS50：取消模块停止状态1：进入模块停止状态。	R/W
b24	MSTPD24	High-Speed Analog比较器4模块停止	目标模块：ACMPHS40：取消模块停止状态1：进入模块停止状态。	R/W
b25	MSTPD25	High-Speed Analog比较器3模块停止	目标模块：ACMPHS30：取消模块停止状态1：进入模块停止状态。	R/W

Bit	Symbol	Bit name	Description	R/W
b26	MSTPD26	High-Speed Analog Comparator 2 Module Stop	Target module: ACMPHS2 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b27	MSTPD27	High-Speed Analog Comparator 1 Module Stop	Target module: ACMPHS1 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b28	MSTPD28	High-Speed Analog Comparator 0 Module Stop	Target module: ACMPHS0 0: Cancel the module-stop state 1: Enter the module-stop state.	R/W
b31 to b29	—	Reserved	These bits are read as 1. The write value should be 1.	R/W

Note 1. When the count source is sub-clock oscillator or LOCO, AGT1 counting does not stop even if MSTPD2 bit is set to 1. If the count source is the sub-clock oscillator or LOCO, this bit must be set to 1 except when accessing the AGT1 registers.
Note 2. When the count source is sub-clock oscillator or LOCO, AGT0 counting does not stop even if MSTPD3 bit is set to 1. If the count source is the sub-clock oscillator or LOCO, this bit must be set to 1 except when accessing the AGT0 registers.

11.2.6 Operating Power Control Register (OPCCR)

Address(es): SYSTEM.OPCCR 4001 E0A0h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	OPCMTSF	—	—	OPCM[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	OPCM[1:0]	Operating Power Control Mode Select	b1 b0 0 0: High-speed mode 1 1: Low-speed mode. Other settings are prohibited.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	OPCMTSF	Operating Power Control Mode Transition Status Flag	• Read 0: Transition completed 1: Transition in progress. • Write The write value should be 0.	R
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The OPCCR register is used to reduce power consumption in Normal mode and Sleep mode by specifying a lower operating frequency and operating voltage. For the procedure to change the operating power control modes, see section 11.5, Function for Lower Operating Power Consumption.

When transitioning from Software Standby mode to Normal or Snooze mode, the settings in the OPCCR.OPCM[1:0] and SOPCCR.SOPCM bits are as follows, regardless of their settings before entering Software Standby mode:

- OPCCR.OPCM[1:0] = 00b (High-speed mode)
- SOPCCR.SOPCM = 0b (not Subosc-speed mode).

If Software Standby mode is canceled before the transition to Software Standby completes, the OPCCR.OPCM[1:0] and SOPCCR.SOPCM bits retain their settings from before the WFI instruction is executed. If this causes a problem, set the MCU to High-speed mode during the exception handling procedure when canceling Software Standby mode.

OPCM[1:0] bits (Operating Power Control Mode Select)

The OPCM[1:0] bits select the operating power control mode in Normal mode and Sleep mode. Table 11.4 shows the relationship between the operating power control modes, the OPCM[1:0], and SOPCM bit settings.

OPCMTSF flag (Operating Power Control Mode Transition Status Flag)

The OPCMTSF flag indicates the switching control state when the operating power control mode is switched. This flag

Bit	Symbol	位名称	Description	R/W
b26	MSTPD26	High-Speed Analog 比较器2模块停止	目标模块：ACMPHS20：取消模块停止状态1：进入模块停止状态。	R/W
b27	MSTPD27	High-Speed Analog 比较器1模块停止	目标模块：ACMPHS10：取消模块停止状态1：进入模块停止状态。	R/W
b28	MSTPD28	High-Speed Analog 比较器0模块停止	目标模块：ACMPHS00：取消模块停止状态1：进入模块停止状态。	R/W
b31 to b29	—	Reserved	这些位被读取为1。写入值应为1。	R/W

Note 1. 当计数源是副时钟振荡器或LOCO时，即使MSTPD2位设置为1，AGT1计数也不会停止。如果计数源是副时钟振荡器或LOCO，则该位必须设置为1，除非访问AGT1寄存器。
Note 2. 当计数源为副时钟振荡器或LOCO时，即使MSTPD3位设置为1，AGT0计数也不会停止。如果计数源为副时钟振荡器或LOCO，该位必须设置为1，除非访问AGT0寄存器。

11.2.6 工作电源控制寄存器(OPCCR)

Address(es): SYSTEM.OPCCR 4001 E0A0h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	OPCMTSF	—	—	OPCM[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	OPCM[1:0]	工作功率控制模式选择	b1b000：高速模式11：低速模式。禁止其他设置。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	OPCMTSF	工作功率控制模式转换状态Flag	读取0：转换已完成1：转换正在进行中。 写入写入值应为0。	R
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

OPCCR寄存器用于通过指定较低的工作频率和工作电压来降低正常模式和休眠模式下的功耗。有关更改运行功耗控制模式的步骤，请参阅第11.5节"降低运行功耗的功能"。

当从软件待机模式转换到正常或贪睡模式时，OPCCR.OPCM[1:0]中的设置和SOPCCR.SOPCM位如下，无论它们在进入软件待机模式之前的设置如何：

- OPCCR.OPCM[1:0] = 00b (High-speed mode)
- SOPCCR.SOPCM = 0b (not Subosc-speed mode).

如果在转换到软件待机完成之前取消软件待机模式，则OPCCR.OCM[1:0]和SOPCCR.SOPCM位将保留其在执行WFI指令之前的设置。如果这会导致问题，请设置
取消软件待机模式时，MCU在异常处理过程中进入高速模式。

OPCM[1:0]位（工作电源控制模式选择）

OPCM[1:0]位选择正常模式和休眠模式下的工作功率控制模式。表11.4显示了工作功率控制模式、OPCM[1:0]和SOPCM位设置之间的关系。

OPCMTSF标志（工作电源控制模式转换状态标志）

OPCMTSF标志指示切换操作功率控制模式时的切换控制状态。这面旗帜

becomes 1 when the OPCM[1:0] bits are written, and 0 when the mode transition completes. Read this flag and confirm that it is 0 before proceeding.

11.2.7 Sub Operating Power Control Register (SOPCCR)

Address(es): SYSTEM.SOPCCR 4001 E0AAh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SOPCMTSF	—	—	—	SOPCM
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SOPCM	Sub Operating Power Control Mode Select	0: Not Subosc-speed mode 1: Subosc-speed mode.	R/W
b3 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	SOPCMTSF	Sub Operating Power Control Mode Transition Status Flag	0: Transition completed 1: Transition in progress.	R
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The SOPCCR register is used to reduce power consumption in Normal and Sleep modes by initiating entry to and exit from Subosc-speed mode. Subosc-speed mode is only available when using the sub-clock oscillator or LOCO without dividing the frequency.

The flash cache function should be set to disabled by setting FCACHEE.FCACHEEN to 0 before switching the operating power control mode. For details, see section 41, Flash Memory.

For the procedure to change operating power control modes, see section 11.5, Function for Lower Operating Power Consumption.

SOPCM bit (Sub Operating Power Control Mode Select)

The SOPCM bit selects the operating power control mode in Normal mode and Sleep mode. Setting this bit to 1 allows transition to Subosc-speed mode. Setting this bit to 0 allows a return to the operating mode (set in OPCCR.OPCM[1:0]) before the transition to Subosc-speed mode.

When transitioning from Software Standby mode to Normal mode or Snooze mode, the OPCCR.OPCM[1:0] and SOPCCR.SOPCM settings are as follows, regardless of their settings before entering Software Standby mode:

- OPCCR.OPCM[1:0] = 00b (High-speed mode)
- SOPCCR.SOPCM = 0b (not Subosc-speed mode).

If Software Standby mode is canceled before the transition to Software Standby completes, the OPCCR.OPCM[1:0] and SOPCCR.SOPCM bits retain their settings from before the WFI instruction is executed. If this causes a problem, set the MCU to High-speed mode during the exception handling procedure when canceling Software Standby mode.

Table 11.4 shows the relationship between the operating power control modes, the OPCM[1:0], and SOPCM bit settings.

SOPCMTSF flag (Sub Operating Power Control Mode Transition Status Flag)

The SOPCMTSF flag indicates the switching control state when the operating power control mode is switched from or to Subosc-speed mode. This flag becomes 1 when the SOPCM bit is written, and 0 when mode transition completes. Read this flag and confirm that it is 0 before proceeding.

Table 11.4 shows the operating power control modes.

写入OPCM[1:0]位时变为1，模式转换完成时变为0。阅读此标志并确认其为0，然后再继续。

11.2.7 副操作功率控制寄存器(SOPCCR)

Address(es): SYSTEM.SOPCCR 4001 E0AAh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SOPCMTSF	—	—	—	SOPCM
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SOPCM	副操作功率控制 模式选择	0：非Subosc速度模式1：S ubosc速度模式。	R/W
b3 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	SOPCMTSF	副操作功率控制 模式转换状态标志	0：转换完成1：转换进 行中。	R
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SOPCCR寄存器用于通过启动进入和退出Subosc速度模式来降低正常和睡眠模式下的功耗。Subosc速度模式仅在使用副时钟振荡器或LOCO而不分频时可用。

在切换工作电源控制模式之前，应通过将FCACHEE.FCACHEEN设置为0将闪存缓存功能设置为禁用。有关详细信息，请参阅第41节，闪存。

有关更改操作功率控制模式的步骤，请参阅第11.5节，降低操作功率的功能
Consumption.

SOPCM位（副工作功率控制模式选择）

SOPCM位选择正常模式和休眠模式下的工作功率控制模式。将此位设置为1允许转换到Subosc速度模式。将此位设置为0允许在转换到Subosc速度模式之前返回到操作模式（在OPCCR.OPCM[1:0]中设置）。

当从软件待机模式转换到正常模式或贪睡模式时，OPCCR.OCM[1:0]和
SOPCCR.SOPCM设置如下，无论其进入软件待机模式前的设置如何：

- OPCCR.OPCM[1:0] = 00b (High-speed mode)
- SOPCCR.SOPCM = 0b (not Subosc-speed mode).

如果在转换到软件待机完成之前取消软件待机模式，则OPCCR.OCM[1:0]和SOPCCR.SOPCM位将保留其在执行WFI指令之前的设置。如果这会导致问题，请设置
取消软件待机模式时，MCU在异常处理过程中进入高速模式。

表11.4显示了工作功率控制模式、OPCM[1:0]和SOPCM位设置之间的关系。

SOPCMTSF标志（子工作电源控制模式转换状态标志）

SOPCMTSF标志指示当操作功率控制模式从或切换到Subosc速度模式时的切换控制状态。写入SOPCM位时该标志变为1，模式转换完成时变为0。阅读此标志并确认其为0，然后再继续。

表11.4显示了工作功率控制模式。

Table 11.4 Relationship between the operating power control modes, and the OPCM[1:0] and SOPCM bits

Operating power control mode	OPCM[1:0] bits	SOPCM bit	Power consumption
High-speed mode	00b	0	High
Low-speed mode	11b	0	↓
Subosc-speed mode	00b, 11b	1	Low

Note: See section 43, Electrical Characteristics for the operating frequency range and voltage range.

High-speed operating mode

After a reset cancellation, the MCU is activated in this mode.

Low-speed mode

The following constraints apply in low-speed mode:

- Programming and erasure operations for the flash memory are prohibited
- Using the PLL is prohibited. See section 11.10.1, Register Access.

In low-speed mode, lower power consumption is possible than in High-speed mode when the same operation is performed under the same conditions, such as operating frequency and operating voltage.

Subosc-speed mode

The following constraints apply in Subosc-speed mode:

- Programming and erasure operations for the flash memory are prohibited
- Reading of the data flash is prohibited
- Using MOSC, PLL, MOCO, or HOCO is prohibited. See section 11.10.1, Register Access.
- Using the divided clock for ICK or FCK is prohibited. See section 11.10.1, Register Access.
- Using the oscillation stop detection function of the main clock oscillator is prohibited.

11.2.8 Snooze Control Register (SNZCR)

Address(es): SYSTEM.SNZCR 4001 E092h

	b7	b6	b5	b4	b3	b2	b1	b0
	SNZE	—	—	—	—	—	SNZDTCEN	RXDREQEN
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	RXDREQEN	RXD0 Snooze Request Enable	0: Ignore RXD0 falling edge in Software Standby mode 1: Detect RXD0 falling edge in Software Standby mode.	R/W
b1	SNZDTCEN	DTC Enable in Snooze mode	0: Disable DTC operation in Snooze mode 1: Enable DTC operation in Snooze mode.	R/W
b6 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	SNZE	Snooze Mode Enable	0: Disable Snooze mode 1: Enable Snooze mode.	R/W

RXDREQEN bit (RXD0 Snooze Request Enable)

The RXDREQEN bit specifies whether to detect a falling edge of the RXD0 pin in Software Standby mode. This bit is only available when SCI0 operates in asynchronous mode. To detect a falling edge of the RXD0 pin, set this bit before entering Software Standby mode. When this bit is set to 1, a falling edge of the RXD0 pin in Software Standby mode causes the MCU to enter Snooze mode.

Table 11.4 工作功率控制模式与OPCM[1:0]和SOPCM位之间的关系

工作功率控制方式	OPCM[1:0] bits	SOPCM bit	能量消耗
High-speed mode	00b	0	High
Low-speed mode	11b	0	↓
Subosc-speed mode	00b, 11b	1	Low

Note: 有关工作频率范围和电压范围，请参见第43节电气特性。

高速运行模式

复位取消后，MCU在此模式下激活。

Low-speed mode

以下约束适用于低速模式：

- 禁止对闪存进行编程和擦除操作
- 禁止使用PLL。请参阅第11.10.1节，注册访问。

在工作频率和工作电压等相同条件下进行相同操作时，低速模式下的功耗可能低于高速模式下。

Subosc-speed mode

以下约束适用于Subosc速度模式：

- 禁止对闪存进行编程和擦除操作
- 禁止读取数据闪存
- 禁止使用MOSC、PLL、MOCO或HOCO。请参阅第11.10.1节，注册访问。
- 禁止将分频时钟用于ICK或FCK。请参阅第11.10.1节，注册访问。
- 禁止使用主时钟振荡器的振荡停止检测功能。

11.2.8 贪睡控制寄存器(SNZCR)

Address(es): SYSTEM.SNZCR 4001 E092h

	b7	b6	b5	b4	b3	b2	b1	b0
	SNZE	—	—	—	—	—	SNZDTCEN	RXDREQEN
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	RXDREQEN	RXD0贪睡请求启用	0：在软件待机模式下忽略RXD0下降沿1：在软件待机模式下检测RXD0下降沿。	R/W
b1	SNZDTCEN	在贪睡模式下启用DTC	0：在贪睡模式下禁用DTC操作1：在贪睡模式下启用DTC操作。	R/W
b6 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	SNZE	贪睡模式启用	0：禁用贪睡模式1：启用贪睡模式。	R/W

RXDREQEN位（RXD0贪睡请求使能）

RXDREQEN位指定在软件待机模式下是否检测RXD0引脚的下降沿。该位仅在SCI0工作在异步模式时可用。要检测RXD0引脚的下降沿，请在进入软件待机模式之前设置该位。当该位设置为1时，软件待机模式下RXD0引脚的下降沿会导致MCU进入贪睡模式。

SNZDTCEN bit (DTC Enable in Snooze mode)

The SNZDTCEN bit specifies whether to use the DTC and SRAM in Snooze mode. To use the DTC and SRAM in Snooze mode, set this bit to 1 before entering Software Standby mode. When this bit is set to 1, the DTC can be activated by setting IELSRn (ICU Event Link Setting Register n).

SNZE bit (Snooze Mode Enable)

The SNZE bit enables or disables a transition from Software Standby to Snooze mode. To use Snooze mode, set this bit to 1 before entering Software Standby mode. When this bit is set to 1, a trigger as shown in Table 11.7 in Software Standby mode causes the MCU to enter Snooze mode. After the MCU transitions from Software Standby mode or Snooze mode to Normal mode, clear the SNZE bit once then set it before re-entering Software Standby mode. For details, see section 11.8, Snooze Mode.

11.2.9 Snooze End Control Register (SNZEDCR)

Address(es): SYSTEM.SNZEDCR 4001 E094h

	b7	b6	b5	b4	b3	b2	b1	b0
	SCI0UMTED	AD1UMTED	AD1MATED	AD0UMTED	AD0MATED	DTCNZRED	DTCZRED	AGTUNFED
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	AGTUNFED	AGT1 Underflow Snooze End Enable	0: Disable the Snooze end request 1: Enable the Snooze end request.	R/W
b1	DTCZRED	Last DTC Transmission Completion Snooze End Enable	0: Disable the Snooze end request 1: Enable the Snooze end request.	R/W
b2	DTCNZRED	Not Last DTC Transmission Completion Snooze End Enable	0: Disable the Snooze end request 1: Enable the Snooze end request.	R/W
b3	AD0MATED	AD Compare Match 0 Snooze End Enable	0: Disable the Snooze end request 1: Enable the Snooze end request.	R/W
b4	AD0UMTED	AD Compare Mismatch 0 Snooze End Enable	0: Disable the Snooze end request 1: Enable the Snooze end request.	R/W
b5	AD1MATED	AD Compare Match 1 Snooze End Enable	0: Disable the Snooze end request 1: Enable the Snooze end request.	R/W
b6	AD1UMTED	AD Compare Mismatch 1 Snooze End Enable	0: Disable the Snooze end request 1: Enable the Snooze end request.	R/W
b7	SCI0UMTED	SCI0 Address Mismatch Snooze End Enable	0: Disable the Snooze end request 1: Enable the Snooze end request.	R/W

To use a trigger shown in Table 11.8 as a condition to switch from Snooze mode to Software Standby mode, set the associated bit in the SNZEDCR register to 1.

The event that is used to return to Normal mode from Snooze mode listed in Table 11.3 must not be enabled in the SNZEDCR register.

AGTUNFED bit (AGT1 Underflow Snooze End Enable)

The AGTUNFED bit specifies whether to enable a transition from Snooze mode to Software Standby mode on an AGT1 underflow. For details on the trigger conditions, see section 24, Low Power Asynchronous General-Purpose Timer (AGT).

DTCZRED bit (Last DTC Transmission Completion Snooze End Enable)

The DTCZRED bit specifies whether to enable a transition from Snooze mode to Software Standby mode on completion of the last DTC transmission, that is, when CRA or CRB register in the DTC is 0. For details on the trigger conditions, see section 17, Data Transfer Controller (DTC).

SNZDTCEN位（在贪睡模式下启用DTC）

SNZDTCEN位指定是否在贪睡模式下使用DTC和SRAM。使用DTC和SRAM
贪睡模式，在进入软件待机模式之前将该位设置为1。当该位设置为1时，可以通过设置IELSRn（ICU事件链接设置寄存器n）来激活DTC。

SNZE位（贪睡模式启用）

SNZE位启用或禁用从软件待机到贪睡模式的转换。要使用贪睡模式，请在进入软件待机模式之前将此位设置为1。当该位设置为1时，软件待机模式下如表11.7所示的触发会导致MCU进入贪睡模式。在MCU从软件待机模式或贪睡模式转换到正常模式后，清除一次SNZE位，然后在重新进入软件待机模式之前将其设置。有关详细信息，请参阅第11.8节，贪睡模式。

11.2.9 贪睡结束控制寄存器(SNZEDCR)

Address(es): SYSTEM.SNZEDCR 4001 E094h

	b7	b6	b5	b4	b3	b2	b1	b0
	SCI0UMTED	AD1UMTED	AD1MATED	AD0UMTED	AD0MATED	DTCNZRED	DTCZRED	AGTUNFED
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	AGTUNFED	AGT1下溢贪睡结束使能	0：禁用贪睡结束请求1：启用贪睡结束请求。	R/W
b1	DTCZRED	上次DTC传输完成 贪睡结束启用	0：禁用贪睡结束请求1：启用贪睡结束请求。	R/W
b2	DTCNZRED	不是最后一个DTC传输完成 贪睡结束启用	0：禁用贪睡结束请求1：启用贪睡结束请求。	R/W
b3	AD0MATED	AD比较匹配0贪睡结束启用	0：禁用贪睡结束请求1：启用贪睡结束请求。	R/W
b4	AD0UMTED	AD比较不匹配0暂停结束 Enable	0：禁用贪睡结束请求1：启用贪睡结束请求。	R/W
b5	AD1MATED	AD比较匹配1贪睡结束启用	0：禁用贪睡结束请求1：启用贪睡结束请求。	R/W
b6	AD1UMTED	AD比较不匹配1暂停结束 Enable	0：禁用贪睡结束请求1：启用贪睡结束请求。	R/W
b7	SCI0UMTED	SCI0地址不匹配贪睡结束 Enable	0：禁用贪睡结束请求1：启用贪睡结束请求。	R/W

要将表11.8中所示的触发器用作从贪睡模式切换到软件待机模式的条件，请将SNZEDCR寄存器中的相关位设置为1。

表11.3中列出的用于从贪睡模式返回正常模式的事件不得在
SNZEDCR register.

AGTUNFED位（AGT1下溢贪睡结束使能）

AGTUNFED位指定是否在AGT1下溢时启用从贪睡模式到软件待机模式的转换。有关触发条件的详细信息，请参见第24节，低功耗异步通用定时器(AGT)。

DTCZRED位（最后一个DTC传输完成贪睡结束使能）

DTCZRED位指定是否在最后一次DTC传输完成时，即当DTC中的CRA或CRB寄存器为0时，使能从贪睡模式到软件待机模式的转换。有关触发条件的详细信息，请参见第17节，数据传输控制器(DTC)。

DTCNZRED bit (Not Last DTC Transmission Completion Snooze End Enable)

The DTCNZRED bit specifies whether to enable a transition from Snooze to Software Standby mode on completion of each DTC transmission, that is, when CRA or CRB register in the DTC is not 0. For details on the trigger conditions, see section 17, Data Transfer Controller (DTC).

AD0MATED bit (AD Compare Match 0 Snooze End Enable)

The AD0MATED bit specifies whether to enable a transition from Snooze mode to Software Standby mode on an AD0 event when a conversion result matches the expected data. For details on the trigger conditions, see section 35, 12-Bit A/D Converter (ADC12).

AD0UMTED bit (AD Compare Mismatch 0 Snooze End Enable)

The AD0UMTED bit specifies whether to enable a transition from Snooze mode to Software Standby mode on an AD0 event when the conversion result does not match the expected data. For details on the trigger conditions, see section 35, 12-Bit A/D Converter (ADC12).

AD1MATED bit (AD Compare Match 1 Snooze End Enable)

The AD1MATED bit specifies whether to enable a transition from Snooze mode to Software Standby mode on an AD1 event when the conversion result matches the expected data. For details on the trigger conditions, see section 35, 12-Bit A/D Converter (ADC12).

AD1UMTED bit (AD Compare Mismatch 1 Snooze End Enable)

The AD1UMTED bit specifies whether to enable a transition from Snooze mode to Software Standby mode on an AD1 event when the conversion result does not match the expected data. For details on the trigger conditions, see section 35, 12-Bit A/D Converter (ADC12).

SCI0UMTED bit (SCI0 Address Mismatch Snooze End Enable)

The SCI0UMTED bit specifies whether to enable a transition from Snooze mode to Software Standby mode on an SCI0 event when an address received in Software Standby mode does not match the expected data. For details on the trigger conditions, see section 27, Serial Communications Interface (SCI). Only set this bit to 1 when SCI0 operates in asynchronous mode.

11.2.10 Snooze Request Control Register (SNZREQCR)

Address(es): SYSTEM.SNZREQCR 4001 E098h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	SNZREQEN30	SNZREQEN29	SNZREQEN28	—	—	—	—	—	SNZREQEN22	—	—	—	—	SNZREQEN17	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	SNZREQEN13	SNZREQEN12	SNZREQEN11	SNZREQEN10	SNZREQEN9	SNZREQEN8	SNZREQEN7	SNZREQEN6	SNZREQEN5	SNZREQEN4	SNZREQEN3	SNZREQEN2	SNZREQEN1	SNZREQEN0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SNZREQEN0	Snooze Request Enable 0	Enable IRQ0 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b1	SNZREQEN1	Snooze Request Enable 1	Enable IRQ1 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b2	SNZREQEN2	Snooze Request Enable 2	Enable IRQ2 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W

DTCNZRED位（非最后一个DTC传输完成贪睡结束使能）

DTCNZRED位指定是否在每次DTC传输完成时启用从贪睡到软件待机模式的转换，即当DTC中的CRA或CRB寄存器不为0时。有关触发条件的详细信息，请参见第17节，数据传输控制器(DTC)。

AD0MATED位（AD比较匹配0贪睡结束使能）

AD0MATED位指定当转换结果与预期数据匹配时，是否在发生AD0事件时启用从贪睡模式到软件待机模式的转换。有关触发条件的详细信息，请参阅第35节，12位AD转换器(ADC12)。

AD0UMTED位（AD比较不匹配0贪睡结束使能）

AD0UMTED位指定当转换结果与预期数据不匹配时，是否在发生AD0事件时启用从贪睡模式到软件待机模式的转换。有关触发条件的详细信息，请参阅第35节，12位AD转换器(ADC12)。

AD1MATED位（AD比较匹配1贪睡结束使能）

AD1MATED位指定当转换结果与预期数据匹配时，是否在发生AD1事件时启用从贪睡模式到软件待机模式的转换。有关触发条件的详细信息，请参阅第35节，12位AD转换器(ADC12)。

AD1UMTED位（AD比较不匹配1贪睡结束使能）

AD1UMTED位指定当转换结果与预期数据不匹配时，是否在发生AD1事件时启用从贪睡模式到软件待机模式的转换。有关触发条件的详细信息，请参阅第35节，12位AD转换器(ADC12)。

SCI0UMTED位（SCI0地址不匹配贪睡结束使能）

SCI0UMTED位指定当在软件待机模式下接收到的地址与预期数据不匹配时，是否在发生SCI0事件时启用从贪睡模式到软件待机模式的转换。有关触发条件的详细信息，请参阅第27节，串行通信接口(SCI)。仅当SCI0在异步模式下工作时将该位设置为1。

11.2.10 贪睡请求控制寄存器(SNZREQCR)

Address(es): SYSTEM.SNZREQCR 4001 E098h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	SNZREQEN30	SNZREQEN29	SNZREQEN28	—	—	—	—	—	SNZREQEN22	—	—	—	—	SNZREQEN17	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	SNZREQEN13	SNZREQEN12	SNZREQEN11	SNZREQEN10	SNZREQEN9	SNZREQEN8	SNZREQEN7	SNZREQEN6	SNZREQEN5	SNZREQEN4	SNZREQEN3	SNZREQEN2	SNZREQEN1	SNZREQEN0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SNZREQEN0	暂停请求启用0	启用IRQ0引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b1	SNZREQEN1	贪睡请求启用1	启用IRQ1引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b2	SNZREQEN2	贪睡请求启用2	EnableIRQ2pinsnoozerequest：0：禁用贪睡请求1：启用贪睡请求。	R/W

Bit	Symbol	Bit name	Description	R/W
b3	SNZREQEN3	Snooze Request Enable 3	Enable IRQ3 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b4	SNZREQEN4	Snooze Request Enable 4	Enable IRQ4 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b5	SNZREQEN5	Snooze Request Enable 5	Enable IRQ5 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b6	SNZREQEN6	Snooze Request Enable 6	Enable IRQ6 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b7	SNZREQEN7	Snooze Request Enable 7	Enable IRQ7 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b8	SNZREQEN8	Snooze Request Enable 8	Enable IRQ8 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b9	SNZREQEN9	Snooze Request Enable 9	Enable IRQ9 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b10	SNZREQEN10	Snooze Request Enable 10	Enable IRQ10 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b11	SNZREQEN11	Snooze Request Enable 11	Enable IRQ11 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b12	SNZREQEN12	Snooze Request Enable 12	Enable IRQ12 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b13	SNZREQEN13	Snooze Request Enable 13	Enable IRQ13 pin snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b16 to b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b17	SNZREQEN17	Snooze Request Enable 17	Enable Key Interrupt snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b21 to b18	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b22	SNZREQEN22	Snooze Request Enable 22	Enable ACMPHS0 snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b27 to b23	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b28	SNZREQEN28	Snooze Request Enable 28	Enable AGT1 underflow snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b29	SNZREQEN29	Snooze Request Enable 29	Enable AGT1 compare match A snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b30	SNZREQEN30	Snooze Request Enable 30	Enable AGT1 compare match B snooze request: 0: Disable the snooze request 1: Enable the snooze request.	R/W
b31	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

The SNZREQCR register controls which trigger causes the MCU to switch from Software Standby mode to Snooze mode. If a trigger is selected as a request to cancel Software Standby mode by setting the WUPEN register, see section 13, Interrupt Controller Unit (ICU), the MCU enters Normal mode when the trigger is generated while the associated bit of the SNZREQCR is 1. The setting of the WUPEN register always has a higher priority than the SNZREQCR register settings. For details, see section 11.8, Snooze Mode and section 13, Interrupt Controller Unit (ICU).

Bit	Symbol	位名称	Description	R/W
b3	SNZREQEN3	贪睡请求启用3	EnableIRQ3pinsnoozerequest：0：禁用贪睡请求1：启用贪睡请求。	R/W
b4	SNZREQEN4	贪睡请求启用4	EnableIRQ4pinsnoozerequest：0：禁用贪睡请求1：启用贪睡请求。	R/W
b5	SNZREQEN5	贪睡请求启用5	启用IRQ5引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b6	SNZREQEN6	贪睡请求启用6	启用IRQ6引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b7	SNZREQEN7	暂停请求启用7	启用IRQ7引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b8	SNZREQEN8	贪睡请求启用8	启用IRQ8引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b9	SNZREQEN9	贪睡请求启用9	启用IRQ9引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b10	SNZREQEN10	暂停请求启用10	启用IRQ10引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b11	SNZREQEN11	暂停请求启用11	启用IRQ11引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b12	SNZREQEN12	暂停请求启用12	启用IRQ12引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b13	SNZREQEN13	暂停请求启用13	启用IRQ13引脚贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b16 to b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b17	SNZREQEN17	暂停请求启用17	EnableKeyInterrupt贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b21 to b18	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b22	SNZREQEN22	贪睡请求启用22	启用ACMPHS0贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b27 to b23	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b28	SNZREQEN28	贪睡请求启用28	启用AGT1下溢贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b29	SNZREQEN29	贪睡请求启用29	启用AGT1比较匹配贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b30	SNZREQEN30	暂停请求启用30	启用AGT1比较匹配B贪睡请求：0：禁用贪睡请求1：启用贪睡请求。	R/W
b31	—	Reserved	该位读取为0。写入值应为0。	R/W

SNZREQCR寄存器控制哪个触发器导致MCU从软件待机模式切换到贪睡模式。如果通过设置WUPEN寄存器选择触发作为取消软件待机模式的请求，请参见第13节，中断控制器单元(ICU)，当SNZREQCR的相关位为1时生成触发时，MCU进入正常模式。WUPEN寄存器的设置始终具有比SNZREQCR寄存器设置更高的优先级。有关详细信息，请参阅第11.8节，贪睡模式和第13节，中断控制器单元(ICU)。

RA生态工作室

11.2.11 Deep Software Standby Control Register (DPSBYCR)

Address(es): SYSTEM.DPSBYCR 4001 E400h

	b7	b6	b5	b4	b3	b2	b1	b0
	DPSBY	IOKEEP	—	—	—	—	DEEPCUT[1:0]	
Value after reset:	0	0	0	0	0	0	0	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	DEEPCUT[1:0]	Power-Supply Control	b1 b0 0 0: Supply power to the low-speed on-chip oscillator and AGTn in Deep Software Standby mode 0 1: Do not supply power to the low-speed on-chip oscillator and AGTn in Deep Software Standby mode 1 0: Setting prohibited 1 1: Do not supply power to the low-speed on-chip oscillator and AGTn in Deep Software Standby mode. In addition, disable the LVD and enable the low power function of the power-on reset circuit.	R/W
b5 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	IOKEEP	I/O Port Retention	0: When Deep Software Standby mode is canceled, clear the I/O ports to the reset state 1: When Deep Software Standby mode is canceled, keep the I/O ports in the same state as in Deep Software Standby mode.	R/W
b7	DPSBY	Deep Software Standby	0: Sleep mode (SBYCR.SSBY = 0) or Software Standby mode (SBYCR.SSBY = 1) 1: Sleep mode (SBYCR.SSBY = 0) or Deep Software Standby mode (SBYCR.SSBY = 1).	R/W

The DPSBYCR register is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source.

DEEPCUT[1:0] bits (Power-Supply Control)

The DEEPCUT[1:0] bits control the internal power supply to the low-speed on-chip oscillator and AGTn in Deep Software Standby mode. In addition, these bits control the state of the LVD and power-on reset circuit in Deep Software Standby mode. When an LVD interrupt is used in Deep Software Standby mode, the DEEPCUT[1:0] bits must be set to 00b or 01b.

For lower power consumption, set the DEEPCUT[1:0] bits to 11b so that the LVD is stopped and the low power mode function of the power-on reset circuit is enabled. The internal power supply of the SRAM stops in Deep Software Standby mode regardless of the DEEPCUT[1:0] bit settings.

IOKEEP bit (I/O Port Retention)

In Deep Software Standby mode, the I/O ports keep the same states as in Software Standby mode. The IOKEEP bit specifies whether to reset the state of the I/O ports when Deep Software Standby mode is canceled.

DPSBY bit (Deep Software Standby)

The DPSBY bit controls transitions to Deep Software Standby mode. See Table 11.6 for details.

When the WFI instruction is executed while the SBYCR.SSBY and DPSBYCR.DPSBY bits are both 1, the MCU enters Deep Software Standby mode through Software Standby mode.

The DPSBY bit remains 1 when Deep Software Standby mode is canceled by certain pins that are the sources of external pin interrupts (NMI, IRQ0-DS, IRQ1-DS, and IRQ4-DS to IRQ12-DS) or by a peripheral interrupt (voltage monitor 1 or voltage monitor 2). Write 0 to this bit to clear it.

The DPSBY setting is invalid when the OFS0.IWDTSTPCTL bit is 0 (counting continues), regardless of the setting in the OFS0.IWDTSTRT bit. When the SBYCR.SSBY and DPSBY bits are 1, the MCU transitions to Software Standby mode on execution of a WFI instruction.

The DPSBY setting is invalid when the voltage monitor 1 reset is enabled (LVD1CR0.RI = 1) or when the voltage

11.2.11 深度软件待机控制寄存器(DPSBYCR)

Address(es): SYSTEM.DPSBYCR 4001 E400h

	b7	b6	b5	b4	b3	b2	b1	b0
	DPSBY	IOKEEP	—	—	—	—	DEEPCUT[1:0]	
重置后的值:	0	0	0	0	0	0	0	1

Bit	Symbol	位名称	Description	R/W
b1, b0	DEEPCUT[1:0]	Power-Supply Control	b1b000：在深度软件待机模式下给低速内部振荡器和AGTn供电01：在深度软件待机模式下不给低速内部振荡器和AGTn供电10：设置禁止11：在深度软件待机模式下，不给低速片内振荡器和AGTn供电。另外，禁用LVD，启用上电复位电路的低功耗功能。	R/W
b5 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	IOKEEP	IO端口保留	0：取消深度软件待机模式时，将IO端口清除为复位状态1：取消深度软件待机模式时，保持IO端口处于与深度软件待机模式相同的状态。	R/W
b7	DPSBY	深度软件Standby	0：休眠模式（SBYCR.SSBY=0）或软件待机模式（SBYCR.SSBY=1）1：休眠模式（SBYCR.SSBY=0）或深度软件待机模式（SBYCR.SSBY=1）。	R/W

取消深度软件待机模式的内部复位信号不会初始化DPSBYCR寄存器。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。

DEEPCUT[1:0]位（电源控制）

DEEPCUT[1:0]位控制低速片内振荡器和深度AGTn的内部电源
软件待机模式。此外，这些位在深度软件待机模式下控制LVD和上电复位电路的状态。在深度软件待机模式下使用LVD中断时，DEEPCUT[1:0]位必须设置为00b或01b。

为降低功耗，将DEEPCUT[1:0]位设置为11b，以使LVD停止并启用上电复位电路的低功耗模式功能。无论DEEPCUT[1:0]位设置如何，SRAM的内部电源都会在深度软件待机模式下停止。

IOKEEP位（IO端口保留）

在深度软件待机模式下，IO端口保持与软件待机模式相同的状态。IOKEEP位指定当深度软件待机模式被取消时是否复位IO端口的状态。

DPSBY位（深度软件待机）

DPSBY位控制向深度软件待机模式的转换。详见表11.6。

当SBYCR.SSBY和DPSBYCR.DPSBY位均为1时执行WFI指令，MCU进入
深度软件待机模式到软件待机模式。

当深度软件待机模式被某些作为外部引脚中断源（NMI、IRQ0-DS、IRQ1-DS和IRQ4-DS到IRQ12-DS）或外设中断（电压监视器1或电压监视器2）。向该位写入0以清除它。

当OFS0.IWDTSTPCTL位为0（计数继续）时，DPSBY设置无效，无论OFS0.IWDTSTRT位中的设置如何。当SBYCR.SSBY和DPSBY位为1时，MCU在执行WFI指令时转换到软件待机模式。

当电压监视器1复位启用(LVD1CR0.RI=1)或当电压

monitor 2 reset is enabled (LVD2CR0.RI = 1). When the SBYCR.SSBY and the DPSBY bits are 1, the MCU transitions to Software Standby mode on execution of a WFI instruction.

11.2.12 Deep Software Standby Interrupt Enable Register 0 (DPSIER0)

Address(es): SYSTEM.DPSIER0 4001 E402h

	b7	b6	b5	b4	b3	b2	b1	b0
	DIRQ7E	DIRQ6E	DIRQ5E	DIRQ4E	—	—	DIRQ1E	DIRQ0E
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DIRQ0E	IRQ0-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ0-DS pin: 0: Disable 1: Enable.	R/W
b1	DIRQ1E	IRQ1-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ1-DS pin: 0: Disable 1: Enable.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	DIRQ4E	IRQ4-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ4-DS pin: 0: Disable 1: Enable.	R/W
b5	DIRQ5E	IRQ5-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ5-DS pin: 0: Disable 1: Enable.	R/W
b6	DIRQ6E	IRQ6-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ6-DS pin: 0: Disable 1: Enable.	R/W
b7	DIRQ7E	IRQ7-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ7-DS pin: 0: Disable 1: Enable.	R/W

The DPSIER0 register is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source. After a setting in DPSIER0 is changed, an edge can be internally generated depending on the associated pin state, resulting in the associated DPSIFR0 bit being set to 1. Clear DPSIFR0 to 0 before entering Deep Software Standby mode.

11.2.13 Deep Software Standby Interrupt Enable Register 1 (DPSIER1)

Address(es): SYSTEM.DPSIER1 4001 E403h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DIRQ12E	DIRQ11E	DIRQ10E	DIRQ9E	DIRQ8E
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DIRQ8E	IRQ8-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ8-DS pin: 0: Disable 1: Enable.	R/W
b1	DIRQ9E	IRQ9-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ9-DS pin: 0: Disable 1: Enable.	R/W

启用监视器2复位(LVD2CR0.RI=1)。当SBYCR.SSBY和DPSBY位为1时，MCU在执行WFI指令时转换到软件待机模式。

11.2.12 深度软件待机中断使能寄存器0(DPSIER0)

Address(es): SYSTEM.DPSIER0 4001 E402h

	b7	b6	b5	b4	b3	b2	b1	b0
	DIRQ7E	DIRQ6E	DIRQ5E	DIRQ4E	—	—	DIRQ1E	DIRQ0E
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DIRQ0E	IRQ0-DS引脚使能	通过IRQ0-DS引脚启用深度软件待机模式的取消：0：禁用1：启用。	R/W
b1	DIRQ1E	IRQ1-DS引脚使能	通过IRQ1-DS引脚启用深度软件待机模式的取消：0：禁用1：启用。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	DIRQ4E	IRQ4-DS引脚使能	启用通过IRQ4-DS引脚取消深度软件待机模式：0：禁用1：启用。	R/W
b5	DIRQ5E	IRQ5-DS引脚使能	启用通过IRQ5-DS引脚取消深度软件待机模式：0：禁用1：启用。	R/W
b6	DIRQ6E	IRQ6-DS引脚使能	启用通过IRQ6-DS引脚取消深度软件待机模式：0：禁用1：启用。	R/W
b7	DIRQ7E	IRQ7-DS引脚使能	通过IRQ7-DS引脚启用深度软件待机模式的取消：0：禁用1：启用。	R/W

DPSIER0寄存器不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。更改DPSIER0中的设置后，可根据相关引脚状态在内部生成边沿，从而将相关DPSIFR0位设置为1。在进入深度软件待机模式之前将DPSIFR0清零。

11.2.13 深度软件待机中断使能寄存器1(DPSIER1)

Address(es): SYSTEM.DPSIER1 4001 E403h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DIRQ12E	DIRQ11E	DIRQ10E	DIRQ9E	DIRQ8E
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DIRQ8E	IRQ8-DS引脚使能	启用通过IRQ8-DS引脚取消深度软件待机模式：0：禁用1：启用。	R/W
b1	DIRQ9E	IRQ9-DS引脚使能	启用通过IRQ9-DS引脚取消深度软件待机模式：0：禁用1：启用。	R/W

Bit	Symbol	Bit name	Description	R/W
b2	DIRQ10E	IRQ10-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ10-DS pin: 0: Disable 1: Enable.	R/W
b3	DIRQ11E	IRQ11-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ11-DS pin: 0: Disable 1: Enable.	R/W
b4	DIRQ12E	IRQ12-DS Pin Enable	Enable canceling of Deep Software Standby mode by the IRQ12-DS pin: 0: Disable 1: Enable.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The DPSIER1 register is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source. After a setting in DPSIER1 is changed, an edge can be internally generated depending on the associated pin state, resulting in the associated DPSIFR1 bit being set to 1. Clear DPSIFR1 to 0 before entering Deep Software Standby mode.

11.2.14 Deep Software Standby Interrupt Enable Register 2 (DPSIER2)

Address(es): SYSTEM.DPSIER2 4001 E404h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DNMIE	—	—	DLVD2IE	DLVD1IE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DLVD1IE	LVD1 Deep Software Standby Cancel Signal Enable	Enable canceling of Deep Software Standby mode by the voltage monitor 1 signal: 0: Disable 1: Enable.	R/W
b1	DLVD2IE	LVD2 Deep Software Standby Cancel Signal Enable	Enable canceling of Deep Software Standby mode by the voltage monitor 2 signal: 0: Disable 1: Enable.	R/W
b3 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	DNMIE	NMI Pin Enable	Enable canceling of Deep Software Standby mode by the NMI pin: 0: Disable 1: Enable.	R/W*1
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. 1 can be written only once. After 1 is written to this bit, subsequent write accesses are disabled.

The DPSIER2 register is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source. After a setting in DPSIER2 is changed, an edge can be internally generated depending on the associated pin state, resulting in the associated DPSIFR2 bit being set to 1. Clear DPSIFR2 to 0 before entering Deep Software Standby mode.

Bit	Symbol	位名称	Description	R/W
b2	DIRQ10E	IRQ10-DS引脚使能	通过IRQ10-DS引脚启用深度软件待机模式的取消：0：禁用1：启用。	R/W
b3	DIRQ11E	IRQ11-DS引脚使能	通过IRQ11-DS引脚启用深度软件待机模式的取消：0：禁用1：启用。	R/W
b4	DIRQ12E	IRQ12-DS引脚使能	启用通过IRQ12-DS引脚取消深度软件待机模式：0：禁用1：启用。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DPSIER1寄存器未被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。更改DPSIER1中的设置后，可根据相关引脚状态在内部产生边沿，从而将相关DPSIFR1位设置为1。在进入深度软件待机模式之前将DPSIFR1清零。

11.2.14 深度软件待机中断使能寄存器2(DPSIER2)

Address(es): SYSTEM.DPSIER2 4001 E404h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DNMIE	—	—	DLVD2IE	DLVD1IE
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DLVD1IE	LVD1深度软件待机取消信号启用	通过电压监视器1信号启用深度软件待机模式的取消：0：禁用1：启用。	R/W
b1	DLVD2IE	LVD2深度软件待机取消信号启用	通过电压监视器2信号启用深度软件待机模式的取消：0：禁用1：启用。	R/W
b3 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	DNMIE	NMI引脚使能	启用通过NMI引脚取消深度软件待机模式：0：禁用1：启用。	R/W*1
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

注1.1只能写一次。向该位写入1后，禁止后续写访问。

DPSIER2寄存器不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。更改DPSIER2中的设置后，可根据相关引脚状态在内部生成边沿，从而将相关DPSIFR2位设置为1。在进入深度软件待机模式之前将DPSIFR2清零。

11.2.15 Deep Software Standby Interrupt Enable Register 3 (DPSIER3)

Address(es): SYSTEM.DPSIER3 4001 E405h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	DAGT1IE	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b2	DAGT1IE	AGT1 Underflow Deep Software Standby Cancel Signal Enable	Enable canceling of Deep Software Standby mode by an AGT1 underflow: 0: Disable 1: Enable.	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The DPSIER3 register is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source. After a setting in DPSIER3 is changed, an edge can be internally generated depending on the associated pin state, resulting in the associated DPSIFR3 bit being set to 1. Clear DPSIFR3 to 0 before entering Deep Software Standby mode.

11.2.16 Deep Software Standby Interrupt Flag Register 0 (DPSIFR0)

Address(es): SYSTEM.DPSIFR0 4001 E406h

	b7	b6	b5	b4	b3	b2	b1	b0
	DIRQ7F	DIRQ6F	DIRQ5F	DIRQ4F	—	—	DIRQ1F	DIRQ0F
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DIRQ0F	IRQ0-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ0-DS pin: 0: No request generated 1: Request generated.	R(/W) *1
b1	DIRQ1F	IRQ1-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ1-DS pin: 0: No request generated 1: Request generated.	R(/W) *1
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R(/W) *1
b4	DIRQ4F	IRQ4-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ4-DS pin: 0: No request generated 1: Request generated.	R(/W) *1
b5	DIRQ5F	IRQ5-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ5-DS pin: 0: No request generated 1: Request generated.	R(/W) *1
b6	DIRQ6F	IRQ6-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ6-DS pin: 0: No request generated 1: Request generated.	R(/W) *1

11.2.15 深度软件待机中断使能寄存器3(DPSIER3)

Address(es): SYSTEM.DPSIER3 4001 E405h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	DAGT1IE	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b2	DAGT1IE	AGT1下溢深度软件待机 取消信号启用	启用取消深度软件待机模式 AGT1下溢：0： 禁用1：启用。	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DPSIER3寄存器未被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。更改DPSIER3中的设置后，可根据相关引脚状态在内部生成边沿，从而将相关DPSIFR3位设置为1。在进入深度软件待机模式之前将DPSIFR3清零。

11.2.16 深度软件待机中断标志寄存器0(DPSIFR0)

Address(es): SYSTEM.DPSIFR0 4001 E406h

	b7	b6	b5	b4	b3	b2	b1	b0
	DIRQ7F	DIRQ6F	DIRQ5F	DIRQ4F	—	—	DIRQ1F	DIRQ0F
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DIRQ0F	IRQ0-DS深度软件待机 取消标志	指示深度软件待机取消请求由 IRQ0-DS引脚：0：未产 生请求1：产生请求。	R(/W) *1
b1	DIRQ1F	IRQ1-DS深度软件待机 取消标志	指示深度软件待机取消请求由 IRQ1-DS引脚：0：未产 生请求1：产生请求。	R(/W) *1
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R(/W) *1
b4	DIRQ4F	IRQ4-DS深度软件待机 取消标志	指示深度软件待机取消请求由 IRQ4-DS引脚：0：未产 生请求1：产生请求。	R(/W) *1
b5	DIRQ5F	IRQ5-DS深度软件待机 取消标志	指示深度软件待机取消请求由 IRQ5-DS引脚：0：未产 生请求1：产生请求。	R(/W) *1
b6	DIRQ6F	IRQ6-DS深度软件待机 取消标志	指示深度软件待机取消请求由 IRQ6-DS引脚：0：未产 生请求1：产生请求。	R(/W) *1

Bit	Symbol	Bit name	Description	R/W
b7	DIRQ7F	IRQ7-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ7-DS pin: 0: No request generated 1: Request generated.	R(/W) *1

Note 1. Only 0 can be written to clear the flag.

The flags in the DPSIFR0 register is set to 1 when the associated cancel request specified in DPSIEGR0 is generated. Each flag can be set to 1 when a cancel request is generated in any mode, not only in Deep Software Standby mode, or when the setting in DPSIER0 is changed. Clear DPSIFR0 to 00h before entering Deep Software Standby mode.

To clear DPSIFR0 to 00h after modifying DPSIER0, wait for at least 6 PCLKB cycles, read DPSIFR0, and then write 0 to DPSIFR0. Six or more PCLKB cycles can be secured, for example, by reading DPSIER0. DPSIFR0 is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source.

DIRQnF flag (IRQn-DS Deep Software Standby Cancel Flag) (n = 0, 1, 4 to 7)

The DIRQnF flag indicates that a cancel request is generated by the IRQn-DS pin.

[Setting condition]

- A cancel request generated by an IRQn-DS pin specified in DPSIEGR0.

[Clearing condition]

- Writing 0 to the flag after reading it as 1.

11.2.17 Deep Software Standby Interrupt Flag Register 1 (DPSIFR1)

Address(es): SYSTEM.DPSIFR1 4001 E407h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DIRQ12F	DIRQ11F	DIRQ10F	DIRQ9F	DIRQ8F
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DIRQ8F	IRQ8-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ8-DS pin: 0: No request generated 1: Request generated.	R(/W)*1
b1	DIRQ9F	IRQ9-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ9-DS pin: 0: No request generated 1: Request generated.	R(/W)*1
b2	DIRQ10F	IRQ10-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ10-DS pin: 0: No request generated 1: Request generated.	R(/W)*1
b3	DIRQ11F	IRQ11-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ11-DS pin: 0: No request generated 1: Request generated.	R(/W)*1
b4	DIRQ12F	IRQ12-DS Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the IRQ12-DS pin: 0: No request generated 1: Request generated.	R(/W)*1
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R(/W)*1

Note 1. Only 0 can be written to clear the flag.

Bit	Symbol	位名称	Description	R/W
b7	DIRQ7F	IRQ7-DS深度软件待机取消标志	指示深度软件待机取消请求由IRQ7-DS引脚：0：未产生请求1：产生请求。	R(/W) *1

Note 1. 只能写入0来清除标志。

当产生DPSIEGR0中指定的相关取消请求时，DPSIFR0寄存器中的标志设置为1。当在任何模式下生成取消请求时，每个标志都可以设置为1，不仅在深度软件待机模式下，或者当DPSIER0中的设置更改时。在进入深度软件待机模式之前将DPSIFR0清零。

要在修改DPSIER0后将DPSIFR0清除为00h，请等待至少6个PCLKB周期，读取DPSIFR0，然后将0写入DPSIFR0。例如，可以通过读取DPSIER0来确保六个或更多PCLKB周期。DPSIFR0不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。

DIRQnF标志（IRQn-DS深度软件待机取消标志）（n=0、1、4到7）

DIRQnF标志指示取消请求由IRQn-DS引脚产生。

[Setting condition]

- 由DPSIEGR0中指定的IRQn-DS管脚生成的取消请求。

[Clearing condition]

- 读为1后将0写入标志。

11.2.17 深度软件待机中断标志寄存器1(DPSIFR1)

Address(es): SYSTEM.DPSIFR1 4001 E407h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DIRQ12F	DIRQ11F	DIRQ10F	DIRQ9F	DIRQ8F
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DIRQ8F	IRQ8-DS深度软件待机取消标志	指示深度软件待机取消请求由IRQ8-DS引脚：0：未产生请求1：产生请求。	R(/W)*1
b1	DIRQ9F	IRQ9-DS深度软件待机取消标志	指示深度软件待机取消请求由IRQ9-DS引脚：0：未产生请求1：产生请求。	R(/W)*1
b2	DIRQ10F	IRQ10-DS深度软件待机取消标志	指示深度软件待机取消请求由IRQ10-DS引脚：0：未产生请求1：产生请求。	R(/W)*1
b3	DIRQ11F	IRQ11-DS深度软件待机取消标志	指示深度软件待机取消请求由IRQ11-DS引脚：0：未产生请求1：产生请求。	R(/W)*1
b4	DIRQ12F	IRQ12-DS深度软件待机取消标志	指示深度软件待机取消请求由IRQ12-DS引脚：0：未产生请求1：产生请求。	R(/W)*1
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R(/W)*1

Note 1. 只能写入0来清除标志。

The flags in the DPSIFR1 register are set to 1 when the associated cancel request specified in DPSIEGR1 is generated. Each flag can be set to 1 when a cancel request is generated in any mode, not only in Deep Software Standby mode, or when the setting in DPSIER1 is changed. Clear DPSIFR1 to 00h before entering Deep Software Standby mode.

To clear DPSIFR1 to 00h after modifying DPSIER1, wait for at least 6 PCLKB cycles, read DPSIFR1, and then write 0 to DPSIFR1. Six or more PCLKB cycles can be secured, for example, by reading DPSIER1. DPSIFR1 is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source.

DIRQnF flag (IRQn-DS Deep Software Standby Cancel Flag) (n = 8 to 12)

The DIRQnF flag indicates that a cancel request is generated by the IRQn-DS pin.

[Setting condition]

- A cancel request generated by the IRQn-DS pin specified in DPSIEGR1.

[Clearing condition]

- Writing 0 to the flag after reading it as 1.

11.2.18 Deep Software Standby Interrupt Flag Register 2 (DPSIFR2)

Address(es): SYSTEM.DPSIFR2 4001 E408h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DNMIF	—	—	DLVD2IF	DLVD1IF
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DLVD1IF	LVD1 Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the voltage monitor 1 signal: 0: No request generated 1: Request generated.	R(/W)*1
b1	DLVD2IF	LVD2 Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the voltage monitor 2 signal: 0: No request generated 1: Request generated.	R(/W)*1
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	DNMIF	NMI Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by the NMI pin: 0: No request generated 1: Request generated.	R(/W)*1
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. Only 0 can be written to clear the flag.

The flags in the DPSIFR2 register are set to 1 when the associated cancel request specified in DPSIEGR2 is generated. Each flag can be set to 1 when a cancel request is generated in any mode, not only in Deep Software Standby mode, or when the setting in DPSIER2 is changed. Clear DPSIFR2 to 00h before entering Deep Software Standby mode.

To clear DPSIFR2 to 00h after modifying DPSIER2, wait for at least 6 PCLKB cycles, read DPSIFR2, and then write 0 to DPSIFR2. Six or more PCLKB cycles can be secured, for example, by reading DPSIER2. DPSIFR2 is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source.

DLVDmIF flag (LVDm Deep Software Standby Cancel Flag) (m = 1 or 2)

The DLVDmIF flag indicates that a cancel request is generated by the voltage monitor m signal.

[Setting condition]

- A cancel request generated by the voltage monitor m signal specified in DPSIEGR2.

当产生DPSIEGR1中指定的相关取消请求时，DPSIFR1寄存器中的标志设置为1。当在任何模式下生成取消请求时，每个标志都可以设置为1，不仅在深度软件待机模式下，或者当DPSIER1中的设置更改时。在进入深度软件待机模式之前将DPSIFR1清零。

要在修改DPSIER1后将DPSIFR1清除为00h，请等待至少6个PCLKB周期，读取DPSIFR1，然后将0写入DPSIFR1。例如，可以通过读取DPSIER1来确保六个或更多PCLKB周期。DPSIFR1不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。

DIRQnF标志（IRQn-DS深度软件待机取消标志）（n=8到12）

DIRQnF标志指示取消请求由IRQn-DS引脚产生。

[Setting condition]

- 由DPSIEGR1中指定的IRQn-DS引脚生成的取消请求。

[Clearing condition]

- 读为1后将0写入标志。

11.2.18 深度软件待机中断标志寄存器2(DPSIFR2)

Address(es): SYSTEM.DPSIFR2 4001 E408h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DNMIF	—	—	DLVD2IF	DLVD1IF
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DLVD1IF	LVD1深度软件待机取消标志	通过电压监视器1信号指示深度软件待机取消请求：0：未生成请求1：已生成请求。	R(/W)*1
b1	DLVD2IF	LVD2深度软件待机取消标志	通过电压监视器2信号指示深度软件待机取消请求：0：未产生请求1：产生请求。	R(/W)*1
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	DNMIF	NMI深度软件待机取消标志	通过NMI引脚指示深度软件待机取消请求：0：未生成请求1：已生成请求。	R(/W)*1
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 只能写入0来清除标志。

当生成DPSIEGR2中指定的相关取消请求时，DPSIFR2寄存器中的标志设置为1。当在任何模式下生成取消请求时，每个标志都可以设置为1，不仅在深度软件待机模式下，或者当DPSIER2中的设置更改时。在进入深度软件待机模式之前将DPSIFR2清零。

要在修改DPSIER2后将DPSIFR2清除为00h，请等待至少6个PCLKB周期，读取DPSIFR2，然后将0写入DPSIFR2。例如，可以通过读取DPSIER2来确保六个或更多PCLKB周期。DPSIFR2不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。

DLVDmIF标志（LVDm深度软件待机取消标志）（m=1或2）

DLVDmIF标志表示电压监视器m信号产生了取消请求。

[Setting condition]

- 由DPSIEGR2中指定的电压监视器m信号生成的取消请求。

[Clearing condition]

- Writing 0 to the flag after reading it as 1.

DNMIF flag (NMI Deep Software Standby Cancel Flag)

The DNMIF flag indicates that a cancel request is generated by the NMI pin.

[Setting condition]

- A cancel request generated by the NMI pin specified in DPSIEGR2.

[Clearing condition]

- Writing 0 to the flag after reading it as 1.

11.2.19 Deep Software Standby Interrupt Flag Register 3 (DPSIFR3)

Address(es): SYSTEM.DPSIFR3 4001 E409h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	DAGT1IF	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b2	DAGT1IF	AGT1 Underflow Deep Software Standby Cancel Flag	Indicate Deep Software Standby cancel request by an AGT1 underflow: 0: No request generated 1: Request generated.	R(/W)*1
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. Only 0 can be written to clear the flag.

The flags in the DPSIFR3 register are set to 1 when the associated cancel request is generated. Each flag can be set to 1 when a cancel request is generated in any mode, not only in Deep Software Standby mode, or when the setting in DPSIER3 is changed. Clear DPSIFR3 to 00h before entering Deep Software Standby mode.

To clear DPSIFR3 to 00h after modifying DPSIER3, wait for at least 6 PCLKB cycles, read DPSIFR3, and then write 0 to DPSIFR3. Six or more PCLKB cycles can be secured, for example, by reading DPSIER3. DPSIFR3 is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see section 6, Resets.

DAGT1IF flag (AGT1 Underflow Deep Software Standby Cancel Flag)

The DAGT1IF flag indicates that a cancel request is generated by an AGT1 underflow.

[Setting condition]

- A cancel request generated by the AGT1 underflow.

[Clearing condition]

- Writing 0 to the flag after reading it as 1.

[Clearing condition]

- 读为1后将0写入标志。

DNMIF标志（NMI深度软件待机取消标志）

DNMIF标志表示取消请求由NMI引脚生成。

[Setting condition]

- 由DPSIEGR2中指定的NMI引脚生成的取消请求。

[Clearing condition]

- 读为1后将0写入标志。

11.2.19 深度软件待机中断标志寄存器3(DPSIFR3)

Address(es): SYSTEM.DPSIFR3 4001 E409h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	DAGT1IF	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b2	DAGT1IF	AGT1下溢深度软件 待机取消标志	指示深度软件待机取消请求由 AGT1下溢：0：未生成 请求1：生成请求。	R(/W)*1
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 只能写入0来清除标志。

当产生相关的取消请求时，DPSIFR3寄存器中的标志设置为1。当在任何模式下生成取消请求时，每个标志都可以设置为1，不仅在深度软件待机模式下，或者当DPSIER3中的设置更改时。在进入深度软件待机模式之前将DPSIFR3清零。

要在修改DPSIER3后将DPSIFR3清除为00h，请等待至少6个PCLKB周期，读取DPSIFR3，然后将0写入DPSIFR3。例如，可以通过读取DPSIER3来确保六个或更多PCLKB周期。DPSIFR3不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参阅第6节，重置。

DAGT1IF标志（AGT1下溢深度软件待机取消标志）

DAGT1IF标志指示取消请求是由AGT1下溢产生的。

[Setting condition]

- AGT1下溢生成的取消请求。

[Clearing condition]

- 读为1后将0写入标志。

11.2.20 Deep Software Standby Interrupt Edge Register 0 (DPSIEGR0)

Address(es): SYSTEM.DPSIEGR0 4001 E40Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	DIRQ7EG	DIRQ6EG	DIRQ5EG	DIRQ4EG	—	—	DIRQ1EG	DIRQ0EG
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DIRQ0EG	IRQ0-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b1	DIRQ1EG	IRQ1-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	DIRQ4EG	IRQ4-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b5	DIRQ5EG	IRQ5-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b6	DIRQ6EG	IRQ6-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b7	DIRQ7EG	IRQ7-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W

The DPSIEGR0 register is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source.

11.2.21 Deep Software Standby Interrupt Edge Register 1 (DPSIEGR1)

Address(es): SYSTEM.DPSIEGR1 4001 E40Bh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DIRQ12EG	DIRQ11EG	DIRQ10EG	DIRQ9EG	DIRQ8EG
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DIRQ8EG	IRQ8-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b1	DIRQ9EG	IRQ9-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b2	DIRQ10EG	IRQ10-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b3	DIRQ11EG	IRQ11-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b4	DIRQ12EG	IRQ12-DS Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The DPSIEGR1 register is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source.

11.2.20 深度软件待机中断边沿寄存器0(DPSIEGR0)

Address(es): SYSTEM.DPSIEGR0 4001 E40Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	DIRQ7EG	DIRQ6EG	DIRQ5EG	DIRQ4EG	—	—	DIRQ1EG	DIRQ0EG
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DIRQ0EG	IRQ0-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b1	DIRQ1EG	IRQ1-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	DIRQ4EG	IRQ4-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b5	DIRQ5EG	IRQ5-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b6	DIRQ6EG	IRQ6-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b7	DIRQ7EG	IRQ7-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W

DPSIEGR0寄存器不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。

11.2.21 深度软件待机中断边沿寄存器1(DPSIEGR1)

Address(es): SYSTEM.DPSIEGR1 4001 E40Bh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DIRQ12EG	DIRQ11EG	DIRQ10EG	DIRQ9EG	DIRQ8EG
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DIRQ8EG	IRQ8-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b1	DIRQ9EG	IRQ9-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b2	DIRQ10EG	IRQ10-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b3	DIRQ11EG	IRQ11-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b4	DIRQ12EG	IRQ12-DS引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DPSIEGR1寄存器不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。

11.2.22 Deep Software Standby Interrupt Edge Register 2 (DPSIEGR2)

Address(es): SYSTEM.DPSIEGR2 4001 E40Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DNMIEG	—	—	DLVD2EG	DLVD1EG
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DLVD1EG	LVD1 Edge Select	0: Generate cancel request when VCC < V_{det1} (fall) is detected 1: Generate cancel request when VCC ≥ V_{det1} (rise) is detected.	R/W
b1	DLVD2EG	LVD2 Edge Select	0: Generate cancel request when VCC < V_{det2} (fall) is detected 1: Generate cancel request when VCC ≥ V_{det2} (rise) is detected.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	DNMIEG	NMI Pin Edge Select	0: Generate cancel request on falling edge 1: Generate cancel request on rising edge.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The DPSIEGR2 register is not initialized by the internal reset signal that cancels Deep Software Standby mode. For details, see Table 6.2, Reset detect flags initialized by each reset source.

11.2.23 System Control OCD Control Register (SYOCDCR)

Address(es): SYSTEM.SYOCDCR 4001 E40Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	DBGEN	—	—	—	—	—	—	DOCDF
Value after reset:	0	0	0	0	0	0	0	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	DOCDF	Deep Software Standby OCD Flag	Indicate cancel request by the DBIRQ: 0: DBIRQ is not generated 1: DBIRQ is generated.	R/(W)*1
b6 to b1	—	Reserved	These bits are read as 0. The write value must be 0.	R/W
b7	DBGEN	Debugger Enable Bit	0: Disable on-chip debugger 1: Enable on-chip debugger. Set to 1 first in On-Chip Debug (OCD) mode.	R/W

Note 1. Writing 0 clears the flag. Writing 1 is ignored.

SYOCDCR is not initialized by the internal reset signal that cancels Deep Software Standby mode.

DOCDF flag (Deep Software Standby OCD Flag)

The DOCDF flag indicates that a Deep Software Standby cancel request is generated by the MCUCTRL.DBIRQ bit. The flag is set to 1 when the cancel request is generated. The flag can be set to 1 when a cancel request is generated in any mode, not only in Deep Software Standby mode. Clear the DOCDF flag to 0 before entering Deep Software Standby mode.

[Setting condition]

- A cancel request generated by the MCUCTRL.DBIRQ bit.

[Clearing condition]

- Writing 0 to the flag after reading it as 1

11.2.22 深度软件待机中断边沿寄存器2(DPSIEGR2)

Address(es): SYSTEM.DPSIEGR2 4001 E40Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DNMIEG	—	—	DLVD2EG	DLVD1EG
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DLVD1EG	LVD1边沿选择	0：检测到VCC<Vdet1（下降）时产生取消请求1：检测到VCC Vdet1（上升）时产生取消请求。	R/W
b1	DLVD2EG	LVD2边沿选择	0：检测到VCC<Vdet2（下降）时产生取消请求1：检测到VCC Vdet2（上升）时产生取消请求。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	DNMIEG	NMI引脚边沿选择	0：下降沿产生取消请求1：上升沿产生取消请求。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DPSIEGR2寄存器不会被取消深度软件待机模式的内部复位信号初始化。有关详细信息，请参见表6.2，每个复位源初始化的复位检测标志。

11.2.23 系统控制OCD控制寄存器(SYOCDCR)

Address(es): SYSTEM.SYOCDCR 4001 E40Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	DBGEN	—	—	—	—	—	—	DOCDF
重置后的值:	0	0	0	0	0	0	0	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	DOCDF	深度软件待机OCD标志	指示DBIRQ的取消请求：0：不产生DBIRQ1：产生DBIRQ。	R/(W)*1
b6 to b1	—	Reserved	这些位被读取为0。写入值必须为0。	R/W
b7	DBGEN	调试器启用位	0：禁用片上调试器1：启用片上调试器。在片上调试(OCD)模式下首先设置为1。	R/W

Note 1. 写入0清除标志。写入1被忽略。

取消深度软件待机模式的内部复位信号不会初始化SOOCDCR。

DOCDF标志（深度软件待机OCD标志）

DOCDF标志表示深度软件待机取消请求由MCUCTRL.DBIRQ位生成。生成取消请求时，该标志设置为1。当在任何模式下生成取消请求时，该标志可以设置为1，而不仅仅是在深度软件待机模式下。在进入深度软件待机模式之前将DOCDF标志清零。

[Setting condition]

- 由MCUCTRL.DBIRQ位生成的取消请求。

[Clearing condition]

- 读为1后将0写入标志

- When the DBGEN bit is 0.

DBGEN bit (Debugger Enable Bit)

The DBGEN bit enables the OCD mode. This bit must be set to 1 first in OCD mode.

[Setting condition]

- Writing 1 to the bit when the debugger is connected.

[Clearing condition]

- Power-on reset is generated
- Writing 0 to the bit.

11.2.24 Standby Condition Register (STCONR)

Address(es): SYSTEM.STCONR 4001 E40Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	STCON[1:0]	
Value after reset:	1	1	0	0	0	0	1	1

Bit	Symbol	Bit name	Description	R/W
b1 to b0	STCON[1:0]	SSTBY Condition Bit	b1 b0 0 0: Set this value to transition to Software Standby mode when using HOCO 1 1: Set this value to transition to Software Standby mode when not using HOCO.	R/W
b5 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7 to b6	—	Reserved	These bits are read as 1. The write value should be 1.	R/W

STCON[1:0] bits (SSTBY Condition Bit)

The STCON[1:0] bits must always be set to 00b when using HOCO to enter Software Standby mode.

11.3 Reducing Power Consumption by Switching Clock Signals

The clock frequency changes when the following bits are set:

- SCKDIVCR.FCK[2:0]
- ICK[2:0]
- PCKA[2:0]
- PCKB[2:0]
- PCKC[2:0]
- PCKD[2:0].

The module and clock associations are as follows:

- The CPU, DMAC, DTC, flash, and SRAM use the operating clock specified in the ICK[2:0] bits
- Peripheral modules use the operating clocks specified in the PCKA[2:0], PCKB[2:0], PCKC[2:0], and PCKD[2:0] bits
- The flash memory interface uses the operating clock specified in the FCK[2:0] bits.

For details, see section 9, Clock Generation Circuit.

- DBGEN位为0时。

DBGEN位（调试器启用位）

DBGEN位使能OCD模式。在OCD模式下，该位必须首先设置为1。

[Setting condition]

- 连接调试器时向该位写入1。

[Clearing condition]

- 上电复位产生
- 将0写入该位。

11.2.24 待机条件寄存器(STCONR)

Address(es): SYSTEM.STCONR 4001 E40Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	STCON[1:0]	
重置后的值：	1	1	0	0	0	0	1	1

Bit	Symbol	位名称	Description	R/W
b1 to b0	STCON[1:0]	SSTBY条件位	b1b000：设置该值以在使用HOCO时转换到软件待机模式11：设置该值以在不使用HOCO时转换到软件待机模式。	R/W
b5 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7 to b6	—	Reserved	这些位被读取为1。写入值应为1。	R/W

STCON[1:0]位（SSTBY条件位）

当使用HOCO进入软件待机模式时，STCON[1:0]位必须始终设置为00b。

11.3 通过切换时钟信号降低功耗

设置以下位时，时钟频率会发生变化：

- SCKDIVCR.FCK[2:0]
- ICK[2:0]
- PCKA[2:0]
- PCKB[2:0]
- PCKC[2:0]
- PCKD[2:0].

模块和时钟关联如下：

- CPU、DMAC、DTC、闪存和SRAM使用ICK[2:0]位指定的工作时钟
- 外设模块使用PCKA[2:0]、PCKB[2:0]、PCKC[2:0]和PCKD[2:0]位中指定的工作时钟
- 闪存接口使用FCK[2:0]位中指定的工作时钟。

有关详细信息，请参见第9节，时钟生成电路。

11.4 Module-Stop Function

The module-stop function can be set for each on-chip peripheral module.

When the MSTPmi bit (m = A to D, i = 31 to 0) in MSTPCRA to MSTPCRD is set to 1, the specified module stops operating and enters the module-stop state, but the CPU continues to operate independently. Clearing the MSTPmi bit to 0 cancels the module-stop state, allowing the module to resume operation at the end of the bus cycle. The internal states of the modules are retained in the module-stop state.

After a reset is canceled, all modules other than the DMAC, DTC, and SRAM modules are placed in the module-stop state. Do not access the module while the associated MSTPmi bit is 1, otherwise the read/write data or the operation of the module is not guaranteed. Also, do not set the MSTPmi bit to 1 while the associated module is accessed.

When the PLL is selected as the clock source, MSTPmi bits must only be changed one bit at a time. In this case, wait at least 250 ns after changing each MSTPmi bit before starting subsequent processing if you change any of the following bits:

- MSTPA22 (DMAC, DTC)
- MSTPC31 (SCE7)
- MSTPD5 (GPT32EH, GPT32E).

The recommended method to measure the wait time is through software. Be sure to consider the worst-case conditions to ensure that the required wait time elapses.

11.5 Function for Lower Operating Power Consumption

By selecting an appropriate operating power consumption control mode according to the operating frequency and operating voltage, power consumption can be reduced in Normal mode and Sleep mode.

11.5.1 Setting the Operating Power Control Mode

Make sure that the operating conditions such as the voltage and frequency ranges, are always within the specified ranges before and after switching the operating power control modes. This section provides example procedures for switching operating power control modes.

Table 11.5 Available oscillators in each mode

Mode	Oscillator						
	PLL	High-speed on-chip oscillator	Middle-speed on-chip oscillator	Low-speed on-chip oscillator	Main clock oscillator	Sub-clock oscillator	IWDT-dedicated on-chip oscillator
High-speed	Available	Available	Available	Available	Available	Available	Available
Low-speed	N/A	Available	Available	Available	Available	Available	Available
Subosc-speed	N/A	N/A	N/A	Available	N/A	Available	Available

(1) Switching from a higher to a lower power mode

Example 1: From High-speed mode to Low-speed mode

Operation begins in High-speed mode.

1. Change the oscillator to that used in Low-speed mode. Set the frequency of each clock lower than the maximum operating frequency in Low-speed mode.
2. Turn off the oscillator that is not required in Low-speed mode.
3. Confirm that the OPCCR.OPCMTSF flag is 0 (indicates transition completed).
4. Set the OPCCR.OPCM[1:0] bits to 11b (Low-speed mode).
5. Confirm that the OPCCR.OPCMTSF flag is 0 (indicates transition completed).

Operation is now in Low-speed mode.

11.4 Module-Stop Function

可以为每个片上外围模块设置模块停止功能。

当MSTPCRA到MSTPCRD中的MSTPmi位（m=A到D，i=31到0）设置为1时，指定模块停止运行并进入模块停止状态，但CPU继续独立运行。将MSTPmi位清0可取消模块停止状态，允许模块在总线周期结束时恢复运行。模块的内部状态保持在模块停止状态。

取消复位后，除DMAC、DTC和SRAM模块之外的所有模块都置于模块停止状态。相关MSTPmi位为1时请勿访问模块，否则无法保证读写数据或模块的操作。此外，在访问相关模块时不要将MSTPmi位设置为1。

WhenthePLLisselectedastheclocksource MSTPmibitsmustonlybechangedonebitatatime.在这种情况下，如果更改以下任何位，请在更改每个MSTPmi位后至少等待250ns，然后再开始后续处理：

- MSTPA22 (DMAC, DTC)
- MSTPC31 (SCE7)
- MSTPD5 (GPT32EH, GPT32E).

测量等待时间的推荐方法是通过软件。请务必考虑最坏情况，以确保经过所需的等待时间。

11.5 降低运行功耗的功能

通过根据工作频率和工作电压选择合适的工作功耗控制模式，可以降低正常模式和睡眠模式下的功耗。

11.5.1 设置工作电源控制模式

确保在切换操作功率控制模式之前和之后，电压和频率范围等操作条件始终在指定范围内。本节提供切换操作电源控制模式的示例程序。

Table 11.5 每种模式下可用的振荡器

Mode	Oscillator						
	PLL	High-speed on-chip oscillator	Middle-speed on-chip oscillator	Low-speed on-chip oscillator	主时钟振荡器	Sub-clock oscillator	IWDT-dedicated on-chip oscillator
High-speed	Available	Available	Available	Available	Available	Available	Available
Low-speed	N/A	Available	Available	Available	Available	Available	Available
Subosc-speed	N/A	N/A	N/A	Available	N/A	Available	Available

(1) 从高功率模式切换到低功率模式

示例1：从高速模式到低速模式

操作以高速模式开始。

1. 将振荡器更改为低速模式中使用的振荡器。将每个时钟的频率设置为低于低速模式下的最大工作频率。
2. 关闭低速模式下不需要的振荡器。
3. 确认OPCCR.OPCMTSF标志为0（表示转换完成） 。
4. 将OPCCR.OPCM[1:0]位设置为11b（低速模式）。
5. 确认OPCCR.OPCMTSF标志为0（表示转换完成） 。

操作现在处于低速模式。

Example 2: From High-speed mode to Subosc-speed mode

Operation begins in High-speed mode.

1. Switch the clock source to the sub-clock oscillator.
2. Turn off HOCO, MOCO, LOCO, main oscillator, and PLL.
3. Confirm that all clock sources other than the sub-clock oscillator are stopped.
4. Confirm that the SOPCCR.SOPCMTSF flag is 0 (indicates transition completed).
5. Set the SOPCCR.SOPCM bit to 1 (Subosc-speed mode).
6. Confirm that the SOPCCR.SOPCMTSF flag is 0 (indicates transition completed).

Operation is now in Subosc-speed mode.

(2) Switching from a lower to a higher power mode

Example 1: From Subosc-speed mode to High-speed mode

Operation begins in Subosc-speed mode.

1. Confirm that the SOPCCR.SOPCMTSF flag is 0 (indicates transition completed).
2. Set the SOPCCR.SOPCM bit to 0 (High-speed mode).
3. Confirm that the SOPCCR.SOPCMTSF flag is 0 (indicates transition completed).
4. Turn on the required oscillator in High-speed mode.
5. Set the frequency of each clock lower than the maximum operating frequency for High-speed mode.

Operation is now in High-speed mode.

Example 2: From Low-speed mode to High-speed mode

Operation begins in Low-speed mode.

1. Confirm that the OPCCR.OPCMTSF flag is 0 (indicates transition completed).
2. Set the OPCCR.OPCM[1:0] bits to 00b (High-speed mode).
3. Confirm that the OPCCR.OPCMTSF flag is 0 (indicates transition completed).
4. Turn on any required oscillator in High-speed mode.
5. Set the frequency of each clock to lower than the maximum operating frequency for High-speed mode.

Operation is now in High-speed mode.

11.6 Sleep Mode

11.6.1 Transitioning to Sleep Mode

When a WFI instruction is executed while the SBYCR.SSBY bit is 0, the MCU enters Sleep mode. In Sleep mode, the CPU stops operating, but the contents of its internal registers are retained. Other peripheral functions do not stop. Available resets or interrupts in Sleep mode cause the MCU to cancel Sleep mode. All interrupt sources are available. If using an interrupt to cancel Sleep mode, you must set the associated IELSRn register before executing a WFI instruction. For details, see section 13, Interrupt Controller Unit (ICU).

Counting by the IWDT stops when the MCU enters Sleep mode while the IWDT is in auto start mode and the OFS0.IWDTSTPCTL bit is 1 (IWDT stops in Sleep mode, Software Standby mode, or Snooze mode).

Counting by the IWDT continues when the MCU enters Sleep mode while the IWDT is in auto start mode and the OFS0.IWDTSTPCTL bit is 0 (IWDT does not stop in Sleep mode, Software Standby mode, or Snooze mode).

Counting by the WDT stops when the MCU enters Sleep mode while the WDT is in auto start mode and the OFS0.WDTSTPCTL bit is 1 (WDT stops in Sleep mode). Similarly, counting by the WDT stops when the MCU enters Sleep mode while the WDT is in register start mode and the WDTCSTPR.SLCSTP bit is 1 (WDT stops in Sleep mode).

Counting by the WDT continues when the MCU enters Sleep mode while the WDT is in auto start mode and the OFS0.

示例2：从高速模式到Subosc速度模式

操作以高速模式开始。

1. 将时钟源切换到副时钟振荡器。
2. 关闭HOCO、MOCO、LOCO、主振荡器和PLL。
3. 确认除副时钟振荡器之外的所有时钟源都已停止。
4. 确认SOPCCR.SOPCMTSF标志为0（表示转换完成） 。
5. 将SOPCCR.SOPCM位设置为1（Subosc速度模式）。
6. 确认SOPCCR.SOPCMTSF标志为0（表示转换完成） 。

操作现在处于Subosc速度模式。

(2) 从低功率模式切换到高功率模式

示例1：从Subosc速度模式到高速模式

操作以Subosc速度模式开始。

1. 确认SOPCCR.SOPCMTSF标志为0（表示转换完成） 。
2. 将SOPCCR.SOPCM位设置为0（高速模式）。
3. 确认SOPCCR.SOPCMTSF标志为0（表示转换完成） 。
4. 在高速模式下打开所需的振荡器。
5. 将每个时钟的频率设置为低于高速模式的最大工作频率。

操作现在处于高速模式。

示例2：从低速模式到高速模式

操作以低速模式开始。

1. 确认OPCCR.OPCMTSF标志为0（表示转换完成） 。
2. 将OPCCR.OPCM[1:0]位设置为00b（高速模式）。
3. 确认OPCCR.OPCMTSF标志为0（表示转换完成） 。
4. 在高速模式下打开任何所需的振荡器。
5. 将每个时钟的频率设置为低于高速模式的最大工作频率。

操作现在处于高速模式。

11.6 睡眠模式

11.6.1 转换到睡眠模式

当SBYCR.SSBY位为0时执行WFI指令时，MCU进入休眠模式。在睡眠模式下，CPU停止运行，但其内部寄存器的内容被保留。其他外围功能不会停止。

休眠模式下可用的复位或中断会导致MCU取消休眠模式。所有中断源均可用。如果使用中断取消休眠模式，则必须在执行WFI指令之前设置相关的IELSRn寄存器。有关详细信息，请参阅第13节，中断控制器单元(ICU)。

当MCU进入休眠模式且IWDT处于自动启动模式且
OFS0.IWDTSTPCTL位为1（IWDT在休眠模式、软件待机模式或贪睡模式下停止）。

当MCU进入休眠模式且IWDT处于自动启动模式且
OFS0.IWDTSTPCTL位为0（IWDT在休眠模式、软件待机模式或贪睡模式下不会停止）。

当MCU进入休眠模式且WDT处于自动启动模式且WDT处于自动启动模式时，WDT停止计数
OFS0.WDTSTPCTL位为1（WDT在休眠模式下停止）。同样，当MCU进入休眠模式且WDT处于寄存器启动模式且WDTCSTPR.SLCSTP位为1（WDT在休眠模式下停止）时，WDT停止计数。

当MCU进入休眠模式且WDT处于自动启动模式和OFS0时，WDT继续计数。

WDTSTPCTL bit is 0 (WDT does not stop in Sleep mode). Similarly, counting by the WDT continues when the MCU enters Sleep mode while the WDT is in register start mode and the WDTCSTPR.SLCSTP bit is 0 (WDT does not stop in Sleep mode).

11.6.2 Canceling Sleep Mode

Sleep mode is canceled by:

- An interrupt
- A RES pin reset
- A power-on reset
- A voltage monitor reset
- An SRAM parity error reset
- A bus master MPU error reset
- A bus slave MPU error reset
- A reset caused by an IWDT or WDT underflow.

The operations are as follows:

1. Canceling by an interrupt
   When an available interrupt request (see Table 11.3) is generated, Sleep mode is canceled and the MCU starts the interrupt handling.
2. Canceling by RES pin reset
   When the RES pin is driven low, the MCU enters the reset state. Be sure to keep the RES pin low for the time period specified in section 43, Electrical Characteristics. When the RES pin is driven high after the specified time period, the CPU starts the reset exception handling.
3. Canceling by IWDT reset
   Sleep mode is canceled by an internal reset generated by an IWDT underflow, and the MCU starts the reset exception handling. However, IWDT stops in Sleep mode and an internal reset for canceling Sleep mode is not generated in the following conditions:
   - OFS0.IWDTSTRT = 0 and OFS0.IWDTSTPCTL = 1.
4. Canceling by WDT reset
   Sleep mode is canceled by an internal reset generated by an WDT underflow and the MCU starts the reset exception handling. However, WDT stops in Sleep mode even when counting in Normal mode and an internal reset for canceling Sleep mode is not generated in the following conditions:
   - OFS0.WDTSTRT = 0 (auto start mode) and OFS0.WDTSTPCTL = 1
   - OFS0.WDTSTRT = 1 (register start mode) and WDTCSTPR.SLCSTP = 1.
5. Canceling by other resets available in Sleep mode
   Sleep mode is canceled by other resets and the MCU starts the reset exception handling.

Note: For details on proper setting of the interrupts, see section 13, Interrupt Controller Unit (ICU).

11.7 Software Standby Mode

11.7.1 Transitioning to Software Standby Mode

When a WFI instruction is executed while the SBYCR.SSBY bit is 1 and the DPSBYCR.DPSBY bit is 0, the MCU enters Software Standby mode. In this mode, the CPU, most of the on-chip peripheral functions, and the oscillators stop. However, the contents of the CPU internal registers and SRAM data, the states of the on-chip peripheral functions, and the I/O port states are retained. Software Standby mode allows a significant reduction in power consumption because most of the oscillators stop in this mode. Table 11.2 shows the status of the on-chip peripheral functions and oscillators. Available resets or interrupts in Software Standby mode cause the MCU to cancel Software Standby mode. See Table 11.3 for available interrupt sources and section 13.2.9, Wake Up Interrupt Enable Register (WUPEN) for information on waking up the MCU from Software Standby mode. If using an interrupt to cancel Software Standby mode, you must set

WDTSTPCTL位为0（WDT在休眠模式下不停止）。同样，当MCU进入休眠模式且WDT处于寄存器启动模式且WDTCSTPR.SLCSTP位为0（WDT在休眠模式下不会停止）时，WDT继续计数。

11.6.2 取消睡眠模式

睡眠模式通过以下方式取消：

- 中断
- ARES引脚复位
- A power-on reset
- 电压监视器复位
- SRAM奇偶校验错误复位
- 总线主控MPU错误复位
- 总线从机MPU错误复位
- 由IWDT或WDT下溢引起的复位。

操作如下：

1. 通过中断取消
   当产生可用的中断请求（见表11.3）时，休眠模式被取消，MCU开始中断处理。
2. 通过RES引脚复位取消
   当RES引脚驱动为低电平时，MCU进入复位状态。请务必在第43节"电气特性"中指定的时间段内保持RES引脚为低电平。当RES引脚在指定时间后被驱动为高电平时，CPU开始复位异常处理。
3. 通过IWDT复位取消
   休眠模式由IWDT下溢产生的内部复位取消，MCU开始复位异常处理。但是，IWDT在休眠模式下停止，并且在以下情况下不会产生用于取消休眠模式的内部复位：
   - OFS0.IWDTSTRT = 0 and OFS0.IWDTSTPCTL = 1.
4. 通过WDT复位取消
   睡眠模式由WDT下溢产生的内部复位取消，MCU启动复位异常处理。但是，即使在正常模式下计数，WDT也会在休眠模式下停止，并且在以下情况下不会产生用于取消休眠模式的内部复位：
   - OFS0.WDTSTRT=0（自动启动模式）和OFS0.WDTSTPCTL=1
   - OFS0.WDTSTRT=1（寄存器启动模式）和WDTCSTPR.SLCSTP=1。
5. 通过睡眠模式下可用的其他复位取消
   休眠模式被其他复位取消，MCU开始复位异常处理。

Note: 有关正确设置中断的详细信息，请参阅第13节，中断控制器单元(ICU)。

11.7 软件待机模式

11.7.1 过渡到软件待机模式

当SBYCR.SSBY位为1且DPSBYCR.DPSBY位为0时执行WFI指令，MCU进入软件待机模式。在此模式下，CPU、大部分片上外围功能和振荡器停止。但是，CPU内部寄存器和SRAM数据的内容、片上外围功能的状态以及IO端口的状态都会被保留。软件待机模式可显着降低功耗，因为大多数振荡器在此模式下停止。表11.2显示了片上外围功能和振荡器的状态。软件待机模式下可用的复位或中断会导致MCU取消软件待机模式。有关可用的中断源，请参见表11.3，有关从软件待机模式唤醒MCU的信息，请参见第13.2.9节，唤醒中断使能寄存器(WUPEN)。如果使用中断取消软件待机模式，则必须设置

the associated IELSRn register before executing a WFI instruction. For details, see section 13, Interrupt Controller Unit (ICU).

The status of the address bus and bus control signals in Software Standby mode can be selected with the SBYCR.OPE bit.

Clear the DMAST.DMST and DTCST.DTCST bits to 0 before executing a WFI instruction, except when using the DTC in Snooze mode. If the DTC is required in Snooze mode, set the DTCST.DTCST bit to 1 before executing a WFI instruction.

Counting by the IWDT stops when the MCU enters Software Standby mode while the IWDT is in auto start mode and the OFS0.IWDTSTPCTL bit is 1 (IWDT stops in Sleep, Software Standby, or Snooze mode).

Counting by the IWDT continues when the MCU enters Software Standby mode while the IWDT is in auto start mode and the OFS0.IWDTSTPCTL bit is 0 (IWDT does not stop in Sleep mode, Software Standby mode, or Snooze mode). The WDT stops counting when the MCU enters Software Standby mode.

Do not enter Software Standby mode while OSTDCR.OSTDE is 1 (oscillation stop detection function enabled). To enter Software Standby mode, execute a WFI instruction after disabling the oscillation stop detection function (OSTDCR.OSTDE is 0). If executing a WFI instruction while OSTDCR.OSTDE is 1, the MCU enters Sleep mode even when SBYCR.SSBY is 1. In addition, do not enter Software Standby mode while the flash memory performs a programming or erasing procedure. To enter Software Standby mode, execute a WFI instruction after the programming or erasing procedure completes.

When the PLL is selected as the clock source, set the following modules to the module-stop state before executing a WFI instruction:

- SCE7
- GPT32EH
- GPT32E.

You must also insert a wait time of at least 750 ns before executing the WFI instruction. The recommended method to measure the wait time is through software. Be sure to consider the worst-case conditions to ensure that the required wait time elapses.

Table 11.6 shows the setting of the related control bits and the modes entered when executing a WFI instruction.

Figure 11.2 shows an example flow for transitioning to Software Standby mode or Deep Software Standby mode.

Table 11.6 Bit settings that affect modes when executing a WFI instruction

Other bit settings		SBYCR.SSBY and DPSBYCR.DPSBY bit settings			
		SSBY = 0, DPSBY = 0	SSBY = 0, DPSBY = 1	SSBY = 1, DPSBY = 0	SSBY = 1, DPSBY = 1
OSTDCR.OSTDE	0	Sleep mode	Sleep mode	Software Standby mode	Deep Software Standby mode
	1			Sleep mode	Sleep mode
FENTRYR.FENTRYi	0	Sleep mode	Sleep mode	Software Standby mode	Deep Software Standby mode
	1			Sleep mode	Sleep mode
OFS0.IWDTSTPCTL	0	Sleep mode	Sleep mode	Software Standby mode	Software Standby mode
	1				Deep Software Standby mode
LVD1CR0.RI	0	Sleep mode	Sleep mode	Software Standby mode	Deep Software Standby mode
	1				Software Standby mode
LVD2CR0.RI	0	Sleep mode	Sleep mode	Software Standby mode	Deep Software Standby mode
	1				Software Standby mode

在执行WFI指令之前关联的IELSRn寄存器。有关详细信息，请参阅第13节，中断控制器单元(ICU)。

软件待机模式下的地址总线和总线控制信号的状态可以通过SBYCR.OPE位来选择。

在执行WFI指令之前将DMAST.DMST和DTCST.DTCST位清零，除非在贪睡模式下使用DTC。如果在贪睡模式下需要DTC，请在执行WFI指令之前将DTCST.DTCST位设置为1。

当IWDT处于自动启动模式且OFS0.IWDTSTPCTL位为1（IWDT在休眠、软件待机或贪睡模式下停止）时，当MCU进入软件待机模式时，IWDT停止计数。

当MCU进入软件待机模式且IWDT处于自动启动模式且OFS0.IWDTSTPCL位为0（IWDT在睡眠模式、软件待机模式或贪睡模式下不停止）时，IWDT继续计数。当MCU进入软件待机模式时，WDT停止计数。

OSTDCR.OSTDE为1（振荡停止检测功能启用）时不要进入软件待机模式。要进入软件待机模式，请在禁用振荡停止检测功能（OSTDCR.OSTDE为0）后执行WFI指令。如果在OSTDCR.OSTDE为1时执行WFI指令，即使SBYCR.SSBY为1，MCU也会进入休眠模式。此外，在闪存执行编程或擦除过程时不要进入软件待机模式。要进入软件待机模式，请在编程或擦除过程完成后执行WFI指令。

WhenthePLLisselectedastheclocksource setthefollowingmodulestothemodule-stopstatebeforeexecutingaWFIinstruction:

- SCE7
- GPT32EH
- GPT32E.

您还必须在执行WFI指令之前插入至少750ns的等待时间。测量等待时间的推荐方法是通过软件。请务必考虑最坏情况，以确保经过所需的等待时间。

表11.6显示了执行WFI指令时相关控制位的设置和进入的模式。

图11.2显示了转换到软件待机模式或深度软件待机模式的示例流程。

Table 11.6 执行WFI指令时影响模式的位设置

其他位设置		SBYCR.SSBY和DPSBYCR.DPSBY位设置			
		SSBY = 0, DPSBY = 0	SSBY = 0, DPSBY = 1	SSBY = 1, DPSBY = 0	SSBY = 1, DPSBY = 1
OSTDCR.OSTDE	0	睡眠模式	睡眠模式	软件待机模式	深度软件待机模式
	1			睡眠模式	睡眠模式
FENTRYR.FENTRYi	0	睡眠模式	睡眠模式	软件待机模式	深度软件待机模式
	1			睡眠模式	睡眠模式
OFS0.IWDTSTPCTL	0	睡眠模式	睡眠模式	软件待机模式	软件待机模式
	1				深度软件待机模式
LVD1CR0.RI	0	睡眠模式	睡眠模式	软件待机模式	深度软件待机模式
	1				软件待机模式
LVD2CR0.RI	0	睡眠模式	睡眠模式	软件待机模式	深度软件待机模式
	1				软件待机模式

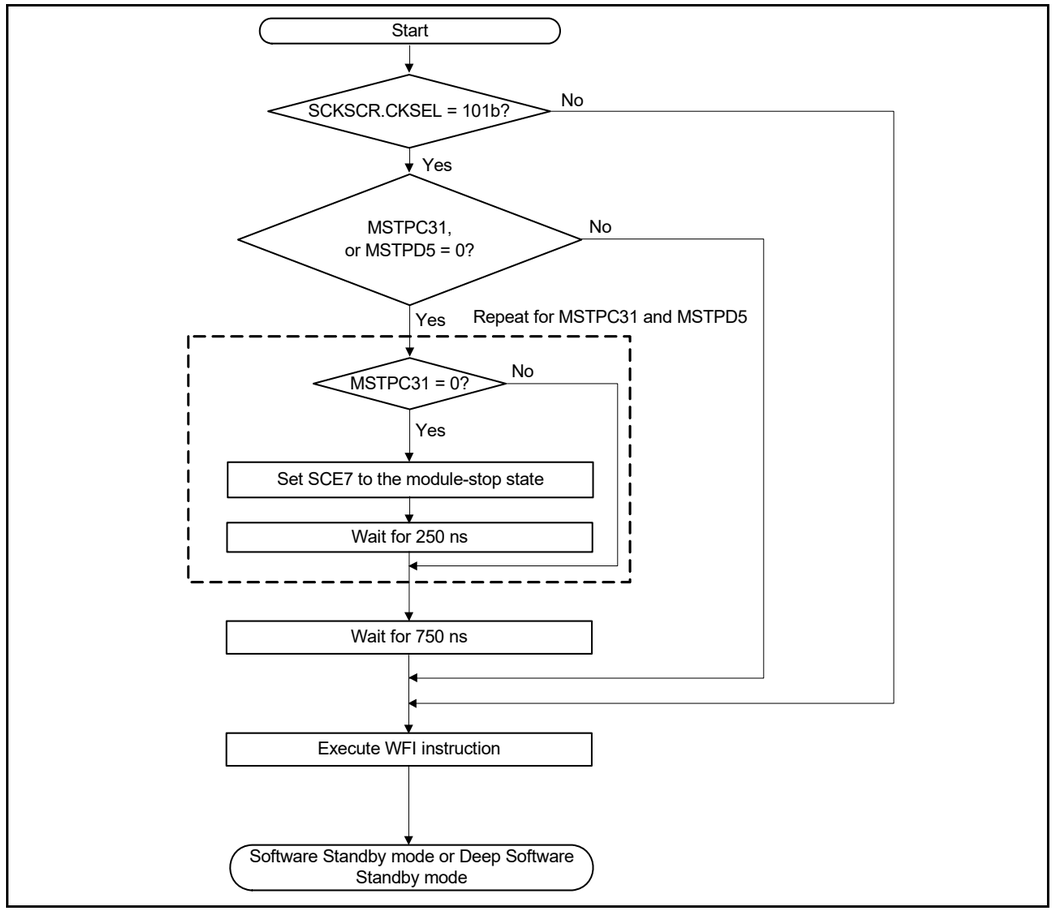


Figure 11.2 Example flow for transition to Software Standby mode or Deep Software Standby mode

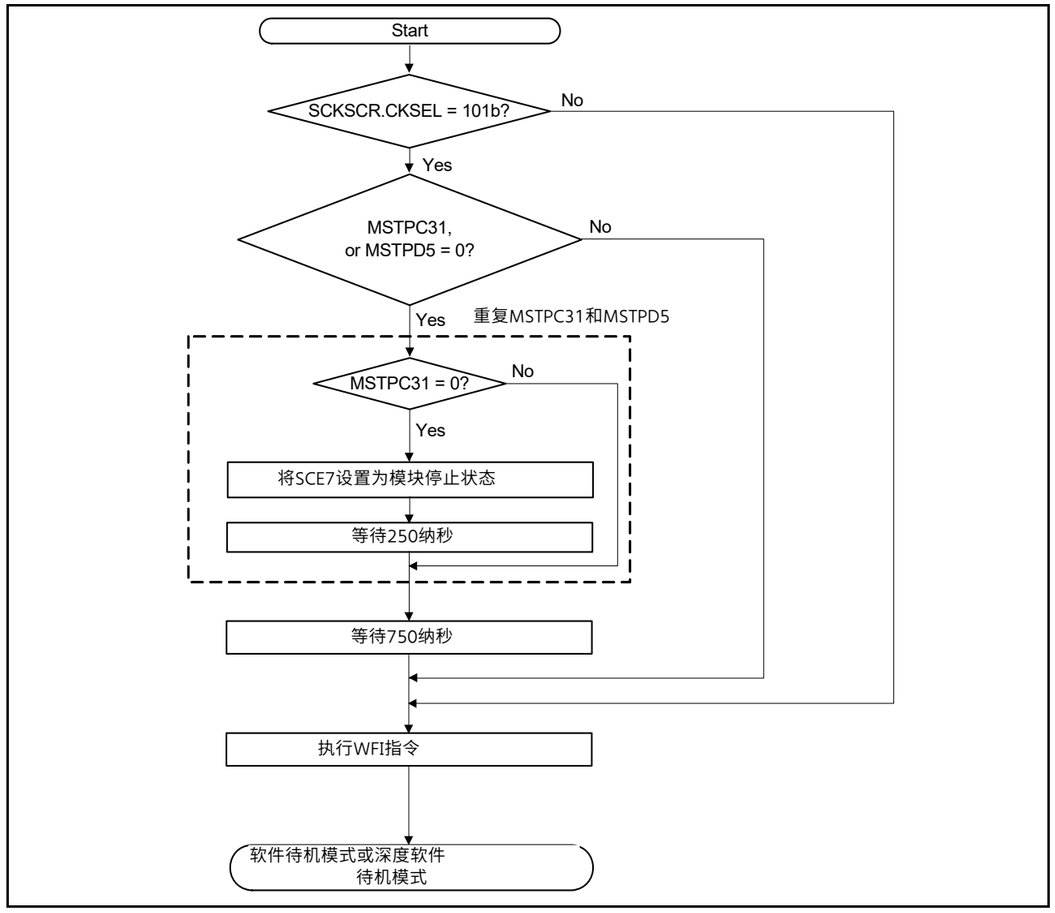


Figure 11.2 转换到软件待机模式或深度软件待机模式的示例流程

11.7.2 Canceling Software Standby Mode

Software Standby mode is canceled by:

- An available interrupt shown in Table 11.3
- A RES pin reset
- A power-on reset
- A voltage monitor reset
- A reset caused by an IWDT underflow.

On exiting Software Standby mode, the oscillators that operate before transitioning to the mode restart. After all the oscillators are stabilized, the MCU returns to Normal mode from Software Standby mode. See section 13.2.9, Wake Up Interrupt Enable Register (WUPEN), for information on waking up the MCU from Software Standby mode.

You can cancel Software Standby mode in any of the following ways:

- Canceling by an interrupt
  When an available interrupt request (see Table 11.3) is generated, an oscillator that operates before the transition to Software Standby mode restarts. After all the oscillators are stabilized, the MCU cancels Software Standby mode and starts the interrupt handling. When the PLL is selected as the clock source, you must insert a wait time of at least 250 ns at the beginning of the interrupt handling. The recommended method to measure the wait time is through software. Be sure to consider the worst-case conditions to ensure that the required wait time elapses. Figure 11.3 shows an example flow for canceling Software Standby mode by an interrupt.
- Canceling by a RES pin reset
  When the RES pin is driven low, the MCU enters the reset state, and the oscillators whose default status is operating, start the oscillation. Be sure to keep the RES pin low for the time period specified in section 43, Electrical Characteristics. When the RES pin is driven high after the specified time period, the CPU starts the reset exception handling.
- Canceling by an IWDT reset
  Software Standby mode is canceled by an internal reset generated by an IWDT underflow, and the MCU starts reset exception handling. However, IWDT stops in Software Standby mode and an internal reset for canceling Software Standby mode is not generated in the following conditions:
  - OFS0.IWDTSTRT = 0 and OFS0.IWDTSTPCTL = 1.
- Canceling by other resets available in Software Standby mode
  Software Standby mode is canceled by other resets, and the MCU starts the reset exception handling.

11.7.2 取消软件待机模式

软件待机模式通过以下方式取消：

- 表11.3中显示的可用中断
- ARES引脚复位
- A power-on reset
- 电压监视器复位
- 由IWDT下溢引起的复位。

在退出软件待机模式时，在转换到该模式之前工作的振荡器会重新启动。在所有振荡器稳定后，MCU从软件待机模式返回到正常模式。有关将MCU从软件待机模式唤醒的信息，请参见第13.2.9节，唤醒中断使能寄存器(WUPEN)。

您可以通过以下任一方式取消软件待机模式：

- 通过中断取消
  当一个可用的中断请求（见表11.3）产生时，一个振荡器在转换到
  软件待机模式重新启动。在所有振荡器稳定后，MCU取消软件待机模式并开始中断处理。WhenthePLLisselectedastheclocksource youmustinsertawaittimeofatleast250nsatthebeginningoftheinterrupthandling.
  测量等待时间的推荐方法是通过软件。请务必考虑最坏情况，以确保经过所需的等待时间。图11.3显示了通过中断取消软件待机模式的示例流程。
- 通过RES引脚复位取消
  当RES引脚驱动为低电平时，MCU进入复位状态，默认状态为工作的振荡器开始振荡。请务必在第43节"电气特性"中指定的时间段内保持RES引脚为低电平。当RES引脚在指定时间后被驱动为高电平时，CPU开始复位异常处理。
- 通过IWDT复位取消
  软件待机模式由IWDT下溢产生的内部复位取消，MCU开始复位异常处理。但是，IWDT在软件待机模式下停止，并且在以下情况下不会产生用于取消软件待机模式的内部复位：
  - OFS0.IWDTSTRT = 0 and OFS0.IWDTSTPCTL = 1.
- 通过软件待机模式下可用的其他复位取消
  软件待机模式被其他复位取消，MCU启动复位异常处理。

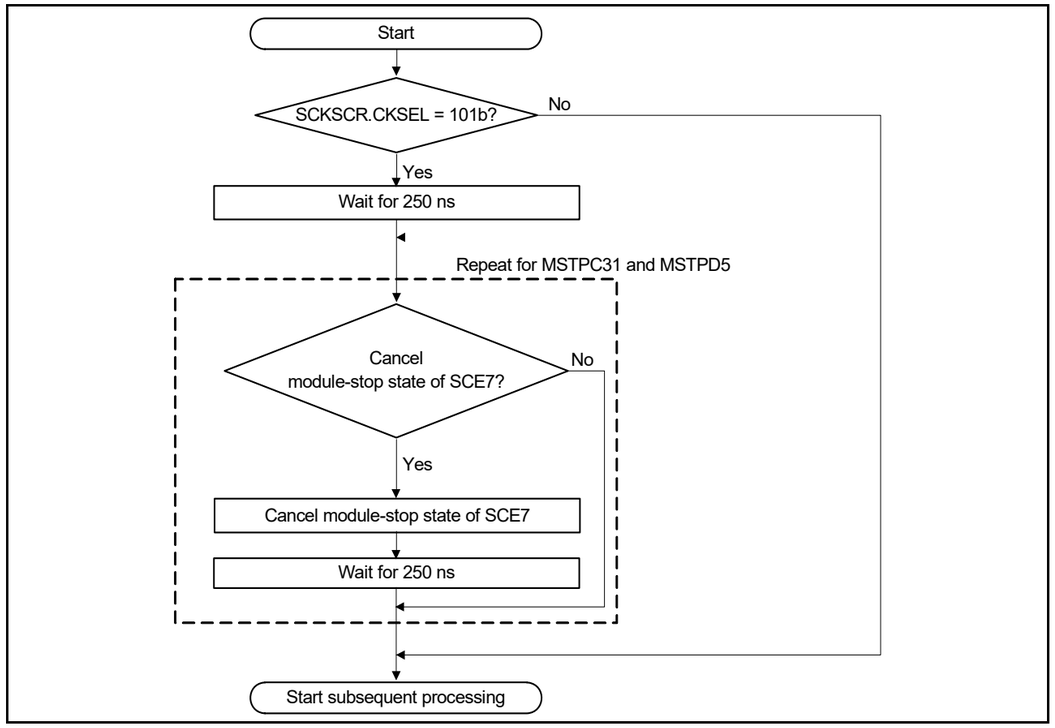


Figure 11.3 Example flow for canceling Software Standby mode

11.7.3 Example of Software Standby Mode Application

Figure 11.4 shows an example of entry to Software Standby mode on detection of a falling edge of the IRQn pin, and exit from Software Standby mode on a rising edge of the IRQn pin.

In this example, an IRQn pin interrupt is accepted when the IRQCRi.IRQMD[1:0] bits of the ICU are set to 01b (falling edge) in Normal mode, and the IRQCRi.IRQMD[1:0] bits set to 10b (rising edge). Next, the SBYCR.SSBY bit is set to 1 and a WFI instruction is executed. As a result, entry to Software Standby mode completes, and exit from Software Standby mode is initiated by a rising edge of the IRQn pin.

Setting the ICU is also required to exit Software Standby mode. For details, see section 13, Interrupt Controller Unit (ICU). The oscillation stabilization time in Figure 11.4 is specified in section 43, Electrical Characteristics.

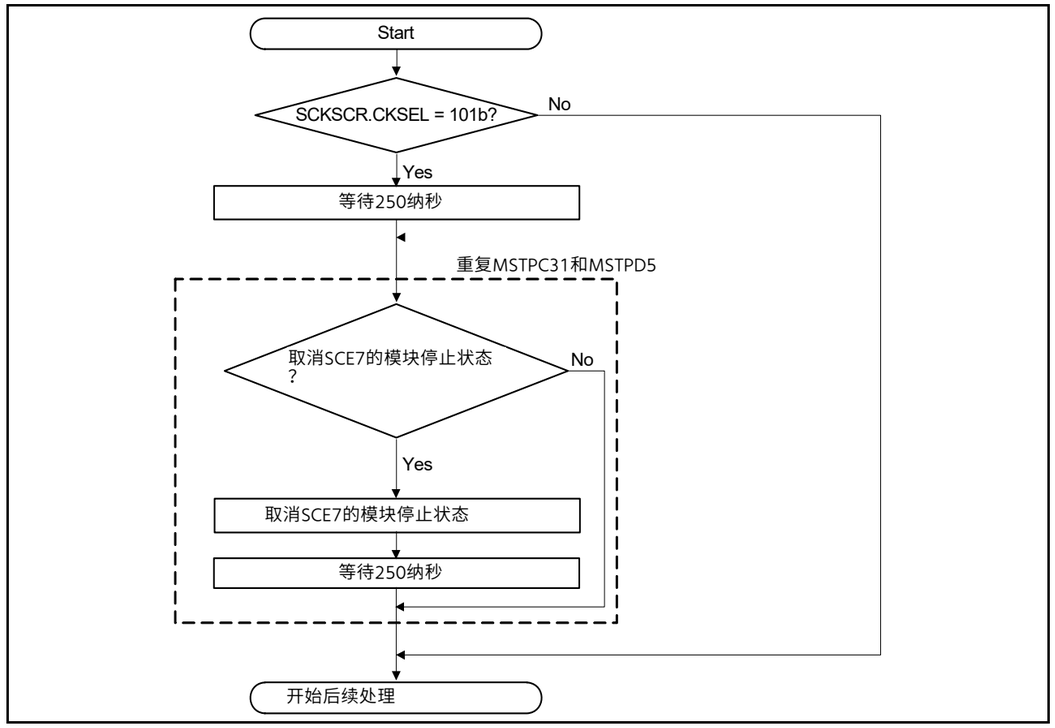


Figure 11.3 取消软件待机模式的示例流程

11.7.3 软件待机模式应用示例

图11.4显示了在检测到IRQn引脚的下降沿进入软件待机模式并在IRQn引脚的上升沿退出软件待机模式的示例。

在此示例中，当ICU的IRQCRi.IRQMD[1:0]位在正常模式下设置为01b（下降沿）并且IRQCRi.IRQMD[1:0]位设置为10b时，接受IRQn引脚中断（上升沿）。接下来，将SBYCR.SSBY位设置为1，并执行WFI指令。结果，进入软件待机模式完成，并且退出软件待机模式由IRQn引脚的上升沿启动。

退出软件待机模式也需要设置ICU。有关详细信息，请参阅第13节，中断控制器单元(ICU)。图11.4中的振荡稳定时间在第43节"电气特性"中指定。

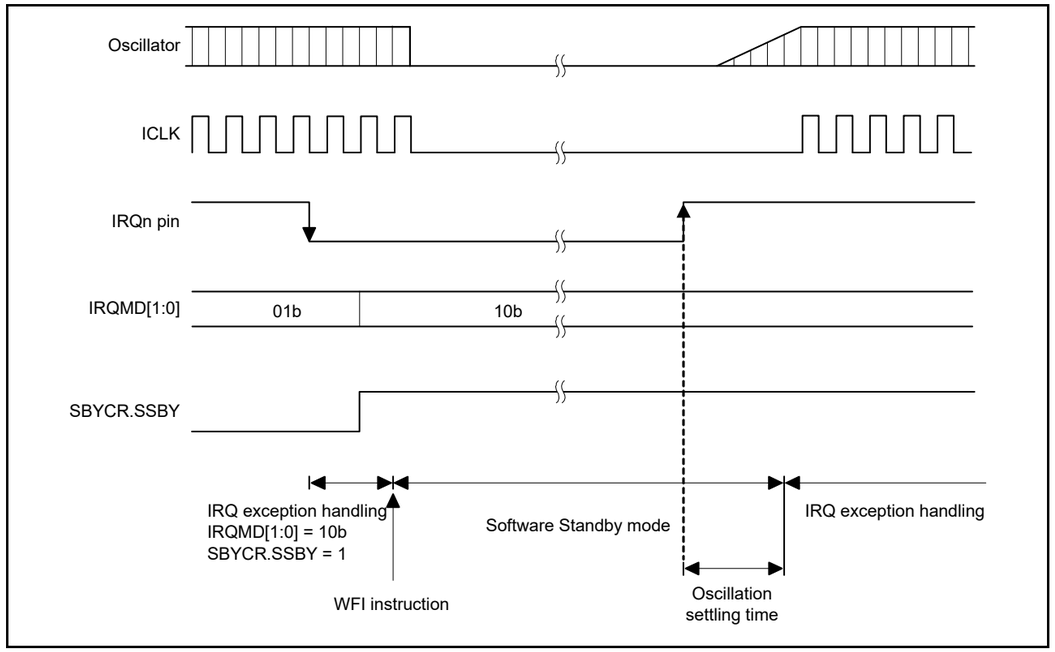


Figure 11.4 Example of Software Standby mode application

11.8 Snooze Mode

11.8.1 Transitioning to Snooze Mode

Figure 11.5 shows snooze mode entry configuration. When the snooze control circuit receives a snooze request in Software Standby mode, the MCU transitions to Snooze mode. In this mode, some peripheral modules operate without waking up the CPU. Table 11.2 shows the peripheral modules that can operate in Snooze mode. Also, DTC operation can be selected in Snooze mode by setting the SNZCR.SNZDTCEN bit.

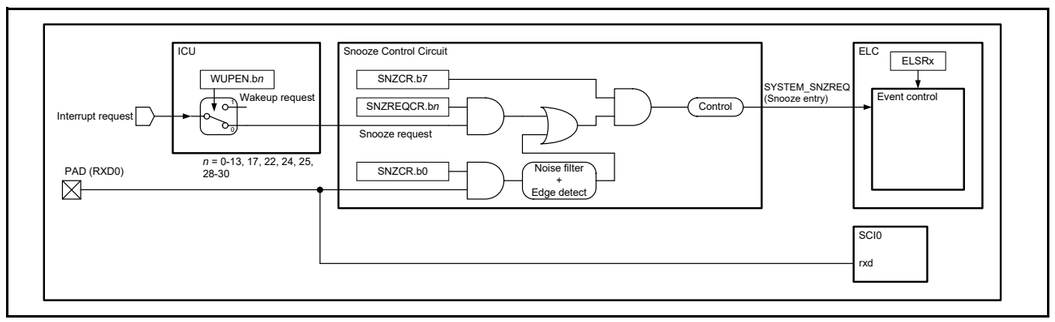


Figure 11.5 Snooze entry configuration

Table 11.7 shows the snooze requests to switch the MCU from Software Standby mode to Snooze mode. To use a listed snooze requests as a trigger to switch to Snooze mode, you must set the associated SNZREQENn bit of the SNZREQCR register or RXDREQEN bit of the SNZCR register before entering Software Standby mode.

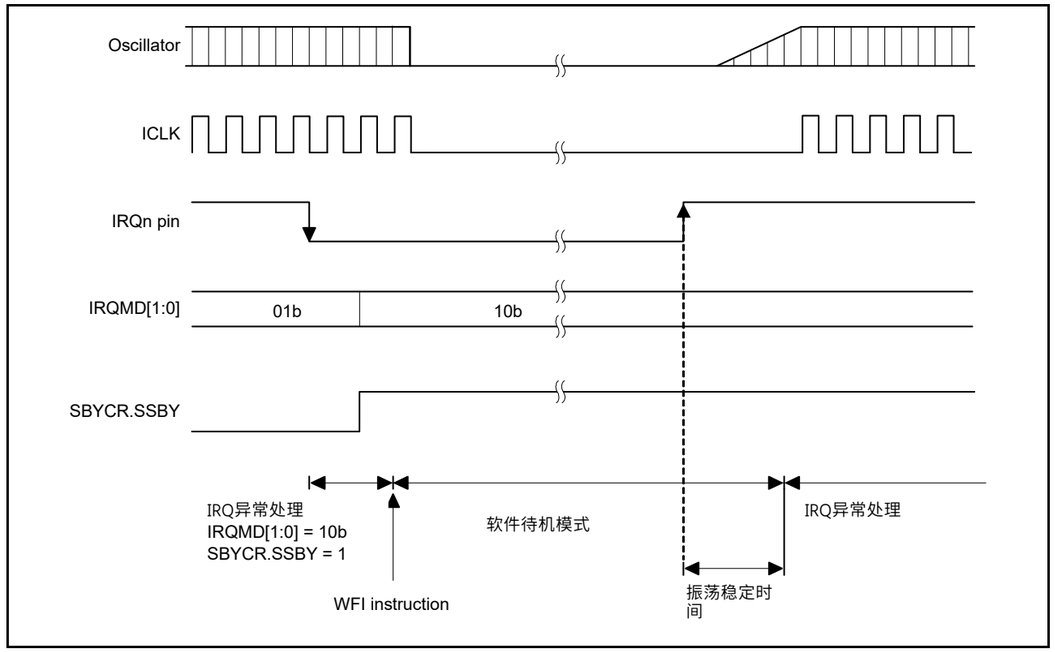


Figure 11.4 软件待机模式应用示例

11.8 贪睡模式

11.8.1 过渡到贪睡模式

图11.5显示了贪睡模式进入配置。当贪睡控制电路接收到贪睡请求时
软件待机模式，MCU转换到贪睡模式。在这种模式下，一些外围模块在不唤醒CPU的情况下运行。表11.2显示了可以在贪睡模式下运行的外围模块。此外，通过设置SNZCR.SNZDTCEN位，可以在贪睡模式下选择DTC操作。

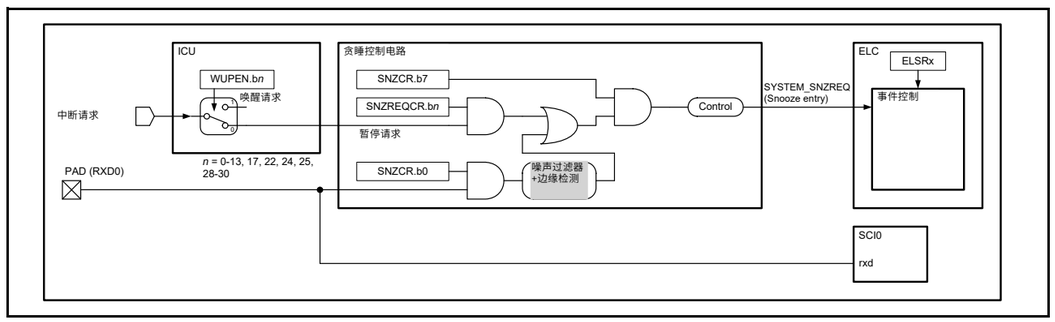


Figure 11.5 贪睡入口配置

表11.7显示了将MCU从软件待机模式切换到贪睡模式的贪睡请求。要将列出的贪睡请求用作切换到贪睡模式的触发器，您必须在进入软件待机模式之前设置SNZREQCR寄存器的相关SNZREQENn位或SNZCR寄存器的RXDREQEN位。

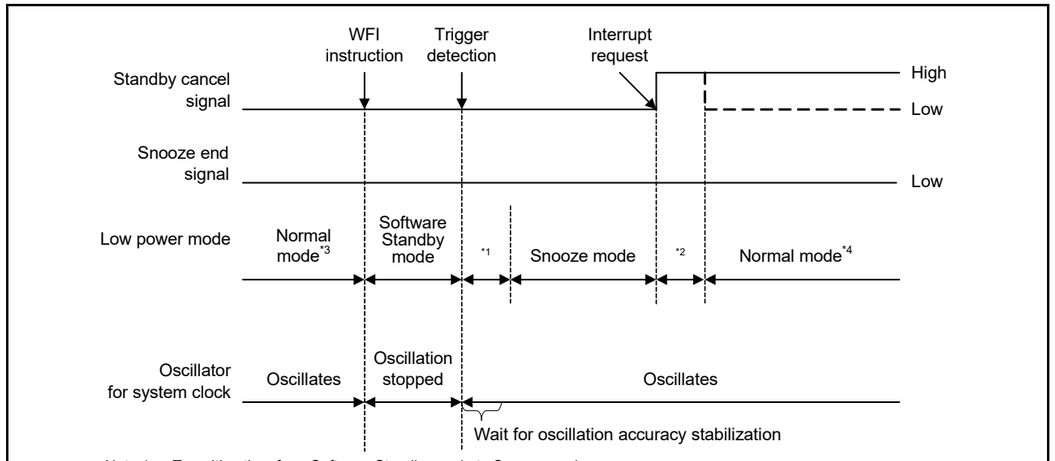
Table 11.7 Available snooze requests to switch to Snooze mode

	Control Register	
Snooze request	**Register**	**Bit*1**
PORT_IRQn (n = 0 to 13)	SNZREQCR	SNZREQENn (n = 0 to 13)
KEY_INTKR	SNZREQCR	SNZREQEN17
ACMP_HS0	SNZREQCR	SNZREQEN22
AGT1_AGTI	SNZREQCR	SNZREQEN28
AGT1_AGTCMAI	SNZREQCR	SNZREQEN29
AGT1_AGTCMBI	SNZREQCR	SNZREQEN30
RXD0 falling edge	SNZCR	RXDREQEN*2

Note 1. Do not enable multiple snooze requests at the same time.
Note 2. Do not set the RXDREQEN bit to 1 except in asynchronous mode.

11.8.2 Canceling Snooze Mode

Snooze mode is canceled by an interrupt request that is available in Software Standby mode or a reset. Table 11.3 shows the requests that can be used to exit each mode. After canceling the Snooze mode, the MCU enters Normal mode and proceeds with exception processing for the given interrupt or reset. The action triggered by the interrupt requests selected in SELSR0, cancels Snooze mode. Interrupt canceling Snooze mode must be selected in IELSRn (n = 0 to 96) to link to the NVIC for the associated interrupt handling. See section 13, Interrupt Controller Unit (ICU), for information on SELSR0 and IELSRn registers.



Note 1. Transition time from Software Standby mode to Snooze mode.
Note 2. Transition time from Snooze mode to Normal mode.
Note 3. Enable Snooze mode (SNZCR.SNZE = 1) immediately before entering Software Standby mode.
Note 4. Disable Snooze mode (SNZCR.SNZE = 0) immediately after canceling Snooze mode.

Figure 11.6 Canceling of Snooze mode when an interrupt request signal is generated

11.8.3 Returning to Software Standby Mode

Table 11.8 shows the snooze end requests that can be used as triggers to return to Software Standby mode. The snooze end requests are available only in Snooze mode. If the requests are generated when the MCU is not in Snooze mode, they are ignored. When multiple requests are selected, each one of the requests invokes transition to Software Standby mode from Snooze mode.

Table 11.9 shows the snooze end conditions that consist of the snooze end requests and the conditions of the peripheral modules. The SCI0, ADC120, ADC121, and DTC modules can keep the MCU in Snooze mode until they complete their

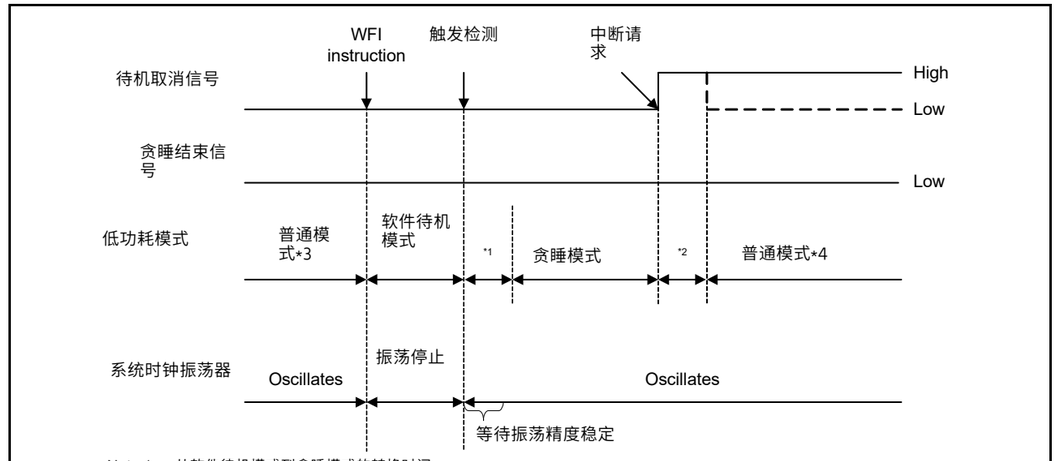
Table 11.7 可用的贪睡请求以切换到贪睡模式

	控制寄存器	
暂停请求	**Register**	**Bit*1**
PORT_IRQn (n = 0 to 13)	SNZREQCR	SNZREQENn (n = 0 to 13)
KEY_INTKR	SNZREQCR	SNZREQEN17
ACMP_HS0	SNZREQCR	SNZREQEN22
AGT1_AGTI	SNZREQCR	SNZREQEN28
AGT1_AGTCMAI	SNZREQCR	SNZREQEN29
AGT1_AGTCMBI	SNZREQCR	SNZREQEN30
RXD0下降沿	SNZCR	RXDREQEN*2

Note 1. 不要同时启用多个贪睡请求。
Note 2. 除非在异步模式下，否则不要将RXDREQEN位设置为1。

11.8.2 取消贪睡模式

贪睡模式由软件待机模式下可用的中断请求或复位取消。表11.3显示了可用于退出每种模式的请求。取消贪睡模式后，MCU进入正常模式并继续对给定中断或复位进行异常处理。SELSR0中选择的中断请求触发的动作取消贪睡模式。必须在IELSRn（n=0到96）中选择中断取消贪睡模式以链接到NVIC以进行相关的中断处理。有关SELSR0和IELSRn寄存器的信息，请参见第13节，中断控制器单元(ICU)。



Note 1. 从软件待机模式到贪睡模式的转换时间。
Note 2. 从贪睡模式到正常模式的过渡时间。
Note 3. 在进入软件待机模式之前立即启用贪睡模式(SNZCR.SNZE=1)。
Note 4. 取消贪睡模式后立即禁用贪睡模式(SNZCR.SNZE=0)。

Figure 11.6 产生中断请求信号时取消贪睡模式

11.8.3 返回软件待机模式

表11.8显示了可用作触发器以返回到软件待机模式的贪睡结束请求。贪睡结束请求仅在贪睡模式下可用。如果请求是在MCU未处于贪睡模式时生成的，则它们将被忽略。Whenmultiplerequestsareselected eachoneofther equestsinvokestransitiontoSoftwareStandbymodefromSnoozemode.

表11.9显示了贪睡结束条件，包括贪睡结束请求和外围模块的条件。SCI0、ADC120、ADC121和DTC模块可以让MCU保持在贪睡模式，直到它们完成它们

operation. However, an AGT1 underflow as a trigger to return to Software Standby mode cancels Snooze mode without waiting for the completion of the SCI0 operation.

Figure 11.7 shows the timing diagram for the transition from Snooze mode to Software Standby mode. This mode transition occurs according to which snooze end requests are set in the SNZEDCR register. A snooze request is cleared automatically after returning to Software Standby mode.

Table 11.8 Available snooze end requests (triggers to return to Software Standby mode)

	Enable/disable control	
Snooze end request	**Register**	**Bit**
AGT1 unterflow or measurement complete (AGT1_AGTI)	SNZEDCR	b0
DTC transfer complete (DTC_COMPLETE)	SNZEDCR	b1
DTC transfer not complete (DTC_TRANSFER)	SNZEDCR	b2
ADC120 window A/B compare match (ADC120_WCMPM)	SNZEDCR	b3
ADC120 window A/B compare mismatch (ADC120_WCMPUM)	SNZEDCR	b4
ADC121 window A/B compare match (ADC121_WCMPM)	SNZEDCR	b5
ADC121 window A/B compare mismatch (ADC121_WCMPUM)	SNZEDCR	b6
SCI0 address mismatch (SCI0_DCUF)	SNZEDCR	b7

Table 11.9 Snooze end conditions

Operating module when a snooze end request occurs	**Snooze end request**	
	AGT1 underflow	**Other than AGT1 underflow**
DTC	The MCU transitions to Software Standby mode after all of the modules listed in this table complete operation	The MCU transitions to Software Standby mode after all of the modules listed to the left of this column complete operation
ADC120		
ADC121		
SCI0	The MCU transitions to Software Standby mode immediately after a snooze end request is generated	
All other modules	The MCU transitions to Software Standby mode immediately after a snooze end request is generated	

Note: If the DTC is used to activate the ADC120, ADC121, or SCI, the MCU transitions to Software Standby mode immediately after a snooze end request is generated.

手术。然而，作为返回软件待机模式的触发器的AGT1下溢会取消贪睡模式，而无需等待SCI0操作完成。

图11.7显示了从贪睡模式转换到软件待机模式的时序图。该模式转换根据SNZEDCR寄存器中设置的贪睡结束请求而发生。返回软件待机模式后，贪睡请求会自动清除。

Table 11.8 可用的暂停结束请求（触发返回到软件待机模式）

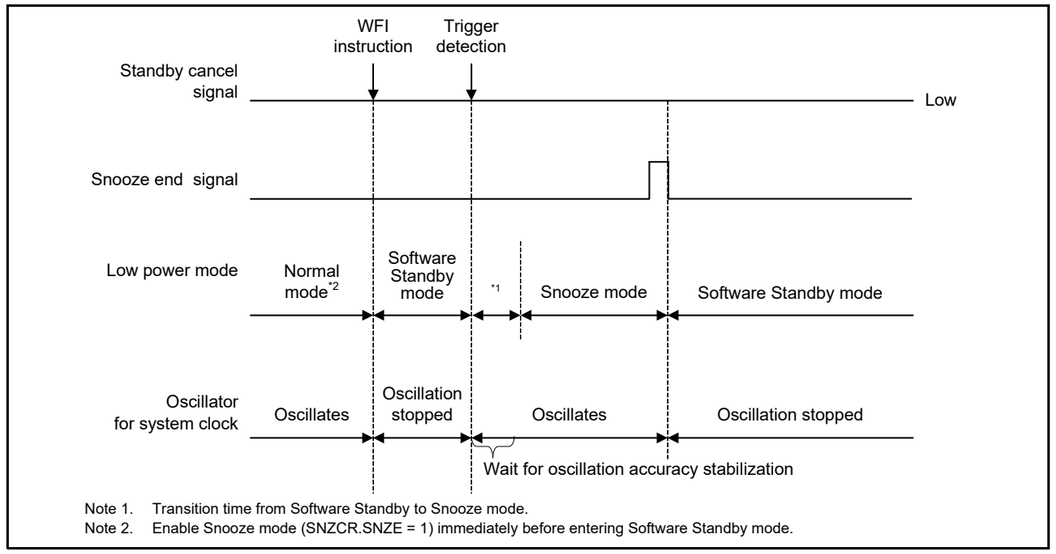
	Enable/disable control	
暂停结束请求	**Register**	**Bit**
AGT1溢流或测量完成(AGT1_AGTI)	SNZEDCR	b0
DTC传输完成(DTC_COMPLETE)	SNZEDCR	b1
DTC传输未完成(DTC_TRANSFER)	SNZEDCR	b2
ADC120窗口AB比较匹配(ADC120_WCMPM)	SNZEDCR	b3
ADC120窗口AB比较不匹配(ADC120_WCMPUM)	SNZEDCR	b4
ADC121窗口AB比较匹配(ADC121_WCMPM)	SNZEDCR	b5
ADC121窗口AB比较不匹配(ADC121_WCMPUM)	SNZEDCR	b6
SCI0地址不匹配(SCI0_DCUF)	SNZEDCR	b7

Table 11.9 暂停结束条件

发生贪睡结束请求时的操作模块	**暂停结束请求**	
	AGT1 underflow	**除了AGT1下溢**
DTC	在此表中列出的所有模块完成操作后，MCU转换到软件待机模式	在此列左侧列出的所有模块完成操作后，MCU转换到软件待机模式
ADC120		
ADC121		
SCI0	产生贪睡结束请求后，MCU立即转换到软件待机模式	
所有其他模块	产生贪睡结束请求后，MCU立即转换到软件待机模式	

Note: 如果DTC用于激活ADC120、ADC121或SCI，则MCU在产生贪睡结束请求后立即转换到软件待机模式。

RA生态工作室

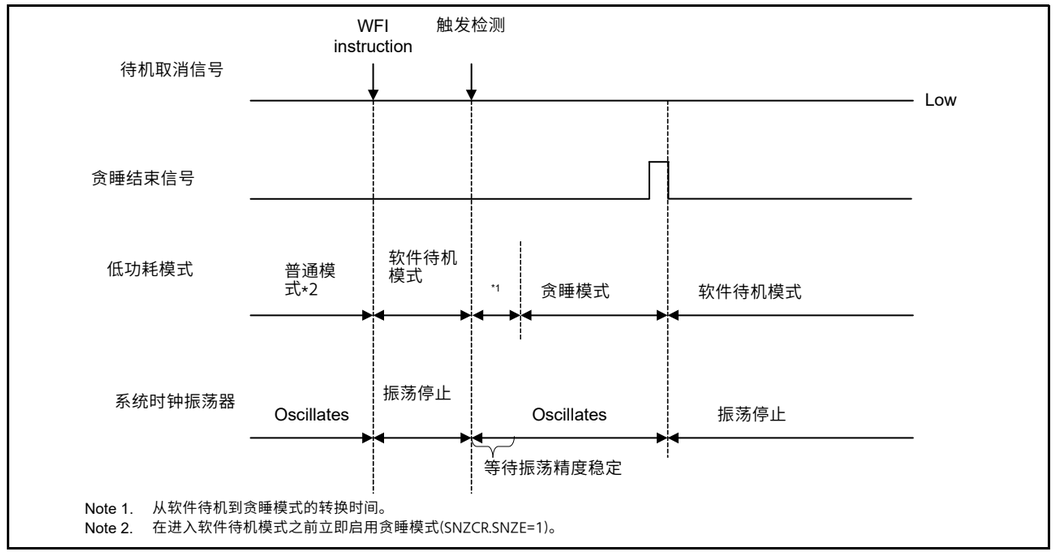


Note 1. Transition time from Software Standby to Snooze mode.
Note 2. Enable Snooze mode (SNZCR.SNZE = 1) immediately before entering Software Standby mode.

Figure 11.7 Canceling of Snooze mode when an interrupt request signal is not generated

11.8.4 Snooze Operation Example

Figure 11.8 shows an example setting for using ELC in Snooze mode.



Note 1. 从软件待机到贪睡模式的转换时间。
Note 2. 在进入软件待机模式之前立即启用贪睡模式(SNZCR.SNZE=1)。

Figure 11.7 未产生中断请求信号时取消贪睡模式

11.8.4 贪睡操作示例

图11.8显示了在贪睡模式下使用ELC的示例设置。

RA生态工作室

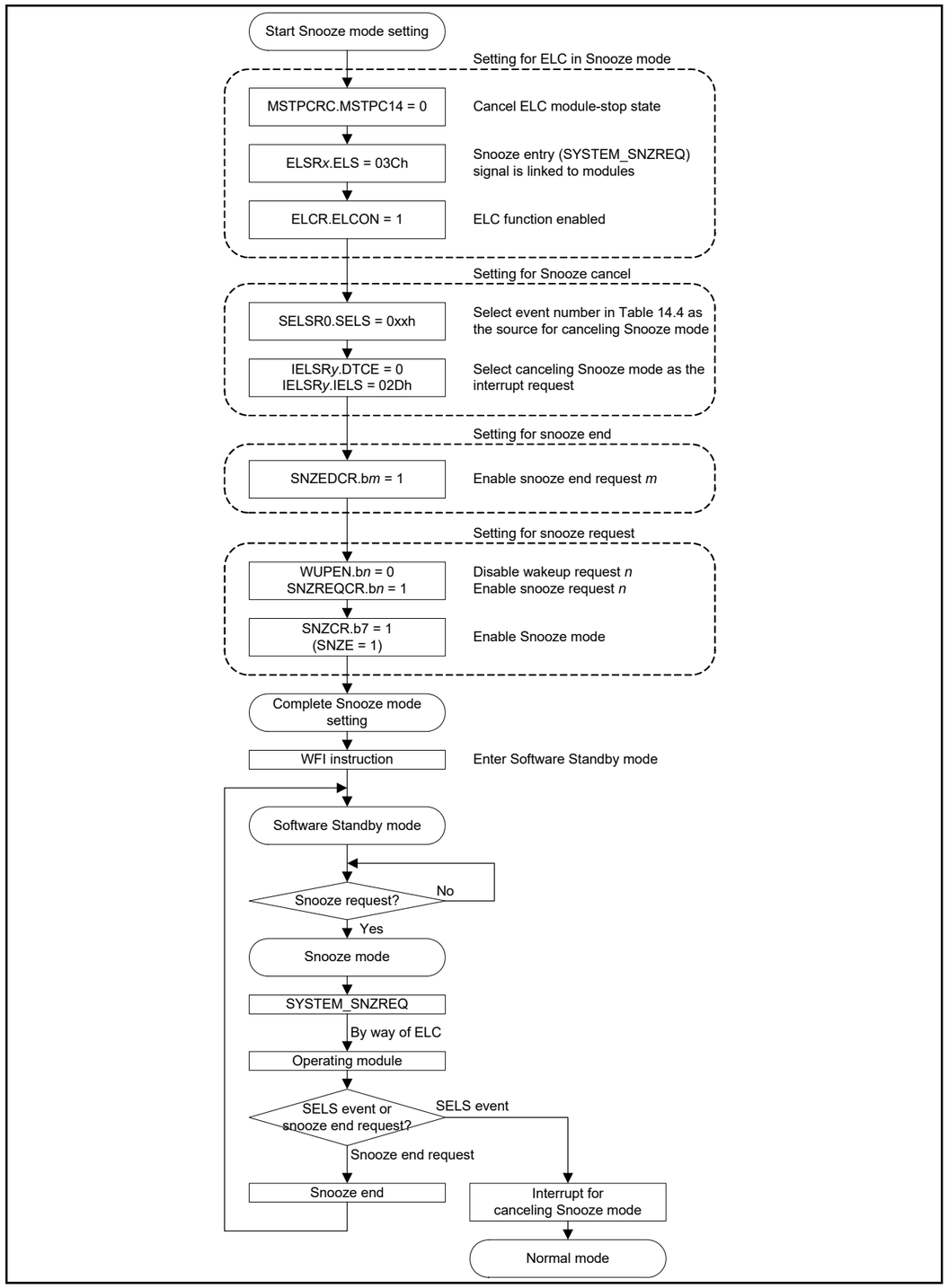


Figure 11.8 Setting example of using ELC in Snooze mode

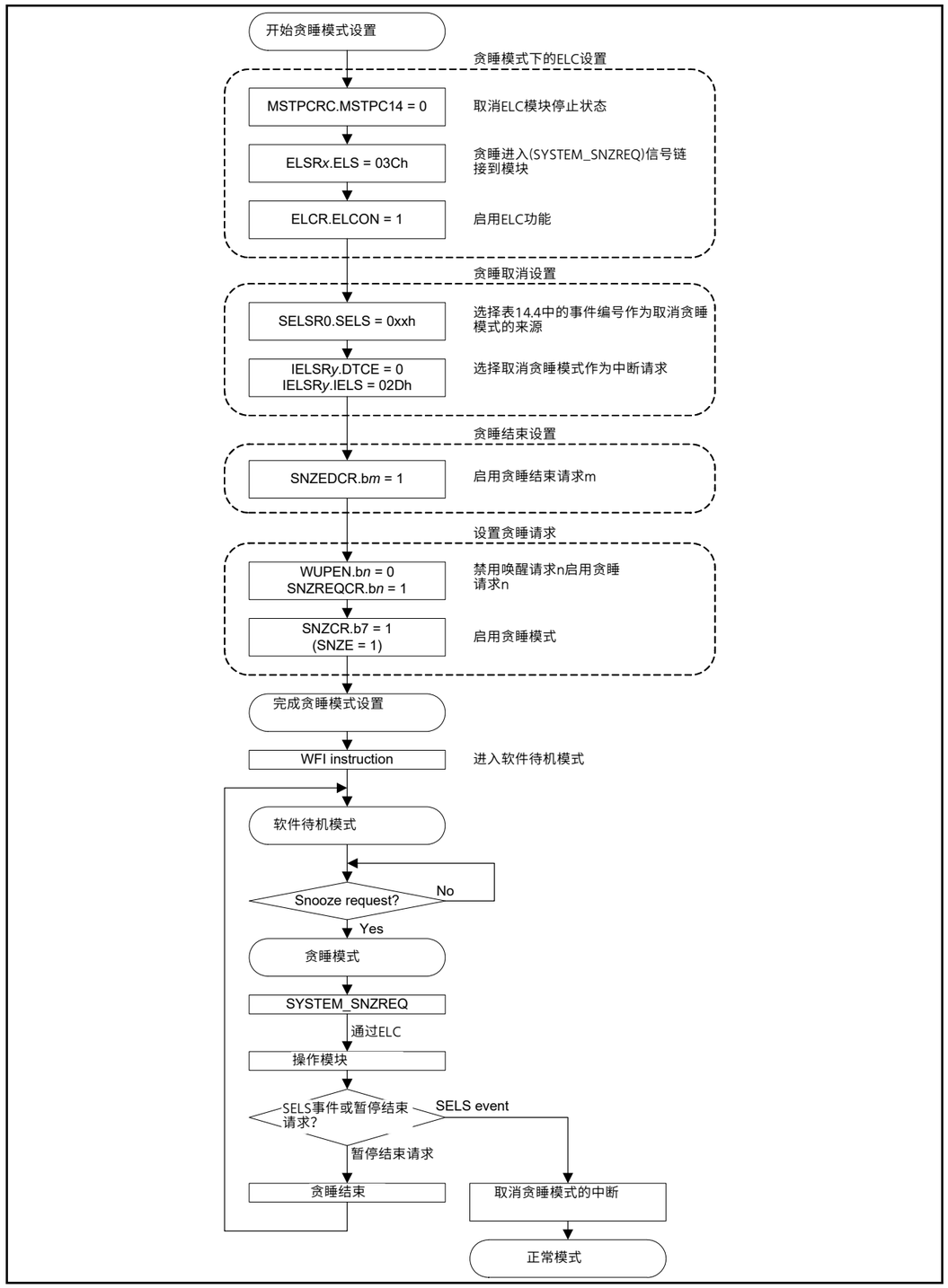


Figure 11.8 在贪睡模式下使用ELC的设置示例

The MCU can transmit and receive data in SCI0 asynchronous mode without CPU intervention. When using the SCI0 in Snooze mode, use either High-speed mode or Low-speed mode.

Do not use Subosc-speed mode. Table 11.10 shows the maximum transfer rate of SCI0 in Snooze mode.

Table 11.10 HOCO: ± 1.4% (Ta = -20 to 105°C) (Unit: bps)

Maximum division ratio of ICLK, PCLKA, PCLKB, PCLKC, PCLKD, FCLK, and TRCLK	HOCO frequency					
	LOCO is not operating			LOCO is operating		
	16 MHz	18 MHz	20 MHz	16 MHz	18 MHz	20 MHz
1	2400			4800		
2						
4						
8						
16						
32	1200			2400		
64						

Figure 11.9 shows an example setting for using SCI0 in Snooze mode entry.

MCU可以在SCI0异步模式下发送和接收数据，无需CPU干预。在使用SCI0时贪睡模式，使用高速模式或低速模式。

不要使用Subosc速度模式。表11.10显示了贪睡模式下SCI0的最大传输速率。

Table 11.10 HOCO: ± 1.4% (Ta = -20 to 105°C) (Unit: bps)

ICLK、PCLKA、PCLKB、PCLKC的最大分频比，PCLKD, FCLK, and TRCLK	HOCO frequency					
	LOCO没有运行			LOCO正在运营		
	16 MHz	18 MHz	20 MHz	16 MHz	18 MHz	20 MHz
1	2400			4800		
2						
4						
8						
16						
32	1200			2400		
64						

图11.9显示了在贪睡模式进入中使用SCI0的示例设置。

RA生态工作室

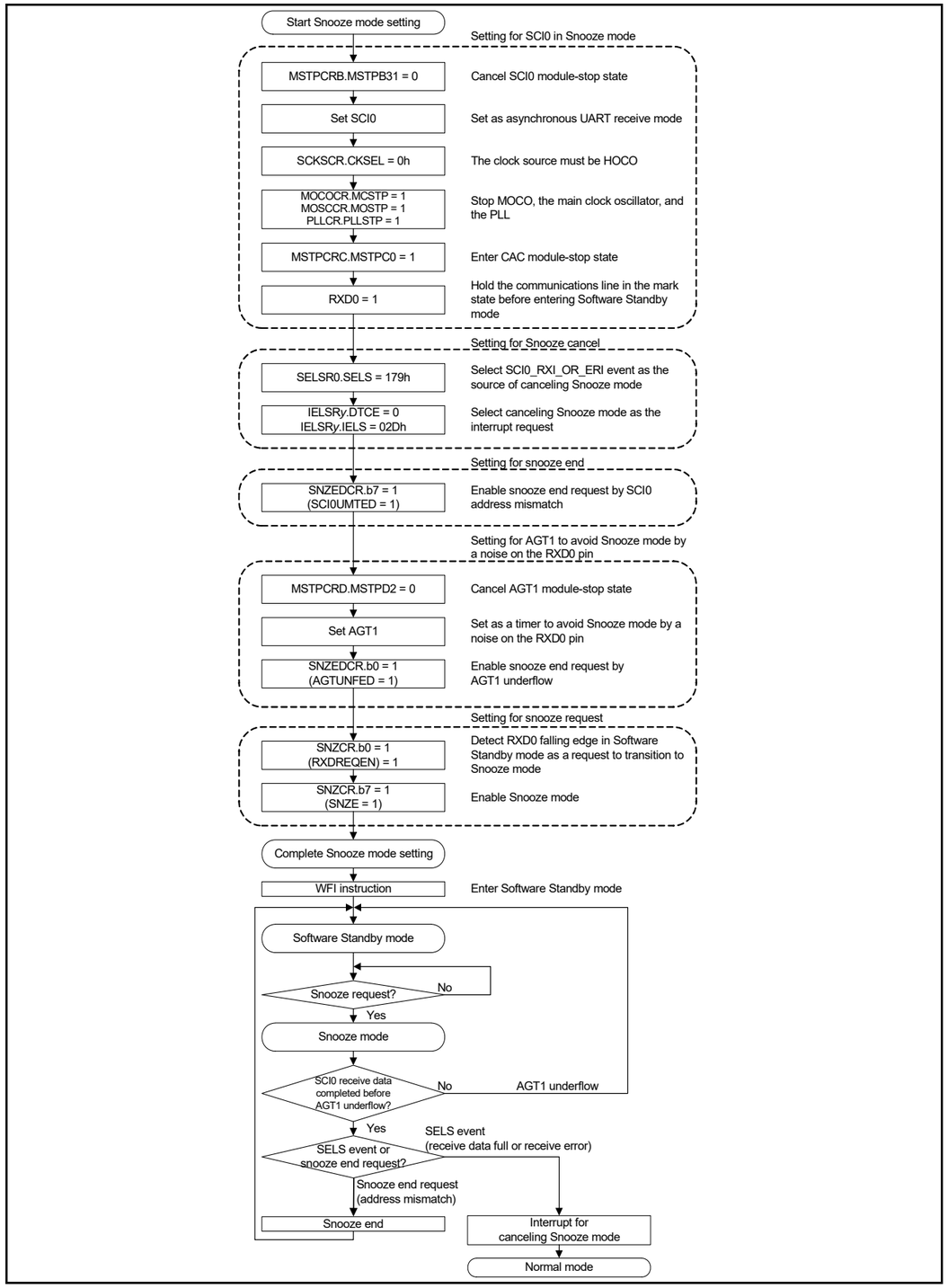


Figure 11.9 Setting example of using SCI0 in Snooze mode entry

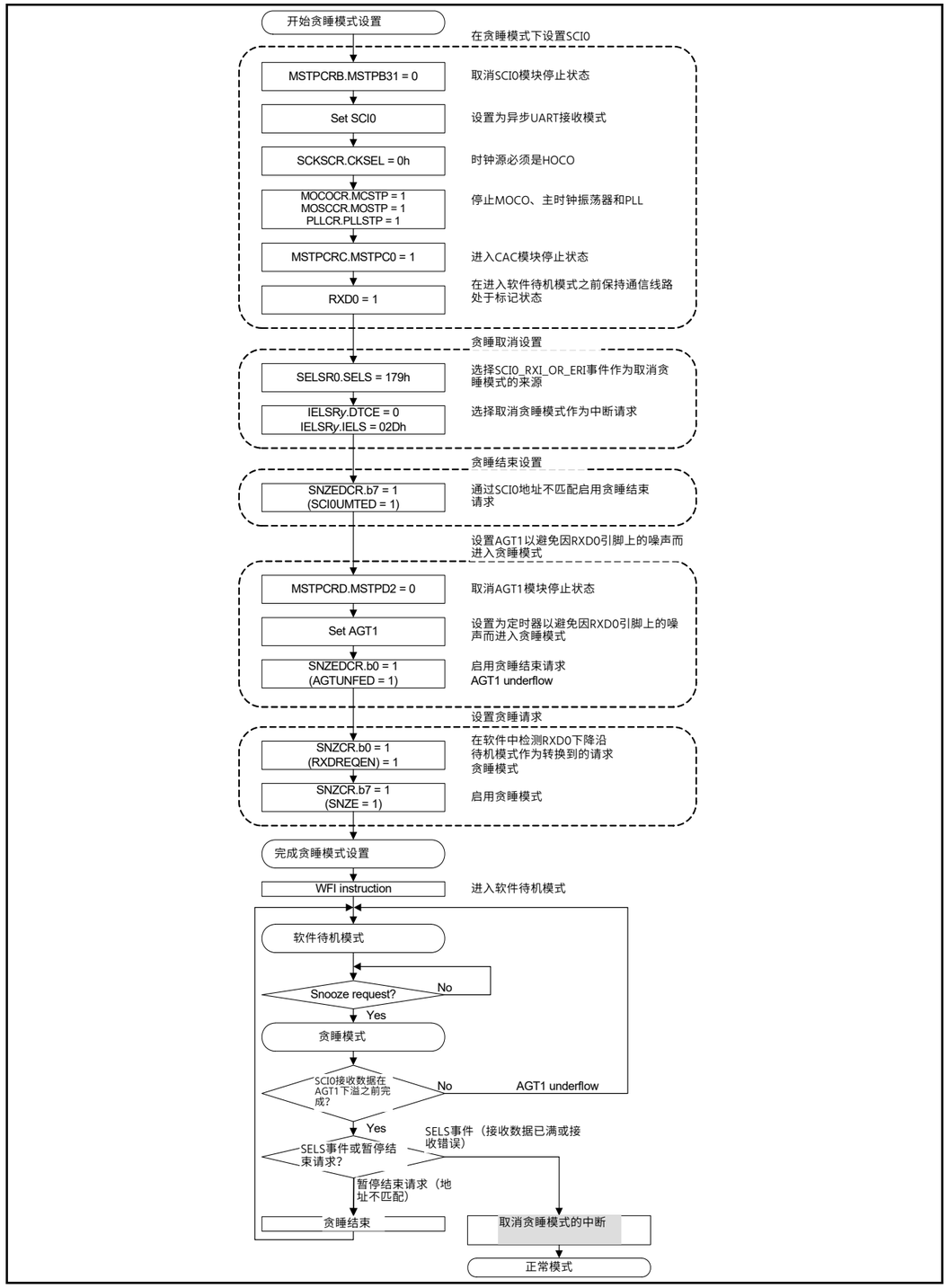


Figure 11.9 在Snooze模式进入使用SCI0的设置示例

11.9 Deep Software Standby Mode

11.9.1 Transitioning to Deep Software Standby Mode

The MCU enters Deep Software Standby mode when a WFI instruction is executed with the SBYCR.SSBY bit set to 1 and the DPSBYCR.DPSBY bit set to 1. See Table 11.6 for the settings of the related control bits.

In Deep Software Standby mode, the following modules are stopped:

- The CPU
- The on-chip peripheral functions
- The SRAM
- All oscillators, except for the sub-clock and low-speed on-chip oscillators.

Power consumption is reduced because the internal power supply to these modules is stopped. The contents of all CPU registers and internal peripheral modules become undefined.

If the setting in the DEEPCUT[1:0] bits is 11b, the internal power supply to the LVD is stopped, and the low power mode function of the power-on reset circuit is enabled. Therefore, power consumption is further reduced. For details, see section 43, Electrical Characteristics.

When the MCU enters Deep Software Standby mode while the IWDT is in auto start mode and the OFS0.IWDTSTPCTL bit is 1, power supply to the IWDT-dedicated clock and the IWDT is cut off. Counting by the IWDT also stops.

When the OFS0.IWDTSTPCTL bit is 0, the MCU enters Software Standby mode instead of Deep Software Standby mode, regardless of the setting in the OFS0.IWDTSTRT or DPSBYCR.DPSBY bit. When the OFS0.IWDTSTPCTL bit is 0 while the OFS0.IWDTSTRT bit is 0 (auto start mode), the IWDT-dedicated clock and IWDT continue operation.

When the LVD1CR0.RI bit is 1 (voltage monitor 1 reset selected) or the LVD2CR0.RI bit is 1 (voltage monitor 2 reset selected), the MCU enters Software Standby mode instead of Deep Software Standby mode. The I/O port states are the same as in Software Standby mode.

When the PLL is selected as the clock source, set the following modules to the module-stop state before executing a WFI instruction:

- SCE7
- GPT32EH
- GPT32E.

In this case, you must also insert a wait time of at least 750 ns before executing the WFI instruction. The recommended method to measure the wait time is through software. Consider the worst-case conditions to ensure that the required wait time elapses.

Figure 11.2 shows an example flow for transitioning to Software Standby mode or Deep Software Standby mode.

Note 1. Conditions on the DTC, DMAC, and IWDT for transitioning to Software Standby mode must be met before the WFI instruction is executed. For details, see section 11.7, Software Standby Mode.

11.9.2 Canceling Deep Software Standby Mode

Deep Software Standby mode is canceled by:

- An interrupt shown in Table 11.3
- A RES pin reset
- A power-on reset
- A voltage monitor 0 reset.

The operations are as follows:

1. Canceling by an interrupt
   Canceling by interrupts is controlled by DPSIERn (n = 0 to 3) and DPSIFRn (n = 0 to 3). When an available

11.9 深度软件待机模式

11.9.1 过渡到深度软件待机模式

当SBYCR.SSBY位设置为1且DPSBYCR.DPSBY位设置为1时执行WFI指令，MCU进入深度软件待机模式。相关控制位设置见表11.6。

在深度软件待机模式下，以下模块将停止：

- 中央处理器
- 片上外围功能
- The SRAM
- 所有振荡器，除了子时钟和低速片上振荡器。

由于停止了对这些模块的内部供电，因此降低了功耗。所有CPU寄存器和内部外围模块的内容变为未定义。

如果DEEPCUT[1:0]位设置为11b，则停止向LVD内部供电，并启用上电复位电路的低功耗模式功能。因此，进一步降低了功耗。有关详细信息，请参阅第43节，电气特性。

当MCU在IWDT处于自动启动模式且OFS0.IWDTSTPCTL位为1时进入深度软件待机模式时，IWDT专用时钟和IWDT的电源将被切断。IWDT的计数也停止。

当OFS0.IWDTSTPCTL位为0时，MCU进入软件待机模式而不是深度软件待机模式，无论OFS0.IWDTSTRT或DPSBYCR.DPSBY位的设置如何。当OFS0.IWDTSTPCTL位为0而OFS0.IWDTSTRT位为0（自动启动模式）时，IWDT专用时钟和IWDT继续运行。

当LVD1CR0.RI位为1（选择电压监视器1复位）或LVD2CR0.RI位为1（选择电压监视器2复位）时，MCU进入软件待机模式而不是深度软件待机模式。IO端口状态与软件待机模式相同。

WhenthePLLisselectedastheclocksource setthefollowingmodulestothemodule-stopstatebeforeexecutingaWFIinstruction:

- SCE7
- GPT32EH
- GPT32E.

在这种情况下，您还必须在执行WFI指令之前插入至少750ns的等待时间。测量等待时间的推荐方法是通过软件。考虑最坏的情况，以确保经过所需的等待时间。

图11.2显示了转换到软件待机模式或深度软件待机模式的示例流程。

注1.在DTC、DMAC和IWDT转换到软件待机模式的条件必须在之前满足
执行WFI指令。有关详细信息，请参阅第11.7节，软件待机模式。

11.9.2 取消深度软件待机模式

深度软件待机模式通过以下方式取消：

- 表11.3所示的中断
- ARES引脚复位
- A power-on reset
- 电压监视器0复位。

操作如下：

1. 通过中断取消
   中断取消由DPSIERn(n=0到3)和DPSIFRn(n=0到3)控制。当一个可用的

interrupt request is generated, the associated flag in DPSIFRn is set to 1. If the interrupt is enabled in DPSIERn, Deep Software Standby mode is canceled. Rising or falling edge detection can be selected in DPSIEGRn (n = 0 to 2). The detection edge can be selected for the NMI, IRQ0-DS, IRQ1-DS, IRQ4-DS to IRQ12-DS, voltage monitor 1, and voltage monitor 2 interrupts. When a Deep Software Standby mode canceling request occurs, internal power is supplied, the MOCO clock starts to oscillate, and an internal reset (deep software standby reset) is generated for the entire MCU. The stable MOCO clock is supplied to the entire MCU and deep software standby reset is canceled. The MCU starts reset exception handling.
When Deep Software Standby mode is canceled by an external interrupt pin or internal interrupt signal, the RSTSR0.DPSRSTF flag is set to 1.

2. Canceling by a RES pin reset
When the RES pin is driven low, the MCU cancels Deep Software Standby mode and enters a reset state. Make sure to keep the RES pin low for the time period specified in section 43, Electrical Characteristics. When the RES pin is driven high after the specified time period, the CPU starts reset exception handling.

3. Canceling by a power-on reset
Deep Software Standby mode is canceled by a power-on reset, and the MCU starts reset exception handling.

4. Canceling by a voltage monitor 0 reset
Deep Software Standby mode is canceled by a voltage monitor 0 reset from the voltage detection circuit, and the MCU starts reset exception handling.

11.9.3 Pin States when Deep Software Standby Mode is Canceled

In Deep Software Standby mode, the I/O ports retain the same states from Software Standby mode. The MCU is initialized by an internal reset generated when Deep Software Standby mode is canceled, and reset exception handling starts immediately. The DPSBYCR.IOKEEP bit setting determines whether to initialize the I/O ports or to retain the I/O ports states for Software Standby mode. The following is the state of the I/O ports for each bit setting:

- When the DPSBYCR.IOKEEP bit = 0
The I/O ports are initialized by an internal reset generated when Deep Software Standby mode is canceled.
- When the DPSBYCR.IOKEEP bit = 1
Although the MCU is initialized by an internal reset generated when Deep Software Standby mode is canceled, the I/O ports retain their states from Software Standby mode regardless of the MCU internal state. The I/O ports states remain unchanged from Software Standby mode even when settings are made to the I/O ports or peripheral modules. The retained I/O ports states are released by clearing the DPSBYCR.IOKEEP bit to 0, and the MCU operates according to the internal state. The DPSBYCR.IOKEEP bit is not initialized by any internal reset generated when Deep Software Standby mode is canceled.

11.9.4 Example of Deep Software Standby Mode Application

(1) Entering and exiting Deep Software Standby mode

Figure 11.10 shows an example transition to Deep Software Standby mode on the falling edge of the IRQn-DS pin, and an exit from Deep Software Standby mode on the rising edge of the IRQn-DS pin. In this example, an IRQn interrupt is accepted with the IRQCRi.IRQMD[1:0] bits of the ICU set to 01b (falling edge). After the DPSIEGRy.DIRQnEG bit (y = 0, 1 and n = 0, 1, 4 to 12) is set to 1 (rising edge) and the SBYCR.SSBY and DPSBYCR.DPSBY bits are both set to 1, the WFI instruction is executed. As a result, the MCU transitions to Deep Software Standby mode. Deep Software Standby mode is then canceled on the rising edge of the IRQn-DS pin.

产生中断请求时，DPSIFRn中的相关标志设置为1。如果在DPSIERn中使能中断，则取消深度软件待机模式。上升沿或下降沿检测可以在DPSIEGRn(n=0到2)中选择。可为NMI、IRQ0-DS、IRQ1-DS、IRQ4-DS至IRQ12-DS、电压监视器1和电压监视器2中断选择检测沿。当产生深度软件待机模式取消请求时，内部电源供应，MOCO时钟开始振荡，并为整个MCU产生内部复位（深度软件待机复位）。为整个MCU提供稳定的MOCO时钟，取消深度软件待机复位。MCU开始复位异常处理。

当深度软件待机模式被外部中断引脚或内部中断信号取消时，
RSTSR0.DPSRSTF标志设置为1。

2. 通过RES引脚复位取消
当RES引脚被驱动为低电平时，MCU取消深度软件待机模式并进入复位状态。确保在第43节"电气特性"中指定的时间段内保持RES引脚为低电平。当RES引脚在指定时间后被驱动为高电平时，CPU开始复位异常处理。

3. 通过上电复位取消
深度软件待机模式通过上电复位取消，MCU开始复位异常处理。

4. 通过电压监视器取消0复位
深度软件待机模式由电压检测电路复位的电压监视器0取消，并且
MCU开始复位异常处理。

11.9.3 取消深度软件待机模式时的引脚状态

在深度软件待机模式下，IO端口保持与软件待机模式相同的状态。MCU通过取消深度软件待机模式时产生的内部复位进行初始化，并立即开始复位异常处理。DPSBYCR.IOKEEP位设置确定是初始化IO端口还是保留软件待机模式下的IO端口状态。以下是每个位设置的IO端口状态：

- 当DPSBYCR.IOKEEP位=0
IO端口由取消深度软件待机模式时产生的内部复位进行初始化。
- 当DPSBYCR.IOKEEP位=1
虽然MCU由取消深度软件待机模式时产生的内部复位来初始化，但无论MCU内部状态如何，IO端口仍会保持软件待机模式下的状态。即使对IO端口或外围模块进行了设置，IO端口状态在软件待机模式下也保持不变。通过将DPSBYCR.IOKEEP位清0来释放保留的IO端口状态，MCU根据内部状态运行。DPSBYCR.IOKEEP位不会被取消深度软件待机模式时产生的任何内部复位初始化。

11.9.4 深度软件待机模式应用示例

(1) 进入和退出深度软件待机模式

图11.10显示了在IRQn-DS引脚的下降沿转换到深度软件待机模式的示例，以及在IRQn-DS引脚的上升沿退出深度软件待机模式的示例。在此示例中，接受IRQn中断，同时ICU的IRQCRi.IRQMD[1:0]位设置为01b（下降沿）。在DPSIEGRy.DIRQnEG位（y=0、1和n=0、1、4到12）设置为1（上升沿）并且SBYCR.SSBY和DPSBYCR.DPSBY位都设置为1后，WFI指令被执行。结果，MCU转换到深度软件待机模式。然后在IRQn-DS引脚的上升沿取消深度软件待机模式。

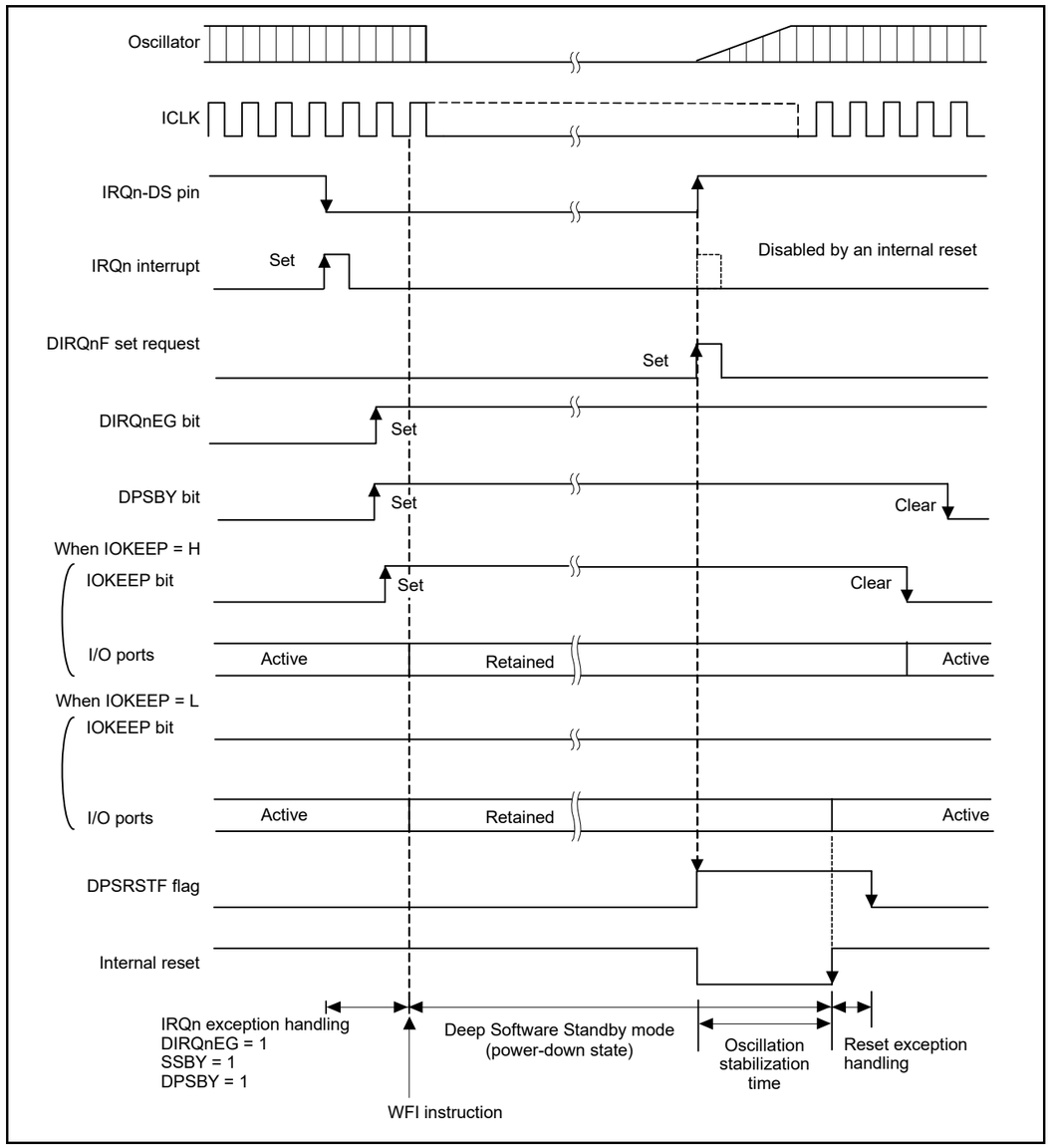


Figure 11.10 Example of Deep Software Standby mode application

11.9.5 Usage Flow for Deep Software Standby Mode

Figure 11.11 shows an example flow for using Deep Software Standby mode. In this example, the RSTSR0.DPSRSTF flag of the reset function is read after reset exception handling to determine whether the reset is generated by the RES pin or by the cancellation of Deep Software Standby mode. For a reset by the RES pin, the MCU transitions to Deep Software Standby mode after the required register settings are made. For a reset by cancellation of Deep Software Standby mode, the DPSBYCR.IOKEEP bit is set to 0 after the I/O port settings are made.

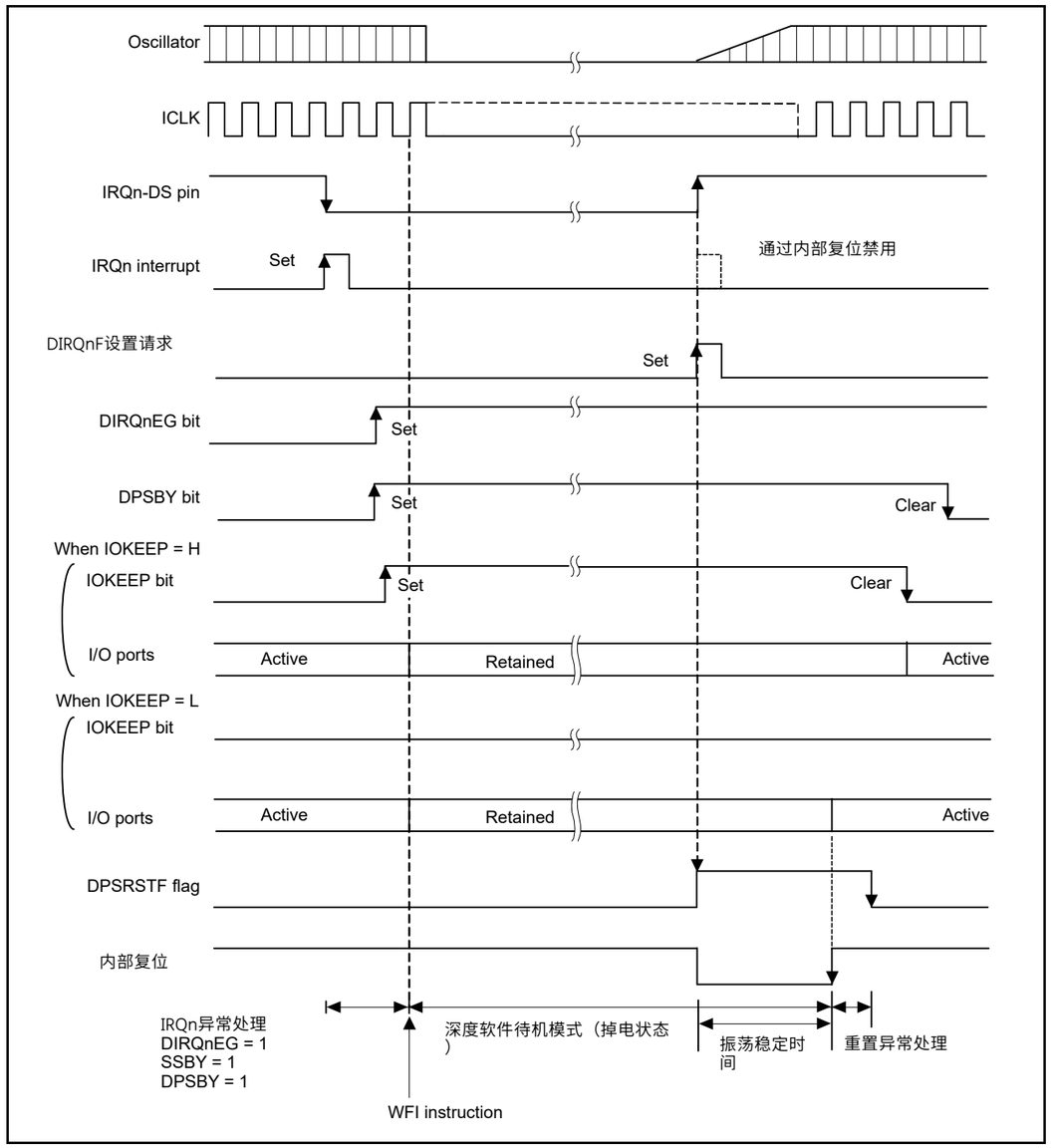


Figure 11.10 深度软件待机模式应用示例

11.9.5 深度软件待机模式的使用流程

图11.11显示了使用深度软件待机模式的示例流程。在本例中，在复位异常处理后读取复位功能的RSTSR0.DPRSTF标志，以确定复位是由RES引脚产生还是由深度软件待机模式的取消产生。对于通过RES引脚进行的复位，在进行所需的寄存器设置后，MCU会转换到深度软件待机模式。通过取消DeepSoftware进行重置

待机模式下，在IO端口设置完成后，DPSBYCR.IOKEEP位被设置为0。

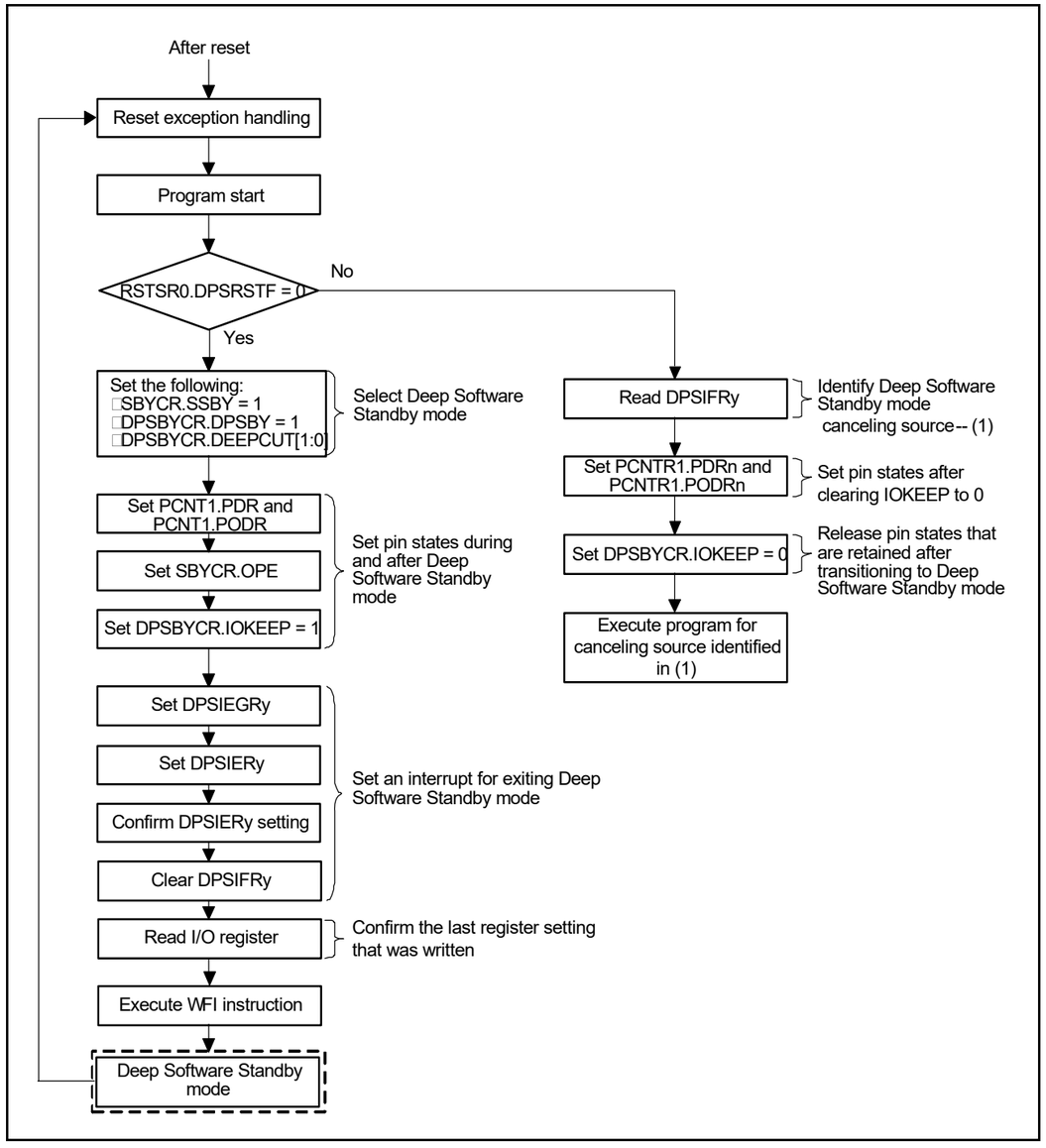


Figure 11.11 Example flow for using Deep Software Standby mode

11.10 Usage Notes

11.10.1 Register Access

(1) Invalid register write accesses during specific modes or transitions

Do not write to registers under any of the conditions listed in this section.

[Registers]

- All registers with a peripheral name of SYSTEM.

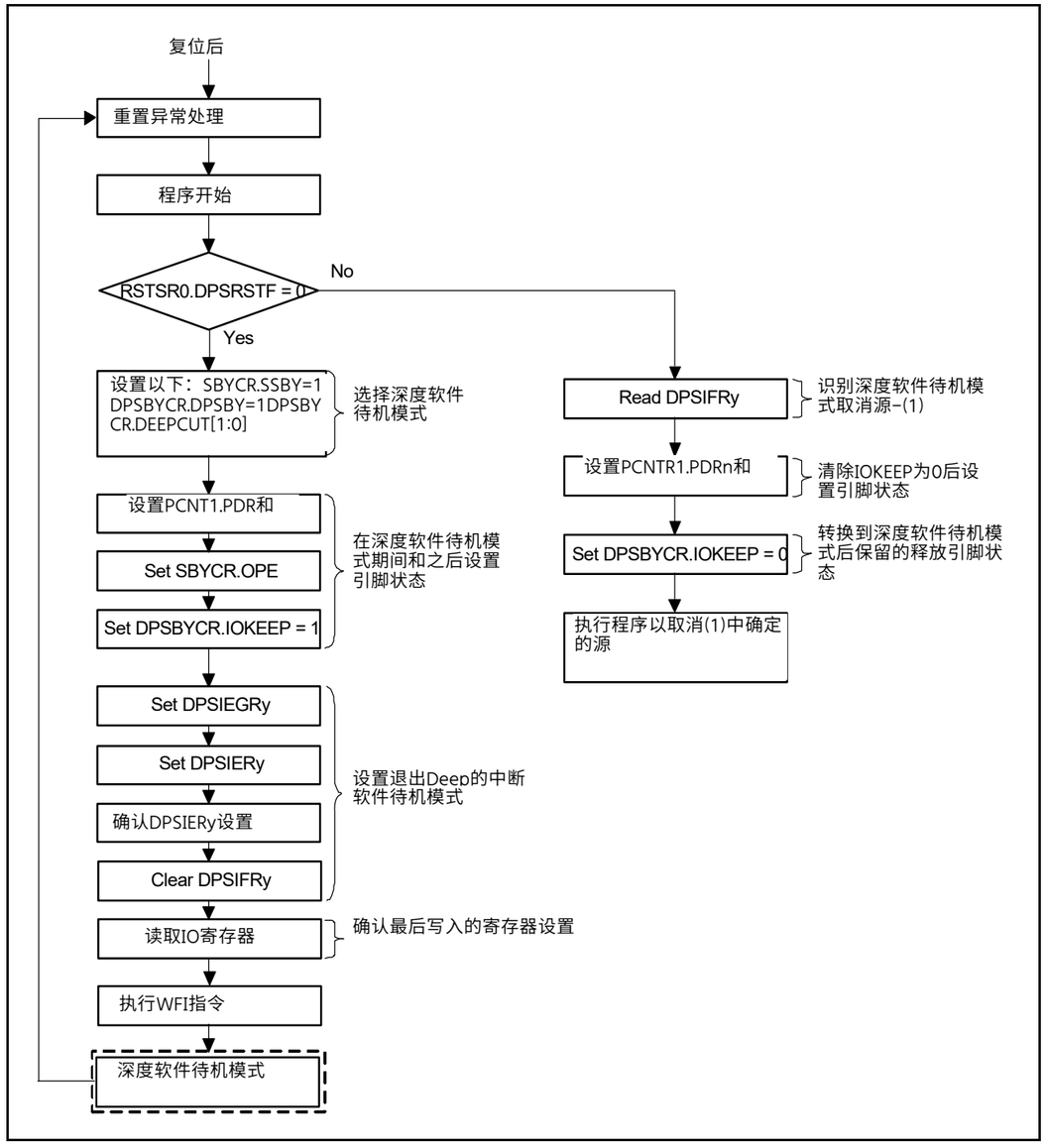


Figure 11.11 使用深度软件待机模式的示例流程

11.10 使用说明

11.10.1 注册访问

(1) 特定模式或转换期间的无效寄存器写访问

不要在本节列出的任何条件下写入寄存器。

[Registers]

- 外设名称为SYSTEM的所有寄存器。

[Conditions]

- OPCCR.OPCMTSF = 1 or SOPCCR.SOPCMTSF = 1 (during transition of the operating power control mode)
- During the time period from executing a WFI instruction to returning to Normal mode
- When FENTRYR.FENTRYi = 1 (i = 0 to 3) (flash P/E mode) or FENTRYR.FENTRYD = 1 (data flash P/E mode).

(2) Valid settings for the clock-related registers

Table 11.11 and Table 11.12 show the valid settings of the clock-related registers in each operating power control mode. Do not write any value other than the valid setting. Any other written value is ignored. Each register has certain prohibited settings under conditions other than those related to the operating power control modes. See section 9, Clock Generation Circuit, for these other conditions for each register.

Table 11.11 Valid settings for the clock-related registers (1)

Mode	Valid settings							
	SCKSCR.CKSEL[2:0], CKOCR.CKOSEL[2:0]	SCKDIVCR.FCK[2:0], ICK[2:0]	PLLCR.PLLSTP	HOCOCR. HCSTP	MOCOCR. MCSTP	LOCOCR. LCSTP	MOSCCR. MOSTP	SOSCCR. SOSTP
High-speed	000b (HOCO) 001b (MOCO) 010b (LOCO) 011b (Main clock) 100b (Sub-clock) 101b (PLL)*1	000b (1/1) 001b (1/2) 010b (1/4) 011b (1/8) 100b (1/16) 101b (1/32) 110b (1/64)	0 (operating) 1 (stopped)	0 (operating) 1 (stopped)	0 (operating) 1 (stop)	0 (operating) 1 (stopped)	0 (operating) 1 (stopped)	0 (operating) 1 (stopped)
Low-speed	000b (HOCO) 001b (MOCO) 010b (LOCO) 011b (Main clock) 100b (Sub-clock)		1 (stopped)					
Subosc-speed	010b (LOCO) 100b (Sub-clock)	000b (1/1)	1 (stopped)	1 (stopped)	1 (stopped)	0 (operating) 1 (stopped)	1 (stopped)	0 (operating) 1 (stopped)

Note 1. SCKSCR.CKSEL[2:0] only.

Table 11.12 Valid settings for the clock related registers (2)

Operating oscillator	Valid settings	
	OPCCR.OPCM[1:0]	SOPCCR.SOPCM
PLL	00b	0
High-speed on-chip oscillator	00b, 11b	0
Middle-speed on-chip oscillator		
Main clock oscillator		
Low-speed on-chip oscillator	00b, 11b	0, 1
Sub-clock oscillator		
IWDT-dedicated on-chip oscillator		

(3) Invalid register write accesses in subosc-speed mode

Do not write to registers under the listed condition in this section.

[Registers]

- SCKSCR, OPCCR.

[Condition]

- SOPCCR.SOPCM = 1 (Subosc-speed mode).

(4) Invalid register write accesses by the DTC or DMAC

Do not write to registers listed in this section by the DTC or DMAC.

[Register]

- MSTPCRA.

[Conditions]

- OPCCR.OPCMTSF=1或SOPCCR.SOPCMTSF=1（在工作功率控制模式转换期间）
- 从执行WFI指令到返回正常模式的时间段内
- 当FENTRYR.FENTRYi=1（i=0到3）（闪存PE模式）或FENTRYR.FENTRYD=1（数据闪存PE模式）时。

(2) 时钟相关寄存器的有效设置

表11.11和表11.12显示了每种工作电源控制模式下时钟相关寄存器的有效设置。请勿写入有效设置以外的任何值。任何其他写入值都将被忽略。每个寄存器在与工作功率控制模式相关的条件下都有某些禁止设置。有关每个寄存器的这些其他条件，请参见第9节，时钟生成电路。

Table 11.11 时钟相关寄存器的有效设置(1)

Mode	有效设置							
	SCKSCR.CKSEL[2:0], CKOCR.CKOSEL[2:0]	SCKDIVCR.FCK[2:0], ICK[2:0]	PLLCR.PLLSTP	HOCOCR. HCSTP	MOCOCR. MCSTP	LOCOCR. LCSTP	MOSCCR. MOSTP	SOSCCR. SOSTP
High-speed	000b (HOCO) 001b (MOCO) 010b (LOCO) 011b (Main clock) 100b (Sub-clock) 101b (PLL)*1	000b (1/1) 001b (1/2) 010b (1/4) 011b (1/8) 100b (1/16) 101b (1/32) 110b (1/64)	0 (operating) 1 (stopped)	0 (operating) 1 (stopped)	0 (operating) 1 (stop)	0 (operating) 1 (stopped)	0 (operating) 1 (stopped)	0 (operating) 1 (stopped)
Low-speed	000b (HOCO) 001b (MOCO) 010b (LOCO) 011b (Main clock) 100b (Sub-clock)		1 (stopped)					
Subosc-speed	010b (LOCO) 100b (Sub-clock)	000b (1/1)	1 (stopped)	1 (stopped)	1 (stopped)	0 (operating) 1 (stopped)	1 (stopped)	0 (operating) 1 (stopped)

Note 1. SCKSCR.CKSEL[2:0] only.

Table 11.12 时钟相关寄存器的有效设置(2)

操作振荡器	有效设置	
	OPCCR.OPCM[1:0]	SOPCCR.SOPCM
PLL	00b	0
High-speed on-chip oscillator	00b, 11b	0
Middle-speed on-chip oscillator		
主时钟振荡器		
Low-speed on-chip oscillator	00b, 11b	0, 1
Sub-clock oscillator		
IWDT-dedicated on-chip oscillator		

(3) subosc-speed模式下的无效寄存器写访问

不要在本节列出的条件下写入寄存器。

[Registers]

- SCKSCR, OPCCR.

[Condition]

- SOPCCR.SOPCM = 1 (Subosc-speed mode).

(4) DTC或DMAC的无效寄存器写访问

不要写入DTC或DMAC在本节中列出的寄存器。

[Register]

- MSTPCRA.

(5) Invalid register write accesses in Snooze mode

Do not write to registers listed in this section in Snooze mode. They must be set before entering Software Standby mode.

[Registers]

- SNZCR, SNZEDCR, SNZREQCR.

(6) Invalid write access to FLWT.FLWT[2:0]

Do not write any value other than 000b to the FLWT.FLWT[2:0] bits under the listed condition.

[Condition]

- SOPCCR.SOPCM = 1 (Subosc-speed mode)

(7) Invalid write access when PRCR.PRC1 is 0

Do not write to registers listed in this section when the PRCR.PRC1 bit is 0.

[Registers]

- SBYCR, SNZCR, SNZEDCR, SNZREQCR, OPCCR, SOPCCR, DPSBYCR, DPSIERn (n = 0 to 3), DPSIFRn (n = 0 to 3), DPSIEGRn (n = 0 to 2), and SYOCDCR.

11.10.2 I/O Port States

The I/O port states in Software Standby, Deep Software Standby, and Snooze modes (except when modifying in Snooze mode) are the same before entering the modes. Therefore, power consumption is not reduced while the output signals are held high.

11.10.3 Module-Stop State of DMAC and DTC

Before writing 1 to MSTPCRA.MSTPA22, clear the DMAST.DMST bit of the DMAC and the DTCST.DTCST bit of the DTC to 0.

11.10.4 Internal Interrupt Sources

Interrupts do not operate in the module-stop state. If the module-stop bit is set when an interrupt request is generated, a CPU interrupt source or a DMAC or DTC startup source cannot be cleared. Always disable the associated interrupts before setting the module-stop bits.

11.10.5 Input Buffer Control by the DIRQnE Bit (n = 0, 1, 4 to 12)

Setting the DPSIERy.DIRQnE bit (y = 0, 1 and n = 0, 1, 4 to 12) to 1 enables the associated input buffer of the IRQ0-DS, IRQ1-DS, and IRQ4-DS to IRQ12-DS pins. Although inputs to these pins are sent to the DPSIFRy.DIRQnF bits (y = 0, 1 and n = 0, 1, 4 to 12), they are not sent to the ICU, peripheral modules, or I/O ports.

11.10.6 Transitioning to Low Power Modes

Because the MCU does not support wakeup by events, do not enter the low power modes (Sleep, Software Standby, or Deep Software Standby mode) by executing a WFE instruction. Also, do not set the SLEEPDEEP bit of the System Control Register in the Cortex®-M4 core, because the MCU does not support low power modes by SLEEPDEEP.

11.10.7 Timing of WFI Instruction

It is possible for the WFI instruction to be executed before I/O register writes are complete, in which case operation might not proceed as intended. This can happen if the WFI is placed immediately after a write to an I/O register. To avoid this problem, read back the register that was written to confirm that the write completed.

11.10.8 Writing to the WDT and IWDT Registers by the DMAC or DTC in Sleep Mode or Snooze Mode

Do not write to the WDT or IWDT registers by the DMAC or DTC while the WDT or IWDT is stopped after entering Sleep mode or Snooze mode.

(5) 贪睡模式下的无效寄存器写访问

不要在贪睡模式下写入本节中列出的寄存器。必须在进入软件待机模式之前设置它们。

[Registers]

- SNZCR, SNZEDCR, SNZREQCR.

(6) 对FLWT.FLWT[2:0]的写入访问无效

在所列条件下，请勿将000b以外的任何值写入FLWT.FLWT[2:0]位。

[Condition]

- SOPCCR.SOPCM = 1 (Subosc-speed mode)

(7) 当PRCR.PRC1为0时，写入访问无效

当PRCR.PRC1位为0时，不要写入本节中列出的寄存器。

[Registers]

- SBYCR、SNZCR、SNZEDCR、SNZREQCR、OPCCR、SOPCCR、DPSBYCR、DPSIERn（n=0到3）、DPSIFRn（n=0到3）、DPSIEGRN（n=0到2）和SOOCDCR。

11.10.2 IO端口状态

软件待机、深度软件待机和贪睡模式下的IO端口状态（在贪睡模式下修改时除外）在进入这些模式之前是相同的。因此，当输出信号保持为高时，功耗不会降低。

11.10.3 DMAC和DTC的模块停止状态

在将1写入MSTPCRA.MSTPA22之前，清除DMAC的DMAST.DMST位和DTCST.DTCST位
DTC to 0.

11.10.4 内部中断源

中断不会在模块停止状态下运行。如果在产生中断请求时设置模块停止位，则
无法清除CPU中断源或DMAC或DTC启动源。在设置模块停止位之前，始终禁用相关的中断。

11.10.5 DIRQnE位的输入缓冲器控制（n=0、1、4到12）

将DPSIERy.DIRQnE位（y=0 1和n=0 1 4至12）设置为1可启用IRQ0-DS、IRQ1-DS和IRQ4-DS至IRQ12-DS引脚的相关输入缓冲器。尽管这些引脚的输入被发送到DPSIFRy.DIRQnF位（y=0、1和n=0、1、4到12），但它们不会被发送到ICU、外设模块或IO端口。

11.10.6 过渡到低功耗模式

由于MCU不支持事件唤醒，请勿进入低功耗模式（睡眠、软件待机或
深度软件待机模式）通过执行WFE指令。此外，不要设置系统的SLEEPDEEP位
Cortex®-M4内核中的控制寄存器，因为MCU不支持SLEEPDEEP的低功耗模式。

11.10.7 WFI指令的时间安排

WFI指令可能在IO寄存器写入完成之前执行，在这种情况下操作可能不会按预期进行。如果在写入IO寄存器后立即放置WFI，则会发生这种情况。为避免此问题，请回读已写入的寄存器以确认写入已完成。

11.10.8 在休眠模式下由DMAC或DTC写入WDT和IWDT寄存器，或贪睡模式

当WDT或IWDT进入后停止时，请勿通过DMAC或DTC写入WDT或IWDT寄存器
睡眠模式或贪睡模式。

11.10.9 Oscillators in Snooze Mode

Oscillators that stop on entering Software Standby mode automatically restart when a trigger for switching to Snooze mode is generated. The MCU does not enter Snooze mode until all of the oscillators stabilize. In Snooze mode, you must disable oscillators that are not required in Snooze mode before entering Software Standby mode. Otherwise, the transition from Software Standby mode to Snooze mode takes longer.

11.10.10 Snooze Mode Entry by RXD0 Falling Edge

When the SNZCR.RXDREQEN bit is 1, noise on the RXD0 pin might cause the MCU transition from Software Standby mode to Snooze mode. Any subsequent RXD0 data can be received in Snooze mode by noise on the RXD0 pin. If the MCU does not receive any RXD0 data after the noise, interrupts such as SCI0_ERI or SCI0_RXI, and address mismatch events are not generated, and the MCU stays in Snooze mode. To avoid this, an AGT1 underflow interrupt must be used to return to Software Standby mode or Normal mode when using SCI0 in Snooze mode. However, set AGT1 underflow not to be a source to return to Software Standby mode during an SCI communication. This makes the SCI0 stop the operation in a half-finished state.

11.10.11 Using SCI0 in Snooze Mode

When using SCI0 in Snooze mode, the AGT1 underflow must be used for the interrupt request or snooze end request. Do not use any other trigger.

When using SCI0 in Snooze mode, the following conditions must be satisfied:

- The clock source must be HOCO
- MOCO, the main clock oscillator, and the PLL must be stopped before entering Software Standby mode
- The RXD0 pin must be kept at the high level before entering Software Standby mode
- A transition to Software Standby mode must not occur during an SCI communication
- The MSTPCRC.MSTPC0 bit must be 1 before entering Software Standby mode.

11.10.12 Conditions of A/D Conversion Start in Snooze Mode

The ADC12 can only be triggered by the ELC in Snooze mode. Do not use a software trigger or ADTRGn pin.

11.10.13 ELC Events in Snooze Mode

Only the ELC events listed in this section are available in Snooze mode. Do not use any other events. If starting peripheral modules for the first time after entering Snooze mode, the Event Link Setting Register (ELSRn) must set a Snooze mode entry event (SYSTEM_SNZREQ) as the trigger.

- Snooze mode entry (SYSTEM_SNZREQ)
- DTC transfer end (DTC_DTCEND)
- ADC12n Window A/B compare match (ADC12n_WCMPM) (n = 0, 1)
- ADC12n Window A/B compare mismatch (ADC12n_WCMPUM) (n = 0, 1)
- Data operation circuit interrupt (DOC_DOPCI).

11.10.9 贪睡模式下的振荡器

进入软件待机模式时停止的振荡器会在生成切换到贪睡模式的触发器时自动重新启动。在所有振荡器稳定之前，MCU不会进入贪睡模式。在贪睡模式下，您必须先禁用贪睡模式下不需要的振荡器，然后才能进入软件待机模式。否则，从软件待机模式到贪睡模式的转换需要更长的时间。

11.10.10 通过RXD0下降沿进入贪睡模式

当SNZCR.RXDREQEN位为1时，RXD0引脚上的噪声可能会导致MCU从软件待机模式转换到贪睡模式。任何后续的RXD0数据都可以通过RXD0引脚上的噪声在贪睡模式下接收。如果噪声后MCU没有收到任何RXD0数据，则不会产生SCI0_ERI或SCI0_RXI等中断和地址不匹配事件，并且MCU处于贪睡模式。为避免这种情况，在贪睡模式下使用SCI0时，必须使用AGT1下溢中断返回到软件待机模式或正常模式。但是，将AGT1下溢设置为不是在SCI通信期间返回软件待机模式的源。这使得SCI0在半完成状态下停止操作。

11.10.11 在贪睡模式下使用SCI0

在贪睡模式下使用SCI0时，AGT1下溢必须用于中断请求或贪睡结束请求。不要使用任何其他触发器。

在贪睡模式下使用SCI0时，必须满足以下条件：

- 时钟源必须是HOCO
- MOCO、主时钟振荡器和PLL必须在进入软件待机模式之前停止
- 进入软件待机模式前，RXD0引脚必须保持高电平
- 在SCI通信期间不得转换到软件待机模式
- 在进入软件待机模式之前，MSTPCRC.MSTPC0位必须为1。

11.10.12 贪睡模式下AD转换开始的条件

ADC12只能由ELC在贪睡模式下触发。不要使用软件触发或ADTRGn引脚。

11.10.13 贪睡模式下的ELC事件

只有本节中列出的ELC事件在贪睡模式下可用。不要使用任何其他事件。如果进入贪睡模式后第一次启动外围模块，事件链接设置寄存器（ELSRn）必须设置贪睡模式进入事件（SYSTEM_SNZREQ）作为触发器。

- 贪睡模式进入(SYSTEM_SNZREQ)
- DTC传输结束(DTC_DTCEND)
- ADC12n窗口AB比较匹配(ADC12n_WCMPM)(n=0 1)
- ADC12n窗口AB比较失配(ADC12n_WCMPUM)(n=0 1)
- 数据操作电路中断（DOC_DOPCI）。

12. Register Write Protection

12.1 Overview

The register write protection function protects important registers from being overwritten because of software errors. The registers to be protected are set with the Protect Register (PRCR).

Table 12.1 lists the association between the PRCR bits and the registers to be protected.

Table 12.1 Association between PRCR bits and registers to be protected

PRCR bit	Registers to be protected
PRC0	• Registers related to the clock generation circuit: SCKDIVCR, SCKSCR, PLLCCR, PLLCR, MOSCCR, HOCOCR, MOCOCR, CKOCR, TRCKCR, OSTDCR, OSTDSR, MOCOUTCR, HOCOUTCR, MOSCWTCR, MOMCR, SOSCCR, SOMCR, LOCOCR, LOCOUTCR, HOCOWTCR, FLLCR1, FLLCR2.
PRC1	• Registers related to the low power modes: SBYCR, SNZCR, SNZEDCR, SNZREQCR, OPCCR, SOPCCR, DPSBYCR, DPSIER0-3, DPSIFR0-3, DPSIEGR0-2, SYOCDCR, STCONR • Registers related to the AGT function: VBTICTLR.
PRC3	• Registers related to the LVD: LVD1CR1, LVD1SR, LVD2CR1, LVD2SR, LVCMPCR, LVDLVLR, LVD1CR0, LVD2CR0.

12.2 Register Descriptions

12.2.1 Protect Register (PRCR)

Address(es): SYSTEM.PRCR 4001 E3FEh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PRKEY[7:0]								—	—	—	—	PRC3	—	PRC1	PRC0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Function	R/W
b0	PRC0	Protect Bit 0	Enable writing to the registers related to the clock generation circuit: 0: Disable writes 1: Enable writes.	R/W
b1	PRC1	Protect Bit 1	Enable writing to the registers related to the low power modes and the AGT function: 0: Disable writes 1: Enable writes.	R/W
b2	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b3	PRC3	Protect Bit 3	Enable writing to the registers related to the LVD: 0: Disable writes 1: Enable writes.	R/W
b7 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15 to b8	PRKEY[7:0]	PRC Key Code	These bits control write access to the PRCR register. To modify the PRCR register, write A5h to the upper 8 bits and the target value to the lower 8 bits as a 16-bit unit.	W*1

Note 1. Write data is not saved. Always reads 00h.

PRCn bits (Protect Bit n) (n = 0, 1, 3)

The PRCn bits enable or disable writing to the protected registers listed in Table 12.1. Setting PRCn to 1 or 0 enables or disables writing, respectively.

12. 寄存器写保护

12.1 Overview

寄存器写保护功能可保护重要寄存器不因软件错误而被覆盖。要保护的寄存器由保护寄存器(PRCR)设置。

表12.1列出了PRCR位和要保护的寄存器之间的关联。

Table 12.1 PRCR位和要保护的寄存器之间的关联

PRCR bit	受保护的寄存器
PRC0	与时钟产生电路相关的寄存器： SCKDIVCR, SCKSCR, PLLCCR, PLLCR, MOSCCR, HOCOCR, MOCOCR, CKOCR, TRCKCR, OSTDCR, OSTDSR, MOCOUTCR, HOCOUTCR, MOSCWTCR, MOMCR, SOSCCR, SOMCR, LOCOCR, LOCOUTCR, HOCOWTCR, FLLCR1, FLLCR2.
PRC1	与低功耗模式相关的寄存器： SBYCR, SNZCR, SNZEDCR, SNZREQCR, OPCCR, SOPCCR, DPSBYCR, DPSIER0-3, DPSIFR0-3, DPSIEGR0-2、SYOCDCR、STCONR 与AGT功能相关的寄存器：VBTICTLR。
PRC3	与LVD相关的寄存器： LVD1CR1, LVD1SR, LVD2CR1, LVD2SR, LVCMPCR, LVDLVLR, LVD1CR0, LVD2CR0.

12.2 注册说明

12.2.1 保护寄存器(PRCR)

Address(es): SYSTEM.PRCR 4001 E3FEh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PRKEY[7:0]								—	—	—	—	PRC3	—	PRC1	PRC0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Function	R/W
b0	PRC0	保护位0	允许写入与时钟生成电路相关的寄存器：0：禁止写入1：允许写入。	R/W
b1	PRC1	保护位1	启用写入与低功耗模式相关的寄存器和AGT功能：0：禁用写入1：启用写入。	R/W
b2	—	Reserved	该位读取为0。写入值应为0。	R/W
b3	PRC3	保护位3	允许写入与LVD相关的寄存器：0：禁止写入1：允许写入。	R/W
b7 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15 to b8	PRKEY[7:0]	中华人民共和国密钥代码	这些位控制对PRCR寄存器的写访问。要修改PRCR寄存器，以16位为单位，将A5h写入高8位，将目标值写入低8位。	W*1

Note 1. 不保存写入数据。始终读取00h。

PRCn位（保护位n）（n=0、1、3）

PRCn位启用或禁用对表12.1中列出的受保护寄存器的写入。将PRCn设置为1或0分别启用或禁用写入。

13. Interrupt Controller Unit (ICU)

13.1 Overview

The Interrupt Controller Unit (ICU) controls which event signals are linked to the Nested Vector Interrupt Controller (NVIC), the DMA Controller (DMAC), and the Data Transfer Controller (DTC) modules. The ICU also controls non-maskable interrupts.

Table 13.1 lists the ICU specifications, Figure 13.1 shows a block diagram, and Table 13.2 lists the I/O pins.

Table 13.1 ICU specifications

Parameter		Specifications
Interrupts	Peripheral function interrupts	• Interrupts from peripheral modules Number of sources: 268 (select factors within event list numbers 64 to 511)
	External pin interrupts	• Interrupt detection on low level, falling edge, rising edge, rising and falling edges. One of these detection methods can be set for each source. • Digital filter function supported • 14 sources, with interrupts from IRQ0 to IRQ13 pins.
	DTC and DMAC control	The DTC and DMAC can be activated using interrupt sources*1
	Interrupt sources for NVIC	96 sources
Non-maskable interrupts*2	NMI pin interrupt	• Interrupt from the NMI pin • Interrupt detection on falling edge or rising edge • Digital filter function supported.
	Oscillation stop detection interrupt*3	Interrupt on detecting that the main oscillator has stopped
	WDT underflow/refresh error*3	Interrupt on an underflow of the down-counter or occurrence of a refresh error
	IWDT underflow/refresh error*3	Interrupt on an underflow of the down-counter or occurrence of a refresh error
	Voltage monitor 1 interrupt*3	Voltage monitor interrupt of low voltage detection detector 1 (LVD1)
	Voltage monitor 2 interrupt*3	Voltage monitor interrupt of low voltage detection detector 2 (LVD2)
	RPEST	Interrupt on SRAM parity error
	BUSSST	Interrupt on MPU bus slave error
	BUSMST	Interrupt on MPU bus master error
	SPEST	Interrupt on CPU stack pointer monitor
Return from low power mode*4		• Sleep mode: return is initiated by non-maskable interrupts or any other interrupt source • Software Standby mode: return is initiated by non-maskable interrupts. Interrupts can be selected in the WUPEN register*5. • Snooze mode: return is initiated by non-maskable interrupts. Interrupts can be selected in the SELSR0 and WUPEN registers*5.

Note 1. For the DTC and DMAC activation sources, see Table 13.4, Event table.
Note 2. Non-maskable interrupts can be enabled only once after a reset release.
Note 3. These non-maskable interrupts can also be used as event signals. When used as interrupts, do not change the value of the NMIER register from the reset state. To enable voltage monitor 1 and voltage monitor 2 interrupts, set the LVD1CR1.IRQSEL and LVD2CR1.IRQSEL bits to 1.
Note 4. For return from Deep Software Standby mode, see section 11.9, Deep Software Standby Mode.
Note 5. See section 13.2.8, SYS Event Link Setting Register (SELSR0), and section 13.2.9, Wake Up Interrupt Enable Register (WUPEN).

13. 中断控制器单元(ICU)

13.1 Overview

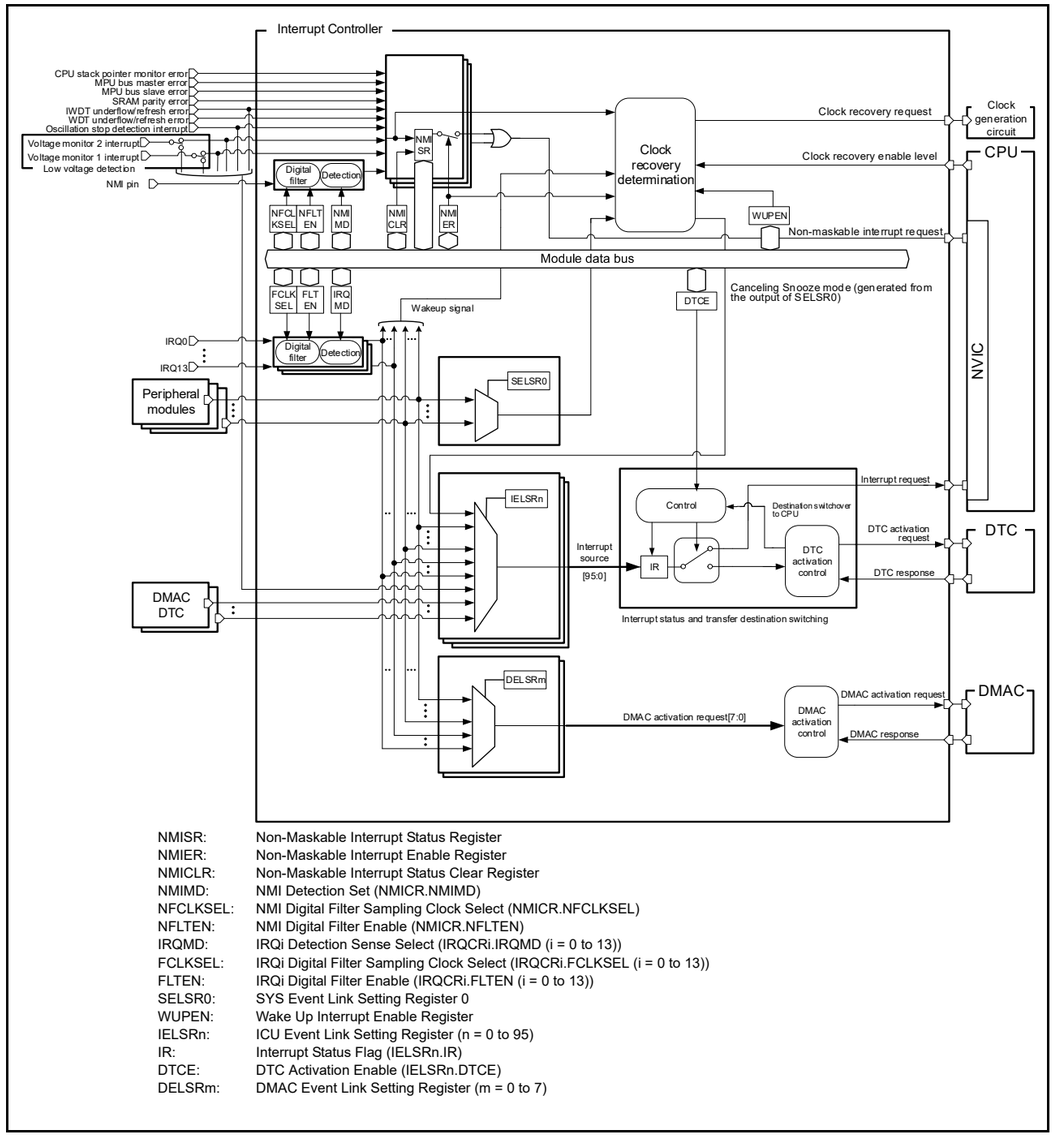
中断控制器单元(ICU)控制哪些事件信号链接到嵌套向量中断控制器(NVIC)、DMA控制器(DMAC)和数据传输控制器(DTC)模块。ICU还控制不可屏蔽的中断。

表13.1列出了ICU规格，图13.1显示了框图，表13.2列出了IO引脚。

Table 13.1 ICU规格

Parameter		Specifications
Interrupts	外设功能中断	来自外围模块的中断 来源数量：268（在事件列表编号64至511中选择因素）
	外部引脚中断	低电平、下降沿、上升沿、上升沿和下降沿的中断检测。可以为每个源设置这些检测方法之一。 支持数字滤波器功能 14个源，中断从IRQ0到IRQ13引脚。
	DTC和DMAC控制	DTC和DMAC可以使用中断源*1激活
	NVIC的中断源	96 sources
Non-maskable interrupts*2	NMI引脚中断	来自NMI引脚的中断 下降沿或上升沿中断检测 支持数字滤波器功能。
	振荡停止检测中断*3	检测到主振荡器停止时中断
	WDT underflow/refresh error*3	递减计数器下溢或发生刷新错误时中断
	IWDT underflow/refresh error*3	递减计数器下溢或发生刷新错误时中断
	电压监视器1中断*3	低电压检测检测器1(LVD1)的电压监控中断
	电压监视器2中断*3	低电压检测检测器2(LVD2)的电压监控中断
	RPEST	SRAM奇偶校验错误中断
	BUSSST	MPU总线从机错误中断
	BUSMST	MPU总线主机错误中断
	SPEST	CPU堆栈指针监视器中断
从低功耗模式返回*4		睡眠模式：由不可屏蔽中断或任何其他中断源启动返回 软件待机模式：由不可屏蔽中断启动返回。可以在WUPEN寄存器*5中选择中断。 贪睡模式：返回由不可屏蔽的中断启动。可以在SELSR0和WUPEN寄存器中选择中断*5。

Note 1. 对于DTC和DMAC激活源，请参见表13.4，事件表。
Note 2. 不可屏蔽中断只能在复位释放后启用一次。
Note 3. 这些不可屏蔽的中断也可以用作事件信号。当用作中断时，不要改变NMIER寄存器从复位状态。要启用电压监视器1和电压监视器2中断，请将LVD1CR1.IRQSEL和LVD2CR1.IRQSEL位设置为1。
Note 4. 要从深度软件待机模式返回，请参阅第11.9节，深度软件待机模式。
Note 5. 请参见第13.2.8节，SYS事件链接设置寄存器(SELSR0)和第13.2.9节，唤醒中断启用寄存器(WUPEN)。



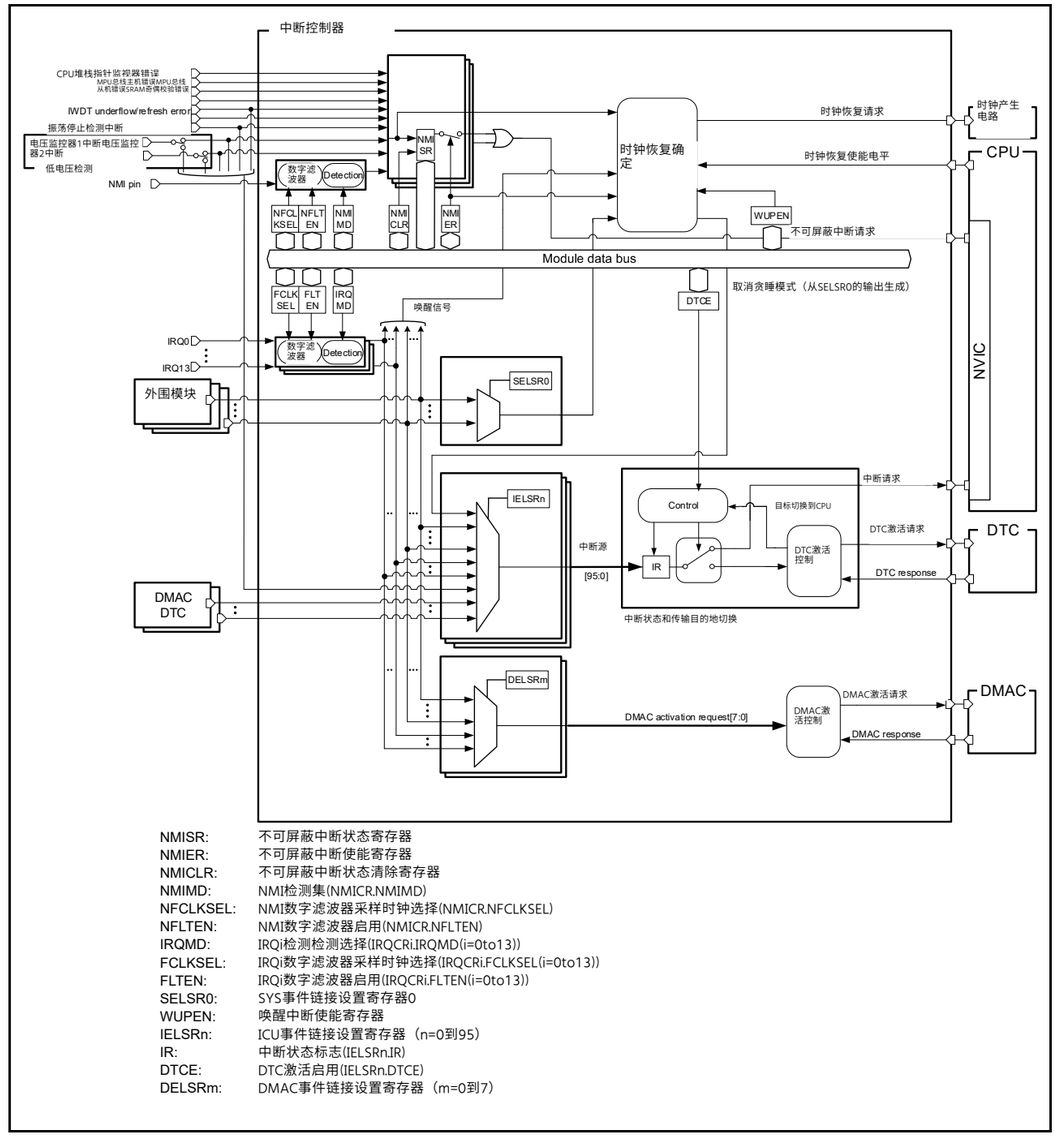
NMISR: Non-Maskable Interrupt Status Register
NMIER: Non-Maskable Interrupt Enable Register
NMICLR: Non-Maskable Interrupt Status Clear Register
NMIMD: NMI Detection Set (NMICR.NMIMD)
NFCLKSEL: NMI Digital Filter Sampling Clock Select (NMICR.NFCLKSEL)
NFLTEN: NMI Digital Filter Enable (NMICR.NFLTEN)
IRQMD: IRQi Detection Sense Select (IRQCRi.IRQMD (i = 0 to 13))
FCLKSEL: IRQi Digital Filter Sampling Clock Select (IRQCRi.FCLKSEL (i = 0 to 13))
FLTEN: IRQi Digital Filter Enable (IRQCRi.FLTEN (i = 0 to 13))
SELSR0: SYS Event Link Setting Register 0
WUPEN: Wake Up Interrupt Enable Register
IELSRn: ICU Event Link Setting Register (n = 0 to 95)
IR: Interrupt Status Flag (IELSRn.IR)
DTCE: DTC Activation Enable (IELSRn.DTCE)
DELSRm: DMAC Event Link Setting Register (m = 0 to 7)

Figure 13.1 ICU block diagram

Table 13.2 lists the ICU input/output pins.

Table 13.2 ICU I/O pins

Pin name	I/O	Description
NMI	Input	Non-maskable interrupt request pin
IRQ0 to IRQ13	Input	External interrupt request pins



NMISR: 不可屏蔽中断状态寄存器
NMIER: 不可屏蔽中断使能寄存器
NMICLR: 不可屏蔽中断状态清除寄存器
NMIMD: NMI检测集(NMICR.NMIMD)
NFCLKSEL: NMI数字滤波器采样时钟选择(NMICR.NFCLKSEL)
NFLTEN: NMI数字滤波器启用(NMICR.NFLTEN)
IRQMD: IRQi检测检测选择(IRQCRi.IRQMD(i=0to13))
FCLKSEL: IRQi数字滤波器采样时钟选择(IRQCRi.FCLKSEL(i=0to13))
FLTEN: IRQi数字滤波器启用(IRQCRi.FLTEN(i=0to13))
SELSR0: SYS事件链接设置寄存器0
WUPEN: 唤醒中断使能寄存器
IELSRn: ICU事件链接设置寄存器（n=0到95）
IR: 中断状态标志(IELSRn.IR)
DTCE: DTC激活启用(IELSRn.DTCE)
DELSRm: DMAC事件链接设置寄存器（m=0到7）

Figure 13.1 ICU框图

表13.2列出了ICU输入输出引脚。

Table 13.2 ICUIO引脚

引脚名称	I/O	Description
NMI	Input	不可屏蔽中断请求引脚
IRQ0 to IRQ13	Input	外部中断请求引脚

RA生态工作室

13.2 Register Descriptions

This chapter does not describe the Arm® NVIC internal registers. For information on these registers, see the *ARM® Cortex®-M4 Processor Technical Reference Manual* (ARM DDI 0439D).

13.2.1 IRQ Control Register i (IRQCRi) (i = 0 to 13)

Address(es): ICU.IRQCR0 4000 6000h, ICU.IRQCR1 4000 6001h, ICU.IRQCR2 4000 6002h, ICU.IRQCR3 4000 6003h, ICU.IRQCR4 4000 6004h, ICU.IRQCR5 4000 6005h, ICU.IRQCR6 4000 6006h, ICU.IRQCR7 4000 6007h ICU.IRQCR8 4000 6008h, ICU.IRQCR9 4000 6009h, ICU.IRQCR10 4000 600Ah, ICU.IRQCR11 4000 600Bh, ICU.IRQCR12 4000 600Ch, ICU.IRQCR13 4000 600Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	FLTEN	—	FCLKSEL[1:0]		—	—	IRQMD[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	IRQMD[1:0]	IRQi Detection Sense Select	b1 b0 0 0: Falling edge 0 1: Rising edge 1 0: Rising and falling edges 1 1: Low level.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b5, b4	FCLKSEL[1:0]	IRQi Digital Filter Sampling Clock Select	b5 b4 0 0: PCLKB 0 1: PCLKB/8 1 0: PCLKB/32 1 1: PCLKB/64.	R/W
b6	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7	FLTEN	IRQi Digital Filter Enable	0: Disable 1: Enable.	R/W

IRQCRi register changes must satisfy the following conditions:

- For a CPU interrupt or DTC trigger:
  Change the IRQCRi register setting before setting the target IELSRn register (n = 0 to 95).
  You can only change the register values when the target IELSRn register is 0000h.
- For a DMAC trigger:
  Change the IRQCRi register setting before setting the target DELSRn register (n = 0 to 7).
  You can change the register values only when the DELSRn.DELS[8:0] bits are 000h.
- For a wakeup enable signal:
  Change the IRQCRi register setting before setting the target WUPEN.IRQWUPEN[n] (n = 0 to 13).
  You can change the register values only when the target WUPEN.IRQWUPEN[n] is 000h.

IRQMD[1:0] bits (IRQi Detection Sense Select)

The IRQMD[1:0] bits set the detection sensing method for the IRQi external pin interrupt sources. For more information on the settings, see section 13.4.4, External Pin Interrupts.

FCLKSEL[1:0] bits (IRQi Digital Filter Sampling Clock Select)

The FCLKSEL[1:0] bits select the digital filter sampling clock for the external pin interrupt request IRQi, selectable to:

- PCLKB (every cycle)
- PCLKB/8 (once every 8 cycles)
- PCLKB/32 (once every 32 cycles)
- PCLKB/64 (once every 64 cycles).

For details on the digital filter, see section 13.4.3, Digital Filter.

13.2 注册说明

本章不介绍Arm®NVIC内部寄存器。有关这些寄存器的信息，请参阅ARM® Cortex®-M4处理器技术参考手册(ARMDDI0439D)。

13.2.1 IRQ控制寄存器i(IRQCRi)(i=0到13)

Address(es): ICU.IRQCR0 4000 6000h, ICU.IRQCR1 4000 6001h, ICU.IRQCR2 4000 6002h, ICU.IRQCR3 4000 6003h, ICU.IRQCR4 4000 6004h, ICU.IRQCR5 4000 6005h, ICU.IRQCR6 4000 6006h, ICU.IRQCR7 4000 6007h ICU.IRQCR8 4000 6008h, ICU.IRQCR9 4000 6009h, ICU.IRQCR10 4000 600Ah, ICU.IRQCR11 4000 600Bh, ICU.IRQCR12 4000 600Ch, ICU.IRQCR13 4000 600Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	FLTEN	—	FCLKSEL[1:0]		—	—	IRQMD[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	IRQMD[1:0]	IRQi检测检测选择	b1 b0 0 0：下降沿 0 1：上升沿 1 0：上升沿和下降沿 1 1：低电平。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b5, b4	FCLKSEL[1:0]	IRQi数字滤波器采样时钟 Select	b5 b4 0 0: PCLKB 0 1: PCLKB/8 1 0: PCLKB/32 1 1: PCLKB/64.	R/W
b6	—	Reserved	该位读取为0。写入值应为0。	R/W
b7	FLTEN	IRQi数字滤波器启用	0：禁用1 ：启用。	R/W

IRQCRi寄存器变更必须满足以下条件：

- 对于CPU中断或DTC触发器：
  在设置目标IELSRn寄存器（n=0到95）之前更改IRQCRi寄存器设置。
  当目标IELSRn寄存器为0000h时，您只能更改寄存器值。
- For a DMAC trigger:
  在设置目标DELSRn寄存器（n=0到7）之前更改IRQCRi寄存器设置。
  只有当DELSRn.DELS[8:0]位为000h时，您才能更改寄存器值。
- 对于唤醒使能信号：
  在设置目标WUPEN.IRQWUPEN[n]（n=0到13）之前更改IRQCRi寄存器设置。
  只有当目标WUPEN.IRQWUPEN[n]为000h时，您才能更改寄存器值。

IRQMD[1:0]位（IRQi检测检测选择）

IRQMD[1:0]位设置IRQi外部引脚中断源的检测检测方法。有关设置的更多信息，请参见第13.4.4节，外部引脚中断。

FCLKSEL[1:0]位（IRQi数字滤波器采样时钟选择）

FCLKSEL[1:0]位为外部引脚中断请求IRQi选择数字滤波器采样时钟，可选择：

- PCLKB (every cycle)
- PCLKB/8 (once every 8 cycles)
- PCLKB/32 (once every 32 cycles)
- PCLKB/64 (once every 64 cycles).

有关数字滤波器的详细信息，请参阅第13.4.3节，数字滤波器。

FLTEN bit (IRQi Digital Filter Enable)

The FLTEN bit enables the digital filter used for the IRQi external pin interrupt sources. The filter is enabled when FLTEN is 1 and disabled when FLTEN is 0. The IRQi pin level is sampled at the clock cycle specified in the FCLKSEL[1:0] bits. When the sampled level matches three times, the output level from the digital filter changes. For details on the digital filter, see section 13.4.3, Digital Filter.

13.2.2 Non-Maskable Interrupt Status Register (NMISR)

Address(es): ICU.NMISR 4000 6140h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SPEST	BUSMST	BUSSST	—	RPEST	NMIST	OSTST	—	—	LVD2ST	LVD1ST	WDTST	IWDTST
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	IWDTST	IWDT Underflow/Refresh Error Status Flag	0: Interrupt not requested 1: Interrupt requested.	R
b1	WDTST	WDT Underflow/Refresh Error Status Flag	0: Interrupt not requested 1: Interrupt requested.	R
b2	LVD1ST	Voltage Monitor 1 Interrupt Status Flag	0: Interrupt not requested 1: Interrupt requested.	R
b3	LVD2ST	Voltage Monitor 2 Interrupt Status Flag	0: Interrupt not requested 1: Interrupt requested.	R
b5, b4	—	Reserved	These bits are read as 0.	R
b6	OSTST	Oscillation Stop Detection Interrupt Status Flag	0: Interrupt not requested for main oscillation stop 1: Interrupt requested for main oscillation stop.	R
b7	NMIST	NMI Status Flag	0: NMI pin interrupt not requested 1: NMI pin interrupt requested.	R
b8	RPEST	SRAM Parity Error Interrupt Status Flag	0: Interrupt not requested 1: Interrupt requested.	R
b9	—	Reserved	This bit is read as 0.	R
b10	BUSSST	MPU Bus Slave Error Interrupt Status Flag	0: Interrupt not requested 1: Interrupt requested.	R
b11	BUSMST	MPU Bus Master Error Interrupt Status Flag	0: Interrupt not requested 1: Interrupt requested.	R
b12	SPEST	CPU Stack Pointer Monitor Interrupt Status Flag	0: Interrupt not requested 1: Interrupt requested.	R
b15 to b13	—	Reserved	These bits are read as 0.	R

The NMISR register monitors the status of non-maskable interrupt sources. Writes to the NMISR register are ignored. The setting in the Non-Maskable Interrupt Enable Register (NMIER) does not affect the status flags in this register. Before the end of the non-maskable interrupt handler, check that all of the bits in this register are set to 0 to confirm that no other NMI requests have occurred during handler processing.

IWDTST flag (IWDT Underflow/Refresh Error Status Flag)

The IWDTST flag indicates an IWDT underflow/refresh error interrupt request. It is read-only and cleared by the NMICLR.IWDTCLR bit.

[Setting condition]

- When an IWDT underflow/refresh error interrupt occurs and this interrupt source is enabled.

[Clearing condition]

- When 1 is written to the NMICLR.IWDTCLR bit.

FLTEN位（IRQi数字滤波器使能）

FLTEN位使能用于IRQi外部引脚中断源的数字滤波器。过滤器启用时
FLTEN为1，当FLTEN为0时禁用。IRQi引脚电平在指定的时钟周期采样
FCLKSEL[1:0]位。当采样电平匹配3次时，数字滤波器的输出电平会发生变化。有关数字滤波器的详细信息，请参阅第13.4.3节，数字滤波器。

13.2.2 不可屏蔽中断状态寄存器(NMISR)

Address(es): ICU.NMISR 4000 6140h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SPEST	BUSMST	BUSSST	—	RPEST	NMIST	OSTST	—	—	LVD2ST	LVD1ST	WDTST	IWDTST
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	IWDTST	IWDT下溢刷新错误状态标志	0：未请求中断1：请求中断。	R
b1	WDTST	WDT下溢刷新错误状态标志	0：未请求中断1：请求中断。	R
b2	LVD1ST	电压监视器1中断状态标志	0：未请求中断1：请求中断。	R
b3	LVD2ST	电压监视器2中断状态标志	0：未请求中断1：请求中断。	R
b5, b4	—	Reserved	这些位读为0。	R
b6	OSTST	振荡停止检测中断状态Flag	0：主振荡停止时不请求中断1：主振荡停止时请求中断。	R
b7	NMIST	NMI状态标志	0：未请求NMI引脚中断1：请求了NMI引脚中断。	R
b8	RPEST	SRAM奇偶校验错误中断状态标志	0：未请求中断1：请求中断。	R
b9	—	Reserved	该位读为0。	R
b10	BUSSST	MPU总线从机错误中断状态标志	0：未请求中断1：请求中断。	R
b11	BUSMST	MPU总线主机错误中断状态标志	0：未请求中断1：请求中断。	R
b12	SPEST	CPU堆栈指针监视器中断状态Flag	0：未请求中断1：请求中断。	R
b15 to b13	—	Reserved	这些位读为0。	R

NMISR寄存器监视不可屏蔽中断源的状态。忽略对NMISR寄存器的写入。
不可屏蔽中断使能寄存器(NMIER)中的设置不会影响该寄存器中的状态标志。
在不可屏蔽中断处理程序结束之前，检查该寄存器中的所有位是否都设置为0，以确认在处理程序处理期间没有发生其他NMI请求。

IWDTST标志（IWDT下溢刷新错误状态标志）

IWDTST标志指示IWDT下溢刷新错误中断　　请求。它是只读的并由
NMICLR.IWDTCLR bit.

[Setting condition]

- 当IWDT下溢刷新错误中断　　发生并且该中断源被使能时。

[Clearing condition]

- 当1写入NMICLR.IWDTCLR位时。

WDTST flag (WDT Underflow/Refresh Error Status Flag)

The WDTST flag indicates a WDT underflow/refresh error interrupt request. It is read-only and cleared by the NMICLR.WDTCLR bit.

[Setting condition]

- When a WDT underflow/refresh error interrupt occurs.

[Clearing condition]

- When 1 is written to the NMICLR.WDTCLR bit.

LVD1ST flag (Voltage Monitor 1 Interrupt Status Flag)

The LVD1ST flag indicates a request for voltage monitor 1 interrupt. It is read-only and cleared by the NMICLR.LVD1CLR bit.

[Setting condition]

- When a voltage monitor 1 interrupt occurs and this interrupt source is enabled.

[Clearing condition]

- When 1 is written to the NMICLR.LVD1CLR bit.

LVD2ST flag (Voltage Monitor 2 Interrupt Status Flag)

The LVD2ST flag indicates a request for voltage monitor 2 interrupt. It is read-only and cleared by the NMICLR.LVD2CLR bit.

[Setting condition]

- When a voltage monitor 2 interrupt occurs and this interrupt source is enabled.

[Clearing condition]

- When 1 is written to the NMICLR.LVD2CLR bit.

OSTST flag (Oscillation Stop Detection Interrupt Status Flag)

The OSTST flag indicates a main oscillation stop detection interrupt request. It is read-only and cleared by the NMICLR.OSTCLR bit.

[Setting condition]

- When an oscillation stop detection interrupt occurs.

[Clearing condition]

- When 1 is written to the NMICLR.OSTCLR bit.

NMIST flag (NMI Status Flag)

The NMIST flag indicates an NMI pin interrupt request. It is read-only and cleared by the NMICLR.NMICLR bit.

[Setting condition]

- When an edge specified in the NMICR.NMIMD bit is input to the NMI pin.

[Clearing condition]

- When 1 is written to the NMICLR.NMICLR bit.

RPEST flag (SRAM Parity Error Interrupt Status Flag)

The RPEST flag indicates an SRAM parity error interrupt request.

[Setting condition]

- When an interrupt occurs in response to an SRAM parity error.

[Clearing condition]

WDTST标志（WDT下溢刷新错误状态标志）

WDTST标志指示WDT下溢刷新错误中断　　请求。它是只读的并由NMICLR.WDTCLR bit.

[Setting condition]

- 当WDT下溢刷新错误中断　　发生时。

[Clearing condition]

- 当1写入NMICLR.WDTCLR位时。

LVD1ST标志（电压监视器1中断状态标志）

LVD1ST标志指示电压监视器1中断请求。它是只读的并由NMICLR.LVD1CLR bit.

[Setting condition]

- 当电压监视器1中断发生并且该中断源被使能时。

[Clearing condition]

- 当1写入NMICLR.LVD1CLR位时。

LVD2ST标志（电压监视器2中断状态标志）

LVD2ST标志指示电压监视器2中断请求。它是只读的并由NMICLR.LVD2CLR bit.

[Setting condition]

- 当电压监视器2中断发生并且该中断源被启用时。

[Clearing condition]

- 当1写入NMICLR.LVD2CLR位时。

OSTST标志（振荡停止检测中断状态标志）

OSTST标志表示主振荡停止检测中断请求。它是只读的并由NMICLR.OSTCLR bit.

[Setting condition]

- 发生振荡停止检测中断时。

[Clearing condition]

- 当1写入NMICLR.OSTCLR位时。

NMIST标志（NMI状态标志）

NMIST标志指示NMI引脚中断请求。它是只读的，由NMICLR.NMICLR位清零。

[Setting condition]

- 当NMICR.NMIMD位中指定的边沿输入到NMI引脚时。

[Clearing condition]

- 当1写入NMICLR.NMICLR位时。

RPEST标志（SRAM奇偶校验错误中断状态标志）

RPEST标志指示SRAM奇偶校验错误中断请求。

[Setting condition]

- 当响应SRAM奇偶校验错误而发生中断时。

[Clearing condition]

- When 1 is written to the NMICLR.RPECLR bit.

BUSSST flag (MPU Bus Slave Error Interrupt Status Flag)

The BUSSST flag indicates a bus slave error interrupt request.

[Setting condition]

- When an interrupt occurs in response to a bus slave error.

[Clearing condition]

- When 1 is written to the NMICLR.BUSSCLR bit.

BUSMST flag (MPU Bus Master Error Interrupt Status Flag)

The BUSMST flag indicates a bus master error interrupt request.

[Setting condition]

- When an interrupt occurs in response to a bus master error.

[Clearing condition]

- When 1 is written to the NMICLR.BUSMCLR bit.

SPEST flag (CPU Stack Pointer Monitor Interrupt Status Flag)

The SPEST flag indicates a CPU stack pointer monitor interrupt request.

[Setting condition]

- When an interrupt occurs in response to a CPU stack pointer monitor error.

[Clearing condition]

- When 1 is written to the NMICLR.SPECLR bit.

13.2.3 Non-Maskable Interrupt Enable Register (NMIER)

Address(es): ICU.NMIER 4000 6120h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SPEEN	BUSMEN	BUSSEN	—	RPEEN	NMIEN	OSTEN	—	—	LVD2EN	LVD1EN	WDTEN	IWDTEN
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	IWDTEN	IWDT Underflow/Refresh Error Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b1	WDTEN	WDT Underflow/Refresh Error Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b2	LVD1EN	Voltage Monitor 1 Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b3	LVD2EN	Voltage Monitor 2 Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b5, b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	OSTEN	Oscillation Stop Detection Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b7	NMIEN	NMI Pin Interrupt Enable	0: Disable 1: Enable.	R/(W) *1
b8	RPEEN	SRAM Parity Error Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b9	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

- 当1写入NMICLR.RPECLR位时。

BUSSST标志（MPU总线从机错误中断状态标志）

BUSSST标志指示总线从机错误中断请求。

[Setting condition]

- 当响应总线从机错误而发生中断时。

[Clearing condition]

- 当1写入NMICLR.BUSSCLR位时。

BUSMST标志（MPU总线主机错误中断状态标志）

BUSMST标志指示总线主机错误中断请求。

[Setting condition]

- 当响应总线主机错误而发生中断时。

[Clearing condition]

- 当1写入NMICLR.BUSMCLR位时。

SPEST标志（CPU堆栈指针监视器中断状态标志）

SPEST标志指示CPU堆栈指针监视中断请求。

[Setting condition]

- 当响应CPU堆栈指针监视器错误而发生中断时。

[Clearing condition]

- 当1写入NMICLR.SPECLR位时。

13.2.3 不可屏蔽中断使能寄存器(NMIER)

Address(es): ICU.NMIER 4000 6120h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SPEEN	BUSMEN	BUSSEN	—	RPEEN	NMIEN	OSTEN	—	—	LVD2EN	LVD1EN	WDTEN	IWDTEN
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	IWDTEN	IWDT下溢刷新错误中断 Enable	0：禁用1 ：启用。	R/(W) *1, *2
b1	WDTEN	WDT下溢刷新错误中断 Enable	0：禁用1 ：启用。	R/(W) *1, *2
b2	LVD1EN	电压监视器1中断使能	0：禁用1 ：启用。	R/(W) *1, *2
b3	LVD2EN	电压监视器2中断使能	0：禁用1 ：启用。	R/(W) *1, *2
b5, b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	OSTEN	振荡停止检测中断 Enable	0：禁用1 ：启用。	R/(W) *1, *2
b7	NMIEN	NMI引脚中断使能	0：禁用1 ：启用。	R/(W) *1
b8	RPEEN	SRAM奇偶校验错误中断使能	0：禁用1 ：启用。	R/(W) *1, *2
b9	—	Reserved	该位读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b10	BUSSEN	MPU Bus Slave Error Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b11	BUSMEN	MPU Bus Master Error Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b12	SPEEN	CPU Stack Pointer Monitor Interrupt Enable	0: Disable 1: Enable.	R/(W) *1, *2
b15 to b13	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. You can write 1 to this bit only once after reset. Subsequent write accesses are invalid. Writing 0 to this bit is invalid.
Note 2. Do not write 1 to this bit when the source is used as an event signal.

IWDTEN bit (IWDT Underflow/Refresh Error Interrupt Enable)

The IWDTEN bit enables IWDT underflow/refresh error interrupts as an NMI trigger.

WDTEN bit (WDT Underflow/Refresh Error Interrupt Enable)

The WDTEN bit enables WDT underflow/refresh error interrupts as an NMI trigger.

LVD1EN bit (Voltage Monitor 1 Interrupt Enable)

The LVD1EN bit enables voltage monitor 1 interrupts as an NMI trigger.

LVD2EN bit (Voltage Monitor 2 Interrupt Enable)

The LVD2EN bit enables voltage monitor 2 interrupts as an NMI trigger.

OSTEN bit (Oscillation Stop Detection Interrupt Enable)

The OSTEN bit enables main oscillation stop detection interrupt as an NMI trigger.

NMIEN bit (NMI Pin Interrupt Enable)

The NMIEN bit enables NMI pin interrupt as an NMI trigger.

RPEEN bit (SRAM Parity Error Interrupt Enable)

The RPEEN bit enables SRAM parity error interrupt as an NMI trigger.

BUSSEN bit (MPU Bus Slave Error Interrupt Enable)

The BUSSEN bit enables bus slave error interrupt as an NMI trigger.

BUSMEN bit (MPU Bus Master Error Interrupt Enable)

The BUSMEN bit enables bus master error interrupt as an NMI trigger.

SPEEN bit (CPU Stack Pointer Monitor Interrupt Enable)

The SPEEN bit enables CPU stack pointer monitor interrupt as an NMI trigger.

13.2.4 Non-Maskable Interrupt Status Clear Register (NMICLR)

Address(es): ICU.NMICLR 4000 6130h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SPECLR	BUSMCLR	BUSSCLR	—	RPECLR	NMICLR	OSTCLR	—	—	LVD2CLR	LVD1CLR	WDTCLR	IWDTCLR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	IWDTCLR	IWDT Clear	0: No effect 1: Clear the NMISR.IWDTST flag.	R/(W)*1

Bit	Symbol	位名称	Description	R/W
b10	BUSSEN	MPU总线从机错误中断使能	0：禁用1 ：启用。	R/(W) *1, *2
b11	BUSMEN	MPU总线主机错误中断使能	0：禁用1 ：启用。	R/(W) *1, *2
b12	SPEEN	CPU堆栈指针监视器中断Enable	0：禁用1 ：启用。	R/(W) *1, *2
b15 to b13	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 复位后您只能向该位写入1一次。随后的写访问无效。向该位写入0无效。
Note 2. 当源用作事件信号时，不要向该位写入1。

IWDTEN位（IWDT下溢刷新错误中断 使能）

IWDTEN位使能IWDT下溢刷新错误中断 作为NMI触发。

WDTEN位（WDT下溢刷新错误中断 使能）

WDTEN位使能WDT下溢刷新错误中断 作为NMI触发。

LVD1EN位（电压监视器1中断允许）

LVD1EN位使能电压监视器1中断作为NMI触发。

LVD2EN位（电压监视器2中断允许）

LVD2EN位使能电压监视器2中断作为NMI触发。

OSTEN位（振荡停止检测中断使能）

OSTEN位使能主振荡停止检测中断作为NMI触发。

NMIEN位（NMI引脚中断允许）

NMIEN位使能NMI引脚中断作为NMI触发器。

RPEEN位（SRAM奇偶校验错误中断使能）

RPEEN位启用SRAM奇偶校验错误中断作为NMI触发器。

BUSSEN位（MPU总线从机错误中断使能）

BUSSEN位使能总线从机错误中断作为NMI触发器。

BUSMEN位（MPU总线主机错误中断使能）

BUSMEN位使能总线主机错误中断作为NMI触发器。

SPEEN位（CPU堆栈指针监视器中断使能）

SPEEN位使能CPU堆栈指针监视中断作为NMI触发器。

13.2.4 不可屏蔽中断状态清除寄存器(NMICLR)

Address(es): ICU.NMICLR 4000 6130h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SPECLR	BUSMCLR	BUSSCLR	—	RPECLR	NMICLR	OSTCLR	—	—	LVD2CLR	LVD1CLR	WDTCLR	IWDTCLR
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	IWDTCLR	IWDT Clear	0：无效1：清除NMISR.IWDTST标志。	R/(W)*1

Bit	Symbol	Bit name	Description	R/W
b1	WDTCLR	WDT Clear	0: No effect 1: Clear the NMISR.WDTST flag.	R/(W)*1
b2	LVD1CLR	LVD1 Clear	0: No effect 1: Clear the NMISR.LVD1ST flag.	R/(W)*1
b3	LVD2CLR	LVD2 Clear	0: No effect 1: Clear the NMISR.LVD2ST flag.	R/(W)*1
b5, b4	—	Reserved	The write value should be 0.	R/(W)
b6	OSTCLR	OST Clear	0: No effect 1: Clear the NMISR.OSTST flag.	R/(W)*1
b7	NMICLR	NMI Clear	0: No effect 1: Clear the NMISR.NMIST flag.	R/(W)*1
b8	RPECLR	SRAM Parity Error Clear	0: No effect 1: Clear the NMISR.RPEST flag.	R/(W)*1
b9	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b10	BUSSCLR	Bus Slave Error Clear	0: No effect 1: Clear the NMISR.BUSSST flag.	R/(W)*1
b11	BUSMCLR	Bus Master Error Clear	0: No effect 1: Clear the NMISR.BUSMST flag.	R/(W)*1
b12	SPECLR	SPEST Clear	0: No effect 1: Clear the NMISR.SPEST flag.	R/(W)*1
b15 to b13	—	Reserved	These bits are read as 0. The write value should be 0.	R/(W)

Note 1. Only write 1 to this bit.

IWDTCLR bit (IWDT Clear)

Writing 1 to the IWDTCLR bit clears the NMISR.IWDTST flag. This bit is read as 0.

WDTCLR bit (WDT Clear)

Writing 1 to the WDTCLR bit clears the NMISR.WDTST flag. This bit is read as 0.

LVD1CLR bit (LVD1 Clear)

Writing 1 to the LVD1CLR bit clears the NMISR.LVD1ST flag. This bit is read as 0.

LVD2CLR bit (LVD2 Clear)

Writing 1 to the LVD2CLR bit clears the NMISR.LVD2ST flag. This bit is read as 0.

OSTCLR bit (OST Clear)

Writing 1 to the OSTCLR bit clears the NMISR.OSTST flag. This bit is read as 0.

NMICLR bit (NMI Clear)

Writing 1 to the NMICLR bit clears the NMISR.NMIST flag. This bit is read as 0.

RPECLR bit (SRAM Parity Error Clear)

Writing 1 to the RPECLR bit clears the NMISR.RPEST flag. This bit is read as 0.

BUSSCLR bit (Bus Slave Error Clear)

Writing 1 to the BUSSCLR bit clears the NMISR.BUSSST flag. This bit is read as 0.

BUSMCLR bit (Bus Master Error Clear)

Writing 1 to the BUSMCLR bit clears the NMISR.BUSMSST flag. This bit is read as 0.

SPECLR bit (SPEST Clear)

Writing 1 to the SPECLR bit clears the NMISR.SPEST flag. This bit is read as 0.

Bit	Symbol	位名称	Description	R/W
b1	WDTCLR	WDT Clear	0：无效1：清除NMISR.WDTST标志。	R/(W)*1
b2	LVD1CLR	LVD1 Clear	0：无效1：清除NMISR.LVD1ST标志。	R/(W)*1
b3	LVD2CLR	LVD2 Clear	0：无效1：清除NMISR.LVD2ST标志。	R/(W)*1
b5, b4	—	Reserved	写入值应为0。	R/(W)
b6	OSTCLR	原声清除	0：无效1：清除NMISR.OSTST标志。	R/(W)*1
b7	NMICLR	NMI Clear	0：无效1：清除NMISR.NMIST标志。	R/(W)*1
b8	RPECLR	SRAM奇偶校验错误清除	0：无效1：清除NMISR.RPEST标志。	R/(W)*1
b9	—	Reserved	该位读取为0。写入值应为0。	R/W
b10	BUSSCLR	总线从机错误清除	0：无效1：清除NMISR.BUSSST标志。	R/(W)*1
b11	BUSMCLR	总线主机错误清除	0：无效1：清除NMISR.BUSMST标志。	R/(W)*1
b12	SPECLR	SPEST Clear	0：无效1：清除NMISR.SPEST标志。	R/(W)*1
b15 to b13	—	Reserved	这些位被读取为0。写入值应为0。	R/(W)

Note 1. 仅向该位写入1。

IWDTCLR位（IWDT清除）

将1写入IWDTCLR位会清除NMISR.IWDTST标志。该位读为0。

WDTCLR位（WDT清除）

将1写入WDTCLR位会清除NMISR.WDTST标志。该位读为0。

LVD1CLR位（LVD1清零）

将1写入LVD1CLR位会清除NMISR.LVD1ST标志。该位读为0。

LVD2CLR位（LVD2清除）

将1写入LVD2CLR位会清除NMISR.LVD2ST标志。该位读为0。

OSTCLR位（OST清除）

将1写入OSTCLR位会清除NMISR.OSTST标志。该位读为0。

NMICLR位（NMI清除）

将1写入NMICLR位会清除NMISR.NMIST标志。该位读为0。

RPECLR位（SRAM奇偶校验错误清除）

将1写入RPECLR位会清除NMISR.RPEST标志。该位读为0。

BUSSCLR位（总线从机错误清除）

将1写入BUSSCLR位会清除NMISR.BUSSST标志。该位读为0。

BUSMCLR位（总线主机错误清除）

将1写入BUSMCLR位会清除NMISR.BUSMSST标志。该位读为0。

SPECLR位（SPEST清除）

将1写入SPECLR位会清除NMISR.SPEST标志。该位读为0。

13.2.5 NMI Pin Interrupt Control Register (NMICR)

Address(es): ICU.NMICR 4000 6100h

	b7	b6	b5	b4	b3	b2	b1	b0
	NFLTEN	—	NFCLKSEL[1:0]		—	—	—	NMIMD
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	NMIMD	NMI Detection Set	0: Falling edge 1: Rising edge.	R/W
b3 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b5, b4	NFCLKSEL[1:0]	NMI Digital Filter Sampling Clock Select	b5 b4 0 0: PCLKB 0 1: PCLKB/8 1 0: PCLKB/32 1 1: PCLKB/64.	R/W
b6	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7	NFLTEN	NMI Digital Filter Enable	0: Disable 1: Enable.	R/W

Change the NMICR register settings before enabling NMI pin interrupts, that is, before setting NMIER.NMIEN to 1.

NMIMD bit (NMI Detection Set)

The NMIMD bit selects the detection sensing method for the NMI pin interrupts.

NFCLKSEL[1:0] bits (NMI Digital Filter Sampling Clock Select)

The NFCLKSEL[1:0] bits select the digital filter sampling clock for the NMI pin interrupts, selectable to:

- PCLKB (every cycle)
- PCLKB/8 (once every 8 cycles)
- PCLKB/32 (once every 32 cycles)
- PCLKB/64 (once every 64 cycles).

For details of the digital filter, see section 13.4.3, Digital Filter.

NFLTEN bit (NMI Digital Filter Enable)

The NFLTEN bit enables the digital filter used for NMI pin interrupts. The filter is enabled when NFLTEN is 1, and disabled when NFLTEN is 0. The NMI pin level is sampled at the clock cycle specified in NMIFLTC.NFCLKSEL[1:0]. When the sampled level matches three times, the output level from the digital filter changes. For details of the digital filter, see section 13.4.3, Digital Filter.

13.2.5 NMI引脚中断控制寄存器(NMICR)

Address(es): ICU.NMICR 4000 6100h

	b7	b6	b5	b4	b3	b2	b1	b0
	NFLTEN	—	NFCLKSEL[1:0]		—	—	—	NMIMD
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	NMIMD	NMI检测集	0：下降沿1： 上升沿。	R/W
b3 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b5, b4	NFCLKSEL[1:0]	NMI数字滤波器采样时钟 Select	b5 b4 0 0: PCLKB 0 1: PCLKB/8 1 0: PCLKB/32 1 1: PCLKB/64.	R/W
b6	—	Reserved	该位读取为0。写入值应为0。	R/W
b7	NFLTEN	NMI数字滤波器启用	0：禁用1 ：启用。	R/W

在启用NMI引脚中断之前更改NMICR寄存器设置，即将NMIER.NMIEN设置为1。

NMIMD位（NMI检测集）

NMIMD位选择NMI引脚中断的检测检测方法。

NFCLKSEL[1:0]位（NMI数字滤波器采样时钟选择）

NFCLKSEL[1:0]位选择用于NMI引脚中断的数字滤波器采样时钟，可选择：

- PCLKB (every cycle)
- PCLKB/8 (once every 8 cycles)
- PCLKB/32 (once every 32 cycles)
- PCLKB/64 (once every 64 cycles).

有关数字滤波器的详细信息，请参阅第13.4.3节“数字滤波器”。

NFLTEN位（NMI数字滤波器使能）

NFLTEN位使能用于NMI引脚中断的数字滤波器。滤波器在NFLTEN为1时启用，在NFLTEN为0时禁用。NMI引脚电平在NMIFLTC.NFCLKSEL[1:0]中指定的时钟周期进行采样。当采样电平匹配3次时，数字滤波器的输出电平会发生变化。有关数字滤波器的详细信息，请参阅第13.4.3节“数字滤波器”。

13.2.6 ICU Event Link Setting Register n (IELSRn) (n = 0 to 95)

Address(es): ICU.IELSR0 4000 6300h, ICU.IELSR1 4000 6304h, ICU.IELSR2 4000 6308h, ICU.IELSR3 4000 630Ch.....
.....ICU.IELSR92 4000 6470h, ICU.IELSR93 4000 6474h, ICU.IELSR94 4000 6478h, ICU.IELSR95 4000 647Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	DTCE	—	—	—	—	—	—	—	IR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	IELS[8:0]								
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b8 to b0	IELS[8:0]	ICU Event Link Select	b8 b0 000000000:Disable interrupts to the associated NVIC or DTC module 000000001 to 111111111:Event signal number to be linked. For details, see Table 13.4.	R/W
b15 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b16	IR	Interrupt Status Flag	0: No interrupt request occurred 1: Interrupt request occurred.	R/(W)*1
b23 to b17	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b24	DTCE	DTC Activation Enable	0: Disable 1: Enable.	R/W
b31 to b25	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: This register requires halfword or word access.
Note 1. Writing 1 to the IR flag is prohibited.

The IELSRn register selects the IRQ source used by the NVIC. For details, see Table 13.4. IELSRn corresponds to the NVIC IRQ input source number, where n = 0 to 95.

IELS[8:0] bits (ICU Event Link Select)

The IELS[8:0] bits link an event signal to the associated NVIC or DTC module. All IELS[8:0] bits must be written to simultaneously.

IR flag (Interrupt Status Flag)

The IR flag indicates an individual interrupt request from the event specified in IELS[8:0].

[Setting condition]

- When an interrupt request is received from the associated peripheral module or IRQi pin.

[Clearing conditions]

- When 0 is written to the flag. DTCE must be set to 0 before writing 0 to the IR flag.

To clear the IR flag:

1. Negate the input interrupt signal.
2. Read access the peripheral once and wait for 2 clock cycles of the target module clock.
3. Clear the IR flag by writing 0.

DTCE bit (DTC Activation Enable)

When the DTCE bit is set to 1, the associated event is selected as the source for DTC activation.

[Setting condition]

- When 1 is written to the DTCE bit.

13.2.6 ICU事件链接设置寄存器n(IELSRn)(n=0到95)

Address(es): ICU.IELSR0 4000 6300h, ICU.IELSR1 4000 6304h, ICU.IELSR2 4000 6308h, ICU.IELSR3 4000 630Ch.....
.....ICU.IELSR92 4000 6470h, ICU.IELSR93 4000 6474h, ICU.IELSR94 4000 6478h, ICU.IELSR95 4000 647Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	DTCE	—	—	—	—	—	—	—	IR
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	IELS[8:0]								
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b8 to b0	IELS[8:0]	ICU事件链接选择	b8b0000000000：禁用对相关NVIC或DTC模块的中断000000001至111111111：要链接的事件信号编号。详见表13.4。	R/W
b15 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b16	IR	中断状态标志	0：未发生中断请求1：发生中断请求。	R/(W)*1
b23 to b17	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b24	DTCE	DTC激活启用	0：禁用1：启用。	R/W
b31 to b25	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 该寄存器需要半字或字访问。
Note 1. 禁止向IR标志写入1。

IELSRn寄存器选择NVIC使用的IRQ源。详见表13.4。IELSRn对应于NVICIRQ输入源编号，其中n=0到95。

IELS[8:0]位（ICU事件链接选择）

IELS[8:0]位将事件信号链接到相关的NVIC或DTC模块。必须同时写入所有IELS[8:0]位。

IR标志（中断状态标志）

IR标志指示来自IELS[8:0]中指定事件的单个中断请求。

[Setting condition]

- 当从相关外设模块或IRQi引脚接收到中断请求时。

[Clearing conditions]

- 当0写入标志时。在将0写入IR标志之前，必须将DTCE设置为0。

清除IR标志：

1. 取反输入中断信号。
2. 读取访问外设一次并等待目标模块时钟的2个时钟周期。
3. 通过写入0清除IR标志。

DTCE位（DTC激活使能）

当DTCE位设置为1时，相关事件被选为DTC激活源。

[Setting condition]

- 当1写入DTCE位时。

[Clearing conditions]

- When the specified number of transfers is complete. For chain transfers, when the specified number of transfers for the last chain transfer is complete
- When 0 is written to the bit.

13.2.7 DMAC Event Link Setting Register n (DELSRn) (n = 0 to 7)

Address(es): ICU.DELSR0 4000 6280h, ICU.DELSR1 4000 6284h, ICU.DELSR2 4000 6288h, ICU.DELSR3 4000 628Ch, ICU.DELSR4 4000 6290h, ICU.DELSR5 4000 6294h, ICU.DELSR6 4000 6298h, ICU.DELSR7 4000 629Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	IR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DELS[8:0]								
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b8 to b0	DELS[8:0]	DMAC Event Link Select	b8 b0 000000000:Disable DMA start requests to the associated DMAC module 000000001 to 111111111:Event signal number to be linked. For details, see Table 13.4.	R/W*1
b15 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b16	IR	Interrupt Status Flag for DMAC	0: No interrupt request is generated 1: An interrupt request is generated.	R/(W)*2
b31 to b17	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. This register requires halfword or word access.
Note 2. Writing 1 to the IR flag is prohibited.

DELS[8:0] bits (DMAC Event Link Select)

The DELS[8:0] bits link an event signal to the DMAC module. All DELS[8:0] bits must be written to simultaneously.

IR flag (Interrupt Status Flag for DMAC)

The IR flag is the status flag of an individual DMA transfer request. This flag corresponds to DELS[8:0] bits of the same register.

[Setting condition]

- The flag is set to 1 when a DMA transfer request is generated from the corresponding peripheral module or IRQi pin.

[Clearing conditions]

- When 0 is written to the flag
- At the start of a DMA transfer after the DMA transfer request is issued.

[Clearing conditions]

- 当指定数量的传输完成时。对于链转移，当最后一次链转移的指定转移次数完成时
- 当0写入该位时。

13.2.7 DMAC事件链接设置寄存器n(DELSRn)(n=0到7)

Address(es): ICU.DELSR0 4000 6280h, ICU.DELSR1 4000 6284h, ICU.DELSR2 4000 6288h, ICU.DELSR3 4000 628Ch, ICU.DELSR4 4000 6290h, ICU.DELSR5 4000 6294h, ICU.DELSR6 4000 6298h, ICU.DELSR7 4000 629Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	IR
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DELS[8:0]								
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b8 to b0	DELS[8:0]	DMAC事件链接选择	b8b0000000000：禁用对关联DMAC模块的DMA启动请求 000000001至111111111：要链接的事件信号编号。详见表13.4。	R/W*1
b15 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b16	IR	DMAC的中断状态标志	0：不产生中断请求1：产生中断请求。	R/(W)*2
b31 to b17	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 该寄存器需要半字或字访问。
Note 2. 禁止向IR标志写入1。

DELS[8:0]位（DMAC事件链接选择）

DELS[8:0]位将事件信号链接到DMAC模块。所有DELS[8:0]位必须同时写入。

IR标志（DMAC的中断状态标志）

IR标志是单个DMA传输请求的状态标志。该标志对应于同一寄存器的DELS[8:0]位。

[Setting condition]

- 当相应外设模块或IRQi引脚产生DMA传输请求时，该标志设置为1。

[Clearing conditions]

- 当0写入标志时
- 在发出DMA传输请求后开始DMA传输。

13.2.8 SYS Event Link Setting Register (SELSR0)

Address(es): ICU.SELSR0 4000 6200h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	SELS[8:0]								
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b8 to b0	SELS[8:0]	SYS Event Link Select	b8 b0 000000000:Disable event output to the associated low-power mode module 000000001 to 111111111:Event signal number to be linked. For details, see Table 13.4.	R/W
b15 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: This register requires halfword access.

The SELSR0 register selects the events that wake up the CPU from Snooze mode. You can only use the events listed in Table 13.4 checked for Canceling Snooze using SELSR0. Events specified in this register are defined as ICU_SNZCANCEL (02Dh) in Table 13.4. When 02Dh is set in IELSRn.IELS, the SELSR0 event interrupt occurs.

SELS[8:0] bits (SYS Event Link Select)

All SELS[8:0] bits must be written to simultaneously.

13.2.9 Wake Up Interrupt Enable Register (WUPEN)

Address(es): ICU.WUPEN 4000 61A0h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	IIC0WUPEN	AGT1CBWUPEN	AGT1CAWUPEN	AGT1UDWUPEN	—	—	—	—	—	ACMPHS0WUPEN	—	—	LVD2WUPEN	LVD1WUPEN	KEYWUPEN	IWDTWUPEN
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	IRQWUPEN[13:0]													
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b13 to b0	IRQWUPEN[13:0]	IRQ Interrupt Software Standby Returns Enable	0: Disable software standby returns by IRQ interrupt 1: Enable software standby returns by IRQ interrupt.	R/W
b15, b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b16	IWDTWUPEN	IWDT Interrupt Software Standby Returns Enable	0: Disable software standby returns by IWDT interrupt 1: Enable software standby returns by IWDT interrupt.	R/W
b17	KEYWUPEN	Key Interrupt Software Standby Returns Enable	0: Disable software standby returns by KEY interrupt 1: Enable software standby returns by KEY interrupt.	R/W
b18	LVD1WUPEN	LVD1 Interrupt Software Standby Returns Enable	0: Disable software standby returns by LVD1 interrupt 1: Enable software standby returns by LVD1 interrupt.	R/W
b19	LVD2WUPEN	LVD2 Interrupt Software Standby Returns Enable	0: Disable software standby returns by LVD2 interrupt 1: Enable software standby returns by LVD2 interrupt.	R/W
b21, b20	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

13.2.8 SYS事件链接设置寄存器(SELSR0)

Address(es): ICU.SELSR0 4000 6200h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	SELS[8:0]								
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b8 to b0	SELS[8:0]	SYS事件链接选择	b8b0000000000：禁用到相关低功耗模式模块的事件输出000000001到111111111：要链接的事件信号编号。详见表13.4。	R/W
b15 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 该寄存器需要半字访问。

SELSR0寄存器选择将CPU从贪睡模式唤醒的事件。您只能使用中列出的事件表13.4检查了使用SELSR0取消贪睡。该寄存器中指定的事件定义为ICU_SNZCANCEL(02Dh)在表13.4中。在IELSRn.IELS中设置02Dh时，发生SELSR0事件中断。

SELS[8:0]位（SYS事件链接选择）

所有SELS[8:0]位必须同时写入。

13.2.9 唤醒中断使能寄存器(WUPEN)

Address(es): ICU.WUPEN 4000 61A0h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	IIC0WUPEN	AGT1CBWUPEN	AGT1CAWUPEN	AGT1UDWUPEN	—	—	—	—	—	ACMPHS0WUPEN	—	—	LVD2WUPEN	LVD1WUPEN	KEYWUPEN	IWDTWUPEN
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	IRQWUPEN[13:0]													
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b13 to b0	IRQWUPEN[13:0]	IRQ中断软件待机返回使能	0：禁止通过IRQ中断返回软件待机1：使能通过IRQ中断返回软件待机。	R/W
b15, b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b16	IWDTWUPEN	IWDT中断软件待机返回使能	0：禁止通过IWDT中断返回软件待机1：使能通过IWDT中断返回软件待机。	R/W
b17	KEYWUPEN	按键中断软件待机返回使能	0：禁止通过KEY中断返回软件待机1：使能通过KEY中断返回软件待机。	R/W
b18	LVD1WUPEN	LVD1中断软件待机返回使能	0：禁止通过LVD1中断返回软件待机1：使能通过LVD1中断返回软件待机。	R/W
b19	LVD2WUPEN	LVD2中断软件待机返回使能	0：禁止通过LVD2中断返回软件待机1：使能通过LVD2中断返回软件待机。	R/W
b21, b20	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b22	ACMPHS0WUPEN	ACMPHS0 Interrupt Software Standby Returns Enable	0: Disable software standby returns by ACMPHS0 interrupt 1: Enable software standby returns by ACMPHS0 interrupt.	R/W
b27 to b23	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b28	AGT1UDWUPEN	AGT1 Underflow Interrupt Software Standby Returns Enable	0: Disable software standby returns by AGT1 underflow interrupt 1: Enable software standby returns by AGT1 underflow interrupt.	R/W
b29	AGT1CAWUPEN	AGT1 Compare Match A Interrupt Software Standby Returns Enable	0: Disable software standby returns by AGT1 compare match A interrupt 1: Enable software standby returns by AGT1 compare match A interrupt.	R/W
b30	AGT1CBWUPEN	AGT1 Compare Match B Interrupt Software Standby Returns Enable	0: Disable software standby returns by AGT1 compare match B interrupt 1: Enable software standby returns by AGT1 compare match B interrupt.	R/W
b31	IIC0WUPEN	IIC0 Address Match Interrupt Software Standby Returns Enable	0: Disable software standby returns by IIC0 address match interrupt 1: Enable software standby returns by IIC0 address match interrupt	R/W

The bits in this register control whether the associated interrupt can wake up the CPU from Software Standby mode.

IRQWUPEN[13:0] bits (IRQ Interrupt Software Standby Returns Enable)

The IRQWUPEN[13:0] bits enable the use of IRQn interrupts to cancel Software Standby mode.

IWDTWUPEN bit (IWDT Interrupt Software Standby Returns Enable)

The IWDTWUPEN bit enables the use of IWDT interrupts to cancel Software Standby mode.

KEYWUPEN bit (Key Interrupt Software Standby Returns Enable)

The KEYWUPEN bit enables the use of key interrupts to cancel Software Standby mode.

LVD1WUPEN bit (LVD1 Interrupt Software Standby Returns Enable)

The LVD1WUPEN bit enables the use of LVD1 interrupts to cancel Software Standby mode.

LVD2WUPEN bit (LVD2 Interrupt Software Standby Returns Enable)

The LVD2WUPEN bit enables the use of LVD2 interrupts to cancel Software Standby mode.

ACMPHS0WUPEN bit (ACMPHS0 Interrupt Software Standby Returns Enable)

The ACMPHS0WUPEN bit enables the use of ACMPHS0 interrupts to cancel Software Standby mode.

AGT1UDWUPEN bit (AGT1 Underflow Interrupt Software Standby Returns Enable)

The AGT1UDWUPEN bit enables the use of AGT1 underflow interrupts to cancel Software Standby mode.

AGT1CAWUPEN bit (AGT1 Compare Match A Interrupt Software Standby Returns Enable)

The AGT1CAWUPEN bit enables the use of AGT1 compare match A interrupts to cancel Software Standby mode.

AGT1CBWUPEN bit (AGT1 Compare Match B Interrupt Software Standby Returns Enable)

The AGT1CBWUPEN bit enables the use of AGT1 compare match B interrupts to cancel Software Standby mode.

IIC0WUPEN bit (IIC0 Address Match Interrupt Software Standby Returns Enable)

The IIC0WUPEN bit enables the use of IIC0 interrupts to cancel Software Standby mode.

13.3 Vector Table

The ICU detects maskable and non-maskable interrupts. Interrupt priorities are set up in the Arm NVIC. See the NVIC

Bit	Symbol	位名称	Description	R/W
b22	ACMPHS0WUPEN	ACMPHS0 Interrupt 软件待机返回 Enable	0：禁止通过ACMPHS0中断返回软件待机1：使能通过ACMPHS0中断返回软件待机。	R/W
b27 to b23	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b28	AGT1UDWUPEN	AGT1下溢中断软件待机返回 Enable	0：禁止通过AGT1下溢中断返回软件待机1：使能通过AGT1下溢中断返回软件待机。	R/W
b29	AGT1CAWUPEN	AGT1比较匹配A 中断软件待机 退货启用	0：禁止通过AGT1比较匹配A中断返回软件待机1：通过AGT1比较匹配A中断启用软件待机返回。	R/W
b30	AGT1CBWUPEN	AGT1比较匹配B 中断软件待机 退货启用	0：通过AGT1比较匹配B中断禁用软件待机返回1：通过AGT1比较匹配B中断启用软件待机返回。	R/W
b31	IIC0WUPEN	IIC0地址匹配 中断软件待机 退货启用	0：通过IIC0地址匹配中断禁止软件待机返回1：通过IIC0地址匹配中断使能软件待机返回	R/W

该寄存器中的位控制相关中断是否可以将CPU从软件待机模式唤醒。

IRQWUPEN[13:0]位（IRQ中断软件待机返回使能）

IRQWUPEN[13:0]位允许使用IRQn中断来取消软件待机模式。

IWDTWUPEN位（IWDT中断软件待机返回使能）

IWDTWUPEN位允许使用IWDT中断来取消软件待机模式。

KEYWUPEN位（按键中断软件待机返回使能）

KEYWUPEN位允许使用按键中断来取消软件待机模式。

LVD1WUPEN位（LVD1中断软件待机返回使能）

LVD1WUPEN位允许使用LVD1中断来取消软件待机模式。

LVD2WUPEN位（LVD2中断软件待机返回使能）

LVD2WUPEN位允许使用LVD2中断来取消软件待机模式。

ACMPHS0WUPEN位（ACMPHS0中断软件待机返回使能）

ACMPHS0WUPEN位允许使用ACMPHS0中断来取消软件待机模式。

AGT1UDWUPEN位（AGT1下溢中断软件待机返回使能）

AGT1UDWUPEN位允许使用AGT1下溢中断来取消软件待机模式。

AGT1CAWUPEN位（AGT1比较匹配中断软件待机返回使能）

AGT1CAWUPEN位允许使用AGT1比较匹配A中断来取消软件待机模式。

AGT1CBWUPEN位（AGT1比较匹配B中断软件待机返回使能）

AGT1CBWUPEN位允许使用AGT1比较匹配B中断来取消软件待机模式。

IIC0WUPEN位（IIC0地址匹配中断软件待机返回使能）

IIC0WUPEN位允许使用IIC0中断来取消软件待机模式。

13.3 向量表

ICU检测可屏蔽和不可屏蔽中断。中断优先级在ArmNVIC中设置。见NVIC

chapter of the *ARM® Cortex®-M4 Processor Technical Reference Manual* (ARM DDI 0439D).

13.3.1 Interrupt Vector Table

Table 13.3 describes the interrupt vectors. The interrupt vector addresses conform to the NVIC specifications.

Table 13.3 Interrupt vector table (1 of 3)

Exception number	IRQ number	Vector offset	Source	Description
0	-	000h	Arm	Initial stack pointer
1	-	004h	Arm	Initial program counter (reset vector)
2	-	008h	Arm	Non-maskable interrupt (NMI)
3	-	00Ch	Arm	Hard fault
4	-	010h	Arm	MemManage fault
5	-	014h	Arm	Bus fault
6	-	018h	Arm	Usage fault
7	-	01Ch	Arm	Reserved
8	-	020h	Arm	Reserved
9	-	024h	Arm	Reserved
10	-	028h	Arm	Reserved
11	-	02Ch	Arm	Supervisor call (SVCall)
12	-	030h	Arm	Debug Monitor
13	-	034h	Arm	Reserved
14	-	038h	Arm	Pendable request for system service (PendableSrvReq)
15	-	03Ch	Arm	System Tick timer (SysTick)
16	0	040h	ICU.IELSR0	Event selected in the ICU.IELSR0 register
17	1	044h	ICU.IELSR1	Event selected in the ICU.IELSR1 register
18	2	048h	ICU.IELSR2	Event selected in the ICU.IELSR2 register
19	3	04Ch	ICU.IELSR3	Event selected in the ICU.IELSR3 register
20	4	050h	ICU.IELSR4	Event selected in the ICU.IELSR4 register
21	5	054h	ICU.IELSR5	Event selected in the ICU.IELSR5 register
22	6	058h	ICU.IELSR6	Event selected in the ICU.IELSR6 register
23	7	05Ch	ICU.IELSR7	Event selected in the ICU.IELSR7 register
24	8	060h	ICU.IELSR8	Event selected in the ICU.IELSR8 register
25	9	064h	ICU.IELSR9	Event selected in the ICU.IELSR9 register
26	10	068h	ICU.IELSR10	Event selected in the ICU.IELSR10 register
27	11	06Ch	ICU.IELSR11	Event selected in the ICU.IELSR11 register
28	12	070h	ICU.IELSR12	Event selected in the ICU.IELSR12 register
29	13	074h	ICU.IELSR13	Event selected in the ICU.IELSR13 register
30	14	078h	ICU.IELSR14	Event selected in the ICU.IELSR14 register
31	15	07Ch	ICU.IELSR15	Event selected in the ICU.IELSR15 register
32	16	080h	ICU.IELSR16	Event selected in the ICU.IELSR16 register
33	17	084h	ICU.IELSR17	Event selected in the ICU.IELSR17 register
34	18	088h	ICU.IELSR18	Event selected in the ICU.IELSR18 register
35	19	08Ch	ICU.IELSR19	Event selected in the ICU.IELSR19 register
36	20	090h	ICU.IELSR20	Event selected in the ICU.IELSR20 register
37	21	094h	ICU.IELSR21	Event selected in the ICU.IELSR21 register
38	22	098h	ICU.IELSR22	Event selected in the ICU.IELSR22 register

ARM®Cortex®–M4处理器技术参考手册(ARMDDI0439D)的章节。

13.3.1 中断向量表

表13.3描述了中断向量。中断向量地址符合NVIC规范。

Table 13.3 中断向量表(1of3)

异常编号	IRQ number	矢量偏移	Source	Description
0	-	000h	Arm	初始堆栈指针
1	-	004h	Arm	初始程序计数器（复位向量）
2	-	008h	Arm	Non-maskable interrupt (NMI)
3	-	00Ch	Arm	硬故障
4	-	010h	Arm	MemManage fault
5	-	014h	Arm	总线故障
6	-	018h	Arm	使用故障
7	-	01Ch	Arm	Reserved
8	-	020h	Arm	Reserved
9	-	024h	Arm	Reserved
10	-	028h	Arm	Reserved
11	-	02Ch	Arm	主管呼叫(SVCall)
12	-	030h	Arm	调试监视器
13	-	034h	Arm	Reserved
14	-	038h	Arm	系统服务的挂起请求(PendableSrvReq)
15	-	03Ch	Arm	系统滴答计时器(SysTick)
16	0	040h	ICU.IELSR0	在ICU.IELSR0寄存器中选择的事件
17	1	044h	ICU.IELSR1	在ICU.IELSR1寄存器中选择的事件
18	2	048h	ICU.IELSR2	在ICU.IELSR2寄存器中选择的事件
19	3	04Ch	ICU.IELSR3	在ICU.IELSR3寄存器中选择的事件
20	4	050h	ICU.IELSR4	在ICU.IELSR4寄存器中选择的事件
21	5	054h	ICU.IELSR5	在ICU.IELSR5寄存器中选择的事件
22	6	058h	ICU.IELSR6	在ICU.IELSR6寄存器中选择的事件
23	7	05Ch	ICU.IELSR7	在ICU.IELSR7寄存器中选择的事件
24	8	060h	ICU.IELSR8	在ICU.IELSR8寄存器中选择的事件
25	9	064h	ICU.IELSR9	在ICU.IELSR9寄存器中选择的事件
26	10	068h	ICU.IELSR10	在ICU.IELSR10寄存器中选择的事件
27	11	06Ch	ICU.IELSR11	在ICU.IELSR11寄存器中选择的事件
28	12	070h	ICU.IELSR12	在ICU.IELSR12寄存器中选择的事件
29	13	074h	ICU.IELSR13	在ICU.IELSR13寄存器中选择的事件
30	14	078h	ICU.IELSR14	在ICU.IELSR14寄存器中选择的事件
31	15	07Ch	ICU.IELSR15	在ICU.IELSR15寄存器中选择的事件
32	16	080h	ICU.IELSR16	在ICU.IELSR16寄存器中选择的事件
33	17	084h	ICU.IELSR17	在ICU.IELSR17寄存器中选择的事件
34	18	088h	ICU.IELSR18	在ICU.IELSR18寄存器中选择的事件
35	19	08Ch	ICU.IELSR19	在ICU.IELSR19寄存器中选择的事件
36	20	090h	ICU.IELSR20	在ICU.IELSR20寄存器中选择的事件
37	21	094h	ICU.IELSR21	在ICU.IELSR21寄存器中选择的事件
38	22	098h	ICU.IELSR22	在ICU.IELSR22寄存器中选择的事件

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Table 13.3 Interrupt vector table (2 of 3)

Exception number	IRQ number	Vector offset	Source	Description
39	23	09Ch	ICU.IELSR23	Event selected in the ICU.IELSR23 register
40	24	0A0h	ICU.IELSR24	Event selected in the ICU.IELSR24 register
41	25	0A4h	ICU.IELSR25	Event selected in the ICU.IELSR25 register
42	26	0A8h	ICU.IELSR26	Event selected in the ICU.IELSR26 register
43	27	0ACh	ICU.IELSR27	Event selected in the ICU.IELSR27 register
44	28	0B0h	ICU.IELSR28	Event selected in the ICU.IELSR28 register
45	29	0B4h	ICU.IELSR29	Event selected in the ICU.IELSR29 register
46	30	0B8h	ICU.IELSR30	Event selected in the ICU.IELSR30 register
47	31	0BCh	ICU.IELSR31	Event selected in the ICU.IELSR31 register
48	32	0C0h	ICU.IELSR32	Event selected in the ICU.IELSR32 register
49	33	0C4h	ICU.IELSR33	Event selected in the ICU.IELSR33 register
50	34	0C8h	ICU.IELSR34	Event selected in the ICU.IELSR34 register
51	35	0CCh	ICU.IELSR35	Event selected in the ICU.IELSR35 register
52	36	0D0h	ICU.IELSR36	Event selected in the ICU.IELSR36 register
53	37	0D4h	ICU.IELSR37	Event selected in the ICU.IELSR37 register
54	38	0D8h	ICU.IELSR38	Event selected in the ICU.IELSR38 register
55	39	0DCh	ICU.IELSR39	Event selected in the ICU.IELSR39 register
56	40	0E0h	ICU.IELSR40	Event selected in the ICU.IELSR40 register
57	41	0E4h	ICU.IELSR41	Event selected in the ICU.IELSR41 register
58	42	0E8h	ICU.IELSR42	Event selected in the ICU.IELSR42 register
59	43	0ECh	ICU.IELSR43	Event selected in the ICU.IELSR43 register
60	44	0F0h	ICU.IELSR44	Event selected in the ICU.IELSR44 register
61	45	0F4h	ICU.IELSR45	Event selected in the ICU.IELSR45 register
62	46	0F8h	ICU.IELSR46	Event selected in the ICU.IELSR46 register
63	47	0FCh	ICU.IELSR47	Event selected in the ICU.IELSR47 register
64	48	100h	ICU.IELSR48	Event selected in the ICU.IELSR48 register
65	49	104h	ICU.IELSR49	Event selected in the ICU.IELSR49 register
66	50	108h	ICU.IELSR50	Event selected in the ICU.IELSR50 register
67	51	10Ch	ICU.IELSR51	Event selected in the ICU.IELSR51 register
68	52	110h	ICU.IELSR52	Event selected in the ICU.IELSR52 register
69	53	114h	ICU.IELSR53	Event selected in the ICU.IELSR53 register
70	54	118h	ICU.IELSR54	Event selected in the ICU.IELSR54 register
71	55	11Ch	ICU.IELSR55	Event selected in the ICU.IELSR55 register
72	56	120h	ICU.IELSR56	Event selected in the ICU.IELSR56 register
73	57	124h	ICU.IELSR57	Event selected in the ICU.IELSR57 register
74	58	128h	ICU.IELSR58	Event selected in the ICU.IELSR58 register
75	59	12Ch	ICU.IELSR59	Event selected in the ICU.IELSR59 register
76	60	130h	ICU.IELSR60	Event selected in the ICU.IELSR60 register
77	61	134h	ICU.IELSR61	Event selected in the ICU.IELSR61 register
78	62	138h	ICU.IELSR62	Event selected in the ICU.IELSR62 register
79	63	13Ch	ICU.IELSR63	Event selected in the ICU.IELSR63 register
80	64	140h	ICU.IELSR64	Event selected in the ICU.IELSR64 register
81	65	144h	ICU.IELSR65	Event selected in the ICU.IELSR65 register
82	66	148h	ICU.IELSR66	Event selected in the ICU.IELSR66 register
83	67	14Ch	ICU.IELSR67	Event selected in the ICU.IELSR67 register

Table 13.3 中断向量表(2of3)

异常编号	IRQ number	矢量偏移	Source	Description
39	23	09Ch	ICU.IELSR23	在ICU.IELSR23寄存器中选择的事件
40	24	0A0h	ICU.IELSR24	在ICU.IELSR24寄存器中选择的事件
41	25	0A4h	ICU.IELSR25	在ICU.IELSR25寄存器中选择的事件
42	26	0A8h	ICU.IELSR26	在ICU.IELSR26寄存器中选择的事件
43	27	0ACh	ICU.IELSR27	在ICU.IELSR27寄存器中选择的事件
44	28	0B0h	ICU.IELSR28	在ICU.IELSR28寄存器中选择的事件
45	29	0B4h	ICU.IELSR29	在ICU.IELSR29寄存器中选择的事件
46	30	0B8h	ICU.IELSR30	在ICU.IELSR30寄存器中选择的事件
47	31	0BCh	ICU.IELSR31	在ICU.IELSR31寄存器中选择的事件
48	32	0C0h	ICU.IELSR32	在ICU.IELSR32寄存器中选择的事件
49	33	0C4h	ICU.IELSR33	在ICU.IELSR33寄存器中选择的事件
50	34	0C8h	ICU.IELSR34	在ICU.IELSR34寄存器中选择的事件
51	35	0CCh	ICU.IELSR35	在ICU.IELSR35寄存器中选择的事件
52	36	0D0h	ICU.IELSR36	在ICU.IELSR36寄存器中选择的事件
53	37	0D4h	ICU.IELSR37	在ICU.IELSR37寄存器中选择的事件
54	38	0D8h	ICU.IELSR38	在ICU.IELSR38寄存器中选择的事件
55	39	0DCh	ICU.IELSR39	在ICU.IELSR39寄存器中选择的事件
56	40	0E0h	ICU.IELSR40	在ICU.IELSR40寄存器中选择的事件
57	41	0E4h	ICU.IELSR41	在ICU.IELSR41寄存器中选择的事件
58	42	0E8h	ICU.IELSR42	在ICU.IELSR42寄存器中选择的事件
59	43	0ECh	ICU.IELSR43	在ICU.IELSR43寄存器中选择的事件
60	44	0F0h	ICU.IELSR44	在ICU.IELSR44寄存器中选择的事件
61	45	0F4h	ICU.IELSR45	在ICU.IELSR45寄存器中选择的事件
62	46	0F8h	ICU.IELSR46	在ICU.IELSR46寄存器中选择的事件
63	47	0FCh	ICU.IELSR47	在ICU.IELSR47寄存器中选择的事件
64	48	100h	ICU.IELSR48	在ICU.IELSR48寄存器中选择的事件
65	49	104h	ICU.IELSR49	在ICU.IELSR49寄存器中选择的事件
66	50	108h	ICU.IELSR50	在ICU.IELSR50寄存器中选择的事件
67	51	10Ch	ICU.IELSR51	在ICU.IELSR51寄存器中选择的事件
68	52	110h	ICU.IELSR52	在ICU.IELSR52寄存器中选择的事件
69	53	114h	ICU.IELSR53	在ICU.IELSR53寄存器中选择的事件
70	54	118h	ICU.IELSR54	在ICU.IELSR54寄存器中选择的事件
71	55	11Ch	ICU.IELSR55	在ICU.IELSR55寄存器中选择的事件
72	56	120h	ICU.IELSR56	在ICU.IELSR56寄存器中选择的事件
73	57	124h	ICU.IELSR57	在ICU.IELSR57寄存器中选择的事件
74	58	128h	ICU.IELSR58	在ICU.IELSR58寄存器中选择的事件
75	59	12Ch	ICU.IELSR59	在ICU.IELSR59寄存器中选择的事件
76	60	130h	ICU.IELSR60	在ICU.IELSR60寄存器中选择的事件
77	61	134h	ICU.IELSR61	在ICU.IELSR61寄存器中选择的事件
78	62	138h	ICU.IELSR62	在ICU.IELSR62寄存器中选择的事件
79	63	13Ch	ICU.IELSR63	在ICU.IELSR63寄存器中选择的事件
80	64	140h	ICU.IELSR64	在ICU.IELSR64寄存器中选择的事件
81	65	144h	ICU.IELSR65	在ICU.IELSR65寄存器中选择的事件
82	66	148h	ICU.IELSR66	在ICU.IELSR66寄存器中选择的事件
83	67	14Ch	ICU.IELSR67	在ICU.IELSR67寄存器中选择的事件

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Table 13.3 Interrupt vector table (3 of 3)

Exception number	IRQ number	Vector offset	Source	Description
84	68	150h	ICU.IELSR68	Event selected in the ICU.IELSR68 register
85	69	154h	ICU.IELSR69	Event selected in the ICU.IELSR69 register
86	70	158h	ICU.IELSR70	Event selected in the ICU.IELSR70 register
87	71	15Ch	ICU.IELSR71	Event selected in the ICU.IELSR71 register
88	72	160h	ICU.IELSR72	Event selected in the ICU.IELSR72 register
89	73	164h	ICU.IELSR73	Event selected in the ICU.IELSR73 register
90	74	168h	ICU.IELSR74	Event selected in the ICU.IELSR74 register
91	75	16Ch	ICU.IELSR75	Event selected in the ICU.IELSR75 register
92	76	170h	ICU.IELSR76	Event selected in the ICU.IELSR76 register
93	77	174h	ICU.IELSR77	Event selected in the ICU.IELSR77 register
94	78	178h	ICU.IELSR78	Event selected in the ICU.IELSR78 register
95	79	17Ch	ICU.IELSR79	Event selected in the ICU.IELSR79 register
96	80	180h	ICU.IELSR80	Event selected in the ICU.IELSR80 register
97	81	184h	ICU.IELSR81	Event selected in the ICU.IELSR81 register
98	82	188h	ICU.IELSR82	Event selected in the ICU.IELSR82 register
99	83	18Ch	ICU.IELSR83	Event selected in the ICU.IELSR83 register
100	84	190h	ICU.IELSR84	Event selected in the ICU.IELSR84 register
101	85	194h	ICU.IELSR85	Event selected in the ICU.IELSR85 register
102	86	198h	ICU.IELSR86	Event selected in the ICU.IELSR86 register
103	87	19Ch	ICU.IELSR87	Event selected in the ICU.IELSR87 register
104	88	1A0h	ICU.IELSR88	Event selected in the ICU.IELSR88 register
105	89	1A4h	ICU.IELSR89	Event selected in the ICU.IELSR89 register
106	90	1A8h	ICU.IELSR90	Event selected in the ICU.IELSR90 register
107	91	1ACh	ICU.IELSR91	Event selected in the ICU.IELSR91 register
108	92	1B0h	ICU.IELSR92	Event selected in the ICU.IELSR92 register
109	93	1B4h	ICU.IELSR93	Event selected in the ICU.IELSR93 register
110	94	1B8h	ICU.IELSR94	Event selected in the ICU.IELSR94 register
111	95	1BCh	ICU.IELSR95	Event selected in the ICU.IELSR95 register

13.3.2 Event Numbers

The following table lists heading details for Table 13.4, which describes each event number.

Heading	Description
Interrupt request source	Name of the source generating the interrupt request
Name	Name of the interrupt
Connect to NVIC	"✓" indicates the interrupt can be used as a CPU interrupt (IELSRn setting)
Invoke DTC	"✓" indicates the interrupt can be used to request DTC activation (IELSRn setting)
Invoke DMAC	"✓" indicates the interrupt can be used to request DMAC activation (DELSRn setting)
Canceling Snooze mode	"✓" indicates the interrupt can be used to request a return from Snooze mode using SELSR0. Otherwise, "✓" indicates it can be used directly
Canceling Software Standby mode	"✓" indicates the interrupt can be used to request a return from Software Standby mode
Canceling Deep Software Standby mode	"✓" indicates the interrupt can be used to request a return from Deep Software Standby mode

Table 13.3 中断向量表(3of3)

异常编号	IRQ number	矢量偏移	Source	Description
84	68	150h	ICU.IELSR68	在ICU.IELSR68寄存器中选择的事件
85	69	154h	ICU.IELSR69	在ICU.IELSR69寄存器中选择的事件
86	70	158h	ICU.IELSR70	在ICU.IELSR70寄存器中选择的事件
87	71	15Ch	ICU.IELSR71	在ICU.IELSR71寄存器中选择的事件
88	72	160h	ICU.IELSR72	在ICU.IELSR72寄存器中选择的事件
89	73	164h	ICU.IELSR73	在ICU.IELSR73寄存器中选择的事件
90	74	168h	ICU.IELSR74	在ICU.IELSR74寄存器中选择的事件
91	75	16Ch	ICU.IELSR75	在ICU.IELSR75寄存器中选择的事件
92	76	170h	ICU.IELSR76	在ICU.IELSR76寄存器中选择的事件
93	77	174h	ICU.IELSR77	在ICU.IELSR77寄存器中选择的事件
94	78	178h	ICU.IELSR78	在ICU.IELSR78寄存器中选择的事件
95	79	17Ch	ICU.IELSR79	在ICU.IELSR79寄存器中选择的事件
96	80	180h	ICU.IELSR80	在ICU.IELSR80寄存器中选择的事件
97	81	184h	ICU.IELSR81	在ICU.IELSR81寄存器中选择的事件
98	82	188h	ICU.IELSR82	在ICU.IELSR82寄存器中选择的事件
99	83	18Ch	ICU.IELSR83	在ICU.IELSR83寄存器中选择的事件
100	84	190h	ICU.IELSR84	在ICU.IELSR84寄存器中选择的事件
101	85	194h	ICU.IELSR85	在ICU.IELSR85寄存器中选择的事件
102	86	198h	ICU.IELSR86	在ICU.IELSR86寄存器中选择的事件
103	87	19Ch	ICU.IELSR87	在ICU.IELSR87寄存器中选择的事件
104	88	1A0h	ICU.IELSR88	在ICU.IELSR88寄存器中选择的事件
105	89	1A4h	ICU.IELSR89	在ICU.IELSR89寄存器中选择的事件
106	90	1A8h	ICU.IELSR90	在ICU.IELSR90寄存器中选择的事件
107	91	1ACh	ICU.IELSR91	在ICU.IELSR91寄存器中选择的事件
108	92	1B0h	ICU.IELSR92	在ICU.IELSR92寄存器中选择的事件
109	93	1B4h	ICU.IELSR93	在ICU.IELSR93寄存器中选择的事件
110	94	1B8h	ICU.IELSR94	在ICU.IELSR94寄存器中选择的事件
111	95	1BCh	ICU.IELSR95	在ICU.IELSR95寄存器中选择的事件

13.3.2 事件编号

下表列出了表13.4的标题详细信息，其中描述了每个事件编号。

Heading	Description
中断请求源	产生中断请求的源名称
Name	中断名称
连接到NVIC	" "表示该中断可以作为CPU中断使用（IELSRn设置）
Invoke DTC	" "表示中断可用于请求DTC激活（IELSRn设置）
Invoke DMAC	" "表示中断可用于请求DMAC激活（DELSRn设置）
取消贪睡模式	" "表示该中断可用于使用SELSR0请求从贪睡模式返回。否则，" "表示可以直接使用
取消软件待机模式	" "表示中断可用于请求从软件待机模式返回
取消深度软件待机模式	" "表示中断可用于请求从深度软件待机模式返回

Table 13.4 Event table (1 of 6)

Event number	Interrupt request source	Name	IELSRn		DELSRn	Canceling Snooze mode	Canceling Software Standby mode	Canceling Deep Software Standby mode
			Connect to NVIC	Invoke DTC	Invoke DMAC			
001h	Port	PORT_IRQ0	✓	✓	✓	✓	✓	✓
002h		PORT_IRQ1	✓	✓	✓	✓	✓	✓
003h		PORT_IRQ2	✓	✓	✓	✓	✓	✓
004h		PORT_IRQ3	✓	✓	✓	✓	✓	✓
005h		PORT_IRQ4	✓	✓	✓	✓	✓	✓
006h		PORT_IRQ5	✓	✓	✓	✓	✓	✓
007h		PORT_IRQ6	✓	✓	✓	✓	✓	✓
008h		PORT_IRQ7	✓	✓	✓	✓	✓	✓
009h		PORT_IRQ8	✓	✓	✓	✓	✓	✓
00Ah		PORT_IRQ9	✓	✓	✓	✓	✓	✓
00Bh		PORT_IRQ10	✓	✓	✓	✓	✓	✓
00Ch		PORT_IRQ11	✓	✓	✓	✓	✓	✓
00Dh		PORT_IRQ12	✓	✓	✓	✓	✓	✓
00Eh		PORT_IRQ13	✓	✓	✓	✓	✓	✓
020h	DMAC0	DMAC0_INT	✓	✓	-	-	-	-
021h	DMAC1	DMAC1_INT	✓	✓	-	-	-	-
022h	DMAC2	DMAC2_INT	✓	✓	-	-	-	-
023h	DMAC3	DMAC3_INT	✓	✓	-	-	-	-
024h	DMAC4	DMAC4_INT	✓	✓	-	-	-	-
025h	DMAC5	DMAC5_INT	✓	✓	-	-	-	-
026h	DMAC6	DMAC6_INT	✓	✓	-	-	-	-
027h	DMAC7	DMAC7_INT	✓	✓	-	-	-	-
029h	DTC	DTC_COMPLETE	✓	-	-	✓*5	-	-
02Dh	ICU	ICU_SNZCANCEL	✓	-	-	✓	-	-
030h	FCU	FCU_FIFERR	✓	-	-	-	-	-
031h		FCU_FRDYI	✓	-	-	-	-	-
038h	LVD	LVD_LVD1	✓	-	-	✓	✓	✓
039h		LVD_LVD2	✓	-	-	✓	✓	✓
03Bh	MOSC	MOSC_STOP	✓	-	-	-	-	-
03Ch	Low power mode	SYSTEM_SNZREQ	-	✓	-	-	-	-
040h	AGT0	AGT0_AGTI	✓	✓	✓	-	-	-
041h		AGT0_AGTCMAI	✓	✓	✓	-	-	-
042h		AGT0_AGTCMBI	✓	✓	✓	-	-	-
043h	AGT1	AGT1_AGTI	✓	✓	✓	✓	✓	✓
044h		AGT1_AGTCMAI	✓	✓	✓	✓	✓	-
045h		AGT1_AGTCMBI	✓	✓	✓	✓	✓	-
046h	IWDT	IWDT_NMIUNDF	✓	-	-	✓	✓	-
047h	WDT	WDT_NMIUNDF	✓	-	-	-	-	-
04Bh	ADC120	ADC120_ADI	✓	✓	✓	-	-	-
04Ch		ADC120_GBADI	✓	✓	✓	-	-	-
04Dh		ADC120_CMPAI	✓	-	-	-	-	-
04Eh		ADC120_CMPBI	✓	-	-	-	-	-
04Fh		ADC120_WCMPM	-	✓	✓	✓*5	-	-
050h		ADC120_WCMPUM	-	✓	✓	✓*5	-	-

Table 13.4 事件表（1个，共6个）

事件编号	中断请求源	Name	IELSRn		DELSRn	Canceling 贪睡模式	取消软件待机模式	取消深度软件待机模式
			连接到NVIC	Invoke DTC	Invoke DMAC			
001h	Port	PORT_IRQ0	✓	✓	✓	✓	✓	✓
002h		PORT_IRQ1	✓	✓	✓	✓	✓	✓
003h		PORT_IRQ2	✓	✓	✓	✓	✓	✓
004h		PORT_IRQ3	✓	✓	✓	✓	✓	✓
005h		PORT_IRQ4	✓	✓	✓	✓	✓	✓
006h		PORT_IRQ5	✓	✓	✓	✓	✓	✓
007h		PORT_IRQ6	✓	✓	✓	✓	✓	✓
008h		PORT_IRQ7	✓	✓	✓	✓	✓	✓
009h		PORT_IRQ8	✓	✓	✓	✓	✓	✓
00Ah		PORT_IRQ9	✓	✓	✓	✓	✓	✓
00Bh		PORT_IRQ10	✓	✓	✓	✓	✓	✓
00Ch		PORT_IRQ11	✓	✓	✓	✓	✓	✓
00Dh		PORT_IRQ12	✓	✓	✓	✓	✓	✓
00Eh		PORT_IRQ13	✓	✓	✓	✓	✓	✓
020h	DMAC0	DMAC0_INT	✓	✓	-	-	-	-
021h	DMAC1	DMAC1_INT	✓	✓	-	-	-	-
022h	DMAC2	DMAC2_INT	✓	✓	-	-	-	-
023h	DMAC3	DMAC3_INT	✓	✓	-	-	-	-
024h	DMAC4	DMAC4_INT	✓	✓	-	-	-	-
025h	DMAC5	DMAC5_INT	✓	✓	-	-	-	-
026h	DMAC6	DMAC6_INT	✓	✓	-	-	-	-
027h	DMAC7	DMAC7_INT	✓	✓	-	-	-	-
029h	DTC	DTC_COMPLETE	✓	-	-	✓*5	-	-
02Dh	ICU	ICU_SNZCANCEL	✓	-	-	✓	-	-
030h	FCU	FCU_FIFERR	✓	-	-	-	-	-
031h		FCU_FRDYI	✓	-	-	-	-	-
038h	LVD	LVD_LVD1	✓	-	-	✓	✓	✓
039h		LVD_LVD2	✓	-	-	✓	✓	✓
03Bh	MOSC	MOSC_STOP	✓	-	-	-	-	-
03Ch	低功耗模式	SYSTEM_SNZREQ	-	✓	-	-	-	-
040h	AGT0	AGT0_AGTI	✓	✓	✓	-	-	-
041h		AGT0_AGTCMAI	✓	✓	✓	-	-	-
042h		AGT0_AGTCMBI	✓	✓	✓	-	-	-
043h	AGT1	AGT1_AGTI	✓	✓	✓	✓	✓	✓
044h		AGT1_AGTCMAI	✓	✓	✓	✓	✓	-
045h		AGT1_AGTCMBI	✓	✓	✓	✓	✓	-
046h	IWDT	IWDT_NMIUNDF	✓	-	-	✓	✓	-
047h	WDT	WDT_NMIUNDF	✓	-	-	-	-	-
04Bh	ADC120	ADC120_ADI	✓	✓	✓	-	-	-
04Ch		ADC120_GBADI	✓	✓	✓	-	-	-
04Dh		ADC120_CMPAI	✓	-	-	-	-	-
04Eh		ADC120_CMPBI	✓	-	-	-	-	-
04Fh		ADC120_WCMPM	-	✓	✓	✓*5	-	-
050h		ADC120_WCMPUM	-	✓	✓	✓*5	-	-

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Table 13.4 Event table (2 of 6)

Event number	Interrupt request source	Name	IELSRn		DELSRn			
			Connect to NVIC	Invoke DTC	Invoke DMAC	Canceling Snooze mode	Canceling Software Standby mode	Canceling Deep Software Standby mode
051h	ADC121	ADC121_ADI	✓	✓	✓	-	-	-
052h		ADC121_GBADI	✓	✓	✓	-	-	-
053h		ADC121_CMPAI	✓	-	-	-	-	-
054h		ADC121_CMPBI	✓	-	-	-	-	-
055h		ADC121_WCMPM	-	✓	✓	✓*5	-	-
056h		ADC121_WCMPUM	-	✓	✓	✓*5	-	-
057h	ACMPHS	ACMP_HS0	✓	-	-	✓*1	✓*1	-
058h		ACMP_HS1	✓	-	-	-	-	-
059h		ACMP_HS2	✓	-	-	-	-	-
05Ah		ACMP_HS3	✓	-	-	-	-	-
05Bh		ACMP_HS4	✓	-	-	-	-	-
05Ch		ACMP_HS5	✓	-	-	-	-	-
063h	IIC0	IIC0_RXI	✓	✓	✓	-	-	-
064h		IIC0_TXI	✓	✓	✓	-	-	-
065h		IIC0_TEI	✓	-	-	-	-	-
066h		IIC0_EEI	✓	-	-	-	-	-
067h		IIC0_WUI	✓	-	-	✓	✓	-
068h	IIC1	IIC1_RXI	✓	✓	✓	-	-	-
069h		IIC1_TXI	✓	✓	✓	-	-	-
06Ah		IIC1_TEI	✓	-	-	-	-	-
06Bh		IIC1_EEI	✓	-	-	-	-	-
085h	KINT	KEY_INTKR	✓	-	-	✓*2	✓*2	-
086h	DOC	DOC_DOPCI	✓	-	-	✓*5	-	-
087h	CAC	CAC_FERRI	✓	-	-	-	-	-
088h		CAC_MENDI	✓	-	-	-	-	-
089h		CAC_OVFI	✓	-	-	-	-	-
08Ah	CAN0	CAN0_ERS	✓	-	-	-	-	-
08Bh		CAN0_RXF	✓	-	-	-	-	-
08Ch		CAN0_TXF	✓	-	-	-	-	-
08Dh		CAN0_RXM	✓	-	-	-	-	-
08Eh		CAN0_TXM	✓	-	-	-	-	-
094h	I/O port	IOPORT_GROUP1	✓	✓*3	✓*3	-	-	-
095h		IOPORT_GROUP2	✓	✓*3	✓*3	-	-	-
096h		IOPORT_GROUP3	✓	✓*3	✓*3	-	-	-
097h		IOPORT_GROUP4	✓	✓*3	✓*3	-	-	-
098h	ELC	ELC_SWEVT0	✓*4	✓	-	-	-	-
099h		ELC_SWEVT1	✓*4	✓	-	-	-	-
09Ah	POEG	POEG_GROUP0	✓	-	-	-	-	-
09Bh		POEG_GROUP1	✓	-	-	-	-	-
09Ch		POEG_GROUP2	✓	-	-	-	-	-
09Dh		POEG_GROUP3	✓	-	-	-	-	-

Table 13.4 事件表（2个，共6个）

事件编号	中断请求源	Name	IELSRn		DELSRn			
			连接到NVIC	Invoke DTC	Invoke DMAC	Canceling 贪睡模式	取消软件待机模式	取消深度软件待机模式
051h	ADC121	ADC121_ADI	✓	✓	✓	-	-	-
052h		ADC121_GBADI	✓	✓	✓	-	-	-
053h		ADC121_CMPAI	✓	-	-	-	-	-
054h		ADC121_CMPBI	✓	-	-	-	-	-
055h		ADC121_WCMPM	-	✓	✓	✓*5	-	-
056h		ADC121_WCMPUM	-	✓	✓	✓*5	-	-
057h	ACMPHS	ACMP_HS0	✓	-	-	✓*1	✓*1	-
058h		ACMP_HS1	✓	-	-	-	-	-
059h		ACMP_HS2	✓	-	-	-	-	-
05Ah		ACMP_HS3	✓	-	-	-	-	-
05Bh		ACMP_HS4	✓	-	-	-	-	-
05Ch		ACMP_HS5	✓	-	-	-	-	-
063h	IIC0	IIC0_RXI	✓	✓	✓	-	-	-
064h		IIC0_TXI	✓	✓	✓	-	-	-
065h		IIC0_TEI	✓	-	-	-	-	-
066h		IIC0_EEI	✓	-	-	-	-	-
067h		IIC0_WUI	✓	-	-	✓	✓	-
068h	IIC1	IIC1_RXI	✓	✓	✓	-	-	-
069h		IIC1_TXI	✓	✓	✓	-	-	-
06Ah		IIC1_TEI	✓	-	-	-	-	-
06Bh		IIC1_EEI	✓	-	-	-	-	-
085h	KINT	KEY_INTKR	✓	-	-	✓*2	✓*2	-
086h	DOC	DOC_DOPCI	✓	-	-	✓*5	-	-
087h	CAC	CAC_FERRI	✓	-	-	-	-	-
088h		CAC_MENDI	✓	-	-	-	-	-
089h		CAC_OVFI	✓	-	-	-	-	-
08Ah	CAN0	CAN0_ERS	✓	-	-	-	-	-
08Bh		CAN0_RXF	✓	-	-	-	-	-
08Ch		CAN0_TXF	✓	-	-	-	-	-
08Dh		CAN0_RXM	✓	-	-	-	-	-
08Eh		CAN0_TXM	✓	-	-	-	-	-
094h	I/O port	IOPORT_GROUP1	✓	✓*3	✓*3	-	-	-
095h		IOPORT_GROUP2	✓	✓*3	✓*3	-	-	-
096h		IOPORT_GROUP3	✓	✓*3	✓*3	-	-	-
097h		IOPORT_GROUP4	✓	✓*3	✓*3	-	-	-
098h	ELC	ELC_SWEVT0	✓*4	✓	-	-	-	-
099h		ELC_SWEVT1	✓*4	✓	-	-	-	-
09Ah	POEG	POEG_GROUP0	✓	-	-	-	-	-
09Bh		POEG_GROUP1	✓	-	-	-	-	-
09Ch		POEG_GROUP2	✓	-	-	-	-	-
09Dh		POEG_GROUP3	✓	-	-	-	-	-

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Table 13.4 Event table (3 of 6)

Event number	Interrupt request source	Name	IELSRn		DELSRn	Canceling Snooze mode	Canceling Software Standby mode	Canceling Deep Software Standby mode
			Connect to NVIC	Invoke DTC	Invoke DMAC			
0B0h	GPT32EH0	GPT0_CCMPA	✓	✓	✓	-	-	-
0B1h		GPT0_CCMPB	✓	✓	✓	-	-	-
0B2h		GPT0_CMPC	✓	✓	✓	-	-	-
0B3h		GPT0_CMPD	✓	✓	✓	-	-	-
0B4h		GPT0_CMPE	✓	✓	✓	-	-	-
0B5h		GPT0_CMPF	✓	✓	✓	-	-	-
0B6h		GPT0_OVF	✓	✓	✓	-	-	-
0B7h		GPT0_UDF	✓	✓	✓	-	-	-
0B8h		GPT0_ADTRGA	✓	✓	✓	-	-	-
0B9h		GPT0_ADTRGB	✓	✓	✓	-	-	-
0BAh	GPT32EH1	GPT1_CCMPA	✓	✓	✓	-	-	-
0BBh		GPT1_CCMPB	✓	✓	✓	-	-	-
0BCh		GPT1_CMPC	✓	✓	✓	-	-	-
0BDh		GPT1_CMPD	✓	✓	✓	-	-	-
0BEh		GPT1_CMPE	✓	✓	✓	-	-	-
0BFh		GPT1_CMPF	✓	✓	✓	-	-	-
0C0h		GPT1_OVF	✓	✓	✓	-	-	-
0C1h		GPT1_UDF	✓	✓	✓	-	-	-
0C2h		GPT1_ADTRGA	✓	✓	✓	-	-	-
0C3h		GPT1_ADTRGB	✓	✓	✓	-	-	-
0C4h	GPT32EH2	GPT2_CCMPA	✓	✓	✓	-	-	-
0C5h		GPT2_CCMPB	✓	✓	✓	-	-	-
0C6h		GPT2_CMPC	✓	✓	✓	-	-	-
0C7h		GPT2_CMPD	✓	✓	✓	-	-	-
0C8h		GPT2_CMPE	✓	✓	✓	-	-	-
0C9h		GPT2_CMPF	✓	✓	✓	-	-	-
0CAh		GPT2_OVF	✓	✓	✓	-	-	-
0CBh		GPT2_UDF	✓	✓	✓	-	-	-
0CCh		GPT2_ADTRGA	✓	✓	✓	-	-	-
0CDh		GPT2_ADTRGB	✓	✓	✓	-	-	-
0CEh	GPT32EH3	GPT3_CCMPA	✓	✓	✓	-	-	-
0CFh		GPT3_CCMPB	✓	✓	✓	-	-	-
0D0h		GPT3_CMPC	✓	✓	✓	-	-	-
0D1h		GPT3_CMPD	✓	✓	✓	-	-	-
0D2h		GPT3_CMPE	✓	✓	✓	-	-	-
0D3h		GPT3_CMPF	✓	✓	✓	-	-	-
0D4h		GPT3_OVF	✓	✓	✓	-	-	-
0D5h		GPT3_UDF	✓	✓	✓	-	-	-
0D6h		GPT3_ADTRGA	✓	✓	✓	-	-	-
0D7h		GPT3_ADTRGB	✓	✓	✓	-	-	-

Table 13.4 事件表（3个，共6个）

事件编号	中断请求源	Name	IELSRn		DELSRn	Canceling 贪睡模式	取消软件待机模式	取消深度软件待机模式
			连接到NVIC	Invoke DTC	Invoke DMAC			
0B0h	GPT32EH0	GPT0_CCMPA	✓	✓	✓	-	-	-
0B1h		GPT0_CCMPB	✓	✓	✓	-	-	-
0B2h		GPT0_CMPC	✓	✓	✓	-	-	-
0B3h		GPT0_CMPD	✓	✓	✓	-	-	-
0B4h		GPT0_CMPE	✓	✓	✓	-	-	-
0B5h		GPT0_CMPF	✓	✓	✓	-	-	-
0B6h		GPT0_OVF	✓	✓	✓	-	-	-
0B7h		GPT0_UDF	✓	✓	✓	-	-	-
0B8h		GPT0_ADTRGA	✓	✓	✓	-	-	-
0B9h		GPT0_ADTRGB	✓	✓	✓	-	-	-
0BAh	GPT32EH1	GPT1_CCMPA	✓	✓	✓	-	-	-
0BBh		GPT1_CCMPB	✓	✓	✓	-	-	-
0BCh		GPT1_CMPC	✓	✓	✓	-	-	-
0BDh		GPT1_CMPD	✓	✓	✓	-	-	-
0BEh		GPT1_CMPE	✓	✓	✓	-	-	-
0BFh		GPT1_CMPF	✓	✓	✓	-	-	-
0C0h		GPT1_OVF	✓	✓	✓	-	-	-
0C1h		GPT1_UDF	✓	✓	✓	-	-	-
0C2h		GPT1_ADTRGA	✓	✓	✓	-	-	-
0C3h		GPT1_ADTRGB	✓	✓	✓	-	-	-
0C4h	GPT32EH2	GPT2_CCMPA	✓	✓	✓	-	-	-
0C5h		GPT2_CCMPB	✓	✓	✓	-	-	-
0C6h		GPT2_CMPC	✓	✓	✓	-	-	-
0C7h		GPT2_CMPD	✓	✓	✓	-	-	-
0C8h		GPT2_CMPE	✓	✓	✓	-	-	-
0C9h		GPT2_CMPF	✓	✓	✓	-	-	-
0CAh		GPT2_OVF	✓	✓	✓	-	-	-
0CBh		GPT2_UDF	✓	✓	✓	-	-	-
0CCh		GPT2_ADTRGA	✓	✓	✓	-	-	-
0CDh		GPT2_ADTRGB	✓	✓	✓	-	-	-
0CEh	GPT32EH3	GPT3_CCMPA	✓	✓	✓	-	-	-
0CFh		GPT3_CCMPB	✓	✓	✓	-	-	-
0D0h		GPT3_CMPC	✓	✓	✓	-	-	-
0D1h		GPT3_CMPD	✓	✓	✓	-	-	-
0D2h		GPT3_CMPE	✓	✓	✓	-	-	-
0D3h		GPT3_CMPF	✓	✓	✓	-	-	-
0D4h		GPT3_OVF	✓	✓	✓	-	-	-
0D5h		GPT3_UDF	✓	✓	✓	-	-	-
0D6h		GPT3_ADTRGA	✓	✓	✓	-	-	-
0D7h		GPT3_ADTRGB	✓	✓	✓	-	-	-

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Table 13.4 Event table (4 of 6)

Event number	Interrupt request source	Name	IELSRn		DELSRn	Canceling Snooze mode	Canceling Software Standby mode	Canceling Deep Software Standby mode
			Connect to NVIC	Invoke DTC	Invoke DMAC			
0D8h	GPT32E4	GPT4_CCMPA	✓	✓	✓	-	-	-
0D9h		GPT4_CCMPB	✓	✓	✓	-	-	-
0DAh		GPT4_CMPC	✓	✓	✓	-	-	-
0DBh		GPT4_CMPD	✓	✓	✓	-	-	-
0DCh		GPT4_CMPE	✓	✓	✓	-	-	-
0DDh		GPT4_CMPF	✓	✓	✓	-	-	-
0DEh		GPT4_OVF	✓	✓	✓	-	-	-
0DFh		GPT4_UDF	✓	✓	✓	-	-	-
0E0h		GPT4_ADTRGA	✓	✓	✓	-	-	-
0E1h		GPT4_ADTRGB	✓	✓	✓	-	-	-
0E2h	GPT32E5	GPT5_CCMPA	✓	✓	✓	-	-	-
0E3h		GPT5_CCMPB	✓	✓	✓	-	-	-
0E4h		GPT5_CMPC	✓	✓	✓	-	-	-
0E5h		GPT5_CMPD	✓	✓	✓	-	-	-
0E6h		GPT5_CMPE	✓	✓	✓	-	-	-
0E7h		GPT5_CMPF	✓	✓	✓	-	-	-
0E8h		GPT5_OVF	✓	✓	✓	-	-	-
0E9h		GPT5_UDF	✓	✓	✓	-	-	-
0EAh		GPT5_ADTRGA	✓	✓	✓	-	-	-
0EBh		GPT5_ADTRGB	✓	✓	✓	-	-	-
0ECh	GPT32E6	GPT6_CCMPA	✓	✓	✓	-	-	-
0EDh		GPT6_CCMPB	✓	✓	✓	-	-	-
0EEh		GPT6_CMPC	✓	✓	✓	-	-	-
0EFh		GPT6_CMPD	✓	✓	✓	-	-	-
0F0h		GPT6_CMPE	✓	✓	✓	-	-	-
0F1h		GPT6_CMPF	✓	✓	✓	-	-	-
0F2h		GPT6_OVF	✓	✓	✓	-	-	-
0F3h		GPT6_UDF	✓	✓	✓	-	-	-
0F4h		GPT6_ADTRGA	✓	✓	✓	-	-	-
0F5h		GPT6_ADTRGB	✓	✓	✓	-	-	-
0F6h	GPT32E7	GPT7_CCMPA	✓	✓	✓	-	-	-
0F7h		GPT7_CCMPB	✓	✓	✓	-	-	-
0F8h		GPT7_CMPC	✓	✓	✓	-	-	-
0F9h		GPT7_CMPD	✓	✓	✓	-	-	-
0FAh		GPT7_CMPE	✓	✓	✓	-	-	-
0FBh		GPT7_CMPF	✓	✓	✓	-	-	-
0FCh		GPT7_OVF	✓	✓	✓	-	-	-
0FDh		GPT7_UDF	✓	✓	✓	-	-	-
0FEh		GPT7_ADTRGA	✓	✓	✓	-	-	-
0FFh		GPT7_ADTRGB	✓	✓	✓	-	-	-

Table 13.4 事件表（4个，共6个）

事件编号	中断请求源	Name	IELSRn		DELSRn	Canceling 贪睡模式	取消软件待机模式	取消深度软件待机模式
			连接到NVIC	Invoke DTC	Invoke DMAC			
0D8h	GPT32E4	GPT4_CCMPA	✓	✓	✓	-	-	-
0D9h		GPT4_CCMPB	✓	✓	✓	-	-	-
0DAh		GPT4_CMPC	✓	✓	✓	-	-	-
0DBh		GPT4_CMPD	✓	✓	✓	-	-	-
0DCh		GPT4_CMPE	✓	✓	✓	-	-	-
0DDh		GPT4_CMPF	✓	✓	✓	-	-	-
0DEh		GPT4_OVF	✓	✓	✓	-	-	-
0DFh		GPT4_UDF	✓	✓	✓	-	-	-
0E0h		GPT4_ADTRGA	✓	✓	✓	-	-	-
0E1h		GPT4_ADTRGB	✓	✓	✓	-	-	-
0E2h	GPT32E5	GPT5_CCMPA	✓	✓	✓	-	-	-
0E3h		GPT5_CCMPB	✓	✓	✓	-	-	-
0E4h		GPT5_CMPC	✓	✓	✓	-	-	-
0E5h		GPT5_CMPD	✓	✓	✓	-	-	-
0E6h		GPT5_CMPE	✓	✓	✓	-	-	-
0E7h		GPT5_CMPF	✓	✓	✓	-	-	-
0E8h		GPT5_OVF	✓	✓	✓	-	-	-
0E9h		GPT5_UDF	✓	✓	✓	-	-	-
0EAh		GPT5_ADTRGA	✓	✓	✓	-	-	-
0EBh		GPT5_ADTRGB	✓	✓	✓	-	-	-
0ECh	GPT32E6	GPT6_CCMPA	✓	✓	✓	-	-	-
0EDh		GPT6_CCMPB	✓	✓	✓	-	-	-
0EEh		GPT6_CMPC	✓	✓	✓	-	-	-
0EFh		GPT6_CMPD	✓	✓	✓	-	-	-
0F0h		GPT6_CMPE	✓	✓	✓	-	-	-
0F1h		GPT6_CMPF	✓	✓	✓	-	-	-
0F2h		GPT6_OVF	✓	✓	✓	-	-	-
0F3h		GPT6_UDF	✓	✓	✓	-	-	-
0F4h		GPT6_ADTRGA	✓	✓	✓	-	-	-
0F5h		GPT6_ADTRGB	✓	✓	✓	-	-	-
0F6h	GPT32E7	GPT7_CCMPA	✓	✓	✓	-	-	-
0F7h		GPT7_CCMPB	✓	✓	✓	-	-	-
0F8h		GPT7_CMPC	✓	✓	✓	-	-	-
0F9h		GPT7_CMPD	✓	✓	✓	-	-	-
0FAh		GPT7_CMPE	✓	✓	✓	-	-	-
0FBh		GPT7_CMPF	✓	✓	✓	-	-	-
0FCh		GPT7_OVF	✓	✓	✓	-	-	-
0FDh		GPT7_UDF	✓	✓	✓	-	-	-
0FEh		GPT7_ADTRGA	✓	✓	✓	-	-	-
0FFh		GPT7_ADTRGB	✓	✓	✓	-	-	-

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Table 13.4 Event table (5 of 6)

Event number	Interrupt request source	Name	IELSRn		DELSRn	Canceling Snooze mode	Canceling Software Standby mode	Canceling Deep Software Standby mode
			Connect to NVIC	Invoke DTC	Invoke DMAC			
100h	GPT328	GPT8_CCMPA	✓	✓	✓	-	-	-
101h		GPT8_CCMPB	✓	✓	✓	-	-	-
102h		GPT8_CMPC	✓	✓	✓	-	-	-
103h		GPT8_CMPD	✓	✓	✓	-	-	-
104h		GPT8_CMPE	✓	✓	✓	-	-	-
105h		GPT8_CMPF	✓	✓	✓	-	-	-
106h		GPT8_OVF	✓	✓	✓	-	-	-
107h		GPT8_UDF	✓	✓	✓	-	-	-
10Ah	GPT329	GPT9_CCMPA	✓	✓	✓	-	-	-
10Bh		GPT9_CCMPB	✓	✓	✓	-	-	-
10Ch		GPT9_CMPC	✓	✓	✓	-	-	-
10Dh		GPT9_CMPD	✓	✓	✓	-	-	-
10Eh		GPT9_CMPE	✓	✓	✓	-	-	-
10Fh		GPT9_CMPF	✓	✓	✓	-	-	-
110h		GPT9_OVF	✓	✓	✓	-	-	-
111h		GPT9_UDF	✓	✓	✓	-	-	-
114h	GPT3210	GPT10_CCMPA	✓	✓	✓	-	-	-
115h		GPT10_CCMPB	✓	✓	✓	-	-	-
116h		GPT10_CMPC	✓	✓	✓	-	-	-
117h		GPT10_CMPD	✓	✓	✓	-	-	-
118h		GPT10_CMPE	✓	✓	✓	-	-	-
119h		GPT10_CMPF	✓	✓	✓	-	-	-
11Ah		GPT10_OVF	✓	✓	✓	-	-	-
11Bh		GPT10_UDF	✓	✓	✓	-	-	-
11Eh	GPT3211	GPT11_CCMPA	✓	✓	✓	-	-	-
11Fh		GPT11_CCMPB	✓	✓	✓	-	-	-
120h		GPT11_CMPC	✓	✓	✓	-	-	-
121h		GPT11_CMPD	✓	✓	✓	-	-	-
122h		GPT11_CMPE	✓	✓	✓	-	-	-
123h		GPT11_CMPF	✓	✓	✓	-	-	-
124h		GPT11_OVF	✓	✓	✓	-	-	-
125h		GPT11_UDF	✓	✓	✓	-	-	-
128h	GPT3212	GPT12_CCMPA	✓	✓	✓	-	-	-
129h		GPT12_CCMPB	✓	✓	✓	-	-	-
12Ah		GPT12_CMPC	✓	✓	✓	-	-	-
12Bh		GPT12_CMPD	✓	✓	✓	-	-	-
12Ch		GPT12_CMPE	✓	✓	✓	-	-	-
12Dh		GPT12_CMPF	✓	✓	✓	-	-	-
12Eh		GPT12_OVF	✓	✓	✓	-	-	-
12Fh		GPT12_UDF	✓	✓	✓	-	-	-
150h	GPT	GPT_UVWEDGE	✓			-	-	-

Table 13.4 事件表（5个，共6个）

事件编号	中断请求源	Name	IELSRn		DELSRn	Canceling 贪睡模式	取消软件待机模式	取消深度软件待机模式
			连接到NVIC	Invoke DTC	Invoke DMAC			
100h	GPT328	GPT8_CCMPA	✓	✓	✓	-	-	-
101h		GPT8_CCMPB	✓	✓	✓	-	-	-
102h		GPT8_CMPC	✓	✓	✓	-	-	-
103h		GPT8_CMPD	✓	✓	✓	-	-	-
104h		GPT8_CMPE	✓	✓	✓	-	-	-
105h		GPT8_CMPF	✓	✓	✓	-	-	-
106h		GPT8_OVF	✓	✓	✓	-	-	-
107h		GPT8_UDF	✓	✓	✓	-	-	-
10Ah	GPT329	GPT9_CCMPA	✓	✓	✓	-	-	-
10Bh		GPT9_CCMPB	✓	✓	✓	-	-	-
10Ch		GPT9_CMPC	✓	✓	✓	-	-	-
10Dh		GPT9_CMPD	✓	✓	✓	-	-	-
10Eh		GPT9_CMPE	✓	✓	✓	-	-	-
10Fh		GPT9_CMPF	✓	✓	✓	-	-	-
110h		GPT9_OVF	✓	✓	✓	-	-	-
111h		GPT9_UDF	✓	✓	✓	-	-	-
114h	GPT3210	GPT10_CCMPA	✓	✓	✓	-	-	-
115h		GPT10_CCMPB	✓	✓	✓	-	-	-
116h		GPT10_CMPC	✓	✓	✓	-	-	-
117h		GPT10_CMPD	✓	✓	✓	-	-	-
118h		GPT10_CMPE	✓	✓	✓	-	-	-
119h		GPT10_CMPF	✓	✓	✓	-	-	-
11Ah		GPT10_OVF	✓	✓	✓	-	-	-
11Bh		GPT10_UDF	✓	✓	✓	-	-	-
11Eh	GPT3211	GPT11_CCMPA	✓	✓	✓	-	-	-
11Fh		GPT11_CCMPB	✓	✓	✓	-	-	-
120h		GPT11_CMPC	✓	✓	✓	-	-	-
121h		GPT11_CMPD	✓	✓	✓	-	-	-
122h		GPT11_CMPE	✓	✓	✓	-	-	-
123h		GPT11_CMPF	✓	✓	✓	-	-	-
124h		GPT11_OVF	✓	✓	✓	-	-	-
125h		GPT11_UDF	✓	✓	✓	-	-	-
128h	GPT3212	GPT12_CCMPA	✓	✓	✓	-	-	-
129h		GPT12_CCMPB	✓	✓	✓	-	-	-
12Ah		GPT12_CMPC	✓	✓	✓	-	-	-
12Bh		GPT12_CMPD	✓	✓	✓	-	-	-
12Ch		GPT12_CMPE	✓	✓	✓	-	-	-
12Dh		GPT12_CMPF	✓	✓	✓	-	-	-
12Eh		GPT12_OVF	✓	✓	✓	-	-	-
12Fh		GPT12_UDF	✓	✓	✓	-	-	-
150h	GPT	GPT_UVWEDGE	✓			-	-	-

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Table 13.4 Event table (6 of 6)

Event number	Interrupt request source	Name	IELSRn		DELSRn	Canceling Snooze mode	Canceling Software Standby mode	Canceling Deep Software Standby mode
			Connect to NVIC	Invoke DTC	Invoke DMAC			
174h	SCI0	SCI0_RXI	✓	✓	✓	-	-	-
175h		SCI0_TXI	✓	✓	✓	-	-	-
176h		SCI0_TEI	✓	-	-	-	-	-
177h		SCI0_ERI	✓	-	-	-	-	-
178h		SCI0_AM	✓	-	-	✓*5	-	-
179h		SCI0_RXI_OR_ERI	-	-	-	✓*5	-	-
17Ah	SCI1	SCI1_RXI	✓	✓	✓	-	-	-
17Bh		SCI1_TXI	✓	✓	✓	-	-	-
17Ch		SCI1_TEI	✓	-	-	-	-	-
17Dh		SCI1_ERI	✓	-	-	-	-	-
17Eh		SCI1_AM	✓	-	-	-	-	-
180h	SCI2	SCI2_RXI	✓	✓	✓	-	-	-
181h		SCI2_TXI	✓	✓	✓	-	-	-
182h		SCI2_TEI	✓	-	-	-	-	-
183h		SCI2_ERI	✓	-	-	-	-	-
184h		SCI2_AM	✓	-	-	-	-	-
186h	SCI3	SCI3_RXI	✓	✓	✓	-	-	-
187h		SCI3_TXI	✓	✓	✓	-	-	-
188h		SCI3_TEI	✓	-	-	-	-	-
189h		SCI3_ERI	✓	-	-	-	-	-
18Ah		SCI3_AM	✓	-	-	-	-	-
18Ch	SCI4	SCI4_RXI	✓	✓	✓	-	-	-
18Dh		SCI4_TXI	✓	✓	✓	-	-	-
18Eh		SCI4_TEI	✓	-	-	-	-	-
18Fh		SCI4_ERI	✓	-	-	-	-	-
190h		SCI4_AM	✓	-	-	-	-	-
1A4h	SCI8	SCI8_RXI	✓	✓	✓	-	-	-
1A5h		SCI8_TXI	✓	✓	✓	-	-	-
1A6h		SCI8_TEI	✓	-	-	-	-	-
1A7h		SCI8_ERI	✓	-	-	-	-	-
1A8h		SCI8_AM	✓	-	-	-	-	-
1AAh	SCI9	SCI9_RXI	✓	✓	✓	-	-	-
1ABh		SCI9_TXI	✓	✓	✓	-	-	-
1ACh		SCI9_TEI	✓	-	-	-	-	-
1ADh		SCI9_ERI	✓	-	-	-	-	-
1AEh		SCI9_AM	✓	-	-	-	-	-
1BCh	SPI0	SPI0_SPRI	✓	✓	✓	-	-	-
1BDh		SPI0_SPTI	✓	✓	✓	-	-	-
1BEh		SPI0_SPII	✓	-	-	-	-	-
1BFh		SPI0_SPEI	✓	-	-	-	-	-
1C0h		SPI0_SPTEND	✓	-	-	-	-	-
1C1h	SPI1	SPI1_SPRI	✓	✓	✓	-	-	-
1C2h		SPI1_SPTI	✓	✓	✓	-	-	-
1C3h		SPI1_SPII	✓	-	-	-	-	-
1C4h		SPI1_SPEI	✓	-	-	-	-	-
1C5h		SPI1_SPTEND	✓	-	-	-	-	-

Table 13.4 事件表（6个中的6个）

事件编号	中断请求源	Name	IELSRn		DELSRn	Canceling 贪睡模式	取消软件待机模式	取消深度软件待机模式
			连接到NVIC	Invoke DTC	Invoke DMAC			
174h	SCI0	SCI0_RXI	✓	✓	✓	-	-	-
175h		SCI0_TXI	✓	✓	✓	-	-	-
176h		SCI0_TEI	✓	-	-	-	-	-
177h		SCI0_ERI	✓	-	-	-	-	-
178h		SCI0_AM	✓	-	-	✓*5	-	-
179h		SCI0_RXI_OR_ERI	-	-	-	✓*5	-	-
17Ah	SCI1	SCI1_RXI	✓	✓	✓	-	-	-
17Bh		SCI1_TXI	✓	✓	✓	-	-	-
17Ch		SCI1_TEI	✓	-	-	-	-	-
17Dh		SCI1_ERI	✓	-	-	-	-	-
17Eh		SCI1_AM	✓	-	-	-	-	-
180h	SCI2	SCI2_RXI	✓	✓	✓	-	-	-
181h		SCI2_TXI	✓	✓	✓	-	-	-
182h		SCI2_TEI	✓	-	-	-	-	-
183h		SCI2_ERI	✓	-	-	-	-	-
184h		SCI2_AM	✓	-	-	-	-	-
186h	SCI3	SCI3_RXI	✓	✓	✓	-	-	-
187h		SCI3_TXI	✓	✓	✓	-	-	-
188h		SCI3_TEI	✓	-	-	-	-	-
189h		SCI3_ERI	✓	-	-	-	-	-
18Ah		SCI3_AM	✓	-	-	-	-	-
18Ch	SCI4	SCI4_RXI	✓	✓	✓	-	-	-
18Dh		SCI4_TXI	✓	✓	✓	-	-	-
18Eh		SCI4_TEI	✓	-	-	-	-	-
18Fh		SCI4_ERI	✓	-	-	-	-	-
190h		SCI4_AM	✓	-	-	-	-	-
1A4h	SCI8	SCI8_RXI	✓	✓	✓	-	-	-
1A5h		SCI8_TXI	✓	✓	✓	-	-	-
1A6h		SCI8_TEI	✓	-	-	-	-	-
1A7h		SCI8_ERI	✓	-	-	-	-	-
1A8h		SCI8_AM	✓	-	-	-	-	-
1AAh	SCI9	SCI9_RXI	✓	✓	✓	-	-	-
1ABh		SCI9_TXI	✓	✓	✓	-	-	-
1ACh		SCI9_TEI	✓	-	-	-	-	-
1ADh		SCI9_ERI	✓	-	-	-	-	-
1AEh		SCI9_AM	✓	-	-	-	-	-
1BCh	SPI0	SPI0_SPRI	✓	✓	✓	-	-	-
1BDh		SPI0_SPTI	✓	✓	✓	-	-	-
1BEh		SPI0_SPII	✓	-	-	-	-	-
1BFh		SPI0_SPEI	✓	-	-	-	-	-
1C0h		SPI0_SPTEND	✓	-	-	-	-	-
1C1h	SPI1	SPI1_SPRI	✓	✓	✓	-	-	-
1C2h		SPI1_SPTI	✓	✓	✓	-	-	-
1C3h		SPI1_SPII	✓	-	-	-	-	-
1C4h		SPI1_SPEI	✓	-	-	-	-	-
1C5h		SPI1_SPTEND	✓	-	-	-	-	-

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Note 1. Only supported when CMPCTL.CSTEN = 1.
Note 2. Only supported when KRCTL.KRMD = 1.
Note 3. Only the first edge detection is valid.
Note 4. Only interrupts after DTC transfer are supported.
Note 5. Using SELSR0.

13.4 Interrupt Operation

The ICU performs the following functions:

- Detecting interrupts
- Enabling and disabling interrupts
- Selecting interrupt request destinations such as CPU interrupt, DTC activation, and DMAC activation.

13.4.1 Detecting Interrupts

External pin interrupt requests are detected by either:

- Edges (falling edge, rising edge, or rising and falling edges) of the interrupt signal
- Level (low level) of the interrupt signal.

Set the IRQMD[1:0] bits in the IRQCRi register to select the detection mode for the IRQi pins. For interrupt sources associated with peripheral modules, see section 13.3.2, Event Numbers. Events must be accepted by the NVIC before an interrupt occurs and is accepted by the CPU.

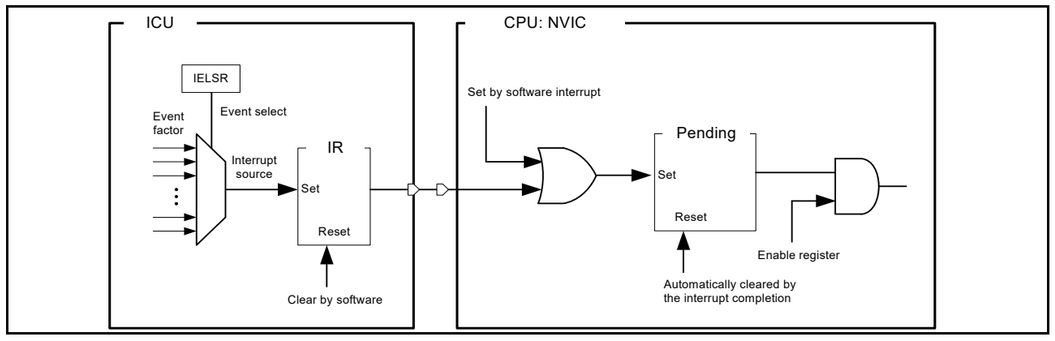

Figure 13.2 Interrupt path of the ICU and CPU: NVIC

Use the following procedures for detecting interrupts.

General operations during an interrupt:

- When a non-software interrupt occurs:
  The IELSRn.IR flag and Interrupt Set/Clear-Pending register (NVIC) are set.
- When a software interrupt occurs:
  Set the Interrupt Set-Pending register.
- When an interrupt is complete:
  Clear the IELSRn.IR flag in the software.
  The Interrupt Set/Clear-Pending register clears automatically.

When interrupts are enabled:

1. Set the Interrupt Set-Enable register (NVIC).
2. Set the IELSRn.IELS[8:0] bits as the interrupt source.
3. Specify the operation settings for the event source.

When interrupts are disabled:

1. Disable the settings for the event source.

Note 1. 仅当CMPCTL.CSTEN=1时支持。
Note 2. 仅当KRCTL.KRMD=1时支持。
Note 3. 只有第一个边缘检测有效。
Note 4. 仅支持DTC传输后的中断。
Note 5. Using SELSR0.

13.4 中断操作

ICU执行以下功能：

- 检测中断
- 启用和禁用中断
- 选择中断请求目标，例如CPU中断、DTC激活和DMAC激活。

13.4.1 检测中断

外部引脚中断请求通过以下任一方式检测：

- 中断信号的边沿（下降沿、上升沿或上升沿和下降沿）
- 中断信号的电平（低电平）。

设置IRQCRi寄存器中的IRQMD[1:0]位以选择IRQi引脚的检测模式。有关与外围模块相关的中断源，请参见第13.3.2节，事件编号。事件必须在中断发生之前被NVIC接受并被CPU接受。

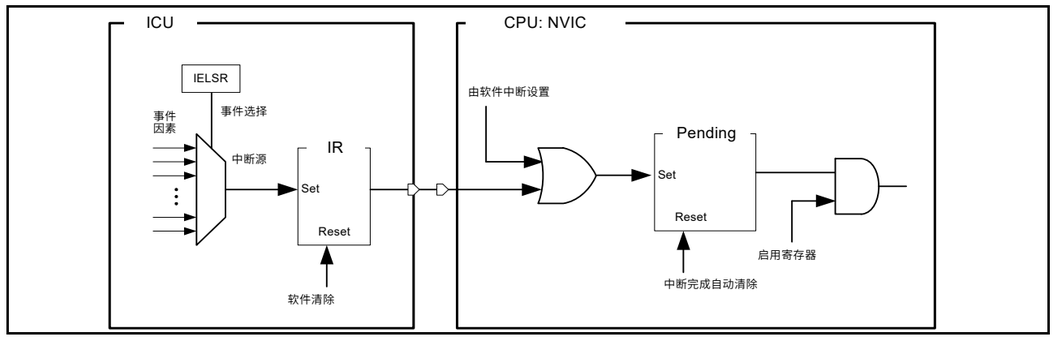

Figure 13.2 ICU和CPU的中断路径：NVIC

使用以下过程检测中断。

中断期间的一般操作：

- 当发生非软件中断时：
  IELSRn.IR标志和中断设置清除挂起寄存器(NVIC)已设置。
- 当发生软件中断时：
  设置中断设置挂起寄存器。
- 当中断完成时：
  清除软件中的IELSRn.IR标志。
  中断设置清除挂起寄存器自动清除。

启用中断时：

1. 设置中断设置启用寄存器(NVIC)。
2. 将IELSRn.IELS[8:0]位设置为中断源。
3. 指定事件源的操作设置。

当中断被禁用时：

1. 禁用事件源的设置。

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2. Clear the IELSRn.IELS[8:0] bits (IELSRn.IELS[8:0] = 0000h). Clear the IELSRn.IR flag as required.
3. Clear the Interrupt Clear-Enable register. Clear the Interrupt Clear-Pending register as required.

When polling for interrupts:

1. Set the Interrupt Clear-Enable register (disabling interrupts).
2. Set the IELSRn.IELS[8:0] bits (selecting the source).
3. Specify the operation settings for the event source.
4. Poll the Interrupt Set-Pending register.
5. When polling is no longer required, follow the procedure for clearing an interrupt when it is complete. Clear the IELSRn.IR flag through software.

13.4.2 Selecting Interrupt Request Destinations

The interrupt output destination, CPU, DTC, or DMAC, can be independently selected for each interrupt source. The available destinations are fixed for each interrupt, as described in Table 13.4.

Note: Use an interrupt request destination setting that is indicated by a "✓" in the event list (see Table 13.4).

If you select the CPU or DTC in one IELSRn register, setting the same interrupt factor in any other IELSRn register is prohibited. Similarly, if you select the DMAC in one DELSRn register, setting the same interrupt factor in any other DELSRn register is prohibited.

Note: Setting the same interrupt factor for IELSRn and DELSRn is prohibited.

If the DMAC or DTC is selected as the destination for requests from an IRQi pin, you must set the IRQMD[1:0] bits in IRQCRi for that interrupt to select edge detection.

13.4.2.1 CPU interrupt request

When IELSRn.DTCE = 0, the event specified in the IELSRn register is output to the NVIC. Set the IELSRn.IELS bits to the target event and the IELSRn.DTCE bit to 0.

13.4.2.2 DTC activation

When IELSRn.DTCE = 1, the event specified in the IELSRn register is output to the DTC. After DTC transmission completes, the associated interrupt occurs. Use the following procedure:

1. Set the IELSRn.IELS bits to the target event and the IELSRn.DTCE bit to 1.
2. Set the DTC Module Start bit (DTCST.DTCST) to 1.

Table 13.5 shows operation when the DTC is the request destination.

2. 清除IELSRn.IELS[8:0]位(IELSRn.IELS[8:0]=0000h)。根据需要清除IELSRn.IR标志。
3. 清除中断清除启用寄存器。根据需要清除中断清除挂起寄存器。

轮询中断时：

1. 设置中断清除启用寄存器（禁用中断）。
2. 设置IELSRn.IELS[8:0]位（选择源）。
3. 指定事件源的操作设置。
4. 轮询中断设置挂起寄存器。
5. 当不再需要轮询时，按照完成后清除中断的过程。清除IELSRn.IR标志通过软件。

13.4.2 选择中断请求目标

可以为每个中断源独立选择中断输出目标CPU、DTC或DMAC。每个中断的可用目的地都是固定的，如表13.4中所述。

Note: 使用事件列表中由" "指示的中断请求目标设置（参见表13.4）。

如果在一个IELSRn寄存器中选择CPU或DTC，则禁止在任何其他IELSRn寄存器中设置相同的中断因子。同样，如果您在一个DELSRn寄存器中选择DMAC，则禁止在任何其他DELSRn寄存器中设置相同的中断因子。

Note: 禁止为IELSRn和DELSRn设置相同的中断因子。

如果选择DMAC或DTC作为来自IRQi引脚的请求的目标，则必须将IRQMD[1:0]位设置为IRQCRi用于选择边缘检测的中断。

13.4.2.1 CPU中断请求

当IELSRn.DTCE=0时，将IELSRn寄存器中指定的事件输出到NVIC。将IELSRn.IELS位设置为目标事件，并将IELSRn.DTCE位设置为0。

13.4.2.2 DTC activation

当IELSRn.DTCE=1时，将IELSRn寄存器中指定的事件输出到DTC。DTC传输完成后，将发生相关中断。使用以下过程：

1. 将IELSRn.IELS位设置为目标事件，并将IELSRn.DTCE位设置为1。
2. 将DTC模块起始位(DTCST.DTCST)设置为1。

表13.5显示了DTC为请求目的地时的操作。

Table 13.5 Operations when the DTC is activated

Interrupt request destination	DISEL*1	Remaining transfer operations	Operations per request	IR*2	Interrupt request destination after transfer
DTC*3	1	≠ 0	DTC transfer → CPU interrupt	Cleared on interrupt acceptance by the CPU	DTC
		= 0	DTC transfer → CPU interrupt	Cleared on interrupt acceptance by the CPU	The IELSRn.DTCE bit is cleared and the CPU becomes the destination
	0	≠ 0	DTC transfer	Cleared at the start of DTC data transfer after DTC transfer data is read	DTC
		= 0	DTC transfer → CPU interrupt	Cleared on interrupt acceptance by the CPU	The IELSRn.DTCE bit is cleared and the CPU becomes the destination

Note 1. Set the interrupt request mode for the DTC in the DTC.MRB.DISEL bit.
Note 2. When the IELSRn.IR flag is 1, an interrupt request (DTC activation request) that occurs again is ignored.
Note 3. For chain transfers, DTC transfer continues until the last chain transfer ends. At this point, the DISEL bit state and the remaining transfer count determine whether a CPU interrupt occurs, the IELSRn.IR flag clear timing, and the interrupt request destination after transfer. See Table 17.3, Chain transfer conditions, in section 17, Data Transfer Controller (DTC).

13.4.2.3 DMAC activation

Events specified in the DELSRn registers are output to the DMAC. When using interrupts, you must select the DMAC as the interrupt source in the IELSRn.IELS[8:0] bits and enable DMAC output by setting IELSRn.DTCE to 1. When IELSRn.DTCE is 0, the events specified in the IELSRn registers are output to the NVIC. Use the following procedure:

1. Set the DELSRn.DELS[8:0] bits to the target event.
2. When using interrupts, set the IELSRn.IELS bit to DMAC interrupts as the source, and set the IELSRn.DTCE bit to 1.
3. Set the activation source for the target DMAC channel (DMACm.DMTMD.DCTG[1:0]) to 01b (interrupt module detection).
4. Set the DMAC transfer enable bit for the target DMAC channel (DMACm.DMCNT.DTE) to 1.
5. Set the DMAC operation enable bit (DMACm.DMAST.DMST) to 1.

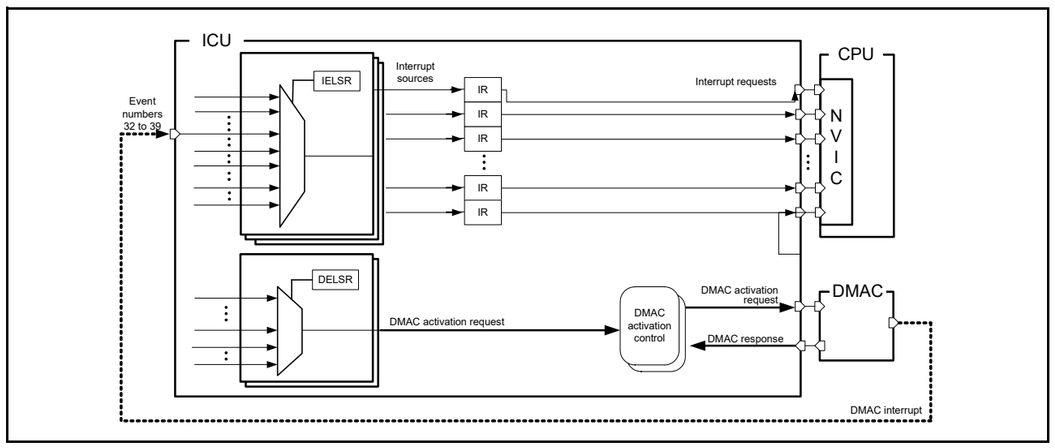

Figure 13.3 DMAC request trigger and interrupt path

Table 13.5 DTC激活时的操作

中断请求目的地	DISEL*1	剩余的转移操作	每个请求的操作	IR*2	传输后的中断请求目的地
DTC*3	1	≠ 0	DTC传输 CPU中断	CPU接受中断时清零	DTC
		= 0	DTC传输 CPU中断	CPU接受中断时清零	IELSRn.DTCE位清零，CPU成为目标
	0	≠ 0	DTC transfer	读取DTC传输数据后，在DTC数据传输开始时清零	DTC
		= 0	DTC传输 CPU中断	CPU接受中断时清零	IELSRn.DTCE位清零，CPU成为目标

Note 1. 在DTC.MRB.DISEL位中设置DTC的中断请求模式。
Note 2. IELSRn.IR标志为1时，忽略再次发生的中断请求（DTC激活请求）。
Note 3. 对于链式传输，DTC传输将持续到最后一个链式传输结束。此时，DISEL位状态和剩余传输计数决定是否发生CPU中断、IELSRn.IR标志清除时序以及传输后的中断请求目的地。请参阅第17节，数据传输控制器(DTC)中的表17.3，链传输条件。

13.4.2.3 DMAC activation

在DELSRn寄存器中指定的事件被输出到DMAC。使用中断时，必须在IELSRn.IELS[8:0]位中选择DMAC作为中断源，并通过将IELSRn.DTCE设置为1来使能DMAC输出。当IELSRn.DTCE为0时，在IELSRn寄存器中指定的事件输出到NVIC。使用以下过程：

1. 将DELSrn.DELS[8:0]位设置为目标事件。
2. 使用中断时，将IELSRn.IELS位设置为DMAC中断作为源，并将IELSRn.DTCE位设置为1。
3. 将目标DMAC通道(DMACm.DMTMD.DCTG[1:0])的激活源设置为01b（中断模块检测）。
4. 将目标DMAC通道(DMACm.DMCNT.DTE)的DMAC传输使能位设置为1。
5. 将DMAC操作使能位(DMACm.DMAST.DMST)设置为1。

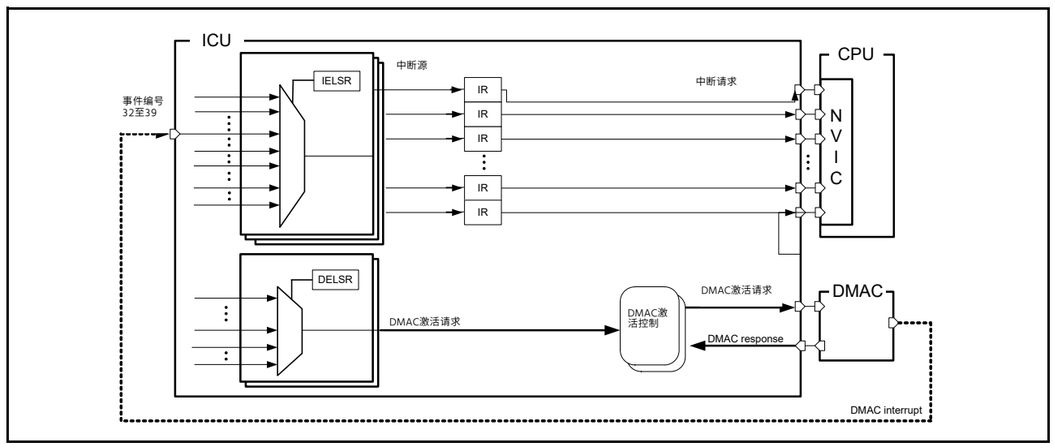

Figure 13.3 DMAC请求触发和中断路径

13.4.3 Digital Filter

A digital filter function is provided for the external interrupt request pins IRQi, (i = 0 to 13) and NMI pin interrupt. It samples input signals on the filter PCLKB sampling clock, and removes any signal with a pulse width less than 3 sampling cycles.

To use the digital filter for an IRQi pin:

1. Set the sampling clock cycle to PCLKB, PCLKB/8, PCLKB/32, or PCLKB/64 in the IRQCRi.FCLKSEL[1:0] bits.
2. Set the IRQCRi.FLTEN bit to 1 (digital filter enabled).

To use the digital filter for the NMI pin:

1. Set the sampling clock cycle to PCLKB, PCLKB/8, PCLKB/32, or PCLKB/64 in the NMICR.NFCLKSEL[1:0] bits.
2. Set the NMICR.NFLTEN bit to 1 (digital filter enabled).

Figure 13.4 shows an example of digital filter operation.

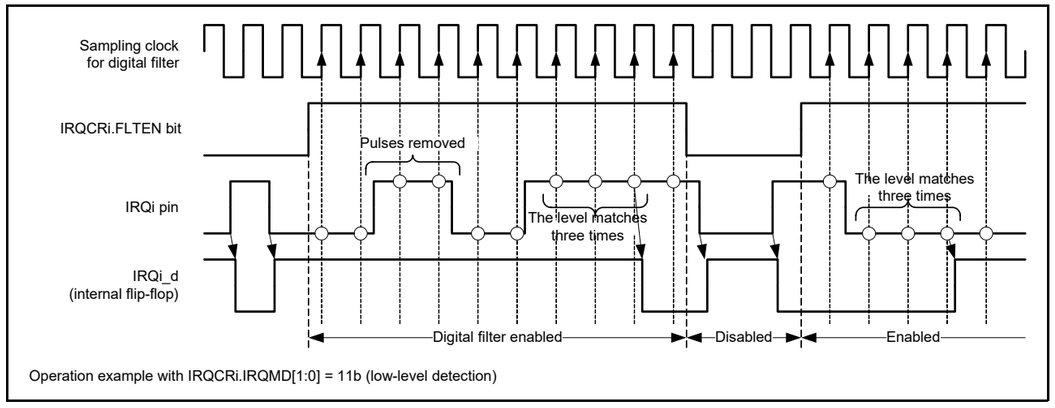

Figure 13.4 Digital filter operation example

Before entering Software Standby mode, disable the digital filters by clearing the IRQCRi.FLTEN and NMICR.NFLTEN bits. The clock for the ICU stops in Software Standby mode. On exiting Software Standby, the circuit detects the edge by comparing the state before standby to the state after standby release. If the input changes during Software Standby, an incorrect edge might be detected. You can enable the digital filters again after exiting Software Standby mode.

13.4.4 External Pin Interrupts

To use external pin interrupts:

1. Clear the IRQCRi.FLTEN bit (i = 0 to 13) to 0 (digital filter disabled).
2. Set or confirm the I/O port settings.
3. Set the IRQMD[1:0] bits, FCLKSEL[1:0] bits, and FLTEN bit of the IRQCRi register.
4. Select the IRQ pin as follows:
   - If the IRQ pin is to be used for CPU interrupt requests, set the IELSRn.IELS bits and set the IELSRn.DTCE bit to 0
   - If the IRQ pin is to be used for DTC activation, set the IELSRn.IELS bits and set the IELSRn.DTCE bit to 1
   - If the IRQ pin is to be used for DMAC activation, set the DELSRn.DELS bits.

13.4.3 数字滤波器

为外部中断请求引脚IRQi（i=0至13）和NMI引脚中断提供了数字过滤功能。它在滤波器PCLKB采样时钟上对输入信号进行采样，并去除脉冲宽度小于3个采样周期的任何信号。

为IRQi引脚使用数字滤波器：

1. 在IRQCRi.FCLKSEL[1:0]位中将采样时钟周期设置为PCLKB、PCLKB8、PCLKB32或PCLKB64。
2. 将IRQCRi.FLTEN位设置为1（启用数字滤波器）。

为NMI引脚使用数字滤波器：

1. 在NMICR.NFCLKSEL[1:0]位中将采样时钟周期设置为PCLKB、PCLKB8、PCLKB32或PCLKB64。
2. 将NMICR.NFLTEN位设置为1（启用数字滤波器）。

图13.4显示了数字滤波器操作的示例。

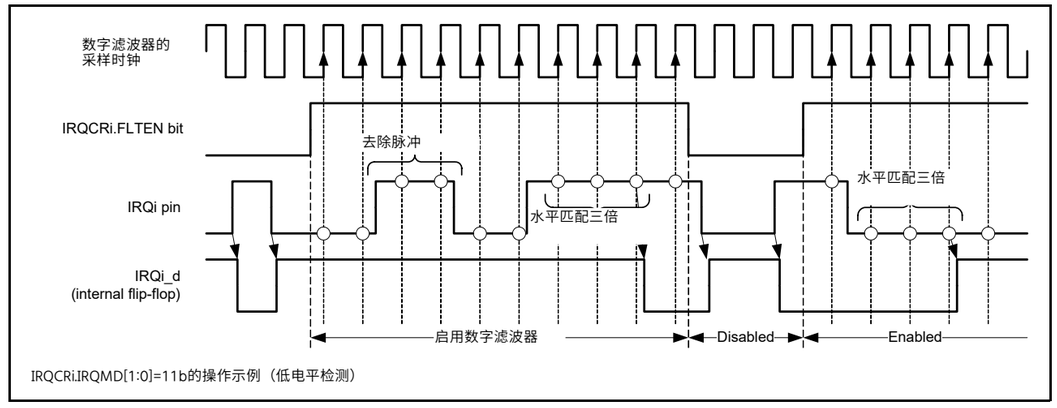

Figure 13.4 数字滤波器操作示例

在进入软件待机模式之前，通过清除IRQCRi.FLTEN和NMICR.NFLTEN位来禁用数字滤波器。ICU的时钟在软件待机模式下停止。在退出软件待机时，电路通过将待机前的状态与待机释放后的状态进行比较来检测边沿。如果在软件待机期间输入发生变化，则可能会检测到不正确的边沿。您可以在退出软件待机模式后再次启用数字滤波器。

13.4.4 外部引脚中断

要使用外部引脚中断：

1. 将IRQCRi.FLTEN位（i=0到13）清零（禁用数字滤波器）。
2. 设置或确认IO端口设置。
3. 设置IRQCRi寄存器的IRQMD[1:0]位、FCLKSEL[1:0]位和FLTEN位。
4. 选择IRQ引脚如下：
   - 如果IRQ引脚用于CPU中断请求，设置IELSRn.IELS位并将IELSRn.DTCE位设置为0
   - 如果IRQ引脚用于DTC激活，设置IELSRn.IELS位并将IELSRn.DTCE位设置为1
   - 如果IRQ引脚用于DMAC激活，则设置DELSRn.DELS位。

13.5 Non-Maskable Interrupt Operation

The following sources can trigger a non-maskable interrupt:

- NMI pin interrupt
- Oscillation stop detection interrupt
- WDT underflow/refresh error interrupt
- IWDT underflow/refresh error interrupt
- Voltage monitor 1 interrupt
- Voltage monitor 2 interrupt
- SRAM parity error interrupt
- MPU bus master error interrupt
- MPU bus slave error interrupt
- CPU stack pointer monitor interrupt.

Non-maskable interrupts can only be used with the CPU, not to activate the DTC or DMAC. Non-maskable interrupts take precedence over all other interrupts. The non-maskable interrupt states can be verified in the Non-Maskable Interrupt Status Register (NMISR). Confirm that all bits in the NMISR are 0 before returning from the NMI handler.

Non-maskable interrupts are disabled by default. To use non-maskable interrupts:

1. Clear the NMICR.NFLTEN bit to 0 (digital filter disabled) to use the NMI pin.
2. Set the NMIMD bit, NFCLKSEL[1:0] bits, and NFLTEN bit of NMICR register to use the NMI pin.
3. Write 1 to the NMICLR.NMICLR bit to clear the NMISR.NMIST flag to 0 to use the NMI pin.
4. Enable the non-maskable interrupt by writing 1 to the associated bit in the Non-Maskable Interrupt Enable Register (NMIER).

After 1 is written to the NMIER register, subsequent write access to the NMIEN bit in NMIER is ignored. An NMI interrupt cannot be disabled when enabled, except by a reset.

13.6 Return from Low Power Modes

Table 13.4 lists the interrupt sources you can use to exit Sleep or Software Standby mode. For more information, see section 11, Low Power Modes. Sections 13.6.1 to 13.6.3 describe how to use interrupts to return from Sleep, Software Standby, and Snooze modes. For Deep Software Standby mode, see section 11.9, Deep Software Standby Mode.

13.6.1 Return from Sleep Mode

To return from Sleep mode in response to an interrupt:

1. Select the CPU as the interrupt request destination.
2. Enable the interrupt in the NVIC.

To return from Sleep mode in response to a non-maskable interrupt, use the NMIER register to enable the target interrupt request.

13.6.2 Return from Software Standby Mode

The ICU can return from Software Standby mode using a non-maskable interrupt or an interrupt selected in the WUPEN register. See section 13.2.9, Wake Up Interrupt Enable Register (WUPEN).

To return from Software Standby mode:

1. Select the interrupt source that enables return from Software Standby:
   - For non-maskable interrupts, use the NMIER register to enable the target interrupt request
   - For maskable interrupts, use the WUPEN register to enable the target interrupt request.

13.5 不可屏蔽中断操作

以下源可以触发不可屏蔽中断：

- NMI引脚中断
- 振荡停止检测中断
- WDT下溢刷新错误中断
- IWDT下溢刷新错误中断
- 电压监视器1中断
- 电压监视器2中断
- SRAM奇偶校验错误中断
- MPU总线主机错误中断
- MPU总线从机错误中断
- CPU堆栈指针监视中断。

不可屏蔽中断只能用于CPU，不能激活DTC或DMAC。不可屏蔽中断优先于所有其他中断。不可屏蔽中断状态可以在不可屏蔽中断状态寄存器(NMISR)中验证。在从NMI处理程序返回之前，确认NMISR中的所有位都为0。

默认情况下禁用不可屏蔽中断。要使用不可屏蔽的中断：

1. 将NMICR.NFLTEN位清零（禁用数字滤波器）以使用NMI引脚。
2. 设置NMICR寄存器的NMIMD位、NFCLKSEL[1:0]位和NFLTEN位以使用NMI引脚。
3. 将1写入NMICLR.NMICLR位以将NMISR.NMIST标志清零以使用NMI引脚。
4. 通过将1写入不可屏蔽中断启用寄存器(NMIER)中的相关位来启用不可屏蔽中断。

将1写入NMIER寄存器后，随后对NMIER中的NMIEN位的写访问将被忽略。启用时不能禁用NMI中断，除非通过复位。

13.6 从低功耗模式返回

表13.4列出了可用于退出休眠或软件待机模式的中断源。有关详细信息，请参阅第11节，低功耗模式。13.6.1到13.6.3节描述了如何使用中断从休眠、软件待机和贪睡模式返回。对于深度软件待机模式，请参阅第11.9节，深度软件待机模式。

13.6.1 从睡眠模式返回

从睡眠模式返回以响应中断：

1. 选择CPU作为中断请求目标。
2. 在NVIC中启用中断。

要从休眠模式返回以响应不可屏蔽的中断，请使用NMIER寄存器来启用目标中断请求。

13.6.2 从软件待机模式返回

ICU可以使用不可屏蔽中断或在WUPEN寄存器中选择的中断从软件待机模式返回。请参见第13.2.9节，唤醒中断使能寄存器(WUPEN)。

从软件待机模式返回：

1. 选择允许从软件待机返回的中断源：
   - 对于不可屏蔽中断，使用NMIER寄存器启用目标中断请求
   - 对于可屏蔽中断，使用WUPEN寄存器启用目标中断请求。

2. Select the CPU as the interrupt request destination.
3. Enable the interrupt in the NVIC.

Interrupt requests through the IRQ pins that do not satisfy these conditions are not detected while the clock is stopped in Software Standby mode.

13.6.3 Return from Snooze Mode

The ICU can return to Normal mode from Snooze mode using the interrupts provided for this mode.

To return to Normal mode from Snooze mode:

1. Use either of the following methods to select the event that you want to trigger a return to Normal mode from Snooze mode:
   - Set the event that you want to trigger a return to Normal mode from Snooze mode in SELSR0.SELS[8:0] and set the value 02Dh (ICU_SNZCANCEL) in IELSRn.IELS[8:0]
   - Set the event that you want to trigger a return to Normal mode from Snooze mode in IELSRn.IELS[8:0].
2. Select the CPU as the interrupt request destination.
3. Enable the interrupt in the NVIC.

Note: In Snooze mode, a clock is supplied to the ICU. If an event selected in IELSRn is detected, the CPU can acknowledge the interrupt after returning to Normal mode from Software Standby mode. If an event selected in DELSRn is detected, the DMAC can acknowledge the interrupt after returning to Normal mode from Software Standby mode.

13.7 Using the WFI Instruction with Non-Maskable Interrupts

Whenever a WFI instruction is executed, confirm that all status flags in the NMISR register are 0.

13.8 Reference

ARM® Cortex®-M4 Processor Technical Reference Manual (ARM DDI 0439D).

2. 选择CPU作为中断请求目标。
3. 在NVIC中启用中断。

不满足这些条件的通过IRQ引脚的中断请求在时钟停止时不会被检测到
软件待机模式。

13.6.3 从贪睡模式返回

ICU可以使用为该模式提供的中断从贪睡模式返回到正常模式。

要从贪睡模式返回正常模式：

1. 使用以下任一方法选择要触发返回正常模式的事件
   Snooze mode:
   - 在SELSR0.SELS[8:0]中设置要触发从贪睡模式返回正常模式的事件，并在IELSRn.IELS[8:0]中设置值02Dh (ICU_SNZCANCEL)
   - 在IELSRn.IELS[8:0]中设置要触发从贪睡模式返回正常模式的事件。
2. 选择CPU作为中断请求目标。
3. 在NVIC中启用中断。

Note: 在贪睡模式下，向ICU提供时钟。如果检测到在IELSRn中选择的事件，CPU可以在从软件待机模式返回到正常模式后确认中断。如果检测到在DELSRn中选择的事件，则DMAC可以在从软件返回到正常模式后确认中断

待机模式。

13.7 将WFI指令与不可屏蔽中断一起使用

每当执行WFI指令时，请确认NMISR寄存器中的所有状态标志为0。

13.8 Reference

ARM®Cortex®–M4处理器技术参考手册(ARMDDI0439D)。

14. Buses

14.1 Overview

Table 14.1 lists the bus specifications, Figure 14.1 shows the bus configuration, and Table 14.2 lists the addresses assigned for each bus.

This bus interface can also be used to connect LCD Intel 8080 and Motorola 6800 interfaces.

Table 14.1 Bus specifications

Bus type		Specifications
Main bus	ICode bus (CPU)	• Connected to the CPU • Connected to the on-chip memory (code flash memory, SRAMHS).
	DCode bus (CPU)	• Connected to the CPU • Connected to the on-chip memory (code flash memory, SRAMHS).
	System bus (CPU)	• Connected to the CPU • Connected to the on-chip memory and internal peripheral buses.
	DMA bus	• Connected to the DMAC and DTC • Connected to the on-chip memory and internal peripheral buses.
Slave interface	Memory bus 1	• Connected to code flash memory
	Memory bus 2	• Connected to SRAMHS
	Memory bus 3	• Connected to code flash memory and SRAMHS through the DMA bus
	Internal peripheral bus 1	• Connected to system control related to peripheral modules
	Internal peripheral bus 3	• Connected to peripheral modules (CAC, ELC, I/O ports, POEG, WDT, IWDT, IIC, CAN, ADC12, DAC12, TSN, and DOC)
	Internal peripheral bus 4	• Connected to peripheral modules (GPT, SCI, IrDA, SPI, and CRC)
	Internal peripheral bus 5	• Connected to peripheral modules (KINT, AGT, and ACMPHS)
	Internal peripheral bus 7	• Connected to Secure IPs (SCE7)
	Internal peripheral bus 9	• Connected to flash memory (in P/E)*1, data flash memory, and TSN

Note 1. P/E: Programming and erasure.

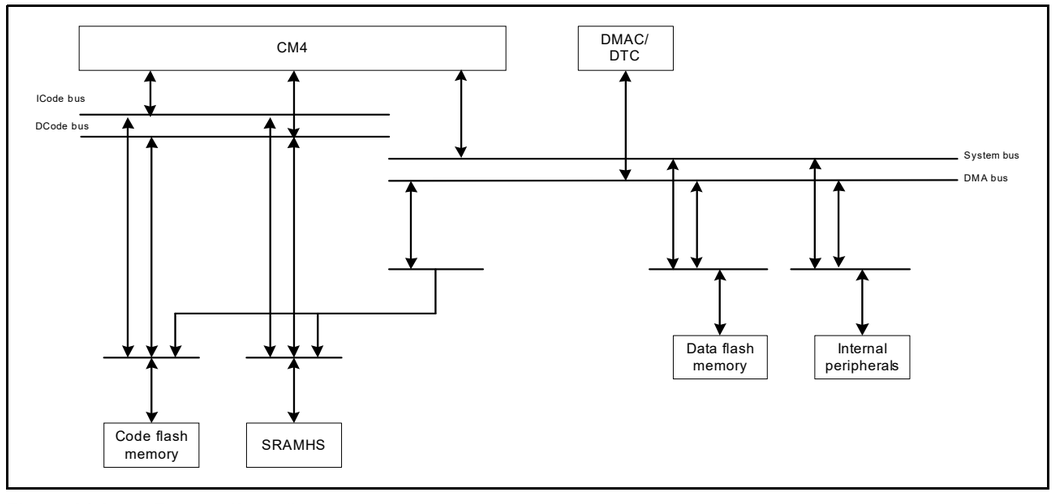

Figure 14.1 Bus configuration

14. Buses

14.1 Overview

表14.1列出了总线规格，图14.1显示了总线配置，表14.2列出了分配给每个总线的地址。

该总线接口也可用于连接LCDIntel8080和Motorola6800接口。

Table 14.1 总线规格

巴士类型		Specifications
主要总线	ICode bus (CPU)	连接到CPU 连接到片上存储器（代码闪存，SRAMHS）。
	DCode bus (CPU)	连接到CPU 连接到片上存储器（代码闪存，SRAMHS）。
	系统总线(CPU)	连接到CPU 连接到片上存储器和内部外围总线。
	DMA bus	连接到DMAC和DTC 连接到片上存储器和内部外围总线。
从接口	内存总线1	连接到代码闪存
	内存总线2	连接到SRAMHS
	内存总线3	通过DMA总线连接到代码闪存和SRAMHS
	内部外围总线1	连接到与外围模块相关的系统控制
	内部外围总线3	连接外围模块（CAC、ELC、IO端口、POEG、WDT、IWDT、IIC、CAN、ADC12、DAC12、TSN和DOC）
	内部外围总线4	连接到外围模块（GPT、SCI、IrDA、SPI和CRC）
	内部外围总线5	连接到外围模块（KINT、AGT和ACMPHS）
	内部外围总线7	连接到安全IP(SCE7)
	内部外围总线9	连接到闪存（在PE中）*1、数据闪存和TSN

注1.PE：编程和擦除。

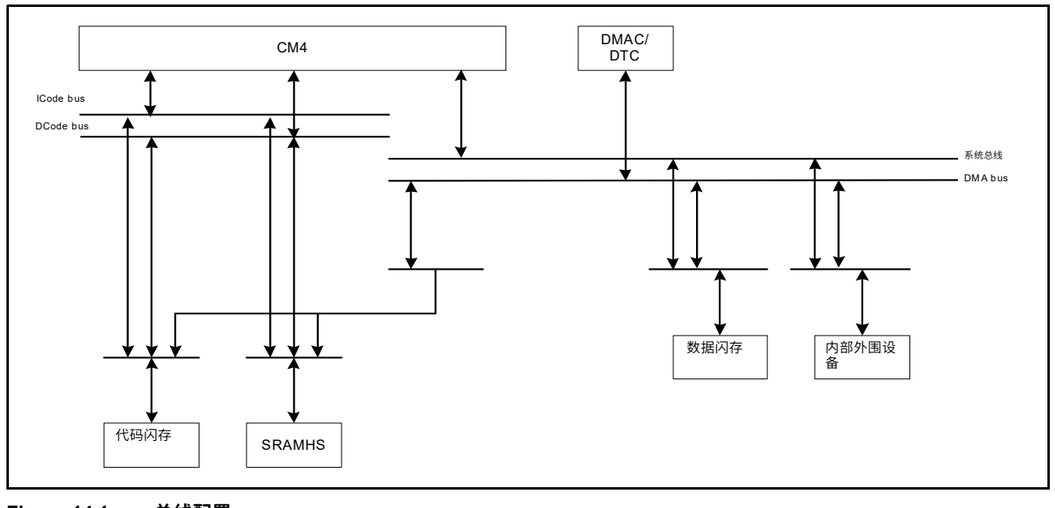

Figure 14.1 总线配置

Table 14.2 Addresses assigned to each bus

Addresses	Bus	Area
0000 0000h to 01FF FFFFh	Memory bus 1, 3	Code flash memory
1FFE 0000h to 1FFE FFFFh	Memory bus 2, 3	SRAMHS
4000 0000h to 4001 FFFFh	Internal peripheral bus 1	Peripheral I/O registers
4004 0000h to 4005 FFFFh	Internal peripheral bus 3	
4006 0000h to 4007 FFFFh	Internal peripheral bus 4	
4008 0000h to 4009 FFFFh	Internal peripheral bus 5	
400C 0000h to 400D FFFFh	Internal peripheral bus 7	Secure IPs
4010 0000h to 407F FFFFh	Internal peripheral bus 9	Flash memory (in P/E*1), data flash memory, and TSN

Note 1. P/E: Programming and erasure.

14.2 Description of Buses

14.2.1 Main Buses

The main buses for the CPU consist of the ICode bus, DCode bus, and system bus:

- The ICode and DCode buses are connected to the code flash memory and SRAMHS. The ICode bus is used for instruction access to the CPU, and the DCode bus is used for data access to the CPU.
- The system bus is connected to the data flash memory and internal peripheral buses. It is used for instruction and data accesses to the CPU.

The main bus for modules other than the CPU consists of the DMA bus:

- The DMA bus is connected to the code flash memory, SRAMHS, and data flash memory.

Different master and slave transfer combinations can proceed simultaneously.

Arbitration between the DMAC and DTC for the mastership of the DMA bus occurs in the DMAC and DTC. The following fixed-priority order is used:

DMAC0 > DMAC1 > DMAC2 > DMAC3 > DMAC4 > DMAC5 > DMAC6 > DMAC7 > DTC.

Only one DTC channel and DMAC channel that have accepted the activation requests can issue the bus mastership request. In addition, requests for bus access from masters other than the DTC are not accepted during reads of transfer control information for the DTC.

The arbitration protocol is selectable as either fixed-priority or round-robin. For more information, see section 14.3.2, Slave Bus Control Register (BUSSCNT<slave>).

14.2.2 Slave Interface

Products using the Cortex®-M4 core contain ICode and DCode bus areas and a system bus area.

To create the ICode and DCode bus areas, a bus matrix connects the ICode bus, DCode bus, and memory bus 3 from the main bus to the slave interfaces of the code flash memory and SRAMHS. Bus access to the slave interfaces is arbitrated between the three buses. The arbitration protocol is selectable as either fixed-priority or round-robin. For more information, see section 14.3.2, Slave Bus Control Register (BUSSCNT<slave>).

To create the system bus area, a bus matrix connects the system bus, and DMA bus from the main bus to the slave interfaces of the data flash memory and internal peripherals. Bus access to the slave interfaces is arbitrated between the three buses. The arbitration protocol is selectable as either fixed-priority or round-robin. For more information, see section 14.3.2, Slave Bus Control Register (BUSSCNT<slave>).

For connections from the main bus to the slave interfaces, see the slave interfaces in Table 14.1.

Different master and slave transfer combinations can proceed simultaneously.

Table 14.2 分配给每条总线的地址

Addresses	Bus	Area
0000 0000h to 01FF FFFFh	内存总线1、3	代码闪存
1FFE 0000h to 1FFE FFFFh	内存总线2、3	SRAMHS
4000 0000h to 4001 FFFFh	内部外围总线1	外设IO寄存器
4004 0000h to 4005 FFFFh	内部外围总线3	
4006 0000h to 4007 FFFFh	内部外围总线4	
4008 0000h to 4009 FFFFh	内部外围总线5	
400C 0000h to 400D FFFFh	内部外围总线7	安全IP
4010 0000h to 407F FFFFh	内部外围总线9	闪存（在PE*1中）、数据闪存和TSN

Note 1. PE：编程和擦除。

14.2 巴士的描述

14.2.1 主要巴士

CPU的主要总线包括ICode总线、DCode总线和系统总线：

- ICode和DCode总线连接到代码闪存和SRAMHS。ICode总线用于对CPU的指令访问，而DCode总线用于对CPU的数据访问。
- 系统总线连接到数据闪存和内部外围总线。它用于对CPU的指令和数据访问。

CPU以外的模块的主总线由DMA总线组成：

- DMA总线连接到代码闪存、SRAMHS和数据闪存。

不同的主从传输组合可以同时进行。

DMAC和DTC之间对DMA总线的主控权的仲裁发生在DMAC和DTC中。使用以下固定优先级顺序：

DMAC0 > DMAC1 > DMAC2 > DMAC3 > DMAC4 > DMAC5 > DMAC6 > DMAC7 > DTC.

只有接受了激活请求的DTC通道和DMAC通道可以发出总线主控请求。此外，在读取DTC的传输控制信息期间，不接受来自DTC以外的主机的总线访问请求。

仲裁协议可选择为固定优先级或循环。有关详细信息，请参阅第14.3.2节，从总线控制寄存器（BUSSCNT<slave>）。

14.2.2 从接口

使用Cortex®-M4内核的产品包含ICode和DCode总线区域以及系统总线区域。

为了创建ICode和DCode总线区域，总线矩阵将ICode总线、DCode总线和存储器总线3从主总线连接到代码闪存和SRAMHS的从接口。对从接口的总线访问在三个总线之间进行仲裁。仲裁协议可选择为固定优先级或循环。有关详细信息，请参阅第14.3.2节，从总线控制寄存器(BUSSCNT<slave>)。

为了创建系统总线区域，总线矩阵将系统总线和DMA总线从主总线连接到数据闪存和内部外围设备的从接口。对从接口的总线访问在三个总线之间进行仲裁。仲裁协议可选择为固定优先级或循环。有关详细信息，请参阅第14.3.2节，从总线控制寄存器(BUSSCNT<slave>)。

对于从主总线到从接口的连接，请参见表14.1中的从接口。

不同的主从传输组合可以同时进行。

14.2.3 Parallel Operations

Parallel operations are possible when different bus masters request access to different slave modules. For example, if the CPU fetches an instruction from the flash and an operand from the SRAM, the DMAC can handle transfers between a peripheral bus and the data flash at the same time.

An example of parallel operations is shown in Figure 14.2. In this example, the CPU uses the instruction and operand buses for simultaneous access to the flash and SRAM, respectively. Additionally, the DMAC/DTC simultaneously use the DMA bus (DMAC/DTC) for access to a peripheral bus or data flash during access to the flash memory and SRAM by the CPU.

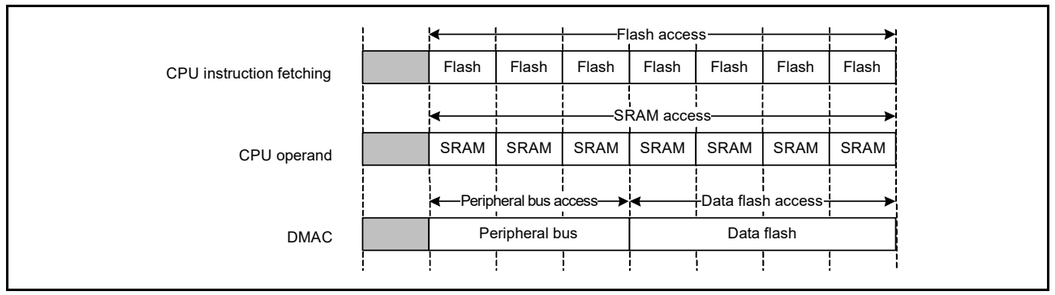

Figure 14.2 Example of parallel operations

14.2.4 Restrictions on Endianness

Memory space must be little-endian to execute code on the Cortex®-M4 core.

14.3 Register Descriptions

14.3.1 Master Bus Control Register (BUSMCNT<master>)

Address(es): BUS.BUSMCNTM4I 4000 4000h, BUS.BUSMCNTM4D 4000 4004h, BUS.BUSMCNTSYS 4000 4008h, BUS.BUSMCNTDMA 4000 400Ch

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	IERES	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b14 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15	IERES	Ignore Error Responses	0: Report bus errors 1: Do not report bus errors.	R/W

Note: Changing reserved bits from the initial value of 0 is prohibited. Operation during the change is not guaranteed.

Table 14.3 shows the registers associated with each bus type.

14.2.3 并行操作

当不同的总线主机请求访问不同的从模块时，并行操作是可能的。例如，如果
CPU从闪存中获取指令，从SRAM中获取操作数，DMAC可以同时处理外设总线和数据闪存之间的传输。

图14.2显示了并行操作的示例。在本例中，CPU使用指令和操作数总线分别同时访问闪存和SRAM。此外，在CPU访问闪存和SRAM期间，DMACDTC同时使用DMA总线(DMACDTC)访问外围总线或数据闪存。

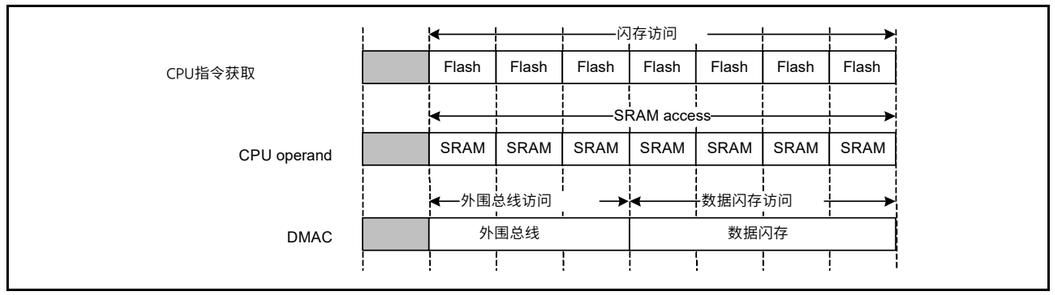

Figure 14.2 并行操作示例

14.2.4 字节序限制

内存空间必须是little-endian才能在Cortex®-M4内核上执行代码。

14.3 注册说明

14.3.1 主总线控制寄存器(BUSMCNT<master>)

Address(es): BUS.BUSMCNTM4I 4000 4000h, BUS.BUSMCNTM4D 4000 4004h, BUS.BUSMCNTSYS 4000 4008h, BUS.BUSMCNTDMA 4000 400Ch

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	IERES	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b14 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15	IERES	忽略错误响应	0：报告总线错误1：不报告总线错误。	R/W

Note: 禁止从初始值0更改保留位。不保证更改期间的操作。

表14.3显示了与每种总线类型相关的寄存器。

Table 14.3 Associations between bus types and registers

Bus type	Master Bus Control Register	Slave Bus Control Register	Bus Error Address Register	Bus Error Status Register
ICode bus (CPU)	BUSMCNTM4I	-	BUS1ERRADD	BUS1ERRSTAT
DCode bus (CPU)	BUSMCNTM4D	-	BUS2ERRADD	BUS2ERRSTAT
System bus (CPU)	BUSMCNTSYS	-	BUS3ERRADD	BUS3ERRSTAT
DMA bus	BUSMCNTDMA	-	BUS4ERRADD	BUS4ERRSTAT
Memory bus 1	-	BUSSCNTFLI	-	-
Memory bus 2	-	BUSSCNTRAMH	-	-
Memory bus 3	-	BUSSCNTMBIU	-	-
Internal peripheral bus 1, 3, 4, 5, 7	-	BUSSCNTPnB (n = 0, 2, 3, 4, 6)	-	-
Internal peripheral bus 9	-	BUSSCNTFBU	-	-

IERES bit (Ignore Error Responses)

The IERES bit, when set, disables the AHB-Lite protocol error response.

14.3.2 Slave Bus Control Register (BUSSCNT<slave>)

Address(es): BUS.BUSSCNTFLI 4000 4100h, BUS.BUSSCNTRAMH 4000 4104h, BUS.BUSSCNTMBIU 4000 4108h, BUS.BUSSCNTP0B 4000 4114h,BUS.BUSSCNTP2B 4000 4118h, BUS.BUSSCNTP3B 4000 411Ch, BUS.BUSSCNTP4B 4000 4120h, BUS.BUSSCNTP6B 4000 4128h, BUS.BUSSCNTFBU 4000 4130h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	EWRES	—	—	ARBMET[1:0]		—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b5, b4	ARBMET[1:0]	Arbitration Method	Specifies the group priorities. b5 b4 0 0: Fixed priority 0 1: Round-robin 1 0: Setting prohibited 1 1: Setting prohibited.	R/W
b7, b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b8	EWRES	Early Write Response	0: Disable early write response 1: Enable early write response.	R/W
b15 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: Changing reserved bits from the initial value of 0 is prohibited. Operation during the change is not guaranteed.

Table 14.3 lists the registers associated with each bus type.

ARBMET[1:0] bits (Arbitration Method)

The ARBMET[1:0] bits specify the arbitration protocol, with priority defined for all bus masters. For fixed priority, see Table 14.4. For round-robin, see Table 14.5.

EWRES bit (Early Write Response)

The EWRES bit indicates whether the next write request is accepted before the response for the current write transaction occurs. When the value is 1, the next write request is accepted and high-speed transfer is possible, but AHB-Lite error responses are not detected. Bus errors are returned to the requesting master IP using the error response protocol for AHB-Lite. For details on errors that occur on each bus, see section 14.4, Bus Error Monitoring. Only use the BUSSCNTMBIU,

Table 14.3 总线类型和寄存器之间的关联

巴士类型	主总线控制寄存器	从总线控制寄存器	总线错误地址 Register	总线错误状态 Register
ICode bus (CPU)	BUSMCNTM4I	-	BUS1ERRADD	BUS1ERRSTAT
DCode bus (CPU)	BUSMCNTM4D	-	BUS2ERRADD	BUS2ERRSTAT
系统总线(CPU)	BUSMCNTSYS	-	BUS3ERRADD	BUS3ERRSTAT
DMA bus	BUSMCNTDMA	-	BUS4ERRADD	BUS4ERRSTAT
内存总线1	-	BUSSCNTFLI	-	-
内存总线2	-	BUSSCNTRAMH	-	-
内存总线3	-	BUSSCNTMBIU	-	-
内部外围总线1、3、4、5、7	-	BUSSCNTPnB (n = 0, 2, 3, 4, 6)	-	-
内部外围总线9	-	BUSSCNTFBU	-	-

IERES位（忽略错误响应）

IERES位在设置时禁用AHB-Lite协议错误响应。

14.3.2 从总线控制寄存器(BUSSCNT<slave>)

Address(es): BUS.BUSSCNTFLI 4000 4100h, BUS.BUSSCNTRAMH 4000 4104h, BUS.BUSSCNTMBIU 4000 4108h, BUS.BUSSCNTP0B 4000 4114h,BUS.BUSSCNTP2B 4000 4118h, BUS.BUSSCNTP3B 4000 411Ch, BUS.BUSSCNTP4B 4000 4120h, BUS.BUSSCNTP6B 4000 4128h, BUS.BUSSCNTFBU 4000 4130h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	EWRES	—	—	ARBMET[1:0]		—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b5, b4	ARBMET[1:0]	仲裁方式	指定组优先级。b5b400：固定优先级01：循环10：禁止设置11：禁止设置。	R/W
b7, b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b8	EWRES	早期写响应	0：禁用早期写入响应1：启用早期写入响应。	R/W
b15 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 禁止从初始值0更改保留位。不保证更改期间的操作。

表14.3列出了与每种总线类型相关的寄存器。

ARBMET[1:0]位（仲裁方法）

ARBMET[1:0]位指定仲裁协议，并为所有总线主机定义优先级。对于固定优先级，请参阅表14.4。对于循环，请参见表14.5。

EWRES位（早期写响应）

EWRES位指示在当前写事务的响应发生之前是否接受下一个写请求。值为1时，接受下一个写请求，可以进行高速传输，但未检测到AHB-Lite错误响应。使用AHBLite的错误响应协议将总线错误返回到请求的主IP。有关每条总线上发生的错误的详细信息，请参阅第14.4节，总线错误监控。仅使用BUSSCNTMBIU，

BUSSCNTP0B, and BUSSCNTEXT registers.

Table 14.4 Bus priorities with fixed-priority arbitration (ARBMET[1:0] = 00b)

Slave Bus Control Register	Slave interface	Priority order
BUSSCNTFLI	Memory bus 1	Memory bus 3 > DCode bus (CPU) > ICode bus (CPU)
BUSSCNTRAMH	Memory bus 2	Memory bus 3 > DCode bus (CPU) > ICode bus (CPU)
BUSSCNTPnB (n = 0, 2, 3, 4, 6)	Internal peripheral bus 1, 3, 4, 5, 7	DMA bus > system bus (CPU)
BUSSCNTFBU	Internal peripheral bus 9	DMA bus > system bus (CPU)

Table 14.5 Bus priorities with round-robin priority arbitration (ARBMET[1:0] = 01b)

Slave Bus Control Register	Slave interface	Priority order*1
BUSSCNTFLI	Memory bus 1	Memory bus 3 <=> DCode bus (CPU) <=> ICode bus (CPU)
BUSSCNTRAMH	Memory bus 2	Memory bus 3 <=> DCode bus (CPU) <=> ICode bus (CPU)
BUSSCNTPnB (n = 0, 2, 3, 4, 6)	Internal peripheral bus 1, 3, 4, 5, 7	DMA bus <=> system bus (CPU)
BUSSCNTFBU	Internal peripheral bus 9	DMA bus <=> system bus (CPU)

Note 1. Round-robin priority is denoted by <=>.

14.3.3 Bus Error Address Register (BUSnERRADD) (n = 1 to 4)

Address(es): BUS.BUS1ERRADD 4000 4800h, BUS.BUS2ERRADD 4000 4810h, BUS.BUS3ERRADD 4000 4820h, BUS.BUS4ERRADD 4000 4830h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	BERAD[31:16]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	BERAD[15:0]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	BERAD[31:0]	Bus Error Address	When a bus error occurs, these bits store the error address	R

Note: This register is cleared only by a reset that is not an MPU-related reset. For more information, see section 6, Resets, and section 15, Memory Protection Unit (MPU).

Table 14.3 lists the registers associated with each bus type.

BERAD[31:0] bits (Bus Error Address)

When a bus error occurs, the BERAD[31:0] bits store the access address. For more information, see the BUSnERRSTAT.ERRSTAT bit description and section 14.4, Bus Error Monitoring.

A value of BUSnERRADD.BERAD[31:0] (n = 1 to 4) is only valid when BUSnERRSTAT.ERRSTAT (n = 1 to 4) is set to 1.

BUSSCNTP0B和BUSSCNTEXT寄存器。

Table 14.4 具有固定优先级仲裁的总线优先级(ARBMET[1:0]=00b)

从总线控制寄存器	从接口	优先顺序
BUSSCNTFLI	内存总线1	内存总线3>DCode总线(CPU)>ICode总线(CPU)
BUSSCNTRAMH	内存总线2	内存总线3>DCode总线(CPU)>ICode总线(CPU)
BUSSCNTPnB (n = 0, 2, 3, 4, 6)	内部外围总线1、3、4、5、7	DMA总线>系统总线(CPU)
BUSSCNTFBU	内部外围总线9	DMA总线>系统总线(CPU)

Table 14.5 具有循环优先级仲裁的总线优先级(ARBMET[1:0]=01b)

从总线控制寄存器	从接口	Priority order*1
BUSSCNTFLI	内存总线1	内存总线3<=>DCode总线(CPU)<=>ICode总线(CPU)
BUSSCNTRAMH	内存总线2	内存总线3<=>DCode总线(CPU)<=>ICode总线(CPU)
BUSSCNTPnB (n = 0, 2, 3, 4, 6)	内部外围总线1、3、4、5、7	DMA总线<=>系统总线(CPU)
BUSSCNTFBU	内部外围总线9	DMA总线<=>系统总线(CPU)

Note 1. 循环优先级由<=>表示。

14.3.3 总线错误地址寄存器(BUSnERRADD)(n=1到4)

Address(es): BUS.BUS1ERRADD 4000 4800h, BUS.BUS2ERRADD 4000 4810h, BUS.BUS3ERRADD 4000 4820h, BUS.BUS4ERRADD 4000 4830h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	BERAD[31:16]															
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	BERAD[15:0]															
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	BERAD[31:0]	总线错误地址	当发生总线错误时，这些位存储错误地址	R

Note: 该寄存器仅由非MPU相关复位的复位清除。有关详细信息，请参阅第6节，复位和第15节，内存保护单元(MPU)。

表14.3列出了与每种总线类型相关的寄存器。

BERAD[31:0]位（总线错误地址）

当发生总线错误时，BERAD[31:0]位存储访问地址。有关详细信息，请参阅BUSnERRSTAT.ERRSTAT位描述和第14.4节，总线错误监控。

BUSnERRADD.BERAD[31:0]（n=1到4）的值仅在BUSnERRSTAT.ERRSTAT（n=1到4）设置为1时有效。

14.3.4 Bus Error Status Register (BUSnERRSTAT) (n = 1 to 4)

Address(es): BUS.BUS1ERRSTAT 4000 4804h, BUS.BUS2ERRSTAT 4000 4814h, BUS.BUS3ERRSTAT 4000 4824h, BUS.BUS4ERRSTAT 4000 4834h

	b7	b6	b5	b4	b3	b2	b1	b0
	ERRSTAT	—	—	—	—	—	—	ACCSTAT
Value after reset:	0	0	0	0	0	0	0	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	ACCSTAT	Error Access Status	Access status when the error occurred: 1: Write access 0: Read access.	R
b6 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	ERRSTAT	Bus Error Status	0: No bus error occurred 1: Bus error occurred.	R

Note: This register is cleared only by a reset that is not an MPU-related reset. For more information, see section 6, Resets, and section 15, Memory Protection Unit (MPU).

Table 14.3 lists the registers associated with each bus type.

ACCSTAT bit (Error Access Status)

The ACCSTAT bit indicates the access status, write access or read access, when an error occurs on the associated bus. For more information, see the BUSnERRSTAT.ERRSTAT bit description and section 14.4, Bus Error Monitoring.

The value is only valid when BUSnERRSTAT.ERRSTAT (n = 1 to 4) is set to 1.

ERRSTAT bit (Bus Error Status)

The ERRSTAT bit indicates whether a bus error occurred. When an error occurs on the associated bus, the access address and status of write or read access are stored. BUSnERRSTATn.ERRSTAT (n = 1 to 4) is set to 1.

The following types of errors can occur on each bus:

- Illegal address access
- Bus master MPU error
- Bus slave MPU error
- Time out.

When detecting bus master MPU errors or bus slave MPU errors, and reset is selected in the respective OAD bit, BUSnERRSTAT.ERRSTAT (n = 1 to 4) is not set to 1 if the bus access that caused the MPU error completes later than the internal reset signal being generated, which may occur depending on the wait setting.

When detecting bus master MPU errors or bus slave MPU errors, and NMI is selected in the respective OAD bit, BUSnERRSTAT.ERRSTAT (n = 1 to 4) is set to 1 when the bus access that caused the MPU error completes.

For more information on errors that occur on each bus, see section 14.4, Bus Error Monitoring, and section 15, Memory Protection Unit (MPU).

14.4 Bus Error Monitoring

The bus error monitoring system monitors each individual area, and whenever an error is detected, it returns the error to the requesting master IP using the AHB-Lite error response protocol.

14.4.1 Bus Error Types

The following types of errors can occur on each bus:

14.3.4 总线错误状态寄存器(BUSnERRSTAT)(n=1到4)

Address(es): BUS.BUS1ERRSTAT 4000 4804h, BUS.BUS2ERRSTAT 4000 4814h, BUS.BUS3ERRSTAT 4000 4824h, BUS.BUS4ERRSTAT 4000 4834h

	b7	b6	b5	b4	b3	b2	b1	b0
	ERRSTAT	—	—	—	—	—	—	ACCSTAT
重置后的值:	0	0	0	0	0	0	0	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	ACCSTAT	错误访问状态	发生错误时的访问状态：1：写访问0： 读访问。	R
b6 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	ERRSTAT	总线错误状态	0：未发生总线错误1： 发生总线错误。	R

Note: 该寄存器仅由非MPU相关复位的复位清除。有关详细信息，请参阅第6节，复位和第15节，内存保护单元(MPU)。

表14.3列出了与每种总线类型相关的寄存器。

ACCSTAT位（错误访问状态）

当相关总线上发生错误时，ACCSTAT位指示访问状态、写访问或读访问。
有关详细信息，请参阅BUSnERRSTAT.ERRSTAT位描述和第14.4节，总线错误监控。

该值仅在BUSnERRSTAT.ERRSTAT（n=1到4）设置为1时有效。

ERRSTAT位（总线错误状态）

ERRSTAT位指示是否发生总线错误。当相关总线上发生错误时，将存储访问地址和写入或读取访问的状态。BUSnERRSTATn.ERRSTAT（n=1到4）设置为1。

每条总线上都可能发生以下类型的错误：

- 非法地址访问
- 总线主控MPU错误
- 总线从机MPU错误
- 暂停。

当检测到总线主MPU错误或总线从MPU错误时，在相应的OAD位中选择复位，
如果导致MPU错误的总线访问在内部复位信号生成之后完成，则BUSnERRSTAT.ERRSTAT（n=1到4）不设置为1，这可能取决于等待设置。

当检测到总线主机MPU错误或总线从机MPU错误时，在各自的OAD位中选择NMI，
当导致MPU错误的总线访问完成时，BUSnERRSTAT.ERRSTAT（n=1到4）设置为1。

有关每条总线上发生的错误的更多信息，请参阅第14.4节，总线错误监控和第15节，内存保护单元（MPU）。

14.4 总线错误监控

总线错误监控系统监控每个单独的区域，每当检测到错误时，它会使用AHB-Lite错误响应协议将错误返回给请求的主IP。

14.4.1 总线错误类型

每条总线上都可能发生以下类型的错误：

- Illegal address access
- Bus master MPU error
- Bus slave MPU error
- Timeout.

Table 14.6 lists the address ranges where access leads to illegal address access errors. The reserved area in the slave does not trigger an illegal address access error. For more information on the bus master MPU and bus slave MPU, see section 15, Memory Protection Unit (MPU).

14.4.2 Operation when a Bus Error Occurs

When a bus error occurs, operation is not guaranteed and the error is returned to the requesting master IP. The bus errors that occur for each master are stored in the BUSnERRADD and BUSnERRSTAT registers. These registers must only be cleared by a reset. For more information, see section 14.3.3, Bus Error Address Register (BUSnERRADD) (n = 1 to 4) and section 14.3.4, Bus Error Status Register (BUSnERRSTAT) (n = 1 to 4).

Note: The DMAC and DTC do not receive bus errors. If the DMAC or DTC accesses the bus, the transfer continues.

14.4.3 Conditions Leading to Illegal Address Access Errors

Table 14.6 lists the address spaces for each bus that trigger illegal address access errors.

Table 14.6 Conditions leading to illegal address access errors

Address	Slave bus name	Master bus	
		CPU (ICode, DCode, System)	DMA
0000 0000h to 01FF FFFFh	Memory bus 1 Memory bus 3	-	-
0200 0000h to 027F FFFFh	Memory mapping area	*1	E
0280 0000h to 1FFD FFFFh	Reserved	E	E
1FFE 0000h to 1FFF FFFFh	Memory bus 2 Memory bus 3	-	-
2000 0000h to 200F FFFFh	Reserved	-	-
2010 0000h to 3FFF FFFFh	Reserved	E	E
4000 0000h to 4001 FFFFh	Peripheral bus 1	-	-
4002 0000h to 4003 FFFFh	Reserved	E	E
4004 0000h to 4005 FFFFh	Peripheral bus 3	-	-
4006 0000h to 4007 FFFFh	Peripheral bus 4	-	-
4008 0000h to 4009 FFFFh	Peripheral bus 5	-	-
400A 0000h to 400B FFFFh	Reserved	-	-
400C 0000h to 400D FFFFh	Peripheral bus 7	-	-
400E 0000h to 400F FFFFh	Reserved	E	E
4010 0000h to 407F FFFFh	Peripheral bus 9	-	-
4080 0000h to 5FFF FFFFh	Reserved	E	E
6000 0000h to 67FF FFFFh	Reserved	-	-
6800 0000h to 7FFF FFFFh	Reserved	E	E
8000 0000h to 97FF FFFFh	Reserved	-	-
9800 0000h to DFFF FFFFh	Reserved	E	E
E000 0000h to FFFF FFFFh	System for Cortex®-M4	-	E

E: Path where an illegal address access error occurs.

Note 1. The bus module does not detect whether the Memory Mirror Function (MMF) switched the address. Therefore, if the MMF is enabled and the CPU accesses 0200 0000h, no error occurs. This depends on the switched address.

- 非法地址访问
- 总线主控MPU错误
- 总线从机MPU错误
- Timeout.

表14.6列出了访问导致非法地址访问错误的地址范围。从机中的保留区域不会触发非法地址访问错误。有关总线主MPU和总线从MPU的更多信息，请参阅第15节，内存保护单元(MPU)。

14.4.2 发生总线错误时的操作

当发生总线错误时，无法保证操作，错误会返回到请求的主IP。每个主机发生的总线错误存储在BUSnERRADD和BUSnERRSTAT寄存器中。这些寄存器只能通过复位清除。有关详细信息，请参阅第14.3.3节，总线错误地址寄存器(BUSnERRADD)（n=1到4）和第14.3.4节，总线错误状态寄存器(BUSnERRSTAT)（n=1到4）。

Note: DMAC和DTC不接收总线错误。如果DMAC或DTC访问总线，则传输继续。

14.4.3 导致非法地址访问错误的条件

表14.6列出了触发非法地址访问错误的每条总线的地址空间。

Table 14.6 导致非法地址访问错误的条件

Address	从总线名称	主总线	
		CPU (ICode, DCode, System)	DMA
0000 0000h to 01FF FFFFh	内存总线1内 存总线3	-	-
0200 0000h to 027F FFFFh	内存映射区	*1	E
0280 0000h to 1FFD FFFFh	Reserved	E	E
1FFE 0000h to 1FFF FFFFh	内存总线2内 存总线3	-	-
2000 0000h to 200F FFFFh	Reserved	-	-
2010 0000h to 3FFF FFFFh	Reserved	E	E
4000 0000h to 4001 FFFFh	外围总线1	-	-
4002 0000h to 4003 FFFFh	Reserved	E	E
4004 0000h to 4005 FFFFh	外围总线3	-	-
4006 0000h to 4007 FFFFh	外围总线4	-	-
4008 0000h to 4009 FFFFh	周边总线5	-	-
400A 0000h to 400B FFFFh	Reserved	-	-
400C 0000h to 400D FFFFh	周边总线7	-	-
400E 0000h to 400F FFFFh	Reserved	E	E
4010 0000h to 407F FFFFh	周边总线9	-	-
4080 0000h to 5FFF FFFFh	Reserved	E	E
6000 0000h to 67FF FFFFh	Reserved	-	-
6800 0000h to 7FFF FFFFh	Reserved	E	E
8000 0000h to 97FF FFFFh	Reserved	-	-
9800 0000h to DFFF FFFFh	Reserved	E	E
E000 0000h to FFFF FFFFh	Cortex®-M4系统	-	E

E：发生非法地址访问错误的路径。

注1.总线模块不检测内存镜像功能(MMF)是否切换了地址。因此，如果启用MMF并且CPU访问02000000h，则不会发生错误。这取决于交换的地址。

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If the MMF is disabled and the CPU accesses 0200 0000h, the bus module can detect the error.

The bus module detects an access error resulting from access to a reserved area, for example if no area is assigned to the slave:

- 0200 0000h to 1FFD FFFFh: access error detection
- 0000 0000h to 01FF FFFFh: memory bus 1 no access error detection.

14.4.4 Timeout

For some peripheral modules, a timeout error occurs with the module-stop function. When there is no response from the slave for a certain period of time, a timeout error is detected and is returned to the requesting master IP using the AHB-Lite error response protocol.

14.5 Notes on using Flash Cache

When using the flash cache through access from the CPU, the Arm MPU should also be set to cacheable. See references 1. and 2. for more information.

14.6 References

1. *ARM®v7-M Architecture Reference Manual* (ARM DDI 0403D)
2. *ARM® Cortex®-M4 Devices Generic User Guide* (ARM DUI 0553A).

如果MMF被禁用并且CPU访问02000000h，则总线模块可以检测到错误。

总线模块检测到因访问保留区域而导致的访问错误，例如，如果没有为从站分配区域：

- 02000000h至1FFDFFFFh：访问错误检测
- 00000000h至01FFFFFFh：内存总线1无访问错误检测。

14.4.4 Timeout

对于某些外围模块，模块停止功能会发生超时错误。当从机在一定时间内没有响应时，检测到超时错误并使用AHBLite错误响应协议返回给请求的主机IP。

14.5 使用FlashCache的注意事项

当通过CPU访问使用闪存缓存时，ArmMPU也应设置为可缓存。有关详细信息，请参阅参考文献1.和2.。

14.6 References

1. ARM®v7-M架构参考手册(ARMDDI0403D)
2. ARM®Cortex®-M4设备通用用户指南(ARMDUI0553A)。

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15. Memory Protection Unit (MPU)

15.1 Overview

The MCU has four Memory Protection Units (MPUs) and a CPU stack pointer monitor function. Table 15.1 lists the MPU specifications and Table 15.2 shows the behavior on detection of each MPU error.

Table 15.1 MPU specifications

Classification	Module/Function	Specifications
Illegal memory access	Arm® Cortex®-M4 CPU	• Arm CPU has a default memory map. If the CPU makes an illegal access, an exception interrupt occurs. • The MPU can change a default memory map.
	CPU stack pointer monitor	2 regions: • Main Stack Pointer (MSP) • Process Stack Pointer (PSP).
Memory protection	Arm MPU	Memory protection function for the CPU: • 8 MPU regions with subregions and background region.
	Bus master MPU	Memory protection function for each bus master except for the CPU: • Bus master MPU group A: 32 regions.
	Bus slave MPU	Memory protection function for each bus slave
Security	Security MPU	Protect accesses from non-secure programs to the following secure regions: • 2 regions (PC) • 4 regions (code flash, SRAM, two secure functions).

Table 15.2 Behavior on MPU error detection

MPU type	Notification type	Bus access on error detection	Storing of error access information
CPU stack pointer monitor	Reset or non-maskable interrupt	Don't care	Not stored
Arm MPU	Hard fault	• Does not correctly have write access • Does not correctly have read access.	Stored in the Cortex-M4 processor
Bus master MPU	Reset or non-maskable interrupt	• Write access to the protection region • Read access to the protection region.	Stored
Bus slave MPU	• Reset or non-maskable interrupt • Hard fault.	• Write access ignored • Read access read as 0.	Stored
Security MPU	Not notified	• Does not correctly have write access • Does not correctly have read access.	Not stored

For information on error access for the Arm MPU, see section 15.7. For information on error access for other MPUs, see section 14.3.3, Bus Error Address Register (BUSnERRADD) (n = 1 to 4) and section 14.3.4, Bus Error Status Register (BUSnERRSTAT) (n = 1 to 4) in section 14, Buses.

15.2 CPU Stack Pointer Monitor

The CPU stack pointer monitor detects underflows and overflows of the stack pointer. Because the Arm CPU has two stack pointers, a Main Stack Pointer (MSP) and a Process Stack Pointer (PSP), it supports two CPU stack pointer monitors. If a stack pointer underflow or overflow is detected, the CPU stack pointer monitor generates a reset or a non-maskable interrupt.

The CPU stack pointer monitor is enabled by setting the Stack Pointer Monitor Enable bit in the Stack Pointer Monitor Access Control Register (MSPMPUCTL, PSPMPUCTL) to 1.

15. 内存保护单元(MPU)

15.1 Overview

MCU具有四个内存保护单元(MPU)和一个CPU堆栈指针监控功能。表15.1列出了MPU规格和表15.2显示了检测每个MPU错误时的行为。

Table 15.1 MPU specifications

Classification	Module/Function	Specifications
非法内存访问	Arm®Cortex®-M4CPU	ArmCPU有一个默认的内存映射。如果CPU进行非法访问，则会发生异常中断。MPU可以更改默认内存映射。
	CPU堆栈指针监视器	2个区域： 主堆栈指针(MSP) 进程堆栈指针(PSP)。
内存保护	Arm MPU	CPU的内存保护功能： 8个带有子区域和背景区域的MPU区域。
	总线主控MPU	除CPU外的每个总线主控的内存保护功能： 总线主控MPU组A：32个区域。
	总线从机MPU	每个总线从机的内存保护功能
Security	Security MPU	保护非安全程序对以下安全区域的访问： 2个区域(PC) 4个区域（代码闪存、SRAM、两个安全功能）。

Table 15.2 MPU错误检测的行为

MPU type	通知类型	错误检测时的总线访问	存储错误访问信息
CPU堆栈指针监视器	复位或不可屏蔽中断	Don't care	未存储
Arm MPU	硬故障	没有正确的写入权限 没有正确的读取权限。	存储在Cortex-M4处理器中
总线主控MPU	复位或不可屏蔽中断	对保护区域的写访问权限 对保护区域的读访问权限。	Stored
总线从机MPU	复位或不可屏蔽中断 硬故障。	写访问被忽略 读访问读为0。	Stored
Security MPU	未通知	没有正确的写入权限 没有正确的读取权限。	未存储

有关ArmMPU错误访问的信息，请参阅第15.7节。有关其他MPU的错误访问的信息，请参阅第14.3.3节，总线错误地址寄存器(BUSnERRADD)(n=1到4)和第14.3.4节，总线错误状态寄存器(BUSnERRSTAT)(n=1到4)第14节，公共汽车。

15.2 CPU堆栈指针监视器

CPU堆栈指针监视器检测堆栈指针的下溢和溢出。由于ArmCPU有两个堆栈指针，一个主堆栈指针(MSP)和一个进程堆栈指针(PSP)，因此它支持两个CPU堆栈指针监视器。如果检测到堆栈指针下溢或溢出，CPU堆栈指针监视器会生成复位或不可屏蔽中断。

通过设置堆栈指针监视器中的堆栈指针监视器启用位来启用CPU堆栈指针监视器访问控制寄存器(MSPMPUCTL PSPMPUCTL)为1。

Table 15.3 lists the specifications of the CPU stack pointer monitor, Figure 15.1 shows a block diagram, and Figure 15.2 shows the register setting flow.

Table 15.3 CPU stack pointer monitor specifications

Parameter	Description
SRAM region	Region to be covered by memory protection
Number of regions	2 regions: • Main Stack Pointer (MSP) • Process Stack Pointer (PSP).
Address specification for individual regions	Region start and end addresses configurable
Stack pointer monitor enable or disable setting for individual regions	Stack pointer monitor for individual regions can be enabled or disabled
Operation on error detection	Reset or non-maskable interrupts can be generated
Register protection	Registers can be protected from illegal writes

表15.3列出了CPU堆栈指针监视器的规格，图15.1显示了框图，图15.2显示了寄存器设置流程。

Table 15.3 CPU堆栈指针监视器规格

Parameter	Description
SRAM region	内存保护要覆盖的区域
地区数量	2个区域： 主堆栈指针(MSP) 进程堆栈指针(PSP)。
个别地区的地址规范	区域开始和结束地址可配置
堆栈指针监视器启用或禁用各个区域的设置	可以启用或禁用各个区域的堆栈指针监视器
错误检测操作	可以产生复位或不可屏蔽中断
注册保护	可以保护寄存器免受非法写入

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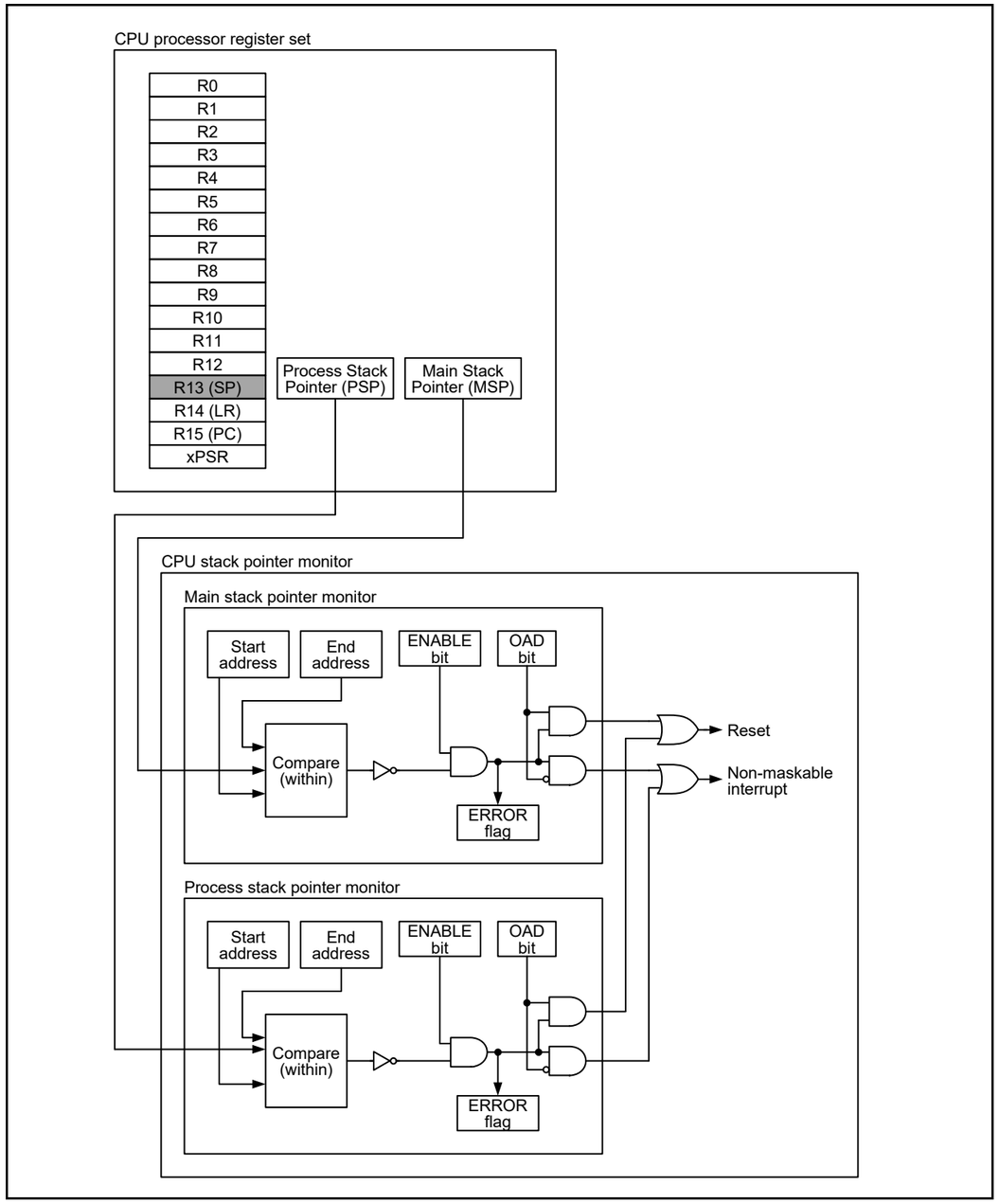

Figure 15.1 CPU stack pointer monitor block diagram

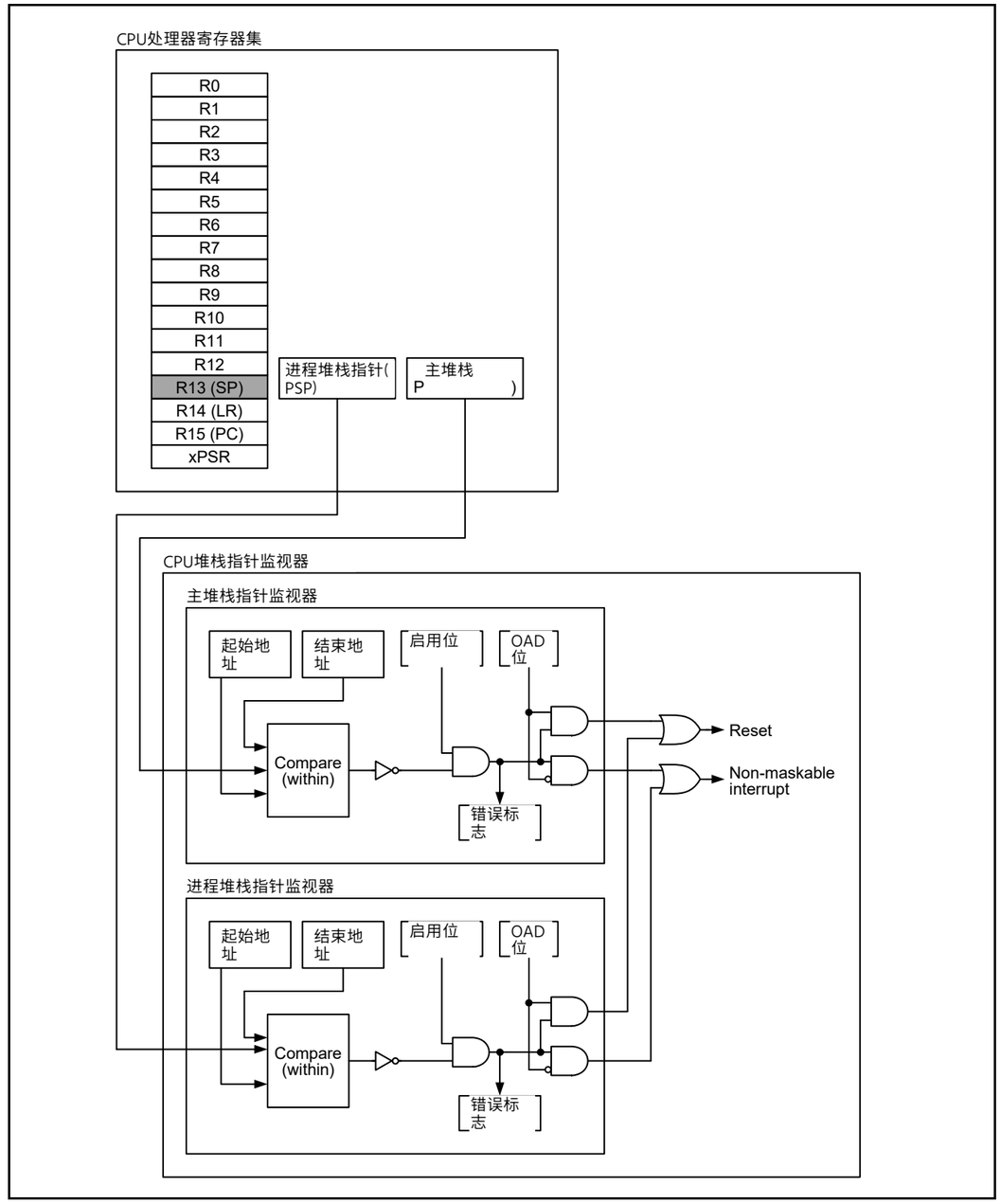

Figure 15.1 CPU堆栈指针监视器框图

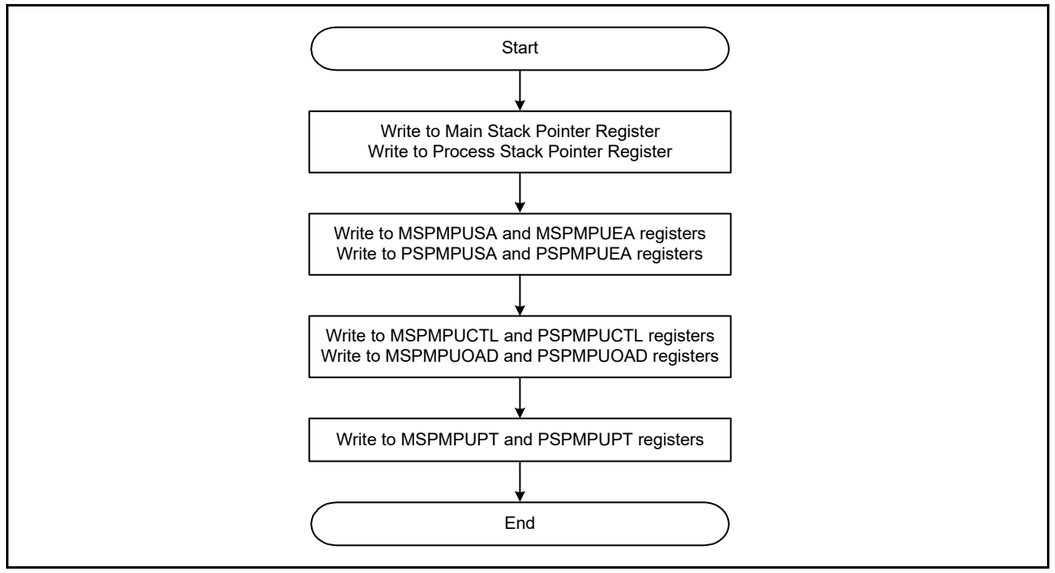

Figure 15.2 Register setting flow

15.2.1 Register Descriptions

Note: Bus access must be stopped before writing to MPU registers.

15.2.1.1 Main Stack Pointer Monitor Start Address Register (MSPMPUSA)

Address(es): SPMON.MSPMPUSA 4000 0D08h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MSPMPUSA[31:16]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MSPMPUSA[15:0]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	MSPMPUSA[31:0]	Region Start Address	Address where the region starts, for use in region determination. The lower 2 bits should be 0. The value range is from 1FF0 0000h to 1FFE FFFCh, excluding reserved areas.	R/W

The MSPMPUSA and MSPMPUEA registers specify the CPU stack region in the SRAM (1FF0 0000h to 1FFE FFFFh, excluding reserved areas). For SRAM area to be covered, see Figure 4.1, Memory map.

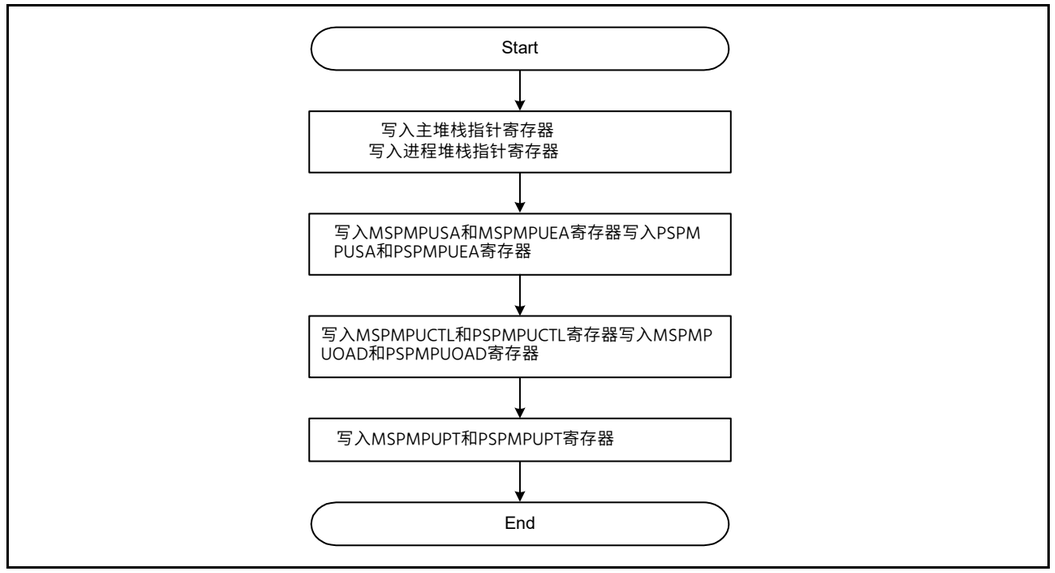

Figure 15.2 注册设置流程

15.2.1 注册说明

Note: 在写入MPU寄存器之前必须停止总线访问。

15.2.1.1 主堆栈指针监视器起始地址寄存器(MSPMPUSA)

Address(es): SPMON.MSPMPUSA 4000 0D08h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MSPMPUSA[31:16]															
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MSPMPUSA[15:0]															
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	MSPMPUSA[31:0]	区域起始地址	区域开始的地址，用于区域确定。 低2位应为0。取值范围为1FF00000h到1FFEFFFCh，不包括保留区。	R/W

MSPMPUSA和MSPMPUEA寄存器指定SRAM中的CPU堆栈区域（1FF00000h到1FFEFFFFh，不包括保留区域）。对于要覆盖的SRAM区域，请参见图4.1，存储器映射。

15.2.1.2 Main Stack Pointer Monitor End Address Register (MSPMPUEA)

Address(es): SPMON.MSPMPUEA 4000 0D0Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MSPMPUEA[31:16]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MSPMPUEA[15:0]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	MSPMPUEA[31:0]	Region End Address	Address where the region ends, for use in region determination. The lower 2 bits should be 1. The value range is from 1FF0 0003h to 1FFE FFFFh, excluding reserved areas.	R/W

15.2.1.3 Process Stack Pointer Monitor Start Address Register (PSPMPUSA)

Address(es): SPMON.PSPMPUSA 4000 0D18h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	PSPMPUSA[31:16]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PSPMPUSA[15:0]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	PSPMPUSA[31:0]	Region Start Address	Address where the region starts, for use in region determination. The lower 2 bits should be 0. The value range is from 1FF0 0000h to 1FFE FFFCh, excluding reserved areas.	R/W

The PSPMPUSA and PSPMPUEA registers specify the CPU stack region in the SRAM (1FF0 0000h to 1FFE FFFFh, excluding reserved areas). For SRAM area to be covered, see Figure 4.1, Memory map.

15.2.1.2 主堆栈指针监视器结束地址寄存器(MSPMPUEA)

Address(es): SPMON.MSPMPUEA 4000 0D0Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MSPMPUEA[31:16]															
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MSPMPUEA[15:0]															
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	MSPMPUEA[31:0]	区域结束地址	区域结束的地址，用于区域确定。 低2位应为1。取值范围为1FF00003h到1FFEFFFFh，不包括保留区。	R/W

15.2.1.3 进程堆栈指针监视器起始地址寄存器(PSPMPUSA)

Address(es): SPMON.PSPMPUSA 4000 0D18h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	PSPMPUSA[31:16]															
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PSPMPUSA[15:0]															
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	PSPMPUSA[31:0]	区域起始地址	区域开始的地址，用于区域确定。 低2位应为0。取值范围为1FF00000h到1FFEFFFCh，不包括保留区。	R/W

PSPMPUSA和PSPMPUEA寄存器指定SRAM中的CPU堆栈区域（1FF00000h到1FFEFFFFh，不包括保留区域）。对于要覆盖的SRAM区域，请参见图4.1，存储器映射。

15.2.1.4 Process Stack Pointer Monitor End Address Register (PSPMPUEA)

Address(es): SPMON.PSPMPUEA 4000 0D1Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	PSPMPUEA[31:16]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PSPMPUEA[15:0]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	PSPMPUEA[31:0]	Region End Address	Address where the region ends, for use in region determination. The lower 2 bits should be 1. The value range is from 1FF0 0003h to1FFE FFFFh, excluding reserved areas.	R/W

15.2.1.5 Stack Pointer Monitor Operation After Detection Register (MSPMPUOAD, PSPMPUOAD)

Address(es): SPMON.MSPMPUOAD 4000 0D00h, SPMON.PSPMPUOAD 4000 0D10h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	—	OAD
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	OAD	Operation after Detection	0: Non-maskable interrupt 1: Reset.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15 to b8	KEY[7:0]	Key Code	These bits enable or disable writes to the OAD bit	R/(W)*1

Note 1. Write data is not saved.

OAD bit (Operation after Detection)

The OAD bit selects either a reset or a non-maskable interrupt when a stack pointer underflow or overflow is detected by the CPU stack pointer monitor.

The main and the process stack pointer monitors each uses an OAD bit to determine which signal is generated when a stack pointer underflow or overflow is detected. When writing to the OAD bit, write A5h simultaneously to the KEY[7:0] bits using halfword access.

KEY[7:0] bits (Key Code)

The KEY[7:0] bits enable or disable writes to the OAD bit. When writing to the OAD bit, write A5h simultaneously to the KEY[7:0] bits. When values other than A5h are written to the KEY[7:0] bits, the OAD bit is not updated. The KEY[7:0] bits are always read as 00h.

15.2.1.4 进程堆栈指针监视器结束地址寄存器(PSPMPUEA)

Address(es): SPMON.PSPMPUEA 4000 0D1Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	PSPMPUEA[31:16]															
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PSPMPUEA[15:0]															
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	PSPMPUEA[31:0]	区域结束地址	区域结束的地址，用于区域确定。 低2位应为1。取值范围为1FF00003h到1FFEFFFFh，不包括保留区。	R/W

15.2.1.5 检测寄存器后的堆栈指针监视器操作（MSPPUOAD，PSPMPUOAD)

Address(es): SPMON.MSPMPUOAD 4000 0D00h, SPMON.PSPMPUOAD 4000 0D10h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	—	OAD
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	OAD	检测后的操作	0：不可屏蔽中断1：复位 。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15 to b8	KEY[7:0]	关键代码	这些位启用或禁用对OAD位的写入	R/(W)*1

注1.写入数据不保存。

OAD位（检测后操作）

当CPU堆栈指针监视器检测到堆栈指针下溢或溢出时，OAD位选择复位或不可屏蔽中断。

主堆栈指针监视器和进程堆栈指针监视器各自使用一个OAD位来确定在检测到堆栈指针下溢或溢出时生成哪个信号。写入OAD位时，使用半字访问同时将A5h写入KEY[7:0]位。

KEY[7:0]位（键码）

KEY[7:0]位启用或禁用对OAD位的写入。写入OAD位时，同时将A5h写入KEY[7:0]位。将A5h以外的值写入KEY[7:0]位时，不会更新OAD位。KEY[7:0]位总是读为00h。

15.2.1.6 Stack Pointer Monitor Access Control Register (MSPMPUCTL, PSPMPUCTL)

Address(es): SPMON.MSPMPUCTL 4000 0D04h, SPMON.PSPMPUCTL 4000 0D14h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	ERROR	—	—	—	—	—	—	—	ENABLE
Value after reset:	0	0	0	0	0	0	0	0/1*1	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	ENABLE	Stack Pointer Monitor Enable	0: Disable stack pointer monitor 1: Enable stack pointer monitor.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b8	ERROR	Stack Pointer Monitor Error Flag	0: No stack pointer overflow or underflow occurred 1: Stack pointer overflow or underflow occurred.	R/W
b15 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. The initial value depends on the reset generation source.

ENABLE bit (Stack Pointer Monitor Enable)

The ENABLE bit enables or disables the stack pointer monitor function, independently set for the main stack pointer monitor and the process stack pointer monitor.

When the MSPMPUCTL.ENABLE bit is set to 1, the following registers are available:

- MSPMPUSA
- MSPMPUEA
- MSPMPUOAD.

When the PSPMPUCTL.ENABLE bit is set to 1, the following registers are available:

- PSPMPUSA
- PSPMPUEA
- PSPMPUOAD.

ERROR bit (Stack Pointer Monitor Error Flag)

The ERROR bit indicates the status of the stack pointer monitor. Each stack pointer monitor has an independent ERROR bit.

[Setting condition]

- Overflow or underflow of the stack pointer.

[Clearing condition]

- 0 is written to this bit
- A reset other than the bus master MPU error reset, bus slave MPU error reset, and stack pointer error reset.

Note: Only 0 can be written to the ERROR bit.

15.2.1.6 堆栈指针监视器访问控制寄存器(MSMPPUCTL PSPMPUCTL)

Address(es): SPMON.MSPMPUCTL 4000 0D04h, SPMON.PSPMPUCTL 4000 0D14h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	ERROR	—	—	—	—	—	—	—	ENABLE
重置后的值:	0	0	0	0	0	0	0	0/1*1	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	ENABLE	堆栈指针监视器 Enable	0：禁用堆栈指针监视器1：启用堆栈指针监视器。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b8	ERROR	堆栈指针监视器错误标志	0：未发生堆栈指针上溢或下溢1：发生堆栈指针上溢或下溢。	R/W
b15 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W

注1.初始值取决于复位产生源。

ENABLE位（堆栈指针监视器启用）

ENABLE位启用或禁用堆栈指针监视器功能，分别为主堆栈指针监视器和进程堆栈指针监视器设置。

当MSMPPUCTL.ENABLE位设置为1时，以下寄存器可用：

- MSPMPUSA
- MSPMPUEA
- MSPMPUOAD.

当PSPMPUCTL.ENABLE位设置为1时，以下寄存器可用：

- PSPMPUSA
- PSPMPUEA
- PSPMPUOAD.

ERROR位（堆栈指针监视器错误标志）

ERROR位指示堆栈指针监视器的状态。每个堆栈指针监视器都有一个独立的ERROR位。

[Setting condition]

- 堆栈指针上溢或下溢。

[Clearing condition]

- 0写入该位
- 总线主MPU错误复位、总线从MPU错误复位和堆栈指针错误复位以外的复位。

Note: ERROR位只能写入0。

15.2.1.7 Stack Pointer Monitor Protection Register (MSPMPUPT, PSPMPUPT)

Address(es): SPMON.MSPMPUPT 4000 0D06h, SPMON.PSPMPUPT 4000 0D16h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	—	PROTECT
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	PROTECT	Protection of Register	0: Stack pointer monitor register writes are permitted 1: Stack pointer monitor register writes are protected. Reads are permitted.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15 to b8	KEY[7:0]	Key Code	These bits enable or disable writes to the PROTECT bit.	R/(W)*1

Note 1. Write data is not saved.

PROTECT bit (Protection of Register)

The PROTECT bit enables or disables writes to the associated registers to be protected, independently set for the main stack pointer monitor and the process stack pointer monitor.

MSPMPUPT.PROTECT controls the following main stack pointer protection registers:

- MSPMPUCTL
- MSPMPUSA
- MSPMPUEA.

PSPMPUT.PROTECT controls the following process stack pointer protection registers:

- PSPMPUCTL
- PSPMPUSA
- PSPMPUEA.

When writing to the PROTECT bit, simultaneously write A5h to the KEY[7:0] bits, using halfword access.

KEY[7:0] bits (Key Code)

The KEY[7:0] bits enable or disable writes to the PROTECT bit. When writing to the PROTECT bit, simultaneously write A5h to the KEY[7:0] bits. When other values are written, the PROTECT bit is not updated. The KEY[7:0] bits are always read as 00h.

15.2.2 Operation

15.2.2.1 Protecting the registers

To protect registers related to the CPU stack pointer monitor, set the associated PROTECT bit.

15.2.2.2 Overflow and underflow errors

The CPU stack pointer monitor generates an error if an overflow or underflow error is detected. Set the OAD bit to select whether the error is reported as a non-maskable interrupt or reset. The non-maskable interrupt status is indicated in ICU.NMISR.SPEST, see section 13, Interrupt Controller Unit (ICU). Reset status is indicated in SYSTEM.RSTSR1.SPERF, see section 6, Resets.

When ICU.NMISR.SPEST indicates that a CPU stack pointer monitor interrupt occurred, confirm it by checking the ERROR bit in MSPMPUCTL and PSPMPUCTL to determine whether the error is a main stack pointer monitor error or process stack pointer monitor error.

15.2.1.7 堆栈指针监视器保护寄存器(MSPMPUPT PSPMPUPT)

Address(es): SPMON.MSPMPUPT 4000 0D06h, SPMON.PSPMPUPT 4000 0D16h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	—	PROTECT
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	PROTECT	登记保护	0：允许堆栈指针监视寄存器写入1：堆栈指针监视寄存器写入受到保护。允许读取。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15 to b8	KEY[7:0]	关键代码	这些位启用或禁用对PROTECT位的写入。	R/(W)*1

注1.写入数据不保存。

PROTECT位（寄存器保护）

PROTECT位启用或禁用对要保护的相关寄存器的写入，为主堆栈指针监视器和进程堆栈指针监视器独立设置。

MSPMPUPT.PROTECT控制以下主堆栈指针保护寄存器：

- MSPMPUCTL
- MSPMPUSA
- MSPMPUEA.

PSPMPUT.PROTECT控制以下进程堆栈指针保护寄存器：

- PSPMPUCTL
- PSPMPUSA
- PSPMPUEA.

写入PROTECT位时，同时使用半字访问将A5h写入KEY[7:0]位。

KEY[7:0]位（键码）

KEY[7:0]位启用或禁用对PROTECT位的写入。写入PROTECT位时，同时将A5h写入KEY[7:0]位。写入其他值时，PROTECT位不会更新。KEY[7:0]位总是读为00h。

15.2.2 Operation

15.2.2.1 保护寄存器

要保护与CPU堆栈指针监视器相关的寄存器，请设置相关的PROTECT位。

15.2.2.2 上溢和下溢错误

如果检测到上溢或下溢错误，CPU堆栈指针监视器会生成错误。设置OAD位以选择将错误报告为不可屏蔽中断还是复位。不可屏蔽中断状态在ICU.NMISR.SPEST中指示，参见第13节，中断控制器单元(ICU)。复位状态显示在

SYSTEM.RSTSR1.SPERF，参见第6节，重置。

当ICU.NMISR.SPEST指示发生CPU堆栈指针监视器中断时，请通过检查
MSPMPUCTL和PSPMPUCTL中的ERROR位来确定该错误是主堆栈指针监视器错误还是进程堆栈指针监视器错误。

A non-maskable interrupt remains set when a stack pointer overflows or underflows. To clear the error, clear the non-maskable interrupt flag by writing 1 to ICU.NMICLR.SPECLR. Write 0 to clear the ERROR bit in MSPMPUCTL or PSPMPUCTL.

15.3 Arm MPU

The Arm MPU provides full support for:

- 8 protected regions
- Overlapping protected regions, with ascending priority:
  7 = highest priority
  0 = lowest priority.
- Access permissions
- Export of memory attributes to the system.

Arm MPU mismatches and permission violations invoke the programmable-priority MemManage fault (HardFault) handler. For details, see section 15.7.

15.4 Bus Master MPU

The bus master MPU monitors the addresses accessed by the bus masters in the entire address space (0000 0000h to FFFF FFFFh). The access control information, consisting of read and write permissions, can be independently set for up to 32 regions. The bus master MPU monitors access to each region based on these settings. If access to a protected region is detected, the bus master MPU generates a reset or a non-maskable interrupt. For details on error access, see section 14.3.3 and section 14.3.4 in section 14, Buses.

Table 15.4 lists the specifications of the bus master MPU and Figure 15.3 shows a block diagram. Figure 15.4 shows bus master MPU group A.

Table 15.4 Bus master MPU specifications

Parameter	Specifications
Protected master groups	Bus master MPU group A: DMA bus.
Protected region	0000 0000h to FFFF FFFFh
Number of regions	Bus master MPU group A: 32 regions.
Address specification for individual regions	Region start and end addresses configurable
Enable/disable setting for memory protection in individual regions	Settings enabled or disabled for the associated region
Access-control settings for individual regions	Permission to read and write
Operation on error detection	Reset or non-maskable interrupt
Register protection	Register can be protected from illegal writes

当堆栈指针上溢或下溢时，不可屏蔽中断保持设置。要清除错误，请通过将1写入ICU.NMICLR.SPECLR来清除不可屏蔽中断标志。写入0以清除MSMPPUCTL或PSPMPUCTL中的ERROR位。

15.3 Arm MPU

ArmMPU全面支持：

- 8个保护区
- 重叠的受保护区域，优先级升序：7=最高优先级0=
  最低优先级。
- 访问权限
- 将内存属性导出到系统。

ArmMPU不匹配和权限违规调用可编程优先级MemManage故障(HardFault)处理程序。有关详细信息，请参阅第15.7节。

15.4 总线主控MPU

总线主控MPU监视总线主控在整个地址空间（00000000h到FFFFFFFFh）。访问控制信息，由读写权限组成，最多可独立设置32个区域。总线主控MPU根据这些设置监控对每个区域的访问。如果检测到对受保护区域的访问，总线主控MPU会产生复位或不可屏蔽中断。有关错误访问的详细信息，请参阅第14节，总线中的第14.3.3节和第14.3.4节。

表15.4列出了总线主控MPU的规格，图15.3显示了框图。图15.4显示了总线主控MPU组A。

Table 15.4 总线主控MPU规格

Parameter	Specifications
受保护的主组	总线主控MPU组A：DMA总线。
保护区	0000 0000h to FFFF FFFFh
地区数量	总线主控MPU组A：32个区域。
个别地区的地址规范	区域开始和结束地址可配置
在各个区域启用禁用内存保护设置	为关联区域启用或禁用的设置
各个区域的访问控制设置	读写权限
错误检测操作	复位或不可屏蔽中断
注册保护	可以保护寄存器免受非法写入

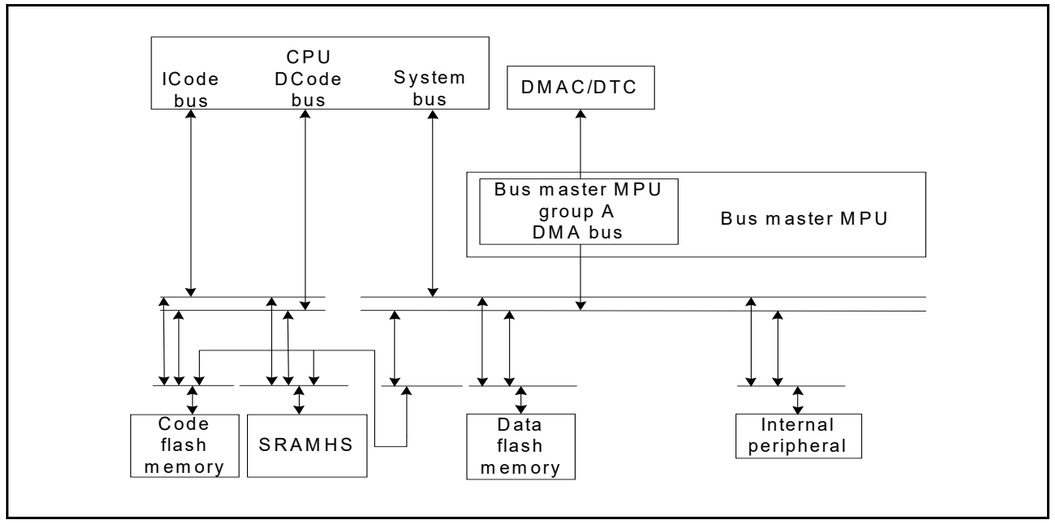

Figure 15.3 MPU bus master block diagram

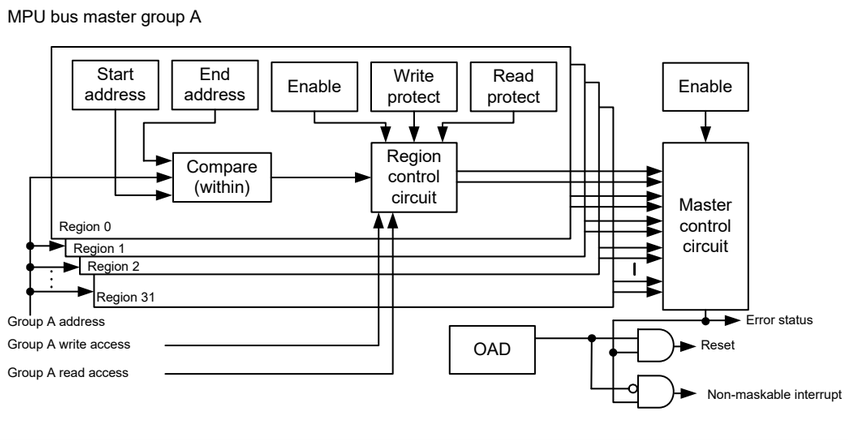

Figure 15.4 MPU bus master group A

15.4.1 Register Descriptions

Note: Bus access must be stopped before writing to MPU registers.

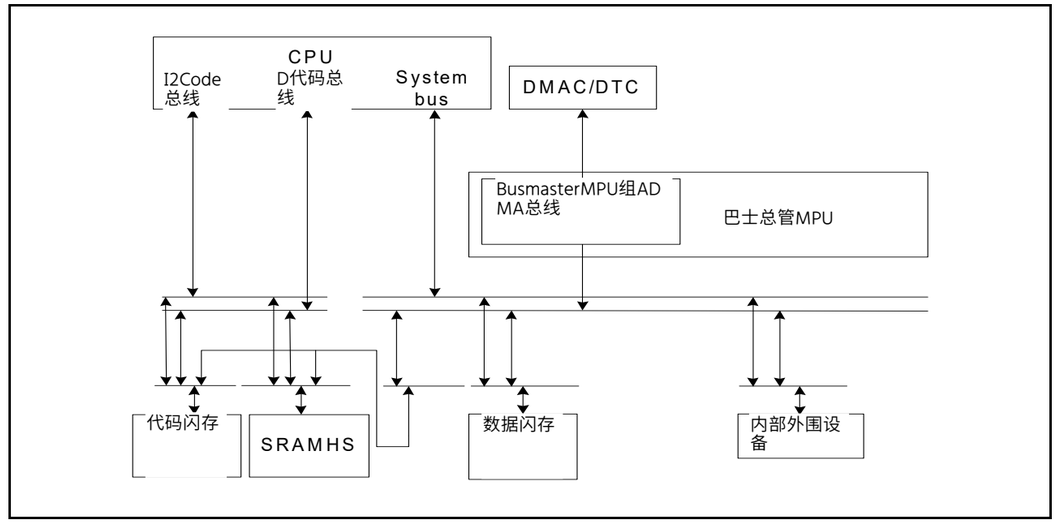

Figure 15.3 MPU总线主控框图

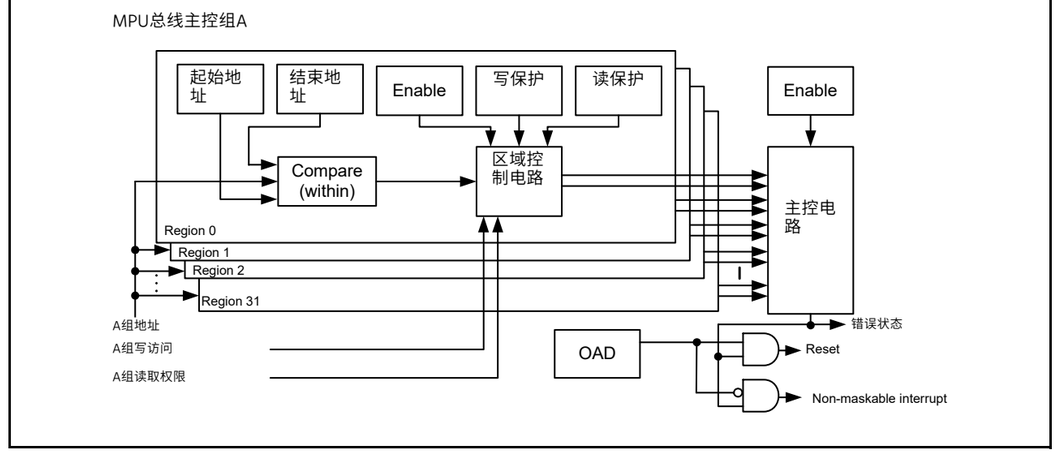

Figure 15.4 MPU总线主控组A

15.4.1 注册说明

Note: 在写入MPU寄存器之前必须停止总线访问。

15.4.1.1 Group A Region n Start Address Register (MMPUSAn) (n = 0 to 31)

Address(es): MMPU.MMPUSA0 4000 0204h, MMPU.MMPUSA1 4000 0214h, MMPU.MMPUSA2 4000 0224h, MMPU.MMPUSA3 4000 0234h, MMPU.MMPUSA4 4000 0244h, MMPU.MMPUSA5 4000 0254h, MMPU.MMPUSA6 4000 0264h, MMPU.MMPUSA7 4000 0274h, MMPU.MMPUSA8 4000 0284h, MMPU.MMPUSA9 4000 0294h, MMPU.MMPUSA10 4000 02A4h, MMPU.MMPUSA11 4000 02B4h, MMPU.MMPUSA12 4000 02C4h, MMPU.MMPUSA13 4000 02D4h, MMPU.MMPUSA14 4000 02E4h, MMPU.MMPUSA15 4000 02F4h, MMPU.MMPUSA16 4000 0304h, MMPU.MMPUSA17 4000 0314h, MMPU.MMPUSA18 4000 0324h, MMPU.MMPUSA19 4000 0334h, MMPU.MMPUSA20 4000 0344h, MMPU.MMPUSA21 4000 0354h, MMPU.MMPUSA22 4000 0364h, MMPU.MMPUSA23 4000 0374h, MMPU.MMPUSA24 4000 0384h, MMPU.MMPUSA25 4000 0394h, MMPU.MMPUSA26 4000 03A4h, MMPU.MMPUSA27 4000 03B4h, MMPU.MMPUSA28 4000 03C4h, MMPU.MMPUSA29 4000 03D4h, MMPU.MMPUSA30 4000 03E4h, MMPU.MMPUSA31 4000 03F4h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MMPUSA[31:16]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MMPUSA[15:0]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	MMPUSA[31:0]	Region Start Address	Address where the region starts, for use in region determination. The lower 2 bits should be 0.	R/W

15.4.1.2 Group A Region n End Address Register (MMPUEAn) (n = 0 to 31)

Address(es): MMPU.MMPUEA0 4000 0208h, MMPU.MMPUEA1 4000 0218h, MMPU.MMPUEA2 4000 0228h, MMPU.MMPUEA3 4000 0238h, MMPU.MMPUEA4 4000 0248h, MMPU.MMPUEA5 4000 0258h, MMPU.MMPUEA6 4000 0268h, MMPU.MMPUEA7 4000 0278h, MMPU.MMPUEA8 4000 0288h, MMPU.MMPUEA9 4000 0298h, MMPU.MMPUEA10 4000 02A8h, MMPU.MMPUEA11 4000 02B8h, MMPU.MMPUEA12 4000 02C8h, MMPU.MMPUEA13 4000 02D8h, MMPU.MMPUEA14 4000 02E8h, MMPU.MMPUEA15 4000 02F8h, MMPU.MMPUEA16 4000 0308h, MMPU.MMPUEA17 4000 0318h, MMPU.MMPUEA18 4000 0328h, MMPU.MMPUEA19 4000 0338h, MMPU.MMPUEA20 4000 0348h, MMPU.MMPUEA21 4000 0358h, MMPU.MMPUEA22 4000 0368h, MMPU.MMPUEA23 4000 0378h, MMPU.MMPUEA24 4000 0388h, MMPU.MMPUEA25 4000 0398h, MMPU.MMPUEA26 4000 03A8h, MMPU.MMPUEA27 4000 03B8h, MMPU.MMPUEA28 4000 03C8h, MMPU.MMPUEA29 4000 03D8h, MMPU.MMPUEA30 4000 03E8h, MMPU.MMPUEA31 4000 03F8h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MMPUEA[31:16]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MMPUEA[15:0]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	MMPUEA[31:0]	Region End Address	Address where the region ends, for use in region determination. The lower 2 bits should be 1.	R/W

15.4.1.1 A组区域n起始地址寄存器(MMPUSan)（n=0至31）

Address(es): MMPU.MMPUSA0 4000 0204h, MMPU.MMPUSA1 4000 0214h, MMPU.MMPUSA2 4000 0224h, MMPU.MMPUSA3 4000 0234h, MMPU.MMPUSA4 4000 0244h, MMPU.MMPUSA5 4000 0254h, MMPU.MMPUSA6 4000 0264h, MMPU.MMPUSA7 4000 0274h, MMPU.MMPUSA8 4000 0284h, MMPU.MMPUSA9 4000 0294h, MMPU.MMPUSA10 4000 02A4h, MMPU.MMPUSA11 4000 02B4h, MMPU.MMPUSA12 4000 02C4h, MMPU.MMPUSA13 4000 02D4h, MMPU.MMPUSA14 4000 02E4h, MMPU.MMPUSA15 4000 02F4h, MMPU.MMPUSA16 4000 0304h, MMPU.MMPUSA17 4000 0314h, MMPU.MMPUSA18 4000 0324h, MMPU.MMPUSA19 4000 0334h, MMPU.MMPUSA20 4000 0344h, MMPU.MMPUSA21 4000 0354h, MMPU.MMPUSA22 4000 0364h, MMPU.MMPUSA23 4000 0374h, MMPU.MMPUSA24 4000 0384h, MMPU.MMPUSA25 4000 0394h, MMPU.MMPUSA26 4000 03A4h, MMPU.MMPUSA27 4000 03B4h, MMPU.MMPUSA28 4000 03C4h, MMPU.MMPUSA29 4000 03D4h, MMPU.MMPUSA30 4000 03E4h, MMPU.MMPUSA31 4000 03F4h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MMPUSA[31:16]															
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MMPUSA[15:0]															
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	MMPUSA[31:0]	区域起始地址	区域开始的地址，用于区域确定。低2位应为0。	R/W

15.4.1.2 A组区域n结束地址寄存器(MMPUEAn)(n=0到31)

Address(es): MMPU.MMPUEA0 4000 0208h, MMPU.MMPUEA1 4000 0218h, MMPU.MMPUEA2 4000 0228h, MMPU.MMPUEA3 4000 0238h, MMPU.MMPUEA4 4000 0248h, MMPU.MMPUEA5 4000 0258h, MMPU.MMPUEA6 4000 0268h, MMPU.MMPUEA7 4000 0278h, MMPU.MMPUEA8 4000 0288h, MMPU.MMPUEA9 4000 0298h, MMPU.MMPUEA10 4000 02A8h, MMPU.MMPUEA11 4000 02B8h, MMPU.MMPUEA12 4000 02C8h, MMPU.MMPUEA13 4000 02D8h, MMPU.MMPUEA14 4000 02E8h, MMPU.MMPUEA15 4000 02F8h, MMPU.MMPUEA16 4000 0308h, MMPU.MMPUEA17 4000 0318h, MMPU.MMPUEA18 4000 0328h, MMPU.MMPUEA19 4000 0338h, MMPU.MMPUEA20 4000 0348h, MMPU.MMPUEA21 4000 0358h, MMPU.MMPUEA22 4000 0368h, MMPU.MMPUEA23 4000 0378h, MMPU.MMPUEA24 4000 0388h, MMPU.MMPUEA25 4000 0398h, MMPU.MMPUEA26 4000 03A8h, MMPU.MMPUEA27 4000 03B8h, MMPU.MMPUEA28 4000 03C8h, MMPU.MMPUEA29 4000 03D8h, MMPU.MMPUEA30 4000 03E8h, MMPU.MMPUEA31 4000 03F8h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MMPUEA[31:16]															
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MMPUEA[15:0]															
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	MMPUEA[31:0]	区域结束地址	区域结束的地址，用于区域确定。低2位应为1。	R/W

15.4.1.3 Group A Region n Access Control Register (MMPUACAn) (n = 0 to 31)

Address(es): MMPU.MMPUACA0 4000 0200h, MMPU.MMPUACA1 4000 0210h, MMPU.MMPUACA2 4000 0220h, MMPU.MMPUACA3 4000 0230h, MMPU.MMPUACA4 4000 0240h, MMPU.MMPUACA5 4000 0250h, MMPU.MMPUACA6 4000 0260h, MMPU.MMPUACA7 4000 0270h, MMPU.MMPUACA8 4000 0280h, MMPU.MMPUACA9 4000 0290h, MMPU.MMPUACA10 4000 02A0h, MMPU.MMPUACA11 4000 02B0h, MMPU.MMPUACA12 4000 02C0h, MMPU.MMPUACA13 4000 02D0h, MMPU.MMPUACA14 4000 02E0h, MMPU.MMPUACA15 4000 02F0h, MMPU.MMPUACA16 4000 0300h, MMPU.MMPUACA17 4000 0310h, MMPU.MMPUACA18 4000 0320h, MMPU.MMPUACA19 4000 0330h, MMPU.MMPUACA20 4000 0340h, MMPU.MMPUACA21 4000 0350h, MMPU.MMPUACA22 4000 0360h, MMPU.MMPUACA23 4000 0370h, MMPU.MMPUACA24 4000 0380h, MMPU.MMPUACA25 4000 0390h, MMPU.MMPUACA26 4000 03A0h, MMPU.MMPUACA27 4000 03B0h, MMPU.MMPUACA28 4000 03C0h, MMPU.MMPUACA29 4000 03D0h, MMPU.MMPUACA30 4000 03E0h, MMPU.MMPUACA31 4000 03F0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	WP	RP	ENABLE
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	ENABLE	Region Enable	0: Group A region n unit disabled 1: Group A region n unit enabled.	R/W
b1	RP	Read Protection	0: Read access permitted 1: Read access protected.	R/W
b2	WP	Write Protection	0: Write access permitted 1: Write access protected.	R/W
b15 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The ENABLE, RP, and WP bits are individually configurable for each group A region n unit.

ENABLE bit (Region Enable)

The ENABLE bit enables or disables the group A region n unit. When the ENABLE bit is set to 1, the RP and WP bits can be set to permit or protect access to the region that is set in MMPUSAn and MMPUEAn. When the ENABLE bit is set to 0, no region is specified for group A region n access.

RP bit (Read Protection)

The RP bit enables or disables read protection for group A region n. The RP bit is available when the ENABLE bit is set to 1.

WP bit (Write Protection)

The WP bit enables or disables write protection for group A region n. The WP bit is available when the ENABLE bit is set to 1.

15.4.1.3 A组区域n访问控制寄存器(MMPUACan)(n=0到31)

Address(es): MMPU.MMPUACA0 4000 0200h, MMPU.MMPUACA1 4000 0210h, MMPU.MMPUACA2 4000 0220h, MMPU.MMPUACA3 4000 0230h, MMPU.MMPUACA4 4000 0240h, MMPU.MMPUACA5 4000 0250h, MMPU.MMPUACA6 4000 0260h, MMPU.MMPUACA7 4000 0270h, MMPU.MMPUACA8 4000 0280h, MMPU.MMPUACA9 4000 0290h, MMPU.MMPUACA10 4000 02A0h, MMPU.MMPUACA11 4000 02B0h, MMPU.MMPUACA12 4000 02C0h, MMPU.MMPUACA13 4000 02D0h, MMPU.MMPUACA14 4000 02E0h, MMPU.MMPUACA15 4000 02F0h, MMPU.MMPUACA16 4000 0300h, MMPU.MMPUACA17 4000 0310h, MMPU.MMPUACA18 4000 0320h, MMPU.MMPUACA19 4000 0330h, MMPU.MMPUACA20 4000 0340h, MMPU.MMPUACA21 4000 0350h, MMPU.MMPUACA22 4000 0360h, MMPU.MMPUACA23 4000 0370h, MMPU.MMPUACA24 4000 0380h, MMPU.MMPUACA25 4000 0390h, MMPU.MMPUACA26 4000 03A0h, MMPU.MMPUACA27 4000 03B0h, MMPU.MMPUACA28 4000 03C0h, MMPU.MMPUACA29 4000 03D0h, MMPU.MMPUACA30 4000 03E0h, MMPU.MMPUACA31 4000 03F0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	WP	RP	ENABLE
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	ENABLE	区域启用	0：A组区域n单元禁用1：A组区域n单元启用。	R/W
b1	RP	读保护	0：允许读访问1：读访问受保护。	R/W
b2	WP	写保护	0：允许写访问1：写访问受保护。	R/W
b15 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ENABLE、RP和WP位可针对每个A组区域n单元单独配置。

ENABLE位（区域启用）

ENABLE位启用或禁用组A区域n单元。当ENABLE位设置为1时，可以设置RP和WP位以允许或保护对MMPUSan和MMPUEAn中设置的区域的访问。当ENABLE位设置为0时，没有为组A区域n访问指定区域。

RP位（读保护）

RP位启用或禁用组A区域n的读保护。当ENABLE位设置为1时，RP位可用。

WP位（写保护）

WP位启用或禁用A组区域n的写保护。当ENABLE位设置为1时，WP位可用。

Table 15.5 Function of region control circuit

MMPUACAn.ENABLE*1	MMPUACAn.RP*1	MMPUACAn.WP*1	Access	Region	Output of group A region n unit*1
0	-	-	Read	-	Outside of region
			Write	-	Outside of region
1	0	0	Read	Inside	Permitted region
				Outside	Outside of region
			Write	Inside	Permitted region
				Outside	Outside of region
	0	1	Read	Inside	Permitted region
				Outside	Outside of region
			Write	Inside	Protected region
				Outside	Outside of region
	1	0	Read	Inside	Protected region
				Outside	Outside of region
			Write	Inside	Permitted region
				Outside	Outside of region
	1	1	Read	Inside	Protected region
				Outside	Outside of region
			Write	Inside	Protected region
				Outside	Outside of region

Note 1. n = 0 to 31.

Table 15.6 Function of master control circuit

MMPUCTLA.ENABLE	Output of group A region 0 unit	Output of group A region 1 unit	Output of Group A Region 2 to 31 unit	Function of group A
1	Protected region	Don't care	Don't care	Generate error
1	Don't care	Protected region	Don't care	Generate error
1	Don't care	Don't care	Protected region	Generate error
1	Outside of region	Outside of region	Outside of region	Generate error
Other case				No error

A master MPU error occurs on the following conditions:

- MMPUCTLA.ENABLE = 1, and output of one or more region n units is to a protected region
- MMPUCTLA.ENABLE = 1, and output of all region n units is outside of region.

Other cases are handled as permitted regions.

15.4.1.4 Bus Master MPU Control Register (MMPUCTLA)

Address(es): MMPU.MMPUCTLA 4000 0000h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	OAD	ENABLE
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	ENABLE	Master Group Enable	0: Master group A disabled 1: Master group A enabled.	R/W

Table 15.5 区域控制电路的功能

MMPUACAn.ENABLE*1	MMPUACAn.RP*1	MMPUACAn.WP*1	Access	Region	A组区域n单元的输出*1
0	-	-	Read	-	区域外
			Write	-	区域外
1	0	0	Read	Inside	许可区域
				Outside	区域外
			Write	Inside	许可区域
				Outside	区域外
	0	1	Read	Inside	许可区域
				Outside	区域外
			Write	Inside	保护区
				Outside	区域外
	1	0	Read	Inside	保护区
				Outside	区域外
			Write	Inside	许可区域
				Outside	区域外
	1	1	Read	Inside	保护区
				Outside	区域外
			Write	Inside	保护区
				Outside	区域外

注1.n=0至31。

Table 15.6 主控电路功能

MMPUCTLA.ENABLE	A组区域0单元的输出	A组地区1单位产量	组A区域2至31单元的输出	A组功能
1	保护区	Don't care	Don't care	产生错误
1	Don't care	保护区	Don't care	产生错误
1	Don't care	Don't care	保护区	产生错误
1	区域外	区域外	区域外	产生错误
其他情况				没有错误

主控MPU错误发生在以下情况：

- MMPUCTLA.ENABLE=1，并且一个或多个区域n个单元的输出到受保护区域
- MMPUCTLA.ENABLE=1，所有区域n个单元的输出都在区域之外。

其他情况按许可区域处理。

15.4.1.4 总线主控MPU控制寄存器(MMPUCTLA)

Address(es): MMPU.MMPUCTLA 4000 0000h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	OAD	ENABLE
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	ENABLE	主组启用	0：主控组A禁用1：主控组A启用。	R/W

Bit	Symbol	Bit name	Description	R/W
b1	OAD	Operation After Detection	0: Non-maskable interrupt 1: Reset.	R/W
b7 to b2	—	Reserved	These bits are read as 0.The write value should be 0.	R/W
b15 to b8	KEY[7:0]	Key Code	These bits enable or disable writes to the OAD and ENABLE bits.	R/(W)*1

Note 1. Write data is not saved.

ENABLE bit (Master Group Enable)

The ENABLE bit enables or disables the bus master MPU function of master group A. When this bit is set to 1, MMPUACAn is available. When this bit is set to 0, MMPUACAn is unavailable, including permission for all regions. When writing to the ENABLE bit, simultaneously write A5h to the KEY[7:0] bits using halfword access.

OAD bit (Operation After Detection)

The OAD bit generates either a reset or a non-maskable interrupt when access to the protected region is detected by the bus master MPU. When writing to the OAD bit, simultaneously write A5h to the KEY[7:0] bits using halfword access.

KEY[7:0] bits (Key Code)

The KEY[7:0] bits enable or disable writing to the ENABLE and OAD bits. When writing to the ENABLE and OAD bits, simultaneously write A5h to the KEY[7:0] bits. When other values are written, the ENABLE and OAD bits are not updated. The KEY[7:0] bits are always read as 00h.

15.4.1.5 Group A Protection of Register (MMPUPTA)

Address(es): MMPU.MMPUPTA 4000 0102h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	—	PROTECT
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	PROTECT	Protection of Register	0: All bus master MPU group A register writes are permitted 1: All bus master MPU group A register writes are protected. Reads are possible.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15 to b8	KEY[7:0]	Key Code	These bits enable or disable writes to the PROTECT bit.	R/(W)*1

Note 1. Write data is not saved.

PROTECT bit (Protection of Register)

The PROTECT bit enables or disables writes to the associated registers to be protected.

MMPUTA.PROTECT controls the bus master MPU group A protection registers. The following registers are protected by MMPUPTA.PROTECT:

- MMPUSAn
- MMPUEAn
- MMPUACAn
- MMPUCTLA.

When writing to the PROTECT bit, simultaneously write A5h to the KEY[7:0] bits using halfword access.

KEY[7:0] bits (Key Code)

The KEY[7:0] bits enable or disable writes to the PROTECT bit. When writing to the PROTECT bit, simultaneously

Bit	Symbol	位名称	Description	R/W
b1	OAD	检测后的操作	0：不可屏蔽中断1：复位 。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15 to b8	KEY[7:0]	关键代码	这些位启用或禁用对OAD的写入和启用位。	R/(W)*1

注1.写入数据不保存。

ENABLE位（主组启用）

ENABLE位启用或禁用主机组A的总线主机MPU功能。当该位设置为1时，MMPUACAn可用。当该位设置为0时，MMPUACAn不可用，包括所有区域的权限。写入ENABLE位时，同时使用半字访问将A5h写入KEY[7:0]位。

OAD位（检测后操作）

当总线主控MPU检测到对受保护区域的访问时，OAD位会产生复位或不可屏蔽中断。写入OAD位时，同时使用半字访问将A5h写入KEY[7:0]位。

KEY[7:0]位（键码）

KEY[7:0]位启用或禁用对ENABLE和OAD位的写入。写入ENABLE和OAD位时，同时将A5h写入KEY[7:0]位。写入其他值时，ENABLE和OAD位不会更新。KEY[7:0]位总是读为00h。

15.4.1.5 A组注册保护(MMPUPTA)

Address(es): MMPU.MMPUPTA 4000 0102h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	—	PROTECT
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	PROTECT	登记保护	0：允许所有总线主控MPUA组寄存器写入1：所有总线主控MPUA组寄存器写入受到保护。读取是可能的。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15 to b8	KEY[7:0]	关键代码	这些位启用或禁用对PROTECT位的写入。	R/(W)*1

注1.写入数据不保存。

PROTECT位（寄存器保护）

PROTECT位启用或禁用对要保护的相关寄存器的写入。

MMPUTA.PROTECT控制总线主控MPUA组保护寄存器。以下寄存器受MMPUPTA.PROTECT保护：

- MMPUSAn
- MMPUEAn
- MMPUACAn
- MMPUCTLA.

写入PROTECT位时，同时使用半字访问将A5h写入KEY[7:0]位。

KEY[7:0]位（键码）

KEY[7:0]位启用或禁用对PROTECT位的写入。当写入保护位时，同时

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write A5h to the KEY[7:0] bits. When values other than A5h are written to the KEY[7:0] bits, the PROTECT bit is not updated. The KEY[7:0] bits are always read as 00h.

15.4.2 Operation

15.4.2.1 Memory protection

The bus master MPU monitors memory access using control settings made individually for the access control regions. If access to a protected region is detected, the bus master MPU generates a memory protection error.

The bus master MPU can be configured for up to 32 protected regions. Protected regions include those with overlapping permitted and protected regions, and those with two overlapping permitted regions.

The bus master MPU provides group A. The memory protection function checks the address of the bus for a unified master group, and all master group accesses are protected. The bus master MPU sets the permission for all of the regions after reset. Setting MMPUCTLA.ENABLE to 1 protects all of the regions. A permitted region is set up within the protected region for each region. If access to a protected region is detected, the bus master MPU generates an error.

Figure 15.5 shows the use case of a bus master MPU.

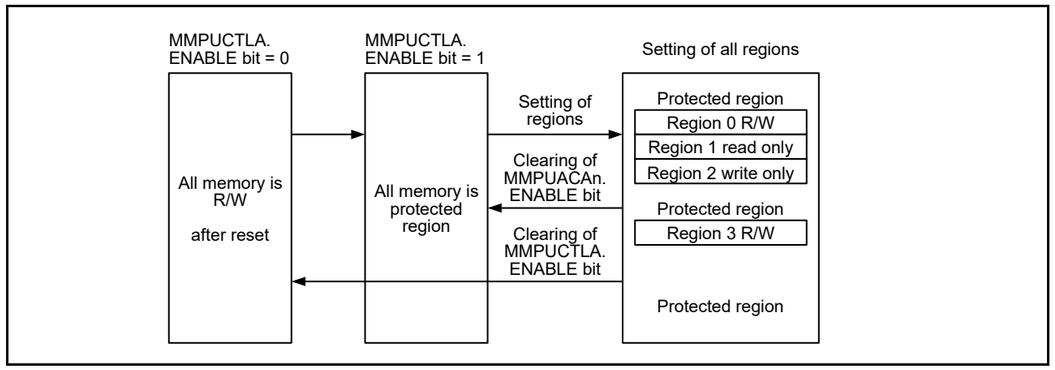


Figure 15.5 Use case of bus master MPU

Figure 15.6 shows the access permission or protection for overlapping bus master MPU regions. Access control for overlapping regions is as follows:

- The region is handled as a protected region when output of one or more region units is a protected region
- The region is handled as a protected region when output of all region units is outside of the regions
- Other cases are handled as permitted regions.

将A5h写入KEY[7:0]位。当A5h以外的值写入KEY[7:0]位时，PROTECT位不会更新。KEY[7:0]位总是读为00h。

15.4.2 Operation

15.4.2.1 内存保护

总线主控MPU使用为访问控制区域单独进行的控制设置来监视内存访问。如果检测到对受保护区域的访问，则总线主控MPU会产生内存保护错误。

总线主控MPU最多可配置为32个受保护区域。保护区包括允许区域和保护区域重叠的区域，以及两个允许区域重叠的区域。

总线主控MPU提供A组。内存保护功能检查总线地址为一个统一的主控组，所有主控组访问都受到保护。总线主控MPU在复位后设置所有区域的权限。将MMPUCTLA.ENABLE设置为1可以保护所有区域。在保护区域内为每个区域设置一个允许区域。如果检测到对受保护区域的访问，则总线主控MPU会产生错误。

图15.5显示了总线主控MPU的用例。

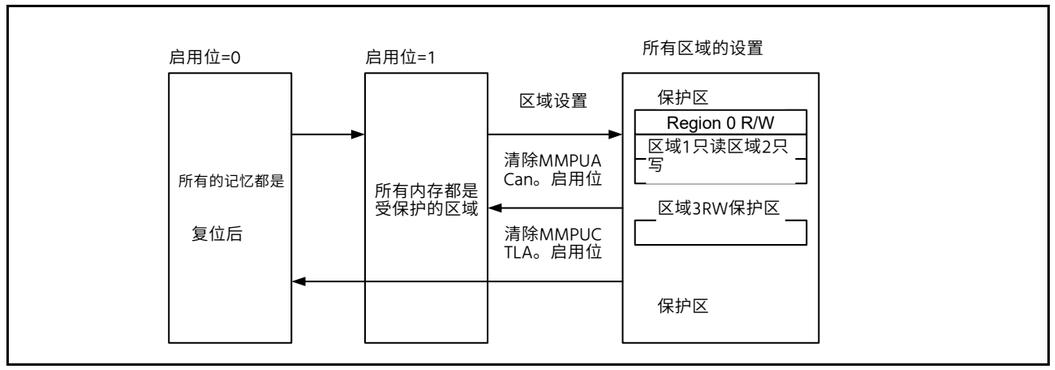


Figure 15.5 总线主控MPU用例

图15.6显示了重叠总线主控MPU区域的访问许可或保护。重叠区域的访问控制如下：

- 当一个或多个区域单元的输出是受保护区域时，该区域被视为受保护区域
- 当所有区域单元的输出都在区域之外时，该区域被视为受保护区域
- 其他情况按许可区域处理。

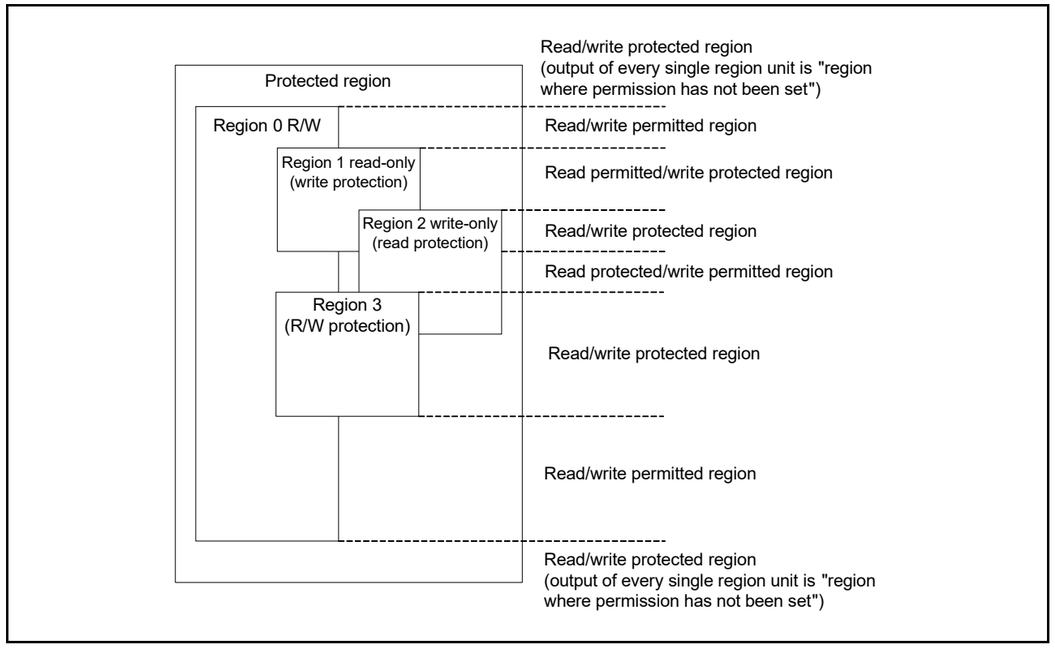


Figure 15.6 Access permission or protection by overlap of the bus master MPU regions

Figure 15.7 shows the register setting flow after reset. During this register setting, stop all the masters except the CPU.

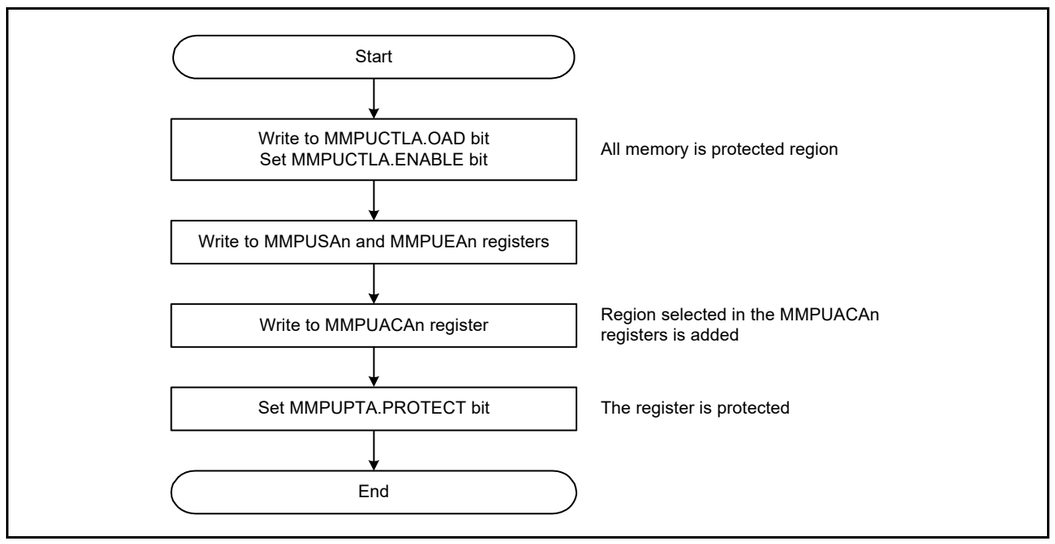


Figure 15.7 Register setting flow after reset

Figure 15.8 shows the register setting flow for adding regions. During this register setting, stop all masters except the CPU.

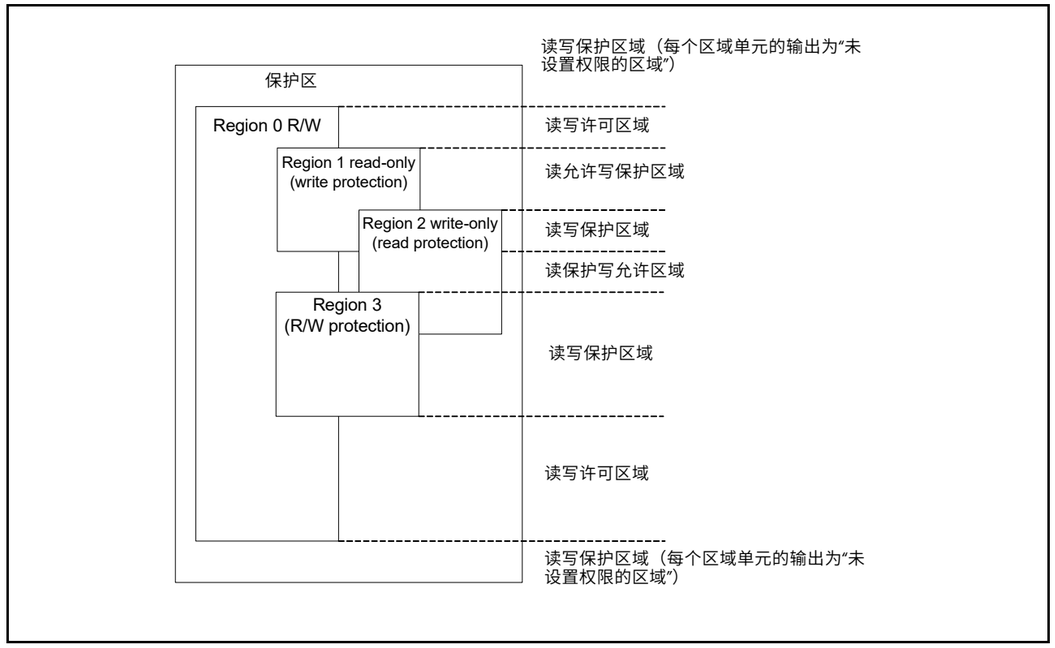


Figure 15.6 通过总线主控MPU区域的重叠访问许可或保护

图15.7显示了复位后的寄存器设置流程。在此寄存器设置期间，停止除CPU之外的所有主机。

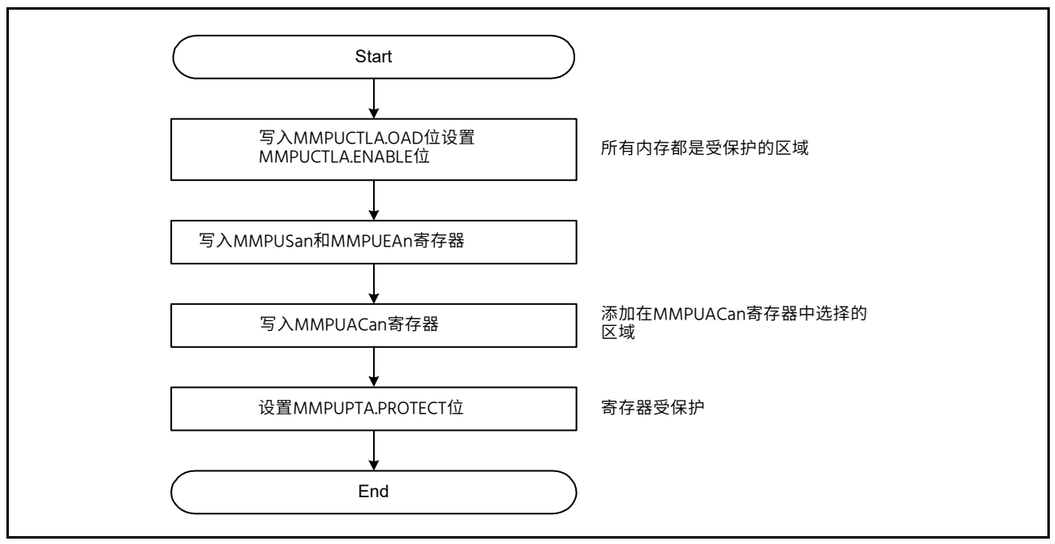


Figure 15.7 复位后的寄存器设置流程

图15.8显示了添加区域的寄存器设置流程。在此寄存器设置期间，停止除CPU.

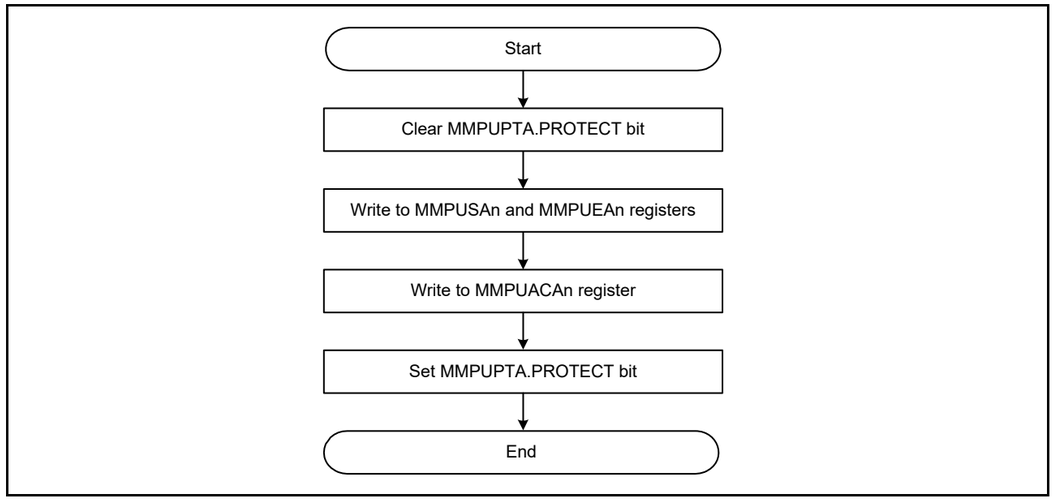


Figure 15.8 Register setting flow for region addition

15.4.2.2 Protecting the registers

To protect the registers related to the bus master MPU, set the PROTECT bit in the associated MMPUPTA register.

15.4.2.3 Memory protection error

If access to a protected region is detected, the bus master MPU generates an error. Set the OAD bit to select whether the error is reported as a non-maskable interrupt or a reset. The non-maskable interrupt status is indicated in ICU.NMISR.BUSMST. For details, see section 13, Interrupt Controller Unit (ICU). The reset status is indicated in SYSTEM.RSTSR1.BUSMRF. For details, see section 6, Resets.

15.5 Bus Slave MPU

The bus slave MPU monitors access to the bus slave functions, such as flash or SRAM. The function can be accessed from two bus masters, the CPU, and the bus master MPU group A. The bus slave MPU has a separate protection register for each of the two bus masters, with individual access protection control, consisting of read and write permissions. If access to a protected region is detected, the bus slave MPU generates a reset or a non-maskable interrupt, and stores the bus error address, bus error status, and error access status. For details, see 14.3.3 and 14.3.4 in section 14, Buses.

Table 15.7 lists the specifications of the bus slave MPU and Figure 15.9 shows a block diagram.

Table 15.7 Specifications of bus slave MPU

Specifications	Description
Protected bus master	Bus master MPU group A: DMA bus.
Protected slave functions	• Memory bus 3: Code flash memory, SRAMHS • Internal peripheral bus 1: Connected to peripheral modules (DTC, DMAC, interrupt controller, flash registers, MPU, SRAM registers, system controller, and bus controller) • Internal peripheral bus 3, 4, 5: Connected to other peripherals • Internal peripheral bus 7: Connected to Secure IP (SCE7) • Internal peripheral bus 9: Flash memory (in P/E), data flash memory, and TSN.
‘	Permission to read and write
Operation on error detection	Reset, non-maskable interrupt, or exception
Protection of register	Register can be protected from illegal writes

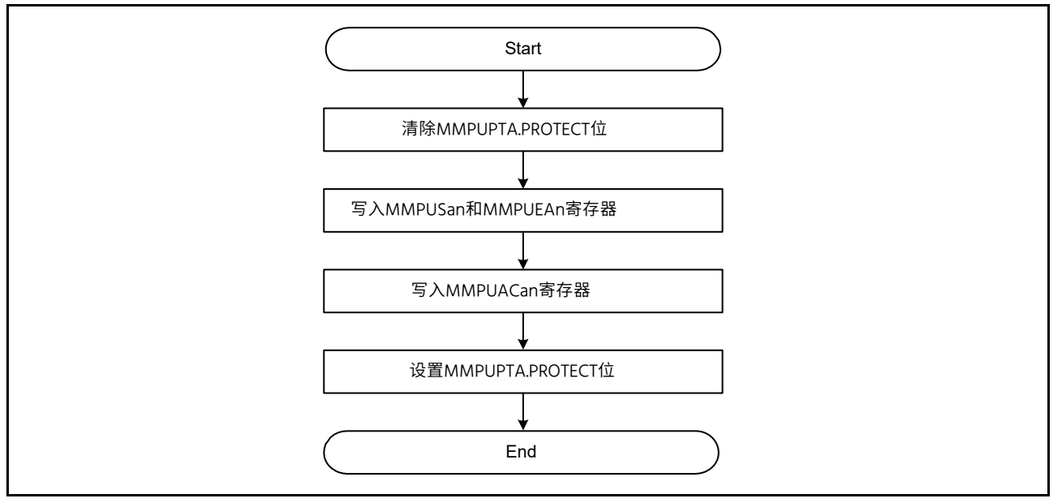


Figure 15.8 区域添加的注册设置流程

15.4.2.2 保护寄存器

要保护与总线主控MPU相关的寄存器，请设置相关MMPUPTA寄存器中的PROTECT位。

15.4.2.3 内存保护错误

如果检测到对受保护区域的访问，则总线主控MPU会产生错误。设置OAD位以选择将错误报告为不可屏蔽中断还是复位。不可屏蔽中断状态在ICU.NMISR.BUSMST中指示。有关详细信息，请参阅第13节，中断控制器单元(ICU)。复位状态显示在

SYSTEM.RSTSR1.BUSMRF。有关详细信息，请参阅第6节，重置。

15.5 总线从MPU

总线从机MPU监控对总线从机功能的访问，例如闪存或SRAM。该功能可以从两个总线主控CPU和总线主控MPU组A访问。总线从属MPU对两个总线主控中的每一个都有一个单独的保护寄存器，具有单独的访问保护控制，包括读取和写入权限.如果检测到对受保护区域的访问，则总线从MPU产生复位或不可屏蔽中断，并存储总线错误地址、总线错误状态和错误访问状态。有关详细信息，请参阅第14节"总线"中的14.3.3和14.3.4。

表15.7列出了总线从MPU的规格，图15.9显示了框图。

Table 15.7 总线从机MPU规格

Specifications	Description
受保护的总线主机	总线主控MPU组A：DMA总线。
受保护的从属功能	内存总线3：代码闪存、SRAMHS 内部外围总线1：连接到外围模块（DTC、DMAC、中断控制器、闪存寄存器、MPU、SRAM寄存器、系统控制器和总线控制器） 内部外围总线3、４5：连接到其他外设 内部外围总线7：连接到安全IP(SCE7) 内部外围总线9：闪存（在PE中）、数据闪存和TSN。
‘	读写权限
错误检测操作	复位、不可屏蔽中断或异常
注册保护	可以保护寄存器免受非法写入

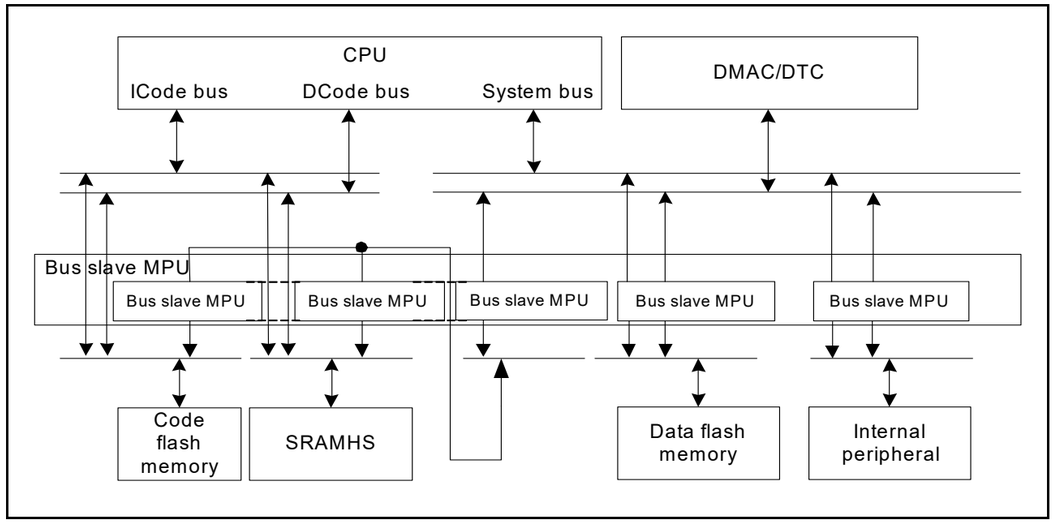


Figure 15.9 Bus slave MPU block diagram

15.5.1 Register Descriptions

Note: Bus access must be stopped before writing to MPU registers.

15.5.1.1 Access Control Register for Memory Bus 3 (SMPUMBIU)

Address(es): SMPU.SMPUMBIU 4000 0C10h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	WPSRAMHS	RPSRAMHS	WPFLI	RPFLI	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	—	—
Value after reset:	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b2	RPGRPA	Master Group A Read Protection	0: Memory protection for master group A reads disabled 1: Memory protection for master group A reads enabled.	R/W
b3	WPGRPA	Master Group A Write Protection	0: Memory protection for master group A writes disabled 1: Memory protection for master group A writes enabled.	R/W
b11 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b12	RPFLI	Code Flash Memory Read Protection	0: Memory protection for code flash memory reads from master group A disabled 1: Memory protection for code flash memory reads from master group A enabled.	R/W
b13	WPFLI	Code Flash Memory Write Protection	0: Memory protection for code flash memory writes from master group A disabled 1: Memory protection for code flash memory writes from master group A enabled. This bit is read as 1. The write value should be 1.	R/W
b14	RPSRAMHS	SRAMHS Read Protection	0: Memory protection for SRAMHS reads from master group A disabled 1: Memory protection for SRAMHS reads from master group A enabled.	R/W

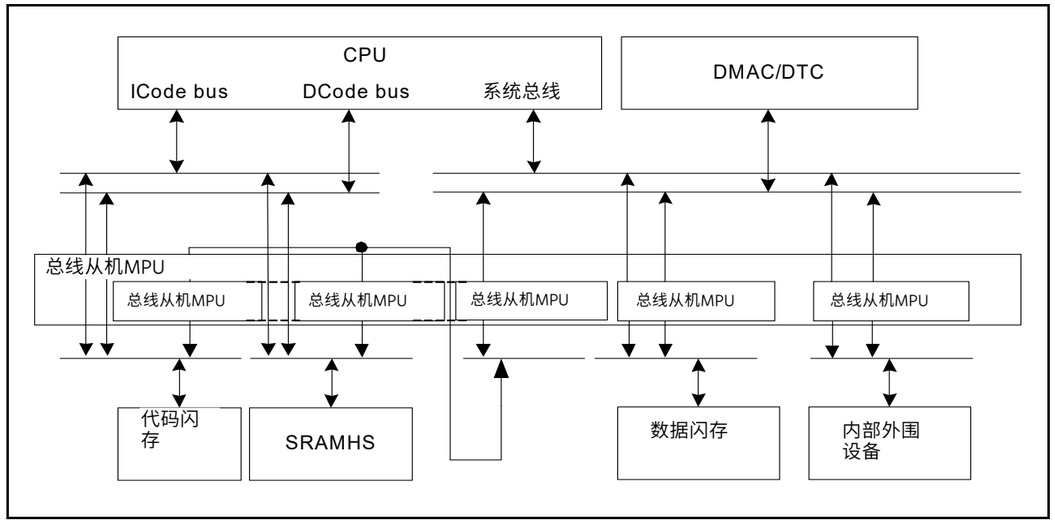


Figure 15.9 总线从机MPU框图

15.5.1 注册说明

Note: 在写入MPU寄存器之前必须停止总线访问。

15.5.1.1 内存总线3的访问控制寄存器(SMPUMBIU)

Address(es): SMPU.SMPUMBIU 4000 0C10h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	WPSRAMHS	RPSRAMHS	WPFLI	RPFLI	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	—	—
重置后的值:	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b2	RPGRPA	大师组A读 Protection	0：禁用主组A读取的内存保护1：启用主组A读取的内存保护。	R/W
b3	WPGRPA	大师组A写 Protection	0：禁用主组A写入的内存保护1：启用主组A写入的内存保护。	R/W
b11 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b12	RPFLI	代码闪存读取 Protection	0：禁止从主机组A读取代码闪存的内存保护1：使能从主机组A读取代码闪存的内存保护。	R/W
b13	WPFLI	代码闪存写入 Protection	0：禁用主组A的代码闪存写入的内存保护1：启用主组A的代码闪存写入的内存保护。该位读取为1。写入值应为1。	R/W
b14	RPSRAMHS	SRAMHS读保护	0：禁用从主机组A读取SRAMHS的内存保护1：启用从主机组A读取SRAMHS的内存保护。	R/W

Bit	Symbol	Bit name	Description	R/W
b15	WPSRAMHS	SRAMHS Write Protection	0: Memory protection for SRAMHS writes from master group A disabled 1: Memory protection for SRAMHS writes from master group A enabled.	R/W

The SMPUMBIU register enables memory protection for the specified master and slave for access from master group A to code flash memory and SRAMHS.

RPGRPA bit (Master Group A Read Protection)

The RPGRPA bit enables or disables memory protection for reads by master group A on memory bus 3.

WPGRPA bit (Master Group A Write Protection)

The WPGRPA bit enables or disables memory protection for writes by master group A on memory bus 3.

RPFLI bit (Code Flash Memory Read Protection)

The RPFLI bit enables or disables memory protection for reads by master group A on the code flash memory.

WPFLI bit (Code Flash Memory Write Protection)

The WPFLI bit enables memory protection for writes by master group A on the code flash memory.

RPSRAMHS bit (SRAMHS Read Protection)

The RPSRAMHS bit enables or disables memory protection for reads by master group A on the SRAMHS.

WPSRAMHS bit (SRAMHS Write Protection)

The WPSRAMHS bit enables or disables memory protection for writes by master group A on the SRAMHS.

15.5.1.2 Access Control Register for Internal Peripheral Bus 9 (SMPUFBIU)

Address(es): SMPU.SMPUFBIU 4000 0C14h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	WPCPU	RPCPU
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	RPCPU	CPU Read Protection	0: Memory protection for CPU reads disabled 1: Memory protection for CPU reads enabled.	R/W
b1	WPCPU	CPU Write Protection	0: Memory protection for CPU writes disabled 1: Memory protection for CPU writes enabled.	R/W
b2	RPGRPA	Master Group A Read Protection	0: Memory protection for master group A reads disabled 1: Memory protection for master group A reads enabled.	R/W
b3	WPGRPA	Master Group A Write Protection	0: Memory protection for master group A writes disabled 1: Memory protection for master group A writes enabled.	R/W
b15 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

RPCPU bit (CPU Read Protection)

The RPCPU bit enables or disables memory protection for reads by the CPU on internal peripheral bus 9.

WPCPU bit (CPU Write Protection)

The WPCPU bit enables or disables memory protection for writes by the CPU on internal peripheral bus 9.

RPGRPA bit (Master Group A Read Protection)

The RPGRPA bit enables or disables memory protection for reads by master group A on internal peripheral bus 9.

Bit	Symbol	位名称	Description	R/W
b15	WPSRAMHS	SRAMHS写保护	0：禁止从主机组A写入SRAMHS的存储器保护1：启用从主机组A写入SRAMHS的存储器保护。	R/W

SMPUMBIU寄存器为指定的主机和从机启用存储器保护，以便从主机组A访问代码闪存和SRAMHS。

RRPGRPA位（主组A读保护）

RPGRPA位启用或禁用内存总线3上的主组A读取的内存保护。

WPGRPA位（主组A写保护）

WPGRPA位启用或禁用内存总线3上主机组A写入的内存保护。

RPFLI位（代码闪存读保护）

RPFLI位启用或禁用主组A对代码闪存的读取的存储器保护。

WPFLI位（代码闪存写保护）

WPFLI位启用内存保护，以保护主组A对代码闪存的写入。

RPSRAMHS位（SRAMHS读保护）

RPSRAMHS位启用或禁用SRAMHS上的主组A读取的存储器保护。

WPSRAMHS位（SRAMHS写保护）

WPSRAMHS位启用或禁用主组A对SRAMHS的写入的存储器保护。

15.5.1.2 内部外围总线9(SMPUFBIU)的访问控制寄存器

Address(es): SMPU.SMPUFBIU 4000 0C14h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	WPCPU	RPCPU
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	RPCPU	CPU读保护	0：禁用CPU读取的内存保护1：启用CPU读取的内存保护。	R/W
b1	WPCPU	CPU写保护	0：禁用CPU写入的内存保护1：启用CPU写入的内存保护。	R/W
b2	RPGRPA	大师组A读Protection	0：禁用主组A读取的内存保护1：启用主组A读取的内存保护。	R/W
b3	WPGRPA	大师组A写Protection	0：禁用主组A写入的内存保护1：启用主组A写入的内存保护。	R/W
b15 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W

RPCPU位（CPU读保护）

RPCPU位启用或禁用CPU在内部外围总线9上读取的内存保护。

WPCPU位（CPU写保护）

WPCPU位启用或禁用CPU在内部外围总线9上写入的内存保护。

RRPGRPA位（主组A读保护）

RPGRPA位启用或禁用内部外设总线9上主机组A读取的内存保护。

WPGRPA bit (Master Group A Write Protection)

The WPGRPA bit enables or disables memory protection for writes by master group A on internal peripheral bus 9.

15.5.1.3 Access Control Register for Internal Peripheral Bus 1 (SMPUP0BIU)

Address(es): SMPU.SMPUP0BIU 4000 0C20h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	WPCPU	RPCPU
Value after reset:	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	RPCPU	CPU Read Protection	0: Memory protection for CPU reads disabled 1: Memory protection for CPU reads enabled.	R/W
b1	WPCPU	CPU Write Protection	0: Memory protection for CPU writes disabled 1: Memory protection for CPU writes enabled.	R/W
b2	RPGRPA	Master Group A Read Protection	0: Memory protection for master group A reads disabled 1: Memory protection for master group A reads enabled.	R/W
b3	WPGRPA	Master Group A Write Protection	0: Memory protection for master group A writes disabled 1: Memory protection for master group A writes enabled.	R/W
b5, b4	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b15 to b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

RPCPU bit (CPU Read Protection)

The RPCPU bit enables or disables memory protection for reads by the CPU on internal peripheral bus 1.

WPCPU bit (CPU Write Protection)

The WPCPU bit enables or disables memory protection for writes by the CPU on internal peripheral bus 1.

RPGRPA bit (Master Group A Read Protection)

The RPGRPA bit enables or disables memory protection for reads by master group A on internal peripheral bus 1.

WPGRPA bit (Master Group A Write Protection)

The WPGRPA bit enables or disables memory protection for writes by master group A on internal peripheral bus 1.

15.5.1.4 Access Control Register for Internal Peripheral Bus 3 (SMPUP2BIU)

Address(es): SMPU.SMPUP2BIU 4000 0C24h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	WPCPU	RPCPU
Value after reset:	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	RPCPU	CPU Read Protection	0: Memory protection for CPU reads disabled 1: Memory protection for CPU reads enabled.	R/W
b1	WPCPU	CPU Write Protection	0: Memory protection for CPU writes disabled 1: Memory protection for CPU writes enabled.	R/W
b2	RPGRPA	Master Group A Read Protection	0: Memory protection for master group A reads disabled 1: Memory protection for master group A reads enabled.	R/W

WPGRPA位（主组A写保护）

WPGRPA位启用或禁用内部外设总线9上主组A写入的存储器保护。

15.5.1.3 内部外围总线1(SMPUP0BIU)的访问控制寄存器

Address(es): SMPU.SMPUP0BIU 4000 0C20h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	WPCPU	RPCPU
重置后的值：	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	RPCPU	CPU读保护	0：禁用CPU读取的内存保护1：启用CPU读取的内存保护。	R/W
b1	WPCPU	CPU写保护	0：禁用CPU写入的内存保护1：启用CPU写入的内存保护。	R/W
b2	RPGRPA	大师组A读Protection	0：禁用主组A读取的内存保护1：启用主组A读取的内存保护。	R/W
b3	WPGRPA	大师组A写Protection	0：禁用主组A写入的内存保护1：启用主组A写入的内存保护。	R/W
b5, b4	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b15 to b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W

RPCPU位（CPU读保护）

RPCPU位启用或禁用CPU在内部外围总线1上读取的内存保护。

WPCPU位（CPU写保护）

WPCPU位启用或禁用CPU在内部外围总线1上写入的内存保护。

RRPGRPA位（主组A读保护）

RPGRPA位启用或禁用内部外设总线1上主机组A读取的内存保护。

WPGRPA位（主组A写保护）

WPGRPA位启用或禁用内部外设总线1上主机组A写入的存储器保护。

15.5.1.4 内部外围总线3(SMPUP2BIU)的访问控制寄存器

Address(es): SMPU.SMPUP2BIU 4000 0C24h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	WPCPU	RPCPU
重置后的值：	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	RPCPU	CPU读保护	0：禁用CPU读取的内存保护1：启用CPU读取的内存保护。	R/W
b1	WPCPU	CPU写保护	0：禁用CPU写入的内存保护1：启用CPU写入的内存保护。	R/W
b2	RPGRPA	大师组A读Protection	0：禁用主组A读取的内存保护1：启用主组A读取的内存保护。	R/W

Bit	Symbol	Bit name	Description	R/W
b3	WPGRPA	Master Group A Write Protection	0: Memory protection for master group A writes disabled 1: Memory protection for master group A writes enabled.	R/W
b5, b4	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b15 to b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

RPCPU bit (CPU Read Protection)

The RPCPU bit enables or disables memory protection for reads by the CPU on internal peripheral buses 3, 4, and 5.

WPCPU bit (CPU Write Protection)

The WPCPU bit enables or disables memory protection for writes by the CPU on internal peripheral buses 3, 4, and 5.

RPGRPA bit (Master Group A Read Protection)

The RPGRPA bit enables or disables memory protection for reads by master group A on internal peripheral buses 3, 4, and 5.

WPGRPA bit (Master Group A Write Protection)

The WPGRPA bit enables or disables memory protection for writes by master group A on internal peripheral buses 3, 4, and 5.

15.5.1.5 Access Control Register for Internal Peripheral Bus 7 (SMPUP6BIU)

Address(es): SMPU.SMPUP6BIU 4000 0C28h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	WPCPU	RPCPU
Value after reset:	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	RPCPU	CPU Read Protection	0: Memory protection for CPU reads disabled 1: Memory protection for CPU reads enabled.	R/W
b1	WPCPU	CPU Write Protection	0: Memory protection for CPU writes disabled 1: Memory protection for CPU writes enabled.	R/W
b2	RPGRPA	Master Group A Read Protection	0: Memory protection for master group A reads disabled 1: Memory protection for master group A reads enabled.	R/W
b3	WPGRPA	Master Group A Write Protection	0: Memory protection for master group A writes disabled 1: Memory protection for master group A writes enabled.	R/W
b5, b4	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b15 to b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

RPCPU bit (CPU Read Protection)

The RPCPU bit enables or disables memory protection for reads by the CPU on internal peripheral bus 7.

WPCPU bit (CPU Write Protection)

The WPCPU bit enables or disables memory protection for writes by the CPU on internal peripheral bus 7.

RPGRPA bit (Master Group A Read Protection)

The RPGRPA bit enables or disables memory protection for reads by master group A on internal peripheral bus 7.

WPGRPA bit (Master Group A Write Protection)

The WPGRPA bit enables or disables memory protection for writes by master group A on internal peripheral bus 7.

Bit	Symbol	位名称	Description	R/W
b3	WPGRPA	大师组A写 Protection	0：禁用主组A写入的内存保护1：启用主组A写入的内存保护。	R/W
b5, b4	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b15 to b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W

RPCPU位（CPU读保护）

RPCPU位启用或禁用CPU在内部外围总线3、4和5上读取的内存保护。

WPCPU位（CPU写保护）

WPCPU位启用或禁用CPU在内部外围总线3、4和5上写入的内存保护。

RRPGRPA位（主组A读保护）

RPGRPA位启用或禁用内部外设总线3、4和5上主机组A读取的内存保护。

WPGRPA位（主组A写保护）

WPGRPA位启用或禁用主机组A在内部外围总线3、4和5上写入的内存保护。

15.5.1.5 内部外设总线7的访问控制寄存器(SMPUP6BIU)

Address(es): SMPU.SMPUP6BIU 4000 0C28h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	WPGRPA	RPGRPA	WPCPU	RPCPU
重置后的值:	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	RPCPU	CPU读保护	0：禁用CPU读取的内存保护1：启用CPU读取的内存保护。	R/W
b1	WPCPU	CPU写保护	0：禁用CPU写入的内存保护1：启用CPU写入的内存保护。	R/W
b2	RPGRPA	大师组A读 Protection	0：禁用主组A读取的内存保护1：启用主组A读取的内存保护。	R/W
b3	WPGRPA	大师组A写 Protection	0：禁用主组A写入的内存保护1：启用主组A写入的内存保护。	R/W
b5, b4	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b15 to b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W

RPCPU位（CPU读保护）

RPCPU位启用或禁用CPU在内部外围总线7上读取的内存保护。

WPCPU位（CPU写保护）

WPCPU位启用或禁用CPU在内部外围总线7上写入的内存保护。

RRPGRPA位（主组A读保护）

RPGRPA位启用或禁用内部外设总线7上主机组A读取的内存保护。

WPGRPA位（主组A写保护）

WPGRPA位启用或禁用内部外设总线7上主组A写入的存储器保护。

15.5.1.6 Slave MPU Control Register (SMPUCTL)

Address(es): SMPU.SMPUCTL 4000 0C00h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	PROTECT	OAD
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	OAD	Operation After Detection	0: Non-maskable interrupt 1: Reset.	R/W
b1	PROTECT	Protection of Register	0: All bus slave MPU register writes are permitted 1: All bus slave MPU register writes are protected. Reads are permitted.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15 to b8	KEY[7:0]	Key Code	These bits enable or disable writes to the OAD and PROTECT bits	R/(W)*1

Note 1. Write data is not saved.

OAD bit (Operation After Detection)

The OAD bit generates either a reset or non-maskable interrupt when access to the protected region is detected by the bus slave MPU. When writing to the OAD bit, simultaneously write A5h to the KEY[7:0] bits using halfword access.

PROTECT bit (Protection of Register)

The PROTECT bit enables or disables writes to the associated registers to be protected. SMPUCTL.PROTECT controls the following registers:

- SMPUMBIU
- SMPUFBIU
- SMPUP0BIU
- SMPUP2BIU
- SMPUP6BIU.

When writing to the PROTECT bit, simultaneously write A5h to the KEY[7:0] bits using halfword access.

KEY[7:0] bits (Key Code)

The KEY[7:0] bits enable or disable writes to the OAD and PROTECT bits. When writing to the OAD and PROTECT bits, simultaneously write A5h to the KEY[7:0] bits. When other values are written, the OAD and PROTECT bits are not updated. The KEY[7:0] bits are always read as 00h.

15.5.2 Operation

15.5.2.1 Memory protection

The bus slave MPU monitoring uses access control information that is set for the individual access control registers. If access to a protected region is detected, the bus slave MPU generates a memory protection error.

The bus slave MPU is enabled by writing 1 to the Write Protect (WPCPU or WPGRPA) bit or the Read Protect (RPCPU or RPGRPA) bit in the access control registers (SMPUMBIU, SMPUFBIU, SMPUP0BIU, SMPUP2BIU, and SMPUP6BIU).

15.5.2.2 Protecting the registers

Registers related to the bus slave MPU can be protected with the PROTECT bit in the SMPUCTL register.

15.5.1.6 从MPU控制寄存器(SMPUCTL)

Address(es): SMPU.SMPUCTL 4000 0C00h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	KEY[7:0]								—	—	—	—	—	—	PROTECT	OAD
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	OAD	之后的操作 Detection	0：不可屏蔽中断1：复位 。	R/W
b1	PROTECT	登记保护	0：允许所有总线从MPU寄存器写入1：所有总线从MPU寄存器写入受到保护。允许读取。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15 to b8	KEY[7:0]	关键代码	这些位启用或禁用对OAD和PROTECT位的写入	R/(W)*1

注1.写入数据不保存。

OAD位（检测后操作）

当总线从机MPU检测到对受保护区域的访问时，OAD位会产生复位或不可屏蔽中断。写入OAD位时，同时使用半字访问将A5h写入KEY[7:0]位。

PROTECT位（寄存器保护）

PROTECT位启用或禁用对要保护的相关寄存器的写入。SMPUCTL.PROTECT控制以下寄存器：

- SMPUMBIU
- SMPUFBIU
- SMPUP0BIU
- SMPUP2BIU
- SMPUP6BIU.

写入PROTECT位时，同时使用半字访问将A5h写入KEY[7:0]位。

KEY[7:0]位（键码）

KEY[7:0]位启用或禁用对OAD和PROTECT位的写入。写入OAD和PROTECT位时，同时将A5h写入KEY[7:0]位。写入其他值时，不会更新OAD和PROTECT位。KEY[7:0]位总是读为00h。

15.5.2 Operation

15.5.2.1 内存保护

总线从MPU监控使用为各个访问控制寄存器设置的访问控制信息。如果检测到对受保护区域的访问，则总线从MPU会产生内存保护错误。

通过将1写入访问控制寄存器（SMPUMBIU、SMPUFBIU、SMPUP0BIU、SMPUP2BIU和SMPUP6BIU）中的写保护（WPCPU或WPGRPA）位或读保护（RPCPU或RPGRPA）位来启用总线从MPU。

15.5.2.2 保护寄存器

与总线从MPU相关的寄存器可以通过SMPUCTL寄存器中的PROTECT位进行保护。

15.5.2.3 Memory protection error

If access to a protected region is detected, the bus slave MPU generates a memory protection error. Set the OAD bit to select whether the error is reported as a non-maskable interrupt or a reset.

The non-maskable interrupt status is indicated in ICU.NMISR.BUSSST. For details, see section 13, Interrupt Controller Unit (ICU). The reset status is indicated in SYSTEM.RSTSR1.BUSSRF. For details, see section 6, Resets.

15.6 Security MPU

The MCU incorporates a security MPU with four secure regions that include the code flash, SRAM, and two security functions. The secure regions can be protected from non-secure program accesses. A non-secure program cannot access a protected region.

Table 15.8 lists the specifications of the security MPU and Figure 15.10 shows a block diagram.

Table 15.8 Security MPU specifications

Specifications	Description
Secure regions	Code flash, SRAM, two security functions
Protected regions	0000 0000h to FFFF FFFFh
Number of regions	Program Counter: 2 regions Data access: 4 regions
Address specification for individual regions	Region start and end addresses configurable
Enable/disable setting for memory protection in individual regions	Settings enabled or disabled for the associated region

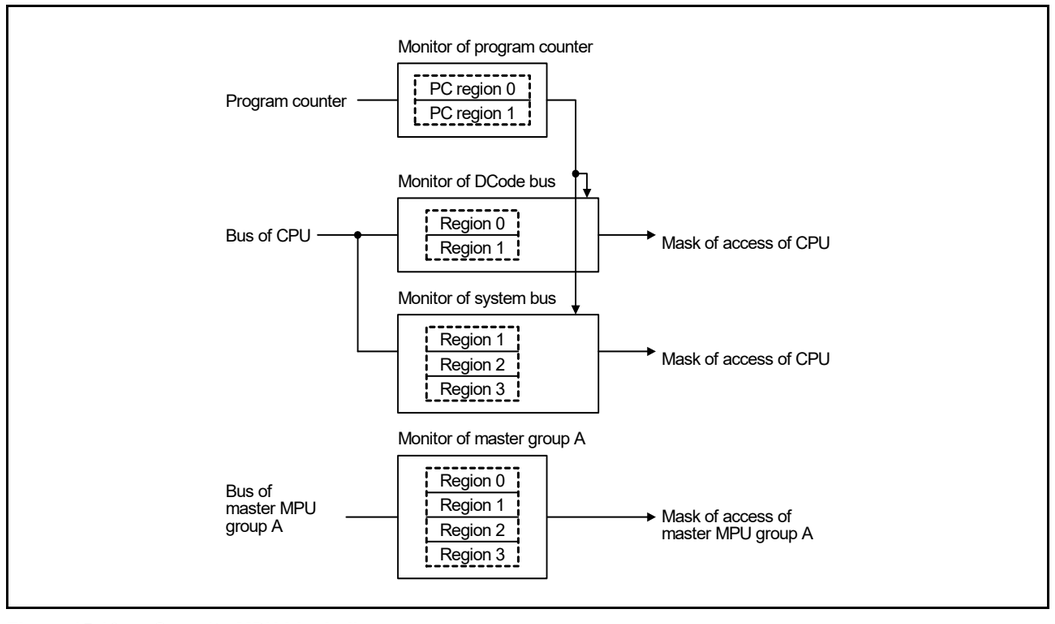


Figure 15.10 Security MPU block diagram

15.6.1 Register Descriptions (Option-Setting memory)

All security MPU registers are option-setting memory. Option-setting memory refers to a set of registers that are provided for selecting the state of the microcontroller after a reset. The option-setting memory is allocated in the code flash.

15.5.2.3 内存保护错误

如果检测到对受保护区域的访问，则总线从MPU会产生内存保护错误。设置OAD位以选择将错误报告为不可屏蔽中断还是复位。

不可屏蔽中断状态在ICU.NMISR.BUSSST中指示。有关详细信息，请参阅第13节，中断控制器单位（ICU）。复位状态在SYSTEM.RSTSR1.BUSSRF中指示。有关详细信息，请参阅第6节，重置。

15.6 Security MPU

MCU包含一个安全MPU，它具有四个安全区域，包括代码闪存、SRAM和两个安全功能。可以保护安全区域免受非安全程序访问。非安全程序无法访问受保护区域。

表15.8列出了安全MPU的规格，图15.10显示了框图。

Table 15.8 安全MPU规格

Specifications	Description
安全区域	代码闪存、SRAM、两个安全功能
保护区	0000 0000h to FFFF FFFFh
地区数量	节目计数器：2个地区 数据访问：4个地区
个别地区的地址规范	区域开始和结束地址可配置
在各个区域启用禁用内存保护设置	为关联区域启用或禁用的设置

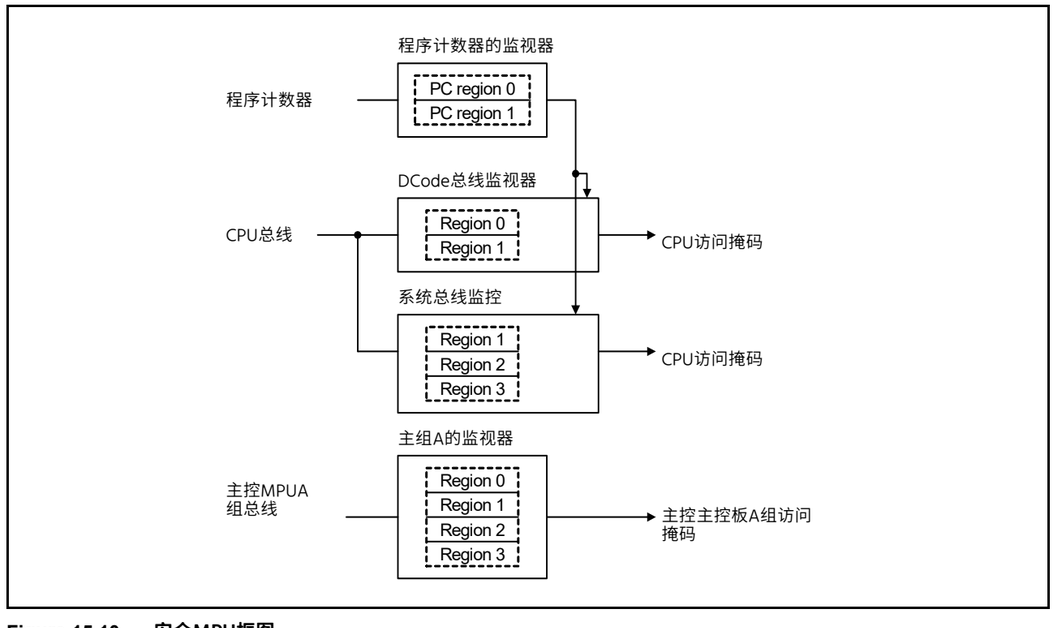


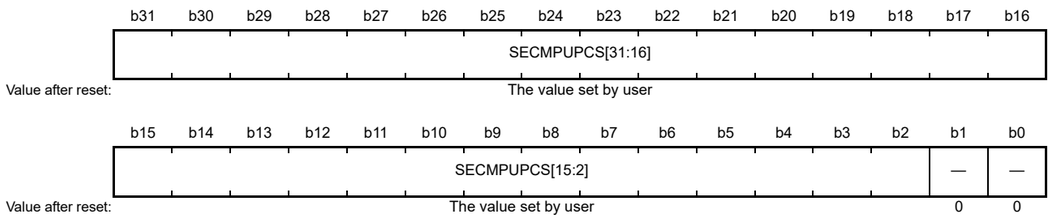
Figure 15.10 安全MPU框图

15.6.1 寄存器说明（选项设置存储器）

所有安全MPU寄存器都是选项设置存储器。选项设置存储器是指一组寄存器，用于在复位后选择微控制器的状态。选项设置存储器分配在代码闪存中。

15.6.1.1 Security MPU Program Counter Start Address Register (SECMPUPCSn) (n = 0, 1)

Address(es): SECMPUPCS0 0000 0408h, SECMPUPCS1 0000 0410h



Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R
b31 to b2	SECMPUPCS[31:2]	Region Start Address	Address where the region starts, for use in region determination	R

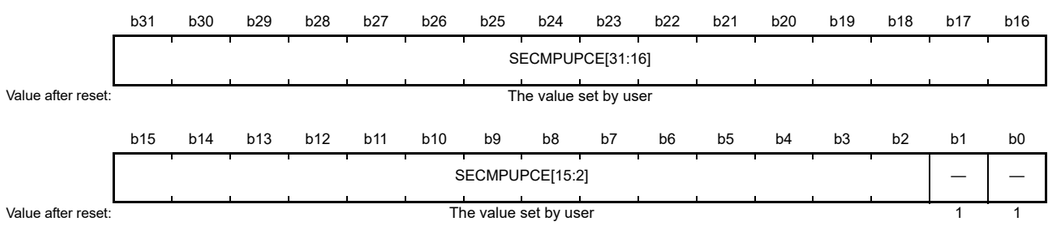
The SECMPUPCSn and SECMPUPCEn registers specify the security fetch region for the code flash or SRAM (0000 0000h to FFFF FFFFh). The secure program is executed in the memory space defined by the SECMPUPCSn and SECMPUPCEn registers, and can access the secure data specified in the SECMPUSm and SECMPUEm registers (m = 0 to 3).

The SECMPUPCSn register specifies the address where the region starts. Setting of the memory mirror space (0200 0000h to 027F FFFFh) for MMF is prohibited.

An address space of greater than 12 bytes is required between the last instruction of the non-secure program and the first instruction of the secure program.

15.6.1.2 Security MPU Program Counter End Address Register (SECMPUPCEn) (n = 0, 1)

Address(es): SECMPUPCE0 0000 040Ch, SECMPUPCE1 0000 0414h



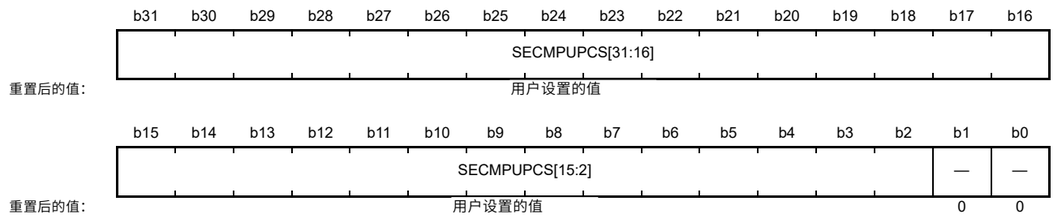
Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 1. When writing to flash, the write value should always be 1.	R
b31 to b2	SECMPUPCE[31:2]	Region End Address	Address where the region ends, for use in region determination.	R

The SECMPUPCSn and SECMPUPCEn registers specify the security fetch region of the code flash or SRAM (0000 0000h to FFFF FFFFh).

The SECMPUPCEn register specifies the address where the region ends.

15.6.1.1 安全MPU程序计数器起始地址寄存器(SECMPUPCSn)(n=0 1)

Address(es): SECMPUPCS0 0000 0408h, SECMPUPCS1 0000 0410h



Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R
b31 to b2	SECMPUPCS[31:2]	区域起始地址	区域起始地址，用于区域确定	R

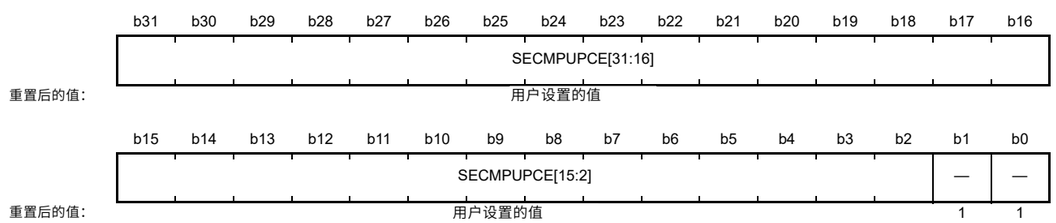
SECMPUPCSn和SECMPPCEn寄存器指定代码闪存或SRAM的安全提取区域（00000000h至FFFFFFFFh）。安全程序在由SECMPUPCSn和SECMPPCEn寄存器定义的存储空间中执行，并且可以访问在SECMPUSm和SECMPUEm寄存器中指定的安全数据（m=0到3）。

SECMPUPCSn寄存器指定区域开始的地址。禁止为MMF设置内存镜像空间（02000000h到027FFFFFh）。

在非安全程序的最后一条指令和安全程序的第一条指令之间需要一个大于12字节的地址空间。

15.6.1.2 安全MPU程序计数器结束地址寄存器(SECMPUPCEn)(n=0 1)

Address(es): SECMPUPCE0 0000 040Ch, SECMPUPCE1 0000 0414h



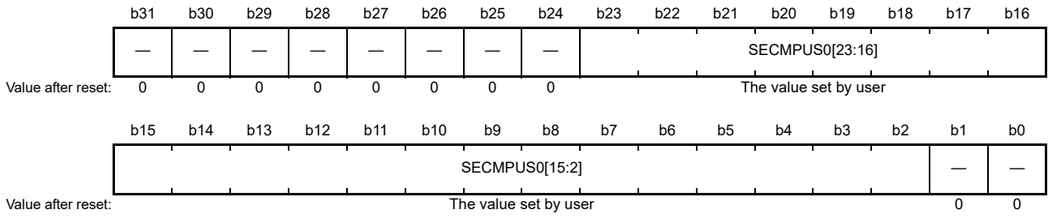
Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位读取为1。写入闪存时，写入值应始终为1。	R
b31 to b2	SECMPUPCE[31:2]	区域结束地址	区域结束的地址，用于区域确定。	R

SECMPUPCSn和SECMPPCEn寄存器指定代码闪存或SRAM的安全提取区域（00000000h至FFFFFFFFh）。

SECPUPCEn寄存器指定区域结束的地址。

15.6.1.3 Security MPU Region 0 Start Address Register (SECMPUS0)

Address(es): SECMPUS0 0000 0418h



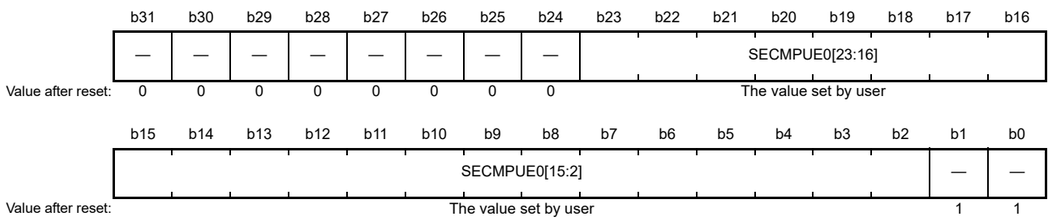
Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R
b23 to b2	SECMPUS0[23:2]	Region Start Address	Address where the region starts, for use in region determination.	R
b31 to b24	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R

The SECMPUS0 and SECMPUE0 registers specify the secure region of the code flash (0000 0000 to 00FF FFFFh). The memory space defined in the SECMPUS0 and SECMPUE0 registers can only be accessed from the secure program set up in the SECMPUPCSn and SECMPUPCEn registers.

The SECMPUS0 register specifies the address where the region starts. Setting of the vector table area is prohibited.

15.6.1.4 Security MPU Region 0 End Address Register (SECMPUE0)

Address(es): SECMPUE0 0000 041Ch



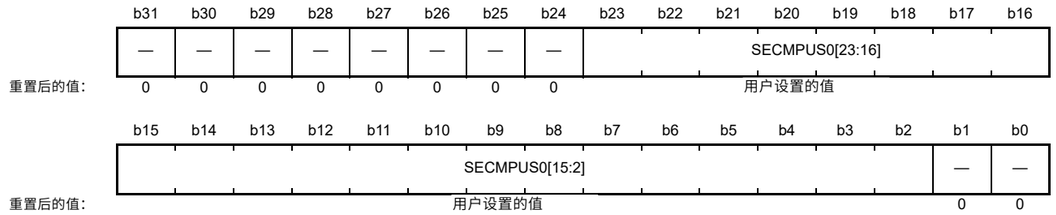
Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 1. When programming to the code flash, the write value should always be 1.	R
b23 to b2	SECMPUE0[23:2]	Region End Address	Address where the region end, for use in region determination.	R
b31 to b24	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R

The SECMPUS0 and SECMPUE0 registers specify the secure region of the flash (0000 0000 to 00FF FFFFh). The memory space defined in the SECMPUS0 and SECMPUE0 registers can only be accessed from the secure program set up in the SECMPUPCSn and SECMPUPCEn registers.

The SECMPUE0 register specifies the address where the region ends.

15.6.1.3 安全MPU区域0起始地址寄存器(SECMPUS0)

Address(es): SECMPUS0 0000 0418h



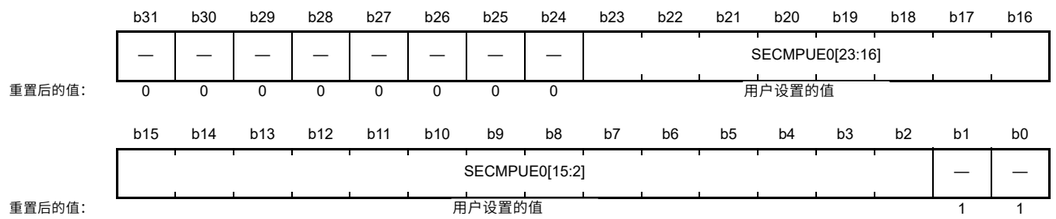
Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R
b23 to b2	SECMPUS0[23:2]	区域起始地址	区域开始的地址，用于区域确定。	R
b31 to b24	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R

SECMPUS0和SECMPUE0寄存器指定代码闪存的安全区域（00000000到00FFFFFFh）。SECMPUS0和SECMPUE0寄存器中定义的存储空间只能从SECMPUPCSn和SECMPPCEn寄存器中设置的安全程序访问。

SECMPUS0寄存器指定区域开始的地址。禁止设置向量表区域。

15.6.1.4 安全MPU区域0结束地址寄存器(SECMPUE0)

Address(es): SECMPUE0 0000 041Ch



Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为1。当编程到代码闪存时，写入值应始终为1。	R
b23 to b2	SECMPUE0[23:2]	区域结束地址	区域结束的地址，用于区域确定。	R
b31 to b24	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R

SECMPUS0和SECMPUE0寄存器指定闪存的安全区域（00000000到00FFFFFFh）。SECMPUS0和SECMPUE0寄存器中定义的存储空间只能从SECMPUPCSn和SECMPPCEn寄存器中设置的安全程序访问。

SECMPUE0寄存器指定区域结束的地址。

15.6.1.5 Security MPU Region 1 Start Address Register (SECMPUS1)

Address(es): SECMPUS1 0000 0420h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	SECMPUS1[31:16]															
Value after reset:	The value set by user															

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUS1[15:2]														—	—
Value after reset:	The value set by user														0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. When writing to flash, the write value should always be 0.	R
b19 to b2	SECMPUS1[19:2]	Region Start Address	Address where the region starts, for use in region determination	R
b31 to b20	SECMPUS1[31:20]	Region Start Address	Address where the region starts, for use in region determination. The write value should always be 1FFh.	R

The SECMPUS1 and SECMPUE1 registers specify the secure region of the SRAM (1FF0 0000h to 1FFE FFFFh). The memory space defined in the SECMPUS1 and SECMPUE1 registers can only be accessed from the secure program set up in the SECMPUPCSn and SECMPUPCEn registers.

The SECMPUS1 register specifies the start address where the region starts. Setting of the stack area and the vector table are prohibited.

15.6.1.6 Security MPU Region 1 End Address Register (SECMPUE1)

Address(es): SECMPUE1 0000 0424h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	SECMPUE1[31:16]															
Value after reset:	The value set by user															

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUE1[15:2]														—	—
Value after reset:	The value set by user														1	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 1. When writing to flash, the write value should always be 1.	R
b19 to b2	SECMPUE1[19:2]	Region End Address	Address where the region ends, for use in region determination	R
b31 to b20	SECMPUE1[31:20]	Region End Address	Address where the region ends, for use in region determination. The write value should always be 1FFh.	R

The SECMPUS1 and SECMPUE1 registers specify the secure region of the SRAM (1FF0 0000h to 1FFE FFFFh). The memory space defined in the SECMPUS1 and SECMPUE1 registers can only be accessed from the secure program set up the SECMPUPCSn and SECMPUPCEn registers.

The SECMPUE1 register specifies the address where the region ends.

15.6.1.5 安全MPU区域1起始地址寄存器(SECMPUS1)

Address(es): SECMPUS1 0000 0420h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	SECMPUS1[31:16]															
重置后的值：	用户设置的值															

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUS1[15:2]														—	—
重置后的值：	用户设置的值														0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。写入闪存时，写入值应始终为0。	R
b19 to b2	SECMPUS1[19:2]	区域起始地址	区域起始地址，用于区域确定	R
b31 to b20	SECMPUS1[31:20]	区域起始地址	区域开始的地址，用于区域确定。写入值应始终为1FFh。	R

SECMPUS1和SECMPUE1寄存器指定SRAM的安全区域（1FF00000h到1FFEFFFFh）。SECMPUS1和SECMPUE1寄存器中定义的存储空间只能从SECMPUPCSn和SECMPPCEn寄存器中设置的安全程序访问。

SECMPUS1寄存器指定区域开始的起始地址。禁止设置堆栈区和向量表。

15.6.1.6 安全MPU区域1结束地址寄存器(SECMPUE1)

Address(es): SECMPUE1 0000 0424h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	SECMPUE1[31:16]															
重置后的值：	用户设置的值															

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUE1[15:2]														—	—
重置后的值：	用户设置的值														1	1

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位读取为1。写入闪存时，写入值应始终为1。	R
b19 to b2	SECMPUE1[19:2]	区域结束地址	区域结束的地址，用于区域确定	R
b31 to b20	SECMPUE1[31:20]	区域结束地址	区域结束的地址，用于区域确定。写入值应始终为1FFh。	R

SECMPUS1和SECMPUE1寄存器指定SRAM的安全区域（1FF00000h到1FFEFFFFh）。SECMPUS1和SECMPUE1寄存器中定义的存储空间只能从SECMPUPCSn和SECMPPCEn寄存器中设置的安全程序访问。

SECMPUE1寄存器指定区域结束的地址。

15.6.1.7 Security MPU Region 2 Start Address Register (SECMPUS2)

Address(es): SECMPUS2 0000 0428h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	SECMPUS2[22:16]						
Value after reset:	0	1	0	0	0	0	0	0	0	The value set by user						

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUS2[15:2]														—	—
Value after reset:	The value set by user														0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R
b22 to b2	SECMPUS2[22:2]	Region Start Address	Address where the region starts, for use in region determination	R
b29 to b23	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R
b30	—	Reserved	This bit is read as 1. When programming to the code flash, the write value should always be 1.	R
b31	—	Reserved	This bit is read as 0. When programming to the code flash, the write value should always be 0.	R

The SECMPUS2 and SECMPUE2 registers specify the secure region of security function 1 (400C 0000h to 400D FFFFh and 4010 0000h to 407F FFFFh). The memory space defined in the SECMPUS2 and SECMPUE2 registers can only be accessed from the secure program set up in the SECMPUPCSn and SECMPUPCEn registers.

The SECMPUS2 register specifies the address where the region starts.

15.6.1.8 Security MPU Region 2 End Address Register (SECMPUE2)

Address(es): SECMPUE2 0000 042Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	SECMPUE2[22:16]						
Value after reset:	0	1	0	0	0	0	0	0	0	The value set by user						

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUE2[15:2]														—	—
Value after reset:	The value set by user														1	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 1. When programming to the code flash, the write value should always be 1.	R
b22 to b2	SECMPUE2[22:2]	Region End Address	Address where the region ends, for use in region determination	R
b29 to b23	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R
b30	—	Reserved	This bit is read as 1. When programming to the code flash, the write value should always be 1.	R

15.6.1.7 安全MPU区域2起始地址寄存器(SECMPUS2)

Address(es): SECMPUS2 0000 0428h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	SECMPUS2[22:16]						
重置后的值：	0	1	0	0	0	0	0	0	0	用户设置的值						

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUS2[15:2]														—	—
重置后的值：	用户设置的值														0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R
b22 to b2	SECMPUS2[22:2]	区域起始地址	区域起始地址，用于区域确定	R
b29 to b23	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R
b30	—	Reserved	该位被读取为1。当编程到代码闪存时，写入值应始终为1。	R
b31	—	Reserved	该位被读取为0。当编程到代码闪存时，写入值应始终为0。	R

SECMPUS2和SECMPUE2寄存器指定安全功能1的安全区域（400C0000h到400DFFFFh和40100000h到407FFFFFh）。SECMPUS2和SECMPUE2寄存器中定义的存储空间只能从SECMPUPCSn和SECMPPCEn寄存器中设置的安全程序访问。

SECMPUS2寄存器指定区域开始的地址。

15.6.1.8 安全MPU区域2结束地址寄存器(SECMPUE2)

Address(es): SECMPUE2 0000 042Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	SECMPUE2[22:16]						
重置后的值：	0	1	0	0	0	0	0	0	0	用户设置的值						

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUE2[15:2]														—	—
重置后的值：	用户设置的值														1	1

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为1。当编程到代码闪存时，写入值应始终为1。	R
b22 to b2	SECMPUE2[22:2]	区域结束地址	区域结束的地址，用于区域确定	R
b29 to b23	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R
b30	—	Reserved	该位被读取为1。当编程到代码闪存时，写入值应始终为1。	R

Bit	Symbol	Bit name	Description	R/W
b31	—	Reserved	This bit is read as 0. When programming to the code flash, the write value should always be 0.	R

The SECMPUS2 and SECMPUE2 registers specify the secure region of security function 1 (400C 0000h to 400D FFFFh and 4010 0000h to 407F FFFFh). The memory space defined in the SECMPUS2 and SECMPUE2 registers can only be accessed from the secure program set up in the SECMPUPCSn and SECMPUPCEn registers.

The SECMPUE2 register specifies the address where the region ends.

15.6.1.9 Security MPU Region 3 Start Address Register (SECMPUS3)

Address(es): SECMPUS3 0000 0430h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	SECMPUS3[22:16]						
Value after reset:	0	1	0	0	0	0	0	0	0	The value set by user						

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUS3[15:2]														—	—
Value after reset:	The value set by user														0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R
b22 to b2	SECMPUS3[22:2]	Region Start Address	Address where the region starts, for use in region determination.	R
b29 to b23	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R
b30	—	Reserved	This bit is read as 1. When programming to the code flash, the write value should always be 1.	R
b31	—	Reserved	This bit is read as 0. When programming to the code flash, the write value should always be 0.	R

The SECMPUS3 and SECMPUE3 registers specify the secure region of security function 2 (400C 0000h to 400D FFFFh and 4010 0000h to 407F FFFFh). The memory space defined in the SECMPUS3 and SECMPUE3 registers can only be accessed from the secure program set up in the SECMPUPCSn and SECMPUPCEn registers.

The SECMPUS3 register specifies the address where the region starts.

Bit	Symbol	位名称	Description	R/W
b31	—	Reserved	该位被读取为0。当编程到代码闪存时，写入值应始终为0。	R

SECMPUS2和SECMPUE2寄存器指定安全功能1的安全区域（400C0000h到400DFFFFh和40100000h到407FFFFFh）。SECMPUS2和SECMPUE2寄存器中定义的存储空间只能从SECMPUPCSn和SECMPPCEn寄存器中设置的安全程序访问。

SECMPUE2寄存器指定区域结束的地址。

15.6.1.9 安全MPU区域3起始地址寄存器(SECMPUS3)

Address(es): SECMPUS3 0000 0430h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	SECMPUS3[22:16]						
重置后的值：	0	1	0	0	0	0	0	0	0	用户设置的值						

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUS3[15:2]														—	—
重置后的值：	用户设置的值														0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R
b22 to b2	SECMPUS3[22:2]	区域起始地址	区域开始的地址，用于区域确定。	R
b29 to b23	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R
b30	—	Reserved	该位被读取为1。当编程到代码闪存时，写入值应始终为1。	R
b31	—	Reserved	该位被读取为0。当编程到代码闪存时，写入值应始终为0。	R

SECMPUS3和SECMPUE3寄存器指定安全功能2的安全区域（400C0000h到400DFFFFh和40100000h到407FFFFFh）。SECMPUS3和SECMPUE3寄存器中定义的存储空间只能从SECMPUPCSn和SECMPPCEn寄存器中设置的安全程序访问。

SECMPUS3寄存器指定区域开始的地址。

15.6.1.10 Security MPU Region 3 End Address Register (SECMPUE3)

Address(es): SECMPUE3 0000 0434h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	SECMPUE3[22:16]						
Value after reset:	0	1	0	0	0	0	0	0	0	The value set by user						

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUE3[15:2]														—	—
Value after reset:	The value set by user														1	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 1. When writing to flash, the write value should always be 1.	R
b22 to b2	SECMPUE3[22:2]	Region End Address	Address where the region ends, for use in region determination.	R
b29 to b23	—	Reserved	These bits are read as 0. When programming to the code flash, the write value should always be 0.	R
b30	—	Reserved	This bit is read as 1. When programming to the code flash, the write value should always be 1.	R
b31	—	Reserved	This bit is read as 0. When programming to the code flash, the write value should always be 0.	R

The SECMPUS3 and SECMPUE3 registers specify the secure region of security function 2 (400C 0000h to 400D FFFFh and 4010 0000h to 407F FFFFh). The memory space defined in the SECMPUS3 and SECMPUE3 registers can only be accessed from the secure program set up in the SECMPUPCSn and SECMPUPCEn registers.

The SECMPUE3 register specifies the address where the region ends.

15.6.1.11 Security MPU Access Control Register (SECMPUAC)

Address(es): SECMPUAC 0000 0438h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	DISPC1	DISPC0	—	—	—	—	DIS3	DIS2	DIS1	DIS0
Value after reset:	1	1	1	1	1	1	The value set by user		1	1	1	1	The value set by user			

Bit	Symbol	Bit name	Description	R/W
b0	DIS0	Region 0 Disable	0: Security MPU region 0 enabled 1: Security MPU region 0 disabled.	R
b1	DIS1	Region 1 Disable	0: Security MPU region 1 enabled 1: Security MPU region 1 disabled.	R
b2	DIS2	Region 2 Disable	0: Security MPU region 2 enabled 1: Security MPU region 2 disabled.	R
b3	DIS3	Region 3 Disable	0: Security MPU region 3 enabled 1: Security MPU region 3 disabled.	R
b7 to b4	—	Reserved	These bits are read as 1. When programming to the code flash, the write value should always be 1.	R
b8	DISPC0	PC Region 0 Disable	0: Security MPU PC region 0 enabled 1: Security MPU PC region 0 disabled.	R

15.6.1.10 安全MPU区域3结束地址寄存器(SECMPUE3)

Address(es): SECMPUE3 0000 0434h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	SECMPUE3[22:16]						
重置后的值：	0	1	0	0	0	0	0	0	0	用户设置的值						

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SECMPUE3[15:2]														—	—
重置后的值：	用户设置的值														1	1

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位读取为1。写入闪存时，写入值应始终为1。	R
b22 to b2	SECMPUE3[22:2]	区域结束地址	区域结束的地址，用于区域确定。	R
b29 to b23	—	Reserved	这些位被读取为0。当编程到代码闪存时，写入值应始终为0。	R
b30	—	Reserved	该位被读取为1。当编程到代码闪存时，写入值应始终为1。	R
b31	—	Reserved	该位被读取为0。当编程到代码闪存时，写入值应始终为0。	R

SECMPUS3和SECMPUE3寄存器指定安全功能2的安全区域（400C0000h到400DFFFFh和40100000h到407FFFFFh）。SECMPUS3和SECMPUE3寄存器中定义的存储空间只能从SECMPUPCSn和SECMPPCEn寄存器中设置的安全程序访问。

SECMPUE3寄存器指定区域结束的地址。

15.6.1.11 安全MPU访问控制寄存器(SECPUAC)

Address(es): SECMPUAC 0000 0438h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	DISPC1	DISPC0	—	—	—	—	DIS3	DIS2	DIS1	DIS0
重置后的值：	1	1	1	1	1	1	用户设置的值		1	1	1	1	用户设置的值			

Bit	Symbol	位名称	Description	R/W
b0	DIS0	区域0禁用	0：启用安全MPU区域01：禁用安全MPU区域0。	R
b1	DIS1	区域1禁用	0：启用安全MPU区域11：禁用安全MPU区域1。	R
b2	DIS2	区域2禁用	0：启用安全MPU区域21：禁用安全MPU区域2。	R
b3	DIS3	区域3禁用	0：启用安全MPU区域31：禁用安全MPU区域3。	R
b7 to b4	—	Reserved	这些位被读取为1。当编程到代码闪存时，写入值应始终为1。	R
b8	DISPC0	PC区域0禁用	0：启用安全MPUPC区域01：禁用安全MPUPC区域0。	R

Bit	Symbol	Bit name	Description	R/W
b9	DISPC1	PC Region 1 Disable	0: Security MPU PC region 1 enabled 1: Security MPU PC region 1 disabled.	R
b15 to b10	—	Reserved	These bits are read as 1. When programming to the code flash, the write value should always be 1.	R

Note: When flash memory is erased, the security MPU is disabled.
Note: To enable or disable the security MPU, see section 15.6.2, Memory Protection.

DIS0 bit (Region 0 Disable)

The DIS0 bit enables or disables the security MPU region 0. If security MPU region 0 is enabled, the code flash region within the limits set up by SECMPUS0 and SECMPUE0 is secure data.

DIS1 bit (Region 1 Disable)

The DIS1 bit enables or disables the security MPU region 1. If security MPU region 1 is enabled, the SRAM region within the limits set up by SECMPUS1 and SECMPUE1 is secure data.

DIS2 bit (Region 2 Disable)

The DIS2 bit enables or disables the security MPU region 2. If security MPU region 2 is enabled, the region within the limits set up by SECMPUS2 and SECMPUE2 is secure data.

DIS3 bit (Region 3 Disable)

The DIS3 bit enables or disables the security MPU region 3. If security MPU region 3 is enabled, the region within the limits set up by SECMPUS3 and SECMPUE3 is secure data.

DISPC0 bit (PC Region 0 Disable)

The DISPC0 bit enables or disables the security MPU PC region 0. If security MPU PC region 0 is enabled, the code flash or the SRAM region within the limits set up by SECMPUPCS0 and SECMPUPCE0 contains a secure program.

DISPC1 bit (PC Region 1 Disable)

The DISPC1 bit enables or disables the security MPU PC region 1. If security MPU PC region 1 is enabled, the code flash or the SRAM region within the limits set up by SECMPUPCS1 and SECMPUPCE1 contains a secure program.

15.6.2 Memory Protection

The security MPU protects the regions (the code flash, the SRAM, and two security function regions) from being accessed by non-secure programs. If access to a protected region is detected, the access becomes invalid.

When the security MPU is enabled, DISPC0 or DISPC1 in the Security MPU Access Control Register (SECMPUAC), and DIS0, DIS1, DIS2, or DIS3 in the Security MPU Access Control Register (SECMPUAC) must be set to 0.

When the security MPU is disabled, all bits in DISPC0, DISPC1, DIS0, DIS1, DIS2, and DIS3 in the Security MPU Access Control Register (SECMPUAC) must be set to 1. Other settings in the Security MPU Access Control Register (SECMPUAC) are prohibited.

The security MPU provides access protection in the following conditions:

- Secure data is accessed from a non-secure program
- Secure data is accessed from other than the CPU (DMAC, DTC)
- Secure data is accessed from the debugger.

Secure data is accessible only from a secure program.

Note: Secure program: Code flash or SRAM region within the limits set up by SECMPUPCS0 and SECMPUPCE0, code flash or SRAM region within the limits set up by SECMPUPCS1 and SECMPUPCE1.
Non-secure program: All regions outside the secure program.
Secure data: Code flash region within the limits set up by SECMPUS0 and SECMPUE0, SRAM region within the limits set up by SECMPUS1 and SECMPUE1, security function region within the limits set up by SECMPUS2 and SECMPUE2, security Function region within the limits set up by SECMPUS3 and SECMPUE3.

Bit	Symbol	位名称	Description	R/W
b9	DISPC1	PC区域1禁用	0：启用安全MPUPC区域11：禁用安全MPUPC区域1。	R
b15 to b10	—	Reserved	这些位被读取为1。当编程到代码闪存时，写入值应始终为1。	R

Note: 当闪存被擦除时，安全MPU被禁用。
Note: 要启用或禁用安全MPU，请参阅第15.6.2节，内存保护。

DIS0位（区域0禁用）

DIS0位启用或禁用安全MPU区域0。如果启用安全MPU区域0，则在SECMPUS0和SECMPUE0设置的限制范围内的代码闪存区域是安全数据。

DIS1位（区域1禁用）

DIS1位启用或禁用安全MPU区域1。如果启用安全MPU区域1，则由SECMPUS1和SECMPUE1设置的限制内的SRAM区域是安全数据。

DIS2位（区域2禁用）

DIS2位启用或禁用安全MPU区域2。如果启用安全MPU区域2，则在SECMPUS2和SECMPUE2设置的限制范围内的区域是安全数据。

DIS3位（区域3禁用）

DIS3位启用或禁用安全MPU区域3。如果启用安全MPU区域3，则在SECMPUS3和SECMPUE3设置的限制范围内的区域是安全数据。

DISPC0位（PC区域0禁用）

DISPC0位启用或禁用安全MPUPC区域0。如果启用安全MPUPC区域0，则在SECMPUPCS0和SECMPUPCE0设置的限制范围内的代码闪存或SRAM区域包含安全程序。

DISPC1位（PC区域1禁用）

DISPC1位启用或禁用安全MPUPC区域1。如果启用安全MPUPC区域1，则在SECMPUPCS1和SECMPUPCE1设置的限制范围内的代码闪存或SRAM区域包含安全程序。

15.6.2 内存保护

安全MPU保护区域（代码闪存、SRAM和两个安全功能区域）不被非安全程序访问。如果检测到对受保护区域的访问，则访问变为无效。

启用安全MPU时，必须将安全MPU访问控制寄存器(SECMPUAC)中的DISPC0或DISPC1以及安全MPU访问控制寄存器(SECMPUAC)中的DIS0、DIS1、DIS2或DIS3设置为0。

禁用安全MPU时，安全MPU中DISPC0、DISPC1、DIS0、DIS1、DIS2和DIS3中的所有位访问控制寄存器(SECMPUAC)必须设置为1。禁止安全MPU访问控制寄存器(SECMPUAC)中的其他设置。

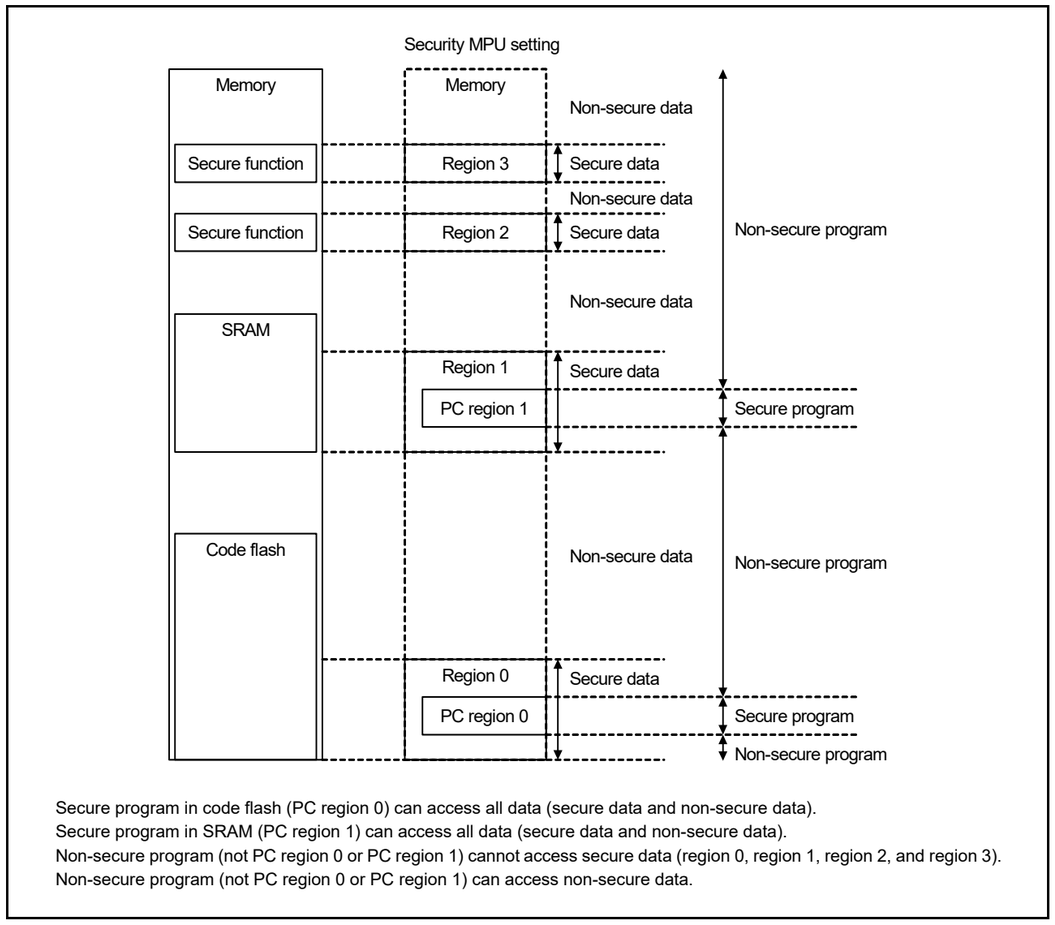
安全MPU在以下情况下提供访问保护：

- 从非安全程序访问安全数据
- 从CPU以外的地方访问安全数据（DMAC、DTC）
- 从调试器访问安全数据。

安全数据只能从安全程序访问。

Note: 安全程序：在SECMPUPCS0和SECMPUPCE0设置的范围内的代码闪存或SRAM区域，在SECMPUPCS1和SECMPUPCE1设置的范围内的代码闪存或SRAM区域。非安全程序：安全程序之外的所有区域。

Secure data: 在SECMPUS0和SECMPUE0设置的限制范围内的代码闪存区域，SRAM区域在SECMPUS1和SECMPUE1设置范围内，安全功能区域在SECMPUS2和SECMPUE2设置范围内，安全功能区域在SECMPUS3和SECMPUE3设置范围内。



Secure program in code flash (PC region 0) can access all data (secure data and non-secure data).
Secure program in SRAM (PC region 1) can access all data (secure data and non-secure data).
Non-secure program (not PC region 0 or PC region 1) cannot access secure data (region 0, region 1, region 2, and region 3).
Non-secure program (not PC region 0 or PC region 1) can access non-secure data.

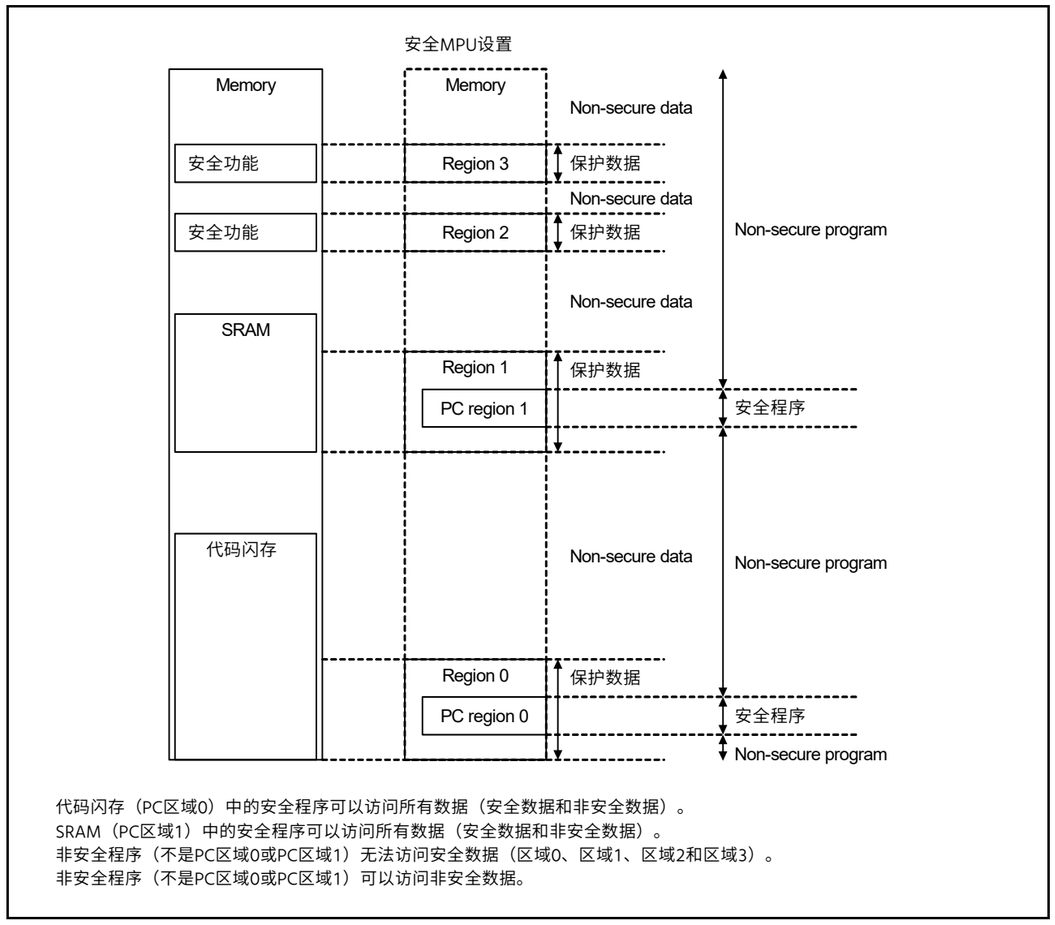
Figure 15.11 Use case of security MPU

15.6.3 Usage Notes

The protected memory cannot be debugged if the security MPU is enabled. Disable the security MPU when debugging a secure program.

15.7 References

1. *ARM®v7-M Architecture Reference Manual* (ARM DDI 0403D)
2. *ARM® Cortex®-M4 Processor Technical Reference Manual* (ARM DDI 0439D)
3. *ARM® Cortex®-M4 Devices Generic User Guide* (ARM DUI 0553A).



代码闪存（PC区域0）中的安全程序可以访问所有数据（安全数据和非安全数据）。
SRAM（PC区域1）中的安全程序可以访问所有数据（安全数据和非安全数据）。
非安全程序（不是PC区域0或PC区域1）无法访问安全数据（区域0、区域1、区域2和区域3）。
非安全程序（不是PC区域0或PC区域1）可以访问非安全数据。

Figure 15.11 安全MPU用例

15.6.3 使用说明

如果启用了安全MPU，则无法调试受保护的内存。调试安全程序时禁用安全MPU。

15.7 References

1. ARM®v7-M架构参考手册(ARMDDI0403D)
2. ARM®Cortex®-M4处理器技术参考手册(ARMDDI0439D)
3. ARM®Cortex®-M4设备通用用户指南(ARMDUI0553A)。

16. DMA Controller (DMAC)

16.1 Overview

The MCU includes an 8-channel DMA Controller (DMAC) that can transfer data without intervention from the CPU. When a DMA transfer request is generated, the DMAC transfers data stored at the transfer source address to the transfer destination address.

Table 16.1 lists the DMAC specifications and Figure 16.1 shows a block diagram.

Table 16.1 DMAC specifications

Parameter		Specifications
Number of channels		8 channels (DMACm, m = 0 to 7)
Transfer space		4 GB (0000 0000h to FFFF FFFFh, excluding reserved areas)
Maximum transfer volume		64M data units (maximum number of transfers in block transfer mode: 1,024 data units × 65,536 blocks)
DMA activation source		Selectable for each channel: • Software trigger • Interrupt requests from peripheral modules or trigger from external interrupt input pins.*1
Channel priority		Channel 0 > Channel 1 > Channel 2 > Channel 3... > Channel 7 (Channel 0: highest)
Transfer data	Single data	Bit length: 8, 16, 32 bits
	Block size	Number of data: 1 to 1,024
Transfer mode	Normal transfer mode	• One data transfer by one DMA transfer request • Selectable free running mode (total number of data transfers is not specified).
	Repeat transfer mode	• One data transfer by one DMA transfer request • Program returns to the transfer start address on completion of the repeat size of data transfer specified for the transfer source or destination • Maximum settable repeat size: 1,024.
	Block transfer mode	• One data block transfer by one DMA transfer request • Maximum settable block size: 1,024 data.
Selective functions	Extended repeat area function	• Allow data to be transferred by repeating the address values in the specified range, with the upper bit values in the transfer address register remaining fixed • Area of 2 bytes to 128 MB individually selectable as the extended repeat area for transfer source and destination.
Interrupt request (DMACm_INT)	Transfer end interrupt	Generated on completion of transferring data volume specified in the transfer counter
	Transfer escape end interrupt	Generated when: • The repeat size of data transfer is complete • The source address of the extended repeat area overflows • The destination address of the extended repeat area overflows.
Event link activation (DMACm_INT)		An event link request is generated after each data transfer (for block transfer, after each block is transferred)
Module-stop function		Module-stop state can be set to reduce power consumption

Note 1. For details on DMAC activation sources, see Table 13.3, Interrupt vector table in section 13, Interrupt Controller Unit (ICU).

16. DMA Controller (DMAC)

16.1 Overview

MCU包含一个8通道DMA控制器(DMAC)，无需CPU干预即可传输数据。
当产生DMA传输请求时，DMAC将存储在传输源地址的数据传输到传输目标地址。

表16.1列出了DMAC规范，图16.1显示了框图。

Table 16.1 DMAC specifications

Parameter		Specifications
通道数		8个通道（DMACm，m=0到7）
转移空间		4GB（00000000h到FFFFFFFFh，不包括保留区域）
最大传输量		64M数据单元（块传输模式下的最大传输数：1 024个数据单元×65 536个块）
DMA激活源		每个通道可选择： 软件触发 来自外围模块的中断请求或来自外部中断输入引脚的触发。*1
通道优先级		Channel 0 > Channel 1 > Channel 2 > Channel 3... > Channel 7 (Channel 0: highest)
传输数据	单一数据	位长：8、16、32位
	块大小	数据数量：1至1 024
传输模式	正常传输模式	一个DMA传输请求传输一个数据 可选择的自由运行模式（未指定数据传输的总数）。
	重复传输模式	通过一个DMA传输请求进行一次数据传输 完成为传输源或目标指定的重复数据传输大小后，程序返回传输起始地址 最大可设置重复大小：1 024。
	块传输模式	一个DMA传输请求传输一个数据块 最大可设置块大小：1 024个数据。
选择性功能	扩展重复区域功能	允许通过重复指定范围内的地址值来传输数据，传输地址寄存器中的高位值保持固定。 2字节到128MB的区域可以单独选择作为传输源和目标的扩展重复区域。
中断请求(DMACm_INT)	传输结束中断	在传输计数器中指定的传输数据量完成时生成
	传输转义结束中断	在以下情况下生成： 数据传输的重复大小已完成 扩展重复区域的源地址溢出 扩展重复区域的目标地址溢出。
事件链接激活(DMACm_INT)		每次数据传输后都会产生一个事件链接请求（对于块传输，在每个块传输后）
Module-stop function		可设置模块停止状态以降低功耗

Note 1. 有关DMAC激活源的详细信息，请参见第13节中断控制器单元(ICU)中的表13.3，中断向量表。

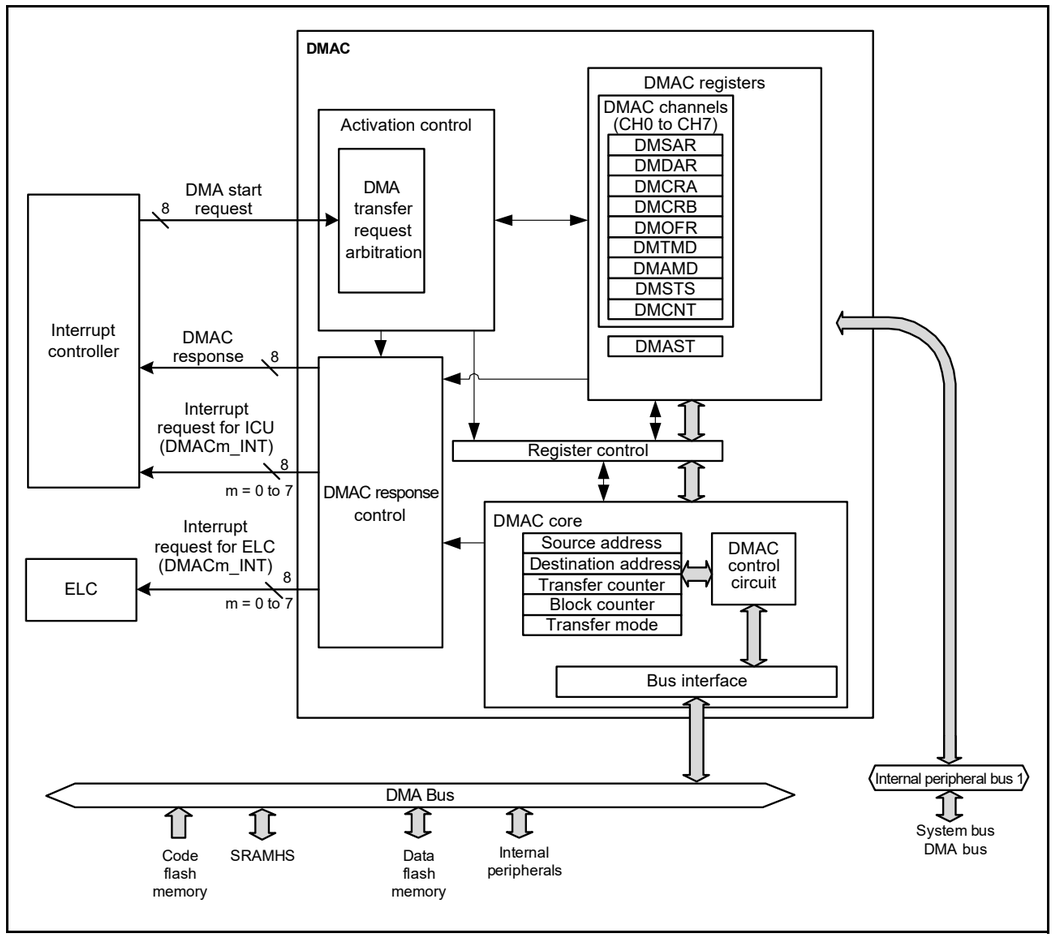


Figure 16.1 DMAC block diagram

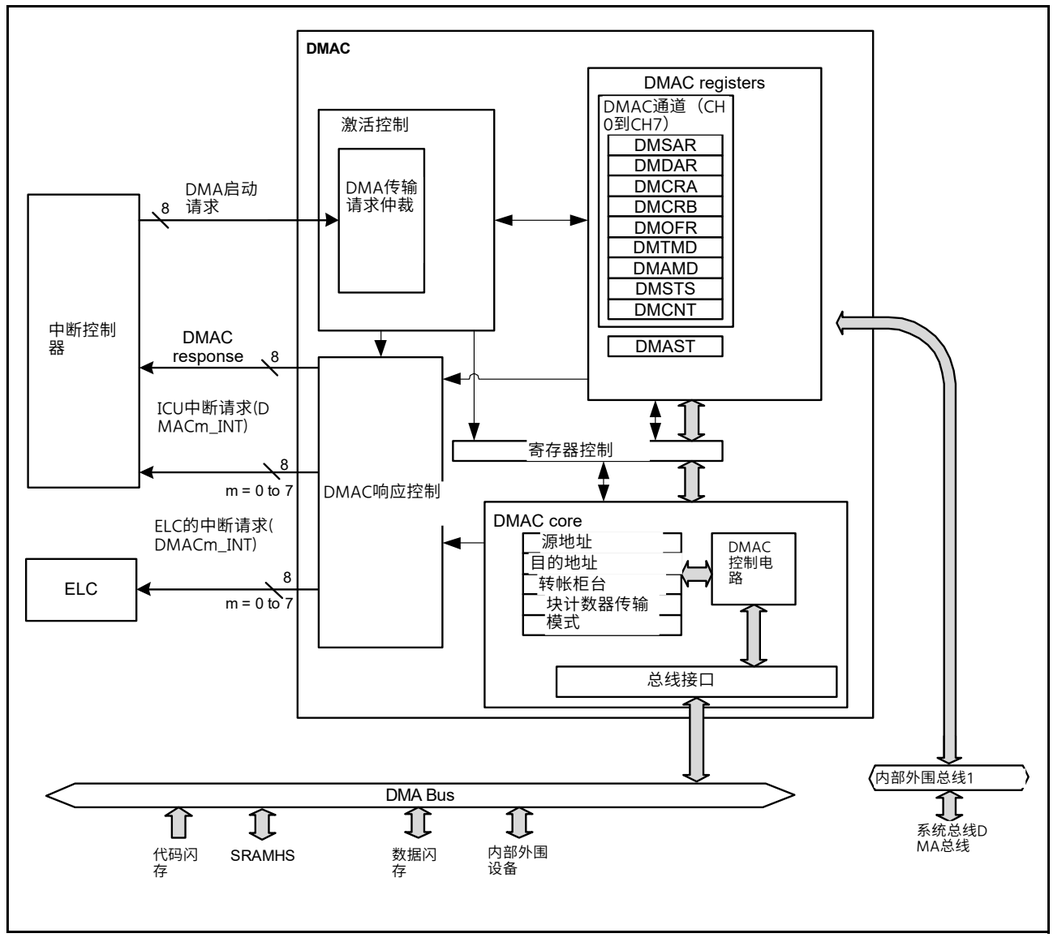


Figure 16.1 DMAC框图

16.2 Register Descriptions

16.2.1 DMA Source Address Register (DMSAR)

Address(es): DMAC0.DMSAR 4000 5000h, DMAC1.DMSAR 4000 5040h, DMAC2.DMSAR 4000 5080h, DMAC3.DMSAR 4000 50C0h, DMAC4.DMSAR 4000 5100h, DMAC5.DMSAR 4000 5140h, DMAC6.DMSAR 4000 5180h, DMAC7.DMSAR 4000 51C0h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	Setting range	R/W
b31 to b0	Specifies the transfer source start address	0000 0000h to FFFF FFFFh (4 GB)	R/W

Set DMSAR while DMAC activation is disabled (the DMST bit in DMAST = 0) or DMA transfer is disabled (the DTE bit in DMCNT = 0).

Note: Address alignment in this register must match the transfer data size value selected in the SZ bit in DMTMD.

16.2.2 DMA Destination Address Register (DMDAR)

Address(es): DMAC0.DMDAR 4000 5004h, DMAC1.DMDAR 4000 5044h, DMAC2.DMDAR 4000 5084h, DMAC3.DMDAR 4000 50C4h, DMAC4.DMDAR 4000 5104h, DMAC5.DMDAR 4000 5144h, DMAC6.DMDAR 4000 5184h, DMAC7.DMDAR 4000 51C4h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	Setting range	R/W
b31 to b0	Specifies the transfer destination start address	0000 0000h to FFFF FFFFh (4 GB)	R/W

Set DMDAR while DMAC activation is disabled (the DMST bit in DMAST = 0) or DMA transfer is disabled (the DTE bit in DMCNT = 0).

Note: Address alignment in this register must match the transfer data size value selected in the SZ bit in DMTMD.

16.2 注册说明

16.2.1 DMA源地址寄存器(DMSAR)

Address(es): DMAC0.DMSAR 4000 5000h, DMAC1.DMSAR 4000 5040h, DMAC2.DMSAR 4000 5080h, DMAC3.DMSAR 4000 50C0h, DMAC4.DMSAR 4000 5100h, DMAC5.DMSAR 4000 5140h, DMAC6.DMSAR 4000 5180h, DMAC7.DMSAR 4000 51C0h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	设定范围	R/W
b31 to b0	指定传输源起始地址	0000 0000h to FFFF FFFFh (4 GB)	R/W

在禁用DMAC激活（DMAST中的DMST位=0）或禁用DMA传输（DMCNT中的DTE位=0）时设置DMSAR。

Note: 该寄存器中的地址对齐必须与在DMTMD的SZ位中选择的传输数据大小值相匹配。

16.2.2 DMA目标地址寄存器(DMDAR)

Address(es): DMAC0.DMDAR 4000 5004h, DMAC1.DMDAR 4000 5044h, DMAC2.DMDAR 4000 5084h, DMAC3.DMDAR 4000 50C4h, DMAC4.DMDAR 4000 5104h, DMAC5.DMDAR 4000 5144h, DMAC6.DMDAR 4000 5184h, DMAC7.DMDAR 4000 51C4h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	设定范围	R/W
b31 to b0	指定传输目标起始地址	0000 0000h to FFFF FFFFh (4 GB)	R/W

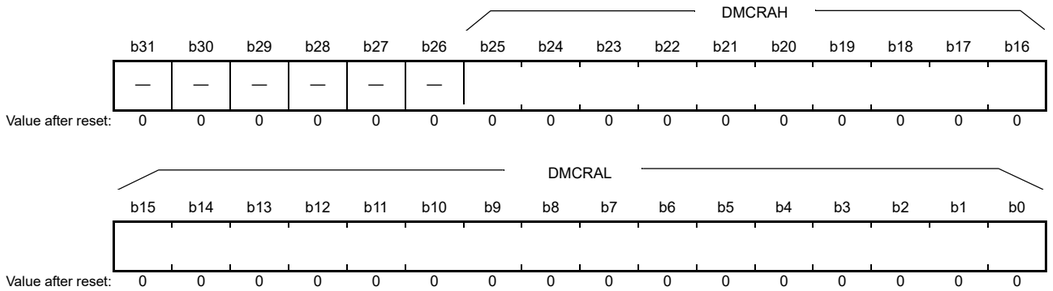
在禁用DMAC激活（DMAST中的DMST位=0）或禁用DMA传输（DMCNT中的DTE位=0）时设置DMDAR。

Note: 该寄存器中的地址对齐必须与在DMTMD的SZ位中选择的传输数据大小值相匹配。

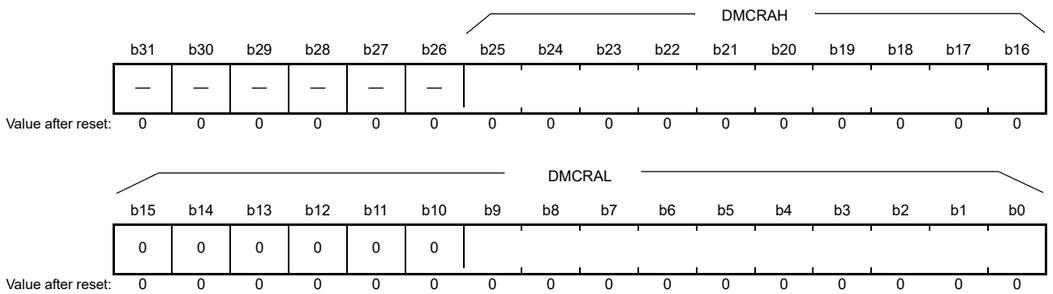
16.2.3 DMA Transfer Count Register (DMCRA)

Address(es): DMAC0.DMCRA 4000 5008h, DMAC1.DMCRA 4000 5048h, DMAC2.DMCRA 4000 5088h, DMAC3.DMCRA 4000 50C8h
DMAC4.DMCRA 4000 5108h, DMAC5.DMCRA 4000 5148h, DMAC6.DMCRA 4000 5188h, DMAC7.DMCRA 4000 51C8h

- Normal transfer mode



- Repeat transfer mode, block transfer mode



Symbol	Bit name	Description	R/W
DMCRAL	Lower bits of transfer count	Specifies the number of transfer operations	R/W
DMCRAH	Upper bits of transfer count		R/W

Note: In repeat and block transfer modes, set the same value for DMCRAH and DMCRAL.

(1) Normal transfer mode (MD[1:0] bits in DMACm.DMTMD = 00b)

In normal transfer mode, DMCRAL functions as a 16-bit transfer counter. The number of transfer operations is one when the setting is 0001h, and 65535 when it is FFFFh. The value is decremented by 1 each time data is transferred. A setting of 0000h indicates an unspecified number of transfer operations. Data transfer is performed with the transfer counter stopped, that is, in free running mode.

Do not use DMCRAH in normal transfer mode. Write 0000h to DMCRAH.

(2) Repeat transfer mode (MD[1:0] bits in DMACm.DMTMD = 01b)

In repeat transfer mode, DMCRAH specifies the repeat size and DMCRAL functions as a 10-bit transfer counter. The number of transfer operations is one when the setting is 001h, 1023 when it is 3FFh, and 1024 when it is 000h. In this mode, a value in the range of 000h to 3FFh (1 to 1024) can be set for DMCRAH and DMCRAL.

Setting bits [15:10] in DMCRAL is invalid. Write 0 to these bits. The value in DMCRAL is decremented by 1 each time data is transferred until it reaches 000h, at which time the value in DMCRAH is loaded into DMCRAL.

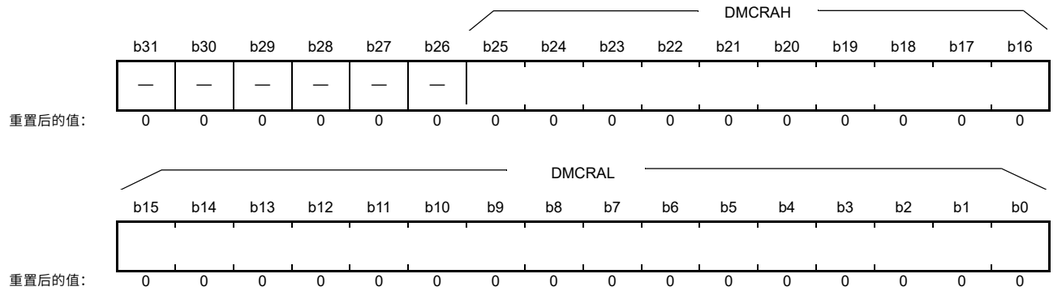
(3) Block transfer mode (MD[1:0] bits in DMACm.DMTMD = 10b)

In block transfer mode, DMCRAH specifies the block size and DMCRAL functions as a 10-bit block size counter. The block size is one when the setting is 001h, 1023 when it is 3FFh, and 1024 when it is 000h. In this mode, a value in the

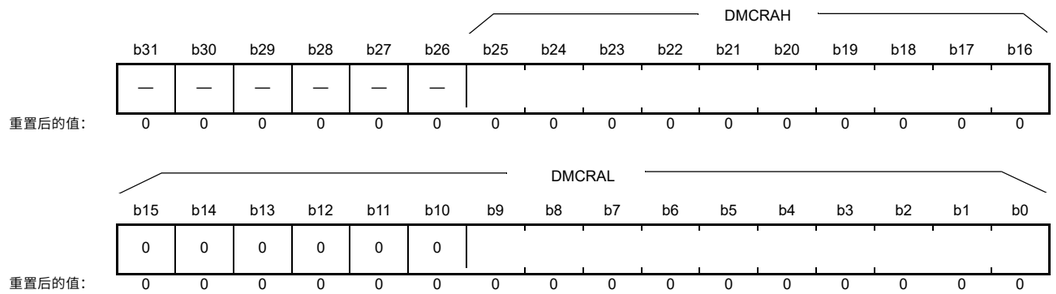
16.2.3 DMA传输计数寄存器(DMCRA)

Address(es): DMAC0.DMCRA 4000 5008h, DMAC1.DMCRA 4000 5048h, DMAC2.DMCRA 4000 5088h, DMAC3.DMCRA 4000 50C8h
DMAC4.DMCRA 4000 5108h, DMAC5.DMCRA 4000 5148h, DMAC6.DMCRA 4000 5188h, DMAC7.DMCRA 4000 51C8h

正常传输模式



重复传输模式、块传输模式



Symbol	位名称	Description	R/W
DMCRAL	传输计数的低位	指定传输操作的次数	R/W
DMCRAH	传输计数的高位		R/W

Note: 在重复和块传输模式下，为DMCRAH和DMCRAL设置相同的值。

(1) 正常传输模式（DMACm.DMTMD=00b中的MD[1:0]位）

在正常传输模式下，DMCRAL用作16位传输计数器。设置为0001h时传输操作数为1，设置为FFFFh时为65535。每次传输数据时，该值减1。设置为0000h表示未指定数量的传输操作。数据传输是在传输计数器停止的情况下执行的，即在自由运行模式下。

不要在正常传输模式下使用DMCRAH。将0000h写入DMCRAH。

(2) 重复传输模式（DMACm.DMTMD=01b中的MD[1:0]位）

在重复传输模式下，DMCRAH指定重复大小，DMCRAL用作10位传输计数器。设置为001h时传输操作数为1，设置为3FFh时为1023，设置为000h时为1024。在此模式下，可以为DMCRAH和DMCRAL设置000h到3FFh（1到1024）范围内的值。

在DMCRAL中设置位[15:10]无效。将0写入这些位。每次传输数据时，DMCRAL中的值减1，直到到达000h，此时DMCRAH中的值被加载到DMCRAL中。

(3) 块传输模式（DMACm.DMTMD=10b中的MD[1:0]位）

在块传输模式下，DMCRAH指定块大小，DMCRAL用作10位块大小计数器。设置为001h时块大小为1，设置为3FFh时为1023，设置为000h时为1024。在这种模式下，在一个值

range of 000h to 3FFh can be set for DMCRAH and DMCRAL.

Setting bits [15:10] in DMCRAL is invalid. Write 0 to these bits. The value in DMCRAL is decremented by 1 each time data is transferred until it reaches 000h, at which time the value in DMCRAH is loaded into DMCRAL.

16.2.4 DMA Block Transfer Count Register (DMCRB)

Address(es): DMAC0.DMCRB 4000 500Ch, DMAC1.DMCRB 4000 504Ch, DMAC2.DMCRB 4000 508Ch, DMAC3.DMCRB 4000 50CCh, DMAC4.DMCRB 4000 510Ch, DMAC5.DMCRB 4000 514Ch, DMAC6.DMCRB 4000 518Ch, DMAC7.DMCRB 4000 51CCh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	Setting range	R/W
b15 to b0	Specifies the number of block or repeat transfer operations	0001h to FFFFh (1 to 65535) 0000h (65536).	R/W

DMCRB specifies the number of operations in block and repeat transfer modes. The number of transfer operations is one when the setting is 0001h, 65535 when it is FFFFh, and 65536 when it is 0000h.

In repeat transfer mode, the value is decremented by 1 when the final data of one repeat size is transferred. In block transfer mode, the value is decremented by 1 when the final data of one block size is transferred. Do not use DMCRB in normal transfer mode as the setting is invalid.

16.2.5 DMA Transfer Mode Register (DMTMD)

Address(es): DMAC0.DMTMD 4000 5010h, DMAC1.DMTMD 4000 5050h, DMAC2.DMTMD 4000 5090h, DMAC3.DMTMD 4000 50D0h, DMAC4.DMTMD 4000 5110h, DMAC5.DMTMD 4000 5150h, DMAC6.DMTMD 4000 5190h, DMAC7.DMTMD 4000 51D0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MD[1:0]		DTS[1:0]		—	—	SZ[1:0]		—	—	—	—	—	—	DCTG[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	DCTG[1:0]	Transfer Request Source Select	b1 b0 0 0: Software 0 1: Interrupts*1 from peripheral modules or external interrupt input pins 1 0: Setting prohibited 1 1: Setting prohibited.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b9, b8	SZ[1:0]	Transfer Data Size Select	b9 b8 0 0: 8 bits 0 1: 16 bits 1 0: 32 bits 1 1: Setting prohibited.	R/W
b11, b10	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b13, b12	DTS[1:0]	Repeat Area Select	b13 b12 0 0: Specify destination as the repeat area or block area 0 1: Specify source as the repeat area or block area 1 0: Do not specify repeat area or block area 1 1: Setting prohibited.	R/W
b15, b14	MD[1:0]	Transfer Mode Select	b15 b14 0 0: Normal transfer 0 1: Repeat transfer 1 0: Block transfer 1 1: Setting prohibited.	R/W

可以为DMCRAH和DMCRAL设置000h到3FFh的范围。

在DMCRAL中设置位[15:10]无效。将0写入这些位。每次传输数据时，DMCRAL中的值减1，直到到达000h，此时DMCRAH中的值被加载到DMCRAL中。

16.2.4 DMA块传输计数寄存器(DMRCB)

Address(es): DMAC0.DMCRB 4000 500Ch, DMAC1.DMCRB 4000 504Ch, DMAC2.DMCRB 4000 508Ch, DMAC3.DMCRB 4000 50CCh, DMAC4.DMCRB 4000 510Ch, DMAC5.DMCRB 4000 514Ch, DMAC6.DMCRB 4000 518Ch, DMAC7.DMCRB 4000 51CCh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	设定范围	R/W
b15 to b0	指定块或重复传输操作的数量	0001h to FFFFh (1 to 65535) 0000h (65536).	R/W

DMCRB指定块和重复传输模式中的操作数。设置为0001h时传输操作数为1，设置为FFFFh时为65535，设置为0000h时为65536。

在重复传输模式下，当传输一个重复大小的最终数据时，该值减1。在块传输模式下，当传输一个块大小的最终数据时，该值减1。请勿在正常传输模式下使用DMCRB，因为该设置无效。

16.2.5 DMA传输模式寄存器(DMTMD)

Address(es): DMAC0.DMTMD 4000 5010h, DMAC1.DMTMD 4000 5050h, DMAC2.DMTMD 4000 5090h, DMAC3.DMTMD 4000 50D0h, DMAC4.DMTMD 4000 5110h, DMAC5.DMTMD 4000 5150h, DMAC6.DMTMD 4000 5190h, DMAC7.DMTMD 4000 51D0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MD[1:0]		DTS[1:0]		—	—	SZ[1:0]		—	—	—	—	—	—	DCTG[1:0]	
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	DCTG[1:0]	转移要求来源选择	b1b000：软件01：来自外围模块或外部中断输入引脚的中断*110：禁止设置11：禁止设置。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b9, b8	SZ[1:0]	传输数据大小Select	b9b800：8位01：16位10：32位11：禁止设置。	R/W
b11, b10	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b13, b12	DTS[1:0]	重复区域选择	b13b1200：指定目标为重复区域或块区域01：指定源为重复区域或块区域10：不指定重复区域或块区域11：禁止设置。	R/W
b15, b14	MD[1:0]	传输模式选择	b15b1400：正常传送01：重复传送10：块传送11：禁止设置。	R/W

Note 1. To select the DMAC activation source, use the DELSRn registers of the ICU. For details on DMAC activation sources, see Table 13.4, Event table in section 13, Interrupt Controller Unit (ICU).

DTS[1:0] bits (Repeat Area Select)

The DTS[1:0] bits select either the source or destination as the repeat area in repeat transfer mode and the block area in block transfer mode. In normal transfer mode, these bit settings are invalid.

16.2.6 DMA Interrupt Setting Register (DMINT)

Address(es): DMAC0.DMINT 4000 5013h, DMAC1.DMINT 4000 5053h, DMAC2.DMINT 4000 5093h, DMAC3.DMINT 4000 50D3h, DMAC4.DMINT 4000 5113h, DMAC5.DMINT 4000 5153h, DMAC6.DMINT 4000 5193h, DMAC7.DMINT 4000 51D3h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DTIE	ESIE	RPTIE	SARIE	DARIE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DARIE	Destination Address Extended Repeat Area Overflow Interrupt Enable	0: Disabled 1: Enabled.	R/W
b1	SARIE	Source Address Extended Repeat Area Overflow Interrupt Enable	0: Disabled 1: Enabled.	R/W
b2	RPTIE	Repeat Size End Interrupt Enable	0: Disabled 1: Enabled.	R/W
b3	ESIE	Transfer Escape End Interrupt Enable	0: Disabled 1: Enabled.	R/W
b4	DTIE	Transfer End Interrupt Enable	0: Disabled 1: Enabled.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

DARIE bit (Destination Address Extended Repeat Area Overflow Interrupt Enable)

When an extended repeat area overflow occurs on the destination address when the DARIE bit is set to 1, the DTE bit in DMCNT is set to 0. At the same time, the ESIF flag in DMSTS is set to 1 to indicate an interrupt request triggered by an extended repeat area overflow on the destination address.

When block transfer mode is used with the extended repeat area function, an interrupt occurs after completion of a 1-block size transfer. When the DTE bit is set to 1 in DMACm.DMCNT of the channel associated with the stopped transfer, the transfer resumes from the state it was in when the transfer stopped. If the extended repeat area is not specified for the destination address, this bit is ignored.

SARIE bit (Source Address Extended Repeat Area Overflow Interrupt Enable)

When an extended repeat area overflow occurs on the source address when the SARIE bit is set to 1, the DTE bit in DMCNT is set to 0. At the same time, the ESIF flag in DMSTS is set to 1 to indicate an interrupt request triggered by an extended repeat area overflow on the source address.

When block transfer mode is used with the extended repeat area function, an interrupt occurs after completion of a 1-block size transfer. When the DTE bit is set to 1 in DMACm.DMCNT of the channel associated with the stopped transfer, the transfer resumes from the state it was in when the transfer stopped. When the extended repeat area is not specified for the source address, this bit is ignored.

RPTIE bit (Repeat Size End Interrupt Enable)

When the RPTIE bit is set to 1 in repeat transfer mode, the DTE bit in DMCNT clears to 0 after completion of a 1-repeat size data transfer. At the same time, the ESIF flag in DMSTS is set to 1 to indicate that the repeat size end interrupt request occurred. The repeat size end interrupt request can be generated even when the DTS[1:0] bits in DMTMD are 10b (repeat area or block area is not specified).

When the RPTIE bit is set to 1 in block transfer mode, the DTE bit in DMCNT sets to 0 after completion of a 1-block

Note 1. 要选择DMAC激活源，请使用ICU的DELSRn寄存器。有关DMAC激活源的详细信息，请参阅表13.4，第13节中的事件表，中断控制器单元(ICU)。

DTS[1:0]位（重复区域选择）

DTS[1:0]位在重复传输模式中选择源或目标作为重复区域，在块传输模式中选择块区域。在正常传输模式下，这些位设置无效。

16.2.6 DMA中断设置寄存器(DMINT)

Address(es): DMAC0.DMINT 4000 5013h, DMAC1.DMINT 4000 5053h, DMAC2.DMINT 4000 5093h, DMAC3.DMINT 4000 50D3h, DMAC4.DMINT 4000 5113h, DMAC5.DMINT 4000 5153h, DMAC6.DMINT 4000 5193h, DMAC7.DMINT 4000 51D3h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	DTIE	ESIE	RPTIE	SARIE	DARIE
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DARIE	目标地址扩展重复区域溢出中断使能	0：禁用1：启用。	R/W
b1	SARIE	源地址扩展重复区溢出中断使能	0：禁用1：启用。	R/W
b2	RPTIE	重复大小结束中断使能	0：禁用1：启用。	R/W
b3	ESIE	传输转义结束中断使能	0：禁用1：启用。	R/W
b4	DTIE	传输结束中断使能	0：禁用1：启用。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DARIE位（目标地址扩展重复区域溢出中断使能）

当DARIE位设置为1时，当目标地址发生扩展重复区域溢出时，DMCNT中的DTE位设置为0。同时，DMSTS中的ESIF标志位设置为1，表示触发了中断请求通过目标地址上的扩展重复区域溢出。

当块传输模式与扩展重复区域功能一起使用时，在完成1块大小的传输后会发生中断。当与停止传输关联的通道的DMACm.DMCNT中的DTE位设置为1时，传输将从传输停止时的状态恢复。如果没有为目标地址指定扩展重复区域，则忽略该位。

SARIE位（源地址扩展重复区溢出中断使能）

当SARIE位设置为1时，当源地址发生扩展重复区域溢出时，DTE位DMCNT设置为0。同时，DMSTS中的ESIF标志设置为1，表示源地址上的扩展重复区域溢出触发的中断请求。

当块传输模式与扩展重复区域功能一起使用时，在完成1块大小的传输后会发生中断。当与停止传输关联的通道的DMACm.DMCNT中的DTE位设置为1时，传输将从传输停止时的状态恢复。当源地址没有指定扩展重复区域时，该位被忽略。

RPTIE位（重复大小结束中断使能）

当RPTIE位在重复传输模式下设置为1时，DMCNT中的DTE位在完成1次重复大小的数据传输后清为0。同时，DMSTS中的ESIF标志设置为1，表示发生了重复大小结束中断请求。即使DMTMD中的DTS[1:0]位为10b（未指定重复区域或块区域），也可以产生重复大小结束中断请求。

当RPTIE位在块传输模式下设置为1时，DMCNT中的DTE位在1块完成后设置为0

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data transfer in the same way as repeat transfer mode. At the same time, the ESIF flag in DMSTS is set to 1 to indicate that the repeat size end interrupt request occurred. The repeat size end interrupt request can be generated even when the DTS[1:0] bits in DMTMD are 10b (repeat area or block area is not specified).

ESIE bit (Transfer Escape End Interrupt Enable)

The ESIE bit enables the transfer escape end interrupt requests (repeat size end interrupt request and extended repeat area overflow interrupt request) that occur during DMA transfer. The interrupt occurs when this bit is 1 and the ESIF flag in DMSTS is set to 1. To clear the transfer escape end interrupt, clear this bit or the ESIF flag in DMSTS to 0.

DTIE bit (Transfer End Interrupt Enable)

The DTIE bit enables the transfer end interrupt request that occurs on completion of a specified number of data transfers. The interrupt occurs when this bit is 1 and the DTIF flag in DMSTS is set to 1. To clear the transfer end interrupt, clear this bit or the DTIF flag in DMSTS to 0.

16.2.7 DMA Address Mode Register (DMAMD)

Address(es): DMAC0.DMAMD 4000 5014h, DMAC1.DMAMD 4000 5054h, DMAC2.DMAMD 4000 5094h, DMAC3.DMAMD 4000 50D4h, DMAC4.DMAMD 4000 5114h, DMAC5.DMAMD 4000 5154h, DMAC6.DMAMD 4000 5194h, DMAC7.DMAMD 4000 51D4h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SM[1:0]		—	SARA[4:0]					DM[1:0]		—	DARA[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	DARA[4:0]	Destination Address Extended Repeat Area	Specifies the extended repeat area on the destination address. For details on the settings, see Table 16.2.	R/W
b5	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7, b6	DM[1:0]	Destination Address Update Mode	b7 b6 0 0: Fixed address 0 1: Offset addition 1 0: Incremented address 1 1: Decremented address.	R/W
b12 to b8	SARA[4:0]	Source Address Extended Repeat Area	Specifies the extended repeat area on the source address. For details on the settings, see Table 16.2.	R/W
b13	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b15, b14	SM[1:0]	Source Address Update Mode	b15 b14 0 0: Fixed address 0 1: Offset addition 1 0: Incremented address 1 1: Decremented address.	R/W

DARA[4:0] bits (Destination Address Extended Repeat Area)

The DARA[4:0] bits specify the extended repeat area on the destination address. The extended repeat area function is realized through an update of the specified lower address bits with the remaining upper address bits fixed. The size of the extended repeat area can be any power of 2 between 2 bytes and 128 MB. The start address of the extended repeat area is set when the lower address overflows the extended repeat area on an address increment. Similarly, the end address of the extended repeat area is set when the lower address underflows the extended repeat area on an address decrement.

Do not specify the extended repeat area on the destination address when a repeat or block area is specified as the transfer destination. When repeat or block transfer is selected, and when DMACm.DMTMD.DTS[1:0] = 00b (the transfer destination is specified as the repeat or block area), write 00000b in the DARA[4:0] bits.

To request an interrupt when an overflow or underflow occurs in the extended repeat area, set the DARIE bit in DMINT to 1. Table 16.2 lists the extended repeat areas associated with each setting.

DM[1:0] bits (Destination Address Update Mode)

The DM[1:0] bits select the update mode for the destination address.

数据传输方式与重复传输模式相同。同时，DMSTS中的ESIF标志设置为1，表示发生了重复大小结束中断请求。即使DMTMD中的DTS[1:0]位为10b（未指定重复区域或块区域），也可以产生重复大小结束中断请求。

ESIE位（传输转义结束中断使能）

ESIE位使能在DMA传输期间发生的传输转义结束中断请求（重复大小结束中断请求和扩展重复区域溢出中断请求）。该位为1且DMSTS中的ESIF标志设置为1时发生中断。要清除传输转义结束中断，请将该位或DMSTS中的ESIF标志清除为0。

DTIE位（传输结束中断使能）

DTIE位使能在完成指定数量的数据传输时发生的传输结束中断请求。当该位为1且DMSTS中的DTIF标志设置为1时发生中断。要清除传输结束中断，请将该位或DMSTS中的DTIF标志清除为0。

16.2.7 DMA地址模式寄存器(DMAMD)

Address(es): DMAC0.DMAMD 4000 5014h, DMAC1.DMAMD 4000 5054h, DMAC2.DMAMD 4000 5094h, DMAC3.DMAMD 4000 50D4h, DMAC4.DMAMD 4000 5114h, DMAC5.DMAMD 4000 5154h, DMAC6.DMAMD 4000 5194h, DMAC7.DMAMD 4000 51D4h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SM[1:0]		—	SARA[4:0]					DM[1:0]		—	DARA[4:0]				
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	DARA[4:0]	目标地址扩展重复区	指定目标地址上的扩展重复区域。有关设置的详细信息，请参见表16.2。	R/W
b5	—	Reserved	该位读取为0。写入值应为0。	R/W
b7, b6	DM[1:0]	目的地地址更新Mode	b7b600：固定地址01：偏移加法10：递增地址11：递减地址。	R/W
b12 to b8	SARA[4:0]	源地址扩展重复区	指定源地址上的扩展重复区域。有关设置的详细信息，请参见表16.2。	R/W
b13	—	Reserved	该位读取为0。写入值应为0。	R/W
b15, b14	SM[1:0]	源地址更新模式	b15b1400：固定地址01：偏移加法10：递增地址11：递减地址。	R/W

DARA[4:0]位（目标地址扩展重复区域）

DARA[4:0]位指定目标地址上的扩展重复区域。扩展重复区功能是通过更新指定的低地址位来实现的，而其余的高地址位是固定的。扩展重复区域的大小可以是2字节到128MB之间的任意2次幂。当低地址在地址增量上溢出扩展重复区域时，设置扩展重复区域的起始地址。类似地，在地址减量时，当低位地址下溢扩展重复区域时，设置扩展重复区域的结束地址。

将重复或块区域指定为传输目标时，请勿在目标地址上指定扩展重复区域。选择重复或块传输时，并且当DMACm.DMTMD.DTS[1:0]=00b（传输目标指定为重复或块区域）时，将00000b写入DARA[4:0]位。

要在扩展重复区域发生上溢或下溢时请求中断，请将DMINT中的DARIE位设置为1。表16.2列出了与每个设置相关的扩展重复区域。

DM[1:0]位（目标地址更新模式）

DM[1:0]位选择目标地址的更新模式。

- When increment is selected and the SZ[1:0] bits in DMTMD are set to 00b, 01b, and 10b, the destination address is incremented by 1, 2, and 4, respectively
- When decrement is selected and the SZ[1:0] bits in DMTMD are set to 00b, 01b, and 10b, the destination address is decremented by 1, 2, and 4, respectively
- When offset addition is selected, the offset specified in the DMACm.DMOFR register is added to the address.

SARA[4:0] bits (Source Address Extended Repeat Area)

The SARA[4:0] bits specify the extended repeat area on the source address. The extended repeat area function is realized through an update of the specified lower address bits with the remaining upper address bits fixed. The size of the extended repeat area can be any power of 2 between 2 bytes and 128 MB. The start address of the extended repeat area is set when the lower address overflows the extended repeat area on an address increment. Similarly, the end address of the extended repeat area is set when the lower address underflows the extended repeat area on an address decrement.

Do not specify the extended repeat area on the source address when a repeat or block area is specified as the transfer source. When repeat or block transfer is selected, and when DMACm.DMTMD.DTS[1:0] = 01b (the transfer source is specified as the repeat or block area), write 00000b in the SARA[4:0] bits.

To request an interrupt when an overflow or underflow occurs in the extended repeat area, set the SARIE bit in DMINT to 1. Table 16.2 lists the extended repeat areas associated with each setting.

SM[1:0] bits (Source Address Update Mode)

The SM[1:0] bits select the update mode for the source address:

- When increment is selected and the SZ[1:0] bits in DMTMD are set to 00b, 01b, and 10b, the source address is incremented by 1, 2, and 4, respectively
- When decrement is selected and the SZ[1:0] bits in DMTMD are set to 00b, 01b, and 10b, the source address is decremented by 1, 2, and 4, respectively
- When offset addition is selected, the offset specified in the DMACm.DMOFR register is added to the address.

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Table 16.2 SARA[4:0] or DARA[4:0] settings and corresponding repeat areas (1 of 2)

SARA[4:0] or DARA[4:0]	Extended repeat area
00000b	Not specified
00001b	2 bytes specified as extended repeat area by the lower 1 bit of the address
00010b	4 bytes specified as extended repeat area by the lower 2 bits of the address
00011b	8 bytes specified as extended repeat area by the lower 3 bits of the address
00100b	16 bytes specified as extended repeat area by the lower 4 bits of the address
00101b	32 bytes specified as extended repeat area by the lower 5 bits of the address
00110b	64 bytes specified as extended repeat area by the lower 6 bits of the address
00111b	128 bytes specified as extended repeat area by the lower 7 bits of the address
01000b	256 bytes specified as extended repeat area by the lower 8 bits of the address
01001b	512 bytes specified as extended repeat area by the lower 9 bits of the address
01010b	1 KB specified as extended repeat area by the lower 10 bits of the address
01011b	2 KB specified as extended repeat area by the lower 11 bits of the address
01100b	4 KB specified as extended repeat area by the lower 12 bits of the address
01101b	8 KB specified as extended repeat area by the lower 13 bits of the address
01110b	16 KB specified as extended repeat area by the lower 14 bits of the address
01111b	32 KB specified as extended repeat area by the lower 15 bits of the address
10000b	64 KB specified as extended repeat area by the lower 16 bits of the address
10001b	128 KB specified as extended repeat area by the lower 17 bits of the address
10010b	256 KB specified as extended repeat area by the lower 18 bits of the address
10011b	512 KB specified as extended repeat area by the lower 19 bits of the address

- WhenincrementisselectedandtheSZ[1:0]bitsinDMTMDaresetto00b 01b and10b thedestinationaddressisincrementedby1 2 and4 respectively
- WhendecrementisselectedandtheSZ[1:0]bitsinDMTMDaresetto00b 01b and10b thedestinationaddressisdecrementedby1 2 and4 respectively
- 选择偏移添加后，将dmacm.dmofr寄存器中指定的偏移添加到地址中。

SARA[4:0]位（源地址扩展重复区）

SARA[4:0]位指定源地址上的扩展重复区域。扩展重复区功能是通过更新指定的低地址位来实现的，而其余的高地址位是固定的。扩展重复区域的大小可以是2字节到128MB之间的任意2次幂。当低地址在地址增量上溢出扩展重复区域时，设置扩展重复区域的起始地址。类似地，在地址减量时，当低位地址下溢扩展重复区域时，设置扩展重复区域的结束地址。

当重复或块区域被指定为传输源时，不要在源地址上指定扩展重复区域。选择重复或块传输时，并且当DMACm.DMTMD.DTS[1:0]=01b（传输源指定为重复或块区域）时，将00000b写入SARA[4:0]位。

要在扩展重复区域发生上溢或下溢时请求中断，请将DMINT中的SARIE位设置为1。表16.2列出了与每个设置相关的扩展重复区域。

SM[1:0]位（源地址更新模式）

SM[1:0]位选择源地址的更新模式：

- WhenincrementisselectedandtheSZ[1:0]bitsinDMTMDaresetto00b 01b and10b thesourceaddressisincrementedby1 2 and4 respectively
- WhendecrementisselectedandtheSZ[1:0]bitsinDMTMDaresetto00b 01b and10b thesourceaddressisdecrementedby1 2 and4 respectively
- 选择偏移添加后，将dmacm.dmofr寄存器中指定的偏移添加到地址中。

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Table 16.2 SARA[4:0]或DARA[4:0]设置和相应的重复区域（1of2）

SARA[4:0] or DARA[4:0]	扩展重复区域
00000b	未指定
00001b	由地址的低1位指定为扩展重复区域的2个字节
00010b	由地址的低2位指定为扩展重复区域的4个字节
00011b	由地址的低3位指定为扩展重复区域的8个字节
00100b	由地址的低4位指定为扩展重复区域的16个字节
00101b	由地址的低5位指定为扩展重复区域的32个字节
00110b	由地址的低6位指定为扩展重复区域的64个字节
00111b	由地址的低7位指定为扩展重复区域的128个字节
01000b	由地址的低8位指定为扩展重复区域的256个字节
01001b	由地址的低9位指定为扩展重复区域的512个字节
01010b	1KB由地址的低10位指定为扩展重复区域
01011b	2KB由地址的低11位指定为扩展重复区域
01100b	4KB由地址的低12位指定为扩展重复区域
01101b	8KB由地址的低13位指定为扩展重复区域
01110b	16KB由地址的低14位指定为扩展重复区域
01111b	32KB由地址的低15位指定为扩展重复区域
10000b	64KB由地址的低16位指定为扩展重复区域
10001b	128KB由地址的低17位指定为扩展重复区域
10010b	256KB由地址的低18位指定为扩展重复区域
10011b	512KB由地址的低19位指定为扩展重复区域

Table 16.2 SARA[4:0] or DARA[4:0] settings and corresponding repeat areas (2 of 2)

SARA[4:0] or DARA[4:0]	Extended repeat area
10100b	1 MB specified as extended repeat area by the lower 20 bits of the address
10101b	2 MB specified as extended repeat area by the lower 21 bits of the address
10110b	4 MB specified as extended repeat area by the lower 22 bits of the address
10111b	8 MB specified as extended repeat area by the lower 23 bits of the address
11000b	16 MB specified as extended repeat area by the lower 24 bits of the address
11001b	32 MB specified as extended repeat area by the lower 25 bits of the address
11010b	64 MB specified as extended repeat area by the lower 26 bits of the address
11011b	128 MB specified as extended repeat area by the lower 27 bits of the address
11100b to 11111b	Setting prohibited

16.2.8 DMA Offset Register (DMOFR)

Address(es): DMAC0.DMOFR 4000 5018h, DMAC1.DMOFR 4000 5058h, DMAC2.DMOFR 4000 5098h, DMAC3.DMOFR 4000 50D8h, DMAC4.DMOFR 4000 5118h, DMAC5.DMOFR 4000 5158h, DMAC6.DMOFR 4000 5198h, DMAC7.DMOFR 4000 51D8h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	Setting range	R/W
b31 to b0	Specifies the offset when offset addition is selected as the address update mode for transfer source or destination	0000 0000h to 00FF FFFFh (0 byte to (16 MB - 1 byte)) FF00 0000h to FFFF FFFFh (-16 MB to -1 byte)	R/W

Only write to this register while DMAC operation is stopped or DMA transfer is disabled, not during data transfer. Setting bits [31:25] is invalid. The value in bit [24] is extended to bits [31:25]. Reading DMOFR returns the extended value.

16.2.9 DMA Transfer Enable Register (DMCNT)

Address(es): DMAC0.DMCNT 4000 501Ch, DMAC1.DMCNT 4000 505Ch, DMAC2.DMCNT 4000 509Ch, DMAC3.DMCNT 4000 50DCh, DMAC4.DMCNT 4000 511Ch, DMAC5.DMCNT 4000 515Ch, DMAC6.DMCNT 4000 519Ch, DMAC7.DMCNT 4000 51DCh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DTE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DTE	DMA Transfer Enable	0: Disabled 1: Enabled.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

DTE bit (DMA Transfer Enable)

The DTE bit enables DMA transfer. To enable DMA transfer, set the DMST bit in DMAST to 1 to enable DMAC activation, then set the DTE bit to 1 to enable DMA transfer for the associated channel.

Table 16.2 SARA[4:0]或DARA[4:0]设置和相应的重复区域(2of2)

SARA[4:0] or DARA[4:0]	扩展重复区域
10100b	1MB由地址的低20位指定为扩展重复区域
10101b	2MB由地址的低21位指定为扩展重复区域
10110b	4MB由地址的低22位指定为扩展重复区域
10111b	8MB由地址的低23位指定为扩展重复区域
11000b	16MB由地址的低24位指定为扩展重复区域
11001b	32MB由地址的低25位指定为扩展重复区域
11010b	64MB由地址的低26位指定为扩展重复区域
11011b	128MB由地址的低27位指定为扩展重复区域
11100b to 11111b	禁止设定

16.2.8 DMA偏移寄存器(DMOFR)

Address(es): DMAC0.DMOFR 4000 5018h, DMAC1.DMOFR 4000 5058h, DMAC2.DMOFR 4000 5098h, DMAC3.DMOFR 4000 50D8h, DMAC4.DMOFR 4000 5118h, DMAC5.DMOFR 4000 5158h, DMAC6.DMOFR 4000 5198h, DMAC7.DMOFR 4000 51D8h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	设定范围	R/W
b31 to b0	Specifiestheoffsetwhenoffsetadditionisselectedastheaddressupdatemodefortransfersourceordestination	00000000h至00FFFFFFh（0字节至（16MB1字节））FF000000h至FFFFFFFFh（-16MB至-1字节）	R/W

仅在DMAC操作停止或DMA传输被禁用时写入该寄存器，而不是在数据传输期间。
设置位[31:25]无效。位[24]中的值扩展到位[31:25]。读取DMOFR返回扩展值。

16.2.9 DMA传输使能寄存器(DMCNT)

Address(es): DMAC0.DMCNT 4000 501Ch, DMAC1.DMCNT 4000 505Ch, DMAC2.DMCNT 4000 509Ch, DMAC3.DMCNT 4000 50DCh, DMAC4.DMCNT 4000 511Ch, DMAC5.DMCNT 4000 515Ch, DMAC6.DMCNT 4000 519Ch, DMAC7.DMCNT 4000 51DCh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DTE
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DTE	DMA传输使能	0：禁用1 ：启用。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DTE位（DMA传输使能）

DTE位启用DMA传输。要启用DMA传输，请将DMAST中的DMST位设置为1以启用DMAC激活，然后将DTE位设置为1以启用相关通道的DMA传输。

[Setting condition]

- When 1 is written to this bit.

[Clearing conditions]

- When 0 is written to this bit
- When the specified volume of data transfer is complete
- When DMA transfer is stopped by a repeat size end interrupt
- When DMA transfer is stopped by an extended repeat area overflow interrupt.

16.2.10 DMA Software Start Register (DMREQ)

Address(es): DMAC0.DMREQ 4000 501Dh, DMAC1.DMREQ 4000 505Dh, DMAC2.DMREQ 4000 509Dh, DMAC3.DMREQ 4000 50DDh, DMAC4.DMREQ 4000 511Dh, DMAC5.DMREQ 4000 515Dh, DMAC6.DMREQ 4000 519Dh, DMAC7.DMREQ 4000 51DDh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	CLRS	—	—	—	SWREQ
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SWREQ	DMA Software Start	0: DMA transfer is not requested 1: DMA transfer is requested.	R/W
b3 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	CLRS	DMA Software Start Bit Auto Clear Select	0: SWREQ bit is cleared after DMA transfer is started by software 1: SWREQ bit is not cleared after DMA transfer is started by software.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

SWREQ bit (DMA Software Start)

Writing 1 to the SWREQ bit generates a DMA transfer request. After DMA transfer starts, SWREQ sets to 0 if the CLRS bit is 0. SWREQ does not clear if CLRS bit is 1. The DMA transfer request can be issued again after the transfer is complete.

Note: Setting this bit is valid and DMA transfer by software is enabled only when the DCTG[1:0] bits in DMTMD are set to 00b, specifying software as the DMA activation source. Setting this bit is invalid when the DCTG[1:0] bits in DMTMD are set to any value other than 00b.

To start DMA transfer by software with the CLRS bit set to 0, ensure that the SWREQ bit is 0, then write 1 to the SWREQ bit.

[Setting condition]

- When 1 is written to this bit.

[Clearing conditions]

- When a DMA transfer request by software is accepted and DMA transfer is started with the CLRS bit set to 0 (the SWREQ bit is cleared after DMA transfer is started by software)
- When 0 is written to this bit.

CLRS bit (DMA Software Start Bit Auto Clear Select)

When an SWREQ setting of 1 triggers a transfer request, the CLRS bit specifies whether to clear the SWREQ bit to 0 after DMA transfer starts. When the CLRS bit is set to 0, SWREQ sets to 0 after DMA transfer starts. When the CLRS bit is set to 1, SWREQ is not set to 0. A DMA transfer request can be issued again after the transfer is complete.

[Setting condition]

- 当1写入该位时。

[Clearing conditions]

- 当0写入该位时
- 当指定的数据传输量完成时
- 当DMA传输因重复大小结束中断而停止时
- 当DMA传输因扩展重复区域溢出中断而停止时。

16.2.10 DMA软件启动寄存器(DMREQ)

Address(es): DMAC0.DMREQ 4000 501Dh, DMAC1.DMREQ 4000 505Dh, DMAC2.DMREQ 4000 509Dh, DMAC3.DMREQ 4000 50DDh, DMAC4.DMREQ 4000 511Dh, DMAC5.DMREQ 4000 515Dh, DMAC6.DMREQ 4000 519Dh, DMAC7.DMREQ 4000 51DDh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	CLRS	—	—	—	SWREQ
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SWREQ	DMA软件启动	0：不请求DMA传输1：请求DMA传输。	R/W
b3 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	CLRS	DMA软件启动位自动清除选择	0：软件启动DMA传输后SWREQ位清零1：软件启动DMA传输后SWREQ位不清零。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SWREQ位（DMA软件启动）

将1写入SWREQ位会生成DMA传输请求。DMA传输开始后，如果CLRS位为0，则SWREQ设置为0。如果CLRS位为1，则SWREQ不清除。传输完成后可以再次发出DMA传输请求。

Note: 只有当DMTMD中的DCTG[1:0]位设置为00b时，设置该位才有效，并且通过软件启用DMA传输，将软件指定为DMA激活源。当DMTMD中的DCTG[1:0]位设置为00b以外的任何值时，设置该位无效。

要在CLRS位设置为0的情况下通过软件启动DMA传输，请确保SWREQ位为0，然后将1写入SWREQ bit.

[Setting condition]

- 当1写入该位时。

[Clearing conditions]

- 当软件的DMA传输请求被接受并且DMA传输开始时CLRS位设置为0（SWREQ位在软件启动DMA传输后清零）
- 当0写入该位时。

CLRS位（DMA软件起始位自动清除选择）

当SWREQ设置为1触发传输请求时，CLRS位指定在DMA传输开始后是否将SWREQ位清除为0。当CLRS位设置为0时，在DMA传输开始后SWREQ设置为0。当CLRS位设置为1时，SWREQ不设置为0。传输完成后可以再次发出DMA传输请求。

16.2.11 DMA Status Register (DMSTS)

Address(es): DMAC0.DMSTS 4000 501Eh, DMAC1.DMSTS 4000 505Eh, DMAC2.DMSTS 4000 509Eh, DMAC3.DMSTS 4000 50DEh, DMAC4.DMSTS 4000 511Eh, DMAC5.DMSTS 4000 515Eh, DMAC6.DMSTS 4000 519Eh, DMAC7.DMSTS 4000 51DEh

	b7	b6	b5	b4	b3	b2	b1	b0
	ACT	—	—	DTIF	—	—	—	ESIF
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	ESIF	Transfer Escape End Interrupt Flag	0: No interrupt occurred 1: Interrupt occurred.	R/W*1
b3 to b1	—	Reserved	These bits are read as 0. Writing to these bits has no effect.	R
b4	DTIF	Transfer End Interrupt Flag	0: No interrupt occurred 1: Interrupt occurred.	R/W*1
b6, b5	—	Reserved	These bits are read as 0. Writing to these bits has no effect.	R
b7	ACT	DMA Active Flag	0: DMAC operation suspended 1: DMAC operating.	R

Note 1. Only 0 can be written to clear the flag.

ESIF flag (Transfer Escape End Interrupt Flag)

The ESIF flag indicates that a transfer escape end interrupt occurred.

[Setting conditions]

- In repeat transfer mode, when one repeat size data transfer completes with the RPTIE bit in DMINT set to 1
- In block transfer mode, when one block data transfer completes with the RPTIE bit in DMINT set to 1
- When an extended repeat area overflow on the source address occurs with the SARIE bit in DMINT set to 1, and the SARA[4:0] bits in DMAMD set to any value other than 00000b (extended repeat area is specified on the transfer source address)
- When an extended repeat area overflow on the destination address occurs with the DARIE bit in DMINT set to 1, and the DARA[4:0] bits in DMAMD set to any value other than 00000b (extended repeat area is specified on the transfer destination address).

[Clearing conditions]

- When 0 is written to this flag
- When 1 is written to the DTE bit in DMCNT.

DTIF flag (Transfer End Interrupt Flag)

The DTIF flag indicates that a transfer end interrupt occurred.

[Setting conditions]

- In normal transfer mode, when the specified number of unit transfers completes (the value of DMCRAL becomes 0 on completion of transfer)
- In repeat transfer mode, when the specified number of repeat transfer operations completes (the value of DMCRB becomes 0 on completion of transfer)
- In block transfer mode, when the specified number of blocks is transferred (the value of DMCRB becomes 0 on completion of transfer).

[Clearing conditions]

- When 0 is written to this flag
- When 1 is written to the DTE bit in DMCNT.

16.2.11 DMA状态寄存器(DMSTS)

Address(es): DMAC0.DMSTS 4000 501Eh, DMAC1.DMSTS 4000 505Eh, DMAC2.DMSTS 4000 509Eh, DMAC3.DMSTS 4000 50DEh, DMAC4.DMSTS 4000 511Eh, DMAC5.DMSTS 4000 515Eh, DMAC6.DMSTS 4000 519Eh, DMAC7.DMSTS 4000 51DEh

	b7	b6	b5	b4	b3	b2	b1	b0
	ACT	—	—	DTIF	—	—	—	ESIF
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	ESIF	传输转义结束中断Flag	0：未发生中断1：发生中断。	R/W*1
b3 to b1	—	Reserved	这些位被读取为0。写入这些位无效。	R
b4	DTIF	传输结束中断标志	0：未发生中断1：发生中断。	R/W*1
b6, b5	—	Reserved	这些位被读取为0。写入这些位无效。	R
b7	ACT	DMA活动标志	0：DMAC操作暂停1：DMAC操作。	R

Note 1. 只能写入0来清除标志。

ESIF标志（传输转义结束中断标志）

ESIF标志表示发生了传输转义结束中断。

[Setting conditions]

- 在重复传输模式下，当一个重复大小的数据传输完成且DMINT中的RPTIE位设置为1时
- 在块传输模式下，当一个块数据传输完成且DMINT中的RPTIE位设置为1
- 当源地址发生扩展重复区域溢出且DMINT中的SARIE位设置为1，并且DMAMD中的SARA[4:0]位设置为00000b以外的任何值（在传输源地址上指定扩展重复区域）
- 当DMINT中的DARIE位设置为1且DMAMD中的DARA[4:0]位设置为00000b以外的任何值时，目标地址发生扩展重复区域溢出时（扩展重复区域在传输目标地址上指定）。

[Clearing conditions]

- 当0写入此标志时
- 当1写入DMCNT中的DTE位时。

DTIF标志（传输结束中断标志）

DTIF标志表示发生了传输结束中断。

[Setting conditions]

- 在正常传输模式下，当指定数量的单元传输完成时（传输完成时DMCRAL的值变为0）
- 在重复传输模式下，当指定次数的重复传输操作完成时（传输完成时DMRCB的值变为0）
- 在块传输模式下，当传输指定数量的块时（传输完成时DMCRB的值变为0）。

[Clearing conditions]

- 当0写入此标志时
- 当1写入DMCNT中的DTE位时。

ACT flag (DMA Active Flag)

The ACT flag indicates whether the DMAC is in the idle or active state.

[Setting condition]

- When the DMAC starts a data transfer.

[Clearing condition]

- When the data transfer in response to one transfer request completes.

16.2.12 DMAC Module Activation Register (DMAST)

Address(es): DMA.DMAST 4000 5200h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DMST
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DMST	DMAC Operation Enable	0: Disabled 1: Enabled.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

DMST bit (DMAC Operation Enable)

Setting the DMST bit to 1 enables DMAC activation for all channels. When the DMST bit is set to 1 (DMAC activation is enabled), and 1 is written to the DMACm.DMCNT.DTE bit (DMA transfer is enabled) for multiple channels, all of the associated channels can be placed in the transfer request ready state at the same time.

When the DMST bit sets to 0 during DMA transfer, DMA transfer is suspended after the current data transfer associated with a single transfer request completes. To resume DMA transfer, set the DMST bit to 1 again.

[Setting condition]

- When 1 is written to this bit.

[Clearing condition]

- When 0 is written to this bit.

16.3 Operation

16.3.1 Transfer Mode

(1) Normal transfer mode

In normal transfer mode, one data unit is transferred for one transfer request. You can specify the number of transfer operations, up to a maximum of 65535, in DMACm.DMCRAL. When these bits are set to 0000h, no number of operations is specified and data transfer is performed with the transfer counter stopped (free running mode). A transfer end interrupt request can be generated after completion of the specified number of transfer operations, except when in free running mode. Setting DMACm.DMCRB is invalid in normal transfer mode.

Table 16.3 summarizes the register update operation in normal transfer mode.

Table 16.3 Register update operation in normal transfer mode (1 of 2)

Register	Function	Update operation after completion of a transfer for one transfer request
DMACm.DMSAR	Transfer source address	Increment, decrement, fixed, or offset addition
DMACm.DMDAR	Transfer destination address	Increment, decrement, fixed, or offset addition

ACT标志（DMA活动标志）

ACT标志指示DMAC是处于空闲状态还是活动状态。

[Setting condition]

- 当DMAC开始数据传输时。

[Clearing condition]

- 当响应一个传输请求的数据传输完成时。

16.2.12 DMAC模块激活寄存器(DMAST)

Address(es): DMA.DMAST 4000 5200h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DMST
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DMST	DMAC操作使能	0：禁用1 ：启用。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DMST位（DMAC操作使能）

将DMST位设置为1启用所有通道的DMAC激活。当DMST位设置为1（启用DMAC激活），并且为多个通道向DMACm.DMCNT.DTE位写入1（启用DMA传输）时，所有关联的通道都可以置于传输请求就绪状态同时状态。

如果在DMA传输期间DMST位设置为0，则在与单个传输请求相关的当前数据传输完成后，DMA传输将暂停。要恢复DMA传输，请将DMST位再次设置为1。

[Setting condition]

- 当1写入该位时。

[Clearing condition]

- 当0写入该位时。

16.3 Operation

16.3.1 传输模式

(1) 正常传输模式

在正常传输模式下，对于一个传输请求传输一个数据单元。您可以在DMACm.DMCRAL中指定传输操作的数量，最多为65535。当这些位设置为0000h时，不指定操作数，并且在传输计数器停止的情况下执行数据传输（自由运行模式）。在完成指定数量的传输操作后，可以生成传输结束中断请求，自由运行模式除外。在正常传输模式下设置DMACm.DMCRB无效。

表16.3总结了正常传输模式下的寄存器更新操作。

Table 16.3 正常传输模式下的寄存器更新操作（1of2）

Register	Function	一个传输请求的传输完成后的更新操作
DMACm.DMSAR	传输源地址	递增、递减、固定或偏移添加
DMACm.DMDAR	转移目的地地址	递增、递减、固定或偏移添加

Table 16.3 Register update operation in normal transfer mode (2 of 2)

Register	Function	Update operation after completion of a transfer for one transfer request
DMACm.DMCRAL	Transfer count	Decremented by 1 or not updated (in free running mode)
DMACm.DMCRAH	-	Not updated (not used in normal transfer mode)
DMACm.DMCRB	-	Not updated (not used in normal transfer mode)

Figure 16.2 shows the operation in normal transfer mode.

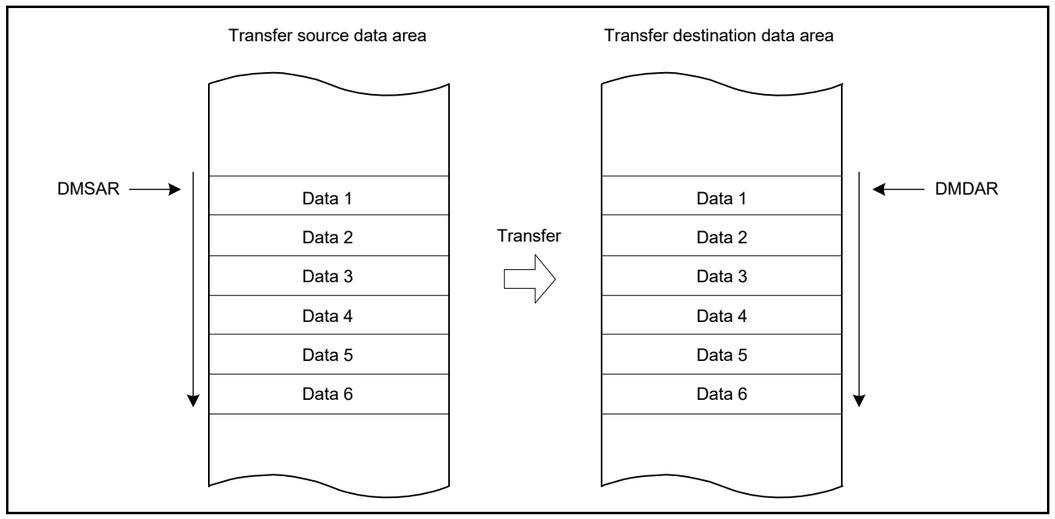

Figure 16.2 Operation in normal transfer mode

(2) Repeat transfer mode

In repeat transfer mode, one data unit is transferred for one transfer request. The repeat transfer size, up to a maximum of 1K data units, is set in DMACm.DMCRA. The number of repeat transfers, up to a maximum of 64K, is set in DMACm.DMCRB. The total data transfer size can be set to a maximum of 64M data units (1K data units × 64K repeat transfer operations).

You can specify either the transfer source or destination as a repeat area. When transfer of the repeat size data is complete, the address of the specified repeat area (DMSAR or DMDAR in DMACm) returns to the transfer start address. In this mode, when all data of the specified repeat size is transferred, DMA transfer can be stopped and a repeat size end interrupt can be requested. To resume DMA transfer, write 1 to the DTE bit in DMACm.DMCNT during repeat size end interrupt handling.

A transfer end interrupt request can be generated after completion of the specified number of repeat transfers.

Table 16.4 summarizes the register update operation in repeat transfer mode, and Figure 16.3 shows the operation in repeat transfer mode.

Table 16.4 Register update operation in repeat transfer mode (1 of 2)

		Update operation after completion of a transfer for one transfer request	
Register	Function	When DMACm.DMCRAL is not 1	When DMACm.DMCRAL is 1 (transfer of the last repeat size data unit)
DMACm.DMSAR	Transfer source address	Increment, decrement, fixed, or offset addition	• DMACm.DMTMD.DTS[1:0] = 00b Increment, decrement, fixed, or offset addition • DMACm.DMTMD.DTS[1:0] = 01b Initial value of DMACm.DMSAR • DMACm.DMTMD.DTS[1:0] = 10b Increment, decrement, fixed, or offset addition.

Table 16.3 正常传输模式下的寄存器更新操作(2of2)

Register	Function	一个传输请求的传输完成后的更新操作
DMACm.DMCRAL	转移计数	减1或不更新（在自由运行模式下）
DMACm.DMCRAH	-	未更新（ 未在正常传输模式下使用）
DMACm.DMCRB	-	未更新（ 未在正常传输模式下使用）

图16.2显示了正常传输模式下的操作。

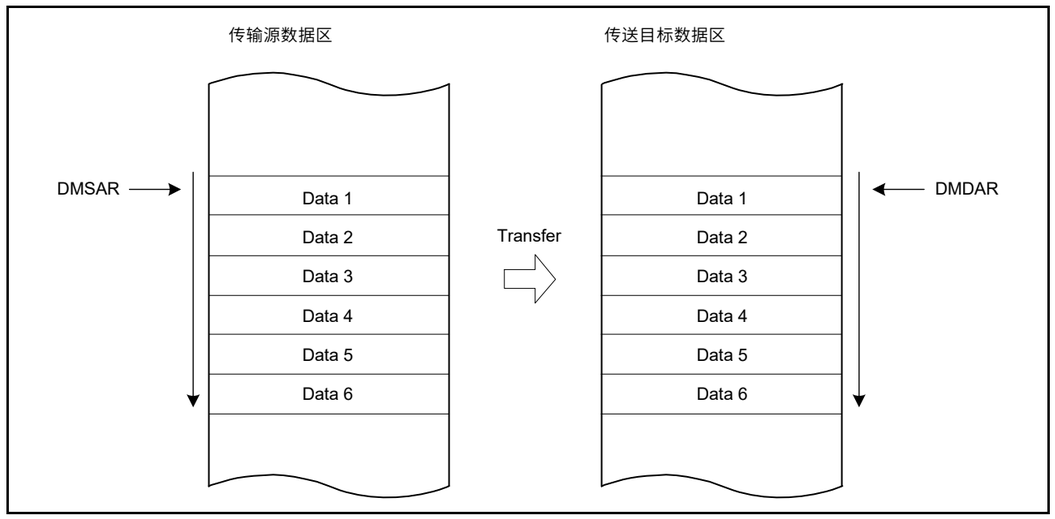

Figure 16.2 正常传输模式下的操作

(2) 重复传输模式

在重复传输模式中，对于一个传输请求传输一个数据单元。在DMACm.DMCRA中设置了最多1K数据单元的重复传输大小。在DMACm.DMCRB中设置了最多64K的重复传输次数。总数据传输大小最多可设置为64M数据单元（1K数据单元×64K重复传输操作）。

您可以将传输源或目标指定为重复区域。当重复大小数据的传输完成时，指定的重复区域（DMACm中的DMSAR或DMDAR）的地址返回到传输起始地址。在此模式下，当指定重复大小的所有数据都传输完毕后，可以停止DMA传输并请求重复大小结束中断。要恢复DMA传输，请在重复大小结束中断处理期间将1写入DMACm.DMCNT中的DTE位。

完成指定次数的重复传输后，可以产生传输结束中断请求。

表16.4总结了重复传输模式下的寄存器更新操作，图16.3显示了重复传输模式下的操作。

Table 16.4 重复传输模式下的寄存器更新操作（1of2）

		一个传输请求的传输完成后的更新操作	
Register	Function	当DMACm.DMCRAL不为1时	当DMACm.DMCRAL为1时（传输最后一个重复大小数据单元）
DMACm.DMSAR	传输源地址	递增、递减、固定或偏移添加	• DMACm.DMTMD.DTS[1:0] = 00b 递增、递减、固定或偏移加法 DMACm.DMTMD.DTS[1:0]=01bDMACm.DMSAR的初始值 DMACm.DMTMD.DTS[1:0]=10b 递增、递减、固定或偏移添加。

Table 16.4 Register update operation in repeat transfer mode (2 of 2)

		Update operation after completion of a transfer for one transfer request	
Register	**Function**	**When DMACm.DMCRAL is not 1**	**When DMACm.DMCRAL is 1 (transfer of the last repeat size data unit)**
DMACm.DMDAR	Transfer destination address	Increment, decrement, fixed, or offset addition	• DMACm.DMTMD.DTS[1:0] = 00b Initial value of DMACm.DMDAR • DMACm.DMTMD.DTS[1:0] = 01b Increment, decrement, fixed, or offset addition • DMACm.DMTMD.DTS[1:0] = 10b Increment, decrement, fixed, or offset addition.
DMACm.DMCRAH	Repeat size	Not updated	Not updated
DMACm.DMCRAL	Transfer count	Decremented by 1	DMACm.DMCRAH
DMACm.DMCRB	Count of repeat transfer operations	Not updated	Decremented by 1

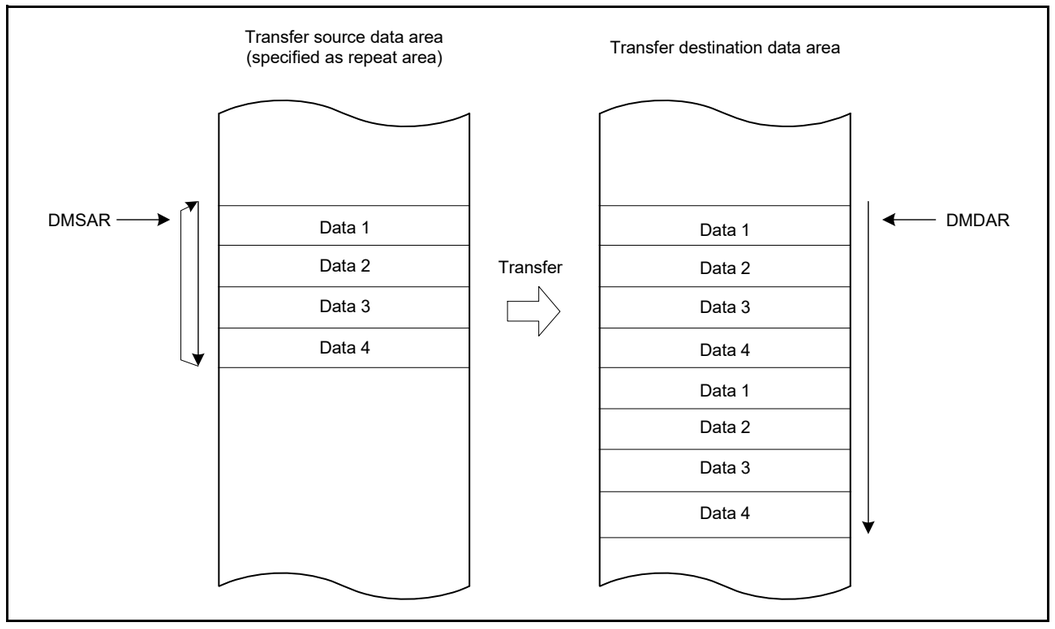

Figure 16.3 Operation in repeat transfer mode

(3) Block transfer mode

In block transfer mode, a single data block is transferred for one transfer request. The block size, up to a maximum of 1K data units, is set in DMACm.DMCRA. The number of block transfers, up to a maximum of 64K, is set in DMACm.DMCRB. A total data transfer size up to a maximum of 64M data units (1K data units × 64K block transfer operations) can be set.

You can specify either the transfer source or destination as a block area. When transfer of a single data block is complete, the address of the specified block area (DMSAR or DMDAR in DMACm) returns to the transfer start address. In this mode, when all data in a single block is transferred, DMA transfer can be stopped and a repeat size end interrupt can be requested. To resume DMA transfer, write 1 to the DTE bit in DMACm.DMCNT during repeat size end interrupt handling.

A transfer end interrupt request can be generated after completion of the specified number of block transfers.

Table 16.5 summarizes the register update operation in block transfer mode, and Figure 16.4 shows the operation in block transfer mode.

Table 16.4 重复传输模式下的寄存器更新操作(2of2)

		一个传输请求的传输完成后的更新操作	
Register	**Function**	**当DMACm.DMCRAL不为1时**	**当DMACm.DMCRAL为1时（传输最后一个重复大小数据单元）**
DMACm.DMDAR	转移目的地地址	递增、递减、固定或偏移添加	DMACm.DMTMD.DTS[1:0]=00bDMACm.DMDAR的初始值 DMACm.DMTMD.DTS[1:0]=01b 递增、递减、固定或偏移加法 DMACm.DMTMD.DTS[1:0]=10b 递增、递减、固定或偏移添加。
DMACm.DMCRAH	重复大小	未更新	未更新
DMACm.DMCRAL	转移计数	Decremented by 1	DMACm.DMCRAH
DMACm.DMCRB	重复传输操作的计数	未更新	Decremented by 1

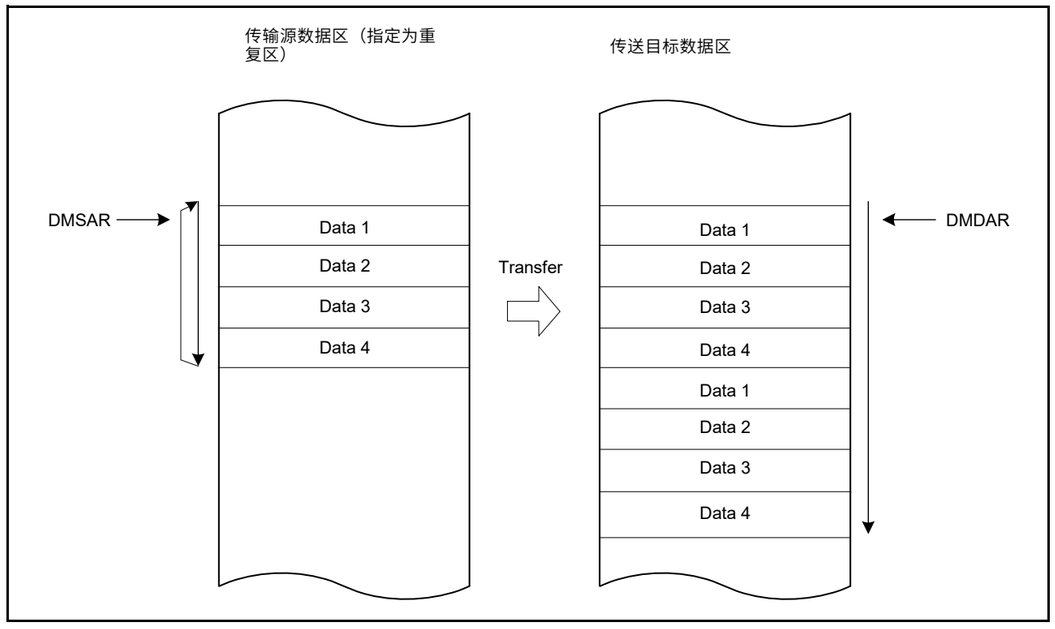

Figure 16.3 重复传输模式下的操作

(3) 块传输模式

在块传输模式下，为一个传输请求传输一个数据块。在DMACm.DMCRA中设置了最多1K个数据单元的块大小。在DMACm.DMCRB中设置了最多64K的块传输次数。总数据传输大小最多可设置为64M数据单元（1K数据单元×64K块传输操作）。

您可以将传输源或目标指定为块区域。当单个数据块的传输完成时，指定块区域的地址（DMACm中的DMSAR或DMDAR）返回到传输起始地址。在这种模式下，当单个块中的所有数据都传输完毕后，可以停止DMA传输并请求重复大小结束中断。要恢复DMA传输，请在重复大小结束中断处理期间将1写入DMACm.DMCNT中的DTE位。

完成指定数量的块传输后，可以产生传输结束中断请求。

表16.5总结了块传输模式下的寄存器更新操作，图16.4显示了块传输模式下的操作。

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Table 16.5 Register update operation in block transfer mode

Register	Function	Update operation after completion of single-block transfer for one transfer request
DMACm.DMSAR	Transfer source address	• DMACm.DMTMD.DTS[1:0] = 00b Increment, decrement, fixed, or offset addition • DMACm.DMTMD.DTS[1:0] = 01b Initial value of DMACm.DMSAR • DMACm.DMTMD.DTS[1:0] = 10b Increment, decrement, fixed, or offset addition.
DMACm.DMDAR	Transfer destination address	• DMACm.DMTMD.DTS[1:0] = 00b Initial value of DMACm.DMDAR • DMACm.DMTMD.DTS[1:0] = 01b Increment, decrement, fixed, or offset addition • DMACm.DMTMD.DTS[1:0] = 10b Increment, decrement, fixed, or offset addition.
DMACm.DMCRAH	Block size	Not updated
DMACm.DMCRAL	Transfer count	DMACm.DMCRAH
DMACm.DMCRB	Count of block transfer operations	Decremented by 1

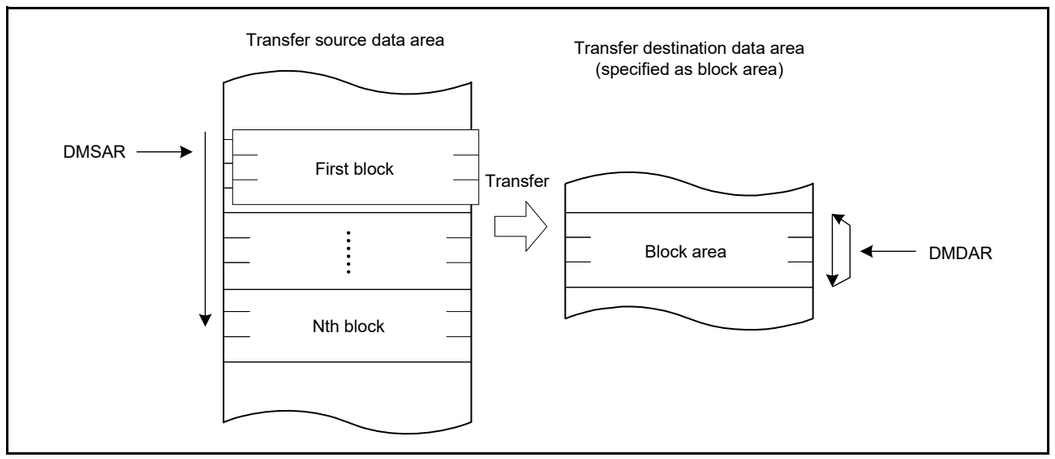

Figure 16.4 Operation in block transfer mode

16.3.2 Extended Repeat Area Function

The DMAC supports extended repeat areas on the transfer source and destination addresses, specified separately in the transfer source address register (DMSAR) and transfer destination address register (DMDAR) of DMACm. When this function is set, the address registers repeatedly indicate the addresses of the specified extended repeat areas.

The extended repeat area on the source address is specified in the SARA[4:0] bits in DMACm.DMAMD. The extended repeat area on the destination address is specified in the DARA[4:0] bits in DMACm.DMAMD. You can specify different sizes for the source and destination. However, you must not specify a transfer source or destination that is set as the repeat or block area as the extended repeat area.

When the address register value reaches the end address of the extended repeat area and the extended repeat area overflows, DMA transfer is stopped and an extended repeat area overflow interrupt can be requested. When an overflow occurs in the extended repeat area on the transfer source while the SARIE bit in DMACm.DMINT is set to 1, the ESIF flag in DMACm.DMSTS is set to 1 and the DTE bit in DMACm.DMCNT sets to 0 to stop DMA transfer. At this point, if the ESIE bit in DMACm.DMINT is set to 1, an extended repeat area overflow interrupt is requested. When the DARIE bit in DMACm.DMINT is set to 1, the destination address register becomes a target for the function. To resume DMA transfer, write 1 to the DTE bit in DMACm.DMCNT during interrupt handling.

Figure 16.5 shows an example of the extended repeat area operation.

Table 16.5 块传输模式下的寄存器更新操作

Register	Function	一个传输请求的单块传输完成后的更新操作
DMACm.DMSAR	传输源地址	• DMACm.DMTMD.DTS[1:0] = 00b 递增、递减、固定或偏移加法 DMACm.DMTMD.DTS[1:0]=01bDMACm.DMSAR的初始值 DMACm.DMTMD.DTS[1:0]=10b 递增、递减、固定或偏移添加。
DMACm.DMDAR	转移目的地地址	DMACm.DMTMD.DTS[1:0]=00bDMACm.DMDAR的初始值 DMACm.DMTMD.DTS[1:0]=01b 递增、递减、固定或偏移加法 DMACm.DMTMD.DTS[1:0]=10b 递增、递减、固定或偏移添加。
DMACm.DMCRAH	块大小	未更新
DMACm.DMCRAL	转移计数	DMACm.DMCRAH
DMACm.DMCRB	块传输操作的计数	Decremented by 1

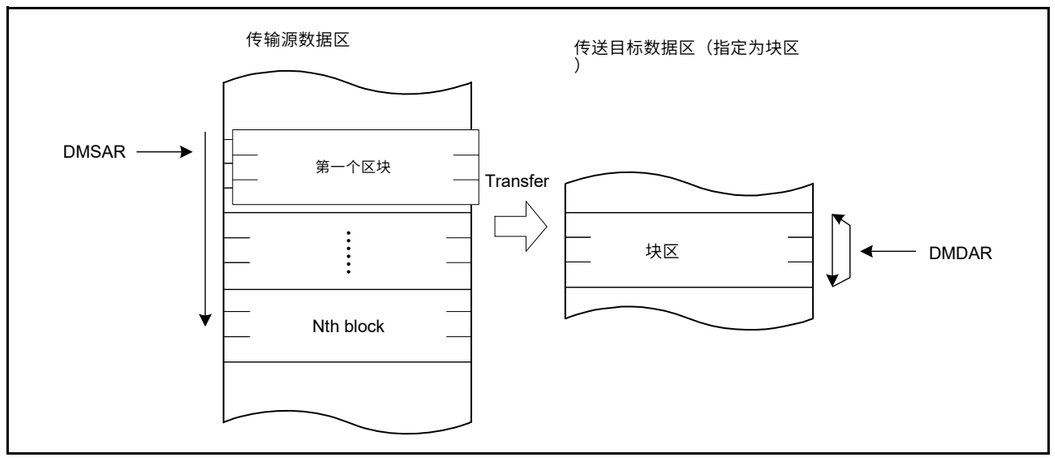

Figure 16.4 块传输模式下的操作

16.3.2 扩展重复区域功能

DMAC支持在传输源地址和目标地址上扩展重复区域，分别在DMACm的传输源地址寄存器(DMSAR)和传输目标地址寄存器(DMDAR)中指定。设置此功能时，地址寄存器重复指示指定扩展重复区域的地址。

源地址上的扩展重复区域在DMACm.DMAMD中的SARA[4:0]位中指定。目标地址上的扩展重复区域在DMACm.DMAMD中的DARA[4:0]位中指定。您可以为源和目标指定不同的大小。但是，您不能将设置为重复或块区域的传输源或目标指定为扩展重复区域。

当地址寄存器值到达扩展重复区的结束地址且扩展重复区溢出时，停止DMA传输，可以请求扩展重复区溢出中断。当DMACm.DMINT中的SARIE位设置为1时，传输源的扩展重复区域发生溢出时，DMACm.DMSTS中的ESIF标志设置为1，DMACm.DMCNT中的DTE位设置为0以停止DMA传输。此时，如果DMACm.DMINT中的ESIE位设置为1，则请求扩展重复区域溢出中断。当DMACm.DMINT中的DARIE位设置为1时，目标地址寄存器成为函数的目标。要恢复DMA传输，请在中断处理期间将1写入DMACm.DMCNT中的DTE位。

图16.5显示了扩展重复区域操作的示例。

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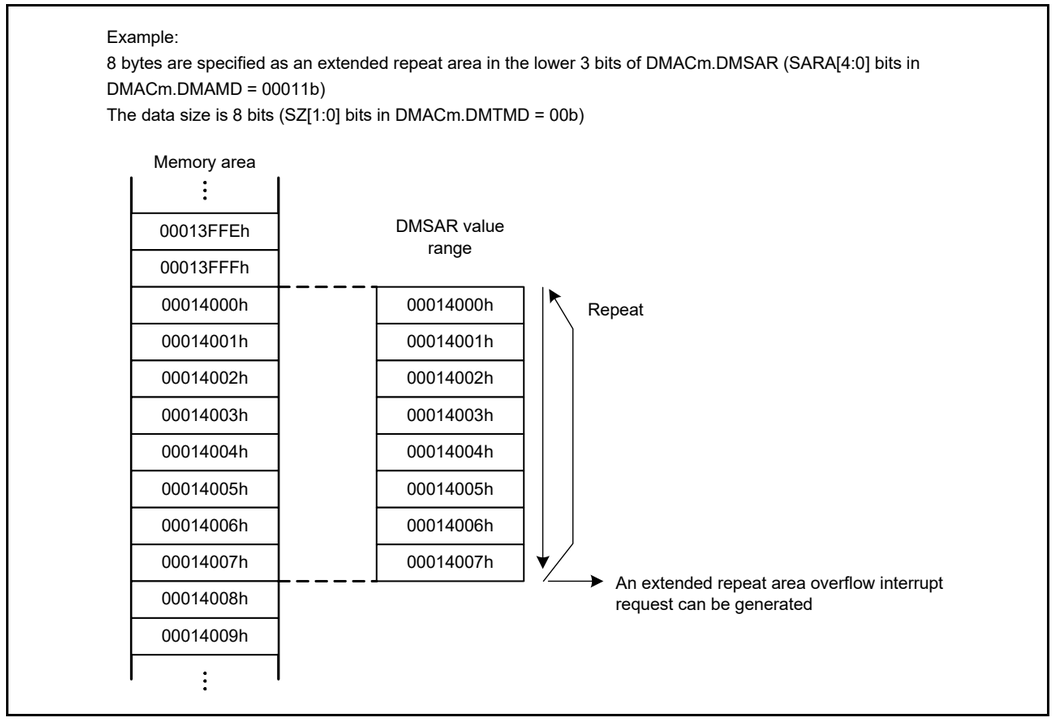

Figure 16.5 Example of extended repeat area operation

When using extended repeat area overflow interrupts in block transfer mode, consider the following points:

- When a transfer is stopped by an extended repeat area overflow interrupt, the address register must be set so that the block size is a power of 2 or the block size boundary is aligned with the extended repeat area boundary. When an overflow on the extended repeat area occurs during a transfer of one block, the overflow interrupt is suspended until transfer of the block is complete, and the transfer overruns.

Figure 16.6 shows an example of using the extended repeat area function in block transfer mode.

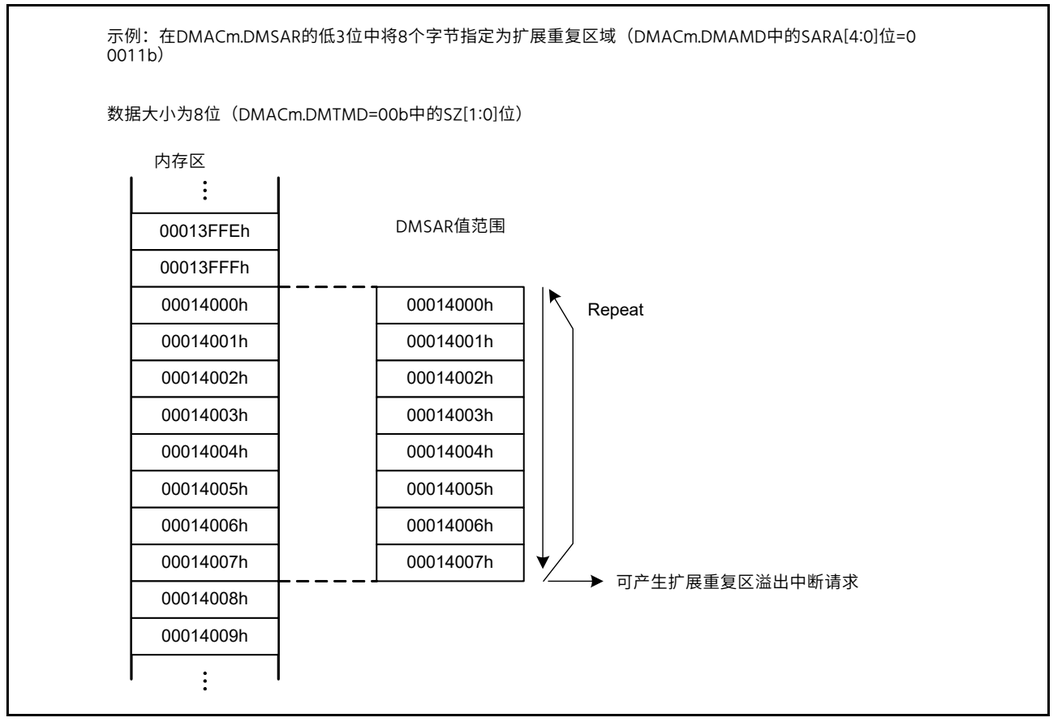

Figure 16.5 扩展重复区域操作示例

在块传输模式下使用扩展重复区域溢出中断时，请考虑以下几点：

- 当传输由扩展重复区域溢出中断停止时，地址寄存器必须设置为块大小为2的幂或块大小边界与扩展重复区域边界对齐。当一个块的传输过程中扩展重复区域发生溢出时，溢出中断被暂停，直到块的传输完成，传输溢出。

图16.6显示了在块传输模式下使用扩展重复区域功能的示例。

Example:
8 bytes are specified as an extended repeat area in the lower 3 bits of DMACm.DMSAR (SARA[4:0] bits in DMACm.DMAMD = 00011b)
Block transfer mode with block size 5 is set (DMACm.DMCRA = 00050005h)
The transfer source address is not specified as a block area
The data size is 8 bits (SZ[1:0] bits in DMACm.DMTMD = 00b)

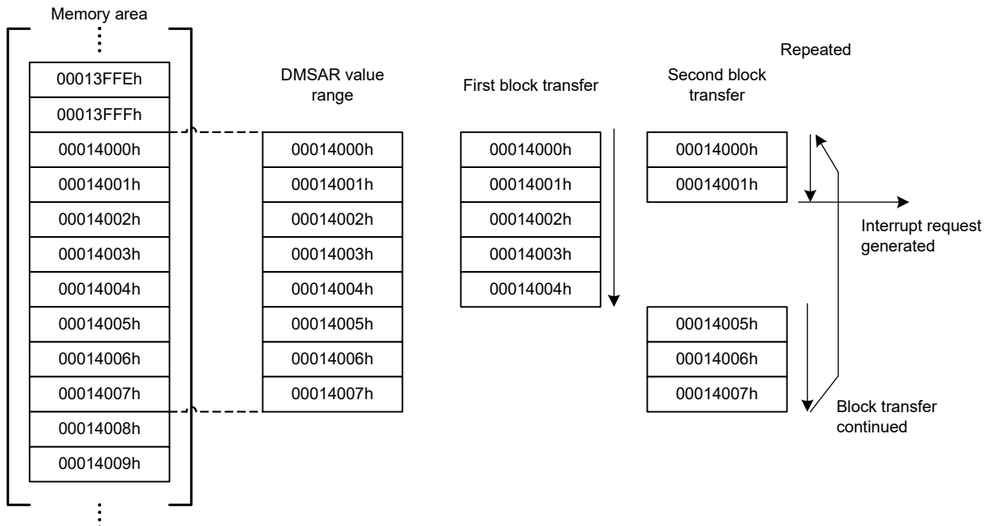

Figure 16.6 Example of extended repeat area function in block transfer mode

16.3.3 Address Update Function Using Offset

The source and destination addresses can be updated by fixing, incrementing, decrementing, or adding an offset. When offset addition is selected, the offset specified in the DMA Offset Register (DMACm.DMOFR) is added to the address every time the DMAC performs one data transfer. You can also subtract an offset by setting a negative value in DMACm.DMOFR. The negative value must be in two's complement.

Table 16.6 shows the address update method in each address update mode.

Table 16.6 Address update method in each address update mode

Address update mode	Settings of DMACm.DMAMD.SM[1:0] and DMACm.DMAMD.DM[1:0] for address update modes	Address update method for different SZ[1:0] settings in DMACm.DMTMD		
		SZ[1:0] = 00b	SZ[1:0] = 01b	SZ[1:0] = 10b
Address fixed	00b	Fixed		
Offset addition	01b	+DMACm.DMOFR*1		
Increment	10b	+1	+2	+4
Decrement	11b	-1	-2	-4

Note 1. When setting a negative value in the DMA Offset Register, the value must be in two's complement, obtained by the following formula:
Two's complement of a negative offset value = ~ (offset) + 1 (~ = bit inversion)

(1) Basic transfer using offset addition

Figure 16.7 shows an example of address updating using offset addition.

示例：在DMACm.DMSAR的低3位中指定8个字节作为扩展重复区域（DMACm.DMAMD中的SARA[4:0]位=00011b）设置块大小为5的块传输模式（DMACm.DMCRA=00050005h）

传输源地址未指定为块区域
数据大小为8位（DMACm.DMTMD=00b中的SZ[1:0]位）

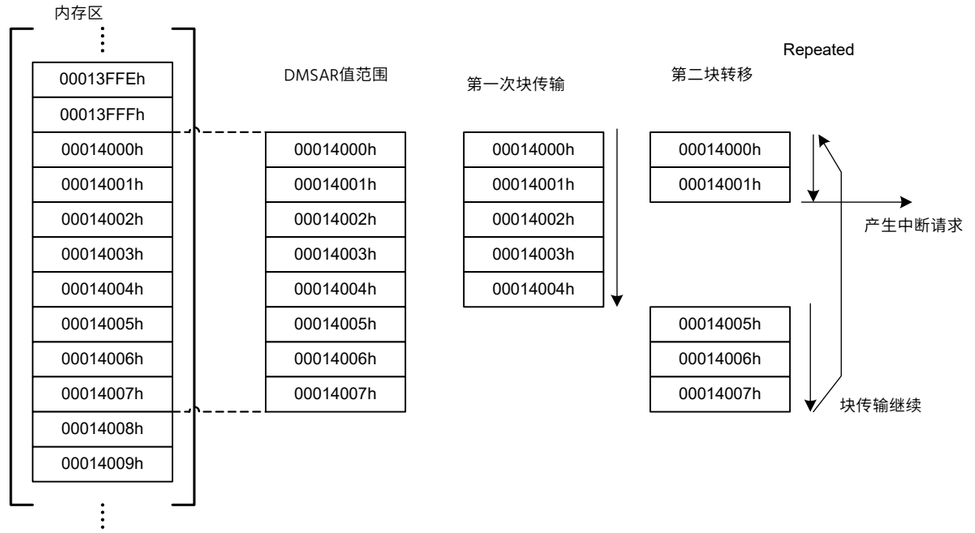

Figure 16.6 块传输模式下的扩展重复区域功能示例

16.3.3 使用偏移的地址更新功能

可以通过固定、递增、递减或添加偏移量来更新源地址和目标地址。选择偏移添加时，DMA偏移寄存器(DMACm.DMOFR)中指定的偏移会在每次DMAC执行一次数据传输时添加到地址。您还可以通过在DMACm.DMOFR中设置负值来减去偏移量。负值必须是二进制补码。

表16.6显示了每种地址更新模式下的地址更新方法。

Table 16.6 各地址更新模式下的地址更新方法

地址更新方式	的设置DMACm.DMAMD.SM[1:0]和DMACm.DMAMD.DM[1:0]用于地址更新模式	不同SZ[1:0]设置的地址更新方法DMACm.DMTMD		
		SZ[1:0] = 00b	SZ[1:0] = 01b	SZ[1:0] = 10b
地址固定	00b	Fixed		
偏移量加法	01b	+DMACm.DMOFR*1		
Increment	10b	+1	+2	+4
Decrement	11b	-1	-2	-4

Note 1. 在DMA偏移寄存器中设置负值时，该值必须是二进制补码，由以下公式获得：负偏移值的二进制补码=~(offset)+1(~=bitinversion)

(1) 使用偏移加法的基本传输

图16.7显示了使用偏移量加法进行地址更新的示例。

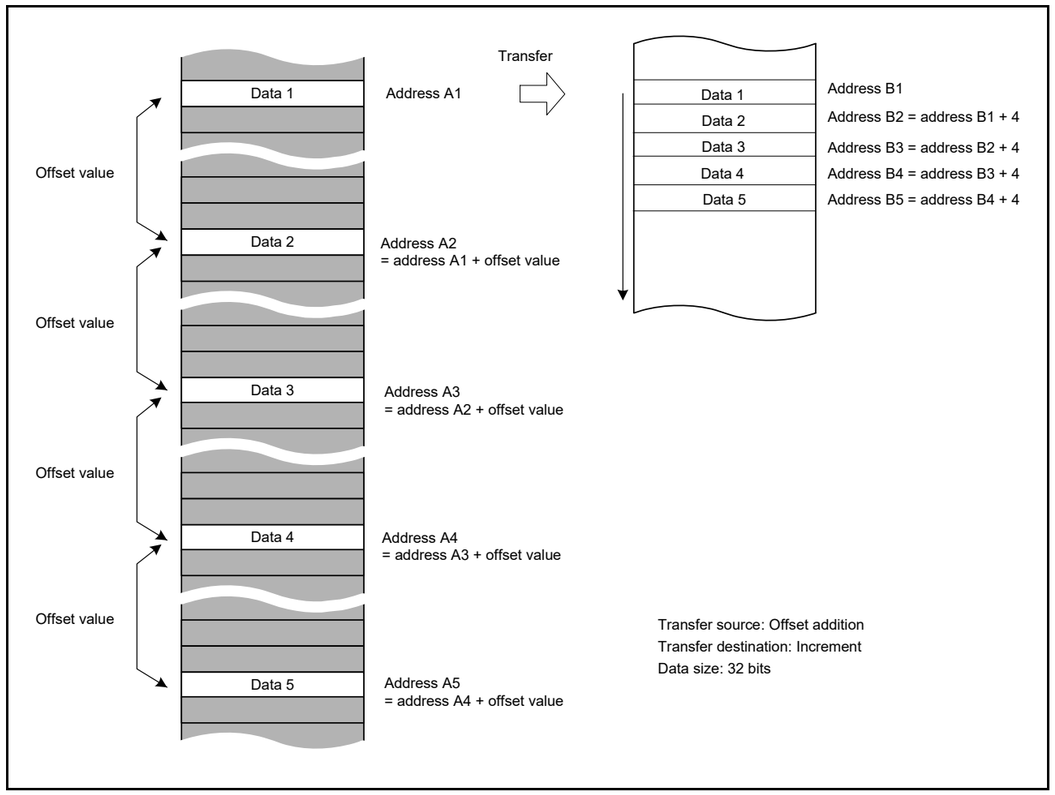

Figure 16.7 Example of address updating through offset addition

In Figure 16.7:

- The transfer data is 32 bits long
- Offset addition is set as the transfer source address update mode
- Increment is set as the transfer destination address update mode.

The second and subsequent data units are each read from the source address obtained by adding the offset value to the previous address. The data read from the addresses at the specified intervals is written to continuous locations on the destination.

(2) Example of XY conversion using offset addition

Figure 16.8 shows XY conversion using offset addition in repeat transfer mode. The settings are as follows:

- DMAC0.DMAMD — Transfer source address update mode: offset addition
- DMAC0.DMAMD — Transfer destination address update mode: destination address is incremented
- DMAC0.DMTMD — Transfer data size select: 32 bits
- DMAC0.DMTMD — Transfer mode select: repeat transfer
- DMAC0.DMTMD — Repeat area select: the source is specified as the repeat area
- DMAC0.DMOFR — Offset address: 10h
- DMAC0.DMCRA — Repeat size: 4h
- DMAC0.DMINT — The repeat size end interrupt is enabled.

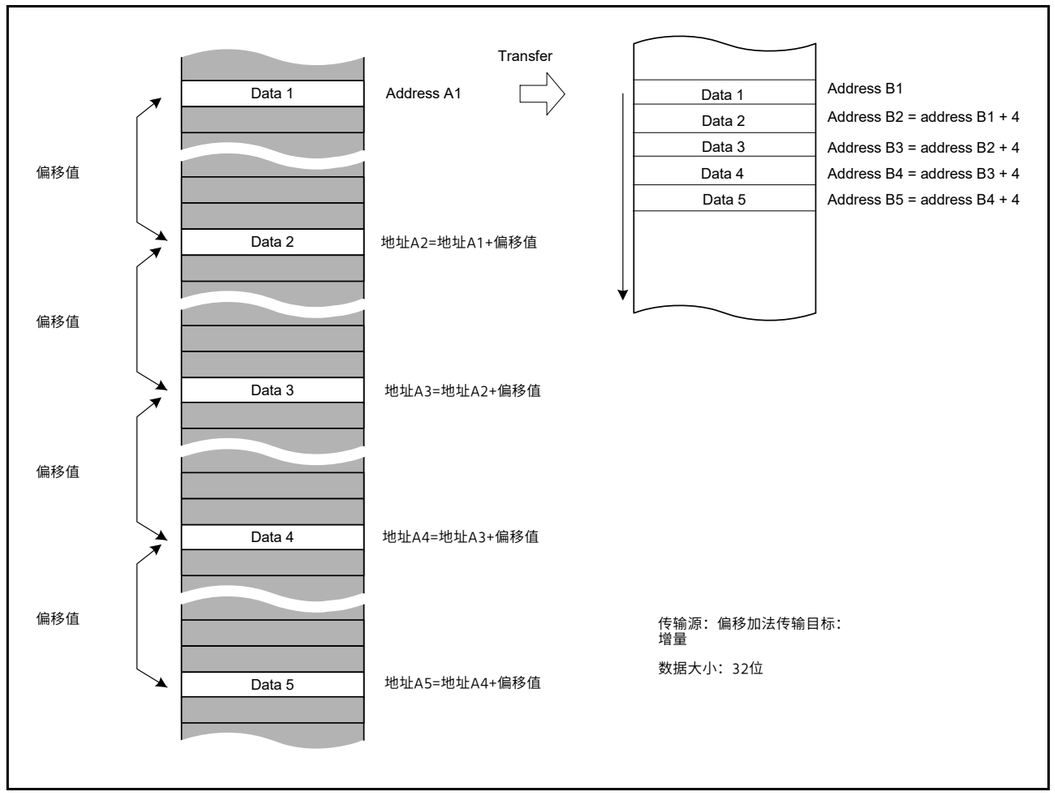

Figure 16.7 通过偏移量添加来更新地址的示例

在图16.7中：

- 传输数据为32位长
- 偏移量加法设置为传输源地址更新方式
- 增量设置为传送目的地地址更新模式。

第二个和随后的数据单元分别从通过将偏移值与前一个地址相加而获得的源地址读取。以指定间隔从地址读取的数据被写入目标上的连续位置。

(2) 使用偏移加法的XY转换示例

图16.8显示了在重复传输模式下使用偏移添加的XY转换。设置如下：

- DMAC0.DMAMD—传输源地址更新模式：偏移量加法
- DMAC0.DMAMD—传输目标地址更新模式：目标地址递增
- DMAC0.DMTMD—传输数据大小选择：32位
- DMAC0.DMTMD—传输模式选择：重复传输
- DMAC0.DMTMD—重复区域选择：源指定为重复区域
- DMAC0.DMOFR — Offset address: 10h
- DMAC0.DMCRA — Repeat size: 4h
- DMAC0.DMINT—启用重复大小结束中断。

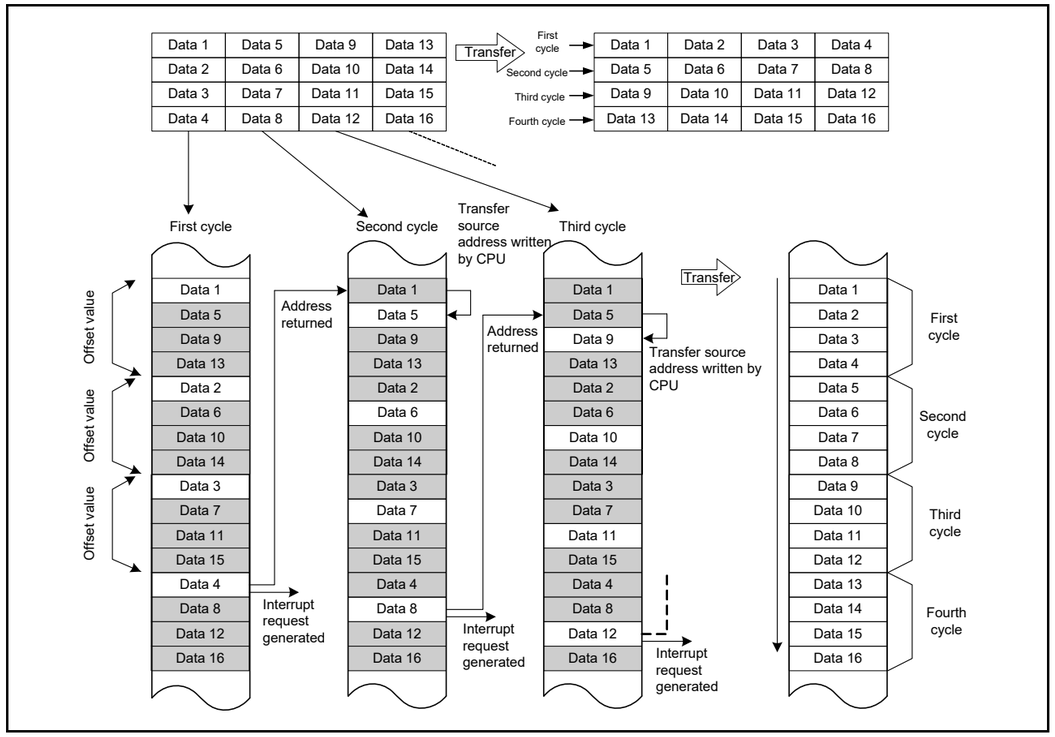

Figure 16.8 XY conversion operation using offset addition in repeat transfer mode

When a transfer starts, the offset value is added to the transfer source address every time data is transferred. The transfer data is written to continuous destination addresses. When data 4 is transferred:

- The repeat size of the transfers is complete
- The transfer source address returns to the transfer start address (the address of data 1 on the transfer source)
- A repeat size end interrupt is requested.

During the time this interrupt pauses the transfer, perform the following:

- DMAC0.DMSAR — Rewrite the DMA transfer source address to the address of data 5 (in this example, the data 1 address + 4)
- DMAC0.DMCNT — Set the DTE bit to 1.

The DMA transfer resumes from the state when the DMA transfer was stopped. The same operations are repeated until the transfer source data is transposed to the destination area (XY conversion).

Figure 16.9 shows a flow of the XY conversion.

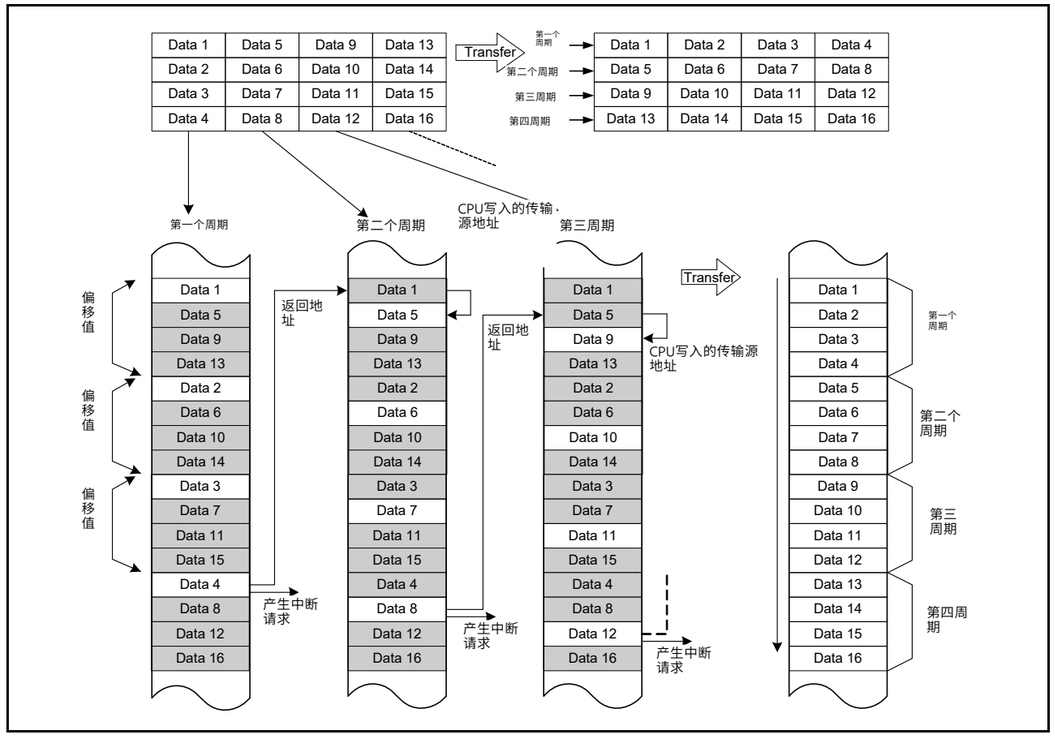

Figure 16.8 重复传输模式下使用偏移加法的XY转换操作

传输开始时，每次传输数据时，都会将偏移值添加到传输源地址。传输数据被写入连续的目标地址。传输数据4时：

- 传输的重复大小已完成
- 传输源地址返回传输起始地址（传输源上数据1的地址）
- 请求重复大小结束中断。

在此中断暂停传输期间，请执行以下操作：

- DMAC0.DMSAR—将DMA传输源地址重写为数据5的地址（在本例中，数据1地址+4）
- DMAC0.DMCNT—将DTE位设置为1。

DMA传输从DMA传输停止时的状态恢复。重复相同的操作，直到将传输源数据转置到目标区域（XY转换）。

图16.9显示了XY转换的流程。

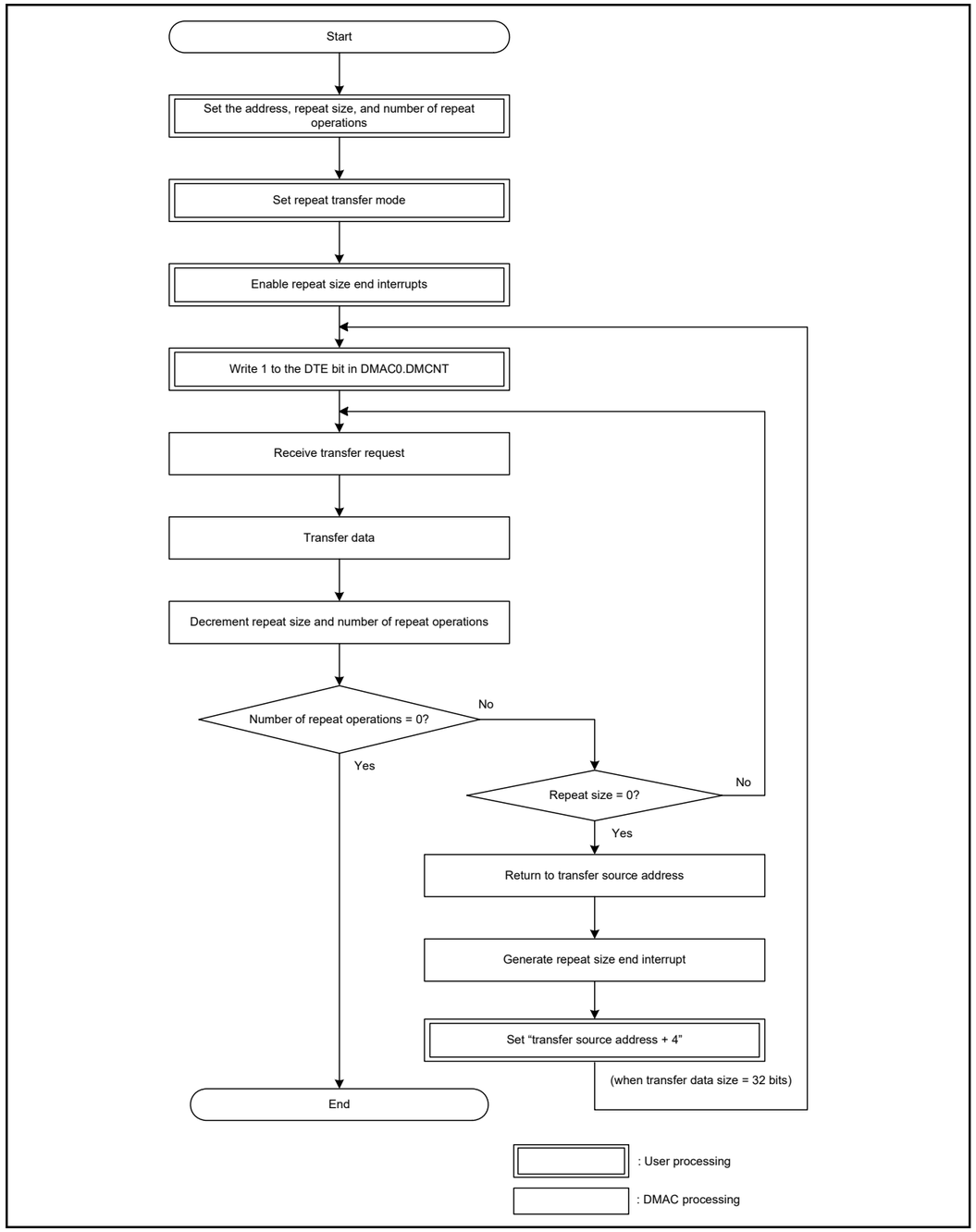

Figure 16.9 XY conversion flow using offset addition in repeat transfer mode

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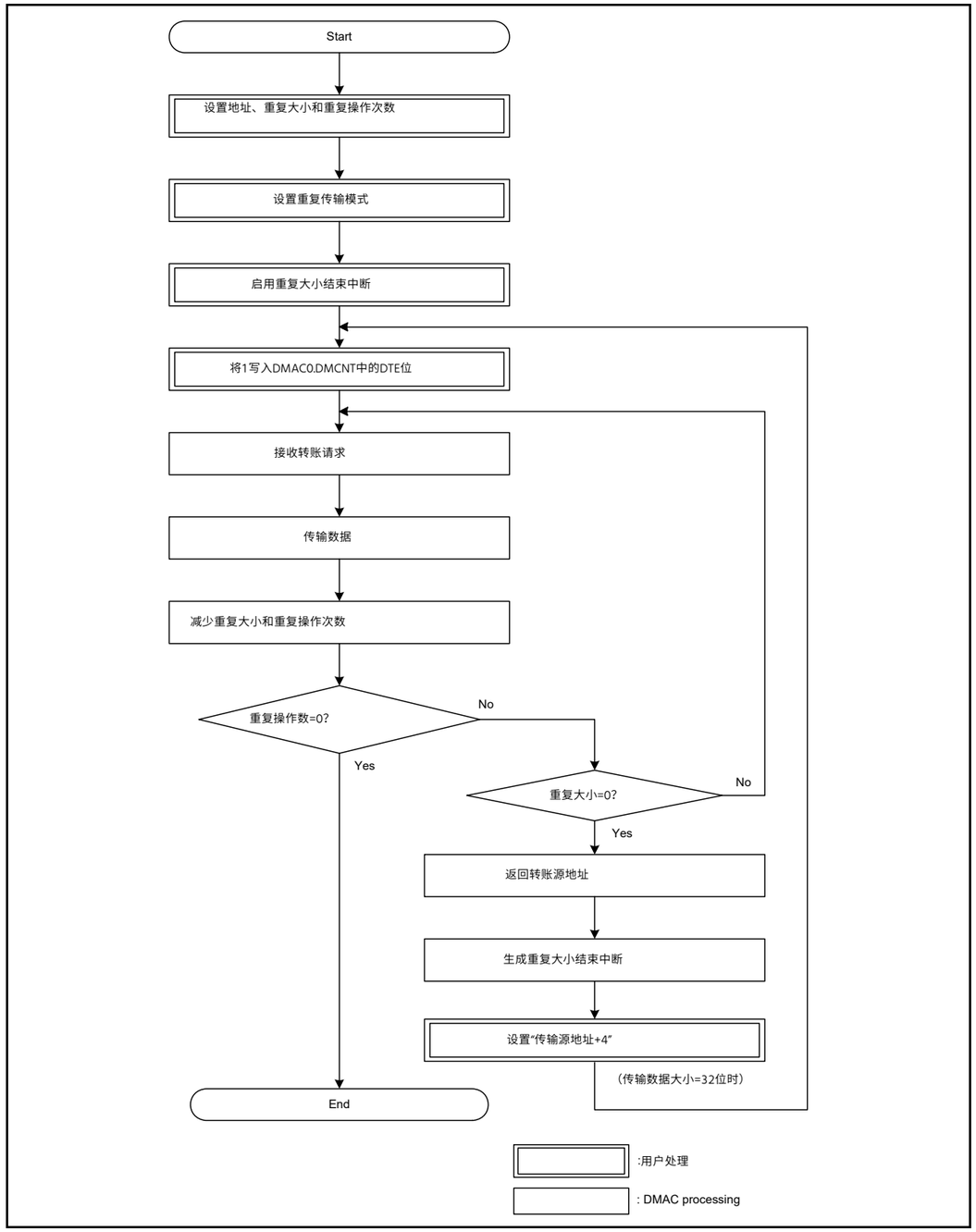

Figure 16.9 在重复传输模式中使用偏移添加的XY转换流程

16.3.4 Activation Sources

Software, interrupt requests from the peripheral modules, and external interrupt requests can all be specified as DMAC activation sources. Set the DCTG[1:0] bits in DMACm.DMTMD to select the activation source.

(1) DMAC activation through software

To start DMA transfer through software:

1. Set the DCTG[1:0] bits in DMACm.DMTMD to 00b.
2. Set the DTE bit in DMACm.DMCNT to 1 (enable DMA transfer).
3. Set the DMST bit in DMAST to 1 (enable DMAC activation).
4. Set the SWREQ bit in DMACm.DMREQ to 1 (request DMA).

When the DMAC is activated by software while the CLRS bit in DMACm.DMREQ is 0, the SWREQ bit in DMACm.DMREQ sets to 0 after data transfer starts in response to a DMA transfer request.

When the DMAC is activated by software while the CLRS bit is 1, SWREQ does not clear to 0 after data transfer starts. A DMA transfer request is issued again after completion of a transfer.

(2) DMAC activation through interrupt requests from on-chip peripheral modules or external interrupt requests

You can specify interrupt requests from on-chip peripheral modules and external interrupt requests as DMAC activation sources. The activation source can be individually selected for each channel in ICU.DELSRn.DELS[8:0] (n = 0 to 7).

To start DMAC transfer through an interrupt request from an on-chip peripheral module or an external interrupt request:

1. Set the DCTG[1:0] bits in DMACm.DMTMD to 01b (select interrupts from the peripheral modules and the external interrupt pins).
2. Set the DTE bit in DMACm.DMCNT to 1 (enable DMA transfer).
3. Set ICU.DELSRn.DSEL to the event number (select the DMAC event link).
4. Set the DMST bit in DMAST to 1 (enable DMAC activation).

For interrupt requests specified as DMAC activation sources, see Table 13.3, Interrupt vector table in section 13, Interrupt Controller Unit (ICU).

16.3.5 Operation Timing

The following timing diagrams show the minimum number of execution cycles.

16.3.4 激活源

软件、外设模块的中断请求和外部中断请求都可以指定为DMAC激活源。设置DMACm.DMTMD中的DCTG[1:0]位以选择激活源。

(1) 通过软件激活DMAC

通过软件启动DMA传输：

1. 将DMACm.DMTMD中的DCTG[1:0]位设置为00b。
2. 将DMACm.DMCNT中的DTE位设置为1（启用DMA传输）。
3. 将DMAST中的DMST位设置为1（启用DMAC激活）。
4. 将DMACm.DMREQ中的SWREQ位设置为1（请求DMA）。

当DMACm.DMREQ中的CLRS位为0时由软件激活DMAC，则DMACm.DMREQ中的SWREQ位在响应DMA传输请求开始数据传输后，DMACm.DMREQ设置为0。

当CLRS位为1时由软件激活DMAC时，数据传输开始后SWREQ不会清为0。
传输完成后再次发出DMA传输请求。

(2) 通过来自片上外围模块的中断请求或外部中断请求激活DMAC

您可以将来自片上外围模块的中断请求和外部中断请求指定为DMAC激活源。可以为ICU.DELSRn.DELS[8:0]（n=0到7）中的每个通道单独选择激活源。

通过来自片上外围模块的中断请求或外部中断请求启动DMAC传输：

1. 将DMACm.DMTMD中的DCTG[1:0]位设置为01b（从外围模块和外部中断引脚选择中断）。
2. 将DMACm.DMCNT中的DTE位设置为1（启用DMA传输）。
3. 将ICU.DELSRn.DSEL设置为事件编号（选择DMAC事件链接）。
4. 将DMAST中的DMST位设置为1（启用DMAC激活）。

对于指定为DMAC激活源的中断请求，请参见表13.3，第13节中的中断向量表，中断控制器单元（ICU）。

16.3.5 操作时间

以下时序图显示了最小执行周期数。

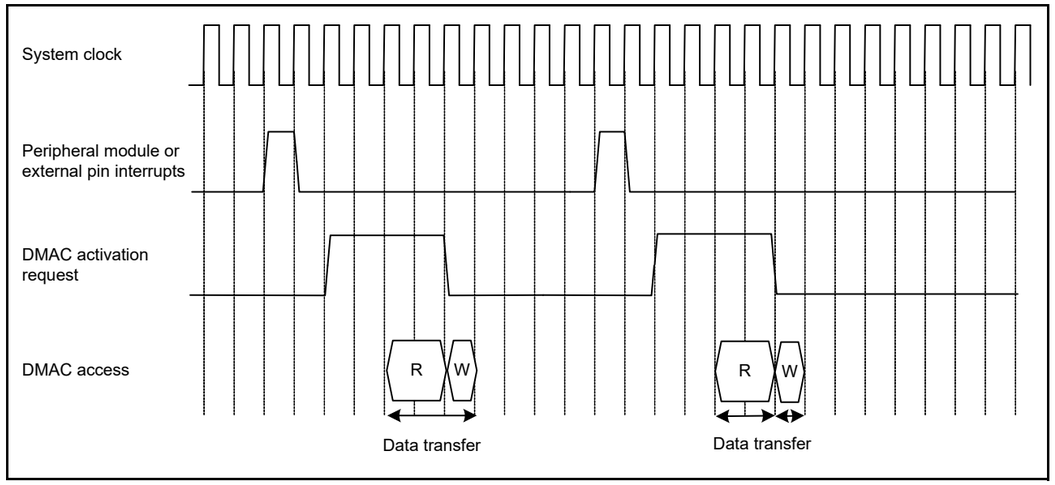

Figure 16.10 DMAC operation timing example 1 with DMA activation by interrupt from peripheral module or external interrupt input pin, in normal transfer mode or repeat transfer mode

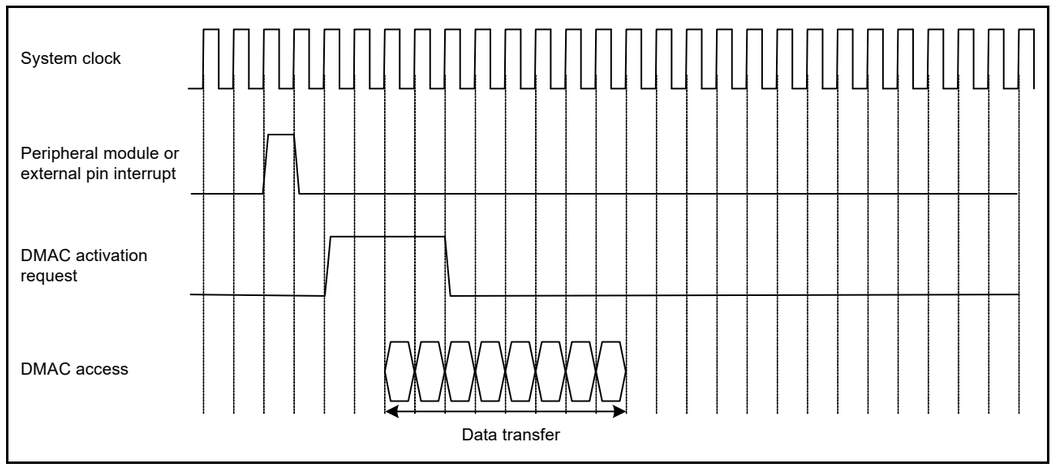

Figure 16.11 DMAC operation timing example 2 with DMA activation by interrupt from peripheral module or external interrupt input pin, in block transfer mode with block size = 4

16.3.6 Execution Cycles of DMAC

Table 16.7 lists the execution cycles in one DMAC data transfer operation.

Table 16.7 DMAC execution cycles

Transfer mode	Data transfer (read)	Data transfer (write)
Normal	Cr+Cs+1	Cw+Cs
Repeat	Cr+Cs+1	Cw+Cs
Block*1	P × (Cr+Cs)	P × (Cw+Cs)

Note: P = Block size (DMCRAH register setting).
Cr = Data read destination access cycle.
Cw = Data write destination access cycle.

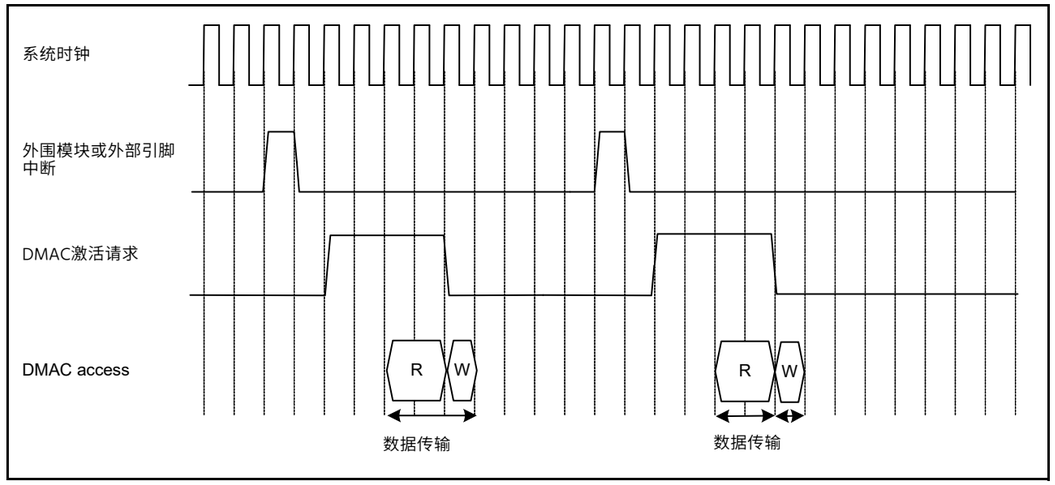

Figure 16.10 DMAC操作时序示例1通过来自外围模块的中断或外部中断输入引脚激活DMA，处于正常传输模式或重复传输模式

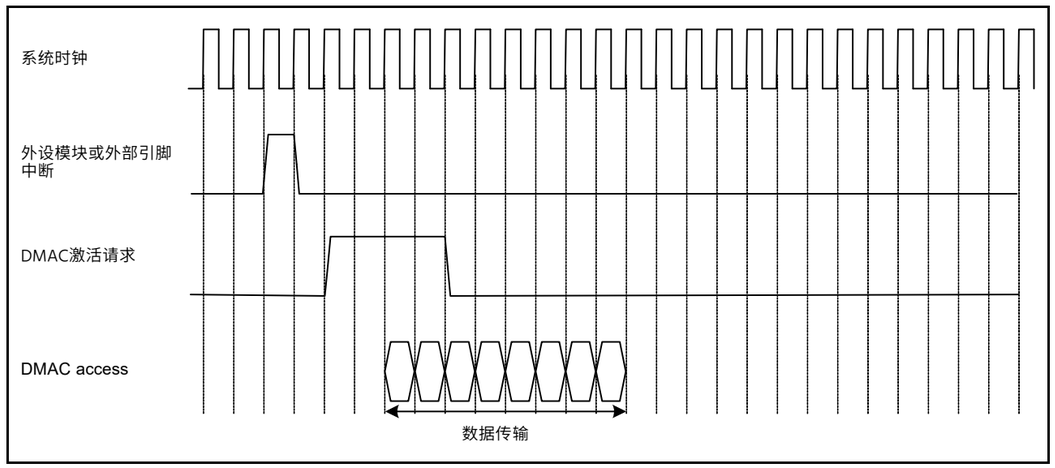

Figure 16.11 DMAC操作时序示例2，通过来自外围模块或外部中断输入引脚的中断激活DMA，在块大小=4的块传输模式下

16.3.6 DMAC的执行周期

表16.7列出了一个DMAC数据传输操作中的执行周期。

Table 16.7 DMAC执行周期

传输模式	数据传输（读取）	数据传输（写入）
Normal	Cr+Cs+1	Cw+Cs
Repeat	Cr+Cs+1	Cw+Cs
Block*1	P × (Cr+Cs)	P × (Cw+Cs)

Note: P=块大小（DMCRAH寄存器设置）。Cr=数据读取目标访问周期。Cw=数据写入目标访问周期。

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Cs = When accessing SRAMHS and peripheral modules related to system control: 2 cycles.
When accessing elsewhere: 0 cycles.
When a slave bus changes by a read/write data transfer, add 1 more cycle.

Note 1. This is the case when the block size is 2 or more. When the block size is 1, normal transfer cycle applies.

Cr and Cw depend on the access destination. For the number of cycles of each access destination, see section 40, SRAM and section 41, Flash Memory. The frequency ratio of the system clock and the peripheral clock is also taken into consideration.

The unit for +1 in the data transfer (read) column is 1 system clock cycle, ICLK. For the operation example, see section 16.3.5, Operation Timing.

The DMAC response time is the time from when the DMAC activation source is detected until the DMAC transfer starts. Table 16.7 does not include the time until the DMAC data transfer starts after the DMAC activation source becomes active.

16.3.7 Activating the DMAC

Figure 16.12 shows the register setting procedure.

Cs=访问SRAMHS和与系统控制相关的外围模块时：2个周期。
在其他地方访问时：0个周期。
当从总线因读写数据传输而改变时，再增加1个周期。

Note 1. 当块大小为2或更大时就是这种情况。当块大小为1时，应用正常传输周期。

Cr和Cw取决于访问目的地。关于每个访问目标的周期数，请参阅第40节，SRAM和第41节，闪存。系统时钟和外设时钟的频率比也被考虑在内。

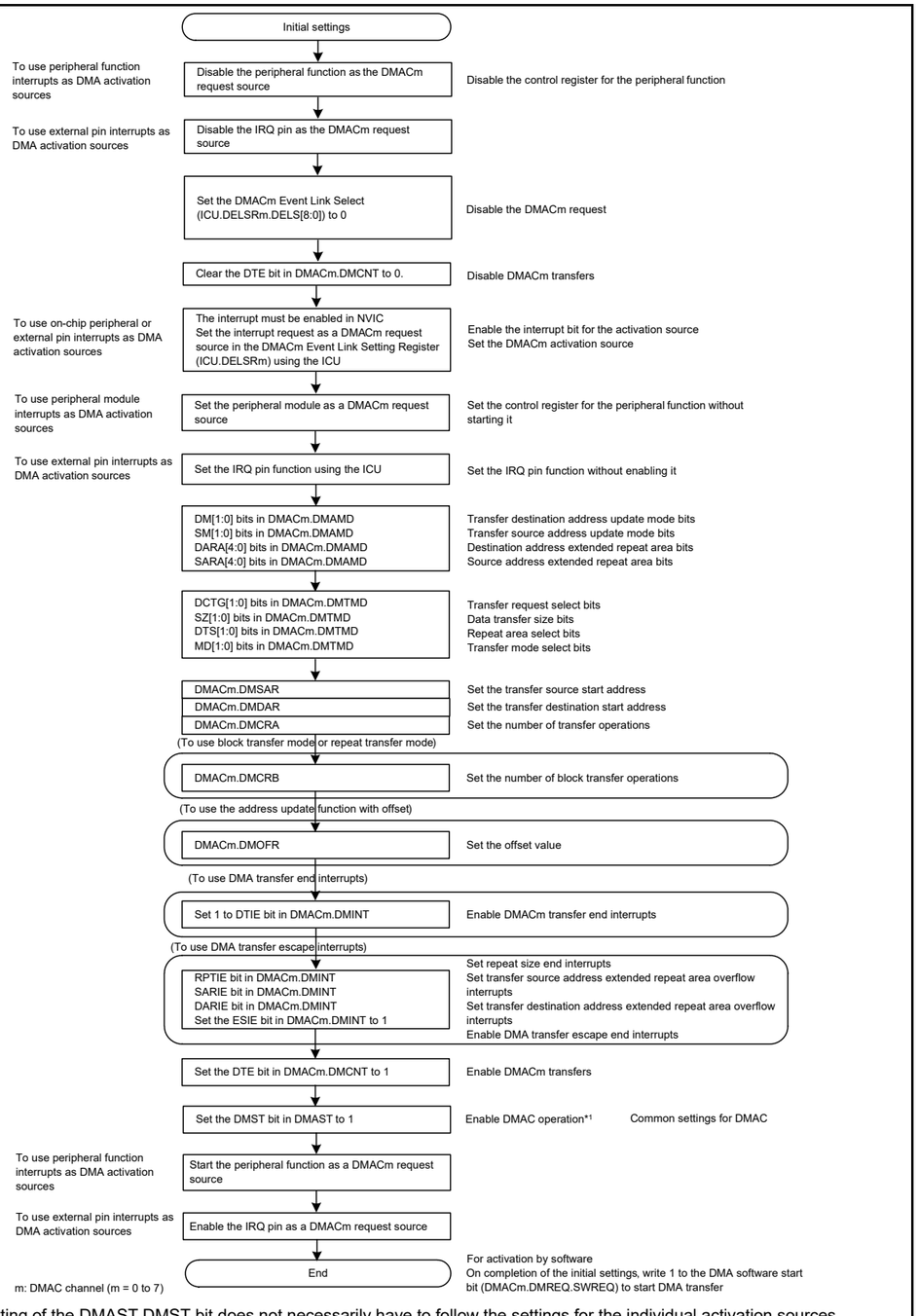
数据传输（读取）列中+1的单位是1个系统时钟周期，ICLK。有关操作示例，请参阅第16.3.5节，操作时序。

DMAC响应时间是从检测到DMAC激活源到DMAC传输开始的时间。
表16.7不包括从DMAC激活源激活到DMAC数据传输开始的时间。

16.3.7 激活DMAC

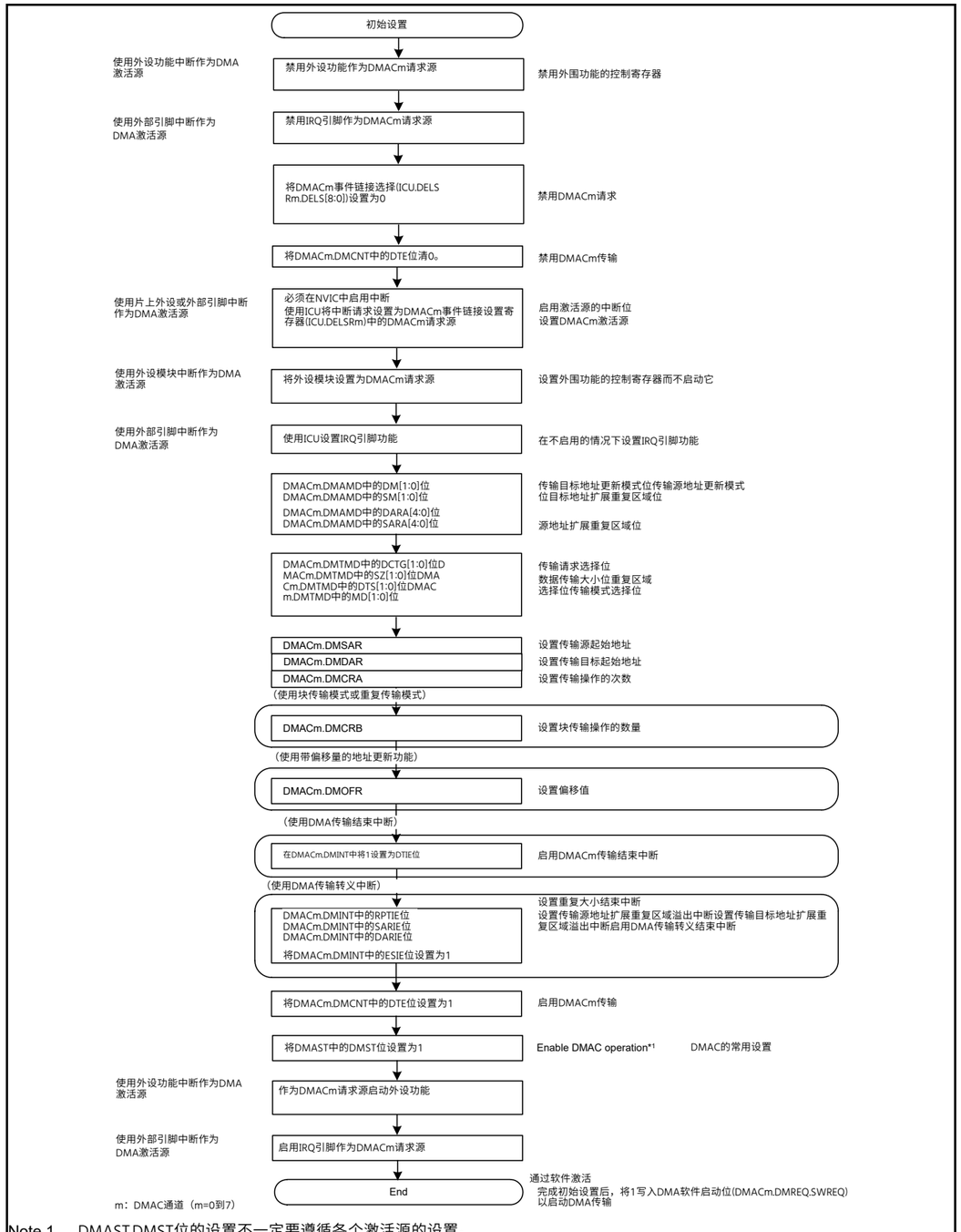
图16.12显示了寄存器设置过程。

RA生态工作室



Note 1. Setting of the DMAST.DMST bit does not necessarily have to follow the settings for the individual activation sources.

Figure 16.12 Register setting procedure



Note 1. DMAST.DMST位的设置不一定要遵循各个激活源的设置。

Figure 16.12 注册设置步骤

16.3.8 Starting DMA Transfer

To enable a DMA transfer of channel m, set the DTE bit in DMACm.DMCNT to 1 (DMA transfer enabled) and set the DMST bit in DMAST to 1 (DMAC activation enabled). New activation requests are not accepted during the transfer of another DMAC channel or DTC. When the proceeding transfer is complete, channel arbitration selects the DMA transfer request of the highest priority channel, and DMA transfer of that channel starts. When DMA transfer starts, the ACT flag in DMACm.DMSTS is set to 1 (the DMAC is in the active state).

16.3.9 Registers during DMA Transfer

The DMAC registers are updated by a DMA transfer. The value to be updated differs according to the other settings and the transfer state. The registers that are updated are DMSAR, DMDAR, DMCRA, DMCRB, DMCNT, and DMACm.DMSTS, described in the following sections. For details on register update operations in each transfer mode, see Table 16.3 to Table 16.5.

(1) DMA Source Address Register (DMACm.DMSAR)

After the data for one transfer request is transferred, the contents of DMSAR are updated to the address to be accessed by the next transfer request.

(2) DMA Destination Address Register (DMACm.DMDAR)

After the data for one transfer request is transferred, the contents of DMDAR are updated to the address to be accessed by the next transfer request.

(3) DMA Transfer Count Register (DMACm.DMCRA)

After the data for one transfer request is transferred, the count value is updated. The update operation depends on the transfer mode selected.

(4) DMA Block Transfer Count Register (DMACm.DMCRB)

After the data for one transfer request is transferred, the count value is updated. The update operation depends on the transfer mode selected.

(5) DMA Transfer Enable bit (DMACm.DMCNT.DTE)

The DMACm.DMCNT.DTE bit enables or disables data transfer through register write access. It is automatically cleared to 0 by the DMAC based on the DMA transfer state.

The conditions for clearing this bit by the DMAC are as follows:

- When the specified total volume of data transfer is complete
- When DMA transfer is stopped by a repeat size end interrupt
- When DMA transfer is stopped by an extended repeat area overflow interrupt.

Writing to the registers for channels whose associated DMACm.DMCNT.DTE bit is set to 1 is prohibited except for DMACm.DMCNT. Writes are only possible after the bit sets to 0.

(6) DMA Active flag (DMACm.DMSTS.ACT)

The ACT flag in DMSTS of DMACm indicates whether the DMACm is in the idle or active state. This flag is set to 1 when the DMAC starts data transfer, and sets to 0 when data transfer for one transfer request is complete. Even when DMA transfer is stopped by a write of 0 to the DTE bit in DMACm.DMCNT, this flag remains 1 until DMA transfer is complete.

(7) Transfer End Interrupt Flag (DMACm.DMSTS.DTIF)

The DTIF flag in DMACm.DMSTS is set to 1 after DMA transfer of the total transfer size is complete. When both this flag and the DTIE bit in DMACm.DMINT are 1, a transfer end interrupt is requested. This flag is set to 1 when the DMA transfer bus cycle is complete and the ACT flag in DMACm.DMSTS sets to 0, indicating the DMA transfer end. The flag automatically sets to 0 when the DTE bit in DMACm.DMCNT is set to 1 during interrupt handling.

(8) Transfer Escape End Interrupt Flag (DMACm.DMSTS.ESIF)

The ESIF flag in DMACm.DMSTS is set to 1 when a repeat size end interrupt or extended repeat area overflow interrupt

16.3.8 启动DMA传输

要启用通道m的DMA传输，请将DMACm.DMCNT中的DTE位设置为1（启用DMA传输）并将DMAST中的DMST位设置为1（启用DMAC激活）。在传输另一个DMAC通道或DTC期间不接受新的激活请求。当正在进行的传输完成时，通道仲裁选择最高优先级通道的DMA传输请求，并开始该通道的DMA传输。当DMA传输开始时，DMACm.DMSTS中的ACT标志设置为1（DMAC处于活动状态）。

16.3.9 DMA传输期间的寄存器

DMAC寄存器由DMA传输更新。要更新的值根据其他设置和传输状态而有所不同。更新的寄存器是DMSAR、DMDAR、DMCRA、DMRCB、DMCNT和DMACm.DMSTS，如下节所述。每种传输模式下寄存器更新操作的详细信息，请参见表16.3至表16.5。

(1) DMA源地址寄存器(DMACm.DMSAR)

一个传输请求的数据传输完成后，DMSAR的内容被更新为下一个传输请求访问的地址。

(2) DMA目标地址寄存器(DMACm.DMDAR)

一个传输请求的数据被传输后，DMDAR的内容被更新为下一个传输请求要访问的地址。

(3) DMA传输计数寄存器(DMACm.DMCRA)

在传输一个传输请求的数据后，更新计数值。更新操作取决于选择的传输模式。

(4) DMA块传输计数寄存器(DMACm.DMCRB)

在传输一个传输请求的数据后，更新计数值。更新操作取决于选择的传输模式。

(5) DMA传输使能位(DMACm.DMCNT.DTE)

DMACm.DMCNT.DTE位通过寄存器写访问启用或禁用数据传输。它由DMAC根据DMA传输状态自动清零。

DMAC清除该位的条件如下：

- 当指定的总数据传输量完成时
- 当DMA传输因重复大小结束中断而停止时
- 当DMA传输因扩展重复区域溢出中断而停止时。

禁止写入相关DMACm.DMCNT.DTE位设置为1的通道的寄存器，除非DMACm.DMCNT。只有在位设置为0后才能进行写入。

(6) DMA活动标志(DMACm.DMSTS.ACT)

DMACm的DMSTS中的ACT标志指示DMACm是处于空闲状态还是活动状态。该标志在DMAC开始数据传输时设置为1，当一个传输请求的数据传输完成时设置为0。即使通过向DMACm.DMCNT中的DTE位写入0来停止DMA传输，该标志仍 保持为1，直到DMA传输完成。

(7) 传输结束中断标志(DMACm.DMSTS.DTIF)

在完成总传输大小的DMA传输后，DMACm.DMSTS中的DTIF标志设置为1。当该标志和DMACm.DMINT中的DTIE位都为1时，请求传输结束中断。当DMA传输总线周期完成并且DMACm.DMSTS中的ACT标志设置为0时，该标志设置为1，表示DMA传输结束。当DMACm.DMCNT中的DTE位在中断处理期间设置为1时，该标志自动设置为0。

(8) 传输转义结束中断标志(DMACm.DMSTS.ESIF)

当重复大小结束中断或扩展重复区域溢出中断时，DMACm.DMSTS中的ESIF标志设置为1

is requested. When this bit and the ESIE bit in DMACm.DMINT are 1, a transfer escape end interrupt is requested. This flag is set to 1 when the bus cycle of the DMA transfer that caused the interrupt request is complete and the ACT flag in DMACm.DMSTS sets to 0, indicating the DMA transfer end. The flag automatically sets to 0 when the DTE bit in DMACm.DMCNT is set to 1 during interrupt handling.

You must set the interrupt control register before sending an interrupt request from the DMAC to the CPU or the DTC. For more information, see section 13, Interrupt Controller Unit (ICU).

16.3.10 Channel Priority

When multiple DMA transfer requests occur, the DMAC determines the priority of channels that have DMA transfer requests.

The priority is fixed as channel 0 > channel 1 > channel 2 > channel 3 > channel 4 > channel 5 > channel 6 > channel 7. (channel 0 is the highest.)

When a DMA transfer request occurs during data transfer, channel arbitration starts after the final data unit is transferred, and DMA transfer of the highest-priority channel starts.

16.4 Ending DMA Transfer

The operation for ending a DMA transfer depends on the transfer end conditions. When a DMA transfer ends, the DTE bit in DMCNT and the ACT flag in DMACm.DMSTS change from 1 to 0.

16.4.1 Transfer End by Completion of Specified Total Number of Transfer Operations

(1) In normal transfer mode (DMACm.DMTMD.MD[1:0] = 00b)

When the value of DMACm.DMCRAL changes from 1 to 0, DMA transfer ends on the associated channel, the DTE bit in DMACm.DMCNT is set to 0, and the DTIF flag in DMACm.DMSTS is set to 1. If the DTIE bit in DMACm.DMINT is 1 at this time, a transfer end interrupt request is sent to the CPU or the DTC.

(2) In repeat transfer mode (DMACm.DMTMD.MD[1:0] = 01b)

When the value of DMACm.DMCRB changes from 1 to 0, DMA transfer ends on the associated channel, the DTE bit in DMACm.DMCNT is set to 0, and the DTIF flag in DMACm.DMSTS is set to 1. If the DTIE bit in DMACm.DMINT is 1 at this time, an interrupt request is sent to the CPU or the DTC.

(3) In block transfer mode (DMACm.DMTMD.MD[1:0] = 10b)

When the value of DMACm.DMCRB changes from 1 to 0, DMA transfer ends on the associated channel, the DTE bit in DMACm.DMCNT is set to 0, and the DTIF flag in DMACm.DMSTS is set to 1. If the DTIE bit in DMACm.DMINT is 1 at this time, an interrupt request is sent to the CPU or the DTC.

You must set the interrupt control register before sending an interrupt request from the DMAC to the CPU or the DTC. For more information, see section 13, Interrupt Controller Unit (ICU).

16.4.2 Transfer End by Repeat Size End Interrupt

In repeat transfer mode, if the RPTIE bit in DMACm.DMINT is 1, a repeat size end interrupt is requested when transfer of a single repeat size of data is complete. The DTE bit in DMACm.DMCNT is set to 0 and the ESIF flag in DMACm.DMSTS is set to 1. If the ESIE bit in DMACm.DMINT is 1 at this time, an interrupt request is sent to the CPU or the DTC. To resume the transfer, write 1 to the DTE bit in DMACm.DMCNT.

A repeat size end interrupt can also be requested in block transfer mode. When transfer of a single block size of data is complete, the interrupt is requested in the same way as in repeat transfer mode.

You must set the interrupt control register before sending an interrupt request from the DMAC to the CPU or the DTC. For more information, see section 13, Interrupt Controller Unit (ICU).

16.4.3 Transfer End by Interrupt on Extended Repeat Area Overflow

When an overflow on the extended repeat area occurs while the extended repeat area is specified and the SARIE or DARIE bit in DMACm.DMINT is 1, an extended repeat area overflow interrupt is requested. The DMA transfer is terminated, the DTE bit in DMACm.DMCNT is set to 0, and the ESIF flag in DMACm.DMSTS is set to 1. If the ESIE

被要求。当该位和DMACm.DMINT中的ESIE位为1时，请求传输转义结束中断。当导致中断请求的DMA传输的总线周期完成并且DMACm.DMSTS中的ACT标志设置为0时，该标志设置为1，表示DMA传输结束。当DTE位在

DMACm.DMCNT在中断处理期间设置为1。

在从DMAC向CPU或DTC发送中断请求之前，您必须设置中断控制寄存器。
有关详细信息，请参阅第13节，中断控制器单元(ICU)。

16.3.10 频道优先级

当出现多个DMA传输请求时，DMAC确定有DMA传输请求的通道的优先级。

优先级固定为通道0>通道1>通道2>通道3>通道4>通道5>通道6>通道7。（通道0最高。）

当数据传输过程中出现DMA传输请求时，在传输完最后一个数据单元后开始通道仲裁，并开始最高优先级通道的DMA传输。

16.4 结束DMA传输

结束DMA传输的操作取决于传输结束条件。当DMA传输结束时，DMCNT中的DTE位和DMACm.DMSTS中的ACT标志从1变为0。

16.4.1 完成指定的转移操作总数后转移结束

(1) 在正常传输模式下（DMACm.DMTMD.MD[1:0]=00b）

当DMACm.DMCRAL的值从1变为0时，DMA传输在关联通道上结束，DMACm.DMCNT中的DTE位设置为0，并且DMACm.DMSTS中的DTIF标志设置为1。如果DTIE位此时DMACm.DMINT为1，向CPU或DTC发送传输结束中断请求。

(2) 在重复传输模式下（DMACm.DMTMD.MD[1:0]=01b）

当DMACm.DMCRB的值从1变为0时，DMA传输在相关通道上结束，DMACm.DMCNT中的DTE位设置为0，并且DMACm.DMSTS中的DTIF标志设置为1。如果DTIE位此时DMACm.DMINT为1，向CPU或DTC发送中断请求。

(3) 在块传输模式下（DMACm.DMTMD.MD[1:0]=10b）

当DMACm.DMCRB的值从1变为0时，DMA传输在相关通道上结束，DMACm.DMCNT中的DTE位设置为0，并且DMACm.DMSTS中的DTIF标志设置为1。如果DTIE位此时DMACm.DMINT为1，向CPU或DTC发送中断请求。

在从DMAC向CPU或DTC发送中断请求之前，您必须设置中断控制寄存器。
有关详细信息，请参阅第13节，中断控制器单元(ICU)。

16.4.2 按重复大小结束传输结束中断

在重复传输模式下，如果DMACm.DMINT中的RPTIE位为1，则在单个重复大小的数据传输完成时请求重复大小结束中断。DMACm.DMCNT中的DTE位设置为0，DMACm.DMSTS中的ESIF标志位设置为1。如果此时DMACm.DMINT中的ESIE位为1，则向CPU或DTC发送中断请求。要恢复传输，请将1写入DMACm.DMCNT中的DTE位。

在块传输模式下也可以请求重复大小结束中断。当单个块大小的数据传输完成时，以与重复传输模式相同的方式请求中断。

在从DMAC向CPU或DTC发送中断请求之前，您必须设置中断控制寄存器。
有关详细信息，请参阅第13节，中断控制器单元(ICU)。

16.4.3 扩展重复区溢出中断传输结束

如果在指定扩展重复区域且DMACm.DMINT中的SARIE或DARIE位为1时扩展重复区域发生溢出，则请求扩展重复区域溢出中断。DMA传输终止，DMACm.DMCNT中的DTE位设置为0，DMACm.DMSTS中的ESIF标志设置为1。如果ESIE

bit in DMACm.DMINT is 1 at this time, an interrupt request is sent to the CPU or the DTC.

If this interrupt is requested during a read cycle, the subsequent write cycle is performed. In block transfer mode, if the interrupt is requested during a 1-block transfer, the remaining data in the block is transferred before transfer stops.

Before sending an interrupt request from the DMAC to the CPU or the DTC, the interrupt control register must be set. For more information, see section 13, Interrupt Controller Unit (ICU).

16.4.4 Precautions for the End of DMA Transfer

A DMA activation request source might occur in the next request after a DMA transfer completes. If this happens, the DMA transfer starts and the DMA activation request is held in DMAC. To prevent this, stop the DMA activation requests by clearing the DELSRn.DSELS[8:0] bits in the ICU to 0.

When the DMA activation request occurs after the last round of the DMA transfer is generated, clear the DMA activation request by setting ICU.DELSRm.IR bit to 0.

16.5 Interrupts

Each DMAC channel can output an interrupt request (DMACm_INT) to the CPU or DTC after transfer for one request is complete.

Table 16.8 lists the interrupt sources and their associated status flags and enable bits. Figure 16.13 shows the schematic logic diagram of the interrupt outputs (DMAC0 to DMAC7). Figure 16.14 shows the DMAC interrupt handling routine for resuming and terminating DMA transfers.

Table 16.8 Association between interrupt sources, interrupt status flags, and interrupt enable bits

Interrupt sources		Interrupt enable bits	Interrupt status flags	Request output enable bits
Transfer end		—	DMACm.DMSTS.DTIF	DMACm.DMINT.DTIE
Escape transfer end	Repeat size end	DMACm.DMINT.RPTIE	DMACm.DMSTS.ESIF	DMACm.DMINT.ESIE
	Source address extended repeat area overflow	DMACm.DMINT.SARIE		
	Destination address extended repeat area overflow	DMACm.DMINT.DARIE		

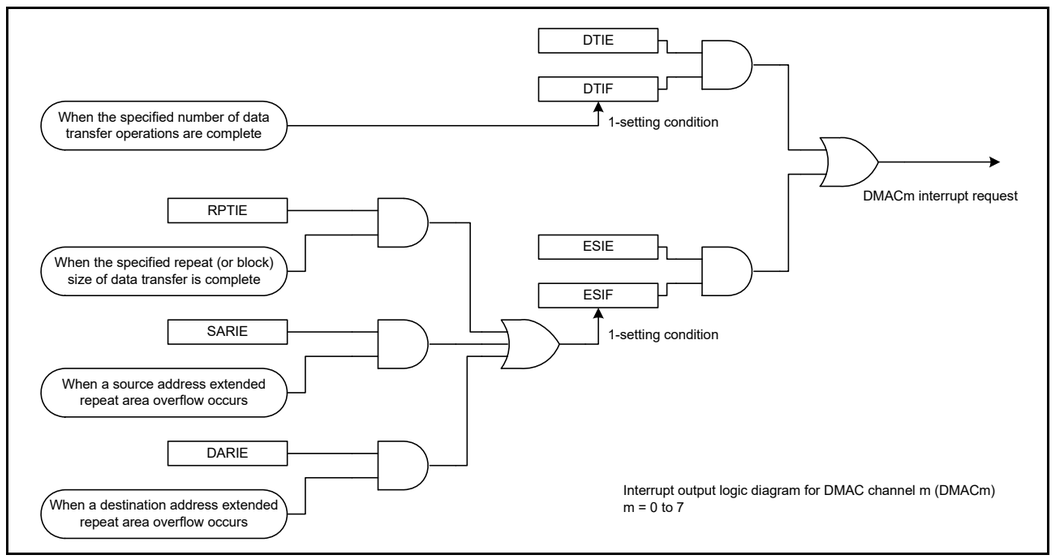


Figure 16.13 Schematic logic diagram of interrupt outputs for DMAC0 to DMAC7

此时DMACm.DMINT中的位为1，向CPU或DTC发送中断请求。

如果在读周期内请求此中断，则执行后续写周期。在块传输模式下，如果在1块传输期间请求中断，则在传输停止之前传输块中剩余的数据。

在从DMAC向CPU或DTC发送中断请求之前，必须设置中断控制寄存器。
有关详细信息，请参阅第13节，中断控制器单元(ICU)。

16.4.4 DMA传输结束的注意事项

DMA传输完成后的下一个请求中可能会出现DMA激活请求源。如果发生这种情况，
DMA传输开始，DMA激活请求保存在DMAC中。为防止这种情况发生，通过将ICU中的DELSRn.DSELS[8:0]位清除为0来停止DMA激活请求。

当最后一轮DMA传输产生后发生DMA激活请求时，通过将ICU.DELSRm.IR位设置为0来清除DMA激活请求。

16.5 Interrupts

每个DMAC通道可以在一个请求的传输完成后向CPU或DTC输出一个中断请求(DMACm_INT)。

表16.8列出了中断源及其相关的状态标志和使能位。图16.13显示了中断输出（DMAC0到DMAC7）的逻辑示意图。图16.14显示了用于恢复和终止DMA传输的DMAC中断处理程序。

Table 16.8 中断源、中断状态标志和中断使能位之间的关联

中断源		中断使能位	中断状态标志	请求输出使能位
转账结束		—	DMACm.DMSTS.DTIF	DMACm.DMINT.DTIE
逃生转移结束	重复大小结束	DMACm.DMINT.RPTIE	DMACm.DMSTS.ESIF	DMACm.DMINT.ESIE
	源地址扩展重复区溢出	DMACm.DMINT.SARIE		
	目的地址扩展重复区溢出	DMACm.DMINT.DARIE		

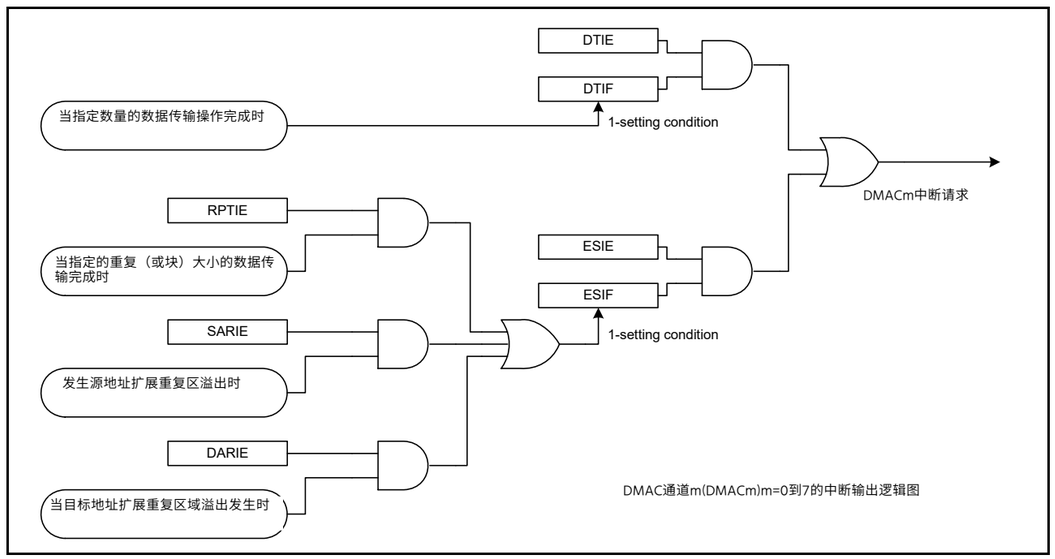


Figure 16.13 DMAC0到DMAC7的中断输出逻辑示意图

Different procedures are used for canceling an interrupt to restart a DMA transfer as in the following cases:

- When terminating a DMA transfer
- When continuing a DMA transfer.

(1) When terminating a DMA transfer

Write 0 to the DTIF flag in DMACm.DMSTS to clear a transfer end interrupt, and to the ESIF flag in DMACm.DMSTS to clear a repeat size interrupt or an extended repeat area overflow interrupt. DMACm remains in the stopped state. When starting another DMA transfer, set the appropriate registers and set the DTE bit in DMACm.DMCNT to 1 (DMA transfer enabled).

(2) When continuing a DMA transfer

Write 1 to the DTE bit in DMACm.DMCNT. The ESIF flag in DMSTS of DMACm automatically sets to 0 (interrupt source cleared), and the DMA transfer resumes.

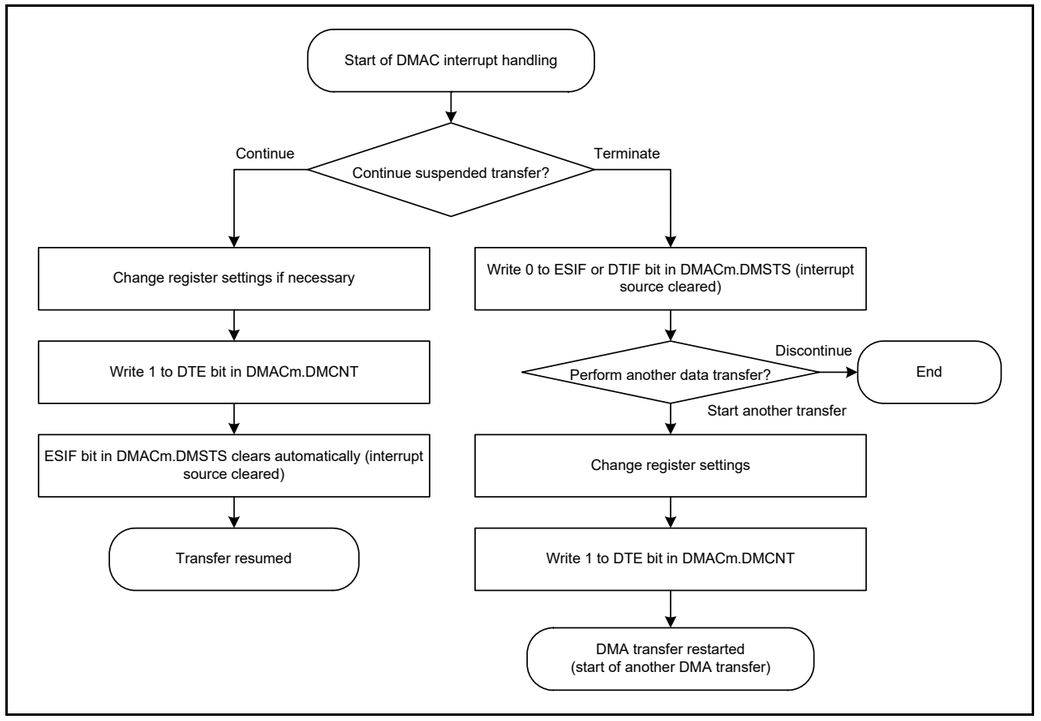


Figure 16.14 DMAC interrupt handling routine to resume or terminate a DMA transfer

16.6 Event Link

Each DMAC channel outputs an event link request signal (DMACm_INT) every time it completes a data transfer, or a block transfer in block transfer mode. For more information, see section 18, Event Link Controller (ELC).

16.7 Low Power Consumption Function

Before entering the module-stop state, Software Standby mode, or Deep Software Standby mode, you must first set the DMST bit in DMAST to 0 (DMAC suspended) and use the settings in the sections that follow.

(1) Module-stop function

Writing 1 to the MSTPA22 bit in MSTPCRA enables the module-stop function of the DMAC. If a DMA transfer is in progress when 1 is written to MSTPA22, the transition to the module-stop state continues after DMA transfer ends.

不同的程序用于取消中断以重新启动DMA传输，如下所示：

- 终止DMA传输时
- 继续DMA传输时。

(1) 终止DMA传输时

将0写入DMACm.DMSTS中的DTIF标志以清除传输结束中断，并写入DMACm.DMSTS中的ESIF标志以清除重复大小中断或扩展重复区域溢出中断。DMACm保持在停止状态。当开始另一个DMA传输时，设置适当的寄存器并将DMACm.DMCNT中的DTE位设置为1（启用DMA传输）。

(2) 继续DMA传输时

将1写入DMACm.DMCNT中的DTE位。DMACm的DMSTS中的ESIF标志自动设置为0（中断源清除），DMA传输恢复。

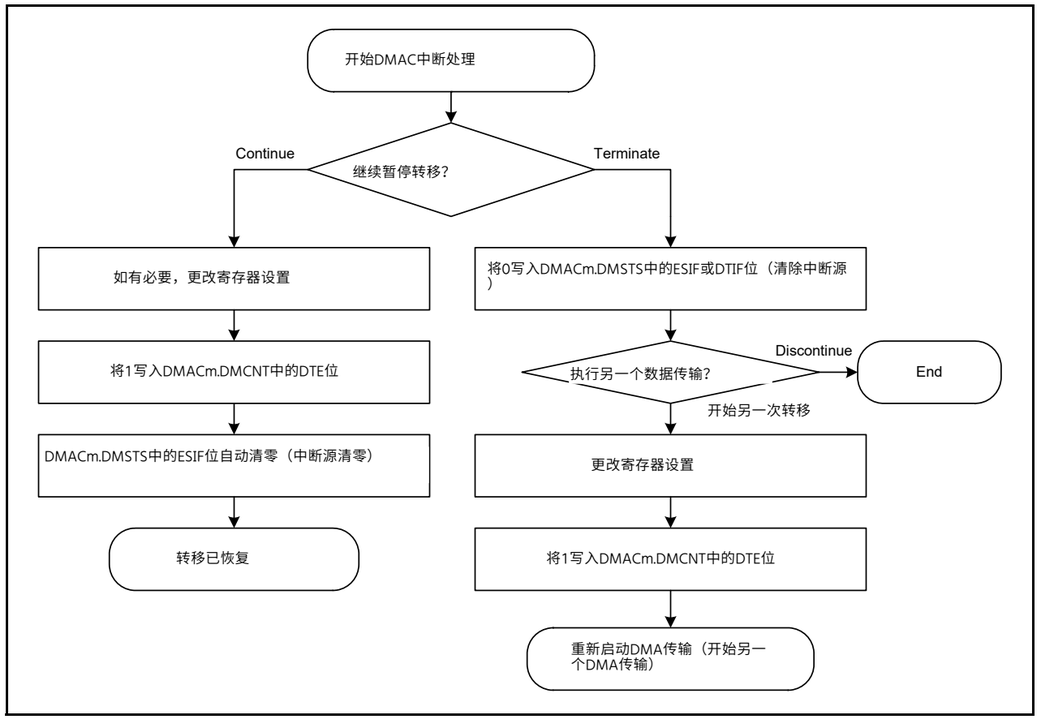


Figure 16.14 用于恢复或终止DMA传输的DMAC中断处理例程

16.6 活动链接

每个DMAC通道在每次完成数据传输或块传输模式下的块传输时都会输出一个事件链接请求信号(DMACm_INT)。有关详细信息，请参阅第18节，事件链接控制器(ELC)。

16.7 低功耗功能

在进入模块停止状态、软件待机模式或深度软件待机模式之前，您必须先设置DMAST中的DMST位为0（DMAC暂停）并使用以下部分中的设置。

(1) Module-stop function

向MSTPCRA中的MSTPA22位写入1使能DMAC的模块停止功能。如果在将1写入MSTPA22时正在进行DMA传输，则在DMA传输结束后继续转换到模块停止状态。

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Access to the DMAC registers is prohibited while MSTPA22 is 1. Writing 0 to the MSTPA22 bit releases the DMAC from the module-stop state.

(2) Software Standby and Deep Software Standby modes

Use the settings described in section 11.7.1, Transitioning to Software Standby Mode and section 11.9.1, Transitioning to Deep Software Standby Mode.

If DMA transfer operations are in progress when the WFI instruction is executed, the DMA transfer completes before the transition to Software Standby mode or Deep Software Standby mode.

(3) Notes on low power consumption function

For information on the WFI instruction and register settings, see section 11.10.7, Timing of WFI Instruction.

To perform a DMA transfer after returning from a low power consumption mode, set the DMST bit in DMAST to 1 again. To use a request that is generated in Software Standby mode as an interrupt request to the CPU but not as a DMAC startup request, specify the CPU as the interrupt request destination, as described in section 13.4.2, Selecting Interrupt Request Destinations, then execute the WFI instruction.

16.8 Usage Notes

16.8.1 Access to Registers during DMA Transfer

Do not write to the following registers of DMACm while the ACT flag in DMSTS of the associated channel is set to 1 (DMAC active state) or the DTE bit in DMCNT of the associated channel is set to 1 (DMA transfer enabled):

- DMSAR
- DMDAR
- DMCRA
- DMCRB
- DMTMD
- DMINT
- DMAMD
- DMOFR.

16.8.2 DMA Transfer to Reserved Areas

DMA transfer to reserved areas is prohibited. If such an access is made, transfer results are not guaranteed. For details on reserved areas, see section 4, Address Space.

16.8.3 Setting the DMAC Event Link Setting Register of the Interrupt Controller Unit (ICU.DELSRn)

Before setting the DMAC Event Link Setting Register (ICU.DELSRn), make sure the DMA Transfer Enable bit (DMACm.DMCNT.DTE) is set to 0, to disable DMA transfer. Additionally, ensure that the DTC Activation Enable bit (ICU.IELSRn.DTCE) associated with the event number set in the ICU.DELSRn register is not set to 1. For details on ICU.IELSRn.DTCE and ICU.DELSRn, see section 13, Interrupt Controller Unit (ICU).

16.8.4 Suspending or Restarting DMA Activation

To suspend a DMA activation request, write 0 to the DMAC Event Link Select bits (ICU.DELSRn.DELS[8:0]). To restart the DMA transfer, write the event number to the ICU.DELSRn.DELS[8:0] bits with the settings shown in section 16.3.7, Activating the DMAC.

当MSTPA22为1时，禁止访问DMAC寄存器。将0写入MSTPA22位可将DMAC从模块停止状态释放。

(2) 软件待机和深度软件待机模式

使用第11.7.1节，转换到软件待机模式和第11.9.1节，转换到深度软件待机模式。

如果在执行WFI指令时DMA传输操作正在进行，则DMA传输在转换到软件待机模式或深度软件待机模式之前完成。

(3) 低功耗功能注意事项

有关WFI指令和寄存器设置的信息，请参阅第11.10.7节，WFI指令的时序。

要在从低功耗模式返回后执行DMA传输，请将DMAST中的DMST位再次设置为1。要将在软件待机模式下生成的请求用作对CPU的中断请求但不用作DMAC启动请求，请指定CPU作为中断请求目标，如第13.4.2节，选择中断请求目标中所述，然后执行WFI指令。

16.8 使用说明

16.8.1 在DMA传输期间访问寄存器

当相关通道的DMSTS中的ACT标志设置为1（DMAC活动状态）或相关通道的DMCNT中的DTE位设置为1（启用DMA传输）时，请勿写入DMACm的以下寄存器：

- DMSAR
- DMDAR
- DMCRA
- DMCRB
- DMTMD
- DMINT
- DMAMD
- DMOFR.

16.8.2 DMA传输到保留区域

禁止对保留区域进行DMA传输。如果进行此类访问，则无法保证传输结果。有关保留区域的详细信息，请参阅第4节，地址空间。

16.8.3 设置中断控制器单元(ICU.DELSRn)的DMAC事件链接设置寄存器

在设置DMAC事件链接设置寄存器(ICU.DELSRn)之前，确保DMA传输启用位(DMACm.DMCNT.DTE)设置为0，以禁用DMA传输。此外，确保与ICU.DELSRn寄存器中设置的事件编号相关的DTC激活启用位(ICU.IELSRn.DTCE)未设置为1。有关ICU.IELSRn.DTCE和ICU.DELSRn的详细信息，请参阅第13节，中断控制器单元（ICU）。

16.8.4 暂停或重新启动DMA激活

要暂停DMA激活请求，请将0写入DMAC事件链路选择位(ICU.DELSRn.DELS[8:0])。要重新启动DMA传输，请将事件编号写入ICU.DELSRn.DELS[8:0]位，设置如第16.3.7节，激活DMAC中所示。

17. Data Transfer Controller (DTC)

17.1 Overview

The MCU includes a Data Transfer Controller (DTC) that performs data transfers when activated by an interrupt request. Table 17.1 lists the DTC specifications and Figure 17.1 shows a block diagram.

Table 17.1 DTC specifications

Parameter	Specifications
Transfer modes	• Normal transfer mode A single activation leads to a single data transfer. • Repeat transfer mode A single activation leads to a single data transfer. The transfer address returns to the start address after the number of data transfers reaches the specified repeat size. The maximum number of repeat transfers is 256 and the maximum data transfer size is 256 × 32 bits (1024 bytes). • Block transfer mode A single activation leads to a single block transfer. The maximum block size is 256 × 32 bits = 1024 bytes.
Transfer channel	• Channel transfer can be associated with the interrupt source (transferred by a DTC activation request from the ICU) • Multiple data units can be transferred on a single activation source (chain transfer) • Chain transfers can be set to either execute when the counter is 0, or always execute.
Transfer space	• 4 GB (0000 0000h to FFFF FFFFh, excluding reserved areas)
Data transfer units	• Single data unit: 1 byte (8 bits), 1 halfword (16 bits), or 1 word (32 bits) • Single block size: 1 to 256 data units.
CPU interrupt source	• An interrupt request can be generated to the CPU on a DTC activation interrupt • An interrupt request can be generated to the CPU after a single data transfer • An interrupt request can be generated to the CPU after a data transfer of a specified volume.
Event link function	An event link request is generated after one data transfer (for block, after one block transfer)
Read skip	Read of transfer information can be skipped
Write-back skip	When the transfer source or destination address is specified as fixed, a write-back of transfer information can be skipped
Module-stop function	Module-stop state can be set to reduce power consumption

17. 数据传输控制器(DTC)

17.1 Overview

MCU包括一个数据传输控制器(DTC)，它在被中断请求激活时执行数据传输。
表17.1列出了DTC规范，图17.1显示了框图。

Table 17.1 DTC specifications

Parameter	Specifications
传输模式	正常传输模式 单次激活导致单次数据传输。 重复传输模式 单次激活导致单次数据传输。 数据传输次数达到指定的重复大小后，传输地址返回起始地址。最大重复传输次数为256，最大数据传输大小为256×32位（1024字节）。 块传输模式 单个激活导致单个块传输。 最大块大小为256×32位=1024字节。
传输通道	通道传输可以与中断源相关联（通过来自ICU的DTC激活请求传输） 多个数据单元可以在单个激活源上传输（链传输） 链传输可以设置为在计数器运行时执行0，或始终执行。
转移空间	4GB（00000000h到FFFFFFFFh，不包括保留区域）
数据传输单元	单个数据单元：1个字节（8位）、1个半字（16位）或1个字（32位） 单个块大小：1到256个数据单元。
CPU中断源	可以在DTC激活中断时向CPU生成中断请求 可以在单次数据传输后向CPU生成中断请求 可以在指定量的数据传输后向CPU生成中断请求。
事件链接功能	一次数据传输后产生事件链接请求（对于块，在一次块传输后）
阅读跳过	可以跳过读取传输信息
Write-back skip	当传输源或目标地址指定为固定时，可以跳过传输信息的回写
Module-stop function	可设置模块停止状态以降低功耗

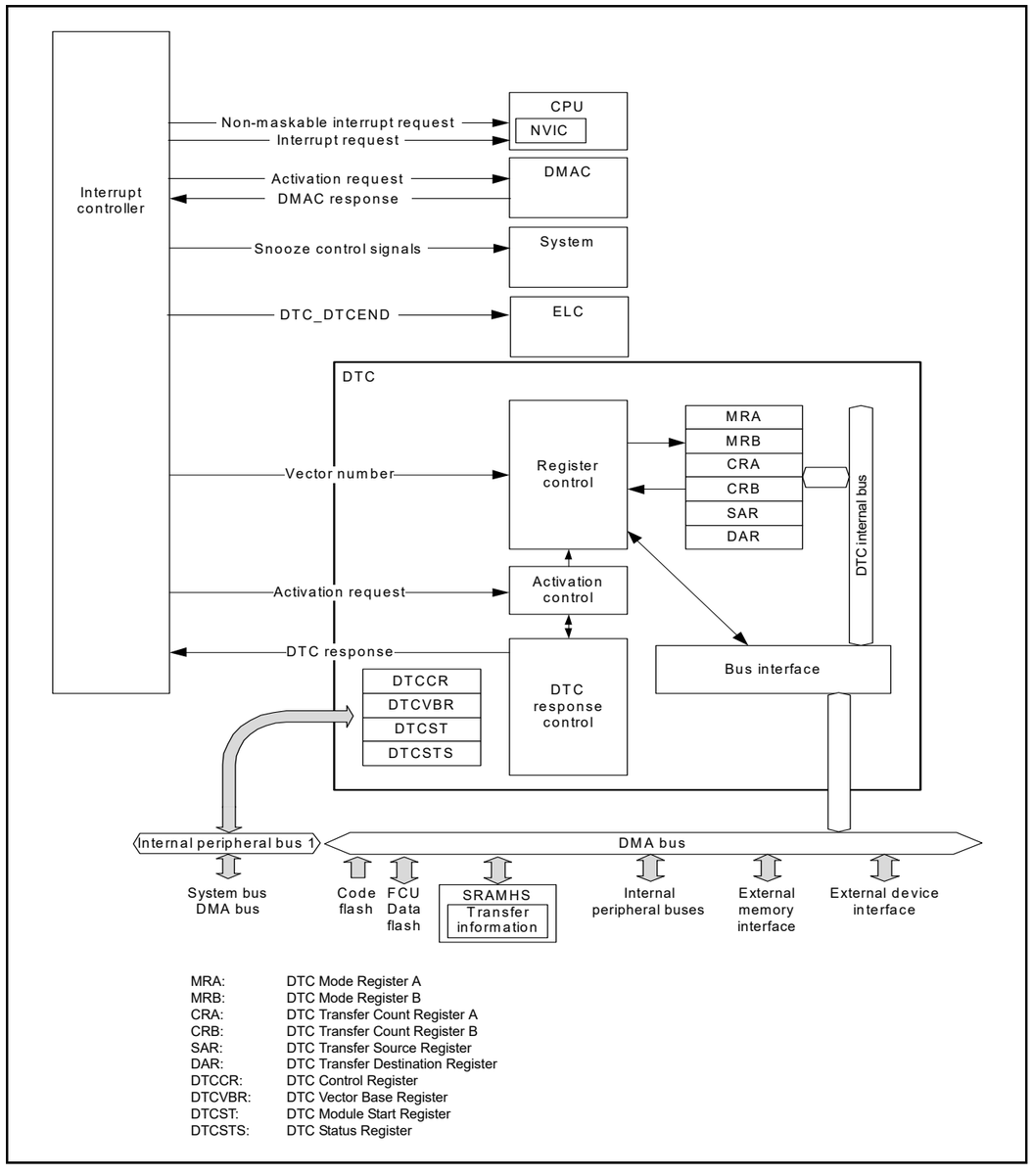


Figure 17.1 DTC block diagram

See 13.1 Overview, in section 13, Interrupt Controller Unit (ICU), for the connections between the DTC and NVIC in the CPU.

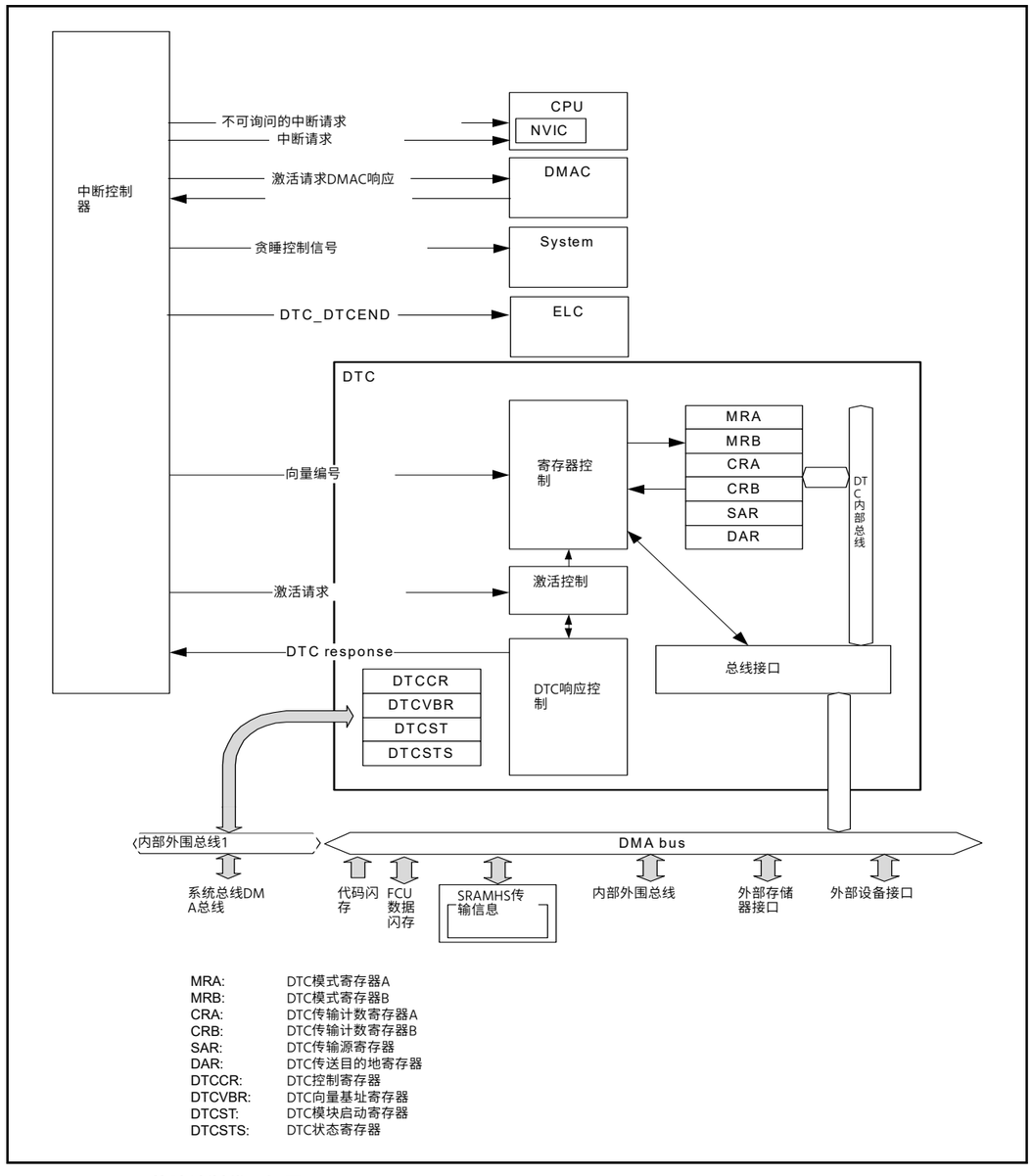


Figure 17.1 故障诊断代码框图

有关DTC和NVIC之间的连接，请参见第13节"中断控制器单元(ICU)"中的13.1概述
CPU.

17.2 Register Descriptions

MRA, MRB, SAR, DAR, CRA, and CRB are all DTC internal registers that cannot be directly accessed from the CPU. Values to be set in these DTC internal registers are placed in the SRAM area as transfer information. When an activation request is generated, the DTC reads the transfer information from the SRAM area and sets it in its internal registers. After the data transfer ends, the internal register contents are written back to the SRAM area as transfer information.

17.2.1 DTC Mode Register A (MRA)

Address(es): (Inaccessible directly from the CPU. See section 17.3.1.)

	b7	b6	b5	b4	b3	b2	b1	b0
	MD[1:0]		SZ[1:0]		SM[1:0]		—	—
Value after reset:	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as undefined. The write value should be 0.	—
b3, b2	SM[1:0]	Transfer Source Address Addressing Mode	b3 b2 0 0: Address in the SAR register is fixed (write-back to SAR) is skipped 0 1: Address in the SAR register is fixed (write-back to SAR is skipped) 1 0: SAR value is incremented after data transfer: +1 when SZ[1:0] = 00b +2 when SZ[1:0] = 01b +4 when SZ[1:0] = 10b. 1 1: SAR value is decremented after data transfer: -1 when SZ[1:0] = 00b -2 when SZ[1:0] = 01b -4 when SZ[1:0] = 10b.	—
b5, b4	SZ[1:0]	DTC Data Transfer Size	b5 b4 0 0: Byte (8-bit) transfer 0 1: Halfword (16-bit) transfer 1 0: Word (32-bit) transfer 1 1: Setting prohibited.	—
b7, b6	MD[1:0]	DTC Transfer Mode Select	b7 b6 0 0: Normal transfer mode 0 1: Repeat transfer mode 1 0: Block transfer mode 1 1: Setting prohibited.	—

The MRA register cannot be accessed directly from the CPU, however the CPU can access the SRAM area (transfer information (n) start address + 03h) and the DTC automatically transfers the MRA transfer information to and from the MRA register. See section 17.3.1, Allocating Transfer Information and the DTC Vector Table.

17.2 注册说明

MRA、MRB、SAR、DAR、CRA、CRB都是DTC内部寄存器，不能直接从CPU访问。在这些DTC内部寄存器中设置的值作为传输信息放置在SRAM区域中。当产生激活请求时，DTC从SRAM区域读取传输信息并将其设置在其内部寄存器中。数据传输结束后，内部寄存器内容作为传输信息回写到SRAM区域。

17.2.1 DTC模式寄存器A(MRA)

地址：（无法直接从CPU访问。请参阅第17.3.1节。）

	b7	b6	b5	b4	b3	b2	b1	b0
	MD[1:0]		SZ[1:0]		SM[1:0]		—	—
重置后的值：	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为未定义。写入值应为0。	—
b3, b2	SM[1:0]	传输源地址寻址 Mode	b3b200：SAR寄存器中的地址固定（回写到SAR）被跳过01：SAR寄存器中的地址固定（回写到SAR被跳过）10：SAR值在数据传输后递增:+1当SZ[1:0]=00b时+2当SZ[1:0]=01b时+4当SZ[1:0]=10b时。11：数据传输后SAR值递减：-1当SZ[1:0]=00b-2当SZ[1:0]=01b-4当SZ[1:0]=10b。	—
b5, b4	SZ[1:0]	DTC数据传输大小	b5b400：字节（8位）传送01：半字（16位）传送10：字（32位）传送11：禁止设置。	—
b7, b6	MD[1:0]	DTC传输模式选择	b7b600：正常传输模式01：重复传输模式10：块传输模式11：禁止设置。	—

MRA寄存器不能直接从CPU访问，但是CPU可以访问SRAM区域（传输信息(n)起始地址+03h），并且DTC会自动将MRA传输信息传输到MRA寄存器或从MRA寄存器传输信息。请参阅第17.3.1节，分配传输信息和DTC向量表。

17.2.2 DTC Mode Register B (MRB)

Address(es): (Inaccessible directly from the CPU. See section 17.3.1.)

	b7	b6	b5	b4	b3	b2	b1	b0
	CHNE	CHNS	DISEL	DTS	DM[1:0]		—	—
Value after reset:	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as undefined. The write value should be 0.	—
b3, b2	DM[1:0]	Transfer Destination Address Addressing Mode	b3 b2 0 0: Address in the DAR register is fixed (write-back to DAR is skipped) 0 1: Address in the DAR register is fixed (write-back to DAR is skipped) 1 0: DAR value is incremented after data transfer: +1 when MRA.SZ[1:0] = 00b +2 when MRA.SZ[1:0] = 01b +4 when MRA.SZ[1:0] = 10b. 1 1: DAR value is decremented after data transfer: -1 when MRA.SZ[1:0] = 00b -2 when MRA.SZ[1:0] = 01b -4 when MRA.SZ[1:0] = 10b.	—
b4	DTS	DTC Transfer Mode Select	0: Select transfer destination as repeat or block area 1: Select transfer source as repeat or block area.	—
b5	DISEL	DTC Interrupt Select	0: Generate an interrupt request to the CPU when specified data transfer is complete 1: Generate an interrupt request to the CPU each time DTC data transfer is performed.	—
b6	CHNS	DTC Chain Transfer Select	0: Select continuous chain transfer 1: Select chain transfer to occur only when the transfer counter is changed from 1 to 0 or 1 to CRAH.	—
b7	CHNE	DTC Chain Transfer Enable	0: Chain transfer disabled 1: Chain transfer enabled.	—

The MRB register cannot be accessed directly from the CPU. However, the CPU can access the SRAM area (transfer information (n) start address + 02h) and the DTC automatically transfers the MRB transfer information to and from the MRB register. See section 17.3.1, Allocating Transfer Information and the DTC Vector Table.

DTS bit (DTC Transfer Mode Select)

The DTS bit selects either the transfer source or transfer destination as the repeat area or block area in repeat or block transfer mode.

CHNS bit (DTC Chain Transfer Select)

The CHNS bit selects the chain transfer condition. When CHNE is 0, the CHNS setting is ignored. For details on the conditions for chain transfer, see Table 17.3, Chain transfer conditions.

When the next transfer is a chain transfer, completion of the specified number of transfers is not determined, the activation source flag is not cleared, and an interrupt request to the CPU is not generated.

CHNE bit (DTC Chain Transfer Enable)

The CHNE bit enables chain transfer. The chain transfer condition is selected in the CHNS bit. For details on chain transfer, see section 17.4.6, Chain Transfer.

17.2.2 DTC模式寄存器B(MRB)

地址：（无法直接从CPU访问。请参阅第17.3.1节。）

	b7	b6	b5	b4	b3	b2	b1	b0
	CHNE	CHNS	DISEL	DTS	DM[1:0]		—	—
重置后的值：	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为未定义。写入值应为0。	—
b3, b2	DM[1:0]	转移目的地地址寻址方式	b3b200：DAR寄存器中的地址固定（跳过回写DAR）01：固定DAR寄存器中的地址（跳过回写DAR）10：数据传输后DAR值递增：+1当MRA.SZ[1:0]=00b时+2当MRA.SZ[1:0]=01b时+4当MRA.SZ[1:0]=10b时。11：数据传输后DAR值递减：−1当MRA.SZ[1:0]=00b−2当MRA.SZ[1:0]=01b−4当MRA.SZ[1:0]=10b.	—
b4	DTS	DTC传输模式选择	0：选择传输目标为重复或块区域1：选择传输源为重复或块区域。	—
b5	DISEL	DTC中断选择	0：指定数据传输完成时向CPU产生中断请求1：每次执行DTC数据传输时，向CPU产生中断请求。	—
b6	CHNS	DTC链转移选择	0：选择连续链转移1：选择链转移仅在转移计数器从1变为0或从1变为CRAH时发生。	—
b7	CHNE	DTC链转移启用	0：禁止链转移1：允许链转移。	—

不能直接从CPU访问MRB寄存器。但是，CPU可以访问SRAM区域（传输信息(n)起始地址+02h），并且DTC会自动将MRB传输信息传输到MRB寄存器或从MRB寄存器传输信息。请参阅第17.3.1节，分配传输信息和DTC向量表。

DTS位（DTC传输模式选择）

在重复或块传输模式下，DTS位选择传输源或传输目标作为重复区域或块区域。

CHNS位（DTC链传输选择）

CHNS位选择链传输条件。当CHNE为0时，忽略CHNS设置。有关链转移条件的详细信息，请参见表17.3，链转移条件。

当下一次传输是链式传输时，指定传输次数的完成未确定，激活源标志未清零，也不向CPU产生中断请求。

CHNE位（DTC链传输使能）

CHNE位启用链式传输。在CHNS位中选择链传输条件。有关链转移的详细信息，请参阅第17.4.6节，链转移。

17.2.3 DTC Transfer Source Register (SAR)

Address(es): (Inaccessible directly from the CPU. See section 17.3.1.)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

The SAR register sets the transfer source start address and cannot be accessed directly from the CPU. However, the CPU can access the SRAM area (transfer information (n) start address + 04h) and the DTC automatically transfers the SAR transfer information to and from the SAR register. See section 17.3.1, Allocating Transfer Information and the DTC Vector Table.

Note: Misalignment is prohibited for DTC transfers. Bit [0] must be 0 when MRA.SZ[1:0] = 01b. Bits [1] and [0] must be 0 when MRA.SZ[1:0] = 10b.

17.2.4 DTC Transfer Destination Register (DAR)

Address(es): (inaccessible directly from the CPU. See section 17.3.1.)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

The DAR register sets the transfer destination start address and cannot be accessed directly from the CPU. However, the CPU can access the SRAM area (transfer information (n) start address + 08h) and the DTC automatically transfers the DAR transfer information to and from the DAR register. See section 17.3.1, Allocating Transfer Information and the DTC Vector Table.

Note: Misalignment is prohibited for DTC transfers. Bit [0] must be 0 when MRA.SZ[1:0] = 01b. Bits [1] and [0] must be 0 when MRA.SZ[1:0] = 10b.

17.2.3 DTC传输源寄存器(SAR)

地址：（无法直接从CPU访问。请参阅第17.3.1节。）

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

SAR寄存器设置传输源起始地址，不能直接从CPU访问。但是，CPU可以访问SRAM区域（传输信息(n)起始地址+04h），并且DTC会自动将SAR传输信息传入和传出SAR寄存器。请参阅第17.3.1节，分配传输信息和DTC向量表。

Note: DTC传输禁止错位。当MRA.SZ[1:0]=01b时，位[0]必须为0。当MRA.SZ[1:0]=10b时，位[1]和[0]必须为0。

17.2.4 DTC传输目的地寄存器(DAR)

地址：（无法直接从CPU访问。请参阅第17.3.1节。）

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

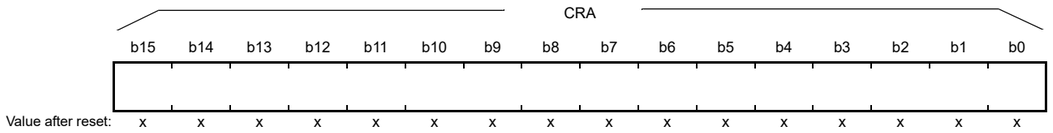
DAR寄存器设置传输目标起始地址，不能直接从CPU访问。但是，那
CPU可以访问SRAM区域（传输信息(n)起始地址+08h）并且DTC会自动传输
DAR将信息传入和传出DAR寄存器。请参阅第17.3.1节，分配传输信息和
DTC向量表。

Note: DTC传输禁止错位。当MRA.SZ[1:0]=01b时，位[0]必须为0。当MRA.SZ[1:0]=10b时，位[1]和[0]必须为0。

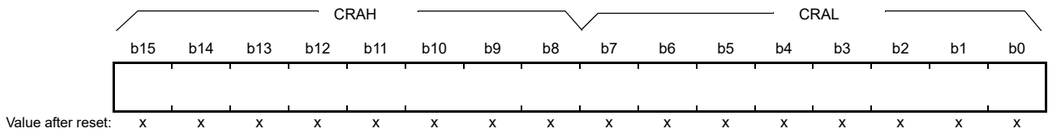
17.2.5 DTC Transfer Count Register A (CRA)

Address(es): (inaccessible directly from the CPU. See section 17.3.1.)

- Normal transfer mode



- Repeat transfer mode/block transfer mode



x: Undefined

Symbol	Register name	Description	R/W
CRAL	Transfer Counter A Lower Register	Specify the transfer count	—
CRAH	Transfer Counter A Upper Register		—

Note: The function depends on the transfer mode.
Note: Set CRAH and CRAL to the same value in repeat transfer mode and block transfer mode.

The CRA register cannot be accessed directly from the CPU. However, the CPU can access the SRAM area (transfer information (n) start address + 0Eh) and the DTC automatically transfers the CRA transfer information to and from the CRA register. See section 17.3.1, Allocating Transfer Information and the DTC Vector Table.

(1) Normal transfer mode (MRA.MD[1:0] = 00b)

In normal transfer mode, CRA functions as a 16-bit transfer counter. The transfer count is 1, 65535, and 65536 when the set value is 0001h, FFFFh, and 0000h, respectively. The CRA value is decremented (-1) on each data transfer.

(2) Repeat transfer mode (MRA.MD[1:0] = 01b)

In repeat transfer mode, the CRAH register holds the transfer count and the CRAL register functions as an 8-bit transfer counter. The transfer count is 1, 255, and 256 when the set value is 01h, FFh, and 00h, respectively. The CRAL value is decremented (-1) on each data transfer. When it reaches 00h, the CRAH value is transferred to CRAL.

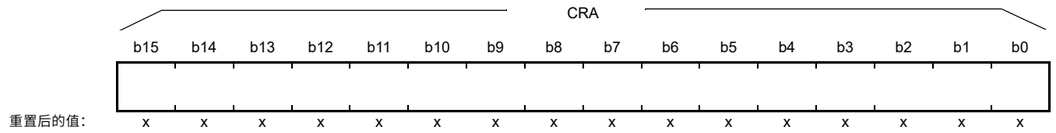
(3) Block transfer mode (MRA.MD[1:0] = 10b)

In block transfer mode, the CRAH register holds the transfer count and the CRAL register functions as an 8-bit block size counter. The transfer count is 1, 255, and 256 when the set value is 01h, FFh, and 00h, respectively. The CRAL value is decremented (-1) at each data transfer. When it reaches 00h, the CRAH value is transferred to CRAL.

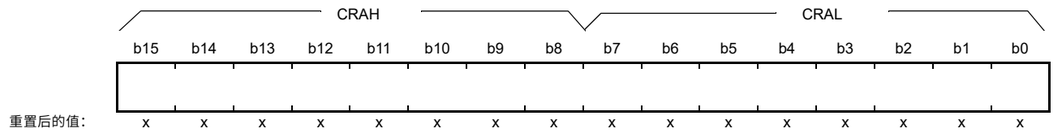
17.2.5 DTC传输计数寄存器A(CRA)

地址：（无法直接从CPU访问。请参阅第17.3.1节。）

正常传输模式



重复传输模式块传输模式



x: Undefined

Symbol	注册名称	Description	R/W
CRAL	传送计数器A低位寄存器	指定传输计数	—
CRAH	传送计数器A高位寄存器		—

Note: 该功能取决于传输模式。
Note: 在重复传输模式和块传输模式下，将CRAH和CRAL设置为相同的值。

CRA寄存器不能直接从CPU访问。但是，CPU可以访问SRAM区域（传输信息(n)起始地址+0Eh），并且DTC会自动将CRA传输信息传输到CRA寄存器或从CRA寄存器传输信息。请参阅第17.3.1节，分配传输信息和DTC向量表。

(1) 正常传输模式（MRA.MD[1:0]=00b）

在正常传输模式下，CRA用作16位传输计数器。当设置值为0001h、FFFFh和0000h时，传输计数分别为1、65535和65536。CRA值在每次数据传输时递减(-1)。

(2) 重复传输模式(MRA.MD[1:0]=01b)

在重复传输模式下，CRAH寄存器保存传输计数，CRAL寄存器用作8位传输计数器。当设置值为01h、FFh和00h时，传输计数分别为1、255和256。CRAL值在每次数据传输时递减(-1)。当它达到00h时，CRAH值被传送到CRAL。

(3) 块传输模式（MRA.MD[1:0]=10b）

在块传输模式下，CRAH寄存器保存传输计数，CRAL寄存器用作8位块大小计数器。当设置值为01h、FFh和00h时，传输计数分别为1、255和256。CRAL值在每次数据传输时递减(-1)。当它达到00h时，CRAH值被传送到CRAL。

17.2.6 DTC Transfer Count Register B (CRB)

Address(es): (Inaccessible directly from the CPU. See section 17.3.1.)

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

The CRB register sets the block transfer count for block transfer mode. The transfer count is 1, 65535, and 65536 when the set value is 0001h, FFFFh, and 0000h, respectively. The CRB value is decremented (-1) when the final data of a single block size is transferred. When normal transfer mode or repeat transfer mode is selected, this register is not used and the set value is ignored.

CRB cannot be accessed directly from the CPU. However, the CPU can access the SRAM area (transfer information (n) start address + 0Ch) and the DTC automatically transfers the CRB transfer information to and from the CRB register. See section 17.3.1, Allocating Transfer Information and the DTC Vector Table.

17.2.7 DTC Control Register (DTCCR)

Address(es): DTC.DTCCR 4000 5400h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	RRS	—	—	—	—
Value after reset:	0	0	0	0	1	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b3	—	Reserved	This bit is read as 1. The write value should be 1.	R/W
b4	RRS	DTC Transfer Information Read Skip Enable	0: Transfer information read is not skipped 1: Transfer information read is skipped when vector numbers match.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

RRS bit (DTC Transfer Information Read Skip Enable)

The RRS bit enables skipping of transfer information reads when the vector numbers match. The DTC vector number is compared with the vector number in the previous activation process. When these vector numbers match and the RRS bit is set to 1, DTC data transfer is performed without reading the transfer information. However, when the previous transfer is a chain transfer, the transfer information is read regardless of the value in the RRS bit.

When the transfer counter (CRA register) becomes 0 during the previous normal transfer and when the transfer counter (CRB register) becomes 0 during the previous block transfer, the transfer information is read regardless of the RRS bit value.

17.2.6 DTC传输计数寄存器B(CRB)

地址：（无法直接从CPU访问。请参阅第17.3.1节。）

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

CRB寄存器设置块传输模式的块传输计数。当设置值为0001h、FFFFh和0000h时，传输计数分别为1、65535和65536。当传输单个块大小的最终数据时，CRB值递减(-1)。Whennormaltransfermodeorrepeattransfermodeisselected thisregisterisnotusedandthesetvalueisignored.

不能直接从CPU访问CRB。但是，CPU可以访问SRAM区域（传输信息(n)起始地址+0Ch），并且DTC会自动将CRB传输信息传输到CRB寄存器或从CRB寄存器传输信息。请参阅第17.3.1节，分配传输信息和DTC向量表。

17.2.7 DTC控制寄存器(DTCCR)

Address(es): DTC.DTCCR 4000 5400h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	RRS	—	—	—	—
重置后的值：	0	0	0	0	1	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b3	—	Reserved	该位读取为1。写入值应为1。	R/W
b4	RRS	DTC传输信息读取跳过启用	0：不跳过传输信息读取1：当向量编号匹配时，跳过传输信息读取。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

RRS位（DTC传输信息读取跳过使能）

当向量编号匹配时，RRS位允许跳过传输信息读取。将DTC向量编号与之前激活过程中的向量编号进行比较。当这些向量编号匹配并且RRS位设置为1时，执行DTC数据传输而不读取传输信息。但是，当前一次传输是链式传输时，无论RRS位中的值如何，都会读取传输信息。

如果在前一次正常传输期间传输计数器（CRA寄存器）变为0，并且在前一次块传输期间传输计数器（CRB寄存器）变为0，则无论RRS位值如何，都将读取传输信息。

17.2.8 DTC Vector Base Register (DTCVBR)

Address(es): DTC.DTCVBR 4000 5404h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Bit name	Description	R/W
b31 to b0	DTC Vector Base Address	Set the DTC vector base address. The lower 10 bits should be 0.	R/W

The DTCVBR register sets the base address to calculate the DTC vector table address, which can be set in the range of 0000 0000h to FFFF FFFFh (4 GB) in 1-KB units.

17.2.9 DTC Module Start Register (DTCST)

Address(es): DTC.DTCST 4000 540Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DTCST
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DTCST	DTC Module Start	0: DTC module stopped 1: DTC module started.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

DTCST bit (DTC Module Start)

Set the DTCST bit to 1 to enable the DTC to accept transfer requests. When the DTCST bit is set to 0, transfer requests are no longer accepted. If this bit is set to 0 during a data transfer, the accepted transfer request is active until processing is complete.

DTCST must be set to 0 before transitioning to any of the following state or mode:

- Module-stop state
- Software Standby mode without Snooze mode transition
- Deep Software Standby mode.

For details on these transitions, see section 17.10, Module-Stop Function, and section 11, Low Power Modes.

17.2.8 DTC向量基址寄存器(DTCVBR)

Address(es): DTC.DTCVBR 4000 5404h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	位名称	Description	R/W
b31 to b0	DTC向量基地址	设置DTC向量基地址。低10位应为0。	R/W

DTCVBR寄存器设置基地址来计算DTC向量表地址，可以设置在00000000h到FFFFFFFFh(4GB)的范围内，以1-KB为单位。

17.2.9 DTC模块启动寄存器(DTCST)

Address(es): DTC.DTCST 4000 540Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	DTCST
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DTCST	DTC模块启动	0：DTC模块停止1：DTC模块启动。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DTCST位（DTC模块启动）

将DTCST位设置为1以使DTC接受传输请求。当DTCST位设置为0时，不再接受传输请求。如果在数据传输期间该位设置为0，则接受的传输请求将处于活动状态，直到处理完成。

在转换到以下任何状态或模式之前，必须将DTCST设置为0：

- Module-stop state
- 没有贪睡模式转换的软件待机模式
- 深度软件待机模式。

有关这些转换的详细信息，请参阅第17.10节，模块停止功能和第11节，低功耗模式。

17.2.10 DTC Status Register (DTCSTS)

Address(es): DTC.DTCSTS 4000 540Eh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ACT	—	—	—	—	—	—	—	VECN[7:0]							
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	VECN[7:0]	DTC-Activating Vector Number Monitoring	These bits indicate the vector number for the activation source when a DTC transfer is in progress. The value is only valid if a DTC transfer is in progress (ACT flag is 1).	R
b14 to b8	—	Reserved	These bits are read as 0. Writing to these bits has no effect.	R
b15	ACT	DTC Active Flag	0: DTC transfer operation is not in progress 1: DTC transfer operation is in progress.	R

VECN[7:0] bits (DTC-Activating Vector Number Monitoring)

While transfer by the DTC is in progress, the VECN[7:0] bits indicate the vector number associated with the activation source for the transfer. The value read from the VECN[7:0] bits is valid if the ACT flag is 1, indicating that a DTC transfer is in progress, and invalid if the ACT flag is 0, indicating that no DTC transfer is in progress.

ACT flag (DTC Active Flag)

The ACT flag indicates the state of the DTC transfer operation.

[Setting condition]

- When the DTC is activated by a transfer request.

[Clearing condition]

- When transfer by the DTC, in response to a transfer request, is complete.

17.3 Activation Sources

The DTC is activated by an interrupt request. Setting the ICU.IELSRn.DTCE bit to 1 enables activation of the DTC by the associated interrupt. The selector output *n* number set in ICU.IELSRn is defined as the interrupt vector number, where n = 0 to 95. For an enabled interrupt, the specific DTC interrupt source associated with each interrupt vector number n is selected in ICU.IELSRn.IELS[8:0] where n = 0 to 95, as listed in Table 13.4, Event table, in section 13, Interrupt Controller Unit (ICU). For activation by software, see section 18.2.2, Event Link Software Event Generation Register n (ELSEGRn) (n = 0, 1).

The interrupt vector number is equivalent to the DTC vector table number. After the DTC accepted an activation request, it does not accept another activation request until transfer for that single request is complete, regardless of the priority of the requests. When multiple activation requests are generated during a DMAC or DTC transfer, a highest priority request is accepted on completion of the transfer. When multiple activation requests are generated while the DTC Module Start bit (DTCST.DTCST) is 0, the DTC accepts the highest-priority request when DTCST.DTCST is subsequently set to 1. The smaller interrupt vector number has higher priority.

The DTC performs the following operations at the start of a single data transfer or for a chain transfer, after the last of the consecutive transfers:

- On completion of a specified round of data transfer, the ICU.IELSRn.DTCE bit is set to 0, and an interrupt request is sent to the CPU
- If the MRB.DISEL bit is 1, an interrupt request is sent to the CPU on completion of a data transfer
- For other transfers, the ICU.IELSRn.IR bit of the activation source is set to 0 at the start of the data transfer.

17.2.10 DTC状态寄存器(DTCSTS)

Address(es): DTC.DTCSTS 4000 540Eh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ACT	—	—	—	—	—	—	—	VECN[7:0]							
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	VECN[7:0]	DTC-Activating Vector 号码监控	当DTC传输正在进行时，这些位指示激活源的向量编号。该值仅在DTC传输正在进行（ACT标志为1）时有效。	R
b14 to b8	—	Reserved	这些位被读取为0。写入这些位无效。	R
b15	ACT	DTC活动标志	0：未进行DTC传输操作1：正在进行DTC传输操作。	R

VECN[7:0]位（DTC–激活向量编号监控）

当DTC进行传输时，VECN[7:0]位指示与传输激活源相关的向量编号。如果ACT标志为1，则从VECN[7:0]位读取的值有效，表示正在进行DTC传输；如果ACT标志为0，则表示无效，表示没有DTC传输正在进行。

ACT标志（DTC活动标志）

ACT标志指示DTC传输操作的状态。

[Setting condition]

- 当DTC被传输请求激活时。

[Clearing condition]

- 当DTC响应传输请求传输完成时。

17.3 激活源

DTC由中断请求激活。将ICU.IELSRn.DTCE位设置为1可以通过相关中断激活DTC。ICU.IELSRn中设置的选择器输出n号定义为中断向量号，其中n=0到95。对于启用的中断，在ICU.IELSRn.IELS中选择与每个中断向量号n关联的特定DTC中断源[8:0]其中n=0到95，如表13.4，事件表，第13节，中断控制器单元(ICU)中所列。对于软件激活，请参见第18.2.2节，事件链接软件事件生成

Register n (ELSEGRn) (n = 0, 1).

中断向量编号相当于DTC向量表编号。在DTC接受激活请求后，它不会接受另一个激活请求，直到该单个请求的传输完成，无论请求的优先级如何。如果在DMAC或DTC传输期间生成多个激活请求，则在传输完成时接受最高优先级的请求。当DTC模块起始位(DTCST.DTCST)为0时产生多个激活请求时，当DTCST.DTCST随后设置为1时，DTC接受最高优先级的请求。较小的中断向量编号具有较高的优先级。

DTC在单次数据传输开始时执行以下操作，或者对于链式传输，在最后一次连续传输之后执行以下操作：

- 完成指定的一轮数据传输后，ICU.IELSRn.DTCE位设置为0，并向CPU发送中断请求
- 如果MRB.DISEL位为1，则在数据传输完成时向CPU发送中断请求
- 对于其他传输，激活源的ICU.IELSRn.IR位在数据传输开始时设置为0。

17.3.1 Allocating Transfer Information and the DTC Vector Table

The DTC reads the start address of the transfer information associated with each activation source from the vector table and reads the transfer information starting at that address.

The vector table must be located so that the lower 10 bits of the base address (start address) are 0. Use the DTC Vector Base Register (DTCVBR) to set the base address of the DTC vector table. Transfer information is allocated in the SRAM area. In the SRAM area, the start address of the transfer information *n* with vector number *n* must be 4n added to the base address in the vector table.

Figure 17.2 shows the relationship between the DTC vector table and transfer information. Figure 17.3 shows the allocation of transfer information in the SRAM area.

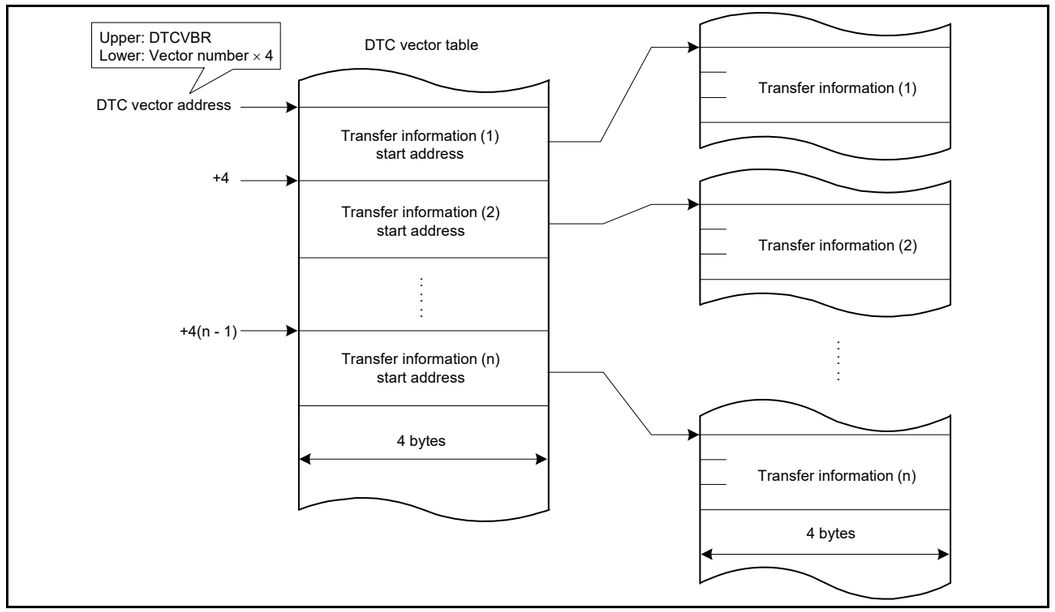


Figure 17.2 DTC vector table and transfer information

17.3.1 分配传输信息和DTC向量表

DTC从向量表中读取与每个激活源相关联的传输信息的起始地址，并读取从该地址开始的传输信息。

向量表的位置必须使基地址（起始地址）的低10位为0。使用DTC向量基址寄存器(DTCVBR)用于设置DTC向量表的基地址。传输信息分配在SRAM区域中。在SRAM区域中，向量编号为n的传输信息n的起始地址必须与向量表中的基地址相加4n。

图17.2显示了DTC向量表和传输信息之间的关系。图17.3显示了SRAM区域中传输信息的分配。

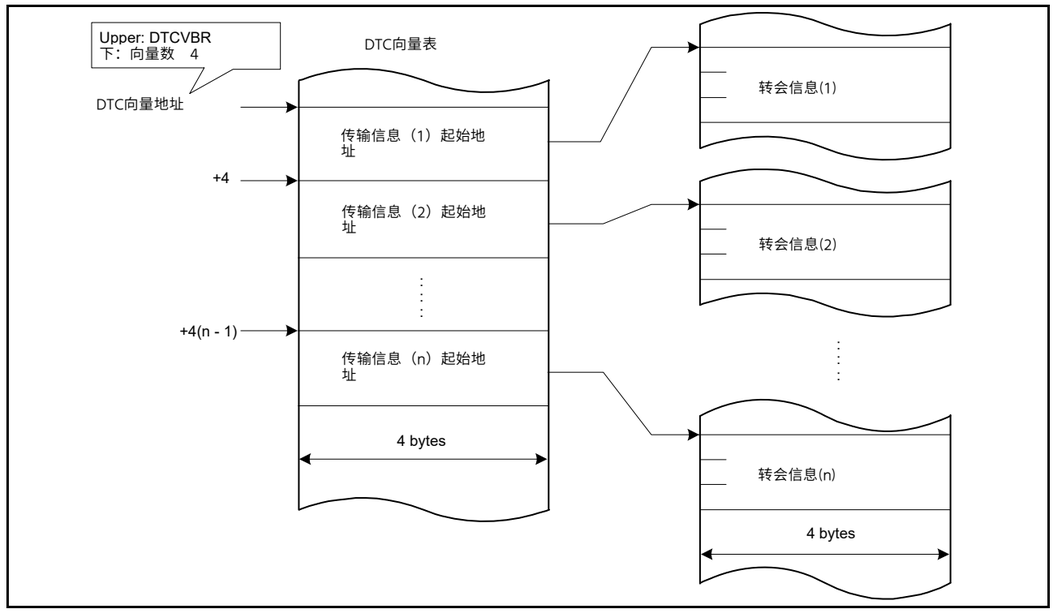


Figure 17.2 DTC向量表和传输信息

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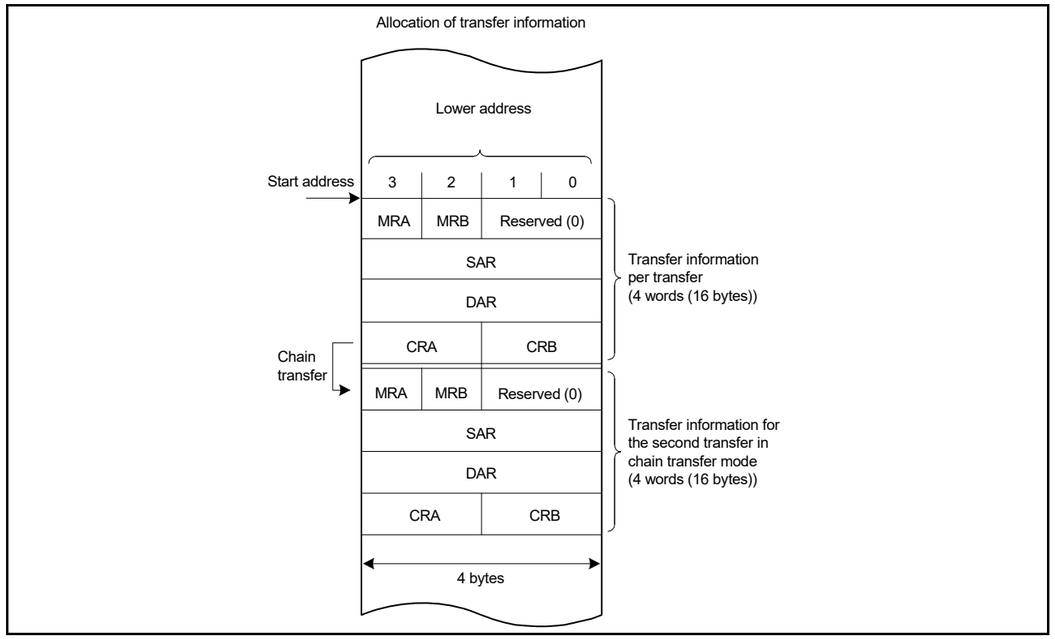

Figure 17.3 Allocation of transfer information in the SRAM area

17.4 Operation

The DTC transfers data according to the transfer information. Storage of the transfer information in the SRAM area is required before a DTC operation. When the DTC is activated, it reads the DTC vector associated with the vector number. The DTC then reads the transfer information from the transfer information store address referenced by the DTC vector and transfers the data. After the data transfer, the DTC writes back the transfer information. Storing the transfer information in the SRAM area allows data transfer of any number of channels.

The transfer modes include:

- Normal transfer mode
- Repeat transfer mode
- Block transfer mode.

The DTC specifies a transfer source address in the SAR register and a transfer destination address in the DAR register. The values in these registers are incremented, decremented, or address-fixed independently after the data transfer.

Table 17.2 describes the DTC transfer modes.

Table 17.2 DTC transfer modes

Transfer mode	Data size transferred on single transfer request	Increment or decrement of memory address	Settable transfer count
Normal transfer mode	1 byte (8 bits), 1 halfword (16 bits), or 1 word (32 bits)	Incremented or decremented by 1, 2, or 4 or address fixed	1 to 65536
Repeat transfer mode*1	1 byte (8 bits), 1 halfword (16 bits), or 1 word (32 bits)	Incremented or decremented by 1, 2, or 4 or address fixed	1 to 256*3
Block transfer mode*2	Block size specified in CRAH (1 to 256 bytes, 1 to 256 halfwords (2 to 512 bytes), or 1 to 256 words (4 to 1024 bytes))	Incremented or decremented by 1, 2, or 4 or address fixed	1 to 65536

Note 1. Set the transfer source or destination as the repeat area.

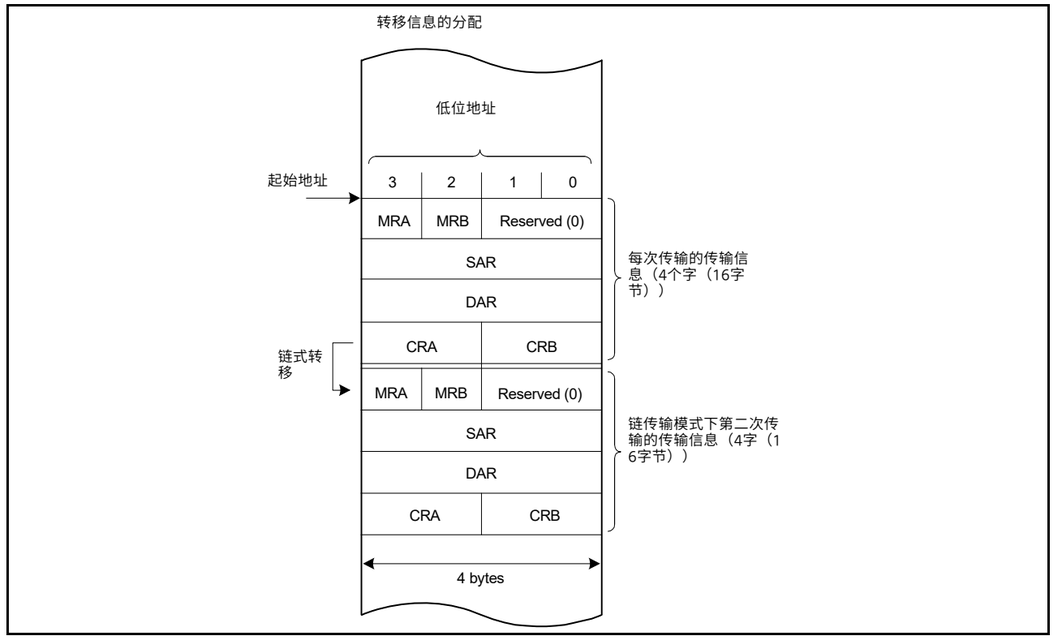

Figure 17.3 SRAM区域中传输信息的分配

17.4 Operation

DTC根据传输信息传输数据。在进行DTC操作之前，需要在SRAM区域中存储传输信息。当DTC被激活时，它会读取与向量编号相关联的DTC向量。然后DTC从DTC向量引用的传输信息存储地址中读取传输信息并传输数据。数据传输后，DTC写回传输信息。将传输信息存储在SRAM区域中可以实现任意数量的通道的数据传输。

传输模式包括：

- 正常传输模式
- 重复传输模式
- 块传输模式。

DTC指定SAR寄存器中的传输源地址和DAR寄存器中的传输目标地址。
这些寄存器中的值在数据传输后独立地递增、递减或固定地址。

表17.2描述了DTC传输模式。

Table 17.2 DTC传输模式

传输模式	在单个传输请求上传输的数据大小	内存地址的递增或递减	可设置的传输次数
正常传输模式	1个字节（8位）、1个半字（16位）或1个字（32位）	递增或递减1、2或4或固定地址	1 to 65536
重复传输模式*1	1个字节（8位）、1个半字（16位）或1个字（32位）	递增或递减1、2或4或固定地址	1 to 256*3
块传输模式*2	CRAH中指定的块大小（1到256字节、1到256个半字（2到512字节）或1到256字（4到1024字节））	递增或递减1、2或4或固定地址	1 to 65536

Note 1. 将传输源或目标设置为重复区域。

Note 2. Set the transfer source or destination as the block area.
Note 3. After a data transfer of the specified count, the initial state is restored and operation restarts.

Setting the MRB.CHNE bit to 1 allows multiple transfers or a chain transfer on a single activation source. It also enables a chain transfer when the specified data transfer is complete.

Figure 17.4 shows the operation flow of the DTC. Table 17.3 lists the chain transfer conditions. The combination of control information for the second and subsequent transfers are omitted in this table.

Note 2. 将传输源或目标设置为块区域。
Note 3. 在指定计数的数据传输后，恢复初始状态并重新开始操作。

将MRB.CHNE位设置为1允许在单个激活源上进行多次传输或链式传输。当指定的数据传输完成时，它还启用链式传输。

图17.4显示了DTC的操作流程。表17.3列出了链转移条件。该表中省略了用于第二次和后续传输的控制信息的组合。

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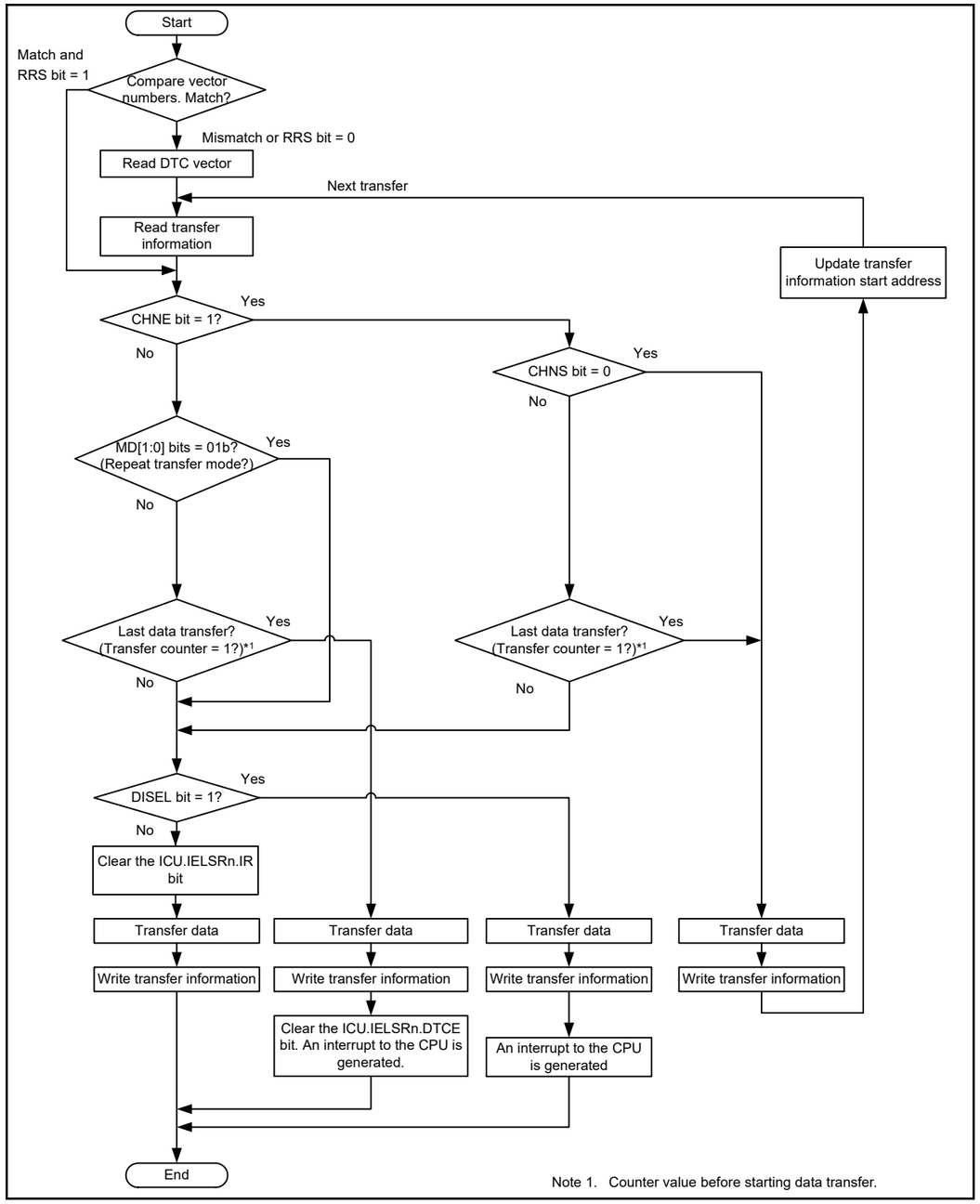


Figure 17.4 DTC operation flow

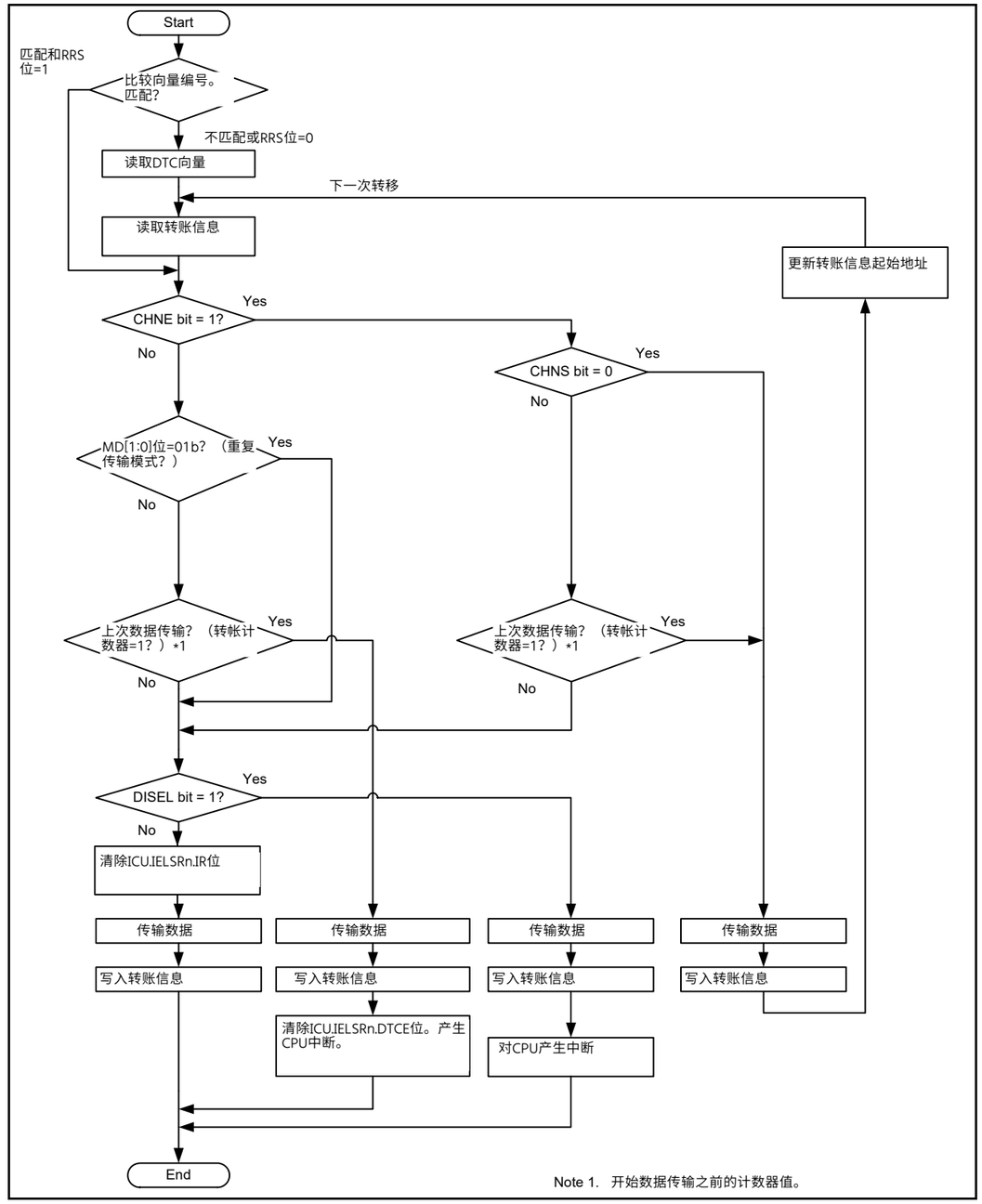


Figure 17.4 DTC操作流程

Table 17.3 Chain transfer conditions

First transfer				Second transfer*3				DTC transfer
CHNE bit	CHNS bit	DISEL bit	Transfer counter*1,*2	CHNE bit	CHNS bit	DISEL bit	Transfer counter*1,*2	
0	-	0	Other than (1 → 0)	-	-	-	-	Ends after the first transfer
0	-	0	(1 → 0)	-	-	-	-	Ends after the first transfer with an interrupt request to the CPU
0	-	1	-	-	-	-	-	
1	0	-	-	0	-	0	Other than (1 → 0)	Ends after the second transfer
				0	-	0	(1 → 0)	Ends after the second transfer with an interrupt request to the CPU
				0	-	1	-	
1	1	0	Other than (1 → *)	-	-	-	-	Ends after the first transfer
1	1	-	(1 → *)	0	-	0	Other than (1 → 0)	Ends after the second transfer
				0	-	0	(1 → 0)	Ends after the second transfer with an interrupt request to the CPU
				0	-	1	-	
1	1	1	Other than (1 → *)	-	-	-	-	Ends after the first transfer with an interrupt request to the CPU

Note 1. The transfer counter used depends on the transfer modes as follows:
Normal transfer mode — CRA register
Repeat transfer mode — CRAL register
Block transfer mode — CRB register

Note 2. On completion of a data transfer, the counters operate as follows:
1 → 0 in normal and block transfer modes
1 → CRAH in repeat transfer mode
(1 → *) in the table indicates both of these two operations, depending on the mode.

Note 3. Chain transfer can be selected for the second or subsequent transfers. The conditions for the combination of the second transfer and CHNE bit = 1 is omitted.

17.4.1 Transfer Information Read Skip Function

Reading of vector addresses and transfer information can be skipped by setting the DTCCR.RRS bit. When a DTC activation request is generated, the current DTC vector number is compared to the DTC vector number in the previous activation process. When these vector numbers match and the RRS bit is set to 1, the DTC data transfer is performed without reading the vector address and transfer information. However, when the previous transfer is a chain transfer, the vector address and transfer information are read. Additionally, when the transfer counter (CRA register) becomes 0 during the previous normal transfer, or when the transfer counter (CRB register) becomes 0 during the previous block transfer, transfer information is read regardless of the RRS bit. Figure 17.12 shows an example of a transfer information read skip.

To update the vector table and transfer information:

1. Set the RRS bit to 0.
2. Update the vector table and transfer information.
3. Set the RRS bit to 1.

The stored vector number is discarded by setting the RRS bit to 0. The updated DTC vector table and transfer information are read in the next activation process.

Table 17.3 链转移条件

首次转让				Second transfer*3				DTC transfer
CHNE bit	CHNS bit	DISEL bit	Transfer counter*1,*2	CHNE bit	CHNS bit	DISEL bit	Transfer counter*1,*2	
0	-	0	（1→0）以外	-	-	-	-	在第一次传输后结束
0	-	0	(1 → 0)	-	-	-	-	在第一次传输后结束，向CPU发出中断请求
0	-	1	-	-	-	-	-	
1	0	-	-	0	-	0	（1→0）以外	在第二次转移后结束
				0	-	0	(1 → 0)	在第二次传输后结束，向CPU发出中断请求
				0	-	1	-	
1	1	0	(1→*)以外	-	-	-	-	在第一次传输后结束
1	1	-	(1 → *)	0	-	0	（1→0）以外	在第二次转移后结束
				0	-	0	(1 → 0)	在第二次传输后结束，向CPU发出中断请求
				0	-	1	-	
1	1	1	(1→*)以外	-	-	-	-	在第一次传输后结束，向CPU发出中断请求

Note 1. 使用的传输计数器取决于传输模式，如下所示：
正常传输模式—CRA寄存器重复传输模式—CRAL寄存器
块传输模式——CRB寄存器

Note 2. 数据传输完成后，计数器操作如下：1→0在正常和块传输模式下1→CRAH在重复传输模式下(1→*)表中表示这两种操作，具体取决于模式。

Note 3. 可以为第二次或后续转移选择链转移。省略了第二次传输和CHNE位=1的组合条件。

17.4.1 传输信息读取跳过功能

通过设置DTCCR.RRS位可以跳过向量地址和传输信息的读取。当产生一个DTC激活请求时，当前的DTC向量编号将与之前激活过程中的DTC向量编号进行比较。当这些向量编号匹配且RRS位设置为1时，执行DTC数据传输而不读取向量地址和传输信息。但是，当上一次传输是链式传输时，会读取向量地址和传输信息。此外，如果在上次正常传输期间传输计数器（CRA寄存器）变为0，或者在前一次块传输期间传输计数器（CRB寄存器）变为0，则无论RRS位如何，都将读取传输信息。图17.12显示了传输信息读取跳过的示例。

更新向量表和传输信息：

1. 将RRS位设置为0。
2. 更新向量表并传递信息。
3. 将RRS位设置为1。

通过将RRS位设置为0来丢弃存储的向量号。在下一个激活过程中读取更新的DTC向量表和传输信息。

17.4.2 Transfer Information Write-Back Skip Function

When the MRA.SM[1:0] bits or the MRB.DM[1:0] bits are set to *address fixed*, a part of the transfer information is not written back. Table 17.4 lists the transfer information write-back skip conditions and the associated registers. The CRA and CRB registers are written back, and the write-back of the MRA and MRB registers is skipped.

Table 17.4 Transfer information write-back skip conditions and applicable registers

MRA.SM[1:0] bits		MRB.DM[1:0] bits			
b3	b2	b3	b2	**SAR register**	**DAR register**
0	0	0	0	Skip	Skip
0	0	0	1		
0	1	0	0		
0	1	0	1		
0	0	1	0	Skip	Write-back
0	0	1	1		
0	1	1	0		
0	1	1	1		
1	0	0	0	Write-back	Skip
1	0	0	1		
1	1	0	0		
1	1	0	1		
1	0	1	0	Write-back	Write-back
1	0	1	1		
1	1	1	0		
1	1	1	1		

17.4.3 Normal Transfer Mode

Normal transfer mode allows a 1-byte (8-bit), 1-halfword (16-bit), or 1-word (32-bit) data transfer on a single activation source. The transfer count can be set from 1 to 65536. Transfer source and destination addresses can be independently set to increment, decrement, or remain fixed. This mode enables an interrupt request to the CPU to be generated at the end of a specified-count transfer.

Table 17.5 lists the register functions in normal transfer mode, and Figure 17.5 shows the memory map of normal transfer mode.

Table 17.5 Register functions in normal transfer mode

Register	Description	Value written back by writing transfer information
SAR	Transfer source address	Increment, decrement, or fixed*1
DAR	Transfer destination address	Increment, decrement, or fixed*1
CRA	Transfer counter A	CRA - 1
CRB	Transfer counter B	Not updated

Note 1. Write-back operation is skipped in address-fixed mode.

17.4.2 传输信息回写跳过功能

当MRA.SM[1:0]位或MRB.DM[1:0]位设置为addressfixed时，部分传输信息不会写回。表17.4列出了传输信息回写跳过条件和相关寄存器。回写CRA和CRB寄存器，跳过回写MRA和MRB寄存器。

Table 17.4 传输信息回写跳过条件和适用寄存器

MRA.SM[1:0] bits		MRB.DM[1:0] bits			
b3	b2	b3	b2	**SAR寄存器**	**DAR寄存器**
0	0	0	0	Skip	Skip
0	0	0	1		
0	1	0	0		
0	1	0	1		
0	0	1	0	Skip	Write-back
0	0	1	1		
0	1	1	0		
0	1	1	1		
1	0	0	0	Write-back	Skip
1	0	0	1		
1	1	0	0		
1	1	0	1		
1	0	1	0	Write-back	Write-back
1	0	1	1		
1	1	1	0		
1	1	1	1		

17.4.3 正常传输模式

正常传输模式允许在单个激活源上传输1字节（8位）、1半字（16位）或1字（32位）数据。传输计数可以设置为1到65536。传输源地址和目标地址可以独立设置为递增、递减或保持固定。此模式允许在指定计数传输结束时向CPU生成中断请求。

表17.5列出了正常传输模式下的寄存器功能，图17.5显示了正常传输模式下的内存映射。

Table 17.5 正常传输模式下的寄存器功能

Register	Description	通过写入传输信息回写的值
SAR	传输源地址	递增、递减或固定*1
DAR	转移目的地地址	递增、递减或固定*1
CRA	转帐柜台A	CRA - 1
CRB	转帐柜台B	未更新

Note 1. 在地址固定模式下会跳过回写操作。

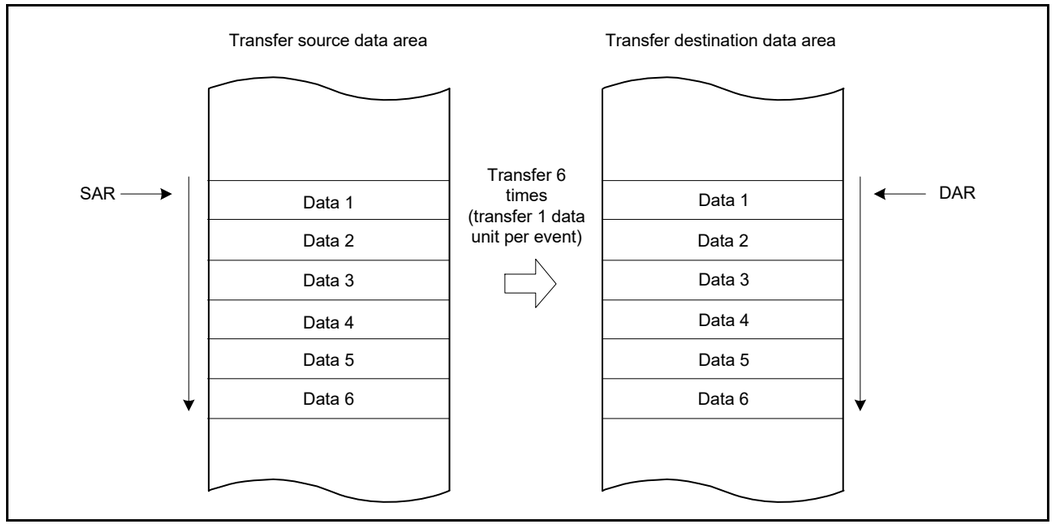


Figure 17.5 Memory map of normal transfer mode (MRA.SM[1:0] = 10b, MRB.DM[1:0] = 10b, CRA = 0006h)

17.4.4 Repeat Transfer Mode

Repeat transfer mode allows a 1-byte (8-bit), 1-halfword (16-bit), or 1-word (32-bit) data transfer on a single activation source. Specify either transfer source or transfer destination for the repeat area in the MRB.DTS bit. The transfer count can be set from 1 to 256. When the specified transfer count is complete, the initial value of the address register specified in the repeat area is restored, the initial value of the transfer counter is restored, and transfer is repeated. The other address register is incremented or decremented continuously or remains unchanged.

When the transfer counter CRAL decrements to 00h in repeat transfer mode, the CRAL value is updated to the value set in the CRAH register. As a result, the transfer counter does not clear to 00h, which disables interrupt requests to the CPU when the MRB.DISEL bit is set to 0. An interrupt request to the CPU is generated when the specified data transfer is complete.

Table 17.6 lists the register functions in repeat transfer mode, and Figure 17.6 shows the memory map of repeat transfer mode.

Table 17.6 Register functions in repeat transfer mode

Register	Description	Value written back by writing transfer information	
		When CRAL is not 1	When CRAL is 1
SAR	Transfer source address	Increment, decrement, or fixed*1	• When the MRB.DTS bit is 0 Increment, decrement, or fixed*1 • When the MRB.DTS bit is 1 SAR register initial value.
DAR	Transfer destination address	Increment, decrement, or fixed*1	• When the MRB.DTS bit is 0 DAR register initial value • When the MRB.DTS bit is 1 Increment, decrement, or fixed.*1
CRAH	Holds transfer counter	CRAH	CRAH
CRAL	Transfer counter A	CRAL - 1	CRAH
CRB	Transfer counter B	Not updated	Not updated

Note 1. Write-back is skipped in address-fixed mode.

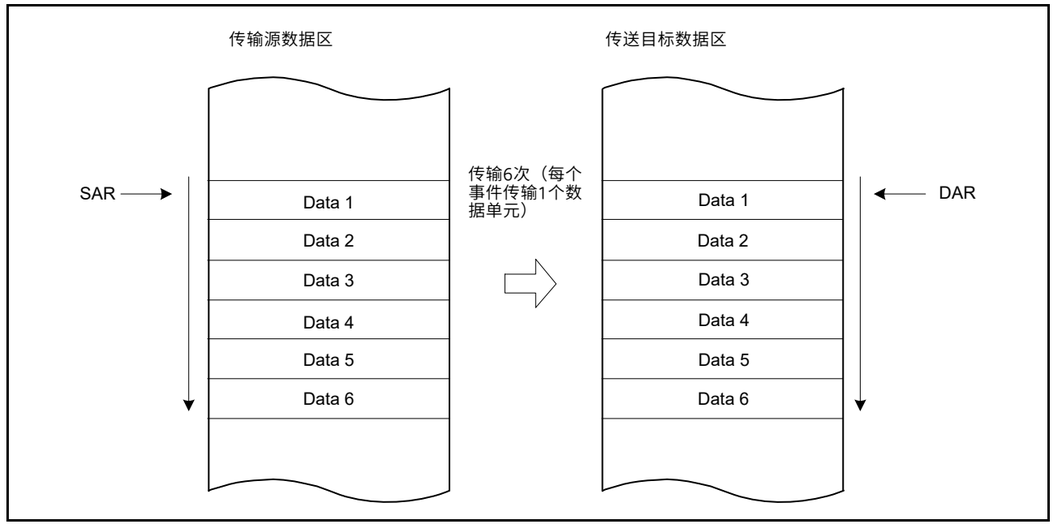


Figure 17.5 正常传输模式的内存映射(MRA.SM[1:0]=10b MRB.DM[1:0]=10b CRA=0006h)

17.4.4 重复传输模式

重复传输模式允许在单个激活源上传输1字节（8位）、1半字（16位）或1字（32位）数据。在MRB.DTS位中指定重复区域的传输源或传输目标。传输计数可设置为1到256。当指定的传输计数完成时，将恢复重复区域中指定的地址寄存器的初始值，恢复传输计数器的初始值，并重复传输。另一个地址寄存器连续递增或递减或保持不变。

当传输计数器CRAL在重复传输模式下递减到00h时，CRAL值将更新为CRAH寄存器中设置的值。因此，传输计数器不会清为00h，这会在MRB.DISEL位设置为0时禁用对CPU的中断请求。当指定的数据传输完成时，会向CPU发出中断请求。

表17.6列出了重复传输模式下的寄存器功能，图17.6显示了重复传输模式的内存映射。

Table 17.6 重复传输模式下的寄存器功能

Register	Description	通过写入传输信息回写的值	
		当CRAL不为1时	当CRAL为1时
SAR	传输源地址	递增、递减或固定*1	当MRB.DTS位为0时递增、递减或固定*1 当MRB.DTS位为1时SAR寄存器初始值。
DAR	转移目的地地址	递增、递减或固定*1	当MRB.DTS位为0时DAR寄存器初始值 当MRB.DTS位为1时递增、递减或固定。*1
CRAH	持有转账柜台	CRAH	CRAH
CRAL	转帐柜台A	CRAL - 1	CRAH
CRB	转帐柜台B	未更新	未更新

Note 1. 在地址固定模式下会跳过回写。

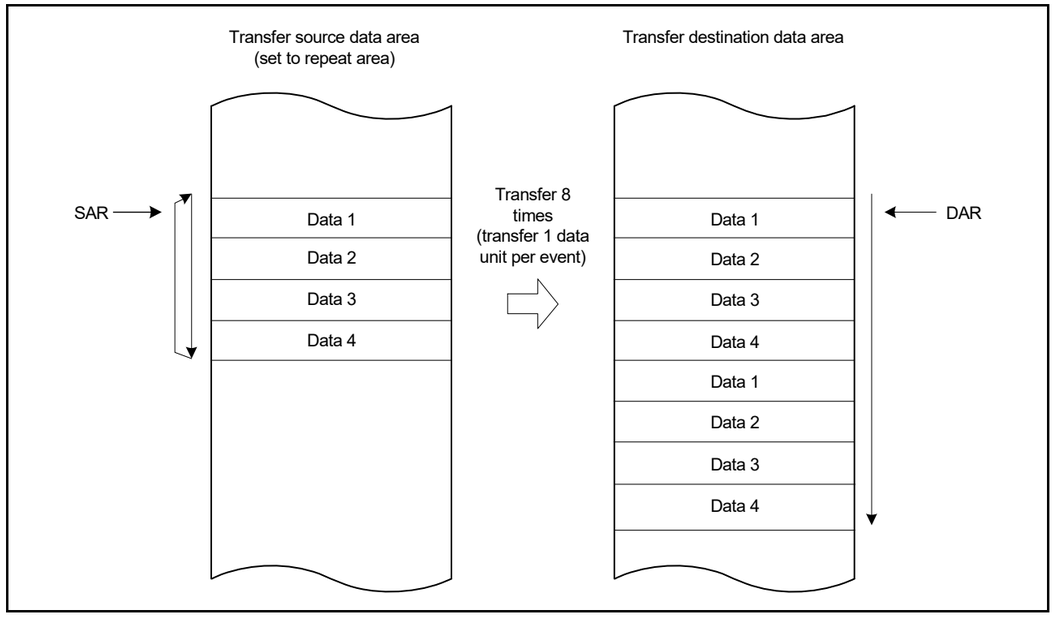


Figure 17.6 Memory map of repeat transfer mode when transfer source is a repeat area (MRA.SM[1:0] = 10b, MRB.DM[1:0] = 10b, CRAH = 04h)

17.4.5 Block Transfer Mode

Block transfer mode allows single-block data transfer on a single activation source. Transfer source or transfer destination for the block area must be specified in the MRB.DTS bit. The block size can be set from 1 to 256 bytes, 1 to 256 halfwords (2 to 512 bytes), or 1 to 256 words (4 to 1024 bytes). When transfer of the specified block completes, the initial values of the block size counter CRAL and the address register (the SAR register when the MRB.DTS bit = 1 or the DAR register when the DTS bit = 0) specified in the block area are restored. The other address register is incremented or decremented continuously or remains unchanged.

The transfer count (block count) can be set from 1 to 65536. This mode enables an interrupt request to the CPU to be generated at the end of the specified-count block transfer.

Table 17.7 lists register functions in block transfer mode, and Figure 17.7 shows the memory map for block transfer mode.

Table 17.7 Register functions in block transfer mode

Register	Description	Value written back by writing transfer information
SAR	Transfer source address	• When MRB.DTS bit is 0 Increment, decrement, or fixed*1 • When MRB.DTS bit is 1 SAR register initial value.
DAR	Transfer destination address	• When MRB.DTS bit is 0 DAR register initial value • When MRB.DTS bit is 1 Increment, decrement, or fixed.*1
CRAH	Holds the block size	CRAH
CRAL	Block size counter	CRAH
CRB	Block transfer counter	CRB - 1

Note 1. Write-back is skipped in address-fixed mode.

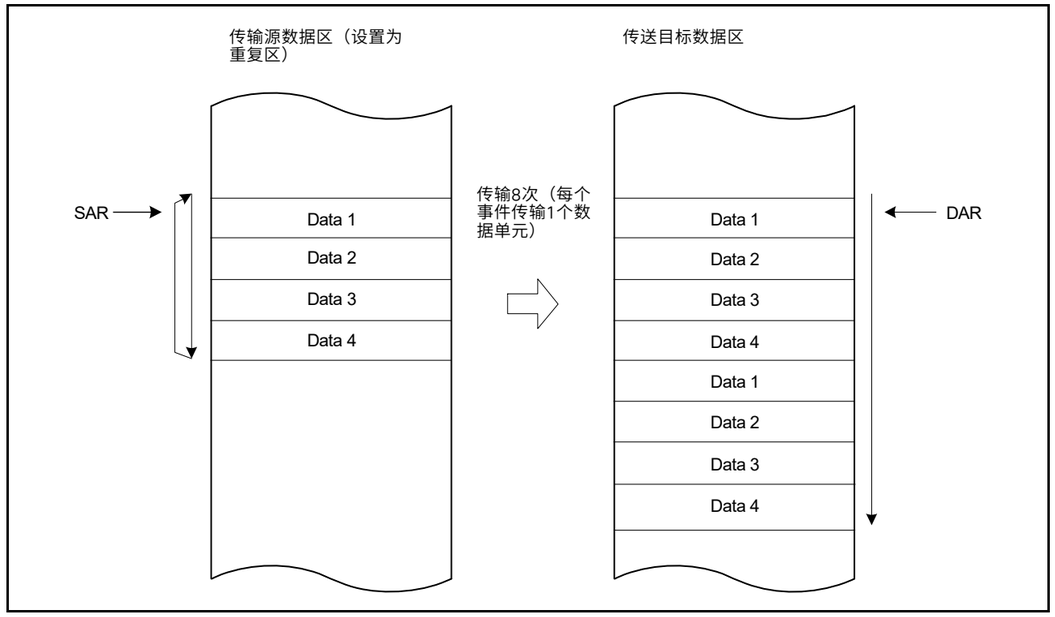


Figure 17.6 传输源为重复区域时重复传输模式的内存映射(MRA.SM[1:0]=10b MRB.DM[1:0] = 10b, CRAH = 04h)

17.4.5 块传输模式

块传输模式允许在单个激活源上进行单块数据传输。块区域的传输源或传输目标必须在MRB.DTS位中指定。块大小可以设置为1到256字节、1到256个半字（2到512字节）或1到256字（4到1024字节）。当指定块的传输完成时，块区域中指定的块大小计数器CRAL和地址寄存器（当MRB.DTS位=1时为SAR寄存器或当DTS位=0时为DAR寄存器）的初始值是恢复。另一个地址寄存器连续递增或递减或保持不变。

传输计数（块计数）可设置为1到65536。此模式允许在指定计数块传输结束时向CPU生成中断请求。

表17.7列出了块传输模式下的寄存器功能，图17.7显示了块传输模式下的存储器映射。

Table 17.7 块传输模式下的寄存器功能

Register	Description	通过写入传输信息回写的值
SAR	传输源地址	当MRB.DTS位为0时递增、递减或固定*1 当MRB.DTS位为1时SAR寄存器初始值。
DAR	转移目的地地址	当MRB.DTS位为0时DAR寄存器初始值 当MRB.DTS位为1时递增、递减或固定。*1
CRAH	保存块大小	CRAH
CRAL	块大小计数器	CRAH
CRB	块传输计数器	CRB - 1

Note 1. 在地址固定模式下会跳过回写。

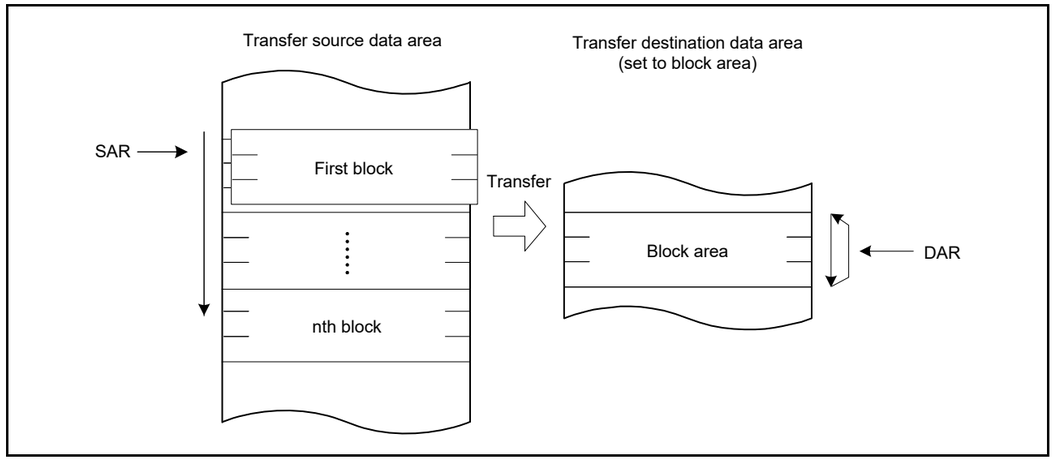


Figure 17.7 Memory map of block transfer mode

17.4.6 Chain Transfer

Setting the MRB.CHNE bit to 1 allows chain transfer to be performed continuously on a single activation source. If MRB.CHNE is set to 1 and CHNS to 0, an interrupt request to the CPU is not generated on completion of the specified number of transfer rounds or by setting the MRB.DISEL bit to 1. An interrupt request is sent to the CPU each time DTC data transfer is performed. Data transfer has no effect on the ICU.IELSRn.IR bit of the activation source.

The SAR, DAR, CRA, CRB, MRA, and MRB registers can be set independently of each other to define the data transfer. Figure 17.8 shows a chain transfer operation.

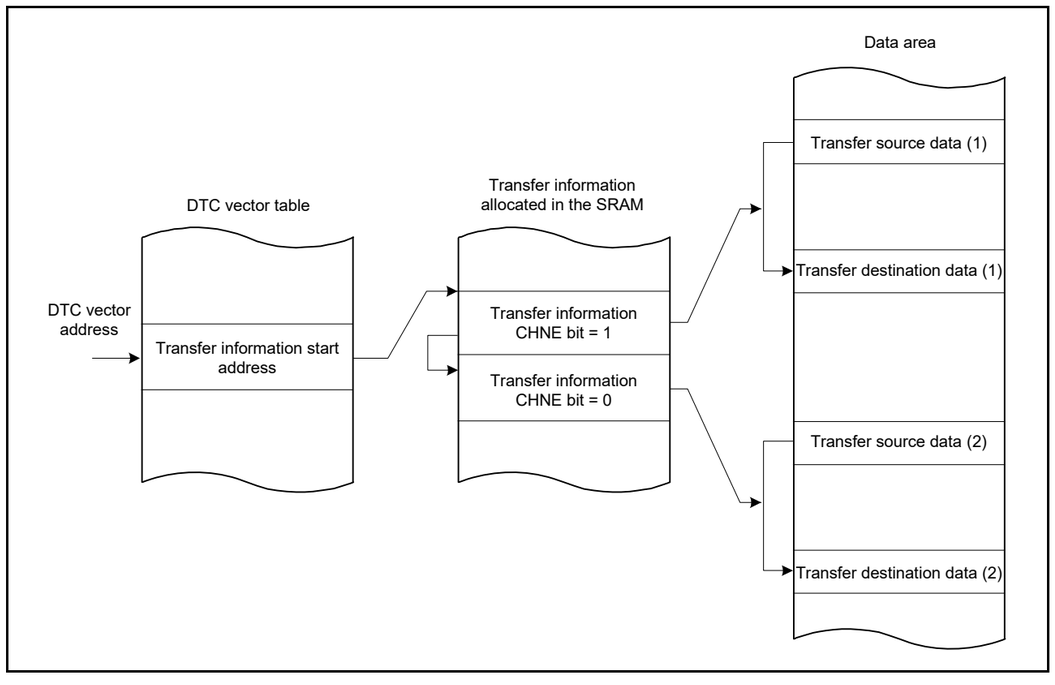


Figure 17.8 Chain transfer operation

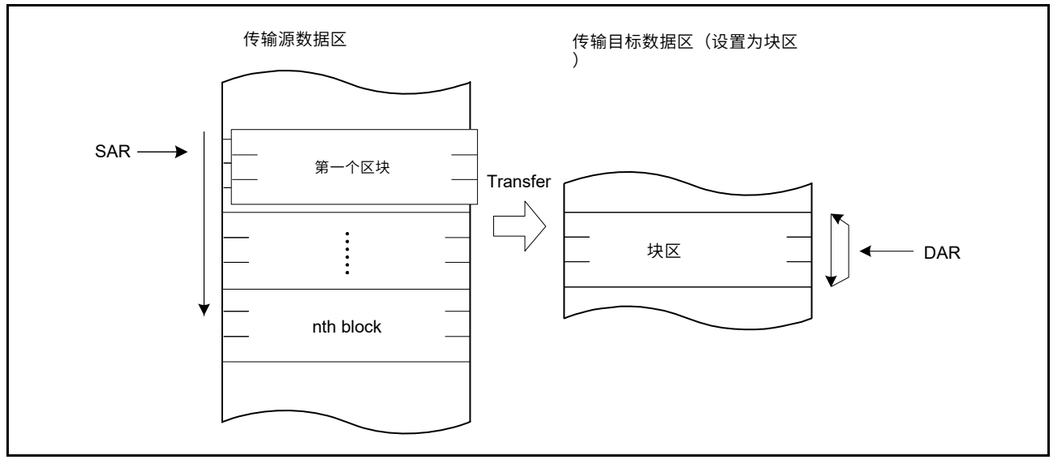


Figure 17.7 块传输模式的内存映射

17.4.6 链转移

将MRB.CHNE位设置为1允许在单个激活源上连续执行链传输。如果
MRB.CHNE设置为1，CHNS设置为0，在完成指定的传输轮数或将MRB.DISEL位设置为1时，不会向CPU产生中断请求。每次向CPU发送一个中断请求执行DTC数据传输的时间。数据传输对激活源的ICU.IELSRn.IR位没有影响。

SAR、DAR、CRA、CRB、MRA和MRB寄存器可以相互独立设置以定义数据传输。
图17.8显示了链式转移操作。

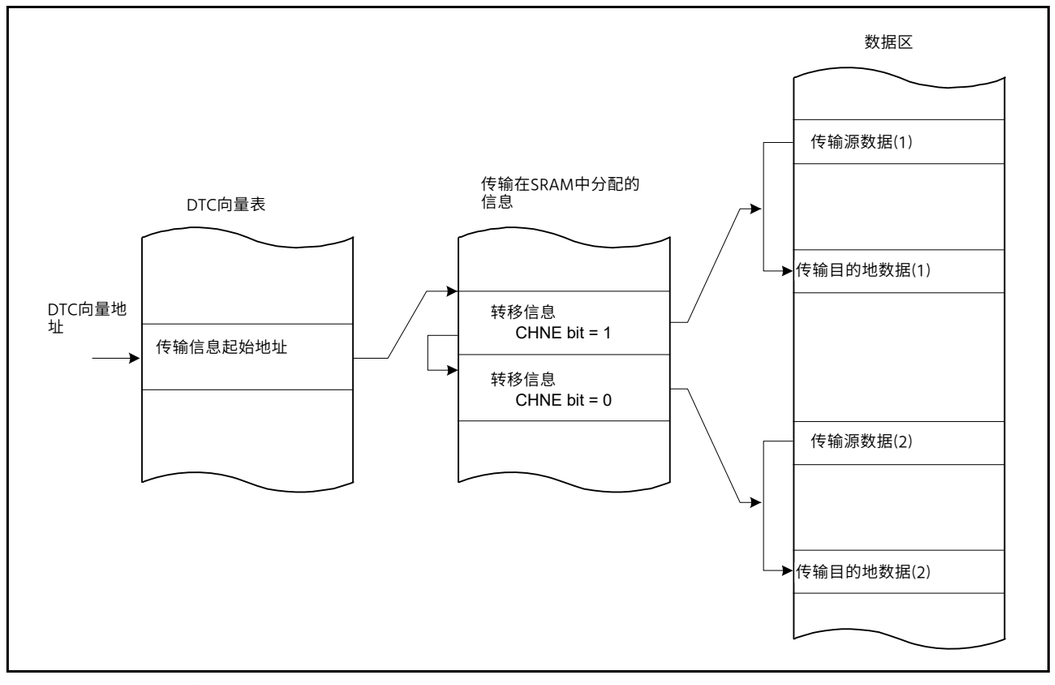


Figure 17.8 链转移操作

Writing 1 to the MRB.CHNE and CHNS bits enables chain transfer to be performed only after completion of the specified data transfer. In repeat transfer mode, chain transfer is performed after completion of the specified data transfer. For details on chain transfer conditions, see Table 17.3, Chain transfer conditions.

17.4.7 Operation Timing

Figure 17.9 to Figure 17.12 are timing diagrams that show the minimum number of execution cycles.

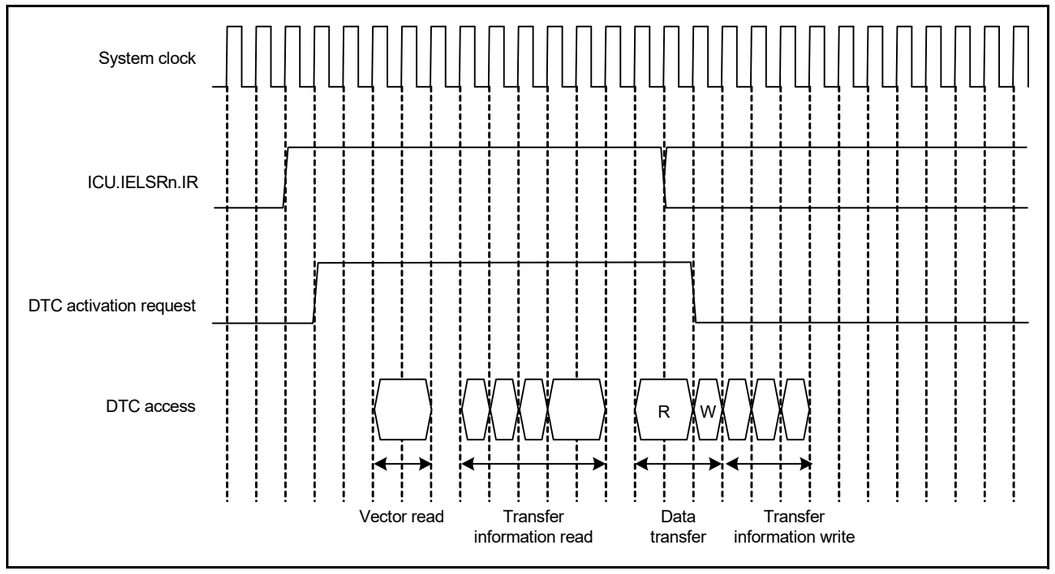


Figure 17.9 Example 1 of DTC operation timing in normal transfer and repeat transfer modes

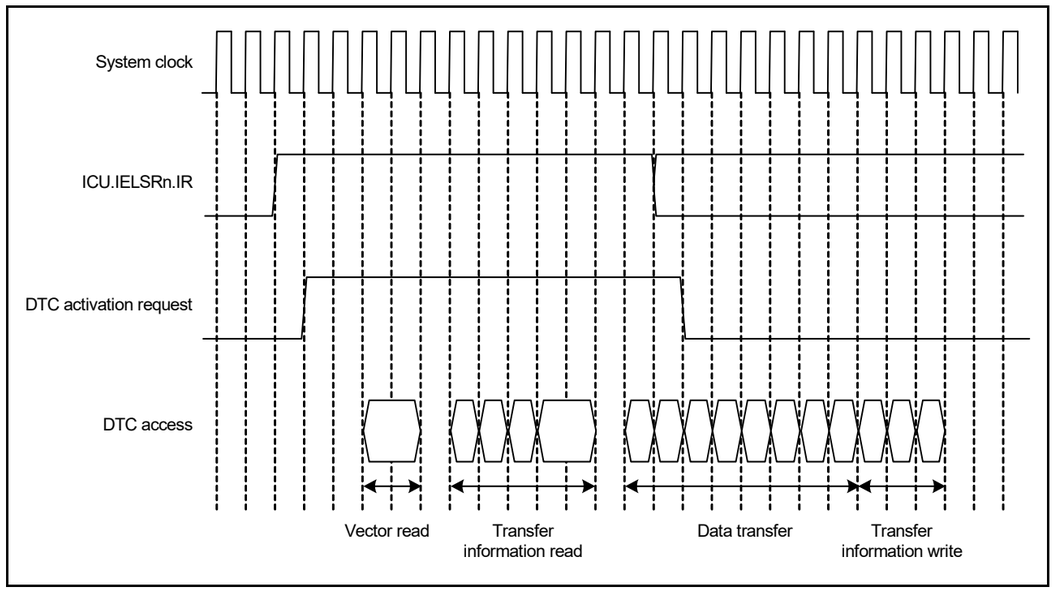


Figure 17.10 Example 2 of DTC operation timing in block transfer mode when the block size = 4

将1写入MRB.CHNE和CHNS位可以使链式传输仅在完成指定的数据传输后执行。在重复传输模式下，在完成指定的数据传输后执行链式传输。有关链转移条件的详细信息，请参见表17.3，链转移条件。

17.4.7 操作时间

图17.9至图17.12是显示最小执行周期数的时序图。

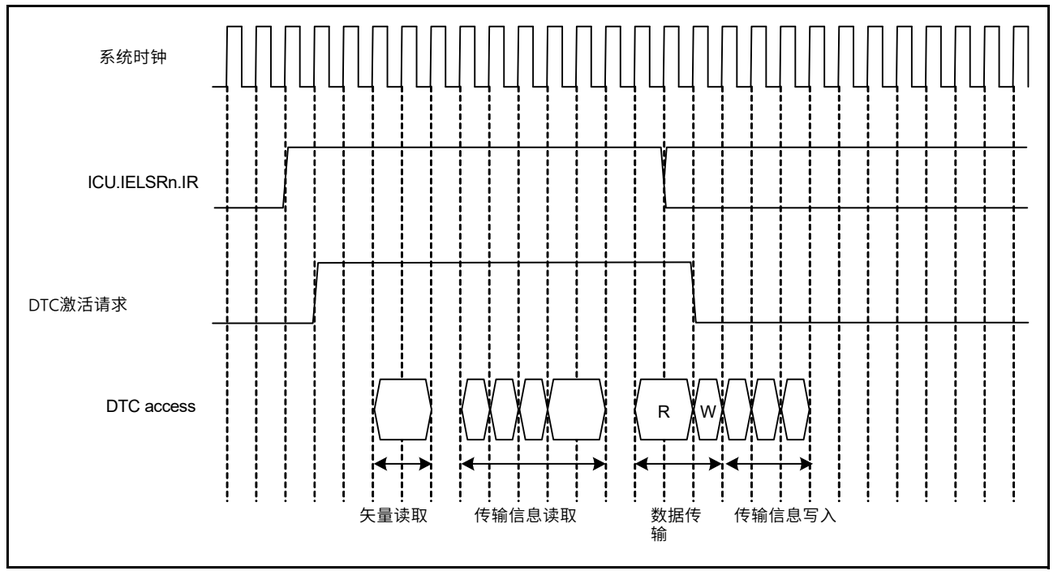


Figure 17.9 正常传输和重复传输模式下的DTC操作时序示例1

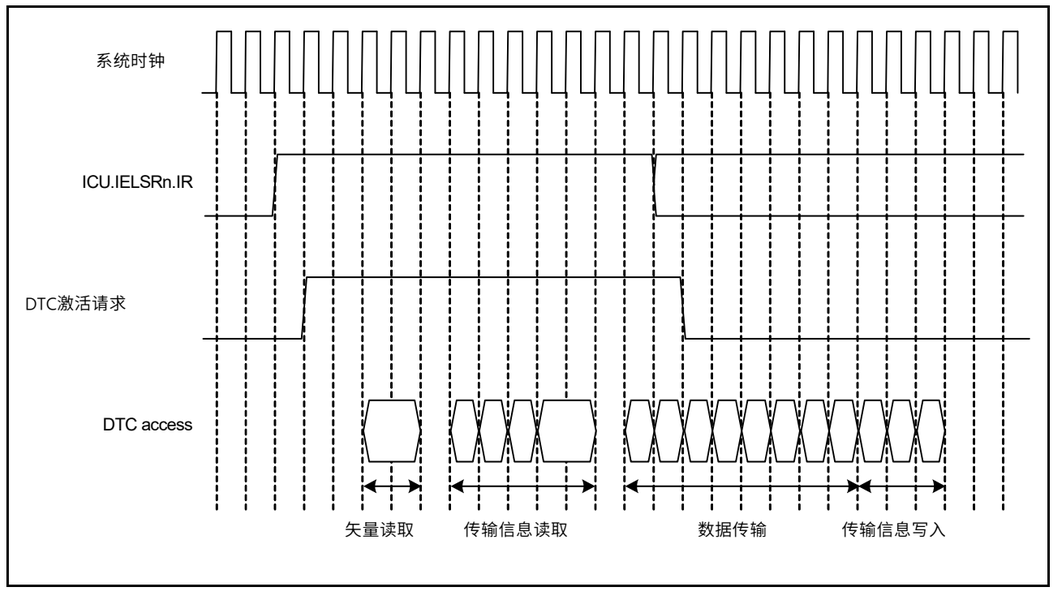


Figure 17.10 块大小=4时块传输模式下的DTC操作时序示例2

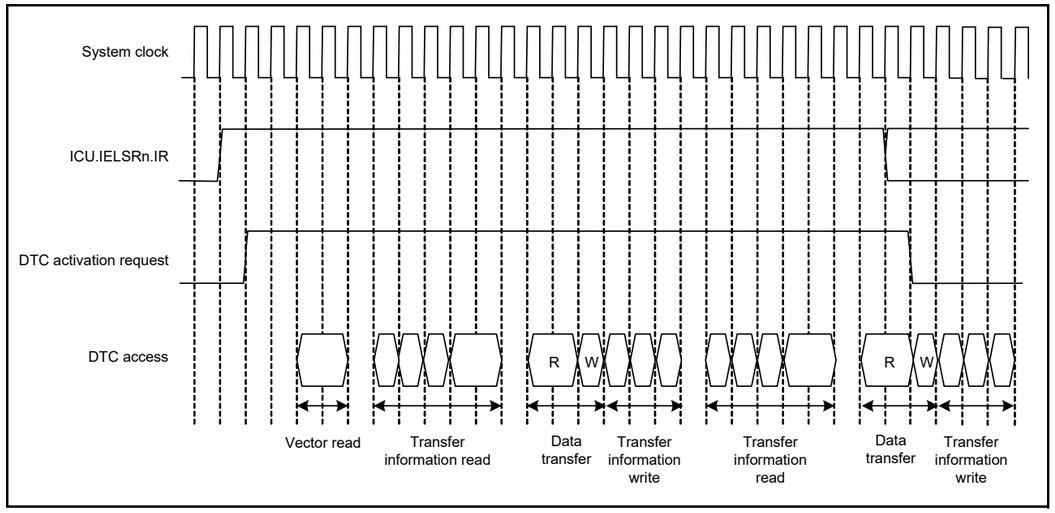
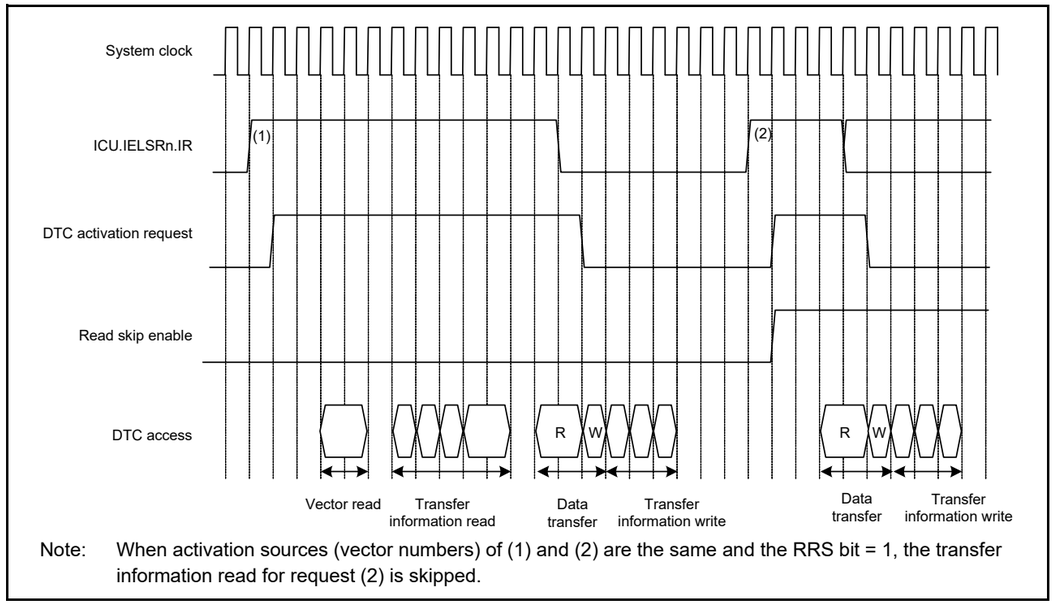


Figure 17.11 Example 3 of DTC operation timing for chain transfer



Note: When activation sources (vector numbers) of (1) and (2) are the same and the RRS bit = 1, the transfer information read for request (2) is skipped.

Figure 17.12 Example of operation when a transfer information read is skipped, with the vector, transfer information, and transfer destination data on the SRAM, and the transfer source data on the peripheral module

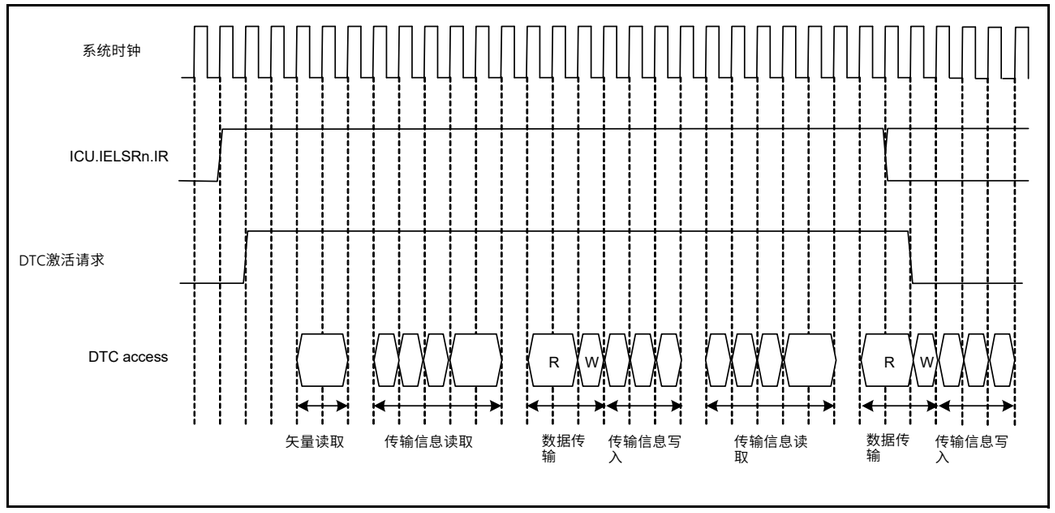
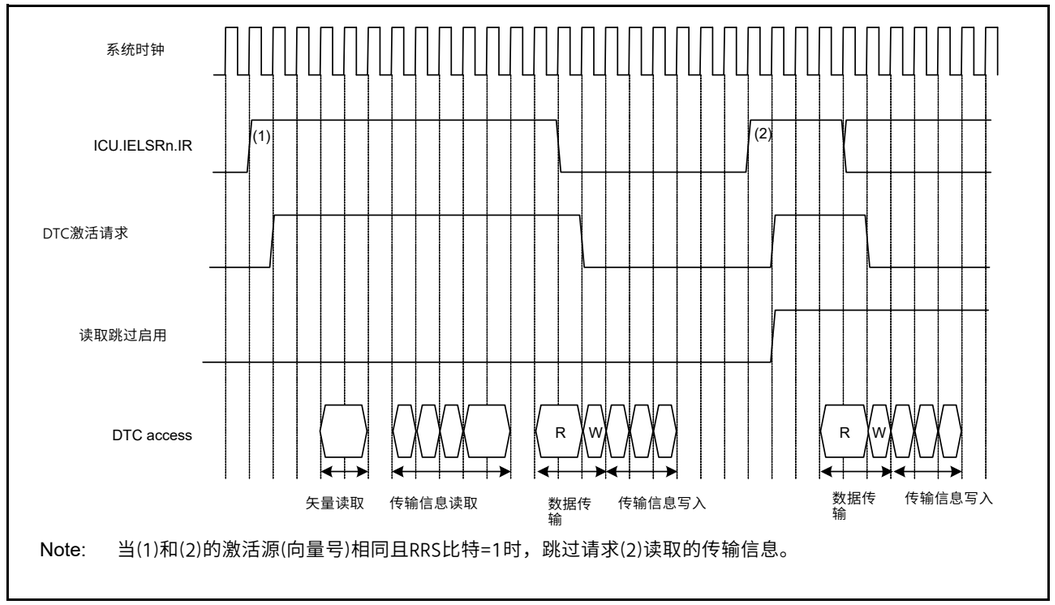


Figure 17.11 链转移的DTC操作时序示例3



Note: 当(1)和(2)的激活源(向量号)相同且RRS比特=1时，跳过请求(2)读取的传输信息。

Figure 17.12 跳过传输信息读取时的操作示例，向量、传输信息和传输目标数据位于SRAM上，传输源数据位于外围模块上

17.4.8 Execution Cycles of DTC

Table 17.8 lists the execution cycles of single data transfer of the DTC.

For the order of the execution states, see section 17.4.7, Operation Timing.

Table 17.8 Execution cycles of DTC

Transfer mode	Vector read		Transfer information read		Transfer information write			Data transfer		Internal operation	
								Read	Write		
Normal	Cv + Cs1 + 1	0*1	4 × (Ci + Cs1) + 1	0*1	3 × (Ci + Cs1) + 1*2	2 × (Ci + Cs1) + 1*3	(Ci + Cs1)*4	Cr + Cs2 + 1	Cw + Cs2 + 1	2	0*1
Repeat								Cr + Cs2 + 1	Cw + Cs2 + 1		
Block*5								P × (Cr + Cs2)	P × (Cw + Cs2)		

Note 1. When transfer information read is skipped.
Note 2. When neither SAR nor DAR is set to address-fixed mode.
Note 3. When SAR or DAR is set to address-fixed mode.
Note 4. When SAR and DAR are set to address-fixed mode.
Note 5. When the block size is 2 or more. If the block size is 1, the cycle number for normal transfer is applied.

P: Block size (initial settings of CRAH and CRAL)
Cv: Cycles for access to vector transfer information storage destination
Ci: Cycles for access to transfer information storage destination address
Cr: Cycles for access to data read destination
Cw: Cycles for access to data write destination
Cs1: When accessing SRAMHS: 2 cycles.
When accessing elsewhere: 0 cycle.
When a slave bus change by a read/write data transfer, add 1 more cycle.
Cs2: When accessing SRAMHS and peripheral modules related to system control: 2 cycles.
When accessing elsewhere: 0 cycle.
When a slave bus change by a read/write data transfer, add 1 more cycle.
The unit is system clock (ICLK) for + 1 in the Vector read, Transfer information read, and Data transfer read columns and 2 in the Internal operation column.
Cv, Ci, Cr, and Cw vary depending on the corresponding access destination. For the number of cycles for respective access destinations, see section 40, SRAM and section 41, Flash Memory.
The frequency ratio of the system clock and peripheral clock is also taken into consideration.
The DTC response time is the time from when the DTC activation source is detected until DTC transfer starts.
This table does not include the time until DTC data transfer starts after the DTC activation source becomes active.

17.4.9 DTC Bus Mastership Release Timing

The DTC does not release bus mastership during transfer information reads. Before the transfer information is read or written, the bus is arbitrated according to the priority determined by the bus master arbitrator. For bus arbitration, see section 14, Buses.

17.5 DTC Setting Procedure

Before using the DTC, set the DTC Vector Base Register (DTCVBR). Figure 17.13 shows the procedure for setting the DTC.

17.4.8 DTC的执行周期

表17.8列出了DTC单次数据传输的执行周期。

有关执行状态的顺序，请参阅第17.4.7节，操作时序。

Table 17.8 DTC的执行周期

传输模式	矢量读取		传输信息读取		传输信息写入			数据传输		内部运作	
								Read	Write		
Normal	Cv + Cs1 + 1	0*1	4 × (Ci + Cs1) + 1	0*1	3 × (Ci + Cs1) + 1*2	2 × (Ci + Cs1) + 1*3	(Ci + Cs1)*4	Cr + Cs2 + 1	Cw + Cs2 + 1	2	0*1
Repeat								Cr + Cs2 + 1	Cw + Cs2 + 1		
Block*5								P × (Cr + Cs2)	P × (Cw + Cs2)		

Note 1. 跳过传输信息读取时。
Note 2. 当SAR和DAR均未设置为地址固定模式时。
Note 3. 当SAR或DAR设置为地址固定模式时。
Note 4. 当SAR和DAR设置为地址固定模式时。
Note 5. 当块大小为2或更大时。如果块大小为1，则应用正常传输的周期数。

P：块大小（CRAH和CRAL的初始设置）
Cv：访问向量传输信息存储目标的周期Ci：访问传输信息存储目标地址的周期
Cr：访问数据读取目标的周期Cw：访问数据写入目标的周期
Cs1：访问SRAMHS时：2个周期。在别处访问时：0循环。
当从总线发生读写数据传输变化时，再增加1个周期。
Cs2：访问SRAMHS和与系统控制相关的外围模块时：2个周期。
在别处访问时：0循环。
当从总线发生读写数据传输变化时，再增加1个周期。
单位是系统时钟(ICLK)，在Vectorread、Transferinformationread和Datatransferread列中为+1，在Internaloperation列中为2。Cv、Ci、Cr和Cw根据相应的访问目的地而变化。有关各个访问目标的周期数，请参见第40节，SRAM和第41节，闪存。系统时钟和外设时钟的频率比也被考虑在内。

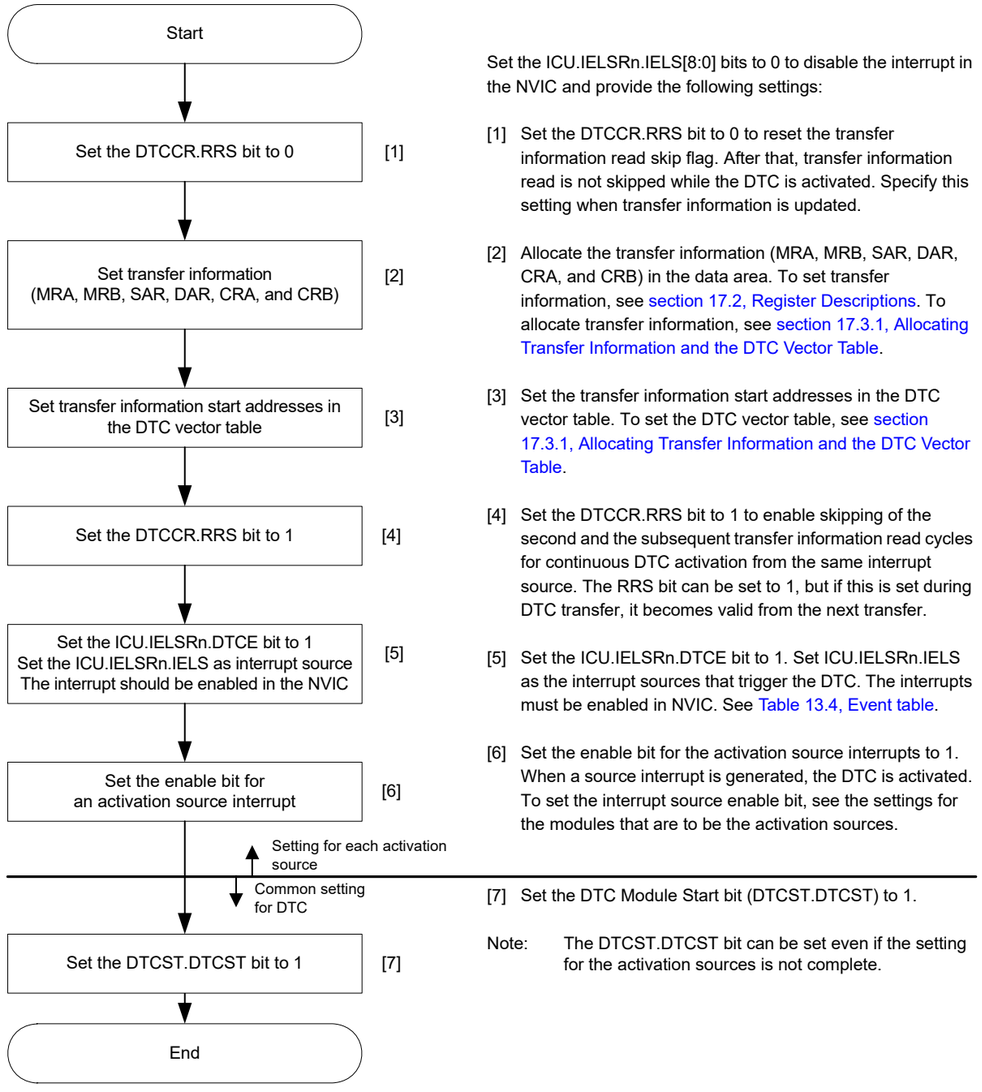
DTC响应时间是从检测到DTC激活源到DTC传输开始的时间。
此表不包括从DTC激活源激活到DTC数据传输开始的时间。

17.4.9 DTC总线主控释放时序

在传输信息读取期间，DTC不会释放总线控制权。在读取或写入传输信息之前，根据总线主仲裁器确定的优先级对总线进行仲裁。对于总线仲裁，请参见第14节，总线。

17.5 DTC设置程序

在使用DTC之前，请设置DTC向量基址寄存器(DTCVBR)。图17.13显示了设置DTC.



Set the ICU.IELSRn.IELS[8:0] bits to 0 to disable the interrupt in the NVIC and provide the following settings:

[1] Set the DTCCR.RRS bit to 0 to reset the transfer information read skip flag. After that, transfer information read is not skipped while the DTC is activated. Specify this setting when transfer information is updated.

[2] Allocate the transfer information (MRA, MRB, SAR, DAR, CRA, and CRB) in the data area. To set transfer information, see section 17.2, Register Descriptions. To allocate transfer information, see section 17.3.1, Allocating Transfer Information and the DTC Vector Table.

[3] Set the transfer information start addresses in the DTC vector table. To set the DTC vector table, see section 17.3.1, Allocating Transfer Information and the DTC Vector Table.

[4] Set the DTCCR.RRS bit to 1 to enable skipping of the second and the subsequent transfer information read cycles for continuous DTC activation from the same interrupt source. The RRS bit can be set to 1, but if this is set during DTC transfer, it becomes valid from the next transfer.

[5] Set the ICU.IELSRn.DTCE bit to 1. Set ICU.IELSRn.IELS as the interrupt sources that trigger the DTC. The interrupts must be enabled in NVIC. See Table 13.4, Event table.

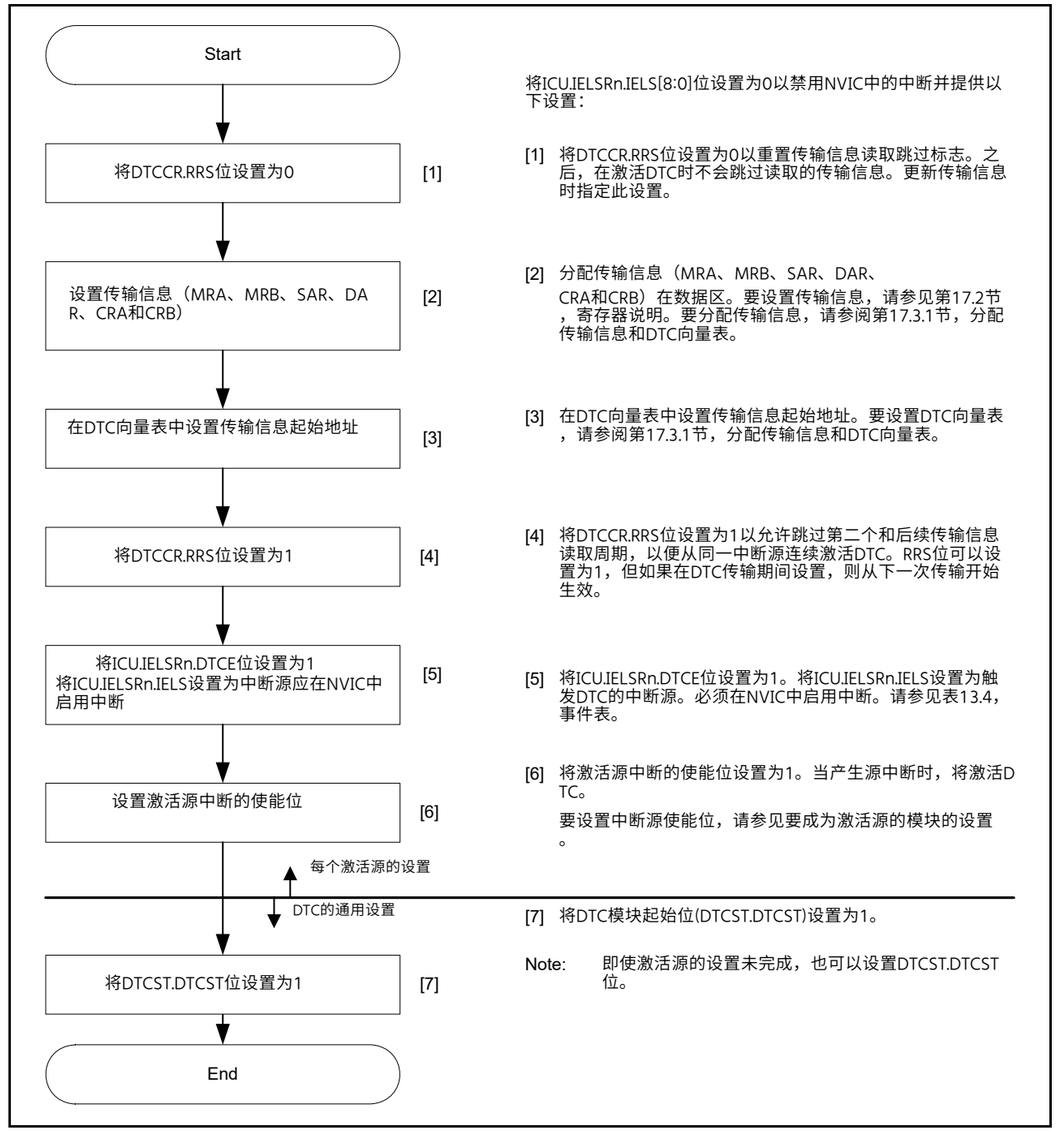
[6] Set the enable bit for the activation source interrupts to 1. When a source interrupt is generated, the DTC is activated. To set the interrupt source enable bit, see the settings for the modules that are to be the activation sources.

[7] Set the DTC Module Start bit (DTCST.DTCST) to 1.

Note: The DTCST.DTCST bit can be set even if the setting for the activation sources is not complete.

Figure 17.13 DTC setting procedure

17.6 Examples of DTC Usage



将ICU.IELSRn.IELS[8:0]位设置为0以禁用NVIC中的中断并提供以下设置：

[1] 将DTCCR.RRS位设置为0以重置传输信息读取跳过标志。之后，在激活DTC时不会跳过读取的传输信息。更新传输信息时指定此设置。

[2] 分配传输信息（MRA、MRB、SAR、DAR、CRA和CRB）在数据区。要设置传输信息，请参见第17.2节，寄存器说明。要分配传输信息，请参阅第17.3.1节，分配传输信息和DTC向量表。

[3] 在DTC向量表中设置传输信息起始地址。要设置DTC向量表，请参阅第17.3.1节，分配传输信息和DTC向量表。

[4] 将DTCCR.RRS位设置为1以允许跳过第二个和后续传输信息读取周期，以便从同一中断源连续激活DTC。RRS位可以设置为1，但如果在DTC传输期间设置，则从下一次传输开始生效。

[5] 将ICU.IELSRn.DTCE位设置为1。将ICU.IELSRn.IELS设置为触发DTC的中断源。必须在NVIC中启用中断。请参见表13.4，事件表。

[6] 将激活源中断的使能位设置为1。当产生源中断时，将激活DTC。
要设置中断源使能位，请参见要成为激活源的模块的设置。

[7] 将DTC模块起始位(DTCST.DTCST)设置为1。

Note: 即使激活源的设置未完成，也可以设置DTCST.DTCST位。

Figure 17.13 DTC设置程序

17.6 DTC使用示例

RA生态工作室

17.6.1 Normal Transfer

This section provides an example of DTC usage and its application when receiving 128 bytes of data from an SCI.

(1) Transfer information settings

In the MRA register, select a fixed source address (MRA.SM[1:0] = 00b), normal transfer mode (MRA.MD[1:0] = 00b), and byte-sized transfer (MRA.SZ[1:0] = 00b). In the MRB register, specify incrementation of the destination address (MRB.DM[1:0] = 10b) and single data transfer by a single interrupt (MRB.CHNE = 0 and MRB.DISEL = 0). The MRB.DTS bit can be set to any value. Set the RDR register address of the SCI in the SAR register, the start address of the SRAM area for data storage in the DAR register, and 128 (0080h) in the CRA register. The CRB register can be set to any value.

(2) DTC vector table settings

The start address of the transfer information for the RXI interrupt is set in the vector table for the DTC.

(3) ICU settings and DTC module activation

Set the ICU.IELSRn.DTCE bit to 1 and set ICU.IELSRn.IELS as the SCI interrupt. The interrupt must be enabled in the NVIC. Set the DTCST.DTCST bit to 1.

(4) SCI settings

Enable the RXI interrupt by setting the SCR.RIE bit in the SCI to 1. If a reception error occurs during the SCI receive operation, reception stops. To manage this, use settings that allow the CPU to accept receive error interrupts.

(5) DTC transfer

Each time a reception of 1 byte by the SCI is complete, an RXI interrupt is generated to activate the DTC. The DTC transfers the received byte from the RDR of the SCI to the SRAM, after which the DAR register is incremented and the CRA register is decremented.

(6) Interrupt handling

After 128 rounds of data transfer are complete and the value in the CRA register becomes 0, an RXI interrupt request is generated for the CPU. Complete the process in the handling routine for this interrupt.

17.6.2 Chain Transfer

This section provides an example of chain transfer by the DTC and describes its use in the output of pulses by the General PWM Timer (GPT). You can use chain transfer to transfer PWM timer compare data and change the period of the PWM timer for GPT.

For the first of the chain transfers, normal transfer mode is specified for transfer to the GPT32m.GTCCRC register (m = EH0 to EH3, E4 to E7, 8 to 12). For the second transfer, normal transfer mode is specified for transfer to the GPT32m.GTCCRE register. For the third transfer, normal transfer mode is specified for transfer to the GPT32m.GTPBR register. This is because clearing of the activation source and generation of an interrupt on completion of the specified number of transfers are restricted to the third of the chain transfers, that is, transfer while MRB.CHNE = 0.

The following example shows how to use the counter overflow interrupt with a GPT32EH0.GTPR register as an activating source for the DTC.

(1) First transfer information settings

Set up transfer to the GPT32EH0.GTCCRC register:

1. In the MRA register, select incrementation of the source address (MRA.SM[1:0] = 10b).
2. Set the transfer to normal transfer mode (MRA.MD[1:0] = 00b) and word-sized transfer (MRA.SZ[1:0] = 10b).
3. In the MRB register, select the destination address as fixed (MRB.DM[1:0] = 00b) and set up chain transfer (MRB.CHNE = 1 and MRB.CHNS = 0).
4. Set the SAR register to the first address of the data table.
5. Set the DAR register to the address of the GPT32EH0.GTCCRC register.

17.6.1 正常转移

本节提供从SCI接收128字节数据时的DTC用法及其应用示例。

(1) 传输信息设置

在MRA寄存器中，选择固定源地址（MRA.SM[1:0]=00b）、正常传输模式（MRA.MD[1:0]=00b）和字节大小传输（MRA.SZ[1:0]=00b)。在MRB寄存器中，指定目标地址的递增(MRB.DM[1:0]=10b)和单个中断的单个数据传输(MRB.CHNE=0和MRB.DISEL=0)。MRB.DTS位可以设置为任何值。在SAR寄存器中设置SCI的RDR寄存器地址，在DAR寄存器中设置用于数据存储的SRAM区域的起始地址，在CRA寄存器中设置128（0080h）。CRB寄存器可以设置为任何值。

(2) DTC向量表设置

RXI中断的传输信息的起始地址在DTC的向量表中设置。

(3) ICU设置和DTC模块激活

将ICU.IELSRn.DTCE位设置为1，并将ICU.IELSRn.IELS设置为SCI中断。中断必须在启用
英伟达。将DTCST.DTCST位设置为1。

(4) SCI设置

通过将SCI中的SCR.RIE位设置为1来启用RXI中断。如果在SCI接收操作期间发生接收错误，则接收停止。要管理此问题，请使用允许CPU接受接收错误中断的设置。

(5) DTC transfer

每次SCI完成1个字节的接收，就会产生一个RXI中断来激活DTC。DTC将接收到的字节从SCI的RDR传输到SRAM，之后DAR寄存器递增，CRA寄存器递减。

(6) 中断处理

在128轮数据传输完成后，CRA寄存器中的值变为0，产生一个RXI中断请求给CPU。完成该中断处理程序中的处理。

17.6.2 链转移

本节提供了DTC链传输的示例，并描述了其在DTC输出脉冲中的使用
通用PWM定时器(GPT)。您可以使用链传输来传输PWM定时器比较数据并更改GPT的PWM定时器的周期。

对于第一个链传输，指定正常传输模式以传输到GPT32m.GTCCRC寄存器（m=EH0到EH3，E4到E7，8到12）。对于第二次传输，指定正常传输模式用于传输到
GPT32m.GTCCRE寄存器。对于第三次传输，指定正常传输模式以传输到GPT32m.GTPBR寄存器。这是因为在完成指定数量的传输时清除激活源和产生中断仅限于链传输的第三个，即在MRB.CHNE=0时传输。

以下示例显示如何使用带有GPT32EH0.GTPR寄存器的计数器溢出中断作为DTC的激活源。

(1) 首次转账信息设置

设置传输到GPT32EH0.GTCCRC寄存器：

1. 在MRA寄存器中，选择源地址的递增(MRA.SM[1:0]=10b)。
2. 将传输设置为正常传输模式(MRA.MD[1:0]=00b)和字大小传输(MRA.SZ[1:0]=10b)。
3. 在MRB寄存器中，选择固定的目标地址（MRB.DM[1:0]=00b）并设置链式传输（MRB.CHNE=1和MRB.CHNS=0）。
4. 将SAR寄存器设置为数据表的首地址。
5. 将DAR寄存器设置为GPT32EH0.GTCCRC寄存器的地址。

6. Set the CRAH and CRAL registers to the size of the data table. The CRB register can be set to any value.

(2) Second transfer information settings

Set up transfer to the GPT32EH0.GTCCRE register:

1. In the MRA register, select incrementation of the source address (MRA.SM[1:0] = 10b).
2. Set the transfer to normal transfer mode (MRA.MD[1:0] = 00b) and word-sized transfer (MRA.SZ[1:0] = 10b).
3. In the MRB register, select the destination address as fixed (MRB.DM[1:0] = 00b) and set up chain transfer (MRB.CHNE = 1 and MRB.CHNS = 0).
4. Set the SAR register to the first address of the data table.
5. Set the DAR register to the address of the GPT32EH0.GTCCRE register.
6. Set the CRAH and CRAL registers to the size of the data table. The CRB register can be set to any value.

(3) Third transfer information settings

Set up transfer to the GPT32EH0.GTPBR register:

1. In the MRA register, select incrementation of the source address (MRA.SM[1:0] = 10b).
2. Set the transfer to normal transfer mode (MRA.MD[1:0] = 00b) and word-sized transfer (MRA.SZ[1:0] = 10b).
3. In the MRB register, select the destination address as fixed (MRB.DM[1:0] = 00b) and set up single data transfer per interrupt (MRB.CHNE = 0, MRB.DISEL = 0). The MRB.DTS bit can be set to any value.
4. Set the SAR register to the first address of the data table.
5. Set the DAR register to the address of the GPT32EH0.GTPBR register.
6. Set the CRA register to the size of the data table. The CRB register can be set to any value.

(4) Transfer information assignment

Place the transfer information for use in the transfer to GPT32EH0.GTPBR immediately after the transfer control information for use in the GPT32EH0.GTCCRC and GPT32EH0.GTCCRE registers.

(5) DTC vector table

In the DTC vector table, set the address where the transfer control information for use in transfer to the GPT32EH0.GTCCRC and GPT32EH0.GTCCRE registers starts.

(6) ICU setting and DTC module activation

1. Set the ICU.IELSRn.DTCE bit associated with the GPT32EH0 counter overflow interrupt.
2. Set the ICU.IELSRn.IELS[8:0] bits to 182 (B6h) for the GPT32EH0 counter overflow.
3. Set the DTCST.DTCST bit to 1.

(7) GPT settings

1. Set the GPT32EH0.GTIOR register so that the GTCCRA and GTCCRB registers operate as output compare registers.
2. Set the default PWM timer compare values in the GPT32EH0.GTCCRA and GPT32EH0.GTCCRB registers and the next PWM timer compare values in the GPT32EH0.GTCCRC and GPT32EH0.GTCCRE registers.
3. Set the default PWM timer period values in the GPT32EH0.GTPR register and the next PWM timer period values in the GPT32EH0.GTPBR register.
4. Set 1 to the output bit in PmnPFS.PDR, and set 00011b to the Peripheral Select bits in PmnPFS.PSEL[4:0].

(8) GPT activation

Set the GPT32EH0.GTSTR.CSTRT bits to 1 to start the GPT32EH0.GTCNT counter.

6. 将CRAH和CRAL寄存器设置为数据表的大小。CRB寄存器可以设置为任何值。

(2) 二转信息设置

设置传输到GPT32EH0.GTCCRE寄存器：

1. 在MRA寄存器中，选择源地址的递增(MRA.SM[1:0]=10b)。
2. 将传输设置为正常传输模式(MRA.MD[1:0]=00b)和字大小传输(MRA.SZ[1:0]=10b)。
3. 在MRB寄存器中，选择固定的目标地址（MRB.DM[1:0]=00b）并设置链式传输（MRB.CHNE=1和MRB.CHNS=0）。
4. 将SAR寄存器设置为数据表的首地址。
5. 将DAR寄存器设置为GPT32EH0.GTCCRE寄存器的地址。
6. 将CRAH和CRAL寄存器设置为数据表的大小。CRB寄存器可以设置为任何值。

(3) 第三次转账信息设置

设置传输到GPT32EH0.GTPBR寄存器：

1. 在MRA寄存器中，选择源地址的递增(MRA.SM[1:0]=10b)。
2. 将传输设置为正常传输模式(MRA.MD[1:0]=00b)和字大小传输(MRA.SZ[1:0]=10b)。
3. 在MRB寄存器中，选择固定的目标地址（MRB.DM[1:0]=00b）并设置每次中断的单次数据传输（MRB.CHNE=0，MRB.DISEL=0）。MRB.DTS位可以设置为任何值。
4. 将SAR寄存器设置为数据表的首地址。
5. 将DAR寄存器设置为GPT32EH0.GTPBR寄存器的地址。
6. 将CRA寄存器设置为数据表的大小。CRB寄存器可以设置为任何值。

(4) 转移信息分配

将用于传输到GPT32EH0.GTPBR的传输信息放置在GPT32EH0.GTCCRC和GPT32EH0.GTCCRE寄存器中使用的传输控制信息之后。

(5) DTC向量表

在DTC向量表中，设置传输控制信息的地址，用于传输到GPT32EH0.GTCCRC和GPT32EH0.GTCCRE寄存器启动。

(6) ICU设置和DTC模块激活

1. 设置与GPT32EH0计数器溢出中断相关的ICU.IELSRn.DTCE位。
2. 将ICU.IELSRn.IELS[8:0]位设置为182(B6h)以用于GPT32EH0计数器溢出。
3. 将DTCST.DTCST位设置为1。

(7) GPT settings

1. 设置GPT32EH0.GTIOR寄存器，使GTCCRA和GTCCRB寄存器作为输出比较寄存器运行。
2. 在GPT32EH0.GTCCRA和GPT32EH0.GTCCRB寄存器中设置默认PWM定时器比较值，在GPT32EH0.GTCCRC和GPT32EH0.GTCCRE寄存器中设置下一个PWM定时器比较值。
3. 在GPT32EH0.GTPR寄存器中设置默认PWM定时器周期值，在GPT32EH0.GTPBR寄存器中设置下一个PWM定时器周期值。
4. 将PmnPFS.PDR中的输出位设置为1，并将PmnPFS.PSEL[4:0]中的外设选择位设置为00011b。

(8) GPT activation

将GPT32EH0.GTSTR.CSTRT位设置为1以启动GPT32EH0.GTCNT计数器。

(9) DTC transfer

Each time a GPT32EH0 counter overflow is generated with the GPT32EH0.GTPR register, the next PWM timer compare values are transferred to the GPT32EH0.GTCCRC and GPT32EH0.GTCCRE registers. The setting for the next PWM timer period is transferred to the GPT32EH0.GTPBR register.

(10) Interrupt handling

After the specified rounds of data transfer are complete, for example when the value in the CRA register for GPT transfer becomes 0, a GPT counter overflow interrupt request is issued for the CPU. Complete the process for this interrupt in the handling routine.

17.6.3 Chain Transfer when Counter = 0

The second data transfer is performed only when the transfer counter is set to 0 in the first data transfer, and the first data transfer information is repeatedly changed in the second transfer. Chain transfer enables transfers to be repeated 256 times or more.

The following procedure shows an example of configuring a 128-KB input buffer, where the input buffer is set so that its lower address starts with 0000h. Figure 17.14 shows a chain transfer when the counter = 0.

1. Set the normal transfer mode to input data for the first data transfer. Set the following:
   a. Transfer source address = fixed.
   b. CRA register = 0000h (65536) times.
   c. MRB.CHNE bit = 1 (chain transfer is enabled).
   d. MRB.CHNS bit = 1 (chain transfer is performed only when the transfer counter is 0).
   e. MRB.DISEL bit = 0 (an interrupt request to the CPU is generated when the specified data transfer completes).
2. Prepare the upper 8-bit address of the start address at every 65536 times of the transfer destination address for the first data transfer in different area such as the flash. For example, when setting the input buffer to 20 0000h to 21 FFFFh, prepare 21h and 20h.
3. For the second data transfer:
   a. Set the repeat transfer mode (with the source as the repeat area) to reset the transfer destination address of the first data transfer.
   b. Specify the upper 8 bits of the DAR register in the first transfer information area for the transfer destination.
   c. Set the MRB.CHNE bit = 0 (chain transfer is disabled).
   d. Set the MRB.DISEL bit = 0 (an interrupt request to the CPU is generated when the specified data transfer completes).
   e. When setting the input buffer to 20 0000h to 21 FFFFh, also set the transfer counter to 2.
4. The first data transfer is performed by an interrupt 65536 times. When the transfer counter of the first data transfer becomes 0, the second data transfer starts. Set the upper 8 bits of the transfer destination address of the first data transfer to 21h. The lower 16 bits of the transfer destination address and the transfer counter of the first data transfer becomes 0000h.
5. In succession, the first data transfer is performed by an interrupt 65536 times as specified for the first data transfer. When the transfer counter of the first data transfer becomes 0, the second data transfer starts. Set the upper 8 bits of the transfer destination address of the first data transfer to 20h. The lower 16 bits of the transfer destination address and the transfer counter of the first data transfer becomes 0000h.
6. Steps 4 and 5 are repeated indefinitely. Because the second data transfer is in repeat transfer mode, no interrupt request to the CPU is generated.

(9) DTC transfer

每次使用GPT32EH0.GTPR寄存器产生GPT32EH0计数器溢出时，下一个PWM定时器比较值被传送到GPT32EH0.GTCCRC和GPT32EH0.GTCCRE寄存器。下一个PWM定时器周期的设置被传送到GPT32EH0.GTPBR寄存器。

(10)中断处理

在指定轮次的数据传输完成后，例如当GPT传输的CRA寄存器中的值变为0时，会向CPU发出GPT计数器溢出中断请求。在处理例程中完成该中断的处理。

17.6.3 Counter=0时的链式转移

仅当在第一次数据传输中将传输计数器设置为0时才执行第二次数据传输，并且在第二次传输中重复改变第一数据传输信息。链式转移使转移可以重复256次或更多。

以下过程显示了配置128KB输入缓冲区的示例，其中输入缓冲区设置为使其低地址以0000h开头。图17.14显示了当计数器=0时的链式传输。

1. 将正常传输模式设置为第一次数据传输的输入数据。设置以下内容：
   一个。传输源地址=固定。
   湾。CRA寄存器=0000h(65536)次。
   C。MRB.CHNE位=1（启用链式传输）。
   d。MRB.CHNS位=1（仅当传输计数器为0时才执行链式传输）。
   e.MRB.DISEL位=0（指定数据传输完成时向CPU产生中断请求）。
2. 在flash等不同区域的第一次数据传输时，每65536次传输目标地址准备起始地址的高8位地址。例如，将输入缓冲区设置为200000h到21FFFFh时，准备21h和20h。
3. 对于第二次数据传输：
   一个。设置重复传输模式（以源为重复区域）重置第一次数据传输的传输目标地址。
   湾。在传输目标的第一个传输信息区域中指定DAR寄存器的高8位。
   C。设置MRB.CHNE位=0（禁用链传输）。
   d。设置MRB.DISEL位=0（当指定的数据传输完成时向CPU产生一个中断请求）。
   e.将输入缓冲区设置为200000h至21FFFFh时，还要将传输计数器设置为2。
4. 第一次数据传输由中断执行65536次。当第一次数据传输的传输计数器变为0时，第二次数据传输开始。将第一次数据传输的传输目标地址的高8位设置为21h。第一次数据传输的传输目标地址和传输计数器的低16位变为0000h。
5. 随后，第一次数据传输由中断执行65536次，如为第一次数据传输指定的那样。当第一次数据传输的传输计数器变为0时，第二次数据传输开始。将第一次数据传输的传输目标地址的高8位设置为20h。第一次数据传输的传输目标地址和传输计数器的低16位变为0000h。
6. 步骤4和5无限重复。因为第二次数据传输是重复传输模式，所以不会产生对CPU的中断请求。

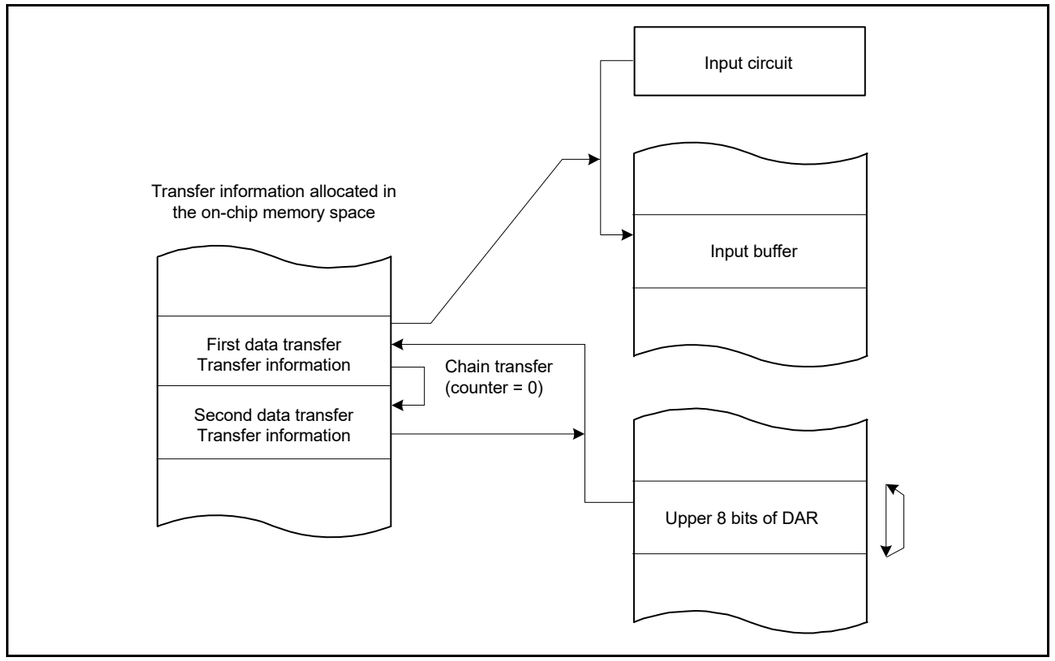


Figure 17.14 Chain transfer when counter = 0

17.7 Interrupt Sources

When the DTC completes data transfer of the specified count or when data transfer with MRB.DISEL set to 1 is complete, a DTC activation source generates an interrupt to the CPU. Interrupts to the CPU are controlled according to the settings in the NVIC and ICU.IELSRn.IELS[8:0] bits. See section 13, Interrupt Controller Unit (ICU).

The DTC prioritizes activation sources by granting the smaller interrupt vector numbers higher priority. The priority of interrupts to the CPU is determined by the NVIC priority.

17.8 Event Link

The DTC can produce an event link request on completion of one transfer request.

17.9 Snooze Control Interface

To return to Software Standby mode from Snooze mode through the DTC, set SYSTEM.SNZEDCR.DTCZRED or SYSTEM.SNZEDCR.DTCNZRED to 1. See section 11.8.3, Returning to Software Standby Mode.

SYSTEM.SNZEDCR.DTCZRED enables or disables a snooze end request on completion of the last DTC transmission, detected on DTC transmission completion when CRA and CRB are 0.

SYSTEM.SNZEDCR.DTCNZRED enables or disables a snooze end request on a not last DTC transmission completion (CRA and CRB are not 0), detected on DTC transmission completion when CRA and CRB are not 0.

17.10 Module-Stop Function

Before transitioning to the module-stop function, Software Standby mode without a Snooze mode transition, or Deep Software Standby mode, set the DTCST.DTCST bit to 0, then perform the operations described in the following sections. The DTC is available in Snooze mode by setting LPW.SNZCR.SNZDTCEN to 1. See section 11, Low Power Modes.

(1) Module-stop function

Writing 1 to the MSTPCRA.MSTPA22 bit enables the module-stop function of the DTC. If the DTC transfer is in progress at the time 1 is written to the MSTPCRA.MSTPA22 bit, the transition to the module-stop state proceeds after

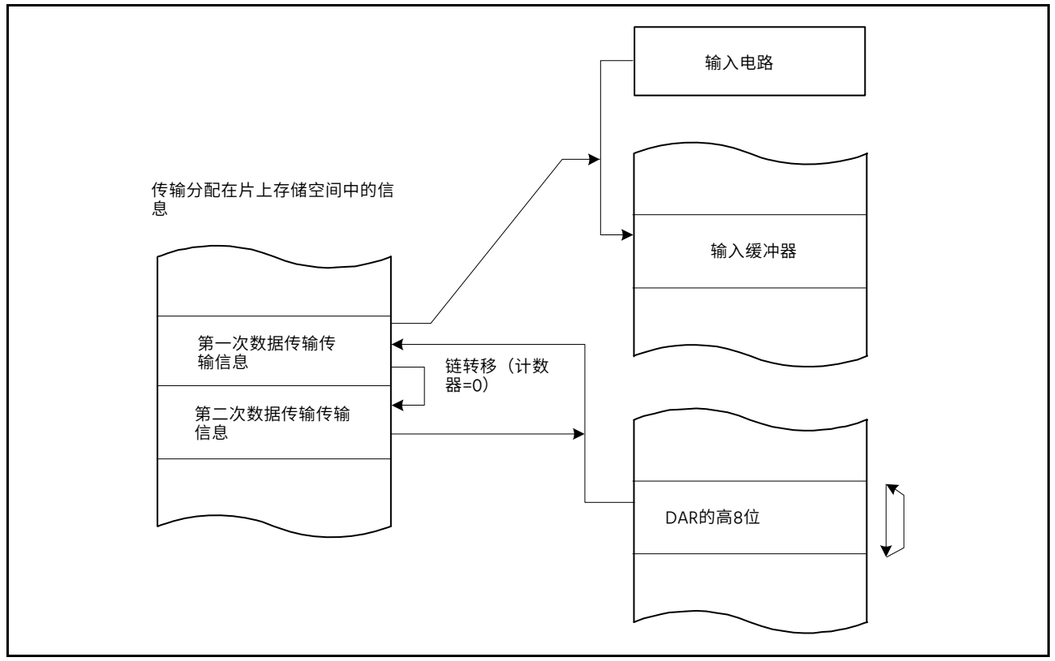


Figure 17.14 counter=0时的链转移

17.7 中断源

当DTC完成指定计数的数据传输或MRB.DISEL设置为1的数据传输完成时，DTC激活源向CPU生成中断。CPU的中断根据NVIC和ICU.IELSRn.IELS[8:0]位中的设置进行控制。请参阅第13节，中断控制器单元(ICU)。

DTC通过授予较小的中断向量编号较高的优先级来确定激活源的优先级。CPU中断的优先级由NVIC优先级决定。

17.8 活动链接

DTC可以在一个传输请求完成时产生一个事件链接请求。

17.9 贪睡控制界面

要通过DTC从贪睡模式返回到软件待机模式，请设置SYSTEM.SNZEDCR.DTCZRED或SYSTEM.SNZEDCR.DTCNZRED为1。请参阅第11.8.3节，返回到软件待机模式。

SYSTEM.SNZEDCR.DTCZRED在最后一次DTC传输完成时启用或禁用贪睡结束请求，当CRA和CRB为0时在DTC传输完成时检测到。

SYSTEM.SNZEDCR.DTCNZRED在非最后一次DTC传输完成（CRA和CRB不为0）时启用或禁用贪睡结束请求，当CRA和CRB不为0时在DTC传输完成时检测到。

17.10 Module-Stop Function

在转换到模块停止功能、没有贪睡模式转换的软件待机模式或深度软件待机模式之前，将DTCST.DTCST位设置为0，然后执行以下部分中描述的操作。

通过将LPW.SNZCR.SNZDTCEN设置为1，可以在贪睡模式下使用DTC。请参阅第11节，低功耗模式。

(1) Module-stop function

向MSTPCRA.MSTPA22位写入1可启用DTC的模块停止功能。如果在将1写入MSTPCRA.MSTPA22位时DTC传输正在进行，则在

DTC transfer ends. When the MSTPCRA.MSTPA22 bit is 1, accessing the DTC registers is prohibited. Writing 0 to the MSTPCRA.MSTPA22 bit releases the DTC from the module-stop state.

(2) Software Standby and Deep Software Standby modes

Use the settings described in section 11.7.1, Transitioning to Software Standby Mode, or section 11.9.1, Transitioning to Deep Software Standby Mode.

If DTC transfer operations are in progress when the WFI instruction is executed, the transition to Software Standby mode or Deep Software Standby mode follows the completion of the DTC transfer.

When the snooze control circuit receives a snooze request in Software Standby mode, the MCU transfers to Snooze mode. See section 11.8.1, Transitioning to Snooze Mode. DTC operation in Snooze mode can be selected in the SYSTEM.SNZCR.SNZDTCEN bit. If DTC operation is enabled in Snooze mode, before transitioning to Software Standby mode, set the DTCST.DTCST bit to 1. To return to Software Standby mode through the DTC, set SYSTEM.SNZEDCR.DTCZRED or SYSTEM.SNZEDCR.DTCNZRED to 1. See section 11.8.3, Returning to Software Standby Mode. The DTC activation request from the ICU is stopped during Software Standby mode but not during Snooze mode.

(3) Notes on the module-stop function

For the WFI instruction and the register setting procedure, see section 11, Low Power Modes.

To perform a DTC transfer after returning from a low power mode without a Snooze mode transition, set the DTCST.DTCST bit to 1 again.

To use a request that is generated in Software Standby mode as an interrupt request to the CPU but not as a DTC activation request, specify the CPU as the interrupt request destination as described in section 13.4.2, Selecting Interrupt Request Destinations, then execute a WFI instruction. If DTC operation is enabled in Snooze mode, do not use the module-stop function of the DTC.

17.11 Usage Notes

17.11.1 Transfer Information Start Address

You must set multiples of 4 for the transfer information start addresses in the vector table. Otherwise, such addresses are accessed with their lowest 2 bits regarded as 00b.

DTC传输结束。当MSTPCRA.MSTPA22位为1时，禁止访问DTC寄存器。将0写入MSTPCRA.MSTPA22位从模块停止状态释放DTC。

(2) 软件待机和深度软件待机模式

使用第11.7.1节，转换到软件待机模式或第11.9.1节，转换到深度软件待机模式。

如果在执行WFI指令时DTC传输操作正在进行，则在DTC传输完成后转换到软件待机模式或深度软件待机模式。

当贪睡控制电路在软件待机模式下接收到贪睡请求时，MCU转入贪睡模式。请参阅第11.8.1节，转换到贪睡模式。可以在SYSTEM.SNZCR.SNZDTCEN位中选择贪睡模式下的DTC操作。如果在贪睡模式下启用了DTC操作，则在转换到软件之前

待机模式，将DTCST.DTCST位设置为1。要通过DTC返回软件待机模式，请设置SYSTEM.SNZEDCR.DTCZRED或SYSTEM.SNZEDCR.DTCNZRED为1。请参阅第11.8.3节，返回软件待机模式。来自ICU的DTC激活请求在软件待机模式期间停止，但在贪睡模式。

(3) 关于模块停止功能的注意事项

关于WFI指令和寄存器设置过程，请参见第11节，低功耗模式。

要在从低功耗模式返回后执行DTC传输而不进行贪睡模式转换，请将DTCST.DTCST位再次为1。

要将在软件待机模式下生成的请求用作对CPU的中断请求但不用作DTC激活请求，请按照第13.4.2节"选择中断请求目标"中的说明将CPU指定为中断请求目标，然后执行WFI指令。如果在贪睡模式下启用DTC操作，请勿使用DTC的模块停止功能。

17.11 使用说明

17.11.1 传输信息起始地址

您必须为向量表中的传输信息起始地址设置4的倍数。否则，这些地址的最低2位被视为00b。

18. Event Link Controller (ELC)

18.1 Overview

The Event Link Controller (ELC) uses the event requests generated by various peripheral modules as source signals to connect them to different modules, allowing direct link between the modules without CPU intervention.

Table 18.1 lists the ELC specifications and Figure 18.1 shows a block diagram.

Table 18.1 ELC specifications

Parameter	Specifications
Event link function	229 types of event signals can be directly connected to modules. The ELC can generate an ELC event signal, and events that activate the DTC.
Module-stop function	Module-stop state can be set

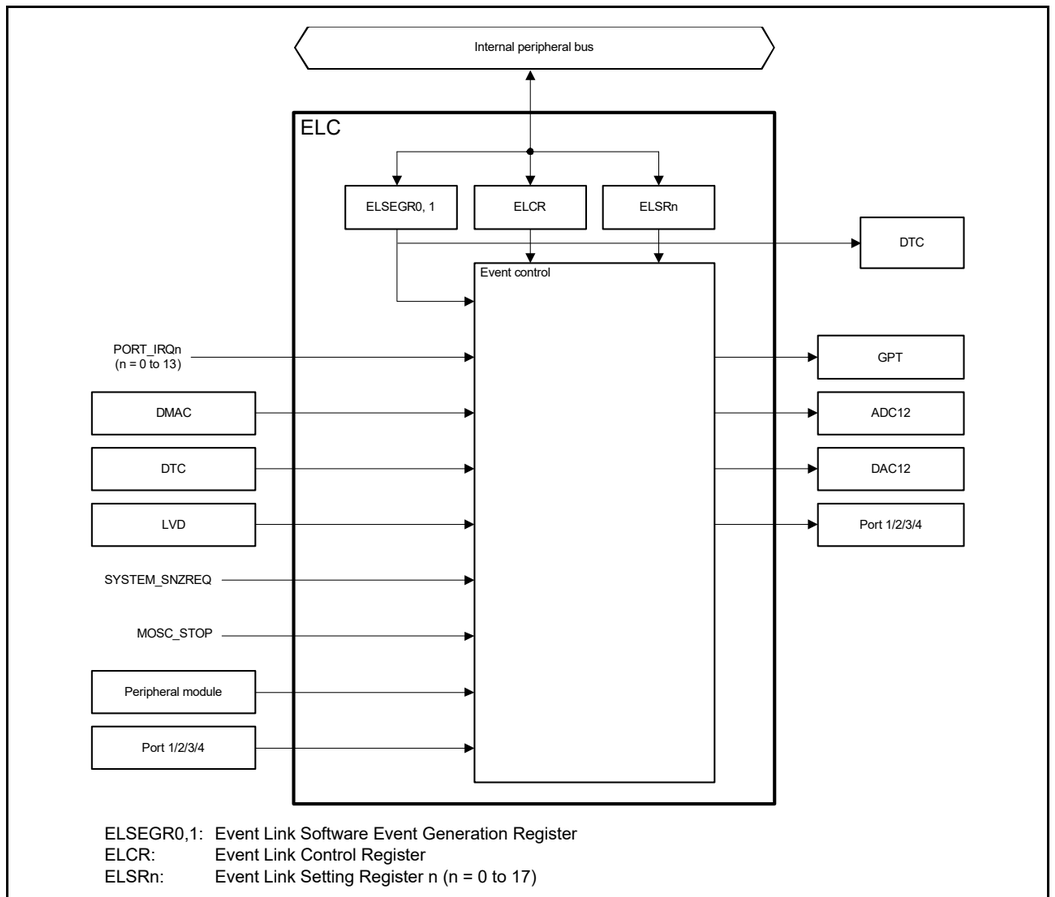


Figure 18.1 ELC block diagram

18. 事件链接控制器(ELC)

18.1 Overview

EventLinkController(ELC)使用各种外围模块产生的事件请求作为源信号，将它们连接到不同的模块，允许模块之间直接链接，无需CPU干预。

表18.1列出了ELC规范，图18.1显示了框图。

Table 18.1 ELC specifications

Parameter	Specifications
事件链接功能	229种事件信号可以直接连接到模块。ELC可以生成ELC事件信号和激活DTC的事件。
Module-stop function	模块停止状态可设置

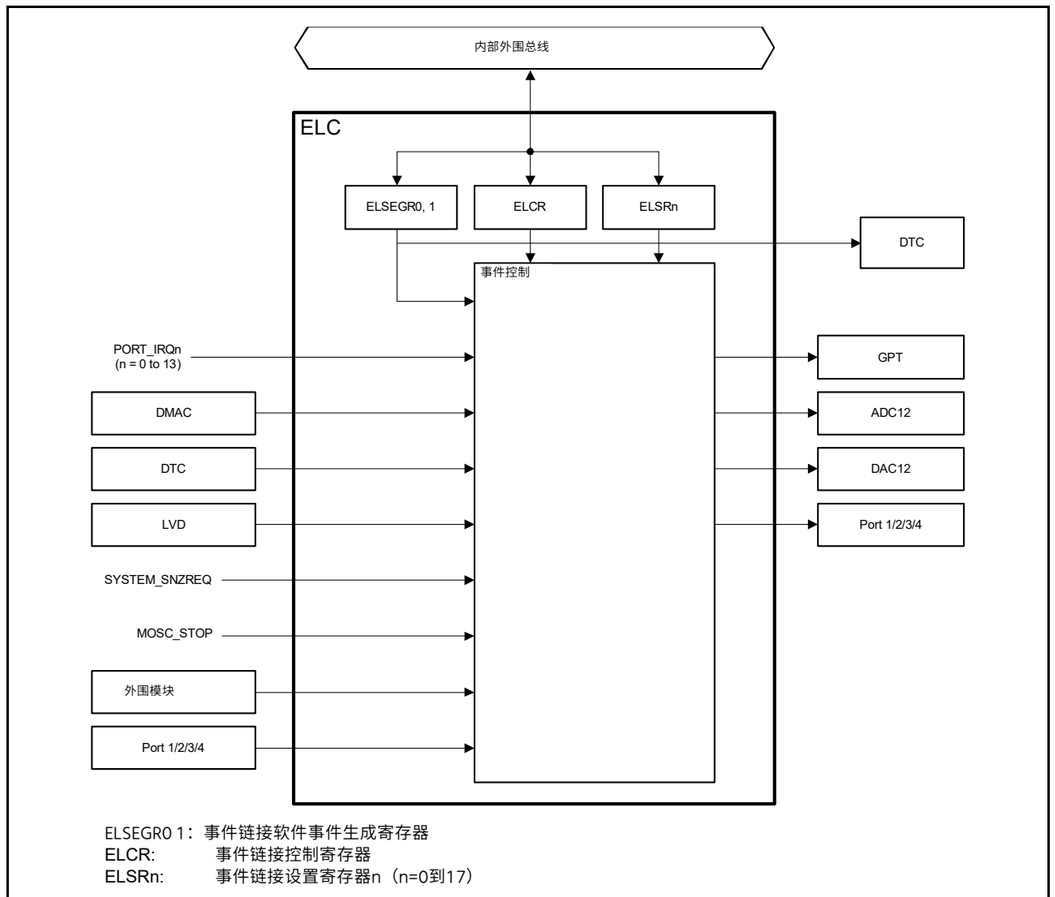


Figure 18.1 ELC框图

18.2 Register Descriptions

18.2.1 Event Link Controller Register (ELCR)

Address(es): ELC.ELCR 4004 1000h

	b7	b6	b5	b4	b3	b2	b1	b0
	ELCON	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b6 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	ELCON	All Event Link Enable	0: ELC function disabled 1: ELC function enabled.	R/W

The ELCR register controls the ELC operation.

18.2.2 Event Link Software Event Generation Register n (ELSEGRn) (n = 0, 1)

Address(es): ELC.ELSEGR0 4004 1002h, ELC.ELSEGR1 4004 1004h

	b7	b6	b5	b4	b3	b2	b1	b0
	WI	WE	—	—	—	—	—	SEG
Value after reset:	1	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SEG	Software Event Generation	0: Normal operation 1: Software event is generated.	W
b5 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	WE	SEG Bit Write Enable	0: Writes to SEG bit disabled 1: Writes to SEG bit enabled.	R/W
b7	WI	ELSEGR Register Write Disable	0: Writes to ELSEGR register enabled 1: Writes to ELSEGR register disabled.	W

SEG bit (Software Event Generation)

When 1 is written to the SEG bit while the WE bit is 1, a software event is generated. This bit is read as 0. Even when 1 is written to this bit, data is not stored. The WE bit must be set to 1 before writing to this bit.

A software event can trigger a linked DTC event.

WE bit (SEG Bit Write Enable)

The SEG bit can only be written to when the WE bit is 1. Clear the WI bit to 0 before writing to this bit.

[Setting condition]

- If 1 is written to this bit while the WI bit is 0, this bit becomes 1.

[Clearing condition]

- If 0 is written to this bit while the WI bit is 0, this bit becomes 0.

WI bit (ELSEGR Register Write Disable)

The ELSEGR register can only be written to when the write value to the WI bit is 0. This bit is read as 1. Before setting the WE or SEG bit, the WI bit must be set to 0.

18.2 注册说明

18.2.1 事件链接控制器寄存器(ELCR)

Address(es): ELC.ELCR 4004 1000h

	b7	b6	b5	b4	b3	b2	b1	b0
	ELCON	—	—	—	—	—	—	—
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b6 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	ELCON	所有事件链接启用	0：ELC功能禁用1：ELC 功能启用。	R/W

ELCR寄存器控制ELC操作。

18.2.2 事件链接软件事件生成寄存器n(ELSEGRn)(n=0 1)

Address(es): ELC.ELSEGR0 4004 1002h, ELC.ELSEGR1 4004 1004h

	b7	b6	b5	b4	b3	b2	b1	b0
	WI	WE	—	—	—	—	—	SEG
重置后的值：	1	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SEG	软件事件生成	0：正常操作1：产生软件事件 。	W
b5 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	WE	SEG位写使能	0：禁止写入SEG位1：允许 写入SEG位。	R/W
b7	WI	ELSEGR寄存器写入禁用	0：允许写入ELSEGR寄存器1：禁止写 入ELSEGR寄存器。	W

SEG位（软件事件生成）

当WE位为1时向SEG位写入1时，将产生软件事件。该位被读取为0。即使向该位写入1，也不存储数据。在写入该位之前，WE位必须设置为1。

软件事件可以触发链接的DTC事件。

WE位（SEG位写使能）

SEG位只能在WE位为1时写入。在写入该位之前将WI位清零。

[Setting condition]

- 如果在WI位为0时向该位写入1，则该位变为1。

[Clearing condition]

- 如果在WI位为0时向该位写入0，则该位变为0。

WI位（ELSEGR寄存器写禁止）

只有当WI位的写入值为0时，才能写入ELSEGR寄存器。该位读为1。在设置WE或SEG位之前，必须将WI位设置为0。

18.2.3 Event Link Setting Register n (ELSRn) (n = 0 to 17)

Address(es): ELC.ELSR0 4004 1010h, ELC.ELSR1 4004 1014h, ELC.ELSR2 4004 1018h, ELC.ELSR3 4004 101Ch, ELC.ELSR4 4004 1020h, ELC.ELSR5 4004 1024h, ELC.ELSR6 4004 1028h, ELC.ELSR7 4004 102Ch, ELC.ELSR8 4004 1030h, ELC.ELSR9 4004 1034h, ELC.ELSR10 4004 1038h, ELC.ELSR11 4004 103Ch, ELC.ELSR12 4004 1040h, ELC.ELSR13 4004 1044h, ELC.ELSR14 4004 1048h, ELC.ELSR15 4004 104Ch, ELC.ELSR16 4004 1050h, ELC.ELSR17 4004 1054h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	ELS[8:0]								
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b8 to b0	ELS[8:0]	Event Link Select	b8 b0 000000000: Event output disabled for the associated peripheral module 000000001 to 111000101b: Number setting for the event signal to be linked. Other settings are prohibited.	R/W
b15 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The ELSRn register specifies an event signal to be linked to each peripheral module. Table 18.2 shows the association between the ELSRn registers and the peripheral modules. Table 18.3 shows the association between the event signal names set in the ELSRn registers and the signal numbers.

Table 18.2 Association between the ELSRn registers and peripheral functions

Register name	Peripheral function (module)	Event name
ELSR0	GPT (A)	ELC_GPTA
ELSR1	GPT (B)	ELC_GPTB
ELSR2	GPT (C)	ELC_GPTC
ELSR3	GPT (D)	ELC_GPTD
ELSR4	GPT (E)	ELC_GPTE
ELSR5	GPT (F)	ELC_GPTF
ELSR6	GPT (G)	ELC_GPTG
ELSR7	GPT (H)	ELC_GPTH
ELSR8	ADC12A0	ELC_AD00
ELSR9	ADC12B0	ELC_AD01
ELSR10	ADC12A1	ELC_AD10
ELSR11	ADC12B1	ELC_AD11
ELSR12	DAC12 channel 0	ELC_DA0
ELSR13	DAC12 channel 1	ELC_DA1
ELSR14	PORT 1	ELC_PORT1
ELSR15	PORT 2	ELC_PORT2
ELSR16	PORT 3	ELC_PORT3
ELSR17	PORT 4	ELC_PORT4

18.2.3 事件链接设置寄存器n(ELSRn)(n=0到17)

Address(es): ELC.ELSR0 4004 1010h, ELC.ELSR1 4004 1014h, ELC.ELSR2 4004 1018h, ELC.ELSR3 4004 101Ch, ELC.ELSR4 4004 1020h, ELC.ELSR5 4004 1024h, ELC.ELSR6 4004 1028h, ELC.ELSR7 4004 102Ch, ELC.ELSR8 4004 1030h, ELC.ELSR9 4004 1034h, ELC.ELSR10 4004 1038h, ELC.ELSR11 4004 103Ch, ELC.ELSR12 4004 1040h, ELC.ELSR13 4004 1044h, ELC.ELSR14 4004 1048h, ELC.ELSR15 4004 104Ch, ELC.ELSR16 4004 1050h, ELC.ELSR17 4004 1054h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	ELS[8:0]								
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b8 to b0	ELS[8:0]	活动链接选择	b8b0000000000：相关外围模块的事件输出禁用000000001至111000101b：要链接的事件信号的编号设置。禁止其他设置。	R/W
b15 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ELSRn寄存器指定要链接到每个外围模块的事件信号。表18.2显示了ELSRn寄存器和外设模块之间的关联。表18.3显示了在ELSRn寄存器中设置的事件信号名称和信号编号之间的关联。

Table 18.2 ELSRn寄存器和外设功能之间的关联

注册名称	外设功能（模块）	活动名称
ELSR0	GPT (A)	ELC_GPTA
ELSR1	GPT (B)	ELC_GPTB
ELSR2	GPT (C)	ELC_GPTC
ELSR3	GPT (D)	ELC_GPTD
ELSR4	GPT (E)	ELC_GPTE
ELSR5	GPT (F)	ELC_GPTF
ELSR6	GPT (G)	ELC_GPTG
ELSR7	GPT (H)	ELC_GPTH
ELSR8	ADC12A0	ELC_AD00
ELSR9	ADC12B0	ELC_AD01
ELSR10	ADC12A1	ELC_AD10
ELSR11	ADC12B1	ELC_AD11
ELSR12	DAC12 channel 0	ELC_DA0
ELSR13	DAC12 channel 1	ELC_DA1
ELSR14	PORT 1	ELC_PORT1
ELSR15	PORT 2	ELC_PORT2
ELSR16	PORT 3	ELC_PORT3
ELSR17	PORT 4	ELC_PORT4

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Table 18.3 Association between event signal names set in ELSRn.ELS[8:0] bits and signal numbers (1 of 6)

Event number	Interrupt request source	Name	Description
001h	Port	PORT_IRQ0*1	External pin interrupt 0
002h		PORT_IRQ1*1	External pin interrupt 1
003h		PORT_IRQ2*1	External pin interrupt 2
004h		PORT_IRQ3*1	External pin interrupt 3
005h		PORT_IRQ4*1	External pin interrupt 4
006h		PORT_IRQ5*1	External pin interrupt 5
007h		PORT_IRQ6*1	External pin interrupt 6
008h		PORT_IRQ7*1	External pin interrupt 7
009h		PORT_IRQ8*1	External pin interrupt 8
00Ah		PORT_IRQ9*1	External pin interrupt 9
00Bh		PORT_IRQ10*1	External pin interrupt 10
00Ch		PORT_IRQ11*1	External pin interrupt 11
00Dh		PORT_IRQ12*1	External pin interrupt 12
00Eh		PORT_IRQ13*1	External pin interrupt 13
020h	DMAC0	DMAC0_INT	DMAC transfer end 0
021h	DMAC1	DMAC1_INT	DMAC transfer end 1
022h	DMAC2	DMAC2_INT	DMAC transfer end 2
023h	DMAC3	DMAC3_INT	DMAC transfer end 3
024h	DMAC4	DMAC4_INT	DMAC transfer end 4
025h	DMAC5	DMAC5_INT	DMAC transfer end 5
026h	DMAC6	DMAC6_INT	DMAC transfer end 6
027h	DMAC7	DMAC7_INT	DMAC transfer end 7
02Ah	DTC	DTC_DTCEND*3	DTC transfer end
038h	LVD	LVD_LVD1	Voltage monitor 1 interrupt
039h		LVD_LVD2	Voltage monitor 2 interrupt
03Bh	MOSC	MOSC_STOP	Main clock oscillation stop
03Ch	Low power mode	SYSTEM_SNZREQ*2, *3	Snooze entry
040h	AGT0	AGT0_AGTI	AGT interrupt
041h		AGT0_AGTCMAI	Compare match A
042h		AGT0_AGTCMBI	Compare match B
043h	AGT1	AGT1_AGTI	AGT interrupt
044h		AGT1_AGTCMAI	Compare match A
045h		AGT1_AGTCMBI	Compare match B
046h	IWDT	IWDT_NMIUNDF	IWDT underflow
047h	WDT	WDT_NMIUNDF	WDT underflow
04Bh	ADC120	ADC120_ADI	A/D scan end interrupt
04Fh		ADC120_WCMPM*3	Compare match
050h		ADC120_WCMPUM*3	Compare mismatch
051h	ADC121	ADC121_ADI	A/D scan end interrupt
055h		ADC121_WCMPM*3	Compare match
056h		ADC121_WCMPUM*3	Compare mismatch

Table 18.3 在ELSRn.ELS[8:0]位中设置的事件信号名称与信号编号之间的关联（1of6）

事件编号	中断请求源	Name	Description
001h	Port	PORT_IRQ0*1	外部引脚中断0
002h		PORT_IRQ1*1	外部引脚中断1
003h		PORT_IRQ2*1	外部引脚中断2
004h		PORT_IRQ3*1	外部引脚中断3
005h		PORT_IRQ4*1	外部引脚中断4
006h		PORT_IRQ5*1	外部引脚中断5
007h		PORT_IRQ6*1	外部引脚中断6
008h		PORT_IRQ7*1	外部引脚中断7
009h		PORT_IRQ8*1	外部引脚中断8
00Ah		PORT_IRQ9*1	外部引脚中断9
00Bh		PORT_IRQ10*1	外部引脚中断10
00Ch		PORT_IRQ11*1	外部引脚中断11
00Dh		PORT_IRQ12*1	外部引脚中断12
00Eh		PORT_IRQ13*1	外部引脚中断13
020h	DMAC0	DMAC0_INT	DMAC传输结束0
021h	DMAC1	DMAC1_INT	DMAC传输结束1
022h	DMAC2	DMAC2_INT	DMAC传输结束2
023h	DMAC3	DMAC3_INT	DMAC传输结束3
024h	DMAC4	DMAC4_INT	DMAC传输结束4
025h	DMAC5	DMAC5_INT	DMAC传输结束5
026h	DMAC6	DMAC6_INT	DMAC传输结束6
027h	DMAC7	DMAC7_INT	DMAC传输结束7
02Ah	DTC	DTC_DTCEND*3	DTC传输结束
038h	LVD	LVD_LVD1	电压监视器1中断
039h		LVD_LVD2	电压监视器2中断
03Bh	MOSC	MOSC_STOP	主时钟振荡停止
03Ch	低功耗模式	SYSTEM_SNZREQ*2, *3	贪睡进入
040h	AGT0	AGT0_AGTI	AGT interrupt
041h		AGT0_AGTCMAI	比较匹配A
042h		AGT0_AGTCMBI	比较匹配B
043h	AGT1	AGT1_AGTI	AGT interrupt
044h		AGT1_AGTCMAI	比较匹配A
045h		AGT1_AGTCMBI	比较匹配B
046h	IWDT	IWDT_NMIUNDF	IWDT underflow
047h	WDT	WDT_NMIUNDF	WDT underflow
04Bh	ADC120	ADC120_ADI	AD扫描结束中断
04Fh		ADC120_WCMPM*3	比较匹配
050h		ADC120_WCMPUM*3	比较不匹配
051h	ADC121	ADC121_ADI	AD扫描结束中断
055h		ADC121_WCMPM*3	比较匹配
056h		ADC121_WCMPUM*3	比较不匹配

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Table 18.3 Association between event signal names set in ELSRn.ELS[8:0] bits and signal numbers (2 of 6)

Event number	Interrupt request source	Name	Description
057h	ACMPHS	ACMP_HS0*1	High-Speed Analog Comparator interrupt 0
058h		ACMP_HS1*1	High-Speed Analog Comparator interrupt 1
059h		ACMP_HS2*1	High-Speed Analog Comparator interrupt 2
05Ah		ACMP_HS3*1	High-Speed Analog Comparator interrupt 3
05Bh		ACMP_HS4*1	High-Speed Analog Comparator interrupt 4
05Ch		ACMP_HS5*1	High-Speed Analog Comparator interrupt 5
063h	IIC0	IIC0_RXI	Receive data full
064h		IIC0_TXI	Transmit data empty
065h		IIC0_TEI	Transmit end
066h		IIC0_EEI	Transfer error
068h	IIC1	IIC1_RXI	Receive data full
069h		IIC1_TXI	Transmit data empty
06Ah		IIC1_TEI	Transmit end
06Bh		IIC1_EEI	Transfer error
086h	DOC	DOC_DOPCI*3	Data Operation Circuit interrupt
094h	I/O port	IOPORT_GROUP1	Port 1 event
095h		IOPORT_GROUP2	Port 2 event
096h		IOPORT_GROUP3	Port 3 event
097h		IOPORT_GROUP4	Port 4 event
098h	ELC	ELC_SWEVT0	Software event 0
099h		ELC_SWEVT1	Software event 1
0B0h	GPT32EH0	GPT0_CCMPA	Compare match A
0B1h		GPT0_CCMPB	Compare match B
0B2h		GPT0_CMPC	Compare match C
0B3h		GPT0_CMPD	Compare match D
0B4h		GPT0_CMPE	Compare match E
0B5h		GPT0_CMPF	Compare match F
0B6h		GPT0_OVF	Overflow
0B7h		GPT0_UDF	Underflow
0B8h		GPT0_ADTRGA	A/D converter start request A
0B9h		GPT0_ADTRGB	A/D converter start request B
0BAh	GPT32EH1	GPT1_CCMPA	Compare match A
0BBh		GPT1_CCMPB	Compare match B
0BCh		GPT1_CMPC	Compare match C
0BDh		GPT1_CMPD	Compare match D
0BEh		GPT1_CMPE	Compare match E
0BFh		GPT1_CMPF	Compare match F
0C0h		GPT1_OVF	Overflow
0C1h		GPT1_UDF	Underflow
0C2h		GPT1_ADTRGA	A/D converter start request A
0C3h		GPT1_ADTRGB	A/D converter start request B

Table 18.3 在ELSRn.ELS[8:0]位中设置的事件信号名称和信号编号之间的关联（6个中的2个）

事件编号	中断请求源	Name	Description
057h	ACMPHS	ACMP_HS0*1	高速模拟比较器中断0
058h		ACMP_HS1*1	高速模拟比较器中断1
059h		ACMP_HS2*1	高速模拟比较器中断2
05Ah		ACMP_HS3*1	高速模拟比较器中断3
05Bh		ACMP_HS4*1	高速模拟比较器中断4
05Ch		ACMP_HS5*1	高速模拟比较器中断5
063h	IIC0	IIC0_RXI	接收数据已满
064h		IIC0_TXI	传输数据为空
065h		IIC0_TEI	发射端
066h		IIC0_EEI	传输错误
068h	IIC1	IIC1_RXI	接收数据已满
069h		IIC1_TXI	传输数据为空
06Ah		IIC1_TEI	发射端
06Bh		IIC1_EEI	传输错误
086h	DOC	DOC_DOPCI*3	数据运算电路中断
094h	I/O port	IOPORT_GROUP1	端口1事件
095h		IOPORT_GROUP2	端口2事件
096h		IOPORT_GROUP3	端口3事件
097h		IOPORT_GROUP4	端口4事件
098h	ELC	ELC_SWEVT0	软件事件0
099h		ELC_SWEVT1	软件事件1
0B0h	GPT32EH0	GPT0_CCMPA	比较匹配A
0B1h		GPT0_CCMPB	比较匹配B
0B2h		GPT0_CMPC	比较匹配C
0B3h		GPT0_CMPD	比较匹配D
0B4h		GPT0_CMPE	比较匹配E
0B5h		GPT0_CMPF	比较匹配F
0B6h		GPT0_OVF	Overflow
0B7h		GPT0_UDF	Underflow
0B8h		GPT0_ADTRGA	AD转换器启动请求A
0B9h		GPT0_ADTRGB	AD转换器启动请求B
0BAh	GPT32EH1	GPT1_CCMPA	比较匹配A
0BBh		GPT1_CCMPB	比较匹配B
0BCh		GPT1_CMPC	比较匹配C
0BDh		GPT1_CMPD	比较匹配D
0BEh		GPT1_CMPE	比较匹配E
0BFh		GPT1_CMPF	比较匹配F
0C0h		GPT1_OVF	Overflow
0C1h		GPT1_UDF	Underflow
0C2h		GPT1_ADTRGA	AD转换器启动请求A
0C3h		GPT1_ADTRGB	AD转换器启动请求B

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Table 18.3 Association between event signal names set in ELSRn.ELS[8:0] bits and signal numbers (3 of 6)

Event number	Interrupt request source	Name	Description
0C4h	GPT32EH2	GPT2_CCMPA	Compare match A
0C5h		GPT2_CCMPB	Compare match B
0C6h		GPT2_CMPC	Compare match C
0C7h		GPT2_CMPD	Compare match D
0C8h		GPT2_CMPE	Compare match E
0C9h		GPT2_CMPF	Compare match F
0CAh		GPT2_OVF	Overflow
0CBh		GPT2_UDF	Underflow
0CCh		GPT2_ADTRGA	A/D converter start request A
0CDh		GPT2_ADTRGB	A/D converter start request B
0CEh	GPT32EH3	GPT3_CCMPA	Compare match A
0CFh		GPT3_CCMPB	Compare match B
0D0h		GPT3_CMPC	Compare match C
0D1h		GPT3_CMPD	Compare match D
0D2h		GPT3_CMPE	Compare match E
0D3h		GPT3_CMPF	Compare match F
0D4h		GPT3_OVF	Overflow
0D5h		GPT3_UDF	Underflow
0D6h		GPT3_ADTRGA	A/D converter start request A
0D7h		GPT3_ADTRGB	A/D converter start request B
0D8h	GPT32E4	GPT4_CCMPA	Compare match A
0D9h		GPT4_CCMPB	Compare match B
0DAh		GPT4_CMPC	Compare match C
0DBh		GPT4_CMPD	Compare match D
0DCh		GPT4_CMPE	Compare match E
0DDh		GPT4_CMPF	Compare match F
0DEh		GPT4_OVF	Overflow
0DFh		GPT4_UDF	Underflow
0E0h		GPT4_ADTRGA	A/D converter start request A
0E1h		GPT4_ADTRGB	A/D converter start request B
0E2h	GPT32E5	GPT5_CCMPA	Compare match A
0E3h		GPT5_CCMPB	Compare match B
0E4h		GPT5_CMPC	Compare match C
0E5h		GPT5_CMPD	Compare match D
0E6h		GPT5_CMPE	Compare match E
0E7h		GPT5_CMPF	Compare match F
0E8h		GPT5_OVF	Overflow
0E9h		GPT5_UDF	Underflow
0EAh		GPT5_ADTRGA	A/D converter start request A
0EBh		GPT5_ADTRGB	A/D converter start request B

Table 18.3 在ELSRn.ELS[8:0]位中设置的事件信号名称与信号编号之间的关联（3of6）

事件编号	中断请求源	Name	Description
0C4h	GPT32EH2	GPT2_CCMPA	比较匹配A
0C5h		GPT2_CCMPB	比较匹配B
0C6h		GPT2_CMPC	比较匹配C
0C7h		GPT2_CMPD	比较匹配D
0C8h		GPT2_CMPE	比较匹配E
0C9h		GPT2_CMPF	比较匹配F
0CAh		GPT2_OVF	Overflow
0CBh		GPT2_UDF	Underflow
0CCh		GPT2_ADTRGA	AD转换器启动请求A
0CDh		GPT2_ADTRGB	AD转换器启动请求B
0CEh	GPT32EH3	GPT3_CCMPA	比较匹配A
0CFh		GPT3_CCMPB	比较匹配B
0D0h		GPT3_CMPC	比较匹配C
0D1h		GPT3_CMPD	比较匹配D
0D2h		GPT3_CMPE	比较匹配E
0D3h		GPT3_CMPF	比较匹配F
0D4h		GPT3_OVF	Overflow
0D5h		GPT3_UDF	Underflow
0D6h		GPT3_ADTRGA	AD转换器启动请求A
0D7h		GPT3_ADTRGB	AD转换器启动请求B
0D8h	GPT32E4	GPT4_CCMPA	比较匹配A
0D9h		GPT4_CCMPB	比较匹配B
0DAh		GPT4_CMPC	比较匹配C
0DBh		GPT4_CMPD	比较匹配D
0DCh		GPT4_CMPE	比较匹配E
0DDh		GPT4_CMPF	比较匹配F
0DEh		GPT4_OVF	Overflow
0DFh		GPT4_UDF	Underflow
0E0h		GPT4_ADTRGA	AD转换器启动请求A
0E1h		GPT4_ADTRGB	AD转换器启动请求B
0E2h	GPT32E5	GPT5_CCMPA	比较匹配A
0E3h		GPT5_CCMPB	比较匹配B
0E4h		GPT5_CMPC	比较匹配C
0E5h		GPT5_CMPD	比较匹配D
0E6h		GPT5_CMPE	比较匹配E
0E7h		GPT5_CMPF	比较匹配F
0E8h		GPT5_OVF	Overflow
0E9h		GPT5_UDF	Underflow
0EAh		GPT5_ADTRGA	AD转换器启动请求A
0EBh		GPT5_ADTRGB	AD转换器启动请求B

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Table 18.3 Association between event signal names set in ELSRn.ELS[8:0] bits and signal numbers (4 of 6)

Event number	Interrupt request source	Name	Description
0ECh	GPT32E6	GPT6_CCMPA	Compare match A
0EDh		GPT6_CCMPB	Compare match B
0EEh		GPT6_CMPC	Compare match C
0EFh		GPT6_CMPD	Compare match D
0F0h		GPT6_CMPE	Compare match E
0F1h		GPT6_CMPF	Compare match F
0F2h		GPT6_OVF	Overflow
0F3h		GPT6_UDF	Underflow
0F4h		GPT6_ADTRGA	A/D converter start request A
0F5h		GPT6_ADTRGB	A/D converter start request B
0F6h	GPT32E7	GPT7_CCMPA	Compare match A
0F7h		GPT7_CCMPB	Compare match B
0F8h		GPT7_CMPC	Compare match C
0F9h		GPT7_CMPD	Compare match D
0FAh		GPT7_CMPE	Compare match E
0FBh		GPT7_CMPF	Compare match F
0FCh		GPT7_OVF	Overflow
0FDh		GPT7_UDF	Underflow
0FEh		GPT7_ADTRGA	A/D converter start request A
0FFh		GPT7_ADTRGB	A/D converter start request B
100h	GPT328	GPT8_CCMPA	Compare match A
101h		GPT8_CCMPB	Compare match B
102h		GPT8_CMPC	Compare match C
103h		GPT8_CMPD	Compare match D
104h		GPT8_CMPE	Compare match E
105h		GPT8_CMPF	Compare match F
106h		GPT8_OVF	Overflow
107h		GPT8_UDF	Underflow
10Ah	GPT329	GPT9_CCMPA	Compare match A
10Bh		GPT9_CCMPB	Compare match B
10Ch		GPT9_CMPC	Compare match C
10Dh		GPT9_CMPD	Compare match D
10Eh		GPT9_CMPE	Compare match E
10Fh		GPT9_CMPF	Compare match F
110h		GPT9_OVF	Overflow
111h		GPT9_UDF	Underflow
114h	GPT3210	GPT10_CCMPA	Compare match A
115h		GPT10_CCMPB	Compare match B
116h		GPT10_CMPC	Compare match C
117h		GPT10_CMPD	Compare match D
118h		GPT10_CMPE	Compare match E
119h		GPT10_CMPF	Compare match F
11Ah		GPT10_OVF	Overflow
11Bh		GPT10_UDF	Underflow

Table 18.3 在ELSRn.ELS[8:0]位中设置的事件信号名称与信号编号之间的关联（4of6）

事件编号	中断请求源	Name	Description
0ECh	GPT32E6	GPT6_CCMPA	比较匹配A
0EDh		GPT6_CCMPB	比较匹配B
0EEh		GPT6_CMPC	比较匹配C
0EFh		GPT6_CMPD	比较匹配D
0F0h		GPT6_CMPE	比较匹配E
0F1h		GPT6_CMPF	比较匹配F
0F2h		GPT6_OVF	Overflow
0F3h		GPT6_UDF	Underflow
0F4h		GPT6_ADTRGA	AD转换器启动请求A
0F5h		GPT6_ADTRGB	AD转换器启动请求B
0F6h	GPT32E7	GPT7_CCMPA	比较匹配A
0F7h		GPT7_CCMPB	比较匹配B
0F8h		GPT7_CMPC	比较匹配C
0F9h		GPT7_CMPD	比较匹配D
0FAh		GPT7_CMPE	比较匹配E
0FBh		GPT7_CMPF	比较匹配F
0FCh		GPT7_OVF	Overflow
0FDh		GPT7_UDF	Underflow
0FEh		GPT7_ADTRGA	AD转换器启动请求A
0FFh		GPT7_ADTRGB	AD转换器启动请求B
100h	GPT328	GPT8_CCMPA	比较匹配A
101h		GPT8_CCMPB	比较匹配B
102h		GPT8_CMPC	比较匹配C
103h		GPT8_CMPD	比较匹配D
104h		GPT8_CMPE	比较匹配E
105h		GPT8_CMPF	比较匹配F
106h		GPT8_OVF	Overflow
107h		GPT8_UDF	Underflow
10Ah	GPT329	GPT9_CCMPA	比较匹配A
10Bh		GPT9_CCMPB	比较匹配B
10Ch		GPT9_CMPC	比较匹配C
10Dh		GPT9_CMPD	比较匹配D
10Eh		GPT9_CMPE	比较匹配E
10Fh		GPT9_CMPF	比较匹配F
110h		GPT9_OVF	Overflow
111h		GPT9_UDF	Underflow
114h	GPT3210	GPT10_CCMPA	比较匹配A
115h		GPT10_CCMPB	比较匹配B
116h		GPT10_CMPC	比较匹配C
117h		GPT10_CMPD	比较匹配D
118h		GPT10_CMPE	比较匹配E
119h		GPT10_CMPF	比较匹配F
11Ah		GPT10_OVF	Overflow
11Bh		GPT10_UDF	Underflow

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Table 18.3 Association between event signal names set in ELSRn.ELS[8:0] bits and signal numbers (5 of 6)

Event number	Interrupt request source	Name	Description
11Eh	GPT3211	GPT11_CCMPA	Compare match A
11Fh		GPT11_CCMPB	Compare match B
120h		GPT11_CMPC	Compare match C
121h		GPT11_CMPD	Compare match D
122h		GPT11_CMPE	Compare match E
123h		GPT11_CMPF	Compare match F
124h		GPT11_OVF	Overflow
125h		GPT11_UDF	Underflow
128h	GPT3212	GPT12_CCMPA	Compare match A
129h		GPT12_CCMPB	Compare match B
12Ah		GPT12_CMPC	Compare match C
12Bh		GPT12_CMPD	Compare match D
12Ch		GPT12_CMPE	Compare match E
12Dh		GPT12_CMPF	Compare match F
12Eh		GPT12_OVF	Overflow
12Fh		GPT12_UDF	Underflow
150h	GPT	GPT_UVWEDGE	UVW edge event
174h	SCI0	SCI0_RXI *4	Receive data full
175h		SCI0_TXI *4	Transmit data empty
176h		SCI0_TEI	Transmit end
177h		SCI0_ERI *4	Receive error
178h		SCI0_AM	Address match event
17Ah	SCI1	SCI1_RXI *4	Receive data full
17Bh		SCI1_TXI *4	Transmit data empty
17Ch		SCI1_TEI	Transmit end
17Dh		SCI1_ERI *4	Receive error
17Eh		SCI1_AM	Address match event
180h	SCI2	SCI2_RXI *4	Receive data full
181h		SCI2_TXI *4	Transmit data empty
182h		SCI2_TEI	Transmit end
183h		SCI2_ERI *4	Receive error
184h		SCI2_AM	Address match event
186h	SCI3	SCI3_RXI *4	Receive data full
187h		SCI3_TXI *4	Transmit data empty
188h		SCI3_TEI	Transmit end
189h		SCI3_ERI *4	Receive error
18Ah		SCI3_AM	Address match event
18Ch	SCI4	SCI4_RXI *4	Receive data full
18Dh		SCI4_TXI *4	Transmit data empty
18Eh		SCI4_TEI	Transmit end
18Fh		SCI4_ERI *4	Receive error
190h		SCI4_AM	Address match event

Table 18.3 在ELSRn.ELS[8:0]位中设置的事件信号名称与信号编号之间的关联（5of6）

事件编号	中断请求源	Name	Description
11Eh	GPT3211	GPT11_CCMPA	比较匹配A
11Fh		GPT11_CCMPB	比较匹配B
120h		GPT11_CMPC	比较匹配C
121h		GPT11_CMPD	比较匹配D
122h		GPT11_CMPE	比较匹配E
123h		GPT11_CMPF	比较匹配F
124h		GPT11_OVF	Overflow
125h		GPT11_UDF	Underflow
128h	GPT3212	GPT12_CCMPA	比较匹配A
129h		GPT12_CCMPB	比较匹配B
12Ah		GPT12_CMPC	比较匹配C
12Bh		GPT12_CMPD	比较匹配D
12Ch		GPT12_CMPE	比较匹配E
12Dh		GPT12_CMPF	比较匹配F
12Eh		GPT12_OVF	Overflow
12Fh		GPT12_UDF	Underflow
150h	GPT	GPT_UVWEDGE	UVW边缘事件
174h	SCI0	SCI0_RXI *4	接收数据已满
175h		SCI0_TXI *4	传输数据为空
176h		SCI0_TEI	发射端
177h		SCI0_ERI *4	接收错误
178h		SCI0_AM	地址匹配事件
17Ah	SCI1	SCI1_RXI *4	接收数据已满
17Bh		SCI1_TXI *4	传输数据为空
17Ch		SCI1_TEI	发射端
17Dh		SCI1_ERI *4	接收错误
17Eh		SCI1_AM	地址匹配事件
180h	SCI2	SCI2_RXI *4	接收数据已满
181h		SCI2_TXI *4	传输数据为空
182h		SCI2_TEI	发射端
183h		SCI2_ERI *4	接收错误
184h		SCI2_AM	地址匹配事件
186h	SCI3	SCI3_RXI *4	接收数据已满
187h		SCI3_TXI *4	传输数据为空
188h		SCI3_TEI	发射端
189h		SCI3_ERI *4	接收错误
18Ah		SCI3_AM	地址匹配事件
18Ch	SCI4	SCI4_RXI *4	接收数据已满
18Dh		SCI4_TXI *4	传输数据为空
18Eh		SCI4_TEI	发射端
18Fh		SCI4_ERI *4	接收错误
190h		SCI4_AM	地址匹配事件

RA生态工作室

Table 18.3 Association between event signal names set in ELSRn.ELS[8:0] bits and signal numbers (6 of 6)

Event number	Interrupt request source	Name	Description
1A4h	SCI8	SCI8_RXI *4	Receive data full
1A5h		SCI8_TXI *4	Transmit data empty
1A6h		SCI8_TEI	Transmit end
1A7h		SCI8_ERI *4	Receive error
1A8h		SCI8_AM	Address match event
1AAh	SCI9	SCI9_RXI *4	Receive data full
1ABh		SCI9_TXI *4	Transmit data empty
1ACh		SCI9_TEI	Transmit end
1ADh		SCI9_ERI *4	Receive error
1AEh		SCI9_AM	Address match event
1BCh	SPI0	SPI0_SPRI	Receive data full
1BDh		SPI0_SPTI	Transmit data empty
1BEh		SPI0_SPII	Idle
1BFh		SPI0_SPEI	Receive error
1C0h		SPI0_SPTEND	Transmit end
1C1h	SPI1	SPI1_SPRI	Receive data full
1C2h		SPI1_SPTI	Transmit data empty
1C3h		SPI1_SPII	Idle
1C4h		SPI1_SPEI	Receive error
1C5h		SPI1_SPTEND	Transmit end

Note 1. Only pulse (edge detection) is supported.
Note 2. ELSR8 to ELSR11, and ELSR14 to ELSR17 can select this event.
Note 3. This event can occur in Snooze mode.
Note 4. This event is not supported in FIFO mode.

18.3 Operation

18.3.1 Relation between Interrupt Handling and Event Linking

Event number for an event link is the same as that for the associated interrupt source. For information on generating event signals, see the explanation in the chapter for each event source module.

18.3.2 Linking Events

When an event occurs and that event is already set as a trigger in the Event Link Setting Register (ELSRn), the associated module is activated. The operation of the module must be set up in advance. Table 18.4 lists the operations of modules when an event occurs.

Table 18.4 Module operations when event occurs (1 of 2)

Module	Operations when event occurs
GPT	• Start counting • Stop counting • Clear counting • Up counting • Down counting • Input capture.
ADC12	Start A/D conversion
DAC12	Start D/A conversion

Table 18.3 ELSRn.ELS[8:0]位中设置的事件信号名称与信号编号之间的关联（6个中的6个）

事件编号	中断请求源	Name	Description
1A4h	SCI8	SCI8_RXI *4	接收数据已满
1A5h		SCI8_TXI *4	传输数据为空
1A6h		SCI8_TEI	发射端
1A7h		SCI8_ERI *4	接收错误
1A8h		SCI8_AM	地址匹配事件
1AAh	SCI9	SCI9_RXI *4	接收数据已满
1ABh		SCI9_TXI *4	传输数据为空
1ACh		SCI9_TEI	发射端
1ADh		SCI9_ERI *4	接收错误
1AEh		SCI9_AM	地址匹配事件
1BCh	SPI0	SPI0_SPRI	接收数据已满
1BDh		SPI0_SPTI	传输数据为空
1BEh		SPI0_SPII	Idle
1BFh		SPI0_SPEI	接收错误
1C0h		SPI0_SPTEND	发射端
1C1h	SPI1	SPI1_SPRI	接收数据已满
1C2h		SPI1_SPTI	传输数据为空
1C3h		SPI1_SPII	Idle
1C4h		SPI1_SPEI	接收错误
1C5h		SPI1_SPTEND	发射端

Note 1. 仅支持脉冲（边缘检测）。
Note 2. ELSR8到ELSR11和ELSR14到ELSR17可以选择此事件。
Note 3. 此事件可以在贪睡模式下发生。
Note 4. FIFO模式不支持此事件。

18.3 Operation

18.3.1 中断处理和事件链接的关系

事件链接的事件编号与关联中断源的事件编号相同。有关生成事件信号的信息，请参阅每个事件源模块的章节中的说明。

18.3.2 链接事件

当事件发生并且该事件已在事件链接设置寄存器(ELSRn)中设置为触发器时，将激活相关模块。模块的操作必须提前设置好。表18.4列出了事件发生时模块的操作。

Table 18.4 事件发生时的模块操作(1of2)

Module	事件发生时的操作
GPT	开始计数 停止计数 清除计数 递增计数 递减计数 输入捕获。
ADC12	开始AD转换
DAC12	开始DA转换

Table 18.4 Module operations when event occurs (2 of 2)

Module	Operations when event occurs
I/O ports	• Change pin output based on the EORR (reset) or EOSR (set) • Latch pin state to EIDR • The following ports can be used for the ELC: PORT 1 PORT 2 PORT 3 PORT 4.
DTC	Start DTC data transfer

18.3.3 Example Procedure for Linking Events

To link events:

1. Set the operation of the module for which an event is to be linked.
2. Set the appropriate ELSRn register for the module to be linked.
3. Set the ELCR.ELCON bit to 1 to enable linkage of all events.
4. Configure the module from which an event is output and activate the module. The link between the two modules is now active.
5. To stop event linkage of modules individually, set 000000000b in the ELSRn.ELS[8:0] bits associated with the modules. To stop linkage of all events, set the ELCR.ELCON bit to 0.

18.4 Usage Notes

18.4.1 Linking DMAC or DTC Transfer End Signals as Events

When linking the DMAC or DTC transfer end signals as events, do not set the same peripheral module as the DMAC or DTC transfer destination and event link destination. If set, the peripheral module might be started before DMAC or DTC transfer to the peripheral module is complete.

18.4.2 Setting the Clocks

To link events, you must enable the ELC and the related modules. The modules cannot operate if the related modules are in the module-stop state or in the specific low power mode in which the module is stopped (Software Standby mode or Deep Software Standby mode). Some modules can perform in Snooze mode. For more information, see Table 18.3 and section 11, Low Power Modes.

18.4.3 Setting the Module-Stop Function

The Module Stop Control Register C (MSTPCRC) can enable or disable ELC operation. The ELC is initially stopped after reset. Releasing the module-stop state enables access to the registers. The ELCON bit must be set to 0 before disabling ELC operation using the Module Stop Control Register. For more information, see Table 18.3 and section 11, Low Power Modes.

18.4.4 ELC delay time

In Figure 18.2, module A accesses module B through the ELC. There is a delay time in the ELC between module A and module B. The ELC delay time is shown in Table 18.5.

If the clock domains on both modules A and B are the same, the delay time is 0. But, if the clock domains on modules A and B are different, the ELC module has some delay. The time delay is defined by the slower clock frequency between module A and module B.

Table 18.4 事件发生时的模块操作(2of2)

Module	事件发生时的操作
I/O ports	根据EORR（复位）或EOSR（设置）更改引脚输出 将引脚状态锁定为EIDR 以下端口可用于ELC：PORT1PORT2PORT3PORT4。
DTC	开始DTC数据传输

18.3.3 链接事件的示例过程

链接事件：

1. 设置要链接事件的模块的操作。
2. 为要链接的模块设置适当的ELSRn寄存器。
3. 将ELCR.ELCON位设置为1以启用所有事件的链接。
4. 配置输出事件的模块并激活该模块。两个模块之间的链接现在处于活动状态。
5. 要单独停止模块的事件链接，请在与模块关联的ELSRn.ELS[8:0]位中设置000000000b。要停止所有事件的链接，请将ELCR.ELCON位设置为0。

18.4 使用说明

18.4.1 将DMAC或DTC传输结束信号作为事件链接

将DMAC或DTC传输结束信号作为事件链接时，请勿将外设模块设置为DMAC或DTC传输目标和事件链接目标。如果设置，则外围模块可能会在DMAC或DTC传输到外围模块完成之前启动。

18.4.2 设置时钟

要链接事件，您必须启用ELC和相关模块。如果相关模块处于模块停止状态或模块停止的特定低功耗模式（软件待机模式或深度软件待机模式），则模块无法运行。某些模块可以在贪睡模式下执行。有关详细信息，请参阅表18.3和第11节，低功耗模式。

18.4.3 设置模块停止功能

模块停止控制寄存器C(MSTPCRC)可以启用或禁用ELC操作。ELC在复位后最初停止。释放模块停止状态可以访问寄存器。在使用模块停止控制寄存器禁用ELC操作之前，必须将ELCON位设置为0。有关详细信息，请参阅表18.3和第11节，低功耗模式。

18.4.4 ELC延迟时间

在图18.2中，模块A通过ELC访问模块B。模块A和模块B之间的ELC存在延迟时间。ELC延迟时间如表18.5所示。

如果模块A和B上的时钟域相同，则延迟时间为0。但是，如果模块A和B上的时钟域不同，则ELC模块有一些延迟。时间延迟由模块A和模块B之间较慢的时钟频率定义。

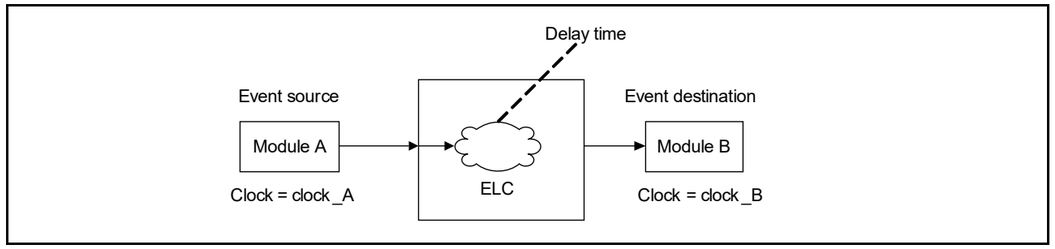

Figure 18.2 ELC delay time

Table 18.5 ELC delay time

Clock domain	Clock frequency	ELC delay time
clock_A = clock_B	clock_A = clock_B	0 cycle
clock_A ≠ clock_B	clock_A = clock_B	1 cycle to 2 cycle
	clock_A > clock_B	1 cycle to 2 cycle of B
	clock_A < clock_B	1 cycle to 2 cycle of A

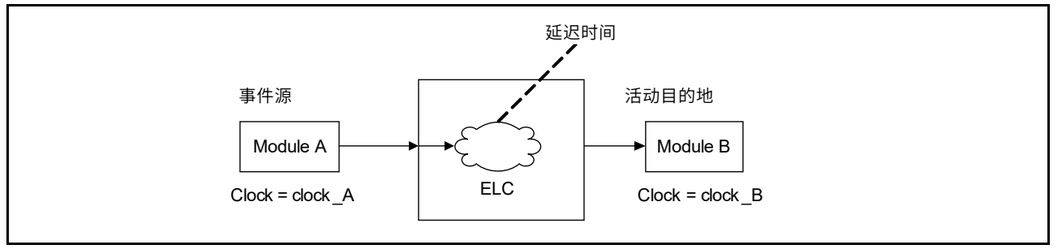

Figure 18.2 ELC延迟时间

Table 18.5 ELC延迟时间

时钟域	时钟频率	ELC延迟时间
clock_A = clock_B	clock_A = clock_B	0 cycle
clock_A ≠ clock_B	clock_A = clock_B	1个周期到2个周期
	clock_A > clock_B	B的1个周期到2个周期
	clock_A < clock_B	A的1个周期到2个周期

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19. I/O Ports

19.1 Overview

The I/O port pins operate as general I/O port pins, I/O pins for peripheral modules, interrupt input pins, analog I/O, or port group function for the ELC. All pins operate as input pins immediately after a reset, and pin functions are switched by register settings. The I/O ports and peripheral modules for each pin are specified in the associated registers.

Figure 19.1 shows a connection diagram for the I/O port registers. The configuration of the I/O ports differs depending on the package. Table 19.1 lists the I/O port specifications by package, and Table 19.2 lists the port functions.

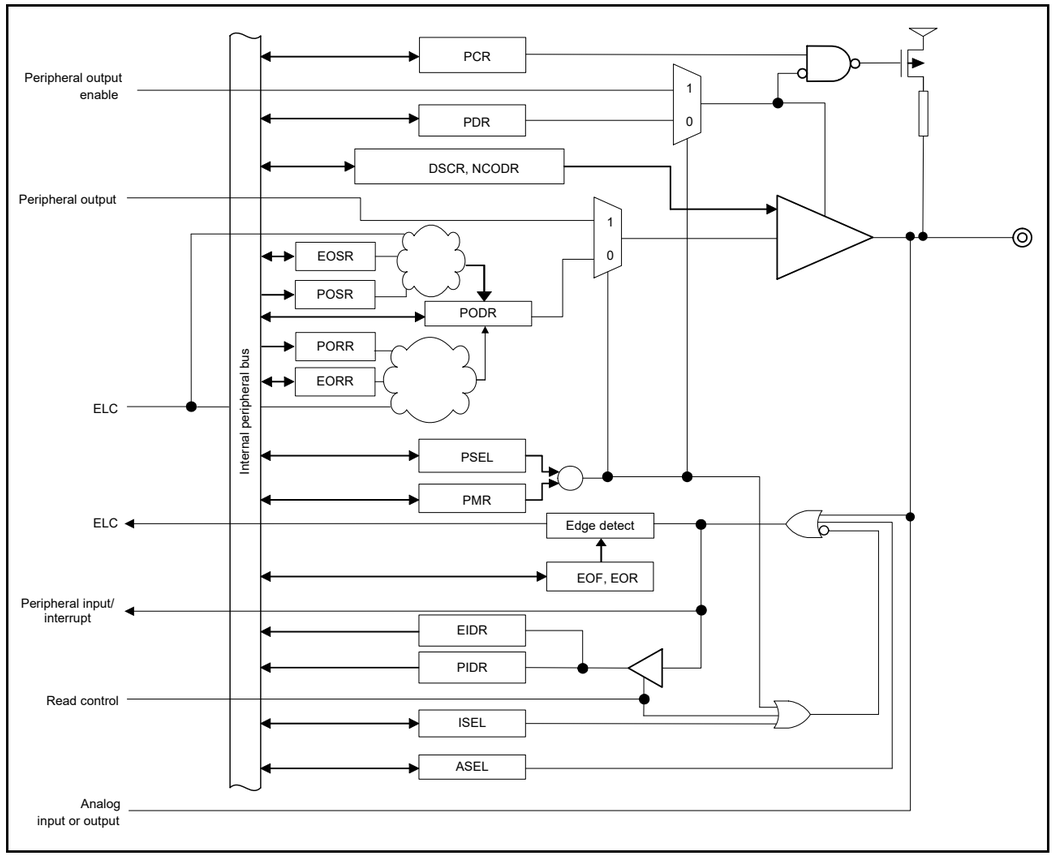

Figure 19.1 Connection diagram for I/O port registers

Note: Figure 19.1 shows a basic port configuration. The configuration differs depending on the ports.

19. I/O Ports

19.1 Overview

IO端口引脚用作通用IO端口引脚、外围模块的IO引脚、中断输入引脚、模拟IO或ELC的端口组功能。所有引脚在复位后立即作为输入引脚工作，引脚功能通过寄存器设置进行切换。每个引脚的IO端口和外围模块在相关寄存器中指定。

图19.1显示了IO端口寄存器的连接图。IO端口的配置因封装而异。表19.1按封装列出了IO端口规格，表19.2列出了端口功能。

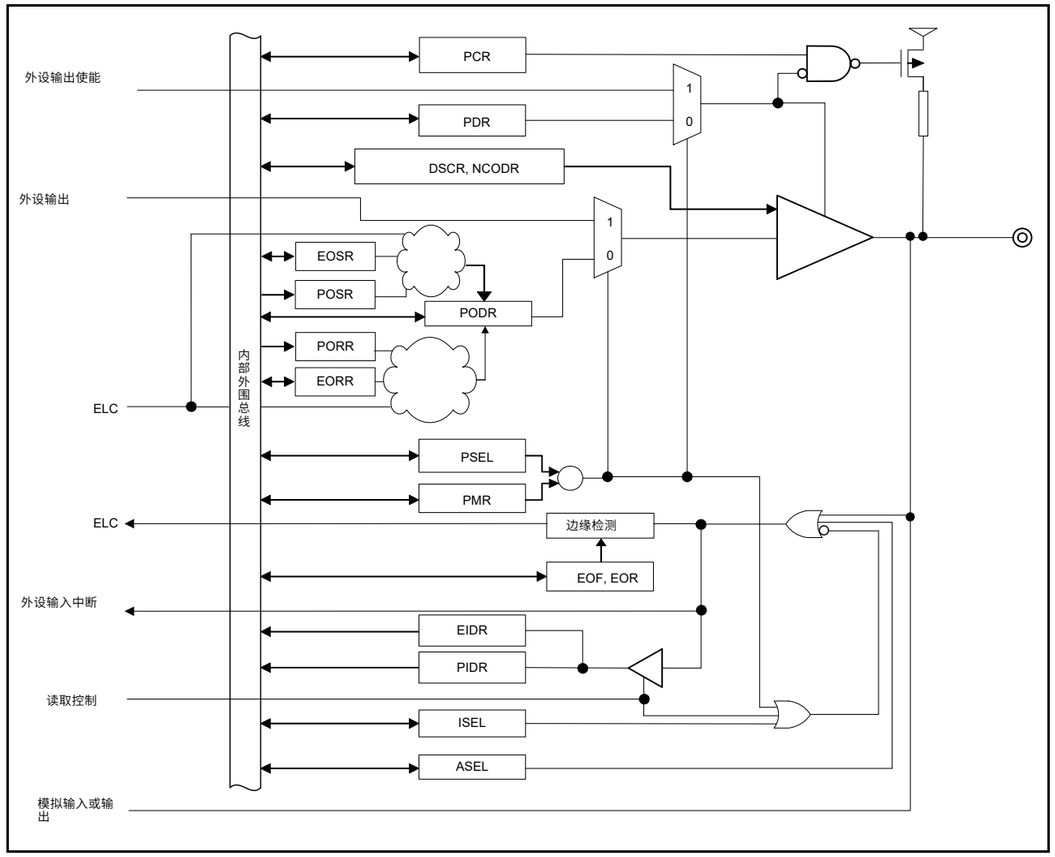

Figure 19.1 IO端口寄存器的连接图

Note: 图19.1显示了一个基本的端口配置。配置因端口而异。

Table 19.1 I/O port specifications

Port	Package 100 pins	Number of pins	Package 64 pins	Number of pins
PORT0	P000 to P008, P014, P015	11	P000 to P003, P014, P015	6
PORT1	P100 to P115	16	P100 to P112	13
PORT2	P200, P201, P205 to P214	12	P200, P201, P205 to P207, P210, P212, P213	8
PORT3	P300 to P307	8	P300 to P302	3
PORT4	P400 to P415	16	P400 to P402, P407 to P411	8
PORT5	P500 to P504, P508	6	P500, P501	2
PORT6	P600 to P602, P608 to P610	6	N/A	0
PORT7	P708	1	N/A	0
	Total pins	76	Total pins	40

Table 19.2 I/O port functions

Port	Port name	Input pull-up	Open-drain output	Drive capacity switching	5 V tolerant
PORT0	P000 to P007	-	-	-	-
	P008, P014, P015	✓	✓	-	-
PORT1	P100 to P115	✓	✓	Low, middle, high	-
PORT2	P200	✓	-	-	-
	P201	✓	✓	-	-
	P205, P206	✓	✓	Low, middle, high	✓
	P207 to P214	✓	✓	Low, middle, high	-
PORT3	P300 to P307	✓	✓	Low, middle, high	-
PORT4	P400, P401, P407 to P415	✓	✓	Low, middle, high	✓
	P402 to P406	✓	✓	Low, middle, high	-
PORT5	P500 to P504, P508	✓	✓	Low, middle, high	-
PORT6	P600 to P602, P608 to P610	✓	✓	Low, middle, high	-
PORT7	P708	✓	✓	Low, middle, high	✓

✓: Available

Table 19.1 IO端口规格

Port	Package 100 pins	引脚数	Package 64 pins	引脚数
PORT0	P000 to P008, P014, P015	11	P000 to P003, P014, P015	6
PORT1	P100 to P115	16	P100 to P112	13
PORT2	P200, P201, P205 to P214	12	P200, P201, P205 to P207, P210, P212, P213	8
PORT3	P300 to P307	8	P300 to P302	3
PORT4	P400 to P415	16	P400 to P402, P407 to P411	8
PORT5	P500 to P504, P508	6	P500, P501	2
PORT6	P600 to P602, P608 to P610	6	N/A	0
PORT7	P708	1	N/A	0
	总针数	76	总针数	40

Table 19.2 IO口功能

Port	端口名称	Input pull-up	Open-drain output	驱动容量切换	5 V tolerant
PORT0	P000 to P007	-	-	-	-
	P008, P014, P015	✓	✓	-	-
PORT1	P100 to P115	✓	✓	低、中、高	-
PORT2	P200	✓	-	-	-
	P201	✓	✓	-	-
	P205, P206	✓	✓	低、中、高	✓
	P207 to P214	✓	✓	低、中、高	-
PORT3	P300 to P307	✓	✓	低、中、高	-
PORT4	P400, P401, P407 to P415	✓	✓	低、中、高	✓
	P402 to P406	✓	✓	低、中、高	-
PORT5	P500 to P504, P508	✓	✓	低、中、高	-
PORT6	P600 to P602, P608 to P610	✓	✓	低、中、高	-
PORT7	P708	✓	✓	低、中、高	✓

✓: Available

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19.2 Register Descriptions

19.2.1 Port Control Register 1 (PCNTR1/PODR/PDR)

Address(es): PORT0.PCNTR1 4004 0000h, PORT1.PCNTR1 4004 0020h, PORT2.PCNTR1 4004 0040h, PORT3.PCNTR1 4004 0060h, PORT4.PCNTR1 4004 0080h, PORT5.PCNTR1 4004 00A0h, PORT6.PCNTR1 4004 00C0h, PORT7.PCNTR1 4004 00E0h

PORT0.PODR 4004 0000h, PORT1.PODR 4004 0020h, PORT2.PODR 4004 0040h, PORT3.PODR 4004 0060h, PORT4.PODR 4004 0080h, PORT5.PODR 4004 00A0h, PORT6.PODR 4004 00C0h, PORT7.PODR 4004 00E0h

PORT0.PDR 4004 0002h, PORT1.PDR 4004 0022h, PORT2.PDR 4004 0042h, PORT3.PDR 4004 0062h, PORT4.PDR 4004 0082h, PORT5.PDR 4004 00A2h, PORT6.PDR 4004 00C2h, PORT7.PDR 4004 00E2h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	PODR 15	PODR 14	PODR 13	PODR 12	PODR 11	PODR 10	PODR 09	PODR 08	PODR 07	PODR 06	PODR 05	PODR 04	PODR 03	PODR 02	PODR 01	PODR 00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PDR15	PDR14	PDR13	PDR12	PDR11	PDR10	PDR09	PDR08	PDR07	PDR06	PDR05	PDR04	PDR03	PDR02	PDR01	PDR00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b15 to b0	PDRn	Pmn Direction	0: Input (functions as an input pin) 1: Output (functions as an output pin).	R/W
b31 to b16	PODRn	Pmn Output Data	0: Low output 1: High output.	R/W

m = 0 to 7
n = 00 to 15

The Port Control Register 1 (PCNTR1/PODR/PDR) is a 32-bit and 16-bit read/write register that controls the port direction and port output data.

The PCNTR1 specifies the port direction and output data, and is accessed in 32-bit units. The PDRn (bits [15:0] in PCNTR1) and PODRn (bits [31:16] in PCNTR1) respectively, are accessed in 16-bit units.

The PDRn bits select the input or output direction for individual pins on the associated port when the pins are configured as general I/O pins. Each pin on port m is associated with a PORTm.PCNTR1.PDRn bit. The I/O direction can be specified in 1-bit units. Bits associated with non-existent pins are reserved. The write value should always be 0. P000 to P007 and P200 are input only, so PORT0.PCNTR1.PDR00-PDR07 and PORT2.PCNTR1.PDR00 are reserved. The PDRn bit in the PORTm.PCNTR1 register serves the same function as the PDR bit in the PFS.PmnPFS register.

The PODRn bits hold data to be output from the general I/O pins. Bits associated with non-existent pins are reserved. The write value should be 0. P000 to P007 and P200 are input only, so PORT0.PCNTR1.PODR00-PODR07 and PORT2.PCNTR1.PODR00 are reserved. Writes to P000 to P007 and P200 have no effect. The PODRn bit in the PORTm.PCNTR1 register serves the same function as the PODR bit in the PFS.PmnPFS register.

19.2 注册说明

19.2.1 端口控制寄存器1(PCNTR1PODRPDR)

Address(es): PORT0.PCNTR1 4004 0000h, PORT1.PCNTR1 4004 0020h, PORT2.PCNTR1 4004 0040h, PORT3.PCNTR1 4004 0060h, PORT4.PCNTR1 4004 0080h, PORT5.PCNTR1 4004 00A0h, PORT6.PCNTR1 4004 00C0h, PORT7.PCNTR1 4004 00E0h

PORT0.PODR 4004 0000h, PORT1.PODR 4004 0020h, PORT2.PODR 4004 0040h, PORT3.PODR 4004 0060h, PORT4.PODR 4004 0080h, PORT5.PODR 4004 00A0h, PORT6.PODR 4004 00C0h, PORT7.PODR 4004 00E0h

PORT0.PDR 4004 0002h, PORT1.PDR 4004 0022h, PORT2.PDR 4004 0042h, PORT3.PDR 4004 0062h, PORT4.PDR 4004 0082h, PORT5.PDR 4004 00A2h, PORT6.PDR 4004 00C2h, PORT7.PDR 4004 00E2h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	PODR 15	PODR 14	PODR 13	PODR 12	PODR 11	PODR 10	PODR 09	PODR 08	PODR 07	PODR 06	PODR 05	PODR 04	PODR 03	PODR 02	PODR 01	PODR 00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PDR15	PDR14	PDR13	PDR12	PDR11	PDR10	PDR09	PDR08	PDR07	PDR06	PDR05	PDR04	PDR03	PDR02	PDR01	PDR00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b15 to b0	PDRn	Pmn Direction	0：输入（用作输入引脚）1：输出（ 用作输出引脚）。	R/W
b31 to b16	PODRn	Pmn输出数据	0：低输出1： 高输出。	R/W

m = 0 to 7
n = 00 to 15

端口控制寄存器1(PCNTR1PODRPDR)是一个32位和16位读写寄存器，用于控制端口方向和端口输出数据。

PCNTR1指定端口方向和输出数据，并以32位为单位进行访问。PDRn（位[15:0]在PCNTR1)和PODRn（PCNTR1中的位[31:16]）分别以16位为单位进行访问。

当引脚配置为通用IO引脚时，PDRn位选择相关端口上各个引脚的输入或输出方向。端口m上的每个引脚都与一个PORTm.PCNTR1.PDRn位相关联。可以以1位为单位指定IO方向。与不存在的引脚相关的位被保留。写入值应始终为0。P000至P007和P200仅为输入，因此保留PORT0.PCNTR1.PDR00-PDR07和PORT2.PCNTR1.PDR00。这

PORTm.PCNTR1寄存器中的PDRn位与PFS.PmnPFS寄存器中的PDR位具有相同的功能。

PODRn位保存要从通用IO引脚输出的数据。与不存在的引脚相关的位被保留。
写入值应为0。P000到P007和P200仅为输入，因此保留PORT0.PCNTR1.PODR00-PODR07和PORT2.PCNTR1.PODR00。写入P000到P007和P200无效。在PODRn位
PORTm.PCNTR1寄存器的功能与PFS.PmnPFS寄存器中的PODR位相同。

19.2.2 Port Control Register 2 (PCNTR2/EIDR/PIDR)

Address(es): PORT0.PCNTR2 4004 0004h, PORT1.PCNTR2 4004 0024h, PORT2.PCNTR2 4004 0044h, PORT3.PCNTR2 4004 0064h, PORT4.PCNTR2 4004 0084h, PORT5.PCNTR2 4004 00A4h, PORT6.PCNTR2 4004 00C4h, PORT7.PCNTR2 4004 00E4h

PORT0.EIDR 4004 0004h, PORT1.EIDR 4004 0024h, PORT2.EIDR 4004 0044h, PORT3.EIDR 4004 0064h, PORT4.EIDR 4004 0084h, PORT5.EIDR 4004 00A4h, PORT6.EIDR 4004 00C4h, PORT7.EIDR 4004 00E4h

PORT0.PIDR 4004 0006h, PORT1.PIDR 4004 0026h, PORT2.PIDR 4004 0046h, PORT3.PIDR 4004 0066h, PORT4.PIDR 4004 0086h, PORT5.PIDR 4004 00A6h, PORT6.PIDR 4004 00C6h, PORT7.PIDR 4004 00E6h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	EIDR15	EIDR14	EIDR13	EIDR12	EIDR11	EIDR10	EIDR09	EIDR08	EIDR07	EIDR06	EIDR05	EIDR04	EIDR03	EIDR02	EIDR01	EIDR00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PIDR15	PIDR14	PIDR13	PIDR12	PIDR11	PIDR10	PIDR09	PIDR08	PIDR07	PIDR06	PIDR05	PIDR04	PIDR03	PIDR02	PIDR01	PIDR00
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b15 to b0	PIDRn	Pmn State	0: Low level 1: High level.	R
b31 to b16	EIDRn	Port Event Input Data*1	When an ELC_PORTx occurs: 0: Low input 1: High input.	R

m = 0 to 7
n = 00 to 15
x = 1 to 4

Note 1. Supported for PORT1 to PORT4.

The Port Control Register 2 (PCNTR2/EIDR/PIDR) allows read access to the Pmn state and the port event input data using 32-bit or 16-bit access.

The PCNTR2 specifies the Pmn state and port event input data, and is accessed in 32-bit units. The PIDRn (bits [15:0] in PCNTR2) and EIDRn (bits [31:16] in PCNTR2) respectively, are accessed in 16-bit units. Bits associated with non-existent pins are reserved. Reserved bits are read as undefined.

The PIDRn bits reflect the individual pin states of the port, regardless of the values set in PmnPFS.PMR and PORTm.PCNTR1.PDRn. The PIDRn bit in the PORTm.PCNTR2 register serves the same function as the PIDR bit in the PFS.PmnPFS register.

A pin state cannot be reflected in PIDRn when one of the following functions is enabled:

- Main clock oscillator (MOSC)
- Analog function (ASEL = 1).

The EIDRn bits latch a pin state when an ELC_PORTx signal occurs. Pin states can only be input to EIDRn when PmnPFS.PMR and PORTm.PCNTR1.PDRn are 0. When the PmnPFS.ASEL bit is set to 1, the associated pin state is not reflected in EIDRn.

19.2.2 端口控制寄存器2(PCNTR2EIDRPIDR)

Address(es): PORT0.PCNTR2 4004 0004h, PORT1.PCNTR2 4004 0024h, PORT2.PCNTR2 4004 0044h, PORT3.PCNTR2 4004 0064h, PORT4.PCNTR2 4004 0084h, PORT5.PCNTR2 4004 00A4h, PORT6.PCNTR2 4004 00C4h, PORT7.PCNTR2 4004 00E4h

PORT0.EIDR 4004 0004h, PORT1.EIDR 4004 0024h, PORT2.EIDR 4004 0044h, PORT3.EIDR 4004 0064h, PORT4.EIDR 4004 0084h, PORT5.EIDR 4004 00A4h, PORT6.EIDR 4004 00C4h, PORT7.EIDR 4004 00E4h

PORT0.PIDR 4004 0006h, PORT1.PIDR 4004 0026h, PORT2.PIDR 4004 0046h, PORT3.PIDR 4004 0066h, PORT4.PIDR 4004 0086h, PORT5.PIDR 4004 00A6h, PORT6.PIDR 4004 00C6h, PORT7.PIDR 4004 00E6h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	EIDR15	EIDR14	EIDR13	EIDR12	EIDR11	EIDR10	EIDR09	EIDR08	EIDR07	EIDR06	EIDR05	EIDR04	EIDR03	EIDR02	EIDR01	EIDR00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PIDR15	PIDR14	PIDR13	PIDR12	PIDR11	PIDR10	PIDR09	PIDR08	PIDR07	PIDR06	PIDR05	PIDR04	PIDR03	PIDR02	PIDR01	PIDR00
重置后的值:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b15 to b0	PIDRn	Pmn State	0：低电平1 ：高电平。	R
b31 to b16	EIDRn	端口事件输入数据*1	当ELC_PORTx发生时：0：低 输入1：高输入。	R

m = 0 to 7
n = 00 to 15
x = 1 to 4

Note 1. 支持PORT1到PORT4。

端口控制寄存器2(PCNTR2EIDRPIDR)允许使用32位或16位访问对Pmn状态和端口事件输入数据进行读取访问。

PCNTR2指定Pmn状态和端口事件输入数据，并以32位为单位进行访问。PIDRn（位[15:0]在PCNTR2)和EIDRn（PCNTR2中的位[31:16]）分别以16位为单位进行访问。与不存在的引脚相关的位被保留。保留位被读取为未定义。

PIDRn位反映端口的各个引脚状态，与PmnPFS.PMR和PORTm.PCNTR1.PDRn。PORTm.PCNTR2寄存器中的PIDRn位与PFS.PmnPFS register.

当启用以下功能之一时，引脚状态无法反映在PIDRn中：

- 主时钟振荡器(MOSC)
- 模拟功能（ASEL=1）。

当ELC_PORTx信号出现时，EIDRn位锁存引脚状态。引脚状态只能输入到EIDRn时PmnPFS.PMR和PORTm.PCNTR1.PDRn为0。当PmnPFS.ASEL位设置为1时，相关引脚状态不会反映在EIDRn中。

19.2.3 Port Control Register 3 (PCNTR3/PORR/POSR)

Address(es): PORT0.PCNTR3 4004 0008h, PORT1.PCNTR3 4004 0028h, PORT2.PCNTR3 4004 0048h, PORT3.PCNTR3 4004 0068h, PORT4.PCNTR3 4004 0088h, PORT5.PCNTR3 4004 00A8h, PORT6.PCNTR3 4004 00C8h, PORT7.PCNTR3 4004 00E8h

PORT0.PORR 4004 0008h, PORT1.PORR 4004 0028h, PORT2.PORR 4004 0048h, PORT3.PORR 4004 0068h, PORT4.PORR 4004 0088h, PORT5.PORR 4004 00A8h, PORT6.PORR 4004 00C8h, PORT7.PORR 4004 00E8h

PORT0.POSR 4004 000Ah, PORT1.POSR 4004 002Ah, PORT2.POSR 4004 004Ah, PORT3.POSR 4004 006Ah, PORT4.POSR 4004 008Ah, PORT5.POSR 4004 00AAh, PORT6.POSR 4004 00CAh, PORT7.POSR 4004 00EAh

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	PORR15	PORR14	PORR13	PORR12	PORR11	PORR10	PORR09	PORR08	PORR07	PORR06	PORR05	PORR04	PORR03	PORR02	PORR01	PORR00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	POSR15	POSR14	POSR13	POSR12	POSR11	POSR10	POSR09	POSR08	POSR07	POSR06	POSR05	POSR04	POSR03	POSR02	POSR01	POSR00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b15 to b0	POSRn	Pmn Output Set	0: No effect on output 1: High output.	W
b31 to b16	PORRn	Pmn Output Reset	0: No effect on output 1: Low output.	W

m = 0 to 7
n = 00 to 15

The Port Control Register 3 (PCNTR3/PORR/POSR) is a 32-bit and 16-bit write register that controls the setting or resetting of the port output data.

The PCNTR3 controls the setting or resetting of the port output data, and is accessed in 32-bit units. The POSRn (bits [15:0] in PCNTR3) and PORRn (bits [31:16] in PCNTR3) respectively, are accessed in 16-bit units.

POSR changes PODR when set by a software write. For example, for P100, when PORT1.PCNTR3.POSR00 is 1, PORT1.PCNTR1.PODR00 outputs 1. Bits associated with non-existent pins are reserved. The write value should always be 0. P000 to P007 and P200 are input only, so PORT0.PCNTR3.POSR00-07 and PORT2.PCNTR3.POSR00 are reserved.

PORR changes PODR when reset by a software write. For example, for P100, when PORT1.PCNTR3.PORR00 is 1, PORT1.PCNTR1.PODR00 outputs 0. Bits associated with non-existent pins are reserved. The write value should always be 0. P000 to P007 and P200 are input only, so PORT0.PCNTR3.PORR00-07 and PORT2.PCNTR3.PORR00 are reserved.

Note: When EORRn or EOSRn is set, writing is prohibited to PODRn, PORRn, and POSRn.
Note: PORRn and POSRn should not be set at the same time.

19.2.3 端口控制寄存器3(PCNTR3PORRPOSR)

Address(es): PORT0.PCNTR3 4004 0008h, PORT1.PCNTR3 4004 0028h, PORT2.PCNTR3 4004 0048h, PORT3.PCNTR3 4004 0068h, PORT4.PCNTR3 4004 0088h, PORT5.PCNTR3 4004 00A8h, PORT6.PCNTR3 4004 00C8h, PORT7.PCNTR3 4004 00E8h

PORT0.PORR 4004 0008h, PORT1.PORR 4004 0028h, PORT2.PORR 4004 0048h, PORT3.PORR 4004 0068h, PORT4.PORR 4004 0088h, PORT5.PORR 4004 00A8h, PORT6.PORR 4004 00C8h, PORT7.PORR 4004 00E8h

PORT0.POSR 4004 000Ah, PORT1.POSR 4004 002Ah, PORT2.POSR 4004 004Ah, PORT3.POSR 4004 006Ah, PORT4.POSR 4004 008Ah, PORT5.POSR 4004 00AAh, PORT6.POSR 4004 00CAh, PORT7.POSR 4004 00EAh

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	PORR15	PORR14	PORR13	PORR12	PORR11	PORR10	PORR09	PORR08	PORR07	PORR06	PORR05	PORR04	PORR03	PORR02	PORR01	PORR00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	POSR15	POSR14	POSR13	POSR12	POSR11	POSR10	POSR09	POSR08	POSR07	POSR06	POSR05	POSR04	POSR03	POSR02	POSR01	POSR00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b15 to b0	POSRn	Pmn输出设置	0：对输出无影响1： 高输出。	W
b31 to b16	PORRn	Pmn输出复位	0：对输出无影响1： 低输出。	W

m = 0 to 7
n = 00 to 15

端口控制寄存器3(PCNTR3PORRPOSR)是一个32位和16位写寄存器，用于控制端口输出数据的设置或复位。

PCNTR3控制端口输出数据的设置或复位，并以32位为单位进行访问。POSRn（PCNTR3中的位[15:0]）和PORRn（PCNTR3中的位[31:16]）分别以16位为单位进行访问。

POSR在通过软件写入设置时改变PODR。例如，对于P100，当PORT1.PCNTR3.POSR00为1时，PORT1.PCNTR1.PODR00输出1。与不存在的引脚相关的位被保留。写入值应始终为0。P000到P007和P200仅为输入，因此保留PORT0.PCNTR3.POSR00-07和PORT2.PCNTR3.POSR00。

PORR在通过软件写入复位时改变PODR。例如，对于P100，当PORT1.PCNTR3.PORR00为1时，PORT1.PCNTR1.PODR00输出0。与不存在的引脚相关的位被保留。写入值应始终为0。P000至P007和P200仅为输入，因此保留PORT0.PCNTR3.PORR00-07和PORT2.PCNTR3.PORR00。

Note: 当设置EORRn或EOSRn时，禁止写入PODRn、PORRn和POSRn。
Note: PORRn和POSRn不应同时设置。

19.2.4 Port Control Register 4 (PCNTR4/EORR/EOSR)

Address(es): PORT1.PCNTR4 4004 002Ch, PORT2.PCNTR4 4004 004Ch, PORT3.PCNTR4 4004 006Ch, PORT4.PCNTR4 4004 008Ch
PORT1.EORR 4004 002Ch, PORT2.EORR 4004 004Ch, PORT3.EORR 4004 006Ch, PORT4.EORR 4004 008Ch
PORT1.EOSR 4004 002Eh, PORT2.EOSR 4004 004Eh, PORT3.EOSR 4004 006Eh, PORT4.EOSR 4004 008Eh

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	EORR 15	EORR 14	EORR 13	EORR 12	EORR 11	EORR 10	EORR 09	EORR 08	EORR 07	EORR 06	EORR 05	EORR 04	EORR 03	EORR 02	EORR 01	EORR 00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	EOSR 15	EOSR 14	EOSR 13	EOSR 12	EOSR 11	EOSR 10	EOSR 09	EOSR 08	EOSR 07	EOSR 06	EOSR 05	EOSR 04	EOSR 03	EOSR 02	EOSR 01	EOSR 00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b15 to b0	EOSRn	Pmn Event Output Set	When an ELC_PORTx occurs: 0: No effect on output 1: High output.	R/W
b31 to b16	EORRn	Pmn Event Output Reset	When an ELC_PORTx occurs: 0: No effect on output 1: Low output.	R/W

m = 1 to 4
n = 00 to 15
x = 1 to 4

The Port Control Register 4 (PCNTR4/EORR/EOSR) is a 32-bit and 16-bit read/write register that controls the setting or resetting of the port output data by an event input from the ELC.

The PCNTR4 controls the setting or resetting of the port output data by an event input from the ELC, and is accessed in 32-bit units. The EOSRn (bits [15:0] in PCNTR4) and EORRn (bits [31:16] in PCNTR4) respectively, are accessed in 16-bit units.

EOSR changes PODR when set because an ELC_PORTx signal occurs. For example, for P100, if PORT1.PCNTR4.EOSR00 is set to 1 when the ELC_PORTx occurs, PORT1.PCNTR1.PODR00 outputs 1. Bits associated with non-existent pins are reserved. The write value should always be 0. P200 is input only, so PORT2.PCNTR4.EOSR00 is reserved.

EORR changes PODR when reset because an ELC_PORTx signal occurs. For example, for P100, if PORT1.PCNTR4.EORR00 is set to 1 when the ELC_PORTx occurs, PORT1.PCNTR1.PODR00 outputs 0. Bits associated with non-existent pins are reserved. The write value should always be 0. P200 is input only, so PORT2.PCNTR4.EORR00 is reserved.

Note: When EORRn or EOSRn is set, writing is prohibited to PODRn, PORRn, and POSRn.
Note: EORRn and EOSRn should not be set at the same time.

19.2.4 端口控制寄存器4(PCNTR4EORREOSR)

Address(es): PORT1.PCNTR4 4004 002Ch, PORT2.PCNTR4 4004 004Ch, PORT3.PCNTR4 4004 006Ch, PORT4.PCNTR4 4004 008Ch
PORT1.EORR 4004 002Ch, PORT2.EORR 4004 004Ch, PORT3.EORR 4004 006Ch, PORT4.EORR 4004 008Ch
PORT1.EOSR 4004 002Eh, PORT2.EOSR 4004 004Eh, PORT3.EOSR 4004 006Eh, PORT4.EOSR 4004 008Eh

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	EORR 15	EORR 14	EORR 13	EORR 12	EORR 11	EORR 10	EORR 09	EORR 08	EORR 07	EORR 06	EORR 05	EORR 04	EORR 03	EORR 02	EORR 01	EORR 00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	EOSR 15	EOSR 14	EOSR 13	EOSR 12	EOSR 11	EOSR 10	EOSR 09	EOSR 08	EOSR 07	EOSR 06	EOSR 05	EOSR 04	EOSR 03	EOSR 02	EOSR 01	EOSR 00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b15 to b0	EOSRn	Pmn事件输出集	当发生ELC_PORTx时：0：对输出没有影响1：高输出。	R/W
b31 to b16	EORRn	Pmn事件输出复位	当ELC_PORTx发生时：0：对输出没有影响1：低输出。	R/W

m = 1 to 4
n = 00 to 15
x = 1 to 4

端口控制寄存器4(PCNTR4EORREOSR)是一个32位和16位读写寄存器，通过来自ELC的事件输入来控制端口输出数据的设置或复位。

PCNTR4通过来自ELC的事件输入来控制端口输出数据的设置或复位，并以32位为单位进行访问。分别以16位为单位访问EOSRn（PCNTR4中的位[15:0]）和EORRn（PCNTR4中的位[31:16]）。

EOSR在设置时会更改PODR，因为发生ELC_PORTx信号。例如，对于P100，如果当ELC_PORTx发生时，PORT1.PCNTR4.EOSR00设置为1，PORT1.PCNTR1.PODR00输出1。与不存在的引脚相关的位被保留。写入值应始终为0。P200仅为输入，因此保留PORT2.PCNTR4.EOSR00。

EORR会在复位时更改PODR，因为发生ELC_PORTx信号。例如，对于P100，如果当ELC_PORTx发生时，PORT1.PCNTR4.EORR00设置为1，PORT1.PCNTR1.PODR00输出0。与不存在的引脚相关的位被保留。写入值应始终为0。P200仅为输入，因此保留PORT2.PCNTR4.EORR00。

Note: 当设置EORRn或EOSRn时，禁止写入PODRn、PORRn和POSRn。
Note: EORRn和EOSRn不应同时设置。

19.2.5 Port mn Pin Function Select Register (PmnPFS/PmnPFS_HA/PmnPFS_BY) (m = 0 to 7; n = 00 to 15)

Address(es): PFS.P000PFS 4004 0800h to PFS.P015PFS 4004 083Ch, PFS.P100PFS 4004 0840h to PFS.P115PFS 4004 087Ch, PFS.P200PFS 4004 0880h to PFS.P214PFS 4004 08B8h, PFS.P300PFS 4004 08C0h to PFS.P307PFS 4004 08DCh, PFS.P400PFS 4004 0900h to PFS.P415PFS 4004 093Ch, PFS.P500PFS 4004 0940h to PFS.P508PFS 4004 0960h, PFS.P600PFS 4004 0980h to PFS.P610PFS 4004 09A8h, PFS.P708PFS 4004 09E0h

PFS.P000PFS_HA 4004 0802h to PFS.P015PFS_HA 4004 083Eh, PFS.P100PFS_HA 4004 0842h to PFS.P115PFS_HA 4004 087Eh, PFS.P200PFS_HA 4004 0882h to PFS.P214PFS_HA 4004 08BAh, PFS.P300PFS_HA 4004 08C2h to PFS.P307PFS_HA 4004 08DEh, PFS.P400PFS_HA 4004 0902h to PFS.P415PFS_HA 4004 093Eh, PFS.P500PFS_HA 4004 0942h to PFS.P508PFS_HA 4004 0962h, PFS.P600PFS_HA 4004 0982h to PFS.P610PFS_HA 4004 09AAh, PFS.P708PFS_HA 4004 09E2h

PFS.P000PFS_BY 4004 0803h to PFS.P015PFS_BY 4004 083Fh, PFS.P100PFS_BY 4004 0843h to PFS.P115PFS_BY 4004 087Fh, PFS.P200PFS_BY 4004 0883h to PFS.P214PFS_BY 4004 08BBh, PFS.P300PFS_BY 4004 08C3h to PFS.P307PFS_BY 4004 08DFh, PFS.P400PFS_BY 4004 0903h to PFS.P415PFS_BY 4004 093Fh, PFS.P500PFS_BY 4004 0943h to PFS.P508PFS_BY 4004 0963h, PFS.P600PFS_BY 4004 0983h to PFS.P610PFS_BY 4004 09ABh, PFS.P708PFS_BY 4004 09E3h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	PSEL[4:0]					—	—	—	—	—	—	—	PMR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0*2

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ASEL	ISEL	EOF	EOR	DSCR[1:0]		—	—	—	NCODR	—	PCR	—	PDR	PIDR	PODR
Value after reset:	0*2	0	0	0	0	0*2	0	0	0	0	0	0*2	0	0	x	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	PODR	Port Output Data	0: Low output 1: High output.	R/W
b1	PIDR	Pmn State	0: Low level 1: High level.	R
b2	PDR	Port Direction	0: Input (functions as an input pin) 1: Output (functions as an output pin).	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	PCR	Pull-up Control	0: Disable input pull-up 1: Enable input pull-up.	R/W
b5	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6	NCODR	N-Channel Open-Drain Control	0: CMOS output 1: NMOS open-drain output.	R/W
b9 to b7	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b11, b10	DSCR[1:0]	Port Drive Capability	b11 b10 0 0: Low drive 0 1: Middle drive 1 0: Setting prohibited 1 1: High drive.	R/W
b13, b12	EOF/EOR	Event on Falling/Event on Rising*1	b13 b12 0 0: Don't care 0 1: Detect rising edge 1 0: Detect falling edge 1 1: Detect both edges.	R/W
b14	ISEL	IRQ Input Enable	0: Not used as an IRQn input pin 1: Used as an IRQn input pin.	R/W
b15	ASEL	Analog Input Enable	0: Not used as analog pin 1: Used as analog pin.	R/W
b16	PMR	Port Mode Control	0: Used as a general I/O pin 1: Used as an I/O port for peripheral functions.	R/W
b23 to b17	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b28 to b24	PSEL[4:0]	Peripheral Select	These bits select the peripheral function. For individual pin functions, see the associated tables in this chapter.	R/W

19.2.5 端口mn引脚功能选择寄存器(PmnPFSPmnPFS_HAPmnPFS_BY)(m=0到7；n=00到15)

Address(es): PFS.P000PFS 4004 0800h to PFS.P015PFS 4004 083Ch, PFS.P100PFS 4004 0840h to PFS.P115PFS 4004 087Ch, PFS.P200PFS 4004 0880h to PFS.P214PFS 4004 08B8h, PFS.P300PFS 4004 08C0h to PFS.P307PFS 4004 08DCh, PFS.P400PFS 4004 0900h to PFS.P415PFS 4004 093Ch, PFS.P500PFS 4004 0940h to PFS.P508PFS 4004 0960h, PFS.P600PFS 4004 0980h to PFS.P610PFS 4004 09A8h, PFS.P708PFS 4004 09E0h

PFS.P000PFS_HA 4004 0802h to PFS.P015PFS_HA 4004 083Eh, PFS.P100PFS_HA 4004 0842h to PFS.P115PFS_HA 4004 087Eh, PFS.P200PFS_HA 4004 0882h to PFS.P214PFS_HA 4004 08BAh, PFS.P300PFS_HA 4004 08C2h to PFS.P307PFS_HA 4004 08DEh, PFS.P400PFS_HA 4004 0902h to PFS.P415PFS_HA 4004 093Eh, PFS.P500PFS_HA 4004 0942h to PFS.P508PFS_HA 4004 0962h, PFS.P600PFS_HA 4004 0982h to PFS.P610PFS_HA 4004 09AAh, PFS.P708PFS_HA 4004 09E2h

PFS.P000PFS_BY 4004 0803h to PFS.P015PFS_BY 4004 083Fh, PFS.P100PFS_BY 4004 0843h to PFS.P115PFS_BY 4004 087Fh, PFS.P200PFS_BY 4004 0883h to PFS.P214PFS_BY 4004 08BBh, PFS.P300PFS_BY 4004 08C3h to PFS.P307PFS_BY 4004 08DFh, PFS.P400PFS_BY 4004 0903h to PFS.P415PFS_BY 4004 093Fh, PFS.P500PFS_BY 4004 0943h to PFS.P508PFS_BY 4004 0963h, PFS.P600PFS_BY 4004 0983h to PFS.P610PFS_BY 4004 09ABh, PFS.P708PFS_BY 4004 09E3h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	PSEL[4:0]					—	—	—	—	—	—	—	PMR
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0*2

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ASEL	ISEL	EOF	EOR	DSCR[1:0]		—	—	—	NCODR	—	PCR	—	PDR	PIDR	PODR
重置后的值:	0*2	0	0	0	0	0*2	0	0	0	0	0	0*2	0	0	x	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	PODR	端口输出数据	0：低输出1： 高输出。	R/W
b1	PIDR	Pmn State	0：低电平1 ：高电平。	R
b2	PDR	港口方向	0：输入（用作输入引脚）1：输出（ 用作输出引脚）。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	PCR	Pull-up Control	0：禁止输入上拉1：使 能输入上拉。	R/W
b5	—	Reserved	该位读取为0。写入值应为0。	R/W
b6	NCODR	N-Channel Open-Drain Control	0: CMOS output 1: NMOS open-drain output.	R/W
b9 to b7	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b11, b10	DSCR[1:0]	端口驱动能力	b11b1000：低驱动01： 中驱动10：禁止设置11 ：高驱动。	R/W
b13, b12	EOF/EOR	坠落事件 Rising*1	b13b1200：无关01：检 测上升沿10：检测下降沿 11：检测两个沿。	R/W
b14	ISEL	IRQ输入使能	0：不用作IRQn输入引脚1：用作 IRQn输入引脚。	R/W
b15	ASEL	模拟输入使能	0：不用作模拟引脚1：用 作模拟引脚。	R/W
b16	PMR	端口模式控制	0：用作通用IO引脚1：用作外围功能的IO端口 。	R/W
b23 to b17	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b28 to b24	PSEL[4:0]	外设选择	这些位选择外设功能。对于各个引脚功能，请参见本章中 的相关表格。	R/W

Bit	Symbol	Bit name	Description	R/W
b31 to b29	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: P009PFS to P013PFS, P202PFS to P204PFS, P505PFS to P507PFS and P603PFS to P607PFS for 32-bit, 16-bit, and 8-bit access are not available.
Note 1. Supported for PORT1 to PORT4.
Note 2. The initial value of P000 to P007, P108, P109, P110, P201 and P300 is not 0000_0000h.
P000 to P007 is 0000_8000h, P108 is 0001_0410h, P109 is 0001_0400h, P110 is 0001_0010h, P201 is 0000_0010h, and P300 is 0001_0010h.

The Port mn Pin Function Select register (PmnPFS/PmnPFS_HA/PmnPFS_BY) is a 32-bit, 16-bit, and 8-bit read/write control register that selects the port mn pin function, and is accessed in 32-bit units. PmnPFS_HA (bits [15:0] in PmnPFS) is accessed in 16-bit units. PmnPFS_BY (bits [7:0]) is accessed in 8-bit units.

The PDR/PIDR/PODR bits serve the same function as the PCNTR. When these bits are read, the PCNTR value is read.

The PCR bit enables or disables an input pull-up resistor on the individual port pins. When a pin is in the input state with the associated bit in PmnPFS.PCR set to 1, the pull-up resistor connected to the pin is enabled. When a pin is set as a general port output pin, or a peripheral function output pin, the pull-up resistor for the pin is disabled regardless of the PCR setting. The pull-up resistor is also disabled in the reset state. Bits associated with non-existent pins are reserved. The write value should be 0.

The NCODR bit specifies the output type for the port pins. Bits associated with non-existent pins are reserved. The write value should be 0.

The DSCR bit switches the drive capacity of the port. If the drive capacity of a pin is fixed, the associated bit is a read/write bit, but the drive capacity cannot be changed. Bits associated with non-existent pins are reserved. The write value should be 0.

The EOR and EOF bits select the edge detection method for the port group input signal. These bits support rising, falling, or both edge detections. When the EOR and EOF bits are set to 01b, 10b, or 11b, the input enable of the I/O cell is asserted. Following that, the event pulse is input from the external pin, and the GPIO outputs the event pulse to the ELC. Bits associated with non-existent pins are reserved. The write value should be 0.

The ISEL bit specifies IRQ input pins. This setting can be used in combination with the peripheral functions, although an IRQn (external pin interrupt) of the same number must only be enabled for one pin.

The ASEL bit specifies analog pins. When a pin is set as an analog pin by this bit:

1. Specify it as a general I/O port with the Port Mode Control bit (PmnPFS.PMR).
2. Disable the Pull-up register with the Pull-up Control bit (PmnPFS.PCR).
3. Specify the input with the Port Direction bit (PmnPFS.PDR). The pin state cannot be read at this point. The PmnPFS register is protected by the Write-Protect Register (PWPR). Release write-protect before modifying the register.

The ISEL bit for an unspecified IRQn is reserved. The ASEL bit for an unspecified analog input/output pin is reserved.

The PMR bit specifies the port pin function. Bits associated with non-existent pins are reserved. The write value should be 0.

The PSEL[4:0] bits assign the peripheral function.

For details on the peripheral settings for each product, see section 19.6, Peripheral Select Settings for each Product.

Bit	Symbol	位名称	Description	R/W
b31 to b29	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: P009PFS到P013PFS、P202PFS到P204PFS、P505PFS到P507PFS和P603PFS到P607PFS用于32位、16位和8位访问不可用。

Note 1. 支持PORT1到PORT4。
Note 2. P000到P007、P108、P109、P110、P201和P300的初始值不是0000_0000h。
P000至P007为0000_8000h，P108为0001_0410h，P109为0001_0400h，P110为0001_0010h，P201为0000_0010h，以及P300 is 0001_0010h.

端口mn引脚功能选择寄存器（PmnPFSPmnPFS_HAPmnPFS_BY）是选择端口mn引脚功能的32位、16位和8位读写控制寄存器，以32位为单位进行访问。PmnPFS_HA（PmnPFS中的位[15:0]）以16位为单位进行访问。PmnPFS_BY（位[7:0]）以8位为单位进行访问。

PDRPIDRPODR位的功能与PCNTR相同。读取这些位时，将读取PCNTR值。

PCR位启用或禁用各个端口引脚上的输入上拉电阻。当引脚处于输入状态且PmnPFS.PCR中的相关位设置为1时，连接到该引脚的上拉电阻被启用。当引脚设置为通用端口输出引脚或外围功能输出引脚时，无论PCR设置如何，该引脚的上拉电阻都被禁用。上拉电阻在复位状态下也被禁用。与不存在的引脚相关的位被保留。

写入值应为0。

NCODR位指定端口引脚的输出类型。与不存在的引脚相关的位被保留。写入值应为0。

DSCR位切换端口的驱动能力。如果某个管脚的驱动能力是固定的，那么相关的位就是一个读写位，但是驱动能力是不能改变的。与不存在的引脚相关的位被保留。写入值应为0。

EOR和EOF位选择端口组输入信号的边沿检测方法。这些位支持上升沿、下降沿或两个边沿检测。当EOR和EOF位设置为01b、10b或11b时，IO单元的输入使能有效。随后，事件脉冲从外部引脚输入，GPIO将事件脉冲输出到ELC。与不存在的引脚相关的位被保留。写入值应为0。

ISEL位指定IRQ输入引脚。此设置可以与外围功能结合使用，尽管相同编号的IRQn（外部引脚中断）只能为一个引脚启用。

ASEL位指定模拟引脚。当一个引脚被该位设置为模拟引脚时：

1. 通过端口模式控制位(PmnPFS.PMR)将其指定为通用IO端口。
2. 使用上拉控制位(PmnPFS.PCR)禁用上拉寄存器。
3. 使用端口方向位(PmnPFS.PDR)指定输入。此时无法读取引脚状态。这PmnPFS寄存器受写保护寄存器(PWPR)保护。在修改寄存器之前释放写保护。

未指定的IRQn的ISEL位被保留。未指定模拟输入输出引脚的ASEL位被保留。

PMR位指定端口引脚功能。与不存在的引脚相关的位被保留。写入值应为0。

PSEL[4:0]位分配外设功能。

有关每个产品的外设设置的详细信息，请参阅第19.6节，每个产品的外设选择设置。

19.2.6 Write-Protect Register (PWPR)

Address(es): PMISC.PWPR 4004 0D03h

	b7	b6	b5	b4	b3	b2	b1	b0
	B0WI	PFSWE	—	—	—	—	—	—
Value after reset:	1	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b5 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	PFSWE	PmnPFS Register Write Enable	0: Writing to the PmnPFS register is disabled 1: Writing to the PmnPFS register is enabled.	R/W
b7	B0WI	PFSWE Bit Write Disable	0: Writing to the PFSWE bit is enabled 1: Writing to the PFSWE bit is disabled.	R/W

PFSWE bit (PmnPFS Register Write Enable)

Writing to the PmnPFS register is enabled only when the PFSWE bit is set to 1. You must first write 0 to the B0WI bit before setting PFSWE to 1.

B0WI bit (PFSWE Bit Write Disable)

Writing to the PFSWE bit is enabled only when the B0WI bit is set to 0.

19.2.7 AGT Input Control Register (VBTICTLR)

Address(es): SYSTEM.VBTICTLR 4001 E4BBh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	VCH2INEN	VCH1INEN	VCH0INEN
Value after reset:	0	0	0	0	0	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	VCH0INEN	AGT Input Enable (P402)	0: Disable 1: Enable.	R/W
b1	VCH1INEN	AGT Input Enable (P403)	0: Disable 1: Enable.	R/W
b2	VCH2INEN	Reserved	The read value is undefined. The write value should be 0.	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The VBTICTLR register selects the AGTIO (P402, P403) direction as input.

VCHnINEN bit (AGT Input Enable) (n= 0 to 1)

The VCHnINEN bit enables the input direction on the associated AGTIO (P402, P403). Bits associated with non-existent pins are reserved. The write value should be 0.

For more information on the associated function of CH0 and CH1, see section 19.5.5, I/O Buffer Specification.

19.3 Operation

19.3.1 General I/O Ports

All pins except P000 to P007, P108 to P110, and P300 operate as general I/O ports after reset. General I/O ports are organized as 16 bits per port and can be accessed by port with the Port Control Registers (PCNTRn, where n = 1 to 4), or

19.2.6 Write-Protect Register (PWPR)

Address(es): PMISC.PWPR 4004 0D03h

	b7	b6	b5	b4	b3	b2	b1	b0
	B0WI	PFSWE	—	—	—	—	—	—
重置后的值:	1	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b5 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	PFSWE	PmnPFS寄存器写入Enable	0：禁止写入PmnPFS寄存器1：允许写入PmnPFS寄存器。	R/W
b7	B0WI	PFSWE位写入禁用	0：允许写入PFSWE位1：禁止写入PFSWE位。	R/W

PFSWE位（PmnPFS寄存器写使能）

仅当PFSWE位设置为1时才允许写入PmnPFS寄存器。您必须先将0写入B0WI位，然后再将PFSWE设置为1。

B0WI位（PFSWE位写入禁用）

仅当B0WI位设置为0时才允许写入PFSWE位。

19.2.7 AGT输入控制寄存器(VBTICTLR)

Address(es): SYSTEM.VBTICTLR 4001 E4BBh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	VCH2INEN	VCH1INEN	VCH0INEN
重置后的值:	0	0	0	0	0	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	VCH0INEN	AGT输入启用(P402)	0：禁用1：启用。	R/W
b1	VCH1INEN	AGT输入启用(P403)	0：禁用1：启用。	R/W
b2	VCH2INEN	Reserved	读取值未定义。写入值应为0。	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

VBTICTLR寄存器选择AGTIO(P402 P403)方向作为输入。

VCHnINEN位（AGT输入使能）（n=0到1）

VCHnINEN位使能相关AGTIO(P402 P403)上的输入方向。与不存在的引脚相关的位被保留。写入值应为0。

有关CH0和CH1相关功能的更多信息，请参阅第19.5.5节，IO缓冲区规范。

19.3 Operation

19.3.1 通用IO端口

除P000到P007、P108到P110和P300之外的所有引脚在复位后都作为通用IO端口工作。通用IO端口组织为每个端口16位，可以通过端口控制寄存器（PCNTRn，其中n=1到4）通过端口访问，或

by individual pins with the Port mn Pin Function Select register. For details on these registers, see section 19, Register Descriptions.

Each port has the following bits:

- Port Direction bit (PDRn), which selects input or output direction
- Port Output Data bit (PODRn), which holds data for output
- Port Input Data bit (PIDRn), which indicates the pin state
- Event Input Data bit (EIDRn), which indicates the pin state when an ELC_PORT1, 2, 3, or 4 signal occurs
- Port Output Set bit (POSRn), which indicates the output value when a software write occurs
- Port Output Reset bit (PORRn), which indicates the output value when a software write occurs
- Event Output Set bit (EOSRn), which indicates the output value when an ELC_PORT1, 2, 3 or 4 signal occurs
- Event Output Reset bit (EORRn), which indicates the output value when an ELC_PORT1, 2, 3 or 4 signal occurs.

19.3.2 Port Function Select

The following port functions are available for configuring each pin:

- I/O configuration: Complementary or open-drain output, pull-up control, and drive strength
- General I/O port: Port direction, output data setting, and reading input data
- Alternate function: Configured function mapping to the pin.

Each pin is associated with a Port mn Pin Function Select register (PmnPFS), which includes the associated PODR, PIDR, and PDR bits. In addition, the PmnPFS register includes:

- PCR: Pull-up resistor control bit that turns the input pull-up MOS on or off
- NCODR: N-channel open-drain control bit that selects the output type for each pin
- DSCR: Drive capacity control bit that selects the drive capacity
- EOR: Event on rising bit used to detect rising edges on the port input
- EOF: Event on falling bit used to detect falling edges on the port input
- ISEL: IRQ input enable bit to specify an IRQ input pin
- ASEL: Analog input enable bit to specify an analog pin
- PMR: Port mode control bit to specify the pin function of each port
- PSEL[4:0]: Port function select bits to select the associated peripheral function.

These configurations can be made by a single-register access to the Port mn Pin Function Select register. For details, see section 19, Port mn Pin Function Select Register (PmnPFS/PmnPFS_HA/PmnPFS_BY) (m = 0 to 7; n = 00 to 15).

19.3.3 Port Group Function for the ELC

In the MCU, PORT1 to PORT4 are assigned for the port group function.

19.3.3.1 Behavior when ELC_PORT1, 2, 3, or 4 is input from the ELC

The MCU supports the two functions described in this section when an ELC_PORT1, 2, 3, or 4 signal comes from the ELC.

(1) Input to EIDR

For the GPI function (PDR = 0 and PMR = 0 in the PmnPFS register), when an ELC_PORT1, 2, 3, or 4 signal comes from the ELC, the input enable of the I/O cell is asserted, and data from the external pins are read into the EIDR bit. See Figure 19.2.

For the GPO function (PDR = 1) or the peripheral mode (PMR = 1), 0 is input into the EIDR bit from the external pins.

通过单个引脚与端口mn引脚功能选择寄存器。有关这些寄存器的详细信息，请参见第19节，寄存器说明。

每个端口都有以下位：

- 端口方向位(PDRn)，用于选择输入或输出方向
- 端口输出数据位(PODRn)，用于保存输出数据
- 端口输入数据位(PIDRn)，指示引脚状态
- 事件输入数据位(EIDRn)，指示发生ELC_PORT1、2、3或4信号时的引脚状态
- 端口输出设置位(POSRn)，表示发生软件写入时的输出值
- 端口输出复位位(PORRn)，指示发生软件写入时的输出值
- 事件输出设置位(EOSRn)，指示ELC_PORT1、2、3或4信号发生时的输出值
- 事件输出复位位(EORRn)，指示发生ELC_PORT1、2、3或4信号时的输出值。

19.3.2 端口功能选择

以下端口功能可用于配置每个引脚：

- IO配置：互补或开漏输出、上拉控制和驱动强度
- 通用IO口：端口方向、输出数据设置、读取输入数据
- 备用功能：配置的功能映射到引脚。

每个管脚都与一个端口mn管脚功能选择寄存器(PmnPFS)相关联，其中包括相关的PODR、PIDR和PDR位。此外，PmnPFS寄存器包括：

- PCR：上拉电阻控制位，用于打开或关闭输入上拉MOS
- NCODR：为每个引脚选择输出类型的N通道开漏控制位
- DSCR：选择驱动器容量的驱动器容量控制位
- EOR：上升位事件，用于检测端口输入的上升沿
- EOF：下降位事件，用于检测端口输入的下降沿
- ISEL：IRQ输入使能位，用于指定IRQ输入引脚
- ASEL：模拟输入使能位，用于指定模拟引脚
- PMR：端口模式控制位，指定每个端口的引脚功能
- PSEL[4:0]：端口功能选择位，用于选择相关的外设功能。

这些配置可以通过单个寄存器访问端口mn引脚功能选择寄存器来进行。有关详细信息，请参见第19节，端口mn引脚功能选择寄存器(PmnPFSPmnPFS_HAPmnPFS_BY)(m=0到7；n=00到15)。

19.3.3 ELC的端口组功能

在MCU中，为端口组功能分配了PORT1到PORT4。

19.3.3.1 从ELC输入ELC_PORT1、2、3或4时的行为

当ELC_PORT1、2、3或4信号来自
ELC.

(1) 输入到EIDR

对于GPI功能（PmnPFS寄存器中的PDR=0和PMR=0），当ELC_PORT1、2、3或4信号来自ELC时，IO单元的输入使能有效，并且来自外部引脚的数据被读入EIDR位。请参见图19.2。

对于GPO功能(PDR=1)或外设模式(PMR=1)，0从外部引脚输入到EIDR位。

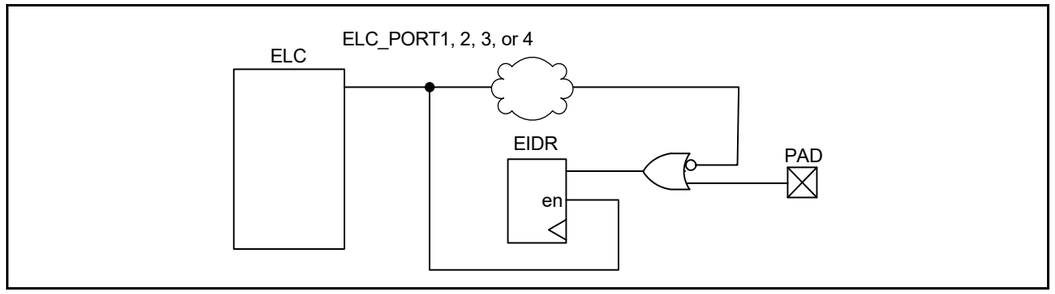

Figure 19.2 Event ports input data

(2) Output from PODR by EOSR/EORR

When an ELC_PORT1, 2, 3, or 4 signal occurs, the data is output from the PODR to the external pin based on the EOSR/EORR bit settings as follows:

- If EOSR is set to 1, when an ELC_PORT1, 2, 3, or 4 signal occurs, the PODR register outputs 1 to the external pin. Otherwise, when EOSR = 0, the PODR value is kept.
- If EORR is set to 1, when an ELC_PORT1, 2, 3, or 4 signal occurs, the PODR register outputs 0 to the external pin. Otherwise, when EORR = 0, the PODR value is kept.

See Figure 19.3.

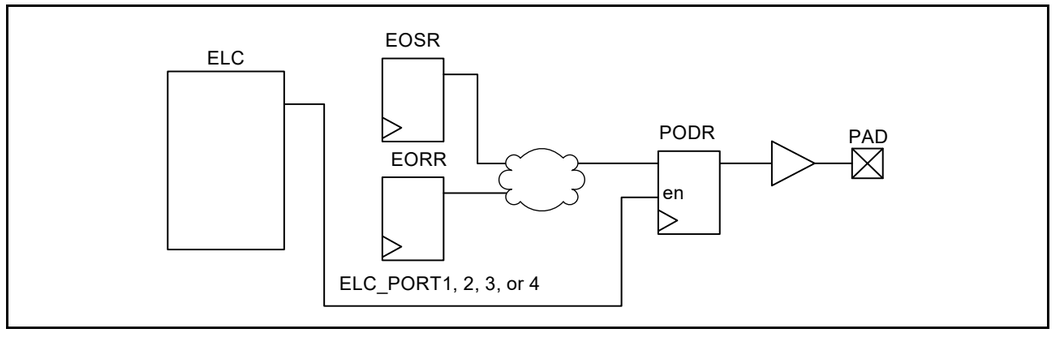

Figure 19.3 Event ports output data

19.3.3.2 Behavior when an event pulse is output to the ELC

To output the event pulse from the external pins to the ELC, set the EOR/EOF bits in the PmnPFS register. For details, see section 19.2.5, Port mn Pin Function Select Register (PmnPFS/PmnPFS_HA/PmnPFS_BY) (m = 0 to 7; n = 00 to 15). When the EOR/EOF bits are set, the input enable of the I/O cell is asserted.

Data from the external pin is the input. For example, for PORT1, when the data is input from P100 to P115, the data of those 16 pins is organized by OR logic. This data is formed into a one-shot pulse that goes to the ELC. The operation of PORT2 to PORT4 is the same. See Figure 19.4.

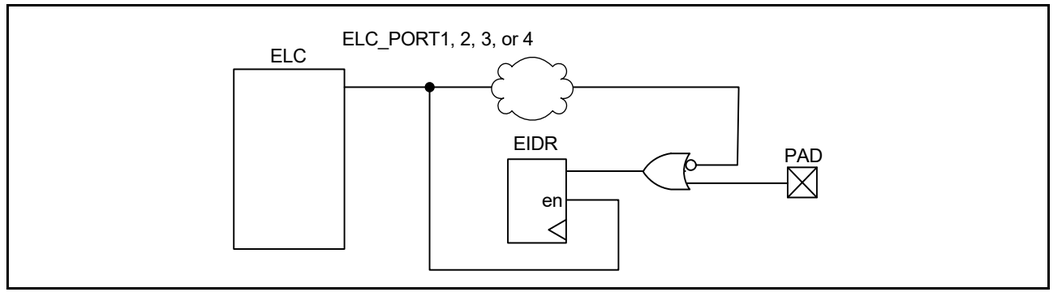

Figure 19.2 事件端口输入数据

(2) EOSREORR从PODR输出

当ELC_PORT1、2、3或4信号发生时，数据从PODR输出到基于外部引脚的EOSREORR位设置如下：

- 如果EOSR设置为1，当ELC_PORT1、2、3或4信号发生时，PODR寄存器输出1到外部引脚。否则，当EOSR=0时，保持PODR值。
- 如果EORR设置为1，则当ELC_PORT1、2、3或4信号发生时，PODR寄存器向外部引脚输出0。否则，当EORR=0时，保持PODR值。

请参见图19.3。

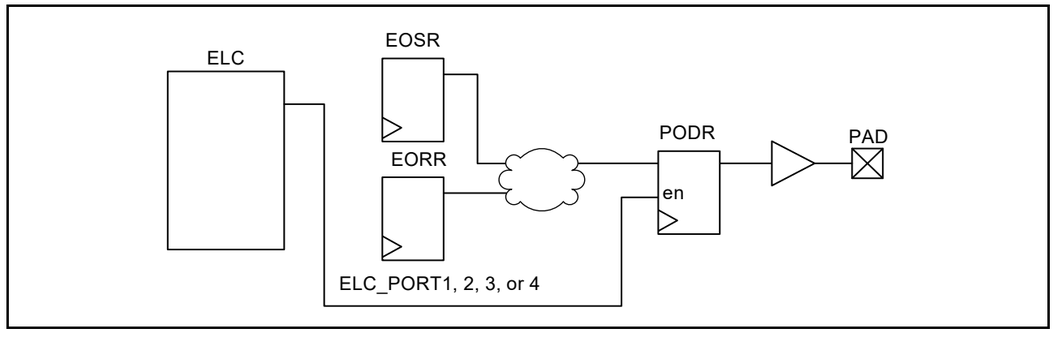

Figure 19.3 事件端口输出数据

19.3.3.2 事件脉冲输出到ELC时的行为

要将事件脉冲从外部引脚输出到ELC，请设置PmnPFS寄存器中的EOREOF位。有关详细信息，请参阅第19.2.5节，端口mn引脚功能选择寄存器(PmnPFSPmnPFS_HAPmnPFS_BY)(m=0至7；n=00至15)。当EOREOF位被置位时，IO单元的输入使能被断言。

来自外部引脚的数据是输入。例如，对于PORT1，当数据从P100输入到P115时，这16个引脚的数据由OR逻辑组织。该数据形成一个单次脉冲，该脉冲进入ELC。PORT2到PORT4的操作是一样的。请参见图19.4。

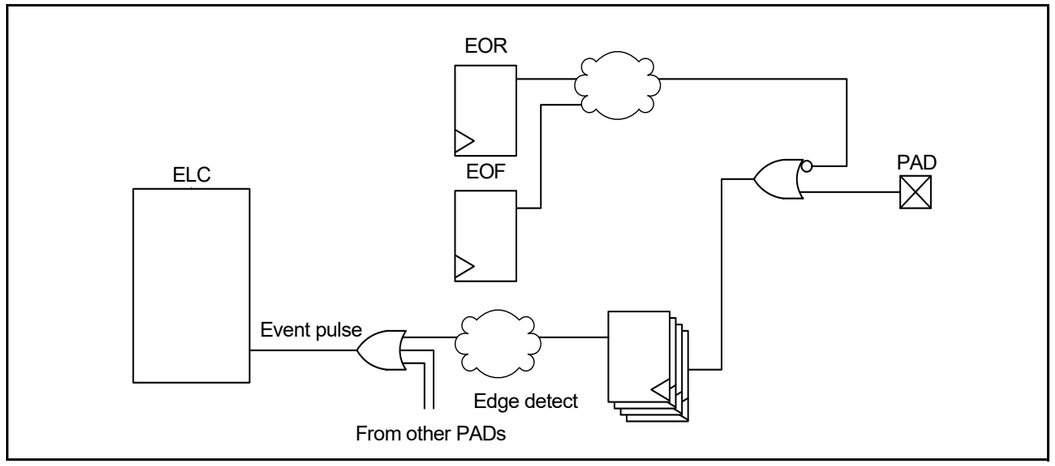

Figure 19.4 Generation of event pulse

19.4 Handling of Unused Pins

Table 19.3 shows how to handle unused pins.

Table 19.3 Handling of unused pins

Pin name	Handling when unused
MD	Use as a mode pin
RES	Connect to VCC through a resistor (pulling up)
P200/NMI	Connect to VCC through a resistor (pulling up)
EXTAL	When the main clock oscillator is not used, set the MOSCCR.MOSTP bit to 1 (general port P212). When this pin is not used as port P212, configure it in the same way as ports 1 to 7.
XTAL	When the main clock oscillator is not used, set the MOSCCR.MOSTP bit to 1 (general port P213). When the external clock is input to the EXTAL pin, the XTAL pin functions as P213. When this pin is not used as port P213, configure it in the same way as ports 1 to 7.
XCIN	Connect to VSS through a resistor (pulling down)
XCOUT	Keep pin open
P000 to P007	Connect to AVCC0 (pulled up) through a resistor or to AVSS0 (pulled down) through a resistor*1, *4
P008, P014, P015	• If the direction is set to input (PCNTR1.PDRn = 0), connect the associated pin to AVCC0 (pulled up) through a resistor or to AVSS0 (pulled down) through a resistor*1 • If the direction is set to output (PCNTR1.PDRn = 1), release the pin*1.
P1x to P7x	• If the direction is set to input (PCNTR1.PDRn = 0), connect the associated pin to VCC (pulled up) through a resistor or to VSS (pulled down) through a resistor*1, *2 • If the direction is set to output (PCNTR1.PDRn = 1), release the pin*1, *3.
VREFH0, VREFH	Connect to AVCC0
VREFL0, VREFL	Connect to AVSS0

Note 1. Clear the PmnPFS.PMR, PmnPFS.ISEL, PmnPFS.PCR, and PmnPFS.ASEL bits to 0.
Note 2. P108, P110, P300 are recommended for pull up VCC (pulled up) through a resistor, because these pins are input pull-up enabled from the initial value (PmnPFS.PCR = 1).
Note 3. P109 is recommended to be set as an output (PCNTR1.PDRn = 1), because this pin is output from the initial value.
Note 4. To reduce input leakage current of P003 and P007, set the P003PFS.ASEL and P007PFS.ASEL bits to 0.
When using 64-pin product, set P007PFS.ASEL bit to 0.

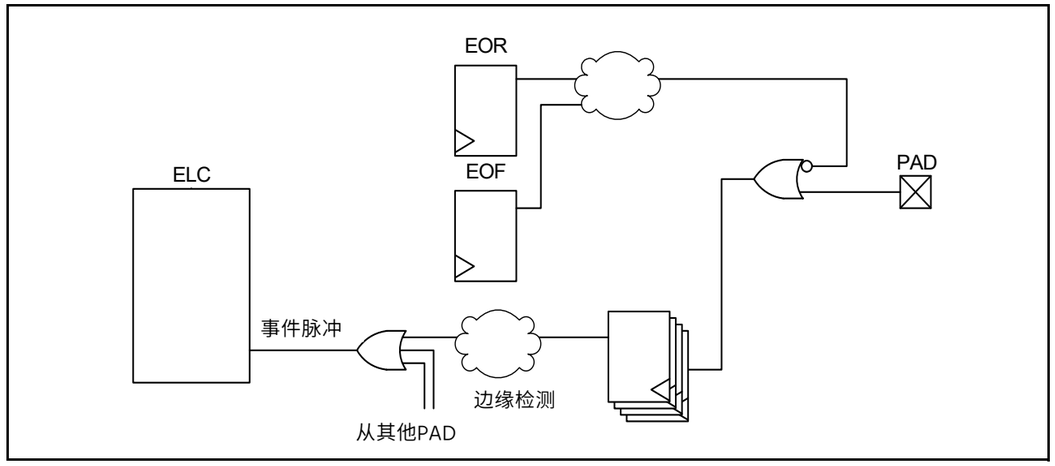

Figure 19.4 事件脉冲的产生

19.4 未使用引脚的处理

表19.3显示了如何处理未使用的引脚。

Table 19.3 处理未使用的引脚

引脚名称	未使用时的处理
MD	用作模式引脚
RES	通过一个电阻连接到VCC（上拉）
P200/NMI	通过一个电阻连接到VCC（上拉）
EXTAL	不使用主时钟振荡器时，将MOSCCR.MOSTP位设置为1（通用端口P212）。 当该管脚不作为端口P212使用时，配置方式与端口1到7相同。
XTAL	不使用主时钟振荡器时，将MOSCCR.MOSTP位设置为1（通用端口P213）。 当外部时钟输入到EXTAL引脚时，XTAL引脚起到P213的作用。当该管脚不作为端口P213使用时，按照与端口1到7相同的方式进行配置。
XCIN	通过一个电阻连接到VSS（下拉）
XCOUT	保持引脚打开
P000 to P007	通过电阻连接到AVCC0（上拉）或通过电阻连接到AVSS0（下拉）*1、*4
P008, P014, P015	如果方向设置为输入(PCNTR1.PDRn=0)，请将相关引脚通过电阻连接到AVCC0（上拉）或通过电阻连接到AVSS0（下拉）*1 如果方向设置为输出（PCNTR1.PDRn=1），释放引脚*1。
P1x to P7x	如果方向设置为输入(PCNTR1.PDRn=0)，则将相关引脚通过电阻连接到VCC（上拉）或通过电阻连接到VSS（下拉）*1、*2 如果设置了方向输出（PCNTR1.PDRn=1），释放引脚*1 *3。
VREFH0, VREFH	连接到AVCC0
VREFL0, VREFL	连接到AVSS0

Note 1. 将PmnPFS.PMR、PmnPFS.ISEL、PmnPFS.PCR和PmnPFS.ASEL位清除为0。
Note 2. 推荐使用P108、P110、P300通过电阻上拉VCC（上拉），因为这些引脚从初始值（PmnPFS.PCR=1）开始输入上拉使能。
Note 3. 建议将P109设置为输出（PCNTR1.PDRn=1），因为该引脚是从初始值输出的。
Note 4. 要降低P003和P007的输入漏电流，请将P003PFS.ASEL和P007PFS.ASEL位设置为0。
使用64针产品时，将P007PFS.ASEL位设置为0。

19.5 Usage Notes

19.5.1 Procedure for Specifying the Pin Functions

To specify the I/O pin functions:

1. Clear the B0WI bit in the PWPR register. This enables writing to the PFSWE bit in the PWPR register.
2. Set 1 to the PFSWE bit in the PWPR register. This enables writing to the PmnPFS register.
3. Clear the Port Mode Control bit in the PMR for the target pin to select the general I/O port.
4. Specify the I/O function for the pin through the PSEL[4:0] bit settings in the PmnPFS register.
5. Set the PMR bit to 1 as required to switch to the selected I/O function for the pin.
6. Clear the PFSWE bit in the PWPR register. This disables writing to the PmnPFS register.
7. Set 1 to the B0WI bit in the PWPR register. This disables writing to the PFSWE bit in the PWPR register.

19.5.2 Procedure for Using Port Group Input

To use the port group input (PORT1 to PORT4):

1. Set the ELSRx.ELS[8:0] bits to 0000 0000b to ignore unexpected pulses. For more information, see section 18, Event Link Controller (ELC).
2. Set the EOF/EOR bit of the PmnPFS register to specify the rising, falling, or both edge detections.
3. Execute a dummy read or wait for a short time, for example 100 ns. Ignoring of unexpected pulses depends on the initial value of the external pin.
4. Set the ELSRx.ELS[8:0] bits to enable the event signals.

19.5.3 Port Output Data Register (PODR) Summary

This register outputs data as follows:

1. Output 0 if PCNTR4.EORRn is set to 1 when an ELC_PORT1, 2, 3, or 4 signal occurs.
2. Output 1 if PCNTR4.EOSRn is set to 1 when an ELC_PORT1, 2, 3, or 4 signal occurs.
3. Output 0 if PCNTR3.PORRn is set to 1.
4. Output 1 if PCNTR3.POSRn is set to 1.
5. Output 0 or 1 because PCNTR1.PODRn is set.
6. Output 0 or 1 because PmnPFS.PODRn is set.

Numbers in this list correspond to the priority for writing to the PODR. For example, if 1. and 3. from the list occur at the same time, the higher priority event 1. is executed.

19.5.4 Notes on Using Analog Functions

To use an analog function, set the Port Mode Control bit (PMR) and Port Direction bit (PDR) to 0 so that the pin acts as a general input port. Next, set the Analog Input Enable bit (ASEL) in the Port mn Pin Function Select register (PmnPFS.ASEL) to 1.

19.5.5 I/O Buffer Specification

The P402, P403, and P404 can be used as AGT input and other peripheral functions.

Table 19.4 lists the P402, P403, P404 specifications.

19.5 使用说明

19.5.1 指定引脚功能的步骤

要指定IO引脚功能：

1. 将PWPR寄存器中的B0WI位清零。这允许写入PWPR寄存器中的PFSWE位。
2. 将PWPR寄存器中的PFSWE位设置为1。这允许写入PmnPFS寄存器。
3. 清除目标引脚的PMR中的端口模式控制位以选择通用IO端口。
4. 通过PmnPFS寄存器中的PSEL[4:0]位设置指定引脚的IO功能。
5. 根据需要将PMR位设置为1，以切换到为引脚选择的IO功能。
6. 将PWPR寄存器中的PFSWE位清零。这将禁止写入PmnPFS寄存器。
7. 将PWPR寄存器中的B0WI位设置为1。这将禁止写入PWPR寄存器中的PFSWE位。

19.5.2 使用端口组输入的过程

要使用端口组输入（PORT1到PORT4）：

1. 将ELSRx.ELS[8:0]位设置为00000000b以忽略意外脉冲。如需更多信息，请参阅第18节，事件链接控制器（ELC）。
2. 设置PmnPFS寄存器的EOFEOR位以指定上升沿、下降沿或两个边沿检测。
3. 执行虚拟读取或等待一小段时间，例如100ns。忽略意外脉冲取决于外部引脚的初始值。
4. 设置ELSRx.ELS[8:0]位以启用事件信号。

19.5.3 端口输出数据寄存器(PODR)摘要

该寄存器输出数据如下：

1. 当ELC_PORT1、2、3或4信号出现时，如果PCNTR4.EORRn设置为1，则输出0。
2. 当ELC_PORT1、2、3或4信号出现时，如果PCNTR4.EOSRn设置为1，则输出1。
3. 如果PCNTR3.PORRn设置为1，则输出0。
4. 如果PCNTR3.POSRn设置为1，则输出1。
5. 输出0或1，因为PCNTR1.PODRn已设置。
6. 输出0或1，因为PmnPFS.PODRn已设置。

此列表中的数字对应于写入PODR的优先级。例如，如果列表中的1.和3.同时发生，则执行优先级较高的事件1.。

19.5.4 使用模拟功能的注意事项

要使用模拟功能，请将端口模式控制位(PMR)和端口方向位(PDR)设置为0，以便引脚用作通用输入端口。接下来，将端口mn引脚功能选择寄存器(PmnPFS.ASEL)中的模拟输入使能位(ASEL)设置为1。

19.5.5 IO缓冲器规格

P402、P403和P404可用作AGT输入和其他外围功能。

表19.4列出了P402、P403、P404规格。

Table 19.4 P402, P403, P404 specifications

	Functions			
I/O port	**AGT**		**Other peripheral**	
	AGT input enable register	AGT	Other peripheral enable register	CAC, GPT, CAN, and interrupt
P402	VBTICTLR .VCH0INEN	AGTIO0 AGTIO1	P402PFS.PSEL and PMR	For details, see Table 19.12 Register settings for I/O pin functions on PORT4
P403	VBTICTLR .VCH1INEN	AGTIO0 AGTIO1	P403PFS.PSEL and PMR	
P404	VBTICTLR .VCH2INEN	—	P404PFS.PSEL and PMR	

These AGT inputs are controlled by the VBTICTLR register, which has the highest priority for selecting the AGT input functions. See Figure 19.5.

The VBTICTLR register is not initialized on reset. Therefore, when not using the AGT inputs, the associated bit of the VBTICTLR register must be set to 0 after reset. Set VBTICTLR.VCH2INEN bit to 0 after reset. When using 64-pin product, also set VBTICTLR.VCH1INEN bit to 0.

For more information on the VBTICTLR register, see section 19.2.7, AGT Input Control Register (VBTICTLR).

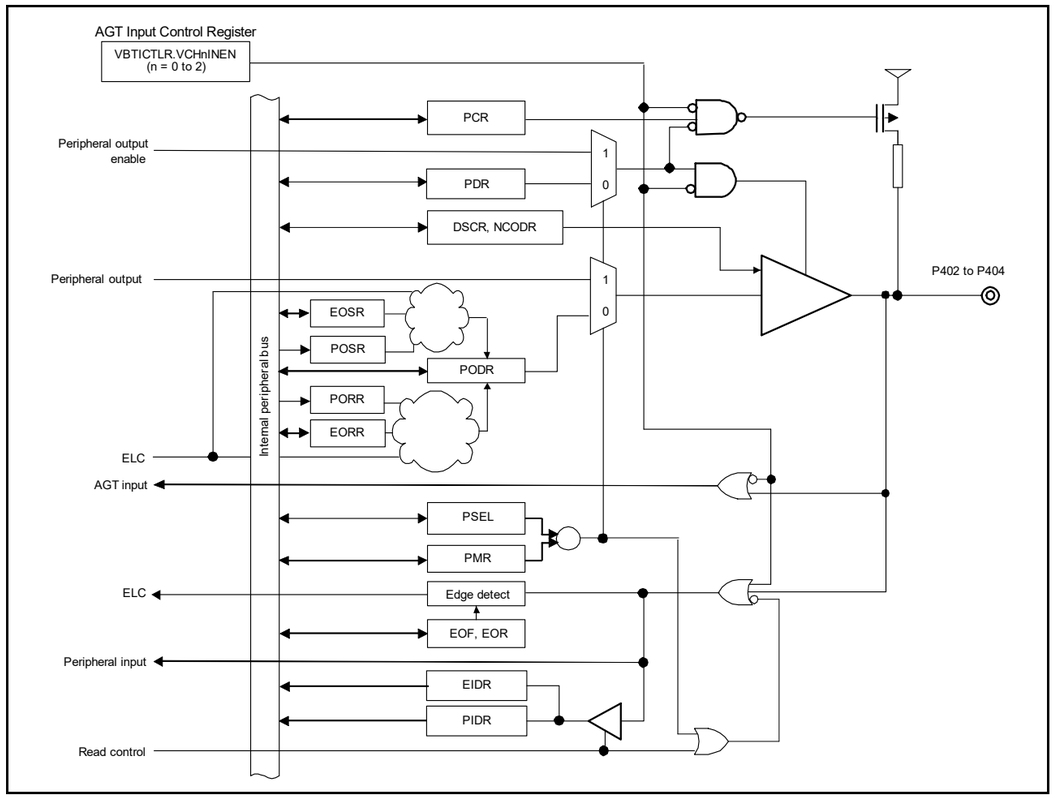

Figure 19.5 P402, P403, P404 diagram

Table 19.4 P402, P403, P404 specifications

	Functions			
I/O port	**AGT**		**其他周边**	
	AGT输入使能寄存器	AGT	其他外设使能寄存器	CAC、GPT、CAN和中断
P402	VBTICTLR .VCH0INEN	AGTIO0 AGTIO1	P402PFS.PSEL and PMR	详见表19.12 PORT4上IO引脚功能的寄存器设置
P403	VBTICTLR .VCH1INEN	AGTIO0 AGTIO1	P403PFS.PSEL and PMR	
P404	VBTICTLR .VCH2INEN	—	P404PFS.PSEL and PMR	

这些AGT输入由VBTICTLR寄存器控制，该寄存器在选择AGT输入功能时具有最高优先级。请参见图19.5。

VBTICTLR寄存器在复位时未初始化。因此，当不使用AGT输入时，相关的位
复位后VBTICTLR寄存器必须设置为0。复位后将VBTICTLR.VCH2INEN位设置为0。使用64引脚产品时，也将VBTICTLR.VCH1INEN位设置为0。

有关VBTICTLR寄存器的更多信息，请参见第19.2.7节，AGT输入控制寄存器(VBTICTLR)。

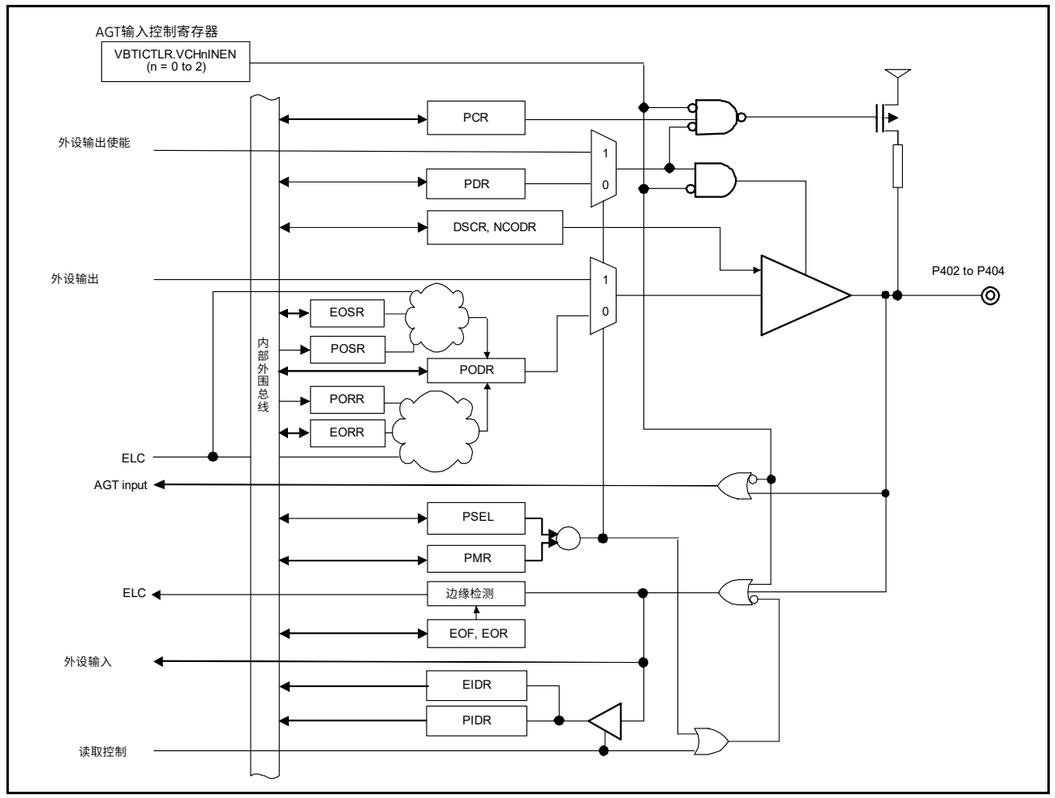

Figure 19.5 P402, P403, P404 diagram

19.6 Peripheral Select Settings for each Product

This section describes the pin function select configuration by the PmnPFS register. Some pin names have added _A and _B suffixes. When assigning IIC and SPI functionality, select the functional pins having the same suffix. The other pins can be selected regardless of the suffix. Assigning the same function to two or more pins simultaneously is prohibited.

19.7 Notes on the PmnPFS Register Setting

(1) In the Port mn Pin Function Select register (PmnPFS), the PSEL bits must be set when the PMR bit of the target pin is 0. If the PSEL bits are set when the PMR bit is 1, unexpected edges might be input for the input function or unexpected pulses might be output to the external pin for the output function.

(2) Only the allowed values (functions) should be specified in the PSEL bits of PmnPFS. If a value that is not allowed for the register is specified, the correct operation is not guaranteed.

(3) A single function should not be assigned to multiple pins by the PmnPFS register.

(4) PORT0 and PORT5 have the analog functions such as A/D converter and D/A converter. When these pins are used as an analog function, to avoid loss of resolution, the PMR and PDR bits should be set to 0. After that, the ASEL bit should be set to 1.

(5) The initial value of the ASEL bit for P003 and P007 is 1. When these pins are not used as an analog function, to reduce the input leakage current, the ASEL bit should be set to 0. When using 64-pin product, clear the P007PFS.ASEL bit to 0.

Table 19.5 Register settings for I/O pin functions (PORT0)

PSEL[4:0] settings	Function	Pin							
		P000	P001	P002	P003	P004	P005	P006	P007
00000b (value after reset)	Hi-z/JTAG/SWD	Hi-Z							
ASEL bit		AN000/ IVCMP2	AN001/ IVCMP2	AN002/ IVCMP2	PGAVSS000/ AN007	AN100/ IVCMP2	AN101/ IVCMP2	AN102/ IVCMP2	PGAVSS100/ AN107
ISEL bit		IRQ6-DS	IRQ7-DS	IRQ8-DS		IRQ9-DS	IRQ10-DS	IRQ11-DS	
DSCR[1:0] bits	Drive capacity control	—	—	—	—	—	—	—	—
NCODR bit	N-ch open-drain	—	—	—	—	—	—	—	—
PCR bit	Pull-up	—	—	—	—	—	—	—	—
Number of pins	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	—	—	—	—

✓: Available

Table 19.6 Register settings for I/O pin functions (PORT0)

PSEL[4:0] settings	Function	Pin		
		P008	P014	P015
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z		
ASEL bit		AN003	AN005/ AN105/ DA0/ IVREF3	AN006/ AN106/ DA1/ IVCMP1
ISEL bit		IRQ12-DS		IRQ13
DSCR[1:0] bits	Drive capacity control	*1	*1	*1
NCODR bit	N-ch open-drain	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓
Number of pins	100 pins	✓	✓	✓
	64 pins	—	✓	✓

✓: Available
—: Setting prohibited

Note 1. The drive strength of this port cannot be controlled by PmnPFS.DSCR[1:0] bits.

19.6 每个产品的外设选择设置

本节介绍PmnPFS寄存器的引脚功能选择配置。一些引脚名称添加了_A和_B后缀。分配IIC和SPI功能时，选择具有相同后缀的功能管脚。无论后缀如何，都可以选择其他引脚。禁止将相同的功能同时分配给两个或多个引脚。

19.7 PmnPFS寄存器设置注意事项

(1)在端口mn引脚功能选择寄存器(PmnPFS)中，当目标引脚的PMR位为0时，必须设置PSEL位。如果在PMR位为1时设置PSEL位，可能会输入意外边沿输入功能或意外脉冲可能会输出到输出功能的外部引脚。

(2)在PmnPFS的PSEL位中只应指定允许的值（功能）。如果指定了寄存器不允许的值，则不能保证正确操作。

(3)PmnPFS寄存器不应将单个功能分配给多个引脚。

(4)PORT0和PORT5具有AD转换器和DA转换器等模拟功能。当这些引脚用作模拟功能时，为避免分辨率损失，应将PMR和PDR位设置为0。之后，应将ASEL位设置为1。

(5)P003和P007的ASEL位初始值为1。当这些引脚不用作模拟功能时，为减少输入漏电流，应将ASEL位设置为0。使用64引脚产品时 将P007PFS.ASEL位清0。

Table 19.5 IO引脚功能的寄存器设置(PORT0)

PSEL[4:0] settings	Function	Pin							
		P000	P001	P002	P003	P004	P005	P006	P007
00000b (value after reset)	Hi-z/JTAG/SWD	Hi-Z							
ASEL bit		AN000/ IVCMP2	AN001/ IVCMP2	AN002/ IVCMP2	PGAVSS000/ AN007	AN100/ IVCMP2	AN101/ IVCMP2	AN102/ IVCMP2	PGAVSS100/ AN107
ISEL bit		IRQ6-DS	IRQ7-DS	IRQ8-DS		IRQ9-DS	IRQ10-DS	IRQ11-DS	
DSCR[1:0] bits	驱动容量控制	—	—	—	—	—	—	—	—
NCODR bit	N-ch open-drain	—	—	—	—	—	—	—	—
PCR bit	Pull-up	—	—	—	—	—	—	—	—
引脚数	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	—	—	—	—

✓: Available

Table 19.6 IO引脚功能的寄存器设置(PORT0)

PSEL[4:0] settings	Function	Pin		
		P008	P014	P015
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z		
ASEL bit		AN003	AN005/ AN105/ DA0/ IVREF3	AN006/ AN106/ DA1/ IVCMP1
ISEL bit		IRQ12-DS		IRQ13
DSCR[1:0] bits	驱动容量控制	*1	*1	*1
NCODR bit	N-ch open-drain	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓
引脚数	100 pins	✓	✓	✓
	64 pins	—	✓	✓

:可用—:禁止设置

Note 1. 此端口的驱动强度不能由PmnPFS.DSCR[1:0]位控制。

Table 19.7 Register settings for I/O pin functions (PORT1)

PSEL[4:0] settings	Function	Pin							
		P100	P101	P102	P103	P104	P105	P106	P107
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z							
00001b	AGT	AGTIO0	AGTEE0	AGTO0	—	—	—	AGTOB0	AGTOA0
00010b	GPT	GTETRGA	GTETRGB	GTOWLO	GTOWUP	GTETRGB	GTETRGA	—	—
00011b	GPT*2	GTIOC5B	GTIOC5A	GTIOC2B_A	GTIOC2A_A	GTIOC1B	GTIOC1A	GTIOC8B	GTIOC8A
00100b	SCI	RXD0/MISO0/ SCL0	TXD0/MOSI0/ SDA0	SCK0	CTS0_RTS0/ SS0	RXD8/MISO8/ SCL8	TXD8/MOSI8/ SDA8	SCK8	CTS8_RTS8/ SS8
00101b	SCI	SCK1	CTS1_RTS1/ SS1	—	—	—	—	—	—
00110b	SPI*1	MISOA_A	MOSIA_A	RSPCKA_A	SSLA0_A	SSLA1_A	SSLA2_A	SSLA3_A	—
00111b	IIC*1	SCL1_B	SDA1_B	—	—	—	—	—	—
01000b	KINT	KR00	KR01	KR02	KR03	KR04	KR05	KR06	KR07
01010b	CAC/ADC12	—	—	ADTRG0	—	—	—	—	—
10000b	CAN	—	—	CRX0	CTX0	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		IRQ2	IRQ1	—	—	IRQ1	IRQ0	—	—
DSCR[1:0] bits	Drive capacity control	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	✓	✓	✓	✓

✓: Available
—: Setting prohibited

Note 1. Renesas recommends using pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the interface, the AC portion of the electrical characteristics is measured for each group.
Note 2. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Table 19.7 IO引脚功能的寄存器设置(PORT1)

PSEL[4:0] settings	Function	Pin							
		P100	P101	P102	P103	P104	P105	P106	P107
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z							
00001b	AGT	AGTIO0	AGTEE0	AGTO0	—	—	—	AGTOB0	AGTOA0
00010b	GPT	GTETRGA	GTETRGB	GTOWLO	GTOWUP	GTETRGB	GTETRGA	—	—
00011b	GPT*2	GTIOC5B	GTIOC5A	GTIOC2B_A	GTIOC2A_A	GTIOC1B	GTIOC1A	GTIOC8B	GTIOC8A
00100b	SCI	RXD0/MISO0/ SCL0	TXD0/MOSI0/ SDA0	SCK0	CTS0_RTS0/ SS0	RXD8/MISO8/ SCL8	TXD8/MOSI8/ SDA8	SCK8	CTS8_RTS8/ SS8
00101b	SCI	SCK1	CTS1_RTS1/ SS1	—	—	—	—	—	—
00110b	SPI*1	MISOA_A	MOSIA_A	RSPCKA_A	SSLA0_A	SSLA1_A	SSLA2_A	SSLA3_A	—
00111b	IIC*1	SCL1_B	SDA1_B	—	—	—	—	—	—
01000b	KINT	KR00	KR01	KR02	KR03	KR04	KR05	KR06	KR07
01010b	CAC/ADC12	—	—	ADTRG0	—	—	—	—	—
10000b	CAN	—	—	CRX0	CTX0	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		IRQ2	IRQ1	—	—	IRQ1	IRQ0	—	—
DSCR[1:0] bits	驱动容量控制	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	✓	✓	✓	✓

:可用—:禁止设置

Note 1. 瑞萨电子建议使用名称后附有字母的引脚，例如"_A"或"_B"，以表示组成员身份。对于接口，测量每组电气特性的交流部分。
Note 2. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

Table 19.8 Register settings for I/O pin functions (PORT1)

PSEL[4:0] settings	Function	Pin							
		P108	P109	P110	P111	P112	P113	P114	P115
00000b (value after reset)	Hi-Z/JTAG/SWD	TMS/SWDIO	TDO/SWO	TDI	Hi-Z				
00010b	GPT	GTOULO	GTOVUP	GTOVLO	—	—	—	—	—
00011b	GPT*2	GTIOC0B_A	GTIOC1A_A	GTIOC1B_A	GTIOC3A_A	GTIOC3B_A	GTIOC2A	GTIOC2B	GTIOC4A
00100b	SCI	—	—	CTS2_RTS2/ SS2	SCK2	TXD2/MOSI2/ SDA2	RXD2/MISO2/ SCL2	—	—
00101b	SCI	CTS9_RTS9/ SS9	TXD9/MOSI9/ SDA9	RXD9/MISO9/ SCL9	SCK9	SCK1	—	—	—
00110b	SPI*1	SSLB0_B	MOSIB_B	MISOB_B	RSPCKB_B	SSLB0_B	—	—	—
01001b	CLKOUT/ACMPHS	—	CLKOUT	VCOUT	—	—	—	—	—
10000b	CAN	—	—	—	—	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		—	—	IRQ3	IRQ4	—	—	—	—
DSCR[1:0] bits	Drive capacity control	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	✓	—	—	—

✓: Available
—: Setting prohibited

Note 1. Renesas recommends using pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the interface, the AC portion of the electrical characteristics is measured for each group.
Note 2. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Table 19.8 IO引脚功能的寄存器设置(PORT1)

PSEL[4:0] settings	Function	Pin							
		P108	P109	P110	P111	P112	P113	P114	P115
00000b (value after reset)	Hi-Z/JTAG/SWD	TMS/SWDIO	TDO/SWO	TDI	Hi-Z				
00010b	GPT	GTOULO	GTOVUP	GTOVLO	—	—	—	—	—
00011b	GPT*2	GTIOC0B_A	GTIOC1A_A	GTIOC1B_A	GTIOC3A_A	GTIOC3B_A	GTIOC2A	GTIOC2B	GTIOC4A
00100b	SCI	—	—	CTS2_RTS2/ SS2	SCK2	TXD2/MOSI2/ SDA2	RXD2/MISO2/ SCL2	—	—
00101b	SCI	CTS9_RTS9/ SS9	TXD9/MOSI9/ SDA9	RXD9/MISO9/ SCL9	SCK9	SCK1	—	—	—
00110b	SPI*1	SSLB0_B	MOSIB_B	MISOB_B	RSPCKB_B	SSLB0_B	—	—	—
01001b	CLKOUT/ACMPHS	—	CLKOUT	VCOUT	—	—	—	—	—
10000b	CAN	—	—	—	—	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		—	—	IRQ3	IRQ4	—	—	—	—
DSCR[1:0] bits	驱动容量控制	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	✓	—	—	—

:可用—:禁止设置

Note 1. 瑞萨电子建议使用名称后附有字母的引脚，例如"_A"或"_B"，以表示组成员身份。对于接口，测量每组电气特性的交流部分。
Note 2. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

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Table 19.9 Register settings for I/O pin functions (PORT2)

PSEL[4:0] settings	Function	Pin				
		P200	P201	P205	P206	P207
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z				
00001b	AGT	—	—	AGTO1	—	—
00010b	GPT	—	—	GTIV	GTIU	—
00011b	GPT*2	—	—	GTIOC4A	—	—
00100b	SCI	—	—	TXD4/MOSI4/SDA4	RXD4/MISO4/SCL4	—
00101b	SCI	—	—	CTS9_RTS9/SS9	—	—
00111b	IIC*1	—	—	SCL1_A	SDA1_A	—
01001b	CLKOUT/ACMPHS	—	—	CLKOUT	—	—
10000b	CAN	—	—	—	—	—
ASEL bit		—	—	—	—	—
ISEL bit		NMI	—	IRQ1-DS	IRQ0-DS	—
DSCR[1:0] bits	Drive capacity control	—	*3	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	—	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	✓

✓: Available
—: Setting prohibited

Note 1. Renesas recommends using pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the interface, the AC portion of the electrical characteristics is measured for each group.

Note 2. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Note 3. The drive strength of this port cannot be controlled by PmnPFS.DSCR[1:0] bits.

Table 19.9 IO引脚功能的寄存器设置(PORT2)

PSEL[4:0] settings	Function	Pin				
		P200	P201	P205	P206	P207
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z				
00001b	AGT	—	—	AGTO1	—	—
00010b	GPT	—	—	GTIV	GTIU	—
00011b	GPT*2	—	—	GTIOC4A	—	—
00100b	SCI	—	—	TXD4/MOSI4/SDA4	RXD4/MISO4/SCL4	—
00101b	SCI	—	—	CTS9_RTS9/SS9	—	—
00111b	IIC*1	—	—	SCL1_A	SDA1_A	—
01001b	CLKOUT/ACMPHS	—	—	CLKOUT	—	—
10000b	CAN	—	—	—	—	—
ASEL bit		—	—	—	—	—
ISEL bit		NMI	—	IRQ1-DS	IRQ0-DS	—
DSCR[1:0] bits	驱动容量控制	—	*3	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	—	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	✓

:可用—:禁止设置

Note 1. 瑞萨电子建议使用名称后附有字母的引脚，例如"_A"或"_B"，以表示组成员身份。对于接口，测量每组电气特性的交流部分。

Note 2. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

Note 3. 此端口的驱动强度不能由PmnPFS.DSCR[1:0]位控制。

Table 19.10 Register settings for I/O pin functions (PORT2)

PSEL[4:0] settings	Function	Pin						
		P208	P209	P210	P211	P212	P213	P214
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z						
00001b	AGT	—	—	—	—	AGTEE1	—	—
00010b	GPT	GTOVL0	GTOVUP	GTIW	GTIV	GTETRGD	GTETRGC	GTIU
00011b	GPT*1	—	—	—	—	GTIOC0B	GTIOC0A	—
00101b	SCI	—	—	—	—	RXD1/MISO1/ SCL1	TXD1/MOSI1/ SDA1	—
01010b	CAC/ADC12	—	—	—	—	—	ADTRG1	—
11010b	Trace (Debug)	TDATA3	TDATA2	TDATA1	TDATA0	—	—	TCLK
ASEL bit		—	—	—	—	—	—	—
ISEL bit		—	—	—	—	IRQ3	IRQ2	—
DSCR[1:0] bits	Drive capacity control	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓	✓	✓
	64 pins	—	—	✓	—	✓	✓	—

✓: Available
—: Setting prohibited

Note 1. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Table 19.10 IO引脚功能的寄存器设置(PORT2)

PSEL[4:0] settings	Function	Pin						
		P208	P209	P210	P211	P212	P213	P214
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z						
00001b	AGT	—	—	—	—	AGTEE1	—	—
00010b	GPT	GTOVL0	GTOVUP	GTIW	GTIV	GTETRGD	GTETRGC	GTIU
00011b	GPT*1	—	—	—	—	GTIOC0B	GTIOC0A	—
00101b	SCI	—	—	—	—	RXD1/MISO1/ SCL1	TXD1/MOSI1/ SDA1	—
01010b	CAC/ADC12	—	—	—	—	—	ADTRG1	—
11010b	Trace (Debug)	TDATA3	TDATA2	TDATA1	TDATA0	—	—	TCLK
ASEL bit		—	—	—	—	—	—	—
ISEL bit		—	—	—	—	IRQ3	IRQ2	—
DSCR[1:0] bits	驱动容量控制	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓	✓	✓
	64 pins	—	—	✓	—	✓	✓	—

:可用—:禁止设置

Note 1. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

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Table 19.11 Register settings for I/O pin functions (PORT3)

PSEL[4:0] settings	Function	Pin							
		P300	P301	P302	P303	P304	P305	P306	P307
00000b (value after reset)	Hi-Z/JTAG/SWD	TCK/SWCLK	Hi-Z						
00001b	AGT	—	AGTIO0	—	—	—	—	—	—
00010b	GPT	—	GTOULO	GTOUUP	—	GTOWLO	GTOWUP	GTOULO	GTOUUP
00011b	GPT*2	GTIOC0A_A	GTIOC4B	GTIOC4A	GTIOC7B	GTIOC7A	—	—	—
00100b	SCI	—	RXD2/MISO2/ SCL2	TXD2/MOSI2/ SDA2	—	—	—	—	—
00101b	SCI	—	CTS9_RTS9/ SS9	—	—	—	—	—	—
00110b	SPI*1	SSLB1_B	SSLB2_B	SSLB3_B	—	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		—	IRQ6	IRQ5	—	IRQ9	IRQ8	—	—
DSCR[1:0] bits	Drive capacity control	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	—	—	—	—	—

✓: Available
—: Setting prohibited

Note 1. Renesas recommends using pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the interface, the AC portion of the electrical characteristics is measured for each group.
Note 2. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Table 19.11 IO引脚功能的寄存器设置(PORT3)

PSEL[4:0] settings	Function	Pin							
		P300	P301	P302	P303	P304	P305	P306	P307
00000b (value after reset)	Hi-Z/JTAG/SWD	TCK/SWCLK	Hi-Z						
00001b	AGT	—	AGTIO0	—	—	—	—	—	—
00010b	GPT	—	GTOULO	GTOUUP	—	GTOWLO	GTOWUP	GTOULO	GTOUUP
00011b	GPT*2	GTIOC0A_A	GTIOC4B	GTIOC4A	GTIOC7B	GTIOC7A	—	—	—
00100b	SCI	—	RXD2/MISO2/ SCL2	TXD2/MOSI2/ SDA2	—	—	—	—	—
00101b	SCI	—	CTS9_RTS9/ SS9	—	—	—	—	—	—
00110b	SPI*1	SSLB1_B	SSLB2_B	SSLB3_B	—	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		—	IRQ6	IRQ5	—	IRQ9	IRQ8	—	—
DSCR[1:0] bits	驱动容量控制	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	—	—	—	—	—

:可用—:禁止设置

Note 1. 瑞萨电子建议使用名称后附有字母的引脚，例如"_A"或"_B"，以表示组成员身份。对于接口，测量每组电气特性的交流部分。
Note 2. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

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Table 19.12 Register settings for I/O pin functions (PORT4)

PSEL[4:0] settings	Function	Pin							
		P400	P401	P402	P403	P404	P405	P406	P407
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z							
00001b	AGT	AGTIO1	—	—	—	—	—	—	AGTIO0
00010b	GPT	—	GTETRGA	—	—	—	—	—	—
00011b	GPT*3	GTIOC6A	GTIOC6B	—	GTIOC3A	GTIOC3B	GTIOC1A	GTIOC1B	—
00100b	SCI	SCK4	CTS4_RTS4/ SS4	—	—	—	—	—	CTS4_RTS4/ SS4
00111b	IIC*2	SCL0_A	SDA0_A	—	—	—	—	—	SDA0_B
01001b	CLKOUT/ACMPHS	—	—	—	—	—	—	—	—
01010b	CAC/ADC12	ADTRG1	—	CACREF	—	—	—	—	ADTRG0
10000b	CAN	—	CTX0	CRX0	—	—	—	—	—
Don't-care	AGT	—	—	AGTIO0*1/ AGTIO1*1	AGTIO0*1/ AGTIO1*1	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		IRQ0	IRQ5-DS	IRQ4-DS	—	—	—	—	—
DSCR[1:0] bits	Drive capacity control	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	—	—	—	—	✓

✓: Available
—: Setting prohibited

Note 1. To use this pin function, set the associated pin as a general input (set the PmnPFS.PDR and PmnPFS.PMR bits to 0).
Note 2. Renesas recommends using pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the interface, the AC portion of the electrical characteristics is measured for each group.
Note 3. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Table 19.12 IO引脚功能的寄存器设置(PORT4)

PSEL[4:0] settings	Function	Pin							
		P400	P401	P402	P403	P404	P405	P406	P407
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z							
00001b	AGT	AGTIO1	—	—	—	—	—	—	AGTIO0
00010b	GPT	—	GTETRGA	—	—	—	—	—	—
00011b	GPT*3	GTIOC6A	GTIOC6B	—	GTIOC3A	GTIOC3B	GTIOC1A	GTIOC1B	—
00100b	SCI	SCK4	CTS4_RTS4/ SS4	—	—	—	—	—	CTS4_RTS4/ SS4
00111b	IIC*2	SCL0_A	SDA0_A	—	—	—	—	—	SDA0_B
01001b	CLKOUT/ACMPHS	—	—	—	—	—	—	—	—
01010b	CAC/ADC12	ADTRG1	—	CACREF	—	—	—	—	ADTRG0
10000b	CAN	—	CTX0	CRX0	—	—	—	—	—
Don't-care	AGT	—	—	AGTIO0*1/ AGTIO1*1	AGTIO0*1/ AGTIO1*1	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		IRQ0	IRQ5-DS	IRQ4-DS	—	—	—	—	—
DSCR[1:0] bits	驱动容量控制	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	—	—	—	—	✓

:可用—:禁止设置

Note 1. 要使用此引脚功能，请将相关引脚设置为通用输入（将PmnPFS.PDR和PmnPFS.PMR位设置为0）。
Note 2. 瑞萨电子建议使用名称后附有字母的引脚，例如"_A"或"_B"，以表示组成员身份。对于接口，测量每组电气特性的交流部分。
Note 3. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

Table 19.13 Register settings for I/O pin functions (PORT4)

PSEL[4:0] settings	Function	Pin							
		P408	P409	P410	P411	P412	P413	P414	P415
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z							
00001b	AGT	—	—	AGTOB1	AGTOA1	AGTEE1	—	—	—
00010b	GPT	GTOWLO	GTOWUP	GTOVLO	GTOVUP	GTOULO	GTOUUP	—	—
00011b	GPT*2	GTIOC10B	GTIOC10A	GTIOC9B	GTIOC9A	—	—	GTIOC0B	GTIOC0A
00100b	SCI	—	—	RXD0/MISO0/ SCL0	TXD0/MOSI0/ SDA0	SCK0	CTS0_RTS0/ SS0	—	—
00101b	SCI	RXD3/MISO3/ SCL3	TXD3/MOSI3/ SDA3	SCK3	CTS3_RTS3/ SS3	—	—	—	—
00110b	SPI*1	—	—	MISOA_B	MOSIA_B	RSPCKA_B	SSLA0_B	SSLA1_B	SSLA2_B
00111b	IIC*1	SCL0_B	—	—	—	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		IRQ7	IRQ6	IRQ5	IRQ4	—	—	IRQ9	IRQ8
DSCR[1:0] bits	Drive capacity control	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	—	—	—	—

✓: Available
—: Setting prohibited

Note 1. Renesas recommends using pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the interface, the AC portion of the electrical characteristics is measured for each group.
Note 2. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Table 19.13 IO引脚功能的寄存器设置(PORT4)

PSEL[4:0] settings	Function	Pin							
		P408	P409	P410	P411	P412	P413	P414	P415
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z							
00001b	AGT	—	—	AGTOB1	AGTOA1	AGTEE1	—	—	—
00010b	GPT	GTOWLO	GTOWUP	GTOVLO	GTOVUP	GTOULO	GTOUUP	—	—
00011b	GPT*2	GTIOC10B	GTIOC10A	GTIOC9B	GTIOC9A	—	—	GTIOC0B	GTIOC0A
00100b	SCI	—	—	RXD0/MISO0/ SCL0	TXD0/MOSI0/ SDA0	SCK0	CTS0_RTS0/ SS0	—	—
00101b	SCI	RXD3/MISO3/ SCL3	TXD3/MOSI3/ SDA3	SCK3	CTS3_RTS3/ SS3	—	—	—	—
00110b	SPI*1	—	—	MISOA_B	MOSIA_B	RSPCKA_B	SSLA0_B	SSLA1_B	SSLA2_B
00111b	IIC*1	SCL0_B	—	—	—	—	—	—	—
ASEL bit		—	—	—	—	—	—	—	—
ISEL bit		IRQ7	IRQ6	IRQ5	IRQ4	—	—	IRQ9	IRQ8
DSCR[1:0] bits	驱动容量控制	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	✓	✓	—	—	—	—

:可用—:禁止设置

Note 1. 瑞萨电子建议使用名称后附有字母的引脚，例如"_A"或"_B"，以表示组成员身份。对于接口，测量每组电气特性的交流部分。
Note 2. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

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Table 19.14 Register settings for I/O pin functions (PORT5)

PSEL[4:0] settings	Function	Pin					
		P500	P501	P502	P503	P504	P508
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z					
00001b	AGT	AGTOA0	AGTOB0	—	—	—	—
00010b	GPT	GTIU	GTIV	GTIW	GTETRGC	GTETRGD	—
00011b	GPT*1	GTIOC11A	GTIOC11B	GTIOC12A	GTIOC12B	—	—
ASEL bit		AN016/ IVREF0	AN116/ IVREF1	AN017/ IVCMP0	AN117	AN018	AN020
ISEL bit		—	IRQ11	IRQ12	—	—	—
DSCR[1:0] bits	Drive capacity control	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	—	—	—	—

✓: Available
—: Setting prohibited

Note 1. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Table 19.14 IO引脚功能的寄存器设置(PORT5)

PSEL[4:0] settings	Function	Pin					
		P500	P501	P502	P503	P504	P508
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z					
00001b	AGT	AGTOA0	AGTOB0	—	—	—	—
00010b	GPT	GTIU	GTIV	GTIW	GTETRGC	GTETRGD	—
00011b	GPT*1	GTIOC11A	GTIOC11B	GTIOC12A	GTIOC12B	—	—
ASEL bit		AN016/ IVREF0	AN116/ IVREF1	AN017/ IVCMP0	AN117	AN018	AN020
ISEL bit		—	IRQ11	IRQ12	—	—	—
DSCR[1:0] bits	驱动容量控制	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓	✓
	64 pins	✓	✓	—	—	—	—

:可用—:禁止设置

Note 1. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

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Table 19.15 Register settings for I/O pin functions (PORT6)

PSEL[4:0] settings	Function	Pin					
		P600	P601	P602	P608	P609	P610
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z					
00011b	GPT*1	GTIOC6B	GTIOC6A	GTIOC7B	GTIOC4B	GTIOC5A	GTIOC5B
00101b	SCI	SCK9	RXD9	TXD9	—	—	—
01001b	CLKOUT/ACMPHS	CLKOUT	—	—	—	—	—
01010b	CAC/ADC12	CACREF	—	—	—	—	—
10000b	CAN	—	—	—	—	—	—
ASEL bit		—	—	—	—	—	—
ISEL bit		—	—	—	—	—	—
DSCR[1:0] bits	Drive capacity control	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓
Number of pins	100 pins	✓	✓	✓	✓	✓	✓
	64 pins	—	—	—	—	—	—

✓: Available
—: Setting prohibited

Note 1. There are two types of output buffer, middle drive and high drive. Renesas recommends using the same drive buffer for output skew spec (t_{GTISK}).

Table 19.15 IO引脚功能的寄存器设置(PORT6)

PSEL[4:0] settings	Function	Pin					
		P600	P601	P602	P608	P609	P610
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z					
00011b	GPT*1	GTIOC6B	GTIOC6A	GTIOC7B	GTIOC4B	GTIOC5A	GTIOC5B
00101b	SCI	SCK9	RXD9	TXD9	—	—	—
01001b	CLKOUT/ACMPHS	CLKOUT	—	—	—	—	—
01010b	CAC/ADC12	CACREF	—	—	—	—	—
10000b	CAN	—	—	—	—	—	—
ASEL bit		—	—	—	—	—	—
ISEL bit		—	—	—	—	—	—
DSCR[1:0] bits	驱动容量控制	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H	L/M/H
NCODR bit	N-ch open-drain	✓	✓	✓	✓	✓	✓
PCR bit	Pull-up	✓	✓	✓	✓	✓	✓
引脚数	100 pins	✓	✓	✓	✓	✓	✓
	64 pins	—	—	—	—	—	—

:可用—:禁止设置

Note 1. 输出缓冲器有两种类型，中驱动和高驱动。Renesas建议使用相同的驱动缓冲器来实现输出偏斜规范(tGTISK)。

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Table 19.16 Register settings for I/O pin functions (PORT7)

PSEL[4:0] settings	Function	Pin
		P708
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z
00101b	SCI	RXD1/MISO1/ SCL1
00110b	SPI*1	SSLA3_B
01010b	CAC/ADC12	CACREF
ASEL bit		—
ISEL bit		IRQ11
DSCR[1:0] bits	Drive capacity control	L/M/H
NCODR bit	N-ch open-drain	✓
PCR bit	Pull-up	✓
Number of pins	100 pins	✓
	64 pins	—

✓: Available
—: Setting prohibited

Note 1. Renesas recommends using pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the interface, the AC portion of the electrical characteristics is measured for each group.

Table 19.16 IO引脚功能的寄存器设置(PORT7)

PSEL[4:0] settings	Function	Pin
		P708
00000b (value after reset)	Hi-Z/JTAG/SWD	Hi-Z
00101b	SCI	RXD1/MISO1/ SCL1
00110b	SPI*1	SSLA3_B
01010b	CAC/ADC12	CACREF
ASEL bit		—
ISEL bit		IRQ11
DSCR[1:0] bits	驱动容量控制	L/M/H
NCODR bit	N-ch open-drain	✓
PCR bit	Pull-up	✓
引脚数	100 pins	✓
	64 pins	—

:可用—:禁止设置

Note 1. 瑞萨电子建议使用名称后附有字母的引脚，例如"_A"或"_B"，以表示组成员身份。对于接口，测量每组电气特性的交流部分。

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20. Key Interrupt Function (KINT)

20.1 Overview

A key interrupt (KEY_INTKR) can be generated by setting the Key Return Mode Register (KRM) and inputting a rising or falling edge to the key interrupt input pins, KR00 to KR07.

Table 20.1 shows the pin assignment for key interrupt detection, Table 20.2 shows the function configuration, and Figure 20.1 shows a block diagram.

Table 20.1 Assignment of key interrupt detection pins

Key interrupt mode control n (n = 0 to 7)	Description
KRM0	Controls KR00 signal in 1-bit units
KRM1	Controls KR01 signal in 1-bit units
KRM2	Controls KR02 signal in 1-bit units
KRM3	Controls KR03 signal in 1-bit units
KRM4	Controls KR04 signal in 1-bit units
KRM5	Controls KR05 signal in 1-bit units
KRM6	Controls KR06 signal in 1-bit units
KRM7	Controls KR07 signal in 1-bit units

Table 20.2 Configuration of key interrupt function

Parameter	Configuration
Input	KR00 to KR07
Control registers	Key Return Control Register (KRCTL) Key Return Mode Register (KRM) Key Return Flag Register (KRF)

20. 按键中断功能(KINT)

20.1 Overview

按键中断(KEY_INTKR)可以通过设置按键返回模式寄存器(KRM)并向按键中断输入引脚KR00到KR07输入上升沿或下降沿来产生。

表20.1显示按键中断检测的引脚分配，表20.2显示功能配置，图20.1显示框图。

Table 20.1 按键中断检测引脚的分配

按键中断模式控制n(n=0to7)	Description
KRM0	以1位为单位控制KR00信号
KRM1	以1位为单位控制KR01信号
KRM2	以1位为单位控制KR02信号
KRM3	以1位为单位控制KR03信号
KRM4	以1位为单位控制KR04信号
KRM5	以1位为单位控制KR05信号
KRM6	以1位为单位控制KR06信号
KRM7	以1位为单位控制KR07信号

Table 20.2 按键中断功能配置

Parameter	Configuration
Input	KR00 to KR07
控制寄存器	密钥返回控制寄存器(KRCTL) 密钥返回模式寄存器(KRM) 密钥返回标志寄存器(KRF)

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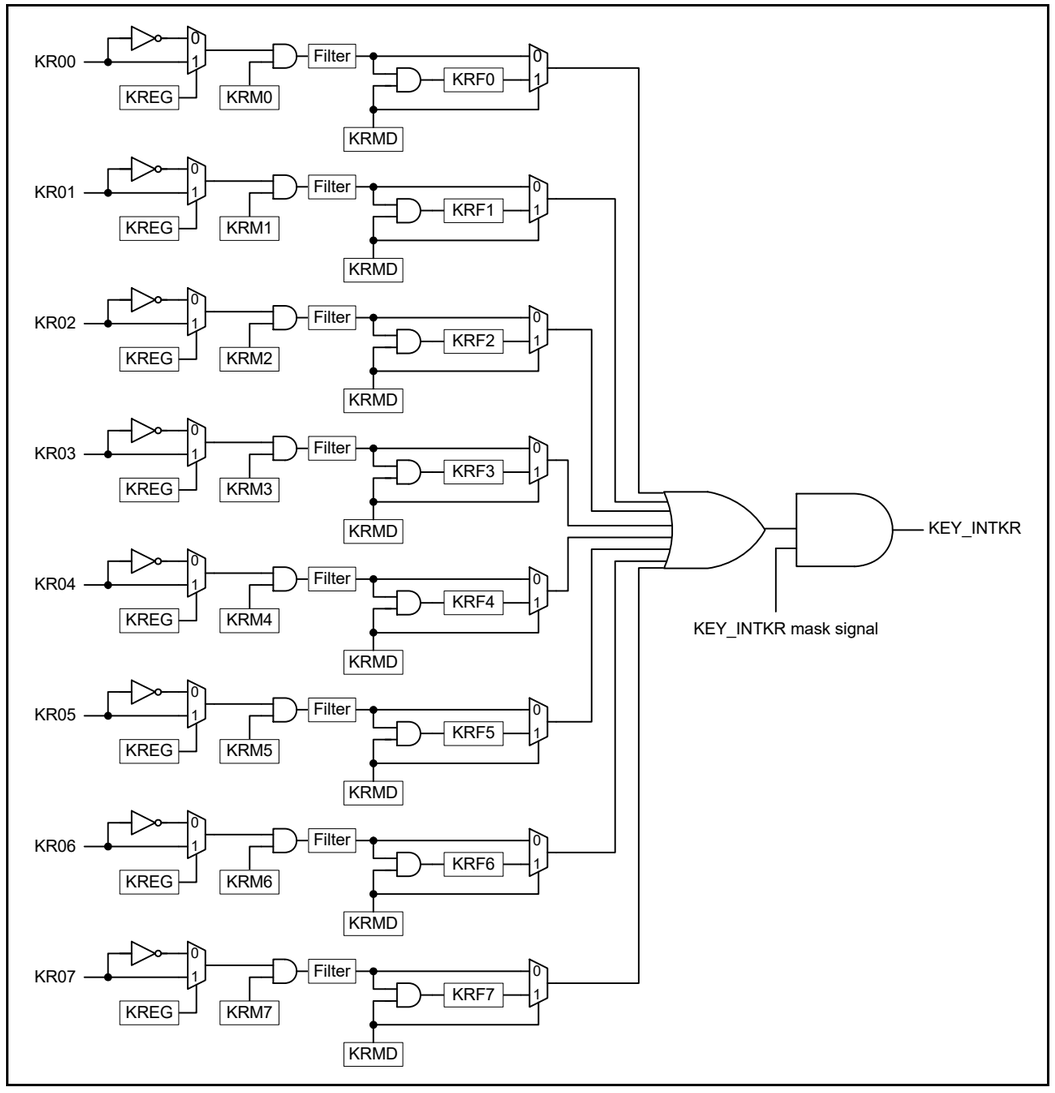


Figure 20.1 Key interrupt function block diagram

Note: In Figure 20.1, all key return factors are merged by an OR gate, and the key interrupt (KEY_INTKR) is the output of the AND gate to mask the merged key return factor by the KEY_INTKR mask signal. When using KRFn (KRMD = 1), the KEY_INTKR mask signal is used as the output mask that is asserted by clearing KRFn.

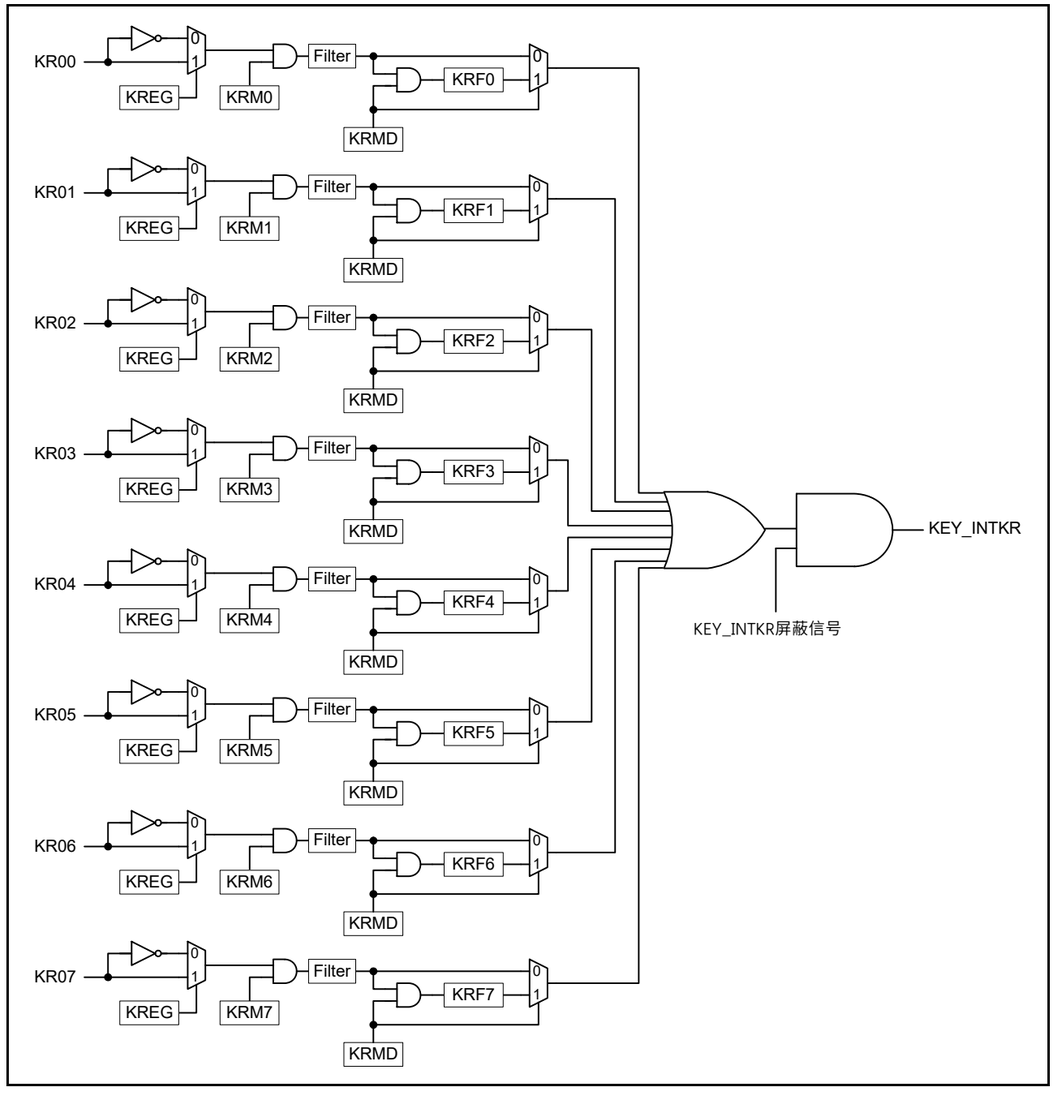


Figure 20.1 按键中断功能框图

Note: 在图20.1中，所有的键返回因子由一个或门合并，键中断（KEY_INTKR）是与门的输出，用于通过KEY_INTKR屏蔽信号屏蔽合并的键返回因子。使用KRFn(KRMD=1)时，KEY_INTKR掩码信号用作通过清除KRFn来断言的输出掩码。

20.2 Register Descriptions

20.2.1 Key Return Control Register (KRCTL)

Address(es): KINT.KRCTL 4008 0000h

	b7	b6	b5	b4	b3	b2	b1	b0
	KRMD	—	—	—	—	—	—	KREG
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	KREG	Detection Edge Selection (KR00 to KR07)	0: Falling edge 1: Rising edge.	R/W
b6 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	KRMD	Usage of Key Interrupt Flags (KRF0 to KRF7)	0: Do not use key interrupt flags 1: Use key interrupt flags.	R/W

The KRCTL register controls the usage of the key interrupt flags, KRF0 to KRF7, and sets the detection edge.

20.2.2 Key Return Flag Register (KRF)

Address(es): KINT.KRF 4008 0004h

	b7	b6	b5	b4	b3	b2	b1	b0
	KRF7	KRF6	KRF5	KRF4	KRF3	KRF2	KRF1	KRF0
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	KRFn	Key Interrupt Flag n	0: No key interrupt detected 1: Key interrupt detected.	R/W

n = 0 to 7

Note: When KRMD = 0, setting the KRFn bit to 1 is prohibited.
When setting the KRFn bit to 1, the KRFn value does not change. To clear the KRFn bit, confirm the target bit is 1 before writing 0 to the bit, then write 1 to the other bits.

The KRF register controls the key interrupt flags, KRF0 to KRF7.

20.2.3 Key Return Mode Register (KRM)

Address(es): KINT.KRM 4008 0008h

	b7	b6	b5	b4	b3	b2	b1	b0
	KRM7	KRM6	KRM5	KRM4	KRM3	KRM2	KRM1	KRM0
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	KRMn	Key Interrupt Mode Control n	0:No key interrupt signal detected 1:Key interrupt signal detected.	R/W

n = 0 to 7

20.2 注册说明

20.2.1 密钥返回控制寄存器(KRCTL)

Address(es): KINT.KRCTL 4008 0000h

	b7	b6	b5	b4	b3	b2	b1	b0
	KRMD	—	—	—	—	—	—	KREG
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	KREG	检测边缘选择（KR00至KR07）	0：下降沿1：上升沿。	R/W
b6 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	KRMD	按键中断标志（KRF0到KRF7）的使用	0：不使用按键中断标志1：使用按键中断标志。	R/W

KRCTL寄存器控制按键中断标志KRF0到KRF7的使用，并设置检测沿。

20.2.2 密钥返回标志寄存器(KRF)

Address(es): KINT.KRF 4008 0004h

	b7	b6	b5	b4	b3	b2	b1	b0
	KRF7	KRF6	KRF5	KRF4	KRF3	KRF2	KRF1	KRF0
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	KRFn	按键中断标志n	0：未检测到按键中断1：检测到按键中断。	R/W

n = 0 to 7

Note: 当KRMD=0时，禁止将KRFn位设置为1。
将KRFn位设置为1时，KRFn值不变。要清除KRFn位，在向该位写入0之前确认目标位为1，然后向其他位写入1。

KRF寄存器控制关键中断标志，KRF0到KRF7。

20.2.3 密钥返回模式寄存器(KRM)

Address(es): KINT.KRM 4008 0008h

	b7	b6	b5	b4	b3	b2	b1	b0
	KRM7	KRM6	KRM5	KRM4	KRM3	KRM2	KRM1	KRM0
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	KRMn	按键中断模式控制n	0：未检测到按键中断信号1：检测到按键中断信号。	R/W

n = 0 to 7

Note: The on-chip pull-up resistors can be applied by setting the associated key interrupt input pin in the pull-up function. For more information, see section 19, I/O Ports.
Key interrupts can be assigned in the PmnPFS.PSEL[4:0] bits. For details, see section 19, I/O Ports.
An interrupt is generated when the target bit in the KRM register is set while a low level (KREG = 0) or a high level (KREG = 1) is being input to the key interrupt input pin. To ignore this interrupt, set the KRM register after disabling the interrupt handling.

The KRM register sets the key interrupt mode.

20.3 Operation

20.3.1 Operation When Not Using Key Interrupt Flag (KRMD = 0)

A key interrupt (KEY_INTKR) is generated when the valid edge specified in the KREG bit is input to a key interrupt pin, KR00 to KR07. To identify the channel to which the valid edge is input, read the port register and check the port level after the key interrupt (KEY_INTKR) is generated.

The KEY_INTKR signal changes based on the input level of the key interrupt input pin, KR00 to KR07.

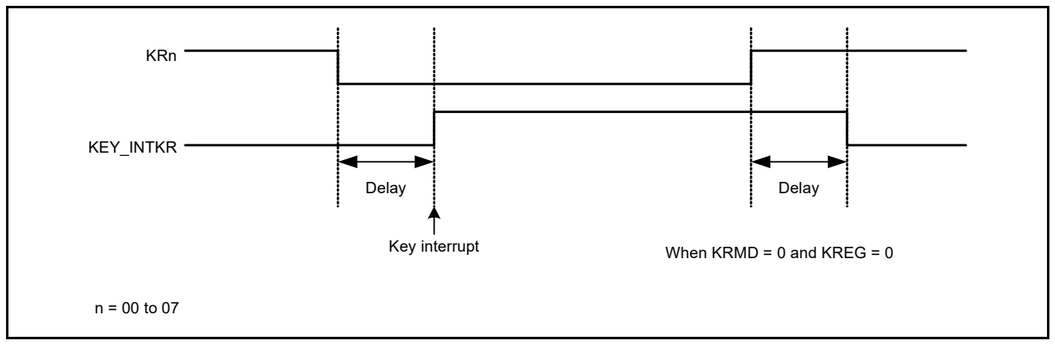


Figure 20.2 Operation of KEY_INTKR signal when a key interrupt is input to a single channel

Figure 20.3 shows the operation when a valid edge is input to multiple key interrupt input pins. The KEY_INTKR signal is set while a low level is being input to one pin (when KREG is 0). Therefore, even if a falling edge is input to another pin in this period, a key interrupt (KEY_INTKR) is not generated again. See [1] in Figure 20.3.

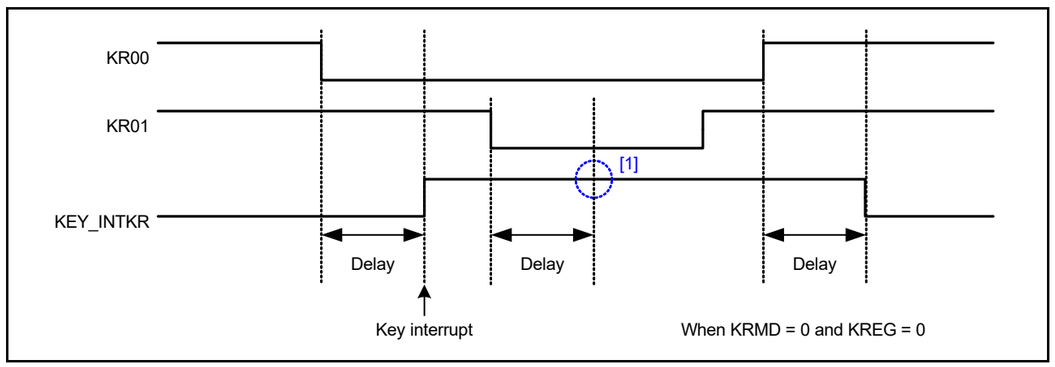


Figure 20.3 Operation of KEY_INTKR signal when key interrupts are input to multiple channels

20.3.2 Operation When Using the Key Interrupt Flags (KRMD = 1)

A key interrupt (KEY_INTKR) is generated when the valid edge specified in the KREG bit is input to a key interrupt pin, KR00 to KR07. To identify the channels to which the valid edge is input, read the Key Return Flag Register (KRF) after the key interrupt (KEY_INTKR) is generated. If the KRMD bit is set to 1, clear the KEY_INTKR signal by clearing the associated bit in the KRF register.

Note: 可以通过在上拉功能中设置相关的按键中断输入引脚来应用片上上拉电阻。有关详细信息，请参阅第19节，IO端口。可以在PmnPFS.PSEL[4:0]位中分配键中断。有关详细信息，请参阅第19节，IO端口。

当低电平(KREG=0)或高电平(KREG=1)被输入到按键中断输入引脚时，如果KRM寄存器中的目标位被置位，就会产生中断。要忽略此中断，请在禁用中断处理后设置KRM寄存器。

KRM寄存器设置按键中断模式。

20.3 Operation

20.3.1 不使用按键中断标志(KRMD=0)时的操作

当KREG位中指定的有效边沿输入到按键中断引脚时，将产生按键中断(KEY_INTKR)，KR00至KR07。要识别输入有效边沿的通道，读取端口寄存器并在按键中断（KEY_INTKR）产生后检查端口电平。

KEY_INTKR信号根据按键中断输入引脚KR00至KR07的输入电平而变化。

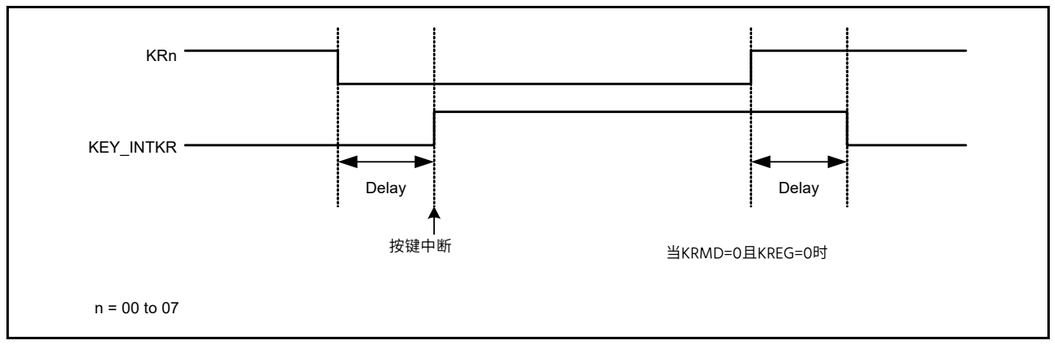


Figure 20.2 按键中断输入到单通道时KEY_INTKR信号的操作

图20.3显示了有效边沿输入到多个按键中断输入引脚时的操作。KEY_INTKR信号在低电平输入到一个引脚时设置（当KREG为0时）。因此，即使在此期间向另一个引脚输入下降沿，也不会再次产生按键中断（KEY_INTKR）。参见图20.3中的[1]。

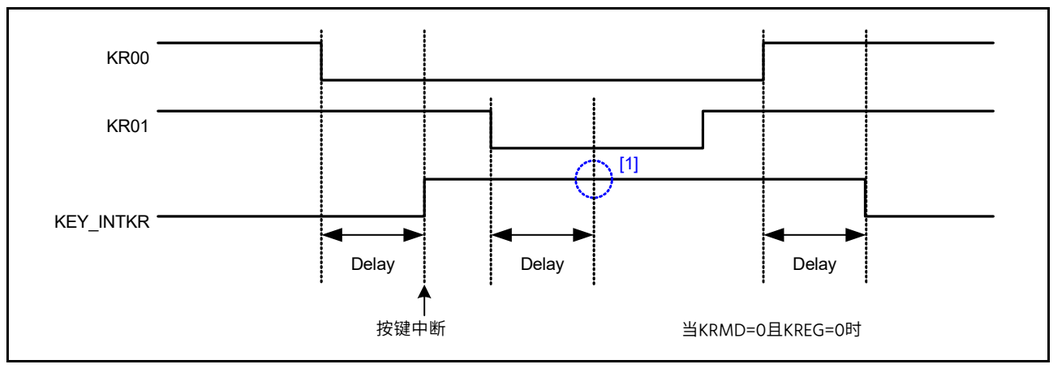


Figure 20.3 按键中断输入到多个通道时KEY_INTKR信号的操作

20.3.2 使用按键中断标志(KRMD=1)时的操作

当KREG位中指定的有效边沿输入到按键中断引脚KR00至KR07时，将产生按键中断(KEY_INTKR)。要识别输入有效边沿的通道，请在生成按键中断(KEY_INTKR)后读取按键返回标志寄存器(KRF)。如果KRMD位设置为1，则通过清除KRF寄存器中的相关位来清除KEY_INTKR信号。

As Figure 20.4 shows, only one interrupt is generated each time a falling edge is input to one channel, that is, when KREG = 0, regardless of whether the KRFn bit is cleared before or after a rising edge is input.

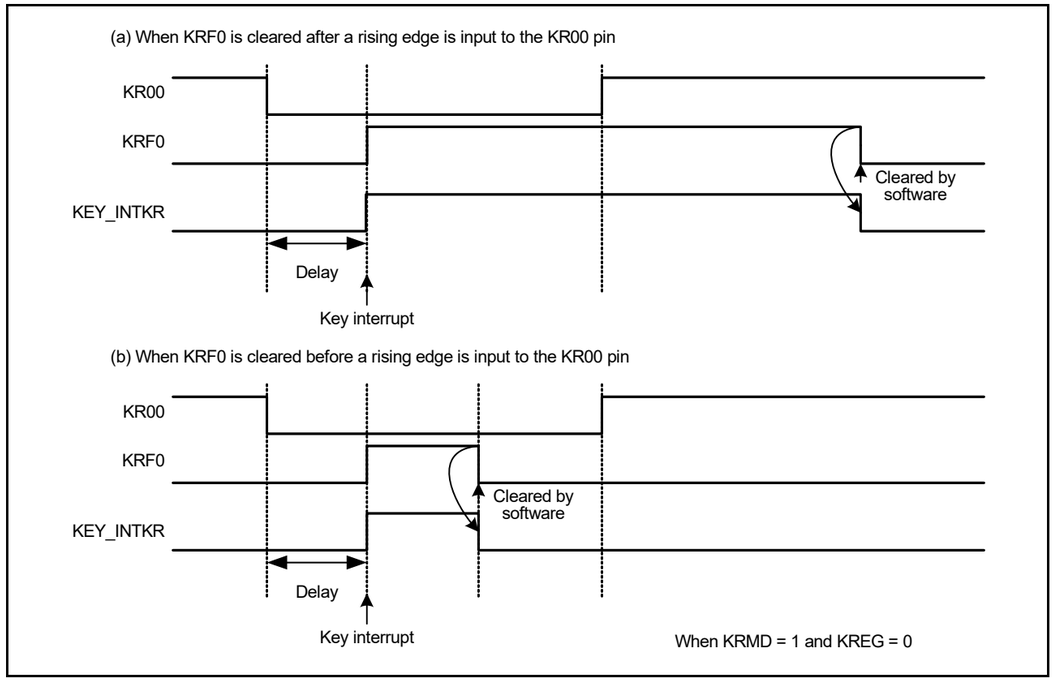


Figure 20.4 Basic operation of KEY_INTKR signal when key interrupt flag is used

Figure 20.5 shows the operation when a valid edge is input to multiple key interrupt input pins. A falling edge is also input to the KR01 and KR05 pins after a falling edge is input to the KR00 pin (when KREG is 0). The KRF1 bit is set when the KRF0 bit is cleared. A key interrupt is generated 1 PCLKB clock cycle, after the KRF0 bit is cleared. See [1] in Figure 20.5. Also, after a falling edge is input to the KR05 pin, the KRF5 bit is set. The KRF1 bit is cleared at time [2] in the figure. A key interrupt is generated 1 PCLKB clock cycle, after the KRF1 bit is cleared. See [3] in the figure. It is therefore possible to generate a key interrupt when a valid edge is input to multiple channels.

如图20.4所示，每次下降沿输入到一个通道时，只产生一个中断，即当KREG=0，无论KRFn位是在输入上升沿之前还是之后清零。

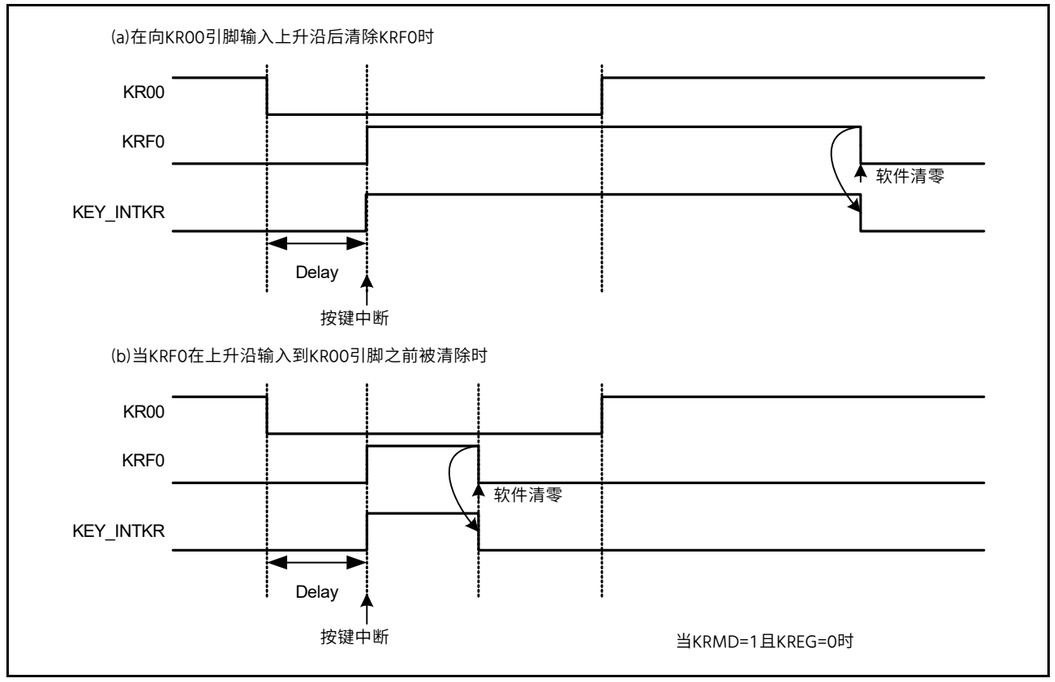


Figure 20.4 使用按键中断标志时KEY_INTKR信号的基本操作

图20.5显示了有效边沿输入到多个按键中断输入引脚时的操作。在向KR00引脚输入下降沿后（当KREG为0时），也会向KR01和KR05引脚输入一个下降沿。当KRF0位被清零时，KRF1位被置位。在KRF0位清零后，1个PCLKB时钟周期产生一个按键中断。请参见图20.5中的[1]。此外，在向KR05引脚输入下降沿后，KRF5位被置位。KRF1位在图中的时间[2]处被清除。在KRF1位清零后，1个PCLKB时钟周期产生一个按键中断。见图[3]。因此，当有效边沿输入到多个通道时，可能会产生按键中断。

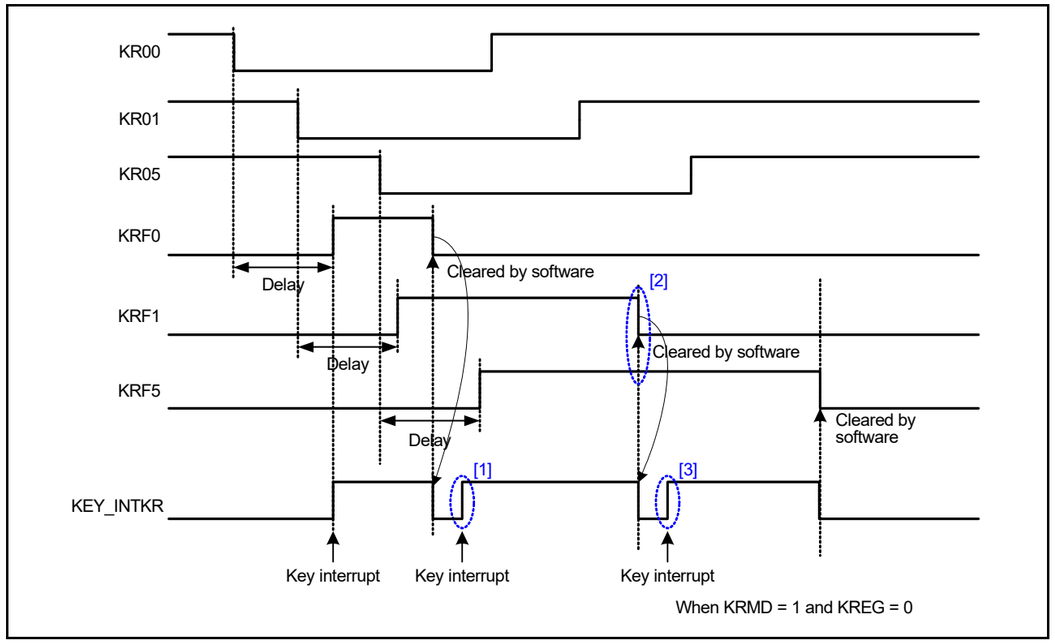


Figure 20.5 Operation of KEY_INTKR signal when key interrupts are input to multiple channels

20.4 Usage Notes

- If KEY_INTKR is used as the snooze request, the KRMD bit must be set to 0.
- If KEY_INTKR is used as the interrupt source for returning to Normal mode from Snooze mode and Software Standby mode, the KRMD bit must be set to 1.
- When the Key Interrupt function (KINT) is assigned to a pin, this pin input is always enabled in Software Standby mode, and if the pin level changes, the associated KRFn flag can be set. Therefore, a key interrupt might occur on canceling Software Standby mode.

To ignore changes to the key interrupt pin during a software standby, clear the associated KRM bit before entering Software Standby mode. After canceling Software Standby mode, you must clear KRFn before the associated KRM bit can be set.

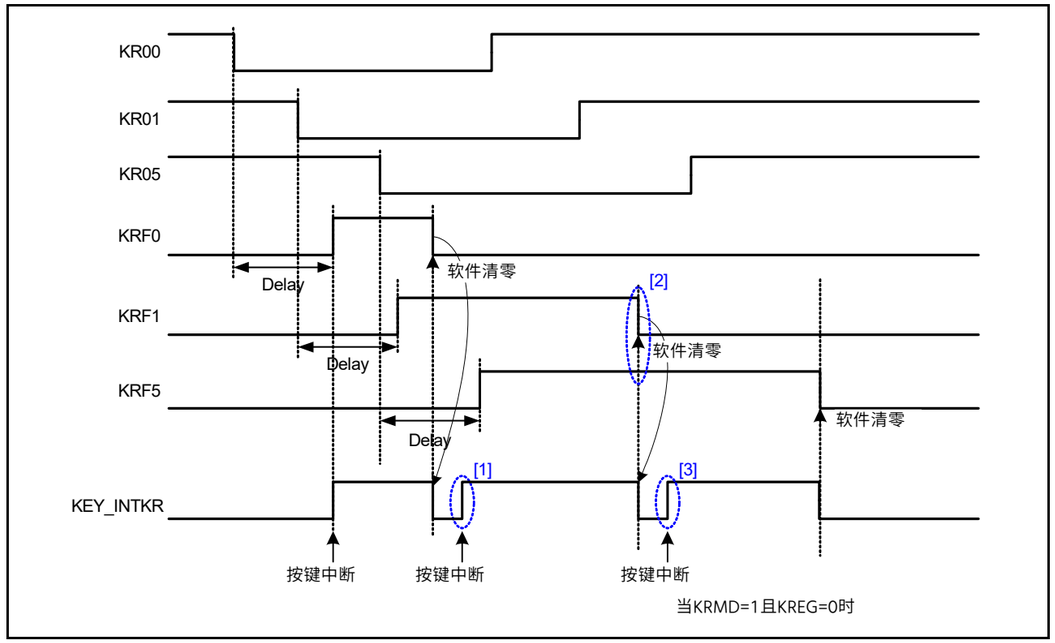


Figure 20.5 按键中断输入到多个通道时KEY_INTKR信号的操作

20.4 使用说明

- 如果KEY_INTKR用作贪睡请求，则KRMD位必须设置为0。
- 如果KEY_INTKR用作从贪睡模式和软件返回正常模式的中断源
  待机模式下，KRMD位必须设置为1。
- 当按键中断功能(KINT)分配给某个引脚时，该引脚输入始终在软件待机模式下启用，如果引脚电平发生变化，则可以设置相关的KRFn标志。因此，取消软件待机模式时可能会发生按键中断。

要在软件待机期间忽略对键中断引脚的更改，请在进入之前清除相关的KRM位
软件待机模式。取消软件待机模式后，必须先清除KRFn，然后才能设置相关的KRM位。

21. Port Output Enable for GPT (POEG)

21.1 Overview

The Port Output Enable for GPT (POEG) function can place the General PWM Timer (GPT) output pins in the output-disable state in one of the following ways:

- Input level detection of the GTETRGn (n = A, B, C, D) pins
- Output-disable request from the GPT
- Comparator interrupt request detection
- Oscillation stop detection of the clock generation circuit
- Register settings.

The GTETRGn (n = A, B, C, D) pins can also be used as GPT external trigger input pins.

Table 21.1 lists the POEG specifications, Figure 21.1 shows a block diagram, and Table 21.2 lists the input pins.

Table 21.1 POEG specifications

Parameter	Specifications
Output-disable control through input level detection	The GPT output pins can be disabled when a GTETRGn rising edge or high level is sampled after polarity and filter selection
Output-disable request from the GPT	• When the GTIOCA and the GTIOCB pins are driven to an active level simultaneously, the GPT generates an output-disable request to the POEG.Through reception of these requests, the POEG can control whether the GTIOCA and GTIOCB pins are output-disabled. • GPT output pins can be disabled when the GPT output pins detect a dead time error.
Output-disable control through comparator (ACMPHS) interrupt detection	The GPT output pins can be disabled when an interrupt request is generated by a change in the output results of any of the comparators
Output-disable control through oscillation stop detection	The GPT output pins can be disabled when oscillation of the clock generation circuit stops
Output-disable control by software (registers)	The GPT output pins can be disabled by modifying the register settings
Interrupts	• Allows output-disable control by the input level detection • Allows output-disable requests from the GPT or ACMPHS.
External trigger output to the GPT (count start, count stop, count clear, up-count, down-count, or input capture function)	The GTETRGn signals can be output to the GPT after polarity and filter selection
Noise filtering	• Three times sampling for every PCLKB/1, PCLKB/8, PCLKB/32, or PCLKB/128 can be set for any of the input pins GTETRGn • Positive or negative polarity can be selected for any of the input pins GTETRGn • Signal state after polarity and filter selection can be monitored.

21. GPT(POEG)的端口输出使能

21.1 Overview

GPT端口输出使能(POEG)功能可以通过以下方式之一将通用PWM定时器(GPT)输出引脚置于输出禁用状态：

- GTETRn(n=A B C D)引脚的输入电平检测
- 来自GPT的输出禁用请求
- 比较器中断请求检测
- 时钟发生电路的振荡停止检测
- 注册设置。

GTETRn(n=A B C D)引脚也可用作GPT外部触发输入引脚。

表21.1列出了POEG规范，图21.1显示了框图，表21.2列出了输入引脚。

Table 21.1 POEG specifications

Parameter	Specifications
通过输入电平检测进行输出禁用控制	在极性和滤波器选择后采样GTETRn上升沿或高电平时，可以禁用GPT输出引脚
来自GPT的输出禁用请求	当GTIOCA和GTIOCB引脚被驱动到有效电平时 同时，GPT向POEG产生一个输出禁止请求。通过接收这些请求，POEG可以控制GTIOCA和GTIOCB引脚是否禁止输出。 当GPT输出引脚检测到死区时间错误时，可以禁用GPT输出引脚。
通过比较器(ACMPHS)中断检测进行输出禁用控制	当任何比较器的输出结果发生变化而产生中断请求时，可以禁用GPT输出引脚
通过振荡停止检测进行输出禁用控制	当时钟生成电路的振荡停止时，可以禁用GPT输出引脚
通过软件（寄存器）进行输出禁用控制	可以通过修改寄存器设置来禁用GPT输出引脚
Interrupts	允许通过输入电平检测进行输出禁用控制 允许来自GPT或ACMPHS的输出禁用请求。
到GPT的外部触发输出（计数开始、计数停止、计数清除、递增计数、递减计数或输入捕捉功能）	GTETRn信号可在极性和滤波器选择后输出到GPT
噪声过滤	可以为任何输入引脚GTETRGn设置每个PCLKB1、PCLKB8、PCLKB32或PCLKB128的3次采样 可以为任何输入引脚GTETRGn选择正极性或负极性 极性和滤波后的信号状态可以监控选择。

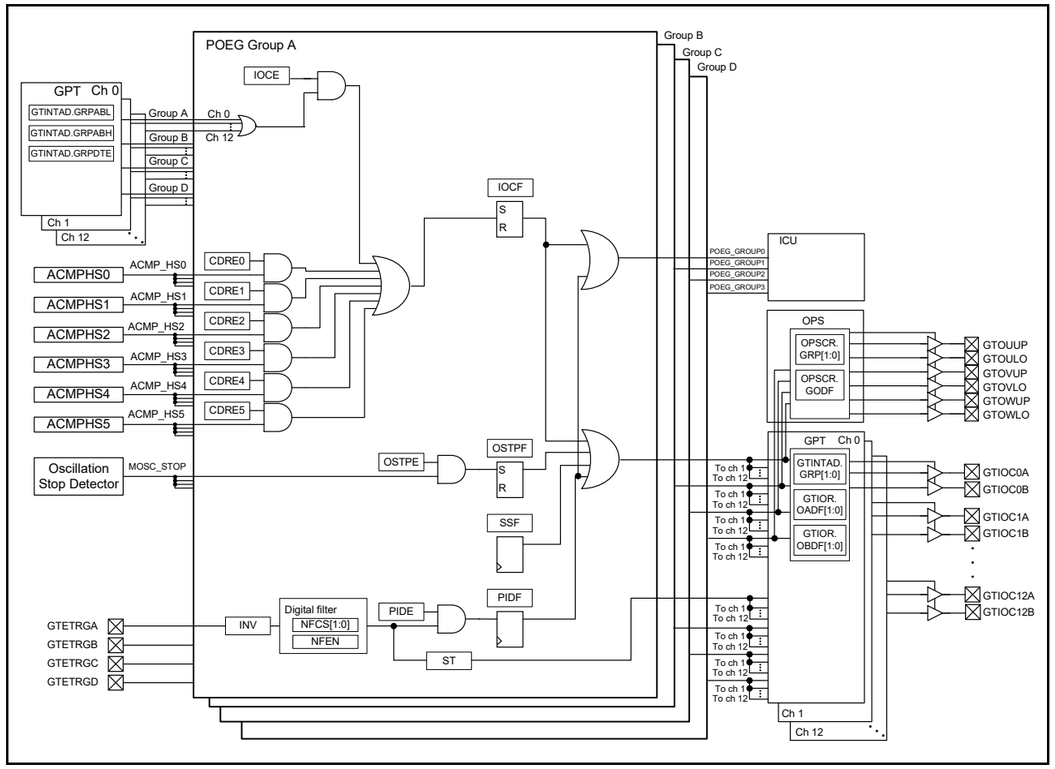


Figure 21.1 POEG block diagram

Table 21.2 POEG input pins

Pin name	I/O	Description
GTETRGA	Input	GPT output pin output-disable request signal and GPT external trigger input pin A
GTETRGB	Input	GPT output pin output-disable request signal and GPT external trigger input pin B
GTETRGC	Input	GPT output pin output-disable request signal and GPT external trigger input pin C
GTETRGD	Input	GPT output pin output-disable request signal and GPT external trigger input pin D

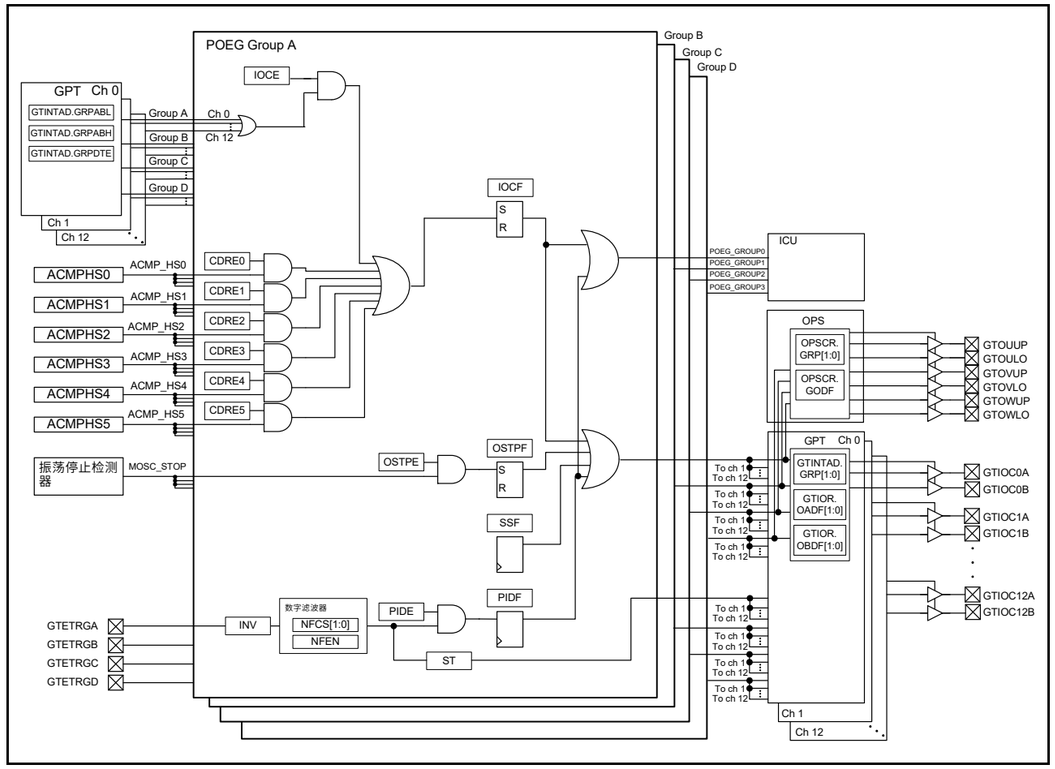


Figure 21.1 POEG框图

Table 21.2 POEG输入引脚

引脚名称	I/O	Description
GTETRGA	Input	GPT输出引脚输出禁止请求信号和GPT外部触发输入引脚A
GTETRGB	Input	GPT输出引脚输出禁止请求信号和GPT外部触发输入引脚B
GTETRGC	Input	GPT输出引脚输出禁止请求信号和GPT外部触发输入引脚C
GTETRGD	Input	GPT输出引脚输出禁止请求信号和GPT外部触发输入引脚D

21.2 Register Descriptions

21.2.1 POEG Group n Setting Register (POEGGn) (n = A to D)

Address(es): POEG.POEGGA 4004 2000h, POEG.POEGGB 4004 2100h, POEG.POEGGC 4004 2200h, POEG.POEGGD 4004 2300h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	NFCS[1:0]		NFEN	INV	—	—	—	—	—	—	—	—	—	—	—	ST
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	CDRE5	CDRE4	CDRE3	CDRE2	CDRE1	CDRE0	—	OSTPE	IOCE	PIDE	SSF	OSTPF	IOCF	PIDF
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	PIDF	Port Input Detection Flag	0: No output-disable request from the GTETRGn pin occurred 1: Output-disable request from the GTETRGn pin occurred.	R(/W)*1
b1	IOCF	Detection Flag for GPT or ACMPHS Output-Disable Request	0: No output-disable request from the GPT disable request or the ACMPHS occurred 1: Output-disable request from the GPT disable request or the ACMPHS occurred.	R(/W)*1
b2	OSTPF	Oscillation Stop Detection Flag	0: No output-disable request from the oscillation stop detection occurred 1: Output-disable request from the oscillation stop detection occurred.	R(/W)*1
b3	SSF	Software Stop Flag	0: No output-disable request from software occurred 1: Output-disable request from software occurred.	R/W
b4	PIDE	Port Input Detection Enable	0: Output-disable requests from the GTETRGn pins disabled 1: Output-disable requests from the GTETRGn pins enabled.	R/W*2
b5	IOCE	Enable for GPT Output-Disable Request	0: Output-disable requests from the GPT disable request disabled 1: Output-disable requests from the GPT disable request enabled.	R/W*2
b6	OSTPE	Oscillation Stop Detection Enable	0: Output-disable requests from the oscillation stop detection disabled 1: Output-disable requests from the oscillation stop detection enabled.	R/W*2
b7	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b8	CDRE0	ACMP_HS0 Enable	0: Comparator 0 disable requests disabled 1: Comparator 0 disable requests enabled.	R/W*2
b9	CDRE1	ACMP_HS1 Enable	0: Comparator 1 disable requests disabled 1: Comparator 1 disable requests enabled.	R/W*2
b10	CDRE2	ACMP_HS2 Enable	0: Comparator 2 disable requests disabled 1: Comparator 2 disable requests enabled.	R/W*2
b11	CDRE3	ACMP_HS3 Enable	0: Comparator 3 disable requests disabled 1: Comparator 3 disable requests enabled.	R/W*2
b12	CDRE4	ACMP_HS4 Enable	0: Comparator 4 disable requests disabled 1: Comparator 4 disable requests enabled.	R/W*2
b13	CDRE5	ACMP_HS5 Enable	0: Comparator 5 disable requests disabled 1: Comparator 5 disable requests enabled.	R/W*2
b15, b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b16	ST	GTETRGn Input Status Flag	0: GTETRGn input after filtering is 0 1: GTETRGn input after filtering is 1.	R
b27 to b17	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

21.2 注册说明

21.2.1 POEG组n设置寄存器(POEGGn)(n=A到D)

Address(es): POEG.POEGGA 4004 2000h, POEG.POEGGB 4004 2100h, POEG.POEGGC 4004 2200h, POEG.POEGGD 4004 2300h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	NFCS[1:0]		NFEN	INV	—	—	—	—	—	—	—	—	—	—	—	ST
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	CDRE5	CDRE4	CDRE3	CDRE2	CDRE1	CDRE0	—	OSTPE	IOCE	PIDE	SSF	OSTPF	IOCF	PIDF
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	PIDF	端口输入检测标志	0：未发生来自GTETRn引脚的输出禁止请求1：发生了来自GTETRn引脚的输出禁止请求。	R(/W)*1
b1	IOCF	GPT或ACMPHS输出禁用检测标志 Request	0：未发生来自GPT禁用请求或ACMPHS的输出禁用请求1：发生了来自GPT禁用请求或ACMPHS的输出禁用请求。	R(/W)*1
b2	OSTPF	振荡停止检测 Flag	0：未发生振荡停止检测的输出禁止请求1：发生了振荡停止检测的输出禁止请求。	R(/W)*1
b3	SSF	软件停止标志	0：没有来自软件的输出禁止请求1：有来自软件的输出禁止请求。	R/W
b4	PIDE	端口输入检测启用	0：禁止来自GTETRn引脚的输出禁止请求1：允许来自GTETRn引脚的输出禁止请求。	R/W*2
b5	IOCE	启用GPT输出禁用请求	0：禁用来自GPT禁用请求的输出禁用请求1：启用来自GPT禁用请求的输出禁用请求。	R/W*2
b6	OSTPE	振荡停止检测 Enable	0：禁止来自振荡停止检测的输出禁止请求1：允许来自振荡停止检测的输出禁止请求。	R/W*2
b7	—	Reserved	该位读取为0。写入值应为0。	R/W
b8	CDRE0	ACMP_HS0 Enable	0：比较器0禁用请求禁用1：比较器0禁用请求启用。	R/W*2
b9	CDRE1	ACMP_HS1 Enable	0：比较器1禁用请求禁用1：比较器1禁用请求启用。	R/W*2
b10	CDRE2	ACMP_HS2 Enable	0：比较器2禁用请求禁用1：比较器2禁用请求启用。	R/W*2
b11	CDRE3	ACMP_HS3 Enable	0：比较器3禁用请求禁用1：比较器3禁用请求启用。	R/W*2
b12	CDRE4	ACMP_HS4 Enable	0：比较器4禁用请求禁用1：比较器4禁用请求启用。	R/W*2
b13	CDRE5	ACMP_HS5 Enable	0：比较器5禁用请求禁用1：比较器5禁用请求启用。	R/W*2
b15, b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b16	ST	GTETRn输入状态标志	0：GTETRn滤波后输入为01：GTETRn滤波后输入为1。	R
b27 to b17	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b28	INV	GTETRGn Input Reverse	0: Input GTETRGn as-is 1: Input GTETRGn reversed.	R/W
b29	NFEN	Noise Filter Enable	0: Noise filtering disabled 1: Noise filtering enabled.	R/W
b31, b30	NFCS[1:0]	Noise Filter Clock Select	b1 b0 0 0: GTETRGn pin input level sampled three times every PCLKB 0 1: GTETRGn pin input level sampled three times every PCLKB/8 1 0: GTETRGn pin input level sampled three times every PCLKB/32 1 1: GTETRGn pin input level sampled three times every PCLKB/128.	R/W

Note 1. Only 0 can be written to clear the flag.
Note 2. Can be modified only once after a reset.

The POEGGA to POEGGD registers control the output-disable state of the GPT pins, interrupts, and the external trigger input to the GPT. In the descriptions, POEGGn represents all of the POEGGA to POEGGD registers.

21.3 Output-Disable Control Operation

If any of the following conditions is satisfied, the GTIOCxA, GTIOCxB, and the 3-phase PWM output for BLDC motor control pins can be set to output-disable:

- Input level or edge detection of the GTETRGn pins
  When POEGGn.PIDE is 1, the POEGGn.PIDF flag is set to 1.
- Output-disable request from the GPT
  When POEGGn.IOCE is 1, the POEGGn.IOCF flag is set to 1 if the disable request is enabled in the GTINTAD register. The GTINTAD.GRPDTE, GTINTAD.GRPABH, and GTINTAD.GRPABL settings apply to the group selected in the GPT registers GTINTAD.GRP[1:0] and OPSCR.GRP[1:0].
- Comparator (ACMPHS) interrupt request detection
  Comparator interrupt detection is activated when any of the POEGGn.CDRE[5:0] registers is 1. When the associated comparator interrupt is generated, the GPT output pins are disabled. POEGGn.IOCF indicates the detection status.
- Oscillation stop detection for the clock generation circuit
  When POEGGn.OSTPE is 1, the POEGGn.OSTPF flag is set to 1.
- SSF bit setting
  When POEGGn.SSF is set to 1, the PWM output is disabled.

The output-disable state is controlled in the GPT. The output-disable of the GTIOCxA and GTIOCxB pins is set in the GTINTAD.GRP[1:0], GTIOR.OADF[1:0], and GTIOR.OBDF[1:0] bits in GPTx. The output-disable of the 3-phase PWM output for the BLDC motor control pins is set in the OPSCR.GRP[1:0] bits and OPSCR.GODF bit in GPT_OPS.

21.3.1 Pin Input Level Detection Operation

If the input conditions set in POEGGn.PIDE, POEGGn.NFCS[1:0], POEGGn.NFEN, and POEGGn.INV occur on the GTETRGn pins, the GPT output pins are output-disabled.

21.3.1.1 Digital filter

Figure 21.2 shows high level detection by the digital filter. When a high level associated with the POEGGn.INV polarity setting is detected three times consecutively with the sampling clock selected in POEGGn.NFCS[1:0] and POEGGn.NFEN, the detected level is recognized as high, and the GPT output pins are output-disabled. If even one low level is detected during this interval, the detected level is not recognized as high. In addition, in an interval where the sampling clock is not output, changes of the levels on the GTETRGn pins are ignored.

Bit	Symbol	位名称	Description	R/W
b28	INV	GTETRn输入反向	0：按原样输入GTETRn1：输入GTETRn反转。	R/W
b29	NFEN	噪声过滤器启用	0：禁用噪声过滤1：启用噪声过滤。	R/W
b31, b30	NFCS[1:0]	噪声滤波器时钟选择	b1b000：GTETRn引脚输入电平每PCLKB采样3次01：GTETRn引脚输入电平每PCLKB采样3次810：GTETRn引脚输入电平每PCLKB采样3次3211：GTETRn引脚输入电平采样3次每个PCLKB128。	R/W

Note 1. 只能写入0来清除标志。
Note 2. 重置后只能修改一次。

POEGGA到POEGGD寄存器控制GPT引脚的输出禁用状态、中断和GPT的外部触发输入。在描述中，POEGGn代表所有的POEGGA到POEGGD寄存器。

21.3 输出禁用控制操作

如果满足以下任一条件，则GTIOCxA、GTIOCxB和BLDC电机控制引脚的3相PWM输出可设置为输出禁用：

- GTETRn引脚的输入电平或边沿检测
  当POEGGn.PIDE为1时，POEGGn.PIDF标志设置为1。
- 来自GPT的输出禁用请求
  当POEGGn.IOCE为1时，如果在GTINTAD寄存器中启用了禁用请求，则POEGGn.IOCF标志设置为1。GTINTAD.GRPDTE、GTINTAD.GRPABH和GTINTAD.GRPABL设置适用于在GPT寄存器GTINTAD.GRP[1:0]和OPSCR.GRP[1:0]中选择的组。
- 比较器(ACMPHS)中断请求检测
  当任何POEGGn.CDRE[5:0]寄存器为1时，比较器中断检测被激活。当相关的比较器中断产生时，GPT输出引脚被禁用。POEGGn.IOCF指示检测状态。
- 时钟发生电路的振荡停止检测
  当POEGGn.OSTPE为1时，POEGGn.OSTPF标志设置为1。
- SSF位设置
  当POEGGn.SSF设置为1时，PWM输出被禁用。

输出禁用状态由GPT控制。GTIOCxA和GTIOCxB引脚的输出禁用在GPTx中的GTINTAD.GRP[1:0]、GTIOR.OADF[1:0]和GTIOR.OBDF[1:0]位中设置。三相输出禁用
BLDC电机控制引脚的PWM输出在GPT_OPS中的OPSCR.GRP[1:0]位和OPSCR.GODF位中设置。

21.3.1 引脚输入电平检测操作

如果在POEGGn.PIDE、POEGGn.NFCS[1:0]、POEGGn.NFEN和POEGGn.INV中设置的输入条件发生在GTETRn引脚，GPT输出引脚输出禁用。

21.3.1.1 数字滤波器

图21.2显示了数字滤波器的高电平检测。当在POEGGn.NFCS[1:0]和POEGGn.NFEN中选择的采样时钟连续3次检测到与POEGGn.INV极性设置相关的高电平时，检测到的电平被识别为高电平，并且GPT输出引脚为输出禁用。如果在此间隔期间甚至检测到一个低电平，则检测到的电平不会被识别为高电平。此外，在不输出采样时钟的时间间隔内，GTETRn引脚的电平变化被忽略。

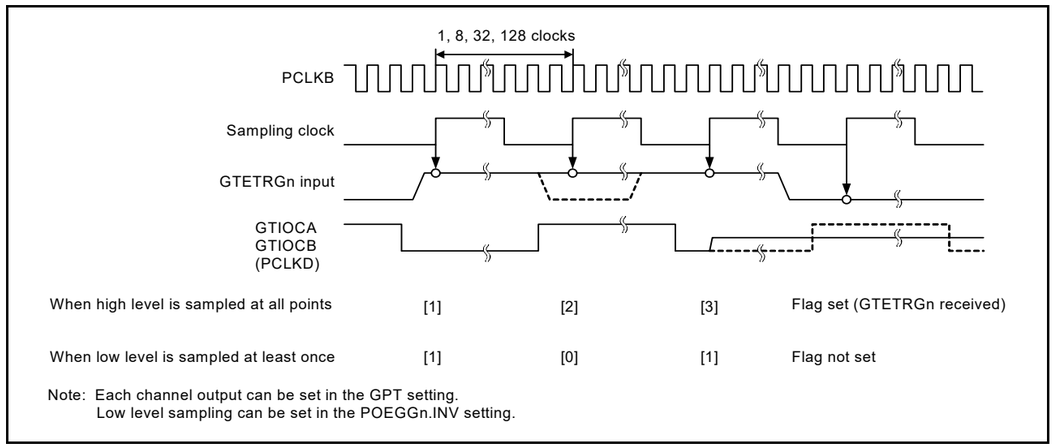


Figure 21.2 Example of digital filter operation

21.3.2 Output-Disable Requests from the GPT

For details on the operation, see the description for GTIOC Pin Output Negate Control in section 22, General PWM Timer (GPT).

21.3.3 Comparator Interrupt Detection

If POEGGn.CDRE[5:0] is 1 when the associated comparator interrupt request is generated, the GPT output pins are output-disabled for each group. The status flag is POEGGn.IOCF, which is shared with GPT output-disable detection.

21.3.4 Output-Disable Control Using Detection of Stopped Oscillation

When the oscillation stop detection function in the clock generation circuit detects stopped oscillation while POEGGn.OSTPE is 1, the GPT output pins are output-disabled for each group.

21.3.5 Output-Disable Control Using Registers

The GPT output pins can be directly controlled by writing to the Software Stop flag, POEGGn.SSF.

21.3.6 Release from Output-Disable

To release the GPT output pins in the output-disabled state, either return them to their initial state with a reset or clear all of the following flags:

- POEGGn.PIDF
- POEGGn.IOCF
- POEGGn.OSTPF
- POEGGn.SSF.

Writing 0 to the POEGGn.PIDF flag is ignored (the flag is not cleared) if the external input pins, GTETRGn, are not disabled and the POEGGn.ST bit is not set to 0.

Writing 0 to the POEGGn.IOCF flag is valid (the flag is cleared) only if all of the GTST.DTEF, GTST.OABHF, and GTST.OABLF flags in the GPT are set to 0.

Writing 0 to the POEGGn.OSTPF flag is ignored (the flag is not cleared) if the OSTDSR.OSTDF flag in the clock generation circuit is not set to 0. In addition, when the flag set and release occur at the same time, the flag set takes precedence.

Figure 21.3 shows the release timing for output-disable. The output-disable is released at the beginning of the next count cycle of the GPT after the flag is cleared.

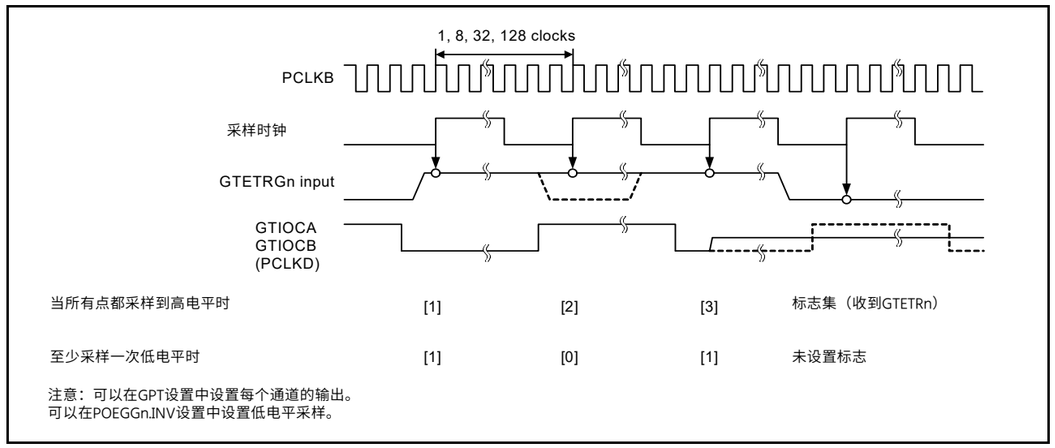


Figure 21.2 数字滤波器操作示例

21.3.2 来自GPT的输出禁用请求

有关操作的详细信息，请参见第22节通用PWM中GTIOC引脚输出否定控制的说明 Timer (GPT).

21.3.3 比较器中断检测

如果在产生相关的比较器中断请求时POEGGn.CDRE[5:0]为1，则每组的GPT输出引脚输出禁用。状态标志是POEGGn.IOCF，它与GPT输出禁用检测共享。

21.3.4 使用停止振荡检测的输出禁用控制

当时钟发生电路中的振荡停止检测功能检测到停止振荡时POEGGn.OSTPE为1，每组的GPT输出引脚输出禁用。

21.3.5 使用寄存器的输出禁用控制

GPT输出引脚可以通过写入软件停止标志POEGGn.SSF来直接控制。

21.3.6 从输出禁用释放

要释放处于输出禁用状态的GPT输出引脚，可以通过复位将它们返回到初始状态，或者清除以下所有标志：

- POEGGn.PIDF
- POEGGn.IOCF
- POEGGn.OSTPF
- POEGGn.SSF.

如果外部输入引脚GTETRn未禁用且POEGGn.ST位未设置为0，则忽略向POEGGn.PIDF标志写入0（该标志未清除）。

仅当所有GTST.DTEF、GTST.OABHF和GPT中的GTST.OABLF标志设置为0。

如果时钟生成电路中的OSTDSR.OSTDF标志未设置为0，则忽略向POEGGn.OSTPF标志写入0（该标志不被清除）。此外，当标志设置和释放同时发生时，标志集优先。

图21.3显示了输出禁用的释放时序。标志清零后，在GPT的下一个计数周期开始时，输出禁用被释放。

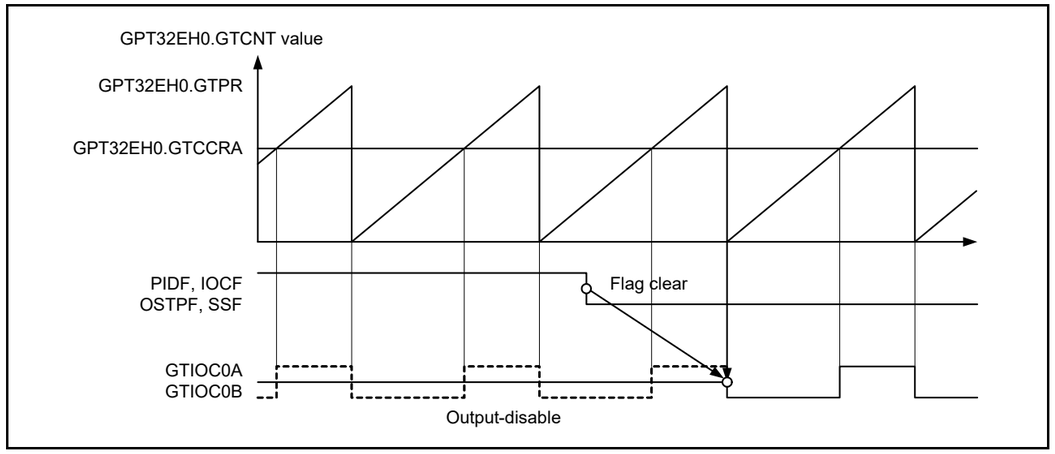


Figure 21.3 Output-disable release timing for the GPT pin outputs

21.4 Interrupt Sources

The POEG generates an interrupt request when triggered by these sources:

- Output-disable control by the input level detection
- Output-disable request from the GPT
- Output-disable request from the comparator interrupt request detection.

Table 21.3 lists the conditions for interrupt requests.

Table 21.3 Interrupt sources and conditions

Interrupt source	Symbol	Associated flag	Trigger conditions
POEG group A interrupt	POEG_GROUP0	POEGGA.IOCF	An output-disable request from a GPT disable request occurred
			An output-disable request from a comparator interrupt request occurred
		POEGGA.PIDF	An output-disable request from the GTETRGA pin occurred
POEG group B interrupt	POEG_GROUP1	POEGGB.IOCF	An output-disable request from a GPT disable request occurred
			An output-disable request from a comparator interrupt request occurred
		POEGGB.PIDF	An output-disable request from the GTETRGB pin occurred
POEG group C interrupt	POEG_GROUP2	POEGGC.IOCF	An output-disable request from a GPT disable request occurred
			An output-disable request from a comparator interrupt request occurred
		POEGGC.PIDF	An output-disable request from the GTETRGC pin occurred
POEG group D interrupt	POEG_GROUP3	POEGGD.IOCF	An output-disable request from a GPT disable request occurred
			An output-disable request from a comparator interrupt request occurred
		POEGGD.PIDF	An output-disable request from the GTETRGD pin occurred

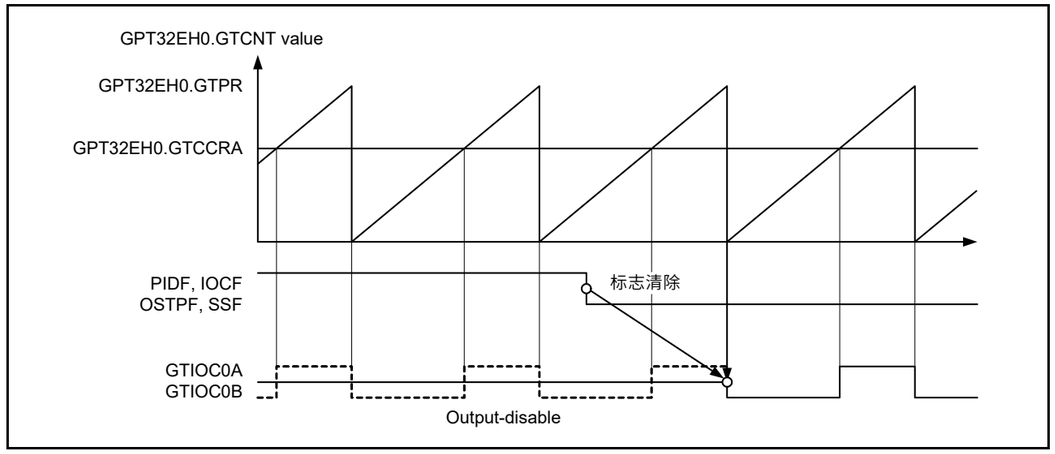


Figure 21.3 GPT引脚输出的输出禁用释放时序

21.4 中断源

当这些源触发时，POEG会产生一个中断请求：

- 通过输入电平检测进行输出禁用控制
- 来自GPT的输出禁用请求
- 来自比较器中断请求检测的输出禁止请求。

表21.3列出了中断请求的条件。

Table 21.3 中断源和条件

中断源	Symbol	相关标志	触发条件
POEGA组中断	POEG_GROUP0	POEGGA.IOCF	发生了来自GPT禁用请求的输出禁用请求
			发生了来自比较器中断请求的输出禁用请求
		POEGGA.PIDF	发生了来自GTETRGA引脚的输出禁用请求
POEGB组中断	POEG_GROUP1	POEGGB.IOCF	发生了来自GPT禁用请求的输出禁用请求
			发生了来自比较器中断请求的输出禁用请求
		POEGGB.PIDF	发生来自GTETRGB引脚的输出禁用请求
POEGC组中断	POEG_GROUP2	POEGGC.IOCF	发生了来自GPT禁用请求的输出禁用请求
			发生了来自比较器中断请求的输出禁用请求
		POEGGC.PIDF	发生了来自GTETRGC引脚的输出禁用请求
POEGD组中断	POEG_GROUP3	POEGGD.IOCF	发生了来自GPT禁用请求的输出禁用请求
			发生了来自比较器中断请求的输出禁用请求
		POEGGD.PIDF	发生来自GTETRGD引脚的输出禁用请求

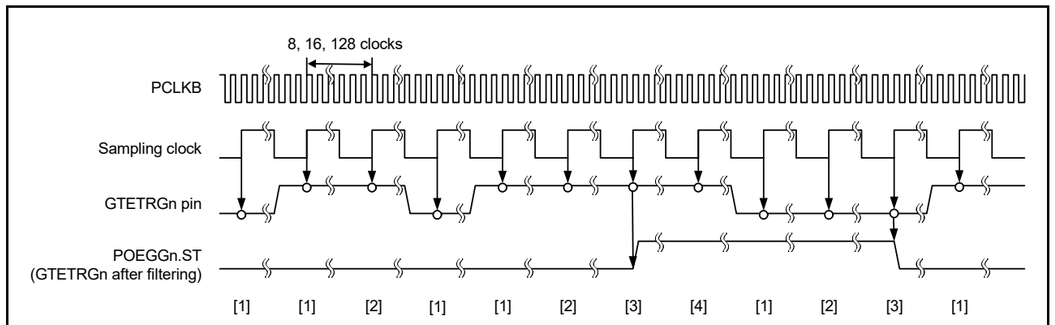
21.5 External Trigger Output to the GPT

The POEG outputs the GTETRGn signals as the GPT operation trigger signal for the following:

- Count start
- Count stop
- Count clear
- Up-count
- Down-count
- Input capture.

For the POEGGn.INV polarity setting signal, when the same level is input three times continuously with the sampling clock selected in POEGGn.NFCS[1:0] and POEGGn.NFEN, that value is output. Set the control registers the same as for the input level detection operation described in section 21.3.1, Pin Input Level Detection Operation. The state after filtering can be monitored in POEGGn.ST.

Figure 21.4 shows the output timing of an external trigger to the GPT.



Note: Each channel output can be set in the GPT settings.
Polarity can be reversed in the POEGGn.INV setting.

Figure 21.4 Output timing of external trigger to the GPT

21.6 Usage Notes

21.6.1 Transition to Software Standby Mode

When using the POEG, do not invoke Software Standby mode. In this mode, the POEG stops and therefore output-disable of the pins cannot be controlled.

21.6.2 Specifying Pins Associated with the GPT

The POEG controls output-disable only when a pin is associated with the GPT in the PmnPFS.PMR and PmnPFS.PSEL[4:0] settings. When the pin is specified as a general I/O pin, the POEG does not perform output-disable control.

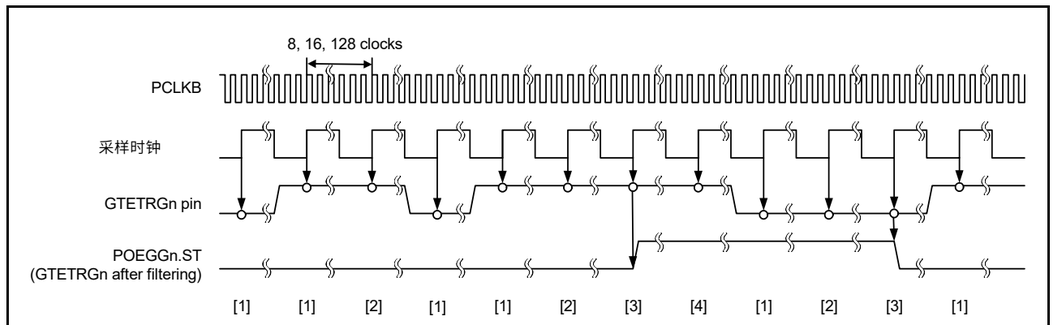
21.5 到GPT的外部触发输出

POEG输出GTETRn信号作为GPT操作触发信号，用于以下用途：

- 计数开始
- 计数停止
- 清点数
- Up-count
- Down-count
- 输入捕获。

对于POEGGn.INV极性设置信号，当在POEGGn.NFCS[1:0]和POEGGn.NFEN中选择的采样时钟连续输入相同电平3次时，输出该值。将控制寄存器设置为与第21.3.1节"引脚输入电平检测操作"中描述的输入电平检测操作相同。过滤后的状态可以在POEGGn.ST中监控。

图21.4显示了外部触发到GPT的输出时序。



Note: 每个通道输出都可以在GPT设置中进行设置。在POEG Gn.INV设置中可以反转极性。

Figure 21.4 外部触发到GPT的输出时序

21.6 使用说明

21.6.1 过渡到软件待机模式

使用POEG时，请勿调用软件待机模式。在此模式下，POEG停止，因此无法控制引脚的输出禁用。

21.6.2 指定与GPT关联的引脚

仅当引脚与PmnPFS.PMR中的GPT相关联时，POEG才控制输出禁用，并且PmnPFS.PSEL[4:0]设置。当引脚指定为通用IO引脚时，POEG不执行输出禁用控制。

22. General PWM Timer (GPT)

22.1 Overview

The General PWM Timer (GPT) is a 32-bit timer with four GPT32EH channels, four GPT32E channels, and five GPT32 channels. PWM waveforms can be generated by controlling the up-counter, down-counter, or the up- and down-counter. In addition, PWM waveforms can be generated for controlling brushless DC motors. The GPT can also be used as a general-purpose timer.

Table 22.1 lists the GPT specifications, Table 22.2 shows the GPT functions, and Figure 22.1 shows a block diagram.

Table 22.1 GPT specifications

Parameter	Specifications
Functions	• 32 bits × 13 channels • Up-counting or down-counting (saw waves) or up/down-counting (triangle waves) for each counter • Clock sources independently selectable for each channel • Two I/O pins per channel • Two output compare/input capture registers per channel • For the two output compare/input capture registers of each channel, four registers are provided as buffer registers and are capable of operating as comparison registers when buffering is not in use • In output compare operation, buffer switching can be at crests or troughs, enabling the generation of laterally asymmetric PWM waveforms • Registers for setting up frame cycles in each channel with capability for generating interrupts at overflow or underflow • Generation of dead times in PWM operation • Synchronous starting, stopping, and clearing counters for arbitrary channels • Starting, stopping, and clearing up/down counters in response to a maximum of eight ELC events • Starting, stopping, and clearing up/down counters in response to input level comparison • Starting, stopping, and clearing up/down counters in response to a maximum of four external triggers • Output pin disable function by dead time error and detected short-circuits between output pins • A/D converter start triggers can be generated • PWM waveform for controlling brushless DC motors can be generated • Compare match A to F event, overflow/underflow event, and input UVW edge event can be output to the ELC • Enables the noise filter for input capture and input UVW • Bus clock: PCLKA • Core clock: PCLKD • Frequency ratio: PCLKA:PCLKD = 1:N (N = 1/2/4/8/16/32/64).

Table 22.2 GPT functions (1 of 2)

Parameter	GPT32EH, GPT32E	GPT32
Count clock	PCLKD PCLKD/4 PCLKD/16 PCLKD/64 PCLKD/256 PCLKD/1024	PCLKD PCLKD/4 PCLKD/16 PCLKD/64 PCLKD/256 PCLKD/1024
Output compare/input capture registers (GTCCR)	GTCCRA GTCCRB	GTCCRA GTCCRB
Compare/buffer registers	GTCCRC GTCCRD GTCCRE GTCCRF	GTCCRC GTCCRD GTCCRE GTCCRF
Cycle setting register	GTPR	GTPR
Cycle setting buffer registers	GTPBR GTPDBR	GTPBR
I/O pins	GTIOCA GTIOCB	GTIOCA GTIOCB

22. 通用PWM定时器(GPT)

22.1 Overview

通用PWM定时器(GPT)是一个32位定时器，具有四个GPT32EH通道、四个GPT32E通道和五个GPT32通道。PWM波形可以通过控制加计数器、减计数器或加减计数器来产生。此外，可以生成PWM波形来控制无刷直流电机。GPT也可以用作通用定时器。

表22.1列出了GPT规范，表22.2显示了GPT功能，图22.1显示了框图。

Table 22.1 GPT specifications

Parameter	Specifications
Functions	32位×13通道 每个计数器的递增计数或递减计数（锯齿波）或递减计数（三角波） 每条通道可独立选择时钟源 每条通道两个IO引脚 两个输出比较输入捕捉每个通道的寄存器 对于每个通道的两个输出比较输入捕捉寄存器，提供四个寄存器作为缓冲寄存器，并且能够在不使用缓冲时作为比较寄存器 在输出比较操作中，缓冲切换可以在波峰或波谷，能够生成横向不对称的PWM波形 用于在每个通道中设置帧周期的寄存器，能够在上溢或下溢时产生中断 在PWM操作中生成死区 任意通道的同步启动、停止和清除计数器 响应最多八个ELC事件启动、停止和清除递减计数器 启动、停止和响应输入电平比较清除递减计数器启动、停止和清除递减计数器以响应最多四个外部触发 死区时间错误和检测到输出引脚之间的短路导致输出引脚禁用功能 AD转换器启动可以生成触发器可以生成用于控制无刷直流电机的PWM波形比较匹配A到F事件、上溢下溢事件和输入UVW边缘事件可以输出到ELC启用用于输入捕获和输入UVW的噪声滤波器总线时钟：PCLKA核心时钟：PCLKD频率比：PCLKA:PCLKD=1:N(N=1248163264)。

Table 22.2 GPT函数(1of2)

Parameter	GPT32EH, GPT32E	GPT32
计数时钟	PCLKD PCLKD/4 PCLKD/16 PCLKD/64 PCLKD/256 PCLKD/1024	PCLKD PCLKD/4 PCLKD/16 PCLKD/64 PCLKD/256 PCLKD/1024
输出比较输入捕捉寄存器(GTCCR)	GTCCRA GTCCRB	GTCCRA GTCCRB
Compare/buffer registers	GTCCRC GTCCRD GTCCRE GTCCRF	GTCCRC GTCCRD GTCCRE GTCCRF
周期设定寄存器	GTPR	GTPR
循环设置缓冲寄存器	GTPBR GTPDBR	GTPBR
I/O pins	GTIOCA GTIOCB	GTIOCA GTIOCB

Table 22.2 GPT functions (2 of 2)

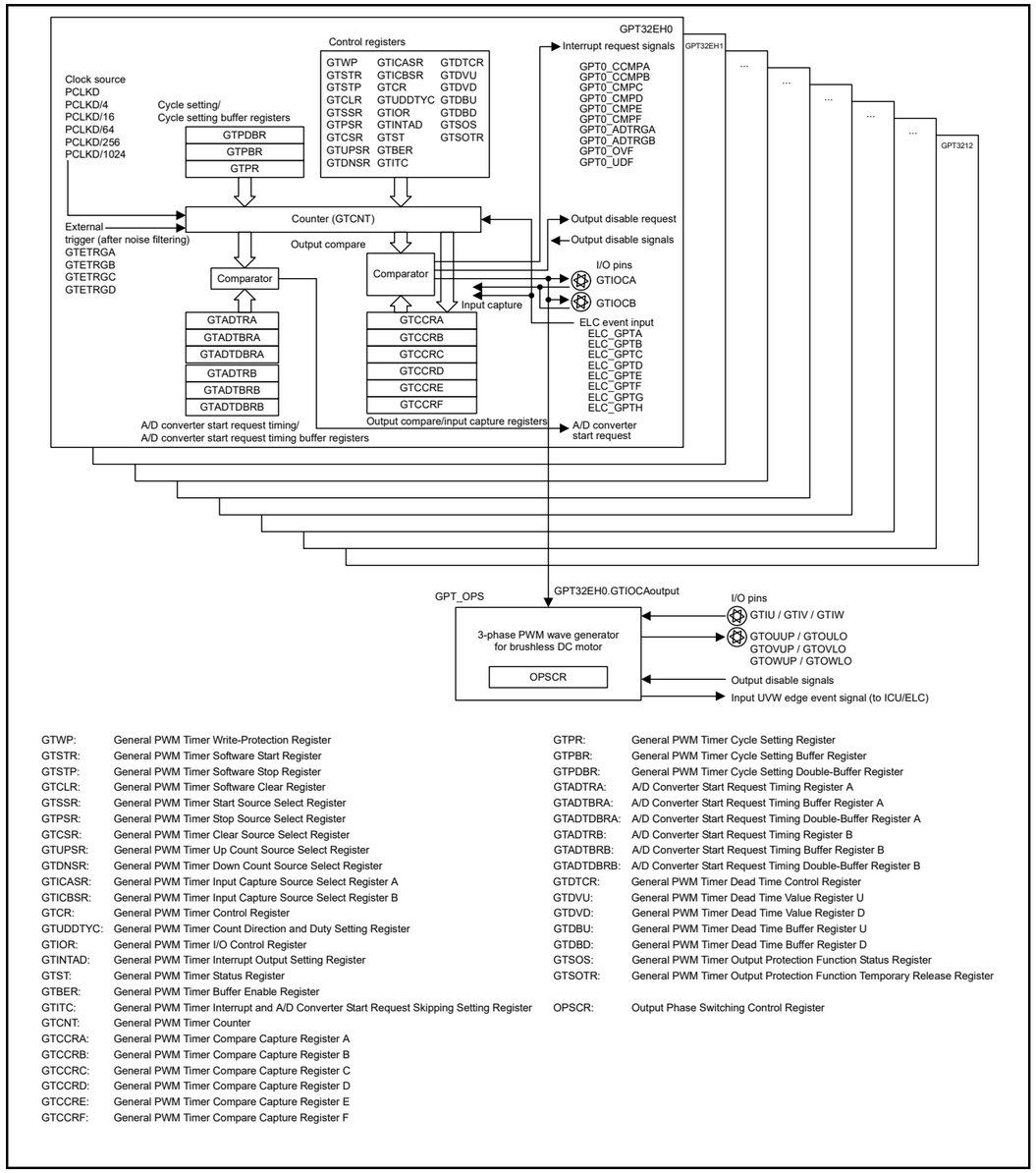
Parameter		GPT32EH, GPT32E	GPT32
External trigger input pin*1		GTETRGA GTETRGB GTETRGC GTETRGD	GTETRGA GTETRGB GTETRGC GTETRGD
Counter clear sources		GTPR register compare match, input capture, input pin status, ELC event input, and GTETRGn (n = A, B, C, D) pin input	GTPR register compare match, input capture, input pin status, ELC event input, and GTETRGn (n = A, B, C, D) pin input
Compare match output	Low output	Available	Available
	High output	Available	Available
	Toggle output	Available	Available
Input capture function		Available	Available
Automatic addition of dead time		Available	Available (no dead time buffer)
PWM mode		Available	Available
Phase count function		Available	Available
Buffer operation		Double buffer	Double buffer
One-shot operation		Available	Available
DTC activation		All the interrupt sources	All the interrupt sources
A/D converter start trigger		Compare match of GTADTRA or GTADTRB	-
Brushless DC motor control function		Available	Available
Interrupt sources		10 sources • GTCCRA compare match/input capture (GPTn_CCMPA) • GTCCRB compare match/input capture (GPTn_CCMPB) • GTCCRC compare match (GPTn_CMPC) • GTCCRD compare match (GPTn_CMPD) • GTCCRE compare match (GPTn_CMPCE) • GTCCRF compare match (GPTn_CMPF) • GTADTRA compare match (GPTn_ADTRGA) • GTADTRB compare match (GPTn_ADTRGB) • GTCNT overflow (GTPR compare match) (GPTn_OVF) • GTCNT underflow (GPTn_UDF)	8 sources • GTCCRA compare match/input capture (GPTn_CCMPA) • GTCCRB compare match/input capture (GPTn_CCMPB) • GTCCRC compare match (GPTn_CMPC) • GTCCRD compare match (GPTn_CMPD) • GTCCRE compare match (GPTn_CMPE) • GTCCRF compare match (GPTn_CMPF) • GTCNT overflow (GTPR compare match) (GPTn_OVF) • GTCNT underflow (GPTn_UDF)
Interrupt skipping function		Skips GTCNT overflows (GTPR compare match) (GPTn_OVF)/ GTCNT underflow (GPTn_UDF) interrupts (with interlocking function for other interrupts or A/D conversion requests)	-
Event linking (ELC) function		Available	Available
Noise filtering function		Available	Available

Note 1. GTRETRGn connects to GPT through the POEG module. Therefore, to use the GPT function, supply the POEG clock by clearing the MSTPD14 bit.

Table 22.2 GPT功能（2个中的2个）

Parameter		GPT32EH, GPT32E	GPT32
外部触发输入引脚*1		GTETRGA GTETRGB GTETRGC GTETRGD	GTETRGA GTETRGB GTETRGC GTETRGD
反清源		GTPR寄存器比较匹配、输入捕捉、输入引脚状态、ELC事件输入和GTETRn(n=A B C D)引脚输入	GTPR寄存器比较匹配、输入捕捉、输入引脚状态、ELC事件输入和GTETRn(n=A B C D)引脚输入
比较匹配输出	低输出	Available	Available
	高输出	Available	Available
	切换输出	Available	Available
输入捕捉功能		Available	Available
自动添加死区时间		Available	可用（无死区时间缓冲区）
PWM mode		Available	Available
相位计数功能		Available	Available
缓冲操作		双缓冲	双缓冲
One-shot operation		Available	Available
DTC activation		所有中断源	所有中断源
AD转换器启动触发		比较GTADTRA的匹配或GTADTRB	-
直流无刷电机控制功能		Available	Available
中断源		10个来源 GTCCRA比较匹配输入捕获(GPTn_CCMPA) GTCCRB比较匹配输入捕获(GPTn_CCMPB) GTCCRC比较匹配(GPTn_CMPC) GTCCRD比较匹配(GPTn_CMPD) GTCCRE比较匹配(GPTn_CMPCE) GTCCRF比较匹配(GPTn_CMPF) GTADTRA比较匹配(GPTn_ADTRGA) GTADTRB比较匹配(GPTn_ADTRGB) GTCNT上溢(GTPR比较匹配)(GPTn_OVF) GTCNT下溢(GPTn_UDF)	8个源 GTCCRA比较匹配输入捕获(GPTn_CCMPA) GTCCRB比较匹配输入捕获(GPTn_CCMPB) GTCCRC比较匹配(GPTn_CMPC) GTCCRD比较匹配(GPTn_CMPD) GTCCRE比较匹配(GPTn_CMPE) GTCCRF比较匹配(GPTn_CMPF) GTCNT上溢（GTPR比较匹配）（GPTn_OVF） GTCNT下溢（GPTn_UDF）
中断跳跃功能		跳过GTCNT上溢（GTPR比较匹配）（GPTn_OVF）GTCNT下溢（GPTn_UDF）中断（具有其他中断或AD转换请求的互锁功能）	-
事件链接(ELC)功能		Available	Available
噪音过滤功能		Available	Available

Note 1. GTRETRGn通过POEG模块连接到GPT。因此，要使用GPT功能，通过清除MSTPD14位来提供POEG时钟。



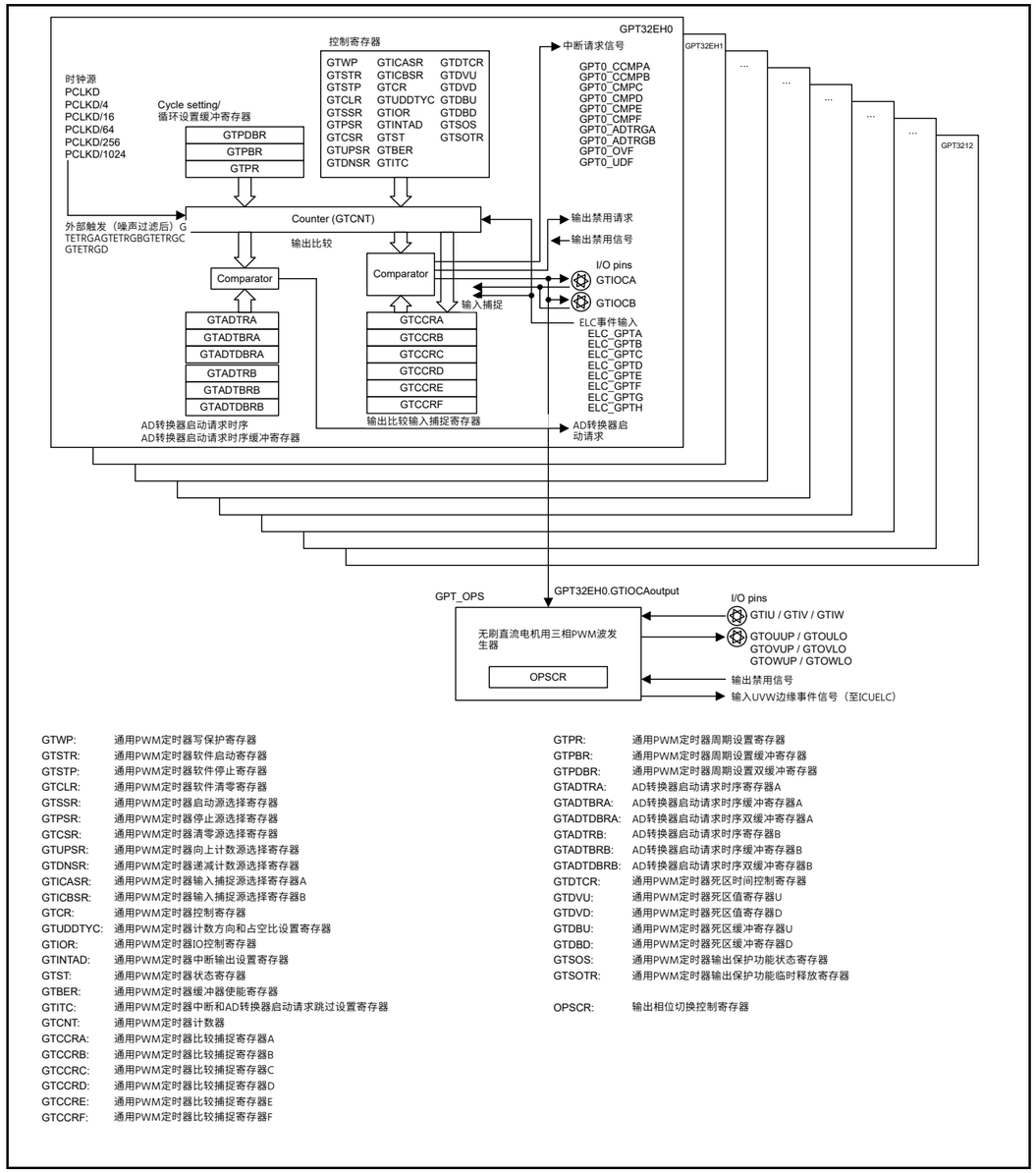
GTWP: General PWM Timer Write-Protection Register
GTSTR: General PWM Timer Software Start Register
GTSTP: General PWM Timer Software Stop Register
GTCLR: General PWM Timer Software Clear Register
GTSSR: General PWM Timer Start Source Select Register
GTPSR: General PWM Timer Stop Source Select Register
GTCSR: General PWM Timer Clear Source Select Register
GTUPSR: General PWM Timer Up Count Source Select Register
GTDNSR: General PWM Timer Down Count Source Select Register
GTICASR: General PWM Timer Input Capture Source Select Register A
GTICBSR: General PWM Timer Input Capture Source Select Register B
GTCR: General PWM Timer Control Register
GTUDDTYC: General PWM Timer Count Direction and Duty Setting Register
GTIOR: General PWM Timer I/O Control Register
GTINTAD: General PWM Timer Interrupt Output Setting Register
GTST: General PWM Timer Status Register
GTBER: General PWM Timer Buffer Enable Register
GTITC: General PWM Timer Interrupt and A/D Converter Start Request Skipping Setting Register
GTCNT: General PWM Timer Counter
GTCCRA: General PWM Timer Compare Capture Register A
GTCCRB: General PWM Timer Compare Capture Register B
GTCCRC: General PWM Timer Compare Capture Register C
GTCCRD: General PWM Timer Compare Capture Register D
GTCCRE: General PWM Timer Compare Capture Register E
GTCCRF: General PWM Timer Compare Capture Register F

GTPR: General PWM Timer Cycle Setting Register
GTPBR: General PWM Timer Cycle Setting Buffer Register
GTPDBR: General PWM Timer Cycle Setting Double-Buffer Register
GTADTRA: A/D Converter Start Request Timing Register A
GTADTBRA: A/D Converter Start Request Timing Buffer Register A
GTADTDBRA: A/D Converter Start Request Timing Double-Buffer Register A
GTADTRB: A/D Converter Start Request Timing Register B
GTADTBRB: A/D Converter Start Request Timing Buffer Register B
GTADTDBRB: A/D Converter Start Request Timing Double-Buffer Register B
GTDTCR: General PWM Timer Dead Time Control Register
GTDVU: General PWM Timer Dead Time Value Register U
GTDVD: General PWM Timer Dead Time Value Register D
GTDBU: General PWM Timer Dead Time Buffer Register U
GTDBD: General PWM Timer Dead Time Buffer Register D
GTSOS: General PWM Timer Output Protection Function Status Register
GTSOTR: General PWM Timer Output Protection Function Temporary Release Register

OPSCR: Output Phase Switching Control Register

Figure 22.1 GPT block diagram

Figure 22.2 shows an example using multiple GPTs.



GTWP: 通用PWM定时器写保护寄存器
GTSTR: 通用PWM定时器软件启动寄存器
GTSTP: 通用PWM定时器软件停止寄存器
GTCLR: 通用PWM定时器软件清零寄存器
GTSSR: 通用PWM定时器启动源选择寄存器
GTPSR: 通用PWM定时器停止源选择寄存器
GTCSR: 通用PWM定时器清零源选择寄存器
GTUPSR: 通用PWM定时器向上计数源选择寄存器
GTDNSR: 通用PWM定时器递减计数源选择寄存器
GTICASR: 通用PWM定时器输入捕捉源选择寄存器A
GTICBSR: 通用PWM定时器输入捕捉源选择寄存器B
GTCR: 通用PWM定时器控制寄存器
GTUDDTYC: 通用PWM定时器计数方向和占空比设置寄存器
GTIOR: 通用PWM定时器IO控制寄存器
GTINTAD: 通用PWM定时器中断输出设置寄存器
GTST: 通用PWM定时器状态寄存器
GTBER: 通用PWM定时器缓冲器使能寄存器
GTITC: 通用PWM定时器中断和AD转换器启动请求跳过设置寄存器
GTCNT: 通用PWM定时器计数器
GTCCRA: 通用PWM定时器比较捕捉寄存器A
GTCCRB: 通用PWM定时器比较捕捉寄存器B
GTCCRC: 通用PWM定时器比较捕捉寄存器C
GTCCRD: 通用PWM定时器比较捕捉寄存器D
GTCCRE: 通用PWM定时器比较捕捉寄存器E
GTCCRF: 通用PWM定时器比较捕捉寄存器F

GTPR: 通用PWM定时器周期设置寄存器
GTPBR: 通用PWM定时器周期设置缓冲寄存器
GTPDBR: 通用PWM定时器周期设置双缓冲寄存器
GTADTRA: AD转换器启动请求时序寄存器A
GTADTBRA: AD转换器启动请求时序缓冲寄存器A
GTADTDBRA: AD转换器启动请求时序双缓冲寄存器A
GTADTRB: AD转换器启动请求时序寄存器B
GTADTBRB: AD转换器启动请求时序缓冲寄存器B
GTADTDBRB: AD转换器启动请求时序双缓冲寄存器B
GTDTCR: 通用PWM定时器死区时间控制寄存器
GTDVU: 通用PWM定时器死区值寄存器U
GTDVD: 通用PWM定时器死区值寄存器D
GTDBU: 通用PWM定时器死区缓冲寄存器U
GTDBD: 通用PWM定时器死区缓冲寄存器D
GTSOS: 通用PWM定时器输出保护功能状态寄存器
GTSOTR: 通用PWM定时器输出保护功能临时释放寄存器

OPSCR: 输出相位切换控制寄存器

Figure 22.1 GPT框图

图22.2显示了使用多个GPT的示例。

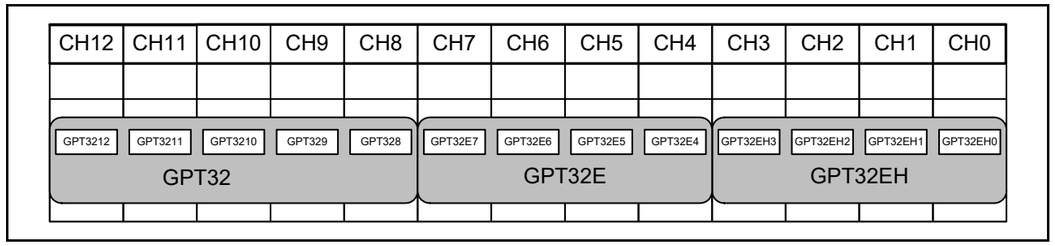


Figure 22.2 Association between GPT channels and module names

Table 22.3 lists the I/O pins.

Table 22.3 GPT I/O pins (1 of 2)

Channel	Pin name	I/O	Function
Shared	GTETRGA	Input	External trigger input pin A (after noise filtering)
	GTETRGB	Input	External trigger input pin B (after noise filtering)
	GTETRGC	Input	External trigger input pin C (after noise filtering)
	GTETRGD	Input	External trigger input pin D (after noise filtering)
GPT32EH0	GTIOC0A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC0B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT32EH1	GTIOC1A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC1B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT32EH2	GTIOC2A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC2B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT32EH3	GTIOC3A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC3B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT32E4	GTIOC4A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC4B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT32E5	GTIOC5A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC5B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT32E6	GTIOC6A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC6B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT32E7	GTIOC7A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC7B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT328	GTIOC8A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC8B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT329	GTIOC9A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC9B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT3210	GTIOC10A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC10B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT3211	GTIOC11A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC11B	I/O	GTCCRB register input capture input/output compare output/PWM output pin
GPT3212	GTIOC12A	I/O	GTCCRA register input capture input/output compare output/PWM output pin
	GTIOC12B	I/O	GTCCRB register input capture input/output compare output/PWM output pin

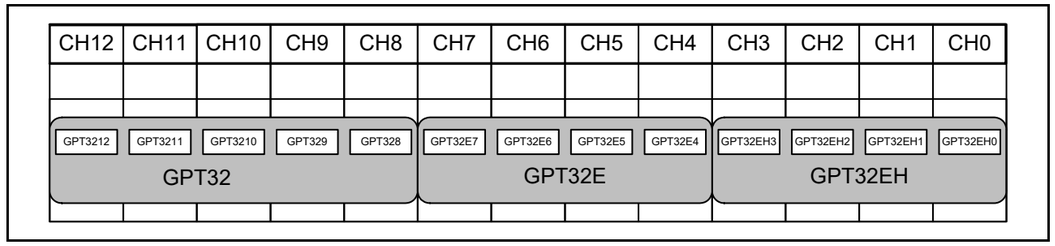


Figure 22.2 GPT通道和模块名称之间的关联

表22.3列出了IO引脚。

Table 22.3 GPTIO引脚（2个中的1个）

Channel	引脚名称	I/O	Function
Shared	GTETRGA	Input	外部触发输入引脚A（噪声过滤后）
	GTETRGB	Input	外部触发输入引脚B（噪声过滤后）
	GTETRGC	Input	外部触发输入引脚C（噪声过滤后）
	GTETRGD	Input	外部触发输入引脚D（噪声过滤后）
GPT32EH0	GTIOC0A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC0B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT32EH1	GTIOC1A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC1B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT32EH2	GTIOC2A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC2B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT32EH3	GTIOC3A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC3B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT32E4	GTIOC4A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC4B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT32E5	GTIOC5A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC5B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT32E6	GTIOC6A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC6B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT32E7	GTIOC7A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC7B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT328	GTIOC8A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC8B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT329	GTIOC9A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC9B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT3210	GTIOC10A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC10B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT3211	GTIOC11A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC11B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚
GPT3212	GTIOC12A	I/O	GTCCRA寄存器输入捕捉输入输出比较输出PWM输出引脚
	GTIOC12B	I/O	GTCCRB寄存器输入捕捉输入输出比较输出PWM输出引脚

Table 22.3 GPT I/O pins (2 of 2)

Channel	Pin name	I/O	Function
GPT_OPS	GTIU	Input	Hall sensor input pin U
	GTIV	Input	Hall sensor input pin V
	GTIW	Input	Hall sensor input pin W
	GTOUUP	Output	3-phase PWM output for BLDC motor control (positive U-phase)
	GTOULO	Output	3-phase PWM output for BLDC motor control (negative U-phase)
	GTOVUP	Output	3-phase PWM output for BLDC motor control (positive V-phase)
	GTOVLO	Output	3-phase PWM output for BLDC motor control (negative V-phase)
	GTOWUP	Output	3-phase PWM output for BLDC motor control (positive W-phase)
	GTOWLO	Output	3-phase PWM output for BLDC motor control (negative W-phase)

22.2 Register Descriptions

Table 22.4 lists the registers in the GPT.

Table 22.4 GPT registers (1 of 2)

Module symbol	Register name	Register symbol	Reset value	Address (m = 0 to 12)	Access size	GPT32EH/ GPT32E	GPT32
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7) GPT32m (m = 8 to 12)	General PWM Timer Write Protection Register	GTWP	0000 0000h	4007 8000h + 0100h × m	32	✓	✓
	General PWM Timer Software Start Register	GTSTR	0000 0000h	4007 8004h + 0100h × m	32	✓	✓
	General PWM Timer Software Stop Register	GTSTP	FFFF FFFFh	4007 8008h + 0100h × m	32	✓	✓
	General PWM Timer Software Clear Register	GTCLR	0000 0000h	4007 800Ch + 0100h × m	32	✓	✓
	General PWM Timer Start Source Select Register	GTSSR	0000 0000h	4007 8010h + 0100h × m	32	✓	✓
	General PWM Timer Stop Source Select Register	GTPSR	0000 0000h	4007 8014h + 0100h × m	32	✓	✓
	General PWM Timer Clear Source Select Register	GTCSR	0000 0000h	4007 8018h + 0100h × m	32	✓	✓
	General PWM Timer Up Count Source Select Register	GTUPSR	0000 0000h	4007 801Ch + 0100h × m	32	✓	✓
	General PWM Timer Down Count Source Select Register	GTDNSR	0000 0000h	4007 8020h + 0100h × m	32	✓	✓
	General PWM Timer Input Capture Source Select Register A	GTICASR	0000 0000h	4007 8024h + 0100h × m	32	✓	✓
	General PWM Timer Input Capture Source Select Register B	GTICBSR	0000 0000h	4007 8028h + 0100h × m	32	✓	✓
	General PWM Timer Control Register	GTCR	0000 0000h	4007 802Ch + 0100h × m	32	✓	✓
	General PWM Timer Count Direction and Duty Setting Register	GTUDDTYC	0000 0001h	4007 8030h + 0100h × m	32	✓	✓
	General PWM Timer I/O Control Register	GTIOR	0000 0000h	4007 8034h + 0100h × m	32	✓	✓
	General PWM Timer Interrupt Output Setting Register	GTINTAD	0000 0000h	4007 8038h + 0100h × m	32	✓	(✓)*1
	General PWM Timer Status Register	GTST	0000 8000h	4007 803Ch + 0100h × m	32	✓	(✓)*1
	General PWM Timer Buffer Enable Register	GTBER	0000 0000h	4007 8040h + 0100h × m	32	✓	(✓)*1
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7)	General PWM Timer Interrupt and A/D Converter Start Request Skipping Setting Register	GTITC	0000 0000h	4007 8044h + 0100h × m	32	✓	-

Table 22.3 GPTIO引脚（2个中的2个）

Channel	引脚名称	I/O	Function
GPT_OPS	GTIU	Input	霍尔传感器输入引脚U
	GTIV	Input	霍尔传感器输入引脚V
	GTIW	Input	霍尔传感器输入引脚W
	GTOUUP	Output	用于BLDC电机控制的3相PWM输出（正U相）
	GTOULO	Output	用于BLDC电机控制的3相PWM输出（负U相）
	GTOVUP	Output	用于BLDC电机控制的3相PWM输出（正V相）
	GTOVLO	Output	用于BLDC电机控制的3相PWM输出（负V相）
	GTOWUP	Output	用于BLDC电机控制的3相PWM输出（正W相）
	GTOWLO	Output	用于BLDC电机控制的3相PWM输出（负W相）

22.2 注册说明

表22.4列出了GPT中的寄存器。

Table 22.4 GPT寄存器(1of2)

模块符号	注册名称	注册符号	重置值	地址（m=0到12）	访问大小	GPT32EH/ GPT32E	GPT32
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7) GPT32m (m = 8 to 12)	通用PWM定时器写保护登记册	GTWP	0000 0000h	4007 8000h + 0100h × m	32	✓	✓
	通用PWM定时器软件启动Register	GTSTR	0000 0000h	4007 8004h + 0100h × m	32	✓	✓
	通用PWM定时器软件停止Register	GTSTP	FFFF FFFFh	4007 8008h + 0100h × m	32	✓	✓
	通用PWM定时器软件清零Register	GTCLR	0000 0000h	4007 800Ch + 0100h × m	32	✓	✓
	通用PWM定时器启动源选择注册	GTSSR	0000 0000h	4007 8010h + 0100h × m	32	✓	✓
	通用PWM定时器停止源选择注册	GTPSR	0000 0000h	4007 8014h + 0100h × m	32	✓	✓
	通用PWM定时器清零源选择注册	GTCSR	0000 0000h	4007 8018h + 0100h × m	32	✓	✓
	通用PWM定时器向上计数源选择寄存器	GTUPSR	0000 0000h	4007 801Ch + 0100h × m	32	✓	✓
	通用PWM定时器递减计数源选择寄存器	GTDNSR	0000 0000h	4007 8020h + 0100h × m	32	✓	✓
	通用PWM定时器输入捕捉源选择寄存器A	GTICASR	0000 0000h	4007 8024h + 0100h × m	32	✓	✓
	通用PWM定时器输入捕捉源选择寄存器B	GTICBSR	0000 0000h	4007 8028h + 0100h × m	32	✓	✓
	通用PWM定时器控制Register	GTCR	0000 0000h	4007 802Ch + 0100h × m	32	✓	✓
	通用PWM定时器计数方向和占空比设置寄存器	GTUDDTYC	0000 0001h	4007 8030h + 0100h × m	32	✓	✓
	通用PWM定时器IO控制Register	GTIOR	0000 0000h	4007 8034h + 0100h × m	32	✓	✓
	通用PWM定时器中断输出设置寄存器	GTINTAD	0000 0000h	4007 8038h + 0100h × m	32	✓	(✓)*1
	通用PWM定时器状态Register	GTST	0000 8000h	4007 803Ch + 0100h × m	32	✓	(✓)*1
	通用PWM定时器缓冲器使能Register	GTBER	0000 0000h	4007 8040h + 0100h × m	32	✓	(✓)*1
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7)	通用PWM定时器中断和AD转换器启动请求跳过设置寄存器	GTITC	0000 0000h	4007 8044h + 0100h × m	32	✓	-

Table 22.4 GPT registers (2 of 2)

Module symbol	Register name	Register symbol	Reset value	Address (m = 0 to 12)	Access size	GPT32EH/ GPT32E	GPT32
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7) GPT32m (m = 8 to 12)	General PWM Timer Counter	GTCNT	0000 0000h	4007 8048h + 0100h × m	32	✓	✓
	General PWM Timer Compare Capture Register A	GTCCRA	FFFF FFFFh	4007 804Ch + 0100h × m	32	✓	✓
	General PWM Timer Compare Capture Register B	GTCCRB	FFFF FFFFh	4007 8050h + 0100h × m	32	✓	✓
	General PWM Timer Compare Capture Register C	GTCCRC	FFFF FFFFh	4007 8054h + 0100h × m	32	✓	✓
	General PWM Timer Compare Capture Register E	GTCCRE	FFFF FFFFh	4007 8058h + 0100h × m	32	✓	✓
	General PWM Timer Compare Capture Register D	GTCCRD	FFFF FFFFh	4007 805Ch + 0100h × m	32	✓	✓
	General PWM Timer Compare Capture Register F	GTCCRF	FFFF FFFFh	4007 8060h + 0100h × m	32	✓	✓
	General PWM Timer Cycle Setting Register	GTPR	FFFF FFFFh	4007 8064h + 0100h × m	32	✓	✓
	General PWM Timer Cycle Setting Buffer Register	GTPBR	FFFF FFFFh	4007 8068h + 0100h × m	32	✓	✓
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7)	General PWM Timer Cycle Setting Double-Buffer Register	GTPDBR	FFFF FFFFh	4007 806Ch + 0100h × m	32	✓	-
	A/D Converter Start Request Timing Register A	GTADTRA	FFFF FFFFh	4007 8070h + 0100h × m	32	✓	-
	A/D Converter Start Request Timing Buffer Register A	GTADTBRA	FFFF FFFFh	4007 8074h + 0100h × m	32	✓	-
	A/D Converter Start Request Timing Double-Buffer Register A	GTADTDBRA	FFFF FFFFh	4007 8078h + 0100h × m	32	✓	-
	A/D Converter Start Request Timing Register B	GTADTRB	FFFF FFFFh	4007 807Ch + 0100h × m	32	✓	-
	A/D Converter Start Request Timing Buffer Register B	GTADTBRB	FFFF FFFFh	4007 8080h + 0100h × m	32	✓	-
	A/D Converter Start Request Timing Double-Buffer Register B	GTADTDBRB	FFFF FFFFh	4007 8084h + 0100h × m	32	✓	-
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7) GPT32m (m = 8 to 12)	General PWM Timer Dead Time Control Register	GTDTCR	0000 0000h	4007 8088h + 0100h × m	32	✓	(✓)*1
	General PWM Timer Dead Time Value Register U	GTDVU	FFFF FFFFh	4007 808Ch + 0100h × m	32	✓	✓
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7)	General PWM Timer Dead Time Value Register D	GTDVD	FFFF FFFFh	4007 8090h + 0100h × m	32	✓	-
	General PWM Timer Dead Time Buffer Register U	GTDBU	FFFF FFFFh	4007 8094h + 0100h × m	32	✓	-
	General PWM Timer Dead Time Buffer Register D	GTDBD	FFFF FFFFh	4007 8098h + 0100h × m	32	✓	-
	General PWM Timer Output Protection Function Status Register	GTSOS	0000 0000h	4007 809Ch + 0100h × m	32	✓	-
	General PWM Timer Output Protection Function Temporary Release Register	GTSOTR	0000 0000h	4007 80A0h + 0100h × m	32	✓	-
GPT_OPS	Output Phase Switching Control Register	OPSCR	0000 0000h	4007 8FF0h	32	✓	✓

Note 1. Some functions are reduced from GPT32EH/GPT32E.

Table 22.4 GPT寄存器（2个中的2个）

模块符号	注册名称	注册符号	重置值	地址（m=0到12）	访问大小	GPT32EH/ GPT32E	GPT32
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7) GPT32m (m = 8 to 12)	通用PWM定时器计数器	GTCNT	0000 0000h	4007 8048h + 0100h × m	32	✓	✓
	通用PWM定时器比较捕获寄存器A	GTCCRA	FFFF FFFFh	4007 804Ch + 0100h × m	32	✓	✓
	通用PWM定时器比较捕获寄存器B	GTCCRB	FFFF FFFFh	4007 8050h + 0100h × m	32	✓	✓
	通用PWM定时器比较捕获寄存器C	GTCCRC	FFFF FFFFh	4007 8054h + 0100h × m	32	✓	✓
	通用PWM定时器比较捕获寄存器E	GTCCRE	FFFF FFFFh	4007 8058h + 0100h × m	32	✓	✓
	通用PWM定时器比较捕获寄存器D	GTCCRD	FFFF FFFFh	4007 805Ch + 0100h × m	32	✓	✓
	通用PWM定时器比较捕获寄存器F	GTCCRF	FFFF FFFFh	4007 8060h + 0100h × m	32	✓	✓
	通用PWM定时器周期设置Register	GTPR	FFFF FFFFh	4007 8064h + 0100h × m	32	✓	✓
	通用PWM定时器周期设置缓冲寄存器	GTPBR	FFFF FFFFh	4007 8068h + 0100h × m	32	✓	✓
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7)	通用PWM定时器周期设置Double-Buffer Register	GTPDBR	FFFF FFFFh	4007 806Ch + 0100h × m	32	✓	-
	AD转换器启动请求时序Register A	GTADTRA	FFFF FFFFh	4007 8070h + 0100h × m	32	✓	-
	AD转换器启动请求时序缓冲寄存器A	GTADTBRA	FFFF FFFFh	4007 8074h + 0100h × m	32	✓	-
	AD转换器启动请求时序Double-Buffer Register A	GTADTDBRA	FFFF FFFFh	4007 8078h + 0100h × m	32	✓	-
	AD转换器启动请求时序Register B	GTADTRB	FFFF FFFFh	4007 807Ch + 0100h × m	32	✓	-
	AD转换器启动请求时序缓冲寄存器B	GTADTBRB	FFFF FFFFh	4007 8080h + 0100h × m	32	✓	-
	AD转换器启动请求时序Double-Buffer Register B	GTADTDBRB	FFFF FFFFh	4007 8084h + 0100h × m	32	✓	-
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7) GPT32m (m = 8 to 12)	通用PWM定时器死区时间控制寄存器	GTDTCR	0000 0000h	4007 8088h + 0100h × m	32	✓	(✓)*1
	通用PWM定时器死区时间值寄存器U	GTDVU	FFFF FFFFh	4007 808Ch + 0100h × m	32	✓	✓
GPT32EHm (m = 0 to 3) GPT32Em (m = 4 to 7)	通用PWM定时器死区时间值寄存器D	GTDVD	FFFF FFFFh	4007 8090h + 0100h × m	32	✓	-
	通用PWM定时器死区时间缓冲寄存器U	GTDBU	FFFF FFFFh	4007 8094h + 0100h × m	32	✓	-
	通用PWM定时器死区时间缓冲寄存器D	GTDBD	FFFF FFFFh	4007 8098h + 0100h × m	32	✓	-
	通用PWM定时器输出保护功能状态寄存器	GTSOS	0000 0000h	4007 809Ch + 0100h × m	32	✓	-
	通用PWM定时器输出保护功能临时释放寄存器	GTSOTR	0000 0000h	4007 80A0h + 0100h × m	32	✓	-
GPT_OPS	输出相位切换控制Register	OPSCR	0000 0000h	4007 8FF0h	32	✓	✓

Note 1. 从GPT32EHGPT32E减少了一些功能。

22.2.1 General PWM Timer Write Protection Register (GTWP)

Address(es): GPT32EHm.GTWP 4007 8000h + 0100h × m (m = 0 to 3)
GPT32Em.GTWP 4007 8000h + 0100h × m (m = 4 to 7)
GPT32m.GTWP 4007 8000h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PRKEY[7:0]								—	—	—	—	—	—	—	WP
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	WP	Register Write Disable	0: Write to the register enabled 1: Write to the register disabled.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15 to b8	PRKEY[7:0]	GTWP Key Code	When A5h is written to these bits, writes to the WP bit are permitted. These bits are read as 0.	R/W
b31 to b16	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

To prevent accidental modification, the GTWP register enables or disables writing to following registers:

GTSSR, GTPSR, GTCSR, GTUPSR, GTDNSR, GTICASR, GTICBSR, GTCR, GTUDDTYC, GTIOR, GTINTAD, GTST, GTBER, GTITC, GTCNT, GTCCRA, GTCCRB, GTCCRC, GTCCRD, GTCCRE, GTCCRF, GTPR, GTPBR, GTPDBR, GTADTRA, GTADTBRA, GTADTDBRA, GTADTRB, GTADTBRB, GTADTDBRB, GTDTCR, GTDVU, GTDVD, GTDBU, GTDBD, GTSOS, GTSOTR.

22.2.2 General PWM Timer Software Start Register (GTSTR)

Address(es): GPT32EHm.GTSTR 4007 8004h + 0100h × m (m = 0 to 3)
GPT32Em.GTSTR 4007 8004h + 0100h × m (m = 4 to 7)
GPT32m.GTSTR 4007 8004h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	CSTRT 12	CSTRT 11	CSTRT 10	CSTRT 9	CSTRT 8	CSTRT 7	CSTRT 6	CSTRT 5	CSTRT 4	CSTRT 3	CSTRT 2	CSTRT 1	CSTRT 0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The GTSTR starts the GTCNT counter operation for each channel n, where n = 0 to 12.

The GTSTR bit number represents the channel number. The GTSTR register is shared by all of the channels. The GTCNT counter starts for the channel associated with the GTSTR bit where 1 is written. Writing 0 has no effect on the status of the GTCNT counter and the value of GTSTR register.

For the association between the GTSTR bit number and a channel number, see Figure 22.2.

CSTRT[12:0] bits (Channel n GTCNT Count Start) (n = 0 to 12)

The CSTRT[12:0] bits start channel n of the GTCNT counter operation. Writing to the GTSTR.CSTRTn bit (n = 0 to 12) has no effect unless the GPTm.GTSSR.CSTRT bit is set to 1 (for GPT32EH, m = 0 to 3, for GPT32E, m = 4 to 7, for GPT32, m = 8 to 12). The read data shows the counter status of each channel (GTCR.CST bit). Zero means the counter is stopped and 1 means the counter is running.

22.2.1 通用PWM定时器写保护寄存器(GTWP)

Address(es): GPT32EHm.GTWP 4007 8000h + 0100h × m (m = 0 to 3)
GPT32Em.GTWP 4007 8000h + 0100h × m (m = 4 to 7)
GPT32m.GTWP 4007 8000h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PRKEY[7:0]								—	—	—	—	—	—	—	WP
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	WP	寄存器写禁用	0：允许写入寄存器1：禁止写入寄存器。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15 to b8	PRKEY[7:0]	GTWP密钥代码	当A5h写入这些位时，允许写入WP位。这些位读为0。	R/W
b31 to b16	—	Reserved	这些位被读取为0。写入值应为0。	R/W

为防止意外修改，GTWP寄存器启用或禁用对以下寄存器的写入：

GTSSR, GTPSR, GTCSR, GTUPSR, GTDNSR, GTICASR, GTICBSR, GTCR, GTUDDTYC, GTIOR, GTINTAD, GTST, GTBER, GTITC, GTCNT, GTCCRA, GTCCRB, GTCCRC, GTCCRD, GTCCRE, GTCCRF, GTPR, GTPBR, GTPDBR, GTADTRA, GTADTBRA, GTADTDBRA, GTADTRB, GTADTBRB, GTADTDBRB, GTDTCR, GTDVU, GTDVD, GTDBU, GTDBD, GTSOS, GTSOTR.

22.2.2 通用PWM定时器软件启动寄存器(GTSTR)

Address(es): GPT32EHm.GTSTR 4007 8004h + 0100h × m (m = 0 to 3)
GPT32Em.GTSTR 4007 8004h + 0100h × m (m = 4 to 7)
GPT32m.GTSTR 4007 8004h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	CSTRT 12	CSTRT 11	CSTRT 10	CSTRT 9	CSTRT 8	CSTRT 7	CSTRT 6	CSTRT 5	CSTRT 4	CSTRT 3	CSTRT 2	CSTRT 1	CSTRT 0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GTSTR启动每个通道n的GTCNT计数器操作，其中n=0到12。

GTSTR位号代表通道号。GTSTR寄存器由所有通道共享。这
GTCNT计数器为与写入1的GTSTR位关联的通道启动。写0对GTCNT计数器的状态和GTSTR寄存器的值没有影响
。

关于GTSTR位号和通道号之间的关联，请参见图22.2。

CSTRT[12:0]位（通道nGTCNT计数开始）（n=0到12）

CSTRT[12:0]位启动GTCNT计数器操作的通道n。写入GTSTR.CSTRTn位（n=0到12）无效，除非GPTm.GTSSR.CSTRT位设置为1（对于GPT32EH，m=0到3，对于GPT32E，m=4到7，对于GPT32 m=8到12）。读取的数据显示每个通道的计数器状态（GTCR.CST位）。零表示计数器停止，1表示计数器正在运行。

22.2.3 General PWM Timer Software Stop Register (GTSTP)

Address(es): GPT32EHm.GTSTP 4007 8008h + 0100h × m (m = 0 to 3)
GPT32Em.GTSTP 4007 8008h + 0100h × m (m = 4 to 7)
GPT32m.GTSTP 4007 8008h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	CSTOP 12	CSTOP 11	CSTOP 10	CSTOP 9	CSTOP 8	CSTOP 7	CSTOP 6	CSTOP 5	CSTOP 4	CSTOP 3	CSTOP 2	CSTOP 1	CSTOP 0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The GTSTP stops the GTCNT counter operation for each channel n, where n = 0 to 12.

The GTSTP bit number represents the channel number. The GTSTP register is shared by all of the channels. The GTCNT counter stops for the channel associated with the GTSTP bit where 1 is written. Writing 0 has no effect on the status of GTCNT counter and the value of GTSTP register. For the association between the GTSTP bit number and a channel number, see Figure 22.2.

CSTOPn bit (channel n GTCNT Count Stop) (n = 0 to 12)

The CSTOPn bit stops channel n of the GTCNT counter operation. Writing to the GTSTP.CSTOPn bit (n = 0 to 12) has no effect unless the GPTm.GTPSR.CSTOP bit is set to 1 (for GPT32EH, m = 0 to 3, for GPT32E, m = 4 to 7, for GPT32, m = 8 to 12).

Read data shows the counter status of each channel (invert of the GTCR.CST bit). Zero means the counter is running and 1 means the counter stops.

22.2.4 General PWM Timer Software Clear Register (GTCLR)

Address(es): GPT32EHm.GTCLR 4007 800Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTCLR 4007 800Ch + 0100h × m (m = 4 to 7)
GPT32m.GTCLR 4007 800Ch + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	CCLR 12	CCLR 11	CCLR 10	CCLR 9	CCLR 8	CCLR 7	CCLR 6	CCLR 5	CCLR 4	CCLR 3	CCLR 2	CCLR 1	CCLR 0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The GTCLR is a write-only register that clears the GTCNT counter operation for each channel n, where n = 0 to 12.

The GTCLR bit number represents the channel number. The GTCLR register is shared by all of the channels. The GTCNT counter is cleared for the channel associated with the GTCLR bit number where 1 is written. Writing 0 has no effect on the status of the GTCNT counter.

For the association between the GTCLR bit number and a channel number, see Figure 22.2.

CCLR[12:0] bits (Channel n GTCNT Count Clear) (n = 0 to 12)

Channel n of the GTCNT counter value is cleared on writing 1 to the CCLRn bit. This bit is read as 0.

22.2.3 通用PWM定时器软件停止寄存器(GTSTP)

Address(es): GPT32EHm.GTSTP 4007 8008h + 0100h × m (m = 0 to 3)
GPT32Em.GTSTP 4007 8008h + 0100h × m (m = 4 to 7)
GPT32m.GTSTP 4007 8008h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	CSTOP 12	CSTOP 11	CSTOP 10	CSTOP 9	CSTOP 8	CSTOP 7	CSTOP 6	CSTOP 5	CSTOP 4	CSTOP 3	CSTOP 2	CSTOP 1	CSTOP 0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTSTP停止每个通道n的GTCNT计数器操作，其中n=0到12。

GTSTP位号代表通道号。GTSTP寄存器由所有通道共享。GTCNT计数器停止与写入1的GTSTP位关联的通道。写0对GTCNT计数器的状态和GTSTP寄存器的值没有影响。GTSTP比特号与通道号的关系见图22.2。

CSTOPn位（通道nGTCNT计数停止）（n=0到12）

CSTOPn位停止GTCNT计数器操作的通道n。写入GTSTP.CSTOPn位（n=0到12）无效，除非GPTm.GTPSR.CSTOP位设置为1（对于GPT32EH，m=0到3，对于GPT32E，m=4到7，对于GPT32 m=8到12）。

读取数据显示每个通道的计数器状态（反转GTCR.CST位）。零表示计数器正在运行，1表示计数器停止。

22.2.4 通用PWM定时器软件清零寄存器(GTCLR)

Address(es): GPT32EHm.GTCLR 4007 800Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTCLR 4007 800Ch + 0100h × m (m = 4 to 7)
GPT32m.GTCLR 4007 800Ch + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	CCLR 12	CCLR 11	CCLR 10	CCLR 9	CCLR 8	CCLR 7	CCLR 6	CCLR 5	CCLR 4	CCLR 3	CCLR 2	CCLR 1	CCLR 0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GTCLR是一个只写寄存器，用于清除每个通道n的GTCNT计数器操作，其中n=0到12。

GTCLR位号代表通道号。GTCLR寄存器由所有通道共享。这
与写入1的GTCLR位号相关的通道的GTCNT计数器清零。写0对GTCNT计数器的状态没有影响。

GTCLR位号和通道号之间的关联，见图22.2。

CCLR[12:0]位（通道nGTCNT计数清除）（n=0到12）

GTCNT计数器值的通道n在向CCLRn位写入1时被清除。该位读为0。

22.2.5 General PWM Timer Start Source Select Register (GTSSR)

Address(es): GPT32EHm.GTSSR 4007 8010h + 0100h × m (m = 0 to 3)
GPT32Em.GTSSR 4007 8010h + 0100h × m (m = 4 to 7)
GPT32m.GTSSR 4007 8010h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	CSTRT	—	—	—	—	—	—	—	SSELCH	SSELCG	SSELCF	SSELCE	SSELCD	SSELCC	SSELCB	SSELCA
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SSCBFAH	SSCBFAL	SSCBRAH	SSCBRAL	SSCAFBH	SSCAFBL	SSCARBH	SSCARBL	SSGTRGDF	SSGTRGDR	SSGTRGCF	SSGTRGCR	SSGTRGBF	SSGTRGBR	SSGTRGAF	SSGTRGAR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SSGTRGAR	GTETRGA Pin Rising Input Source Counter Start Enable	0: Counter start disabled on the rising edge of GTETRGA input 1: Counter start enabled on the rising edge of GTETRGA input.	R/W
b1	SSGTRGAF	GTETRGA Pin Falling Input Source Counter Start Enable	0: Counter start disabled on the falling edge of GTETRGA input 1: Counter start enabled on the falling edge of GTETRGA input.	R/W
b2	SSGTRGBR	GTETRGB Pin Rising Input Source Counter Start Enable	0: Counter start disabled on the rising edge of GTETRGB input 1: Counter start enabled on the rising edge of GTETRGB input.	R/W
b3	SSGTRGBF	GTETRGB Pin Falling Input Source Counter Start Enable	0: Counter start disabled on the falling edge of GTETRGB input 1: Counter start enabled on the falling edge of GTETRGB input.	R/W
b4	SSGTRGCR	GTETRGC Pin Rising Input Source Counter Start Enable	0: Counter start disabled on the rising edge of GTETRGC input 1: Counter start enabled on the rising edge of GTETRGC input.	R/W
b5	SSGTRGCF	GTETRGC Pin Falling Input Source Counter Start Enable	0: Counter start disabled on the falling edge of GTETRGC input 1: Counter start enabled on the falling edge of GTETRGC input	R/W
b6	SSGTRGDR	GTETRGD Pin Rising Input Source Counter Start Enable	0: Counter start disabled on the rising edge of GTETRGD input 1: Counter start enabled on the rising edge of GTETRGD input.	R/W
b7	SSGTRGDF	GTETRGD Pin Falling Input Source Counter Start Enable	0: Counter start disabled on the falling edge of GTETRGD input 1: Counter start enabled on the falling edge of GTETRGD input.	R/W
b8	SSCARBL	GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Start Enable	0: Counter start disabled on the rising edge of GTIOCA input when GTIOCB input is 0 1: Counter start enabled on the rising edge of GTIOCA input when GTIOCB input is 0.	R/W
b9	SSCARBH	GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Start Enable	0: Counter start disabled on the rising edge of GTIOCA input when GTIOCB input is 1 1: Counter start enabled on the rising edge of GTIOCA input when GTIOCB input is 1.	R/W
b10	SSCAFBL	GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Start Enable	0: Counter start disabled on the falling edge of GTIOCA input when GTIOCB input is 0 1: Counter start enabled on the falling edge of GTIOCA input when GTIOCB input is 0.	R/W

22.2.5 通用PWM定时器启动源选择寄存器(GTSSR)

Address(es): GPT32EHm.GTSSR 4007 8010h + 0100h × m (m = 0 to 3)
GPT32Em.GTSSR 4007 8010h + 0100h × m (m = 4 to 7)
GPT32m.GTSSR 4007 8010h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	CSTRT	—	—	—	—	—	—	—	SSELCH	SSELCG	SSELCF	SSELCE	SSELCD	SSELCC	SSELCB	SSELCA
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SSCBFAH	SSCBFAL	SSCBRAH	SSCBRAL	SSCAFBH	SSCAFBL	SSCARBH	SSCARBL	SSGTRGDF	SSGTRGDR	SSGTRGCF	SSGTRGCR	SSGTRGBF	SSGTRGBR	SSGTRGAF	SSGTRGAR
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SSGTRGAR	GTETRGA引脚上升输入源计数器启动启用	0：在GTETRGA输入的上升沿禁止计数器启动1：在GTETRGA输入的上升沿使能计数器启动。	R/W
b1	SSGTRGAF	GTETRGA引脚下降输入源计数器启动启用	0：在GTETRGA输入的下降沿禁止计数器启动1：在GTETRGA输入的下降沿使能计数器启动。	R/W
b2	SSGTRGBR	GTETRGB引脚上升输入源计数器启动启用	0：在GTETRGB输入的上升沿禁止计数器启动1：在GTETRGB输入的上升沿使能计数器启动。	R/W
b3	SSGTRGBF	GTETRGB引脚下降输入源计数器启动启用	0：在GTETRGB输入的下降沿禁用计数器启动1：在GTETRGB输入的下降沿启用计数器启动。	R/W
b4	SSGTRGCR	GTETRGC引脚上升沿输入源计数器启动启用	0：在GTETRGC输入的上升沿禁止计数器启动1：在GTETRGC输入的上升沿使能计数器启动。	R/W
b5	SSGTRGCF	GTETRGC引脚下降输入源计数器启动启用	0：在GTETRGC输入的下降沿禁止计数器启动1：在GTETRGC输入的下降沿使能计数器启动	R/W
b6	SSGTRGDR	GTETRGD引脚上升输入源计数器启动启用	0：在GTETRGD输入的上升沿禁止计数器启动1：在GTETRGD输入的上升沿使能计数器启动。	R/W
b7	SSGTRGDF	GTETRGD引脚下降输入源计数器启动启用	0：在GTETRGD输入的下降沿禁止计数器启动1：在GTETRGD输入的下降沿使能计数器启动。	R/W
b8	SSCARBL	GTIOCA引脚上升期间输入GTIOCB价值低来源计数器启动启用	0：当GTIOCB输入为0时，在GTIOCA输入上升沿禁止计数器启动1：当GTIOCB输入为0时，在GTIOCA输入上升沿使能计数器启动。	R/W
b9	SSCARBH	GTIOCA引脚上升期间输入GTIOCB价值高来源计数器启动启用	0：当GTIOCB输入为1时，在GTIOCA输入上升沿禁止计数器启动1：当GTIOCB输入为1时，在GTIOCA输入上升沿使能计数器启动。	R/W
b10	SSCAFBL	GTIOCA引脚下降期间输入GTIOCB价值低来源计数器启动启用	0：当GTIOCB输入为0时，在GTIOCA输入的下降沿禁止计数器启动1：当GTIOCB输入为0时，在GTIOCA输入的下降沿使能计数器启动。	R/W

Bit	Symbol	Bit name	Description	R/W
b11	SSCAFBH	GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Start Enable	0: Counter start disabled on the falling edge of GTIOCA input when GTIOCB input is 1 1: Counter start enabled on the falling edge of GTIOCA input when GTIOCB input is 1.	R/W
b12	SSCBRAL	GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Start Enable	0: Counter start disabled on the rising edge of GTIOCB input when GTIOCA input is 0 1: Counter start enabled on the rising edge of GTIOCB input when GTIOCA input is 0.	R/W
b13	SSCBRAH	GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Start Enable	0: Counter start disabled on the rising edge of GTIOCB input when GTIOCA input is 1 1: Counter start enabled on the rising edge of GTIOCB input when GTIOCA input is 1.	R/W
b14	SSCBFAL	GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Start Enable	0: Counter start disabled on the falling edge of GTIOCB input when GTIOCA input is 0 1: Counter start enabled on the falling edge of GTIOCB input when GTIOCA input is 0.	R/W
b15	SSCBFAH	GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Start Enable	0: Counter start disabled on the falling edge of GTIOCB input when GTIOCA input is 1 1: Counter start enabled on the falling edge of GTIOCB input when GTIOCA input is 1.	R/W
b16	SSELCA	ELC_GPTA Event Source Counter Start Enable	0: Counter start disabled at the ELC_GPTA event input 1: Counter start enabled at the ELC_GPTA event input.	R/W
b17	SSELCB	ELC_GPTB Event Source Counter Start Enable	0: Counter start disabled at the ELC_GPTB event input 1: Counter start enabled at the ELC_GPTB event input.	R/W
b18	SSELCC	ELC_GPTC Event Source Counter Start Enable	0: Counter start disabled at the ELC_GPTC event input 1: Counter start enabled at the ELC_GPTC event input.	R/W
b19	SSELCD	ELC_GPTD Event Source Counter Start Enable	0: Counter start disabled at the ELC_GPTD event input 1: Counter start enabled at the ELC_GPTD event input.	R/W
b20	SSELCE	ELC_GPTE Event Source Counter Start Enable	0: Counter start disabled at the ELC_GPTE event input 1: Counter start enabled at the ELC_GPTE event input.	R/W
b21	SSELCF	ELC_GPTF Event Source Counter Start Enable	0: Counter start disabled at the ELC_GPTF event input 1: Counter start enabled at the ELC_GPTF event input.	R/W
b22	SSELCG	ELC_GPTG Event Source Counter Start Enable	0: Counter start disabled at the ELC_GPTG event input 1: Counter start enabled at the ELC_GPTG event input.	R/W
b23	SSELCH	ELC_GPTH Event Source Counter Start Enable	0: Counter start disabled at the ELC_GPTH event input 1: Counter start enabled at the ELC_GPTH event input.	R/W
b30 to b24	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b31	CSTRT	Software Source Counter Start Enable	0: Counter start disabled by the GTSTR register 1: Counter start enabled by the GTSTR register.	R/W

The GTSSR sets the source to start the GTCNT counter.

SSGTRGAR bit (GTETRGA Pin Rising Input Source Counter Start Enable)

The SSGTRGAR bit enables or disables the GTCNT counter start on the rising edge of GTETRGA pin input.

SSGTRGAF bit (GTETRGA Pin Falling Input Source Counter Start Enable)

The SSGTRGAF bit enables or disables the GTCNT counter start on the falling edge of GTETRGA pin input.

SSGTRGBR bit (GTETRGB Pin Rising Input Source Counter Start Enable)

The SSGTRGBR bit enables or disables the GTCNT counter start on the rising edge of GTETRGB pin input.

SSGTRGBF bit (GTETRGB Pin Falling Input Source Counter Start Enable)

The SSGTRGBF bit enables or disables the GTCNT counter start on the falling edge of GTETRGB pin input.

SSGTRGCR bit (GTETRGC Pin Rising Input Source Counter Start Enable)

The SSGTRGCR bit enables or disables the GTCNT counter start on the rising edge of GTETRGC pin input.

Bit	Symbol	位名称	Description	R/W
b11	SSCAFBH	GTIOCA引脚下降期间输入GTIOCB价值高来源计数器启动启用	0：当GTIOCB输入为1时，在GTIOCA输入的下降沿禁止计数器启动1：当GTIOCB输入为1时，在GTIOCA输入的下降沿使能计数器启动。	R/W
b12	SSCBRAL	GTIOCB引脚上升期间输入GTIOCA价值低来源计数器启动启用	0：当GTIOCA输入为0时，在GTIOCB输入的上升沿禁止计数器启动1：当GTIOCA输入为0时，在GTIOCB输入的上升沿使能计数器启动。	R/W
b13	SSCBRAH	GTIOCB引脚上升期间输入GTIOCA价值高来源计数器启动启用	0：当GTIOCA输入为1时，在GTIOCB输入的上升沿禁止计数器启动1：当GTIOCA输入为1时，在GTIOCB输入的上升沿使能计数器启动。	R/W
b14	SSCBFAL	在GTIOCB引脚下降输入GTIOCA价值低来源计数器启动启用	0：当GTIOCA输入为0时，在GTIOCB输入的下降沿禁止计数器启动1：当GTIOCA输入为0时，在GTIOCB输入的下降沿使能计数器启动。	R/W
b15	SSCBFAH	在GTIOCB引脚下降输入GTIOCA价值高来源计数器启动启用	0：当GTIOCA输入为1时，在GTIOCB输入的下降沿禁止计数器启动1：当GTIOCA输入为1时，在GTIOCB输入的下降沿使能计数器启动。	R/W
b16	SSELCA	ELC_GPTA事件源计数器启动启用	0：在ELC_GPTA事件输入处禁用计数器启动1：在ELC_GPTA事件输入处启用计数器启动。	R/W
b17	SSELCB	ELC_GPTB事件源计数器启动启用	0：在ELC_GPTB事件输入处禁用计数器启动1：在ELC_GPTB事件输入处启用计数器启动。	R/W
b18	SSELCC	ELC_GPTC事件源计数器启动启用	0：在ELC_GPTC事件输入处禁用计数器启动1：在ELC_GPTC事件输入处启用计数器启动。	R/W
b19	SSELCD	ELC_GPTD事件源计数器启动启用	0：在ELC_GPTD事件输入处禁用计数器启动1：在ELC_GPTD事件输入处启用计数器启动。	R/W
b20	SSELCE	ELC_GPTE事件源计数器启动启用	0：在ELC_GPTE事件输入处禁用计数器启动1：在ELC_GPTE事件输入处启用计数器启动。	R/W
b21	SSELCF	ELC_GPTF事件源计数器启动启用	0：在ELC_GPTF事件输入处禁用计数器启动1：在ELC_GPTF事件输入处启用计数器启动。	R/W
b22	SSELCG	ELC_GPTG事件源计数器启动启用	0：在ELC_GPTG事件输入处禁用计数器启动1：在ELC_GPTG事件输入处启用计数器启动。	R/W
b23	SSELCH	ELC_GPTH事件源计数器启动启用	0：在ELC_GPTH事件输入处禁用计数器启动1：在ELC_GPTH事件输入处启用计数器启动。	R/W
b30 to b24	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b31	CSTRT	软件源计数器启动Enable	0：由GTSTR寄存器禁止计数器启动1：由GTSTR寄存器使能计数器启动。	R/W

GTSSR设置启动GTCNT计数器的源。

SSGTRGAR位（GTETRGA引脚上升沿输入源计数器启动使能）

SSGTRGAR位启用或禁用GTCNT计数器在GTETRGA引脚输入的上升沿启动。

SSGTRGAF位（GTETRGA引脚下降输入源计数器启动使能）

SSGTRGAF位启用或禁用GTCNT计数器在GTETRGA引脚输入的下降沿启动。

SSGTRGBR位（GTETRGB引脚上升输入源计数器启动使能）

SSGTRGBR位在GTETRGB引脚输入的上升沿启用或禁用GTCNT计数器启动。

SSGTRGBF位（GTETRGB引脚下降输入源计数器启动使能）

SSGTRGBF位在GTETRGB引脚输入的下降沿启用或禁用GTCNT计数器启动。

SSGTRGCR位（GTETRGC引脚上升沿输入源计数器启动使能）

SSGTRGCR位启用或禁用GTCNT计数器在GTETRGC引脚输入的上升沿启动。

SSGTRGCF bit (GTETRGC Pin Falling Input Source Counter Start Enable)

The SSGTRGCF bit enables or disables the GTCNT counter start on the falling edge of GTETRGC pin input.

SSGTRGDR bit (GTETRGD Pin Rising Input Source Counter Start Enable)

The SSGTRGDR bit enables or disables the GTCNT counter start on the rising edge of GTETRGD pin input.

SSGTRGDF bit (GTETRGD Pin Falling Input Source Counter Start Enable)

The SSGTRGDF bit enables or disables the GTCNT counter start on the falling edge of GTETRGD pin input.

SSCARBL bit (GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Start Enable)

The SSCARBL bit enables or disables the GTCNT counter start on the rising edge of GTIOCA pin input, when GTIOCB input is 0.

SSCARBH bit (GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Start Enable)

The SSCARBH bit enables or disables the GTCNT counter start on the rising edge of GTIOCA pin input, when GTIOCB input is 1.

SSCAFBL bit (GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Start Enable)

The SSCAFBL bit enables or disables the GTCNT counter start on the falling edge of GTIOCA pin input, when GTIOCB input is 0.

SSCAFBH bit (GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Start Enable)

The SSCAFBH bit enables or disables the GTCNT counter start on the falling edge of GTIOCA pin input, when GTIOCB input is 1.

SSCBRAL bit (GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Start Enable)

The SSCBRAL bit enables or disables the GTCNT counter start on the rising edge of GTIOCB pin input, when GTIOCA input is 0.

SSCBRAH bit (GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Start Enable)

The SSCBRAH bit enables or disables the GTCNT counter start on the rising edge of GTIOCB pin input, when GTIOCA input is 1.

SSCBFAL bit (GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Start Enable)

The SSCBFAL bit enables or disables the GTCNT counter start on the falling edge of GTIOCB pin input, when GTIOCA input is 0.

SSCBFAH bit (GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Start Enable)

The SSCBFAH bit enables or disables the GTCNT counter start on the falling edge of GTIOCB pin input, when GTIOCA input is 1.

SSELCm bit (ELC_GPTm Event Source Counter Start Enable) (m = A to H)

The SSELCm bit enables or disables the GTCNT counter start at the ELC_GPTm event input.

CSTRT bit (Software Source Counter Start Enable)

The CSTRT bit enables or disables the GTCNT counter start by the GTSTR register.

SSGTRGCF位（GTETRGC引脚下降输入源计数器启动使能）

SSGTRGCF位启用或禁用GTCNT计数器在GTETRGC引脚输入的下降沿启动。

SSGTRGDR位（GTETRGD引脚上升沿输入源计数器启动使能）

SSGTRGDR位启用或禁用GTCNT计数器在GTETRGD引脚输入的上升沿启动。

SSGTRGDF位（GTETRGD引脚下降输入源计数器启动使能）

SSGTRGDF位启用或禁用GTCNT计数器在GTETRGD引脚输入的下降沿启动。

SSCARBL位（GTIOCB值低电平期间的GTIOCA引脚上升沿输入源计数器启动使能）

当GTIOCB输入为0时，SSCARBL位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器启动。

SSCARBH位（GTIOCB值高源计数器启动启用期间GTIOCA引脚上升沿输入）

SSCARBH位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器启动，当GTIOCB输入为1。

SSCAFBL位（GTIOCB值低源计数器启动启用期间的GTIOCA引脚下降输入）

SSCAFBL位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器，当GTIOCB输入为0。

SSCAFBH位（GTIOCB值高源计数器启动启用期间GTIOCA引脚下降输入）

SSCAFBH位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器启动，当GTIOCB输入为1。

SSCBRAL位（GTIOCA值低源计数器启动启用期间GTIOCB引脚上升沿输入）

当GTIOCA输入为0时，SSCBRAL位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器启动。

SSCBRAH位（GTIOCA值高源计数器启动启用期间的GTIOCB引脚上升沿输入）

SSCBRAH位启用或禁用GTCNT计数器在GTIOCB引脚输入的上升沿启动，当GTIOCA输入为1。

SSCBFAL位（GTIOCA值低源计数器启动启用期间的GTIOCB引脚下降输入）

SSCBFAL位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器，当GTIOCA输入为0。

SSCBFAH位（GTIOCA值高源计数器启动启用期间GTIOCB引脚下降输入）

SSCBFAH位启用或禁用GTCNT计数器在GTIOCB引脚输入的下降沿启动，当GTIOCA输入为1。

SSELCm位（ELC_GPTm事件源计数器启动启用）（m=A到H）

SSELCm位启用或禁用在ELC_GPTm事件输入时启动的GTCNT计数器。

CSTRT位（软件源计数器启动使能）

CSTRT位启用或禁用由GTSTR寄存器启动的GTCNT计数器。

22.2.6 General PWM Timer Stop Source Select Register (GTPSR)

Address(es): GPT32EHm.GTPSR 4007 8014h + 0100h × m (m = 0 to 3)
GPT32Em.GTPSR 4007 8014h + 0100h × m (m = 4 to 7)
GPT32m.GTPSR 4007 8014h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	CSTOP	—	—	—	—	—	—	—	PSELCH	PSELCG	PSELCF	PSELCE	PSELCD	PSELCC	PSELCB	PSELCA
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PSCBFAH	PSCBFAL	PSCBRAH	PSCBRAL	PSCAFBH	PSCAFBL	PSCARBH	PSCARBL	PSGTRGDF	PSGTRGDR	PSGTRGCF	PSGTRGCR	PSGTRGBF	PSGTRGBR	PSGTRGAF	PSGTRGAR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	PSGTRGAR	GTETRGA Pin Rising Input Source Counter Stop Enable	0: Counter stop disabled on the rising edge of GTETRGA input 1: Counter stop enabled on the rising edge of GTETRGA input.	R/W
b1	PSGTRGAF	GTETRGA Pin Falling Input Source Counter Stop Enable	0: Counter stop disabled on the falling edge of GTETRGA input 1: Counter stop enabled on the falling edge of GTETRGA input.	R/W
b2	PSGTRGBR	GTETRGB Pin Rising Input Source Counter Stop Enable	0: Counter stop disabled on the rising edge of GTETRGB input 1: Counter stop enabled on the rising edge of GTETRGB input.	R/W
b3	PSGTRGBF	GTETRGB Pin Falling Input Source Counter Stop Enable	0: Counter stop disabled on the falling edge of GTETRGB input 1: Counter stop enabled on the falling edge of GTETRGB input.	R/W
b4	PSGTRGCR	GTETRGC Pin Rising Input Source Counter Stop Enable	0: Counter stop disabled on the rising edge of GTETRGC input 1: Counter stop enabled on the rising edge of GTETRGC input.	R/W
b5	PSGTRGCF	GTETRGC Pin Falling Input Source Counter Stop Enable	0: Counter stop disabled on the falling edge of GTETRGC input 1: Counter stop enabled on the falling edge of GTETRGC input.	R/W
b6	PSGTRGDR	GTETRGD Pin Rising Input Source Counter Stop Enable	0: Counter stop disabled on the rising edge of GTETRGD input 1: Counter stop enabled on the rising edge of GTETRGD input.	R/W
b7	PSGTRGDF	GTETRGD Pin Falling Input Source Counter Stop Enable	0: Counter stop disabled on the falling edge of GTETRGD input 1: Counter stop enabled on the falling edge of GTETRGD input.	R/W
b8	PSCARBL	GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Stop Enable	0: Counter stop disabled on the rising edge of GTIOCA input when GTIOCB input is 0 1: Counter stop enabled on the rising edge of GTIOCA input when GTIOCB input is 0.	R/W
b9	PSCARBH	GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Stop Enable	0: Counter stop disabled on the rising edge of GTIOCA input when GTIOCB input is 1 1: Counter stop enabled on the rising edge of GTIOCA input when GTIOCB input is 1.	R/W
b10	PSCAFBL	GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Stop Enable	0: Counter stop disabled on the falling edge of GTIOCA input when GTIOCB input is 0 1: Counter stop enabled on the falling edge of GTIOCA input when GTIOCB input is 0.	R/W

22.2.6 通用PWM定时器停止源选择寄存器(GTPSR)

Address(es): GPT32EHm.GTPSR 4007 8014h + 0100h × m (m = 0 to 3)
GPT32Em.GTPSR 4007 8014h + 0100h × m (m = 4 to 7)
GPT32m.GTPSR 4007 8014h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	CSTOP	—	—	—	—	—	—	—	PSELCH	PSELCG	PSELCF	PSELCE	PSELCD	PSELCC	PSELCB	PSELCA
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	PSCBFAH	PSCBFAL	PSCBRAH	PSCBRAL	PSCAFBH	PSCAFBL	PSCARBH	PSCARBL	PSGTRGDF	PSGTRGDR	PSGTRGCF	PSGTRGCR	PSGTRGBF	PSGTRGBR	PSGTRGAF	PSGTRGAR
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	PSGTRGAR	GTETRGA引脚上升输入源计数器停止启用	0：在GTETRGA输入的上升沿禁止计数器停止1：在GTETRGA输入的上升沿使能计数器停止。	R/W
b1	PSGTRGAF	GTETRGA引脚下降输入源计数器停止启用	0：在GTETRGA输入的下降沿禁止计数器停止1：在GTETRGA输入的下降沿使能计数器停止。	R/W
b2	PSGTRGBR	GTETRGB引脚上升输入源计数器停止启用	0：在GTETRGB输入的上升沿禁止计数器停止1：在GTETRGB输入的上升沿使能计数器停止。	R/W
b3	PSGTRGBF	GTETRGB引脚下降输入源计数器停止启用	0：在GTETRGB输入的下降沿禁用计数器停止1：在GTETRGB输入的下降沿启用计数器停止。	R/W
b4	PSGTRGCR	GTETRGC引脚上升沿输入源计数器停止启用	0：在GTETRGC输入的上升沿禁止计数器停止1：在GTETRGC输入的上升沿使能计数器停止。	R/W
b5	PSGTRGCF	GTETRGC引脚下降输入源计数器停止启用	0：在GTETRGC输入的下降沿禁止计数器停止1：在GTETRGC输入的下降沿使能计数器停止。	R/W
b6	PSGTRGDR	GTETRGD引脚上升输入源计数器停止启用	0：在GTETRGD输入的上升沿禁止计数器停止1：在GTETRGD输入的上升沿使能计数器停止。	R/W
b7	PSGTRGDF	GTETRGD引脚下降输入源计数器停止启用	0：在GTETRGD输入的下降沿禁止计数器停止1：在GTETRGD输入的下降沿使能计数器停止。	R/W
b8	PSCARBL	GTIOCA引脚上升期间输入GTIOCB价值低来源计数器停止启用	0：当GTIOCB输入为0时，在GTIOCA输入上升沿禁止计数器停止1：当GTIOCB输入为0时，在GTIOCA输入上升沿使能计数器停止。	R/W
b9	PSCARBH	GTIOCA引脚上升期间输入GTIOCB价值高来源计数器停止启用	0：当GTIOCB输入为1时，在GTIOCA输入上升沿禁止计数器停止1：当GTIOCB输入为1时，在GTIOCA输入上升沿使能计数器停止。	R/W
b10	PSCAFBL	GTIOCA引脚下降期间输入GTIOCB价值低来源计数器停止启用	0：当GTIOCB输入为0时，在GTIOCA输入下降沿禁止计数器停止1：当GTIOCB输入为0时，在GTIOCA输入下降沿使能计数器停止。	R/W

Bit	Symbol	Bit name	Description	R/W
b11	PSCAFBH	GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Stop Enable	0: Counter stop disabled on the falling edge of GTIOCA input when GTIOCB input is 1 1: Counter stop enabled on the falling edge of GTIOCA input when GTIOCB input is 1.	R/W
b12	PSCBRAL	GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Stop Enable	0: Counter stop disabled on the rising edge of GTIOCB input when GTIOCA input is 0 1: Counter stop enabled on the rising edge of GTIOCB input when GTIOCA input is 0.	R/W
b13	PSCBRAH	GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Stop Enable	0: Counter stop disabled on the rising edge of GTIOCB input when GTIOCA input is 1 1: Counter stop enabled on the rising edge of GTIOCB input when GTIOCA input is 1.	R/W
b14	PSCBFAL	GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Stop Enable	0: Counter stop disabled on the falling edge of GTIOCB input when GTIOCA input is 0 1: Counter stop enabled on the falling edge of GTIOCB input when GTIOCA input is 0	R/W
b15	PSCBFAH	GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Stop Enable	0: Counter stop disabled on the falling edge of GTIOCB input when GTIOCA input is 1 1: Counter stop enabled on the falling edge of GTIOCB input when GTIOCA input is 1	R/W
b16	PSELCA	ELC_GPTA Event Source Counter Stop Enable	0: Counter stop disabled at the ELC_GPTA event input 1: Counter stop enabled at the ELC_GPTA event input.	R/W
b17	PSELCB	ELC_GPTB Event Source Counter Stop Enable	0: Counter stop disabled at the ELC_GPTB event input 1: Counter stop enabled at the ELC_GPTB event input.	R/W
b18	PSELCC	ELC_GPTC Event Source Counter Stop Enable	0: Counter stop disabled at the ELC_GPTC event input 1: Counter stop enabled at the ELC_GPTC event input.	R/W
b19	PSELCD	ELC_GPTD Event Source Counter Stop Enable	0: Counter stop disabled at the ELC_GPTD event input 1: Counter stop enabled at the ELC_GPTD event input.	R/W
b20	PSELCE	ELC_GPTE Event Source Counter Stop Enable	0: Counter stop disabled at the ELC_GPTE event input 1: Counter stop enabled at the ELC_GPTE event input.	R/W
b21	PSELCF	ELC_GPTF Event Source Counter Stop Enable	0: Counter stop disabled at the ELC_GPTF event input 1: Counter stop enabled at the ELC_GPTF event input.	R/W
b22	PSELCG	ELC_GPTG Event Source Counter Stop Enable	0: Counter stop disabled at the ELC_GPTG event input 1: Counter stop enabled at the ELC_GPTG event input.	R/W
b23	PSELCH	ELC_GPTH Event Source Counter Stop Enable	0: Counter stop disabled at the ELC_GPTH event input 1: Counter stop enabled at the ELC_GPTH event input.	R/W
b30 to b24	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b31	CSTOP	Software Source Counter Stop Enable	0: Counter stop disabled by the GTSTP register 1: Counter stop enabled by the GTSTP register.	R/W

The GTPSR sets the source to stop the GTCNT counter.

PSGTRGAR bit (GTETRGA Pin Rising Input Source Counter Stop Enable)

The PSGTRGAR bit enables or disables the GTCNT counter stop on the rising edge of GTETRGA pin input.

PSGTRGAF bit (GTETRGA Pin Falling Input Source Counter Stop Enable)

The PSGTRGAF bit enables or disables the GTCNT counter stop on the falling edge of GTETRGA pin input.

PSGTRGBR bit (GTETRGB Pin Rising Input Source Counter Stop Enable)

The PSGTRGBR bit enables or disables the GTCNT counter stop on the rising edge of GTETRGB pin input.

PSGTRGBF bit (GTETRGB Pin Falling Input Source Counter Stop Enable)

The PSGTRGBF bit enables or disables the GTCNT counter stop on the falling edge of GTETRGB pin input.

PSGTRGCR bit (GTETRGC Pin Rising Input Source Counter Stop Enable)

The PSGTRGCR bit enables or disables the GTCNT counter stop on the rising edge of GTETRGC pin input.

Bit	Symbol	位名称	Description	R/W
b11	PSCAFBH	GTIOCA引脚下降期间输入GTIOCB价值高来源计数器停止启用	0：当GTIOCB输入为1时，在GTIOCA输入下降沿禁止计数器停止1：当GTIOCB输入为1时，在GTIOCA输入下降沿使能计数器停止。	R/W
b12	PSCBRAL	GTIOCB引脚上升期间输入GTIOCA价值低来源计数器停止启用	0：当GTIOCA输入为0时，在GTIOCB输入上升沿禁止计数器停止1：当GTIOCA输入为0时，在GTIOCB输入上升沿使能计数器停止。	R/W
b13	PSCBRAH	GTIOCB引脚上升期间输入GTIOCA价值高来源计数器停止启用	0：当GTIOCA输入为1时，在GTIOCB输入上升沿禁止计数器停止1：当GTIOCA输入为1时，在GTIOCB输入上升沿使能计数器停止。	R/W
b14	PSCBFAL	在GTIOCB引脚下降输入GTIOCA价值低来源计数器停止启用	0：当GTIOCA输入为0时，在GTIOCB输入的下降沿禁止计数器停止1：当GTIOCA输入为0时，在GTIOCB输入的下降沿使能计数器停止	R/W
b15	PSCBFAH	在GTIOCB引脚下降输入GTIOCA价值高来源计数器停止启用	0：当GTIOCA输入为1时，在GTIOCB输入的下降沿禁止计数器停止1：当GTIOCA输入为1时，在GTIOCB输入的下降沿使能计数器停止	R/W
b16	PSELCA	ELC_GPTA事件源计数器停止启用	0：在ELC_GPTA事件输入处禁用计数器停止1：在ELC_GPTA事件输入处启用计数器停止。	R/W
b17	PSELCB	ELC_GPTB事件源计数器停止启用	0：在ELC_GPTB事件输入处禁用计数器停止1：在ELC_GPTB事件输入处启用计数器停止。	R/W
b18	PSELCC	ELC_GPTC事件源计数器停止启用	0：在ELC_GPTC事件输入处禁用计数器停止1：在ELC_GPTC事件输入处启用计数器停止。	R/W
b19	PSELCD	ELC_GPTD事件源计数器停止启用	0：在ELC_GPTD事件输入处禁用计数器停止1：在ELC_GPTD事件输入处启用计数器停止。	R/W
b20	PSELCE	ELC_GPTE事件源计数器停止启用	0：在ELC_GPTE事件输入处禁用计数器停止1：在ELC_GPTE事件输入处启用计数器停止。	R/W
b21	PSELCF	ELC_GPTF事件源计数器停止启用	0：在ELC_GPTF事件输入处禁用计数器停止1：在ELC_GPTF事件输入处启用计数器停止。	R/W
b22	PSELCG	ELC_GPTG事件源计数器停止启用	0：在ELC_GPTG事件输入处禁用计数器停止1：在ELC_GPTG事件输入处启用计数器停止。	R/W
b23	PSELCH	ELC_GPTH事件源计数器停止启用	0：在ELC_GPTH事件输入处禁用计数器停止1：在ELC_GPTH事件输入处启用计数器停止。	R/W
b30 to b24	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b31	CSTOP	软件源计数器停止Enable	0：GTSTP寄存器禁止计数器停止1：GTSTP寄存器使能计数器停止。	R/W

GTPSR设置源以停止GTCNT计数器。

PSGTRGAR位（GTETRGA引脚上升沿输入源计数器停止使能）

PSGTRGAR位在GTETRGA引脚输入的上升沿启用或禁用GTCNT计数器停止。

PSGTRGAF位（GTETRGA引脚下降输入源计数器停止使能）

PSGTRGAF位在GTETRGA引脚输入的下降沿启用或禁用GTCNT计数器停止。

PSGTRGBR位（GTETRGB引脚上升输入源计数器停止使能）

PSGTRGBR位在GTETRGB引脚输入的上升沿启用或禁用GTCNT计数器停止。

PSGTRGBF位（GTETRGB引脚下降输入源计数器停止使能）

PSGTRGBF位在GTETRGB引脚输入的下降沿启用或禁用GTCNT计数器停止。

PSGTRGCR位（GTETRGC引脚上升沿输入源计数器停止使能）

PSGTRGCR位使能或禁止GTCNT计数器在GTETRGC引脚输入的上升沿停止。

PSGTRGCF bit (GTETRGC Pin Falling Input Source Counter Stop Enable)

The PSGTRGCF bit enables or disables the GTCNT counter stop on the falling edge of GTETRGC pin input.

PSGTRGDR bit (GTETRGD Pin Rising Input Source Counter Stop Enable)

The PSGTRGDR bit enables or disables the GTCNT counter stop on the rising edge of GTETRGD pin input.

PSGTRGDF bit (GTETRGD Pin Falling Input Source Counter Stop Enable)

The PSGTRGDF bit enables or disables the GTCNT counter stop on the falling edge of GTETRGD pin input.

PSCARBL bit (GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Stop Enable)

The PSCARBL bit enables or disables the GTCNT counter stop on the rising edge of GTIOCA pin input, when GTIOCB input is 0.

PSCARBH bit (GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Stop Enable)

The PSCARBH bit enables or disables the GTCNT counter stop on the rising edge of GTIOCA pin input, when GTIOCB input is 1.

PSCAFBL bit (GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Stop Enable)

The PSCAFBL bit enables or disables the GTCNT counter stop on the falling edge of GTIOCA pin input, when GTIOCB input is 0.

PSCAFBH bit (GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Stop Enable)

The PSCAFBH bit enables or disables the GTCNT counter stop on the falling edge of GTIOCA pin input, when GTIOCB input is 1.

PSCBRAL bit (GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Stop Enable)

The PSCBRAL bit enables or disables the GTCNT counter stop on the rising edge of GTIOCB pin input, when GTIOCA input is 0.

PSCBRAH bit (GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Stop Enable)

The PSCBRAH bit enables or disables the GTCNT counter stop on the rising edge of GTIOCB pin input, when GTIOCA input is 1.

PSCBFAL bit (GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Stop Enable)

The PSCBFAL bit enables or disables the GTCNT counter stop on the falling edge of GTIOCB pin input, when GTIOCA input is 0.

PSCBFAH bit (GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Stop Enable)

The PSCBFAH bit enables or disables the GTCNT counter stop on the falling edge of GTIOCB pin input, when GTIOCA input is 1.

PSELCm bit (ELC_GPTm Event Source Counter Stop Enable) (m = A to H)

The PSELCm bit enables or disables the GTCNT counter stop at the ELC_GPTm event input.

CSTOP bit (Software Source Counter Stop Enable)

The CSTOP bit enables or disables the GTCNT counter stop by the GTSTP register.

PSGTRGCF位（GTETRGC引脚下降输入源计数器停止使能）

PSGTRGCF位使能或禁止GTCNT计数器在GTETRGC引脚输入的下降沿停止。

PSGTRGDR位（GTETRGD引脚上升输入源计数器停止使能）

PSGTRGDR位使能或禁止GTCNT计数器在GTETRGD引脚输入的上升沿停止。

PSGTRGDF位（GTETRGD引脚下降输入源计数器停止使能）

PSGTRGDF位使能或禁止GTCNT计数器在GTETRGD引脚输入的下降沿停止。

PSCARBL位（GTIOCB值低源计数器停止使能期间GTIOCA引脚上升沿输入）

当GTIOCB输入为0时，PSCARBL位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器停止。

PSCARBH位（GTIOCB值高源计数器停止使能期间GTIOCA引脚上升沿输入）

当GTIOCB输入为1时，PSCARBH位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器停止。

PSCAFBL位（GTIOCB值低源计数器停止使能期间GTIOCA引脚下降输入）

PSCAFBL位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器停止，当GTIOCB输入为0。

PSCAFBH位（GTIOCB值高源计数器停止使能期间GTIOCA引脚下降输入）

PSCAFBH位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器停止，当GTIOCB输入为1。

PSCBRAL位（GTIOCA值低源计数器停止使能期间GTIOCB引脚上升沿输入）

当GTIOCA输入为0时，PSCBRAL位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器停止。

PSCBRAH位（GTIOCA值高源计数器停止使能期间GTIOCB引脚上升沿输入）

当GTIOCA输入为1时，PSCBRAH位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器停止。

PSCBFAL位（GTIOCA值低源计数器停止使能期间GTIOCB引脚下降输入）

PSCBFAL位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器停止，当GTIOCA输入为0。

PSCBFAH位（GTIOCA值高源计数器停止使能期间GTIOCB引脚下降输入）

PSCBFAH位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器停止，当GTIOCA输入为1。

PSELCm位（ELC_GPTm事件源计数器停止使能）（m=A到H）

PSELCm位启用或禁用GTCNT计数器在ELC_GPTm事件输入处停止。

CSTOP位（软件源计数器停止使能）

CSTOP位通过GTSTP寄存器启用或禁用GTCNT计数器停止。

22.2.7 General PWM Timer Clear Source Select Register (GTCSR)

Address(es): GPT32EHm.GTCSR 4007 8018h + 0100h × m (m = 0 to 3)
GPT32Em.GTCSR 4007 8018h + 0100h × m (m = 4 to 7)
GPT32m.GTCSR 4007 8018h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	CCLR	—	—	—	—	—	—	—	CSELCH	CSELCG	CSELCF	CSELCE	CSELCD	CSELCC	CSELCB	CSELCA
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	CSCBFAH	CSCBFAL	CSCBRAH	CSCBRAL	CSCAFBH	CSCAFBL	CSCARBH	CSCARBL	CSGTRGDF	CSGTRGDR	CSGTRGCF	CSGTRGCR	CSGTRGBF	CSGTRGBR	CSGTRGAF	CSGTRGAR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CSGTRGAR	GTETRGA Pin Rising Input Source Counter Clear Enable	0: Counter clear disabled on the rising edge of GTETRGA input 1: Counter clear enabled on the rising edge of GTETRGA input.	R/W
b1	CSGTRGAF	GTETRGA Pin Falling Input Source Counter Clear Enable	0: Counter clear disabled on the falling edge of GTETRGA input 1: Counter clear enabled on the falling edge of GTETRGA input.	R/W
b2	CSGTRGBR	GTETRGB Pin Rising Input Source Counter Clear Enable	0: Counter clear disabled on the rising edge of GTETRGB input 1: Counter clear enabled on the rising edge of GTETRGB input.	R/W
b3	CSGTRGBF	GTETRGB Pin Falling Input Source Counter Clear Enable	0: Counter clear disabled on the falling edge of GTETRGB input 1: Counter clear enabled on the falling edge of GTETRGB input.	R/W
b4	CSGTRGCR	GTETRGC Pin Rising Input Source Counter Clear Enable	0: Counter clear disabled on the rising edge of GTETRGC input 1: Counter clear enabled on the rising edge of GTETRGC input.	R/W
b5	CSGTRGCF	GTETRGC Pin Falling Input Source Counter Clear Enable	0: Counter clear disabled on the falling edge of GTETRGC input 1: Counter clear enabled on the falling edge of GTETRGC input.	R/W
b6	CSGTRGDR	GTETRGD Pin Rising Input Source Counter Clear Enable	0: Counter clear disabled on the rising edge of GTETRGD input 1: Counter clear enabled on the rising edge of GTETRGD input.	R/W
b7	CSGTRGDF	GTETRGD Pin Falling Input Source Counter Clear Enable	0: Counter clear disabled on the falling edge of GTETRGD input 1: Counter clear enabled on the falling edge of GTETRGD input.	R/W
b8	CSCARBL	GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Clear Enable	0: Counter clear disabled on the rising edge of GTIOCA input when GTIOCB input is 0 1: Counter clear enabled on the rising edge of GTIOCA input when GTIOCB input is 0.	R/W
b9	CSCARBH	GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Clear Enable	0: Counter clear disabled on the rising edge of GTIOCA input when GTIOCB input is 1 1: Counter clear enabled on the rising edge of GTIOCA input when GTIOCB input is 1.	R/W
b10	CSCAFBL	GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Clear Enable	0: Counter clear disabled on the falling edge of GTIOCA input when GTIOCB input is 0 1: Counter clear enabled on the falling edge of GTIOCA input when GTIOCB input is 0.	R/W

22.2.7 通用PWM定时器清零源选择寄存器(GTCSR)

Address(es): GPT32EHm.GTCSR 4007 8018h + 0100h × m (m = 0 to 3)
GPT32Em.GTCSR 4007 8018h + 0100h × m (m = 4 to 7)
GPT32m.GTCSR 4007 8018h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	CCLR	—	—	—	—	—	—	—	CSELCH	CSELCG	CSELCF	CSELCE	CSELCD	CSELCC	CSELCB	CSELCA
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	CSCBFAH	CSCBFAL	CSCBRAH	CSCBRAL	CSCAFBH	CSCAFBL	CSCARBH	CSCARBL	CSGTRGDF	CSGTRGDR	CSGTRGCF	CSGTRGCR	CSGTRGBF	CSGTRGBR	CSGTRGAF	CSGTRGAR
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CSGTRGAR	GTETRGA引脚上升输入源计数器清除启用	0：在GTETRGA输入的上升沿禁止计数器清除1：在GTETRGA输入的上升沿使能计数器清除。	R/W
b1	CSGTRGAF	GTETRGA引脚下降输入源计数器清除启用	0：在GTETRGA输入的下降沿禁止计数器清除1：在GTETRGA输入的下降沿使能计数器清除。	R/W
b2	CSGTRGBR	GTETRGB引脚上升输入源计数器清除启用	0：在GTETRGB输入的上升沿禁止计数器清除1：在GTETRGB输入的上升沿使能计数器清除。	R/W
b3	CSGTRGBF	GTETRGB引脚下降输入源计数器清除启用	0：在GTETRGB输入的下降沿禁用计数器清除1：在GTETRGB输入的下降沿启用计数器清除。	R/W
b4	CSGTRGCR	GTETRGC引脚上升沿输入源计数器清除启用	0：在GTETRGC输入的上升沿禁止计数器清除1：在GTETRGC输入的上升沿使能计数器清除。	R/W
b5	CSGTRGCF	GTETRGC引脚下降输入源计数器清除启用	0：在GTETRGC输入的下降沿禁止计数器清除1：在GTETRGC输入的下降沿使能计数器清除。	R/W
b6	CSGTRGDR	GTETRGD引脚上升输入源计数器清除启用	0：在GTETRGD输入的上升沿禁止计数器清除1：在GTETRGD输入的上升沿使能计数器清除。	R/W
b7	CSGTRGDF	GTETRGD引脚下降输入源计数器清除启用	0：在GTETRGD输入的下降沿禁止计数器清除1：在GTETRGD输入的下降沿使能计数器清除。	R/W
b8	CSCARBL	GTIOCA引脚上升期间输入GTIOCB价值低来源计数器清除启用	0：当GTIOCB输入为0时，在GTIOCA输入上升沿禁止计数器清除1：当GTIOCB输入为0时，在GTIOCA输入上升沿使能计数器清除。	R/W
b9	CSCARBH	GTIOCA引脚上升期间输入GTIOCB价值高来源计数器清除启用	0：当GTIOCB输入为1时，在GTIOCA输入上升沿禁止计数器清除1：当GTIOCB输入为1时，在GTIOCA输入上升沿使能计数器清除。	R/W
b10	CSCAFBL	GTIOCA引脚下降期间输入GTIOCB价值低来源计数器清除启用	0：当GTIOCB输入为0时，在GTIOCA输入的下降沿禁止计数器清除1：当GTIOCB输入为0时，在GTIOCA输入的下降沿使能计数器清除。	R/W

Bit	Symbol	Bit name	Description	R/W
b11	CSCAFBH	GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Clear Enable	0: Counter clear disabled on the falling edge of GTIOCA input when GTIOCB input is 1 1: Counter clear enabled on the falling edge of GTIOCA input when GTIOCB input is 1.	R/W
b12	CSCBRAL	GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Clear Enable	0: Counter clear disabled on the rising edge of GTIOCB input when GTIOCA input is 0 1: Counter clear enabled on the rising edge of GTIOCB input when GTIOCA input is 0.	R/W
b13	CSCBRAH	GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Clear Enable	0: Counter clear disabled on the rising edge of GTIOCB input when GTIOCA input is 1 1: Counter clear enabled on the rising edge of GTIOCB input when GTIOCA input is 1.	R/W
b14	CSCBFAL	GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Clear Enable	0: Counter clear disabled on the falling edge of GTIOCB input when GTIOCA input is 0 1: Counter clear enabled on the falling edge of GTIOCB input when GTIOCA input is 0.	R/W
b15	CSCBFAH	GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Clear Enable	0: Counter clear disabled on the falling edge of GTIOCB input when GTIOCA input is 1 1: Counter clear enabled on the falling edge of GTIOCB input when GTIOCA input is 1.	R/W
b16	CSELCA	ELC_GPTA Event Source Counter Clear Enable	0: Counter clear disabled at the ELC_GPTA event input 1: Counter clear enabled at ELC_GPTA event input.	R/W
b17	CSELCB	ELC_GPTB Event Source Counter Clear Enable	0: Counter clear disabled at the ELC_GPTB event input 1: Counter clear enabled at the ELC_GPTB event input.	R/W
b18	CSELCC	ELC_GPTC Event Source Counter Clear Enable	0: Counter clear disabled at the ELC_GPTC event input 1: Counter clear enabled at the ELC_GPTC event input.	R/W
b19	CSELCD	ELC_GPTD Event Source Counter Clear Enable	0: Counter clear disabled at the ELC_GPTD event input 1: Counter clear enabled at the ELC_GPTD event input.	R/W
b20	CSELCE	ELC_GPTE Event Source Counter Clear Enable	0: Counter clear disabled at the ELC_GPTE event input 1: Counter clear enabled at the ELC_GPTE event input.	R/W
b21	CSELCF	ELC_GPTF Event Source Counter Clear Enable	0: Counter clear disabled at the ELC_GPTF event input 1: Counter clear enabled at the ELC_GPTF event input.	R/W
b22	CSELCG	ELC_GPTG Event Source Counter Clear Enable	0: Counter clear disabled at the ELC_GPTG event input 1: Counter clear enabled at the ELC_GPTG event input.	R/W
b23	CSELCH	ELC_GPTH Event Source Counter Clear Enable	0: Counter clear disabled at the ELC_GPTH event input 1: Counter clear enabled at the ELC_GPTH event input.	R/W
b30 to b24	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b31	CCLR	Software Source Counter Clear Enable	0: Counter clear disabled by the GTCLR register 1: Counter clear enabled by the GTCLR register.	R/W

The GTCSR sets the source to clear the GTCNT counter.

CSGTRGAR bit (GTETRGA Pin Rising Input Source Counter Clear Enable)

The CSGTRGAR bit enables or disables the GTCNT counter clear on the rising edge of GTETRGA pin input.

CSGTRGAF bit (GTETRGA Pin Falling Input Source Counter Clear Enable)

The CSGTRGAF bit enables or disables the GTCNT counter clear on the falling edge of GTETRGA pin input.

CSGTRGBR bit (GTETRGB Pin Rising Input Source Counter Clear Enable)

The CSGTRGBR bit enables or disables the GTCNT counter clear on the rising edge of GTETRGB pin input.

CSGTRGBF bit (GTETRGB Pin Falling Input Source Counter Clear Enable)

The CSGTRGBF bit enables or disables the GTCNT counter clear on the falling edge of GTETRGB pin input.

CSGTRGCR bit (GTETRGC Pin Rising Input Source Counter Clear Enable)

The CSGTRGCR bit enables or disables the GTCNT counter clear on the rising edge of GTETRGC pin input.

Bit	Symbol	位名称	Description	R/W
b11	CSCAFBH	GTIOCA引脚下降期间输入GTIOCB价值高来源计数器清除启用	0：当GTIOCB输入为1时，在GTIOCA输入的下降沿禁止计数器清零1：当GTIOCB输入为1时，在GTIOCA输入的下降沿使能计数器清零。	R/W
b12	CSCBRAL	GTIOCB引脚上升期间输入GTIOCA价值低来源计数器清除启用	0：当GTIOCA输入为0时，在GTIOCB输入上升沿禁止计数器清除1：当GTIOCA输入为0时，在GTIOCB输入上升沿使能计数器清除。	R/W
b13	CSCBRAH	GTIOCB引脚上升期间输入GTIOCA价值高来源计数器清除启用	0：当GTIOCA输入为1时，在GTIOCB输入上升沿禁止计数器清除1：当GTIOCA输入为1时，在GTIOCB输入上升沿使能计数器清除。	R/W
b14	CSCBFAL	在GTIOCB引脚下降输入GTIOCA价值低来源计数器清除启用	0：当GTIOCA输入为0时，在GTIOCB输入的下降沿禁止计数器清零1：当GTIOCA输入为0时，在GTIOCB输入的下降沿使能计数器清零。	R/W
b15	CSCBFAH	在GTIOCB引脚下降输入GTIOCA价值高来源计数器清除启用	0：当GTIOCA输入为1时，在GTIOCB输入的下降沿禁止计数器清除1：当GTIOCA输入为1时，在GTIOCB输入的下降沿使能计数器清除。	R/W
b16	CSELCA	ELC_GPTA事件源计数器清除启用	0：在ELC_GPTA事件输入处禁用计数器清除1：在ELC_GPTA事件输入处启用计数器清除。	R/W
b17	CSELCB	ELC_GPTB事件源计数器清除启用	0：在ELC_GPTB事件输入处禁用计数器清除1：在ELC_GPTB事件输入处启用计数器清除。	R/W
b18	CSELCC	ELC_GPTC事件源计数器清除启用	0：在ELC_GPTC事件输入处禁用计数器清除1：在ELC_GPTC事件输入处启用计数器清除。	R/W
b19	CSELCD	ELC_GPTD事件源计数器清除启用	0：在ELC_GPTD事件输入处禁用计数器清除1：在ELC_GPTD事件输入处启用计数器清除。	R/W
b20	CSELCE	ELC_GPTE事件源计数器清除启用	0：在ELC_GPTE事件输入处禁用计数器清除1：在ELC_GPTE事件输入处启用计数器清除。	R/W
b21	CSELCF	ELC_GPTF事件源计数器清除启用	0：在ELC_GPTF事件输入处禁用计数器清除1：在ELC_GPTF事件输入处启用计数器清除。	R/W
b22	CSELCG	ELC_GPTG事件源计数器清除启用	0：在ELC_GPTG事件输入处禁用计数器清除1：在ELC_GPTG事件输入处启用计数器清除。	R/W
b23	CSELCH	ELC_GPTH事件源计数器清除启用	0：在ELC_GPTH事件输入处禁用计数器清除1：在ELC_GPTH事件输入处启用计数器清除。	R/W
b30 to b24	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b31	CCLR	软件源计数器清零Enable	0：GTCLR寄存器禁止计数器清零1：GTCLR寄存器使能计数器清零。	R/W

GTCSR设置源以清除GTCNT计数器。

CSGTRGAR位（GTETRGA引脚上升沿输入源计数器清零使能）

CSGTRGAR位在GTETRGA引脚输入的上升沿启用或禁用GTCNT计数器清零。

CSGTRGAF位（GTETRGA引脚下降输入源计数器清零使能）

CSGTRGAF位在GTETRGA引脚输入的下降沿启用或禁用GTCNT计数器清零。

CSGTRGBR位（GTETRGB引脚上升沿输入源计数器清零使能）

CSGTRGBR位在GTETRGB引脚输入的上升沿启用或禁用GTCNT计数器清零。

CSGTRGBF位（GTETRGB引脚下降输入源计数器清零使能）

CSGTRGBF位在GTETRGB引脚输入的下降沿启用或禁用GTCNT计数器清零。

CSGTRGCR位（GTETRGC引脚上升沿输入源计数器清零使能）

CSGTRGCR位在GTETRGC引脚输入的上升沿启用或禁用GTCNT计数器清零。

CSGTRGCF bit (GTETRGC Pin Falling Input Source Counter Clear Enable)

The CSGTRGCF bit enables or disables the GTCNT counter clear on the falling edge of GTETRGC pin input.

CSGTRGDR bit (GTETRGD Pin Rising Input Source Counter Clear Enable)

The CSGTRGDR bit enables or disables the GTCNT counter clear on the rising edge of GTETRGD pin input.

CSGTRGDF bit (GTETRGD Pin Falling Input Source Counter Clear Enable)

The CSGTRGDF bit enables or disables the GTCNT counter clear on the falling edge of GTETRGD pin input.

CSCARBL bit (GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Clear Enable)

The CSCARBL bit enables or disables the GTCNT counter clear on the rising edge of GTIOCA pin input, when GTIOCB input is 0.

CSCARBH bit (GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Clear Enable)

The CSCARBH bit enables or disables the GTCNT counter clear on the rising edge of GTIOCA pin input, when GTIOCB input is 1.

CSCAFBL bit (GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Clear Enable)

The CSCAFBL bit enables or disables the GTCNT counter clear on the falling edge of GTIOCA pin input, when GTIOCB input is 0.

CSCAFBH bit (GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Clear Enable)

The CSCAFBH bit enables or disables the GTCNT counter clear on the falling edge of GTIOCA pin input, when GTIOCB input is 1.

CSCBRAL bit (GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Clear Enable)

The CSCBRAL bit enables or disables the GTCNT counter clear on the rising edge of GTIOCB pin input, when GTIOCA input is 0.

CSCBRAH bit (GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Clear Enable)

The CSCBRAH bit enables or disables the GTCNT counter clear on the rising edge of GTIOCB pin input, when GTIOCA input is 1.

CSCBFAL bit (GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Clear Enable)

The CSCBFAL bit enables or disables the GTCNT counter clear on the falling edge of GTIOCB pin input, when GTIOCA input is 0.

CSCBFAH bit (GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Clear Enable)

The CSCBFAH bit enables or disables the GTCNT counter clear on the falling edge of GTIOCB pin input, when GTIOCA input is 1.

CSELCm bit (ELC_GPTm Event Source Counter Clear Enable) (m = A to H)

The CSELCm bit enables or disables the GTCNT counter clear at the ELC_GPTm event input.

CCLR bit (Software Source Counter Clear Enable)

The CCLR bit enables or disables the GTCNT counter clear by the GTCLR register.

CSGTRGCF位（GTETRGC引脚下降输入源计数器清零使能）

CSGTRGCF位在GTETRGC引脚输入的下降沿启用或禁用GTCNT计数器清零。

CSGTRGDR位（GTETRGD引脚上升沿输入源计数器清零使能）

CSGTRGDR位在GTETRGD引脚输入的上升沿启用或禁用GTCNT计数器清零。

CSGTRGDF位（GTETRGD引脚下降输入源计数器清零使能）

CSGTRGDF位在GTETRGD引脚输入的下降沿启用或禁用GTCNT计数器清零。

CSCARBL位（在GTIOCB值低源计数器清除启用期间GTIOCA引脚上升输入）

CSCARBL位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器清零，当GTIOCB输入为0。

CSCARBH位（GTIOCB值高电平期间的GTIOCA引脚上升沿输入源计数器清零使能）

CSCARBH位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器清零，当GTIOCB输入为1。

CSCAFBL位（GTIOCB值低源计数器清除启用期间GTIOCA引脚下降输入）

CSCAFBL位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器清零，当GTIOCB输入为0。

CSCAFBH位（在GTIOCB值高源计数器清除启用期间GTIOCA引脚下降输入）

CSCAFBH位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器清零，当GTIOCB输入为1。

CSCBRAL位（GTIOCA值低源计数器清除启用期间GTIOCB引脚上升沿输入）

CSCBRAL位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器清零，当GTIOCA输入为0。

CSCBRAH位（GTIOCA值高源计数器清除启用期间GTIOCB引脚上升沿输入）

CSCBRAH位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器清零，当GTIOCA输入为1。

CSCBFAL位（GTIOCA值低源计数器清除启用期间GTIOCB引脚下降输入）

CSCBFAL位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器清零，当GTIOCA输入为0。

CSCBFAH位（GTIOCA值高源计数器清零启用期间的GTIOCB引脚下降输入）

CSCBFAH位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器清零，当GTIOCA输入为1。

CSELCm位（ELC_GPTm事件源计数器清除启用）（m=A到H）

CSELCm位在ELC_GPTm事件输入处启用或禁用GTCNT计数器清零。

CCLR位（软件源计数器清除使能）

CCLR位启用或禁用由GTCLR寄存器清除的GTCNT计数器。

22.2.8 General PWM Timer Up Count Source Select Register (GTUPSR)

Address(es): GPT32EHm.GTUPSR 4007 801Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTUPSR 4007 801Ch + 0100h × m (m = 4 to 7)
GPT32m.GTUPSR 4007 801Ch + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	USELCH	USELCG	USELCF	USELCE	USELCD	USELCC	USELCB	USELCA
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	USCBFAH	USCBFAL	USCBRAH	USCBRAL	USCAFBH	USCAFBL	USCARBH	USCARBL	USGTRGDF	USGTRGDR	USGTRGCF	USGTRGCR	USGTRGBF	USGTRGBR	USGTRGAF	USGTRGAR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	USGTRGAR	GTETRGA Pin Rising Input Source Counter Count Up Enable	0: Counter count up disabled on the rising edge of GTETRGA input 1: Counter count up enabled on the rising edge of GTETRGA input.	R/W
b1	USGTRGAF	GTETRGA Pin Falling Input Source Counter Count Up Enable	0: Counter count up disabled on the falling edge of GTETRGA input 1: Counter count up enabled on the falling edge of GTETRGA input.	R/W
b2	USGTRGBR	GTETRGB Pin Rising Input Source Counter Count Up Enable	0: Counter count up disabled on the rising edge of GTETRGB input 1: Counter count up enabled on the rising edge of GTETRGB input.	R/W
b3	USGTRGBF	GTETRGB Pin Falling Input Source Counter Count Up Enable	0: Counter count up disabled on the falling edge of GTETRGB input 1: Counter count up enabled on the falling edge of GTETRGB input.	R/W
b4	USGTRGCR	GTETRGC Pin Rising Input Source Counter Count Up Enable	0: Counter count up disabled on the rising edge of GTETRGC input 1: Counter count up enabled on the rising edge of GTETRGC input.	R/W
b5	USGTRGCF	GTETRGC Pin Falling Input Source Counter Count Up Enable	0: Counter count up disabled on the falling edge of GTETRGC input 1: Counter count up enabled on the falling edge of GTETRGC input.	R/W
b6	USGTRGDR	GTETRGD Pin Rising Input Source Counter Count Up Enable	0: Counter count up disabled on the rising edge of GTETRGD input 1: Counter count up enabled on the rising edge of GTETRGD input.	R/W
b7	USGTRGDF	GTETRGD Pin Falling Input Source Counter Count Up Enable	0: Counter count up disabled on the falling edge of GTETRGD input 1: Counter count up enabled on the falling edge of GTETRGD input.	R/W
b8	USCARBL	GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Count Up Enable	0: Counter count up disabled on the rising edge of GTIOCA input when GTIOCB input is 0 1: Counter count up enabled on the rising edge of GTIOCA input when GTIOCB input is 0.	R/W
b9	USCARBH	GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Count Up Enable	0: Counter count up disabled on the rising edge of GTIOCA input when GTIOCB input is 1 1: Counter count up enabled on the rising edge of GTIOCA input when GTIOCB input is 1.	R/W
b10	USCAFBL	GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Count Up Enable	0: Counter count up disabled on the falling edge of GTIOCA input when GTIOCB input is 0 1: Counter count up enabled on the falling edge of GTIOCA input when GTIOCB input is 0.	R/W

22.2.8 通用PWM定时器向上计数源选择寄存器(GTUPSR)

Address(es): GPT32EHm.GTUPSR 4007 801Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTUPSR 4007 801Ch + 0100h × m (m = 4 to 7)
GPT32m.GTUPSR 4007 801Ch + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	USELCH	USELCG	USELCF	USELCE	USELCD	USELCC	USELCB	USELCA
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	USCBFAH	USCBFAL	USCBRAH	USCBRAL	USCAFBH	USCAFBL	USCARBH	USCARBL	USGTRGDF	USGTRGDR	USGTRGCF	USGTRGCR	USGTRGBF	USGTRGBR	USGTRGAF	USGTRGAR
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	USGTRGAR	GTETRGA引脚上升输入源计数器计数启用	0：在GTETRGA输入的上升沿禁止向上计数1：在GTETRGA输入的上升沿使能向上计数。	R/W
b1	USGTRGAF	GTETRGA引脚下降输入源计数器计数启用	0：在GTETRGA输入的下降沿禁止向上计数1：在GTETRGA输入的下降沿使能向上计数。	R/W
b2	USGTRGBR	GTETRGB引脚上升输入源计数器计数启用	0：在GTETRGB输入的上升沿禁止计数器向上计数1：在GTETRGB输入的上升沿使能计数器向上计数。	R/W
b3	USGTRGBF	GTETRGB引脚下降输入源计数器计数启用	0：在GTETRGB输入的下降沿禁止向上计数1：在GTETRGB输入的下降沿使能向上计数。	R/W
b4	USGTRGCR	GTETRGC引脚上升沿输入源计数器计数启用	0：在GTETRGC输入的上升沿禁止计数器向上计数1：在GTETRGC输入的上升沿使能计数器向上计数。	R/W
b5	USGTRGCF	GTETRGC引脚下降输入源计数器计数启用	0：在GTETRGC输入的下降沿禁止计数器向上计数1：在GTETRGC输入的下降沿使能计数器向上计数。	R/W
b6	USGTRGDR	GTETRGD引脚上升输入源计数器计数启用	0：在GTETRGD输入的上升沿禁止计数器向上计数 1：在GTETRGD输入的上升沿使能计数器向上计数 。	R/W
b7	USGTRGDF	GTETRGD引脚下降输入源计数器计数启用	0：在GTETRGD输入的下降沿禁止计数器向上计数1：在GTETRGD输入的下降沿使能计数器向上计数。	R/W
b8	USCARBL	GTIOCA引脚上升期间输入GTIOCB价值低来源计数器计数启用	0：当GTIOCB输入为0时，在GTIOCA输入上升沿禁止计数器向上计数1：当GTIOCB输入为0时，在GTIOCA输入上升沿使能计数器向上计数。	R/W
b9	USCARBH	GTIOCA引脚上升期间输入GTIOCB价值高来源计数器计数启用	0：当GTIOCB输入为1时，在GTIOCA输入上升沿禁止计数器加计数1：当GTIOCB输入为1时，在GTIOCA输入上升沿使能计数器加计数。	R/W
b10	USCAFBL	GTIOCA引脚下降期间输入GTIOCB价值低来源计数器计数启用	0：当GTIOCB输入为0时，在GTIOCA输入的下降沿禁止计数器向上计数1：当GTIOCB输入为0时，在GTIOCA输入的下降沿使能计数器向上计数。	R/W

Bit	Symbol	Bit name	Description	R/W
b11	USCAFBH	GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Count Up Enable	0: Counter count up disabled on the falling edge of GTIOCA input when GTIOCB input is 1 1: Counter count up enabled on the falling edge of GTIOCA input when GTIOCB input is 1.	R/W
b12	USCBRAL	GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Count Up Enable	0: Counter count up disabled on the rising edge of GTIOCB input when GTIOCA input is 0 1: Counter count up enabled on the rising edge of GTIOCB input when GTIOCA input is 0.	R/W
b13	USCBRAH	GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Count Up Enable	0: Counter count up disabled on the rising edge of GTIOCB input when GTIOCA input is 1 1: Counter count up enabled on the rising edge of GTIOCB input when GTIOCA input is 1.	R/W
b14	USCBFAL	GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Count Up Enable	0: Counter count up disabled on the falling edge of GTIOCB input when GTIOCA input is 0 1: Counter count up enabled on the falling edge of GTIOCB input when GTIOCA input is 0.	R/W
b15	USCBFAH	GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Count Up Enable	0: Counter count up disabled on the falling edge of GTIOCB input when GTIOCA input is 1 1: Counter count up enabled on the falling edge of GTIOCB input when GTIOCA input is 1.	R/W
b16	USELCA	ELC_GPTA Event Source Counter Count Up Enable	0: Counter count up disabled at the ELC_GPTA event input 1: Counter count up enabled at the ELC_GPTA event input.	R/W
b17	USELCB	ELC_GPTB Event Source Counter Count Up Enable	0: Counter count up disabled at the ELC_GPTB event input 1: Counter count up enabled at the ELC_GPTB event input.	R/W
b18	USELCC	ELC_GPTC Event Source Counter Count Up Enable	0: Counter count up disabled at the ELC_GPTC event input 1: Counter count up enabled at the ELC_GPTC event input.	R/W
b19	USELCD	ELC_GPTD Event Source Counter Count Up Enable	0: Counter count up disabled at the ELC_GPTD event input 1: Counter count up enabled at the ELC_GPTD event input.	R/W
b20	USELCE	ELC_GPTE Event Source Counter Count Up Enable	0: Counter count up disabled at the ELC_GPTE event input 1: Counter count up enabled at the ELC_GPTE event input.	R/W
b21	USELCF	ELC_GPTF Event Source Counter Count Up Enable	0: Counter count up disabled at the ELC_GPTF event input 1: Counter count up enabled at the ELC_GPTF event input.	R/W
b22	USELCG	ELC_GPTG Event Source Counter Count Up Enable	0: Counter count up disabled at the ELC_GPTG event input 1: Counter count up enabled at the ELC_GPTG event input.	R/W
b23	USELCH	ELC_GPTH Event Source Counter Count Up Enable	0: Counter count up disabled at the ELC_GPTH event input 1: Counter count up enabled at the ELC_GPTH event input.	R/W
b31 to b24	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTUPSR sets the source to count up the GTCNT counter.

When at least one bit in the GTUPSR register is set to 1, the GTCNT counter is counted up by the source that is set to 1 in this register. In this case, GTCR.TPCS has no effect.

USGTRGAR bit (GTETRGA Pin Rising Input Source Counter Count Up Enable)

The USGTRGAR bit enables or disables the GTCNT counter count up on the rising edge of GTETRGA pin input.

USGTRGAF bit (GTETRGA Pin Falling Input Source Counter Count Up Enable)

The USGTRGAF bit enables or disables the GTCNT counter count up on the falling edge of GTETRGA pin input.

USGTRGBR bit (GTETRGB Pin Rising Input Source Counter Count Up Enable)

The USGTRGBR bit enables or disables the GTCNT counter count up on the rising edge of GTETRGB pin input.

USGTRGBF bit (GTETRGB Pin Falling Input Source Counter Count Up Enable)

The USGTRGBF bit enables or disables the GTCNT counter count up on the falling edge of GTETRGB pin input.

USGTRGCR bit (GTETRGC Pin Rising Input Source Counter Count Up Enable)

The USGTRGCR bit enables or disables the GTCNT counter count up on the rising edge of GTETRGC pin input.

Bit	Symbol	位名称	Description	R/W
b11	USCAFBH	GTIOCA引脚下降期间输入GTIOCB价值高来源计数器计数启用	0：当GTIOCB输入为1时，在GTIOCA输入的下降沿禁止计数器向上计数1：当GTIOCB输入为1时，在GTIOCA输入的下降沿使能计数器向上计数。	R/W
b12	USCBRAL	GTIOCB引脚上升期间输入GTIOCA价值低来源计数器计数启用	0：当GTIOCA输入为0时，在GTIOCB输入上升沿禁止计数器加计数1：当GTIOCA输入为0时，在GTIOCB输入上升沿使能计数器加计数。	R/W
b13	USCBRAH	GTIOCB引脚上升期间输入GTIOCA价值高来源计数器计数启用	0：当GTIOCA输入为1时，在GTIOCB输入上升沿禁止计数器加计数1：当GTIOCA输入为1时，在GTIOCB输入上升沿使能计数器加计数。	R/W
b14	USCBFAL	在GTIOCB引脚下降输入GTIOCA价值低来源计数器计数启用	0：当GTIOCA输入为0时，在GTIOCB输入的下降沿禁止计数器向上计数1：当GTIOCA输入为0时，在GTIOCB输入的下降沿使能计数器向上计数。	R/W
b15	USCBFAH	在GTIOCB引脚下降输入GTIOCA价值高来源计数器计数启用	0：当GTIOCA输入为1时，在GTIOCB输入的下降沿禁止计数器向上计数1：当GTIOCA输入为1时，在GTIOCB输入的下降沿使能计数器向上计数。	R/W
b16	USELCA	ELC_GPTA事件源计数器计数启用	0：在ELC_GPTA事件输入处禁用计数器向上计数1：在ELC_GPTA事件输入处启用计数器向上计数。	R/W
b17	USELCB	ELC_GPTB事件源计数器计数启用	0：在ELC_GPTB事件输入处禁用计数器向上计数1：在ELC_GPTB事件输入处启用计数器向上计数。	R/W
b18	USELCC	ELC_GPTC事件源计数器计数启用	0：在ELC_GPTC事件输入处禁用计数器向上计数1：在ELC_GPTC事件输入处启用计数器向上计数。	R/W
b19	USELCD	ELC_GPTD事件源计数器计数启用	0：在ELC_GPTD事件输入处禁用计数器向上计数1：在ELC_GPTD事件输入处启用计数器向上计数。	R/W
b20	USELCE	ELC_GPTE事件源计数器计数启用	0：在ELC_GPTE事件输入处禁用计数器向上计数1：在ELC_GPTE事件输入处启用计数器向上计数。	R/W
b21	USELCF	ELC_GPTF事件源计数器计数启用	0：在ELC_GPTF事件输入处禁用计数器向上计数1：在ELC_GPTF事件输入处启用计数器向上计数。	R/W
b22	USELCG	ELC_GPTG事件源计数器计数启用	0：在ELC_GPTG事件输入处禁用计数器向上计数1：在ELC_GPTG事件输入处启用计数器向上计数。	R/W
b23	USELCH	ELC_GPTH事件源计数器计数启用	0：在ELC_GPTH事件输入处禁用计数器向上计数1：在ELC_GPTH事件输入处启用计数器向上计数。	R/W
b31 to b24	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTUPSR将源设置为对GTCNT计数器进行计数。

当GTUPSR寄存器中的至少一位设置为1时，GTCNT计数器由该寄存器中设置为1的源进行计数。在这种情况下，GTCR.TPCS无效。

USGTRGAR位（GTETRGA引脚上升沿输入源计数器向上计数使能）

USGTRGAR位在GTETRGA引脚输入的上升沿启用或禁用GTCNT计数器向上计数。

USGTRGAF位（GTETRGA引脚下降输入源计数器向上计数使能）

USGTRGAF位在GTETRGA引脚输入的下降沿启用或禁用GTCNT计数器向上计数。

USGTRGBR位（GTETRGB引脚上升输入源计数器向上计数使能）

USGTRGBR位在GTETRGB引脚输入的上升沿启用或禁用GTCNT计数器向上计数。

USGTRGBF位（GTETRGB引脚下降输入源计数器向上计数使能）

USGTRGBF位在GTETRGB引脚输入的下降沿启用或禁用GTCNT计数器向上计数。

USGTRGCR位（GTETRGC引脚上升沿输入源计数器向上计数使能）

USGTRGCR位在GTETRGC引脚输入的上升沿启用或禁用GTCNT计数器向上计数。

USGTRGCF bit (GTETRGC Pin Falling Input Source Counter Count Up Enable)

The USGTRGCF bit enables or disables the GTCNT counter count up on the falling edge of GTETRGC pin input.

USGTRGDR bit (GTETRGD Pin Rising Input Source Counter Count Up Enable)

The USGTRGDR bit enables or disables the GTCNT counter count up on the rising edge of GTETRGD pin input.

USGTRGDF bit (GTETRGD Pin Falling Input Source Counter Count Up Enable)

The USGTRGDF bit enables or disables the GTCNT counter count up on the falling edge of GTETRGD pin input.

USCARBL bit (GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Count Up Enable)

The USCARBL bit enables or disables the GTCNT counter count up on the rising edge of GTIOCA pin input, when GTIOCB input is 0.

USCARBH bit (GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Count Up Enable)

The USCARBH bit enables or disables the GTCNT counter count up on the rising edge of GTIOCA pin input, when GTIOCB input is 1.

USCAFBL bit (GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Count Up Enable)

The USCAFBL bit enables or disables the GTCNT counter count up on the falling edge of GTIOCA pin input, when GTIOCB input is 0.

USCAFBH bit (GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Count Up Enable)

The USCAFBH bit enables or disables the GTCNT counter count up on the falling edge of GTIOCA pin input, when GTIOCB input is 1.

USCBRAL bit (GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Count Up Enable)

The USCBRAL bit enables or disables the GTCNT counter count up on the rising edge of GTIOCB pin input, when GTIOCA input is 0.

USCBRAH bit (GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Count Up Enable)

The USCBRAH bit enables or disables the GTCNT counter count up on the rising edge of GTIOCB pin input, when GTIOCA input is 1.

USCBFAL bit (GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Count Up Enable)

The USCBFAL bit enables or disables the GTCNT counter count up on the falling edge of GTIOCB pin input, when GTIOCA input is 0.

USCBFAH bit (GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Count Up Enable)

The USCBFAH bit enables or disables the GTCNT counter count up on the falling edge of GTIOCB pin input, when GTIOCA input is 1.

USELCm bit (ELC_GPTm Event Source Counter Count Up Enable) (m = A to H)

The USELCm bit enables or disables the GTCNT counter count up at the ELC_GPTm event input.

USGTRGCF位（GTETRGC引脚下降输入源计数器向上计数使能）

USGTRGCF位在GTETRGC引脚输入的下降沿启用或禁用GTCNT计数器向上计数。

USGTRGDR位（GTETRGD引脚上升沿输入源计数器向上计数使能）

USGTRGDR位在GTETRGD引脚输入的上升沿启用或禁用GTCNT计数器向上计数。

USGTRGDF位（GTETRGD引脚下降输入源计数器向上计数使能）

USGTRGDF位在GTETRGD引脚输入的下降沿启用或禁用GTCNT计数器向上计数。

USCARBL位（GTIOCB值低源计数器向上计数启用期间的GTIOCA引脚上升沿输入）

USCARBL位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器向上计数，当GTIOCB输入为0。

USCARBH位（GTIOCB值高电平源计数器向上计数启用期间的GTIOCA引脚上升沿输入）

USCARBH位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器向上计数，当GTIOCB输入为1。

USCAFBL位（GTIOCB值低源计数器向上计数启用期间的GTIOCA引脚下降输入）

USCAFBL位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器向上计数，当GTIOCB输入为0。

USCAFBH位（GTIOCB值高源计数器向上计数启用期间的GTIOCA引脚下降输入）

USCAFBH位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器向上计数，当GTIOCB输入为1。

USCBRAL位（GTIOCA值低源计数器向上计数启用期间的GTIOCB引脚上升输入）

USCBRAL位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器向上计数，当GTIOCA输入为0。

USCBRAH位（GTIOCA值高源计数器向上计数启用期间的GTIOCB引脚上升沿输入）

USCBRAH位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器向上计数，当GTIOCA输入为1。

USCBFAL位（GTIOCA值低源计数器向上计数启用期间的GTIOCB引脚下降输入）

USCBFAL位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器向上计数，当GTIOCA输入为0。

USCBFAH位（GTIOCA值高源计数器向上计数启用期间GTIOCB引脚下降输入）

USCBFAH位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器向上计数，当GTIOCA输入为1。

USELCm位（ELC_GPTm事件源计数器向上计数启用）（m=A到H）

USELCm位在ELC_GPTm事件输入处启用或禁用GTCNT计数器向上计数。

22.2.9 General PWM Timer Down Count Source Select Register (GTDNSR)

Address(es): GPT32EHm.GTDNSR 4007 8020h + 0100h × m (m = 0 to 3)
GPT32Em.GTDNSR 4007 8020h + 0100h × m (m = 4 to 7)
GPT32m.GTDNSR 4007 8020h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	DSELCH	DSELCG	DSELCF	DSELCE	DSELCD	DSELCC	DSELCB	DSELCA
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	DSCBFAH	DSCBFAL	DSCBRAH	DSCBRAL	DSCAFBH	DSCAFBL	DSCARBH	DSCARBL	DSGTRGDF	DSGTRGDR	DSGTRGCF	DSGTRGCR	DSGTRGBF	DSGTRGBR	DSGTRGAF	DSGTRGAR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DSGTRGAR	GTETRGA Pin Rising Input Source Counter Count Down Enable	0: Counter count down disabled on the rising edge of GTETRGA input 1: Counter count down enabled on the rising edge of GTETRGA input.	R/W
b1	DSGTRGAF	GTETRGA Pin Falling Input Source Counter Count Down Enable	0: Counter count down disabled on the falling edge of GTETRGA input 1: Counter count down enabled on the falling edge of GTETRGA input.	R/W
b2	DSGTRGBR	GTETRGB Pin Rising Input Source Counter Count Down Enable	0: Counter count down disabled on the rising edge of GTETRGB input 1: Counter count down enabled on the rising edge of GTETRGB input.	R/W
b3	DSGTRGBF	GTETRGB Pin Falling Input Source Counter Count Down Enable	0: Counter count down disabled on the falling edge of GTETRGB input 1: Counter count down enabled on the falling edge of GTETRGB input.	R/W
b4	DSGTRGCR	GTETRGC Pin Rising Input Source Counter Count Down Enable	0: Counter count down disabled on the rising edge of GTETRGC input 1: Counter count down enabled on the rising edge of GTETRGC input.	R/W
b5	DSGTRGCF	GTETRGC Pin Falling Input Source Counter Count Down Enable	0: Counter count down disabled on the falling edge of GTETRGC input 1: Counter count down enabled on the falling edge of GTETRGC input.	R/W
b6	DSGTRGDR	GTETRGD Pin Rising Input Source Counter Count Down Enable	0: Counter count down disabled on the rising edge of GTETRGD input 1: Counter count down enabled on the rising edge of GTETRGD input.	R/W
b7	DSGTRGDF	GTETRGD Pin Falling Input Source Counter Count Down Enable	0: Counter count down disabled on the falling edge of GTETRGD input 1: Counter count down enabled on the falling edge of GTETRGD input.	R/W
b8	DSCARBL	GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Count Down Enable	0: Counter count down disabled on the rising edge of GTIOCA input when GTIOCB input is 0 1: Counter count down enabled on the rising edge of GTIOCA input when GTIOCB input is 0.	R/W
b9	DSCARBH	GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Count Down Enable	0: Counter count down disabled on the rising edge of GTIOCA input when GTIOCB input is 1 1: Counter count down enabled on the rising edge of GTIOCA input when GTIOCB input is 1.	R/W
b10	DSCAFBL	GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Count Down Enable	0: Counter count down disabled on the falling edge of GTIOCA input when GTIOCB input is 0 1: Counter count down enabled on the falling edge of GTIOCA input when GTIOCB input is 0.	R/W

22.2.9 通用PWM定时器递减计数源选择寄存器(GTDNSR)

Address(es): GPT32EHm.GTDNSR 4007 8020h + 0100h × m (m = 0 to 3)
GPT32Em.GTDNSR 4007 8020h + 0100h × m (m = 4 to 7)
GPT32m.GTDNSR 4007 8020h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	DSELCH	DSELCG	DSELCF	DSELCE	DSELCD	DSELCC	DSELCB	DSELCA
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	DSCBFAH	DSCBFAL	DSCBRAH	DSCBRAL	DSCAFBH	DSCAFBL	DSCARBH	DSCARBL	DSGTRGDF	DSGTRGDR	DSGTRGCF	DSGTRGCR	DSGTRGBF	DSGTRGBR	DSGTRGAF	DSGTRGAR
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DSGTRGAR	GTETRGA引脚上升输入源计数器倒计时启用	0：在GTETRGA输入的上升沿禁用计数器递减计数1：在GTETRGA输入的上升沿启用计数器递减计数。	R/W
b1	DSGTRGAF	GTETRGA引脚下降输入源计数器倒计时启用	0：在GTETRGA输入的下降沿禁止计数器减计数1：在GTETRGA输入的下降沿使能计数器减计数。	R/W
b2	DSGTRGBR	GTETRGB引脚上升输入源计数器倒计时启用	0：在GTETRGB输入的上升沿禁用计数器减计数1：在GTETRGB输入的上升沿启用计数器减计数。	R/W
b3	DSGTRGBF	GTETRGB引脚下降输入源计数器倒计时启用	0：在GTETRGB输入的下降沿禁用计数器递减计数1：在GTETRGB输入的下降沿启用计数器递减计数。	R/W
b4	DSGTRGCR	GTETRGC引脚上升沿输入源计数器倒计时启用	0：在GTETRGC输入的上升沿禁用计数器递减计数1：在GTETRGC输入的上升沿启用计数器递减计数。	R/W
b5	DSGTRGCF	GTETRGC引脚下降输入源计数器倒计时启用	0：在GTETRGC输入的下降沿禁用计数器减计数1：在GTETRGC输入的下降沿启用计数器减计数。	R/W
b6	DSGTRGDR	GTETRGD引脚上升输入源计数器倒计时启用	0：在GTETRGD输入的上升沿禁止计数器减计数1：在GTETRGD输入的上升沿使能计数器减计数。	R/W
b7	DSGTRGDF	GTETRGD引脚下降输入源计数器倒计时启用	0：在GTETRGD输入的下降沿禁止计数器减计数1：在GTETRGD输入的下降沿使能计数器减计数。	R/W
b8	DSCARBL	GTIOCA引脚上升期间输入GTIOCB值低源计数器倒计时启用	0：当GTIOCB输入为0时，在GTIOCA输入上升沿禁止计数器减计数1：当GTIOCB输入为0时，在GTIOCA输入上升沿使能计数器减计数。	R/W
b9	DSCARBH	GTIOCA引脚上升期间输入GTIOCB值高源计数器倒计时启用	0：当GTIOCB输入为1时，在GTIOCA输入上升沿禁止计数器减计数1：当GTIOCB输入为1时，在GTIOCA输入上升沿使能计数器减计数。	R/W
b10	DSCAFBL	GTIOCA引脚下降期间输入GTIOCB值低源计数器倒计时启用	0：当GTIOCB输入为0时，在GTIOCA输入的下降沿禁止计数器减计数1：当GTIOCB输入为0时，在GTIOCA输入的下降沿使能计数器减计数。	R/W

Bit	Symbol	Bit name	Description	R/W
b11	DSCAFBH	GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Count Down Enable	0: Counter count down disabled on the falling edge of GTIOCA input when GTIOCB input is 1 1: Counter count down enabled on the falling edge of GTIOCA input when GTIOCB input is 1.	R/W
b12	DSCBRAL	GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Count Down Enable	0: Counter count down disabled on the rising edge of GTIOCB input when GTIOCA input is 0 1: Counter count down enabled on the rising edge of GTIOCB input when GTIOCA input is 0.	R/W
b13	DSCBRAH	GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Count Down Enable	0: Counter count down disabled on the rising edge of GTIOCB input when GTIOCA input is 1 1: Counter count down enabled on the rising edge of GTIOCB input when GTIOCA input is 1.	R/W
b14	DSCBFAL	GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Count Down Enable	0: Counter count down disabled on the falling edge of GTIOCB input when GTIOCA input is 0 1: Counter count down enabled on the falling edge of GTIOCB input when GTIOCA input is 0.	R/W
b15	DSCBFAH	GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Count Down Enable	0: Counter count down disabled on the falling edge of GTIOCB input when GTIOCA input is 1 1: Counter count down enabled on the falling edge of GTIOCB input when GTIOCA input is 1.	R/W
b16	DSELCA	ELC_GPTA Event Source Counter Count Down Enable	0: Counter count down disabled at the ELC_GPTA event input 1: Counter count down enabled at the ELC_GPTA event input.	R/W
b17	DSELCB	ELC_GPTB Event Source Counter Count Down Enable	0: Counter count down disabled at the ELC_GPTB event input 1: Counter count down enabled at the ELC_GPTB event input.	R/W
b18	DSELCC	ELC_GPTC Event Source Counter Count Down Enable	0: Counter count down disabled at the ELC_GPTC event input 1: Counter count down enabled at the ELC_GPTC event input.	R/W
b19	DSELCD	ELC_GPTD Event Source Counter Count Down Enable	0: Counter count down disabled at the ELC_GPTD event input 1: Counter count down enabled at the ELC_GPTD event input.	R/W
b20	DSELCE	ELC_GPTE Event Source Counter Count Down Enable	0: Counter count down disabled at the ELC_GPTE event input 1: Counter count down enabled at the ELC_GPTE event input.	R/W
b21	DSELCF	ELC_GPTF Event Source Counter Count Down Enable	0: Counter count down disabled at the ELC_GPTF event input 1: Counter count down enabled at the ELC_GPTF event input.	R/W
b22	DSELCG	ELC_GPTG Event Source Counter Count Down Enable	0: Counter count down disabled at the ELC_GPTG event input 1: Counter count down enabled at the ELC_GPTG event input.	R/W
b23	DSELCH	ELC_GPTH Event Source Counter Count Down Enable	0: Counter count down disabled at the ELC_GPTH event input 1: Counter count down enabled at the ELC_GPTH event input.	R/W
b31 to b24	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTDNSR sets the source to count down the GTCNT counter.

When at least one bit in the GTDNSR register is set to 1, the GTCNT counter is counted up by the source that is set to 1 in this register. In this case, GTCR.TPCS has no effect.

DSGTRGAR bit (GTETRGA Pin Rising Input Source Counter Count Down Enable)

The DSGTRGAR bit enables or disables the GTCNT counter count down on the rising edge of GTETRGA pin input.

Bit	Symbol	位名称	Description	R/W
b11	DSCAFBH	GTIOCA引脚下降期间输入GTIOCB值高源计数器倒计时启用	0：当GTIOCB输入为1时，在GTIOCA输入的下降沿禁止计数器减计数1：当GTIOCB输入为1时，在GTIOCA输入的下降沿使能计数器减计数。	R/W
b12	DSCBRAL	GTIOCB引脚上升期间输入GTIOCA值低源计数器倒计时启用	0：当GTIOCA输入为0时，在GTIOCB输入上升沿禁止计数器减计数1：当GTIOCA输入为0时，在GTIOCB输入上升沿使能计数器减计数。	R/W
b13	DSCBRAH	GTIOCB引脚上升期间输入GTIOCA值高源计数器倒计时启用	0：当GTIOCA输入为1时，在GTIOCB输入上升沿禁止计数器减计数1：当GTIOCA输入为1时，在GTIOCB输入上升沿使能计数器减计数。	R/W
b14	DSCBFAL	在GTIOCB引脚下降输入GTIOCA值低源计数器倒计时启用	0：当GTIOCA输入为0时，在GTIOCB输入的下降沿禁止计数器减计数1：当GTIOCA输入为0时，在GTIOCB输入的下降沿使能计数器减计数。	R/W
b15	DSCBFAH	在GTIOCB引脚下降输入GTIOCA值高源计数器倒计时启用	0：当GTIOCA输入为1时，在GTIOCB输入下降沿禁止计数器减计数1：当GTIOCA输入为1时，在GTIOCB输入下降沿使能计数器减计数。	R/W
b16	DSELCA	ELC_GPTA事件源计数器倒计时启用	0：在ELC_GPTA事件输入处禁用计数器递减计数1：在ELC_GPTA事件输入处启用计数器递减计数。	R/W
b17	DSELCB	ELC_GPTB事件源计数器倒计时启用	0：在ELC_GPTB事件输入处禁用计数器递减计数1：在ELC_GPTB事件输入处启用计数器递减计数。	R/W
b18	DSELCC	ELC_GPTC事件源计数器倒计时启用	0：在ELC_GPTC事件输入处禁用计数器递减计数1：在ELC_GPTC事件输入处启用计数器递减计数。	R/W
b19	DSELCD	ELC_GPTD事件源计数器倒计时启用	0：在ELC_GPTD事件输入处禁用计数器递减计数1：在ELC_GPTD事件输入处启用计数器递减计数。	R/W
b20	DSELCE	ELC_GPTE事件源计数器倒计时启用	0：在ELC_GPTE事件输入处禁用计数器递减计数1：在ELC_GPTE事件输入处启用计数器递减计数。	R/W
b21	DSELCF	ELC_GPTF事件源计数器倒计时启用	0：在ELC_GPTF事件输入处禁用计数器递减计数1：在ELC_GPTF事件输入处启用计数器递减计数。	R/W
b22	DSELCG	ELC_GPTG事件源计数器倒计时启用	0：在ELC_GPTG事件输入处禁用计数器递减计数1：在ELC_GPTG事件输入处启用计数器递减计数。	R/W
b23	DSELCH	ELC_GPTH事件源计数器倒计时启用	0：在ELC_GPTH事件输入处禁用计数器递减计数1：在ELC_GPTH事件输入处启用计数器递减计数。	R/W
b31 to b24	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTDNSR将源设置为对GTCNT计数器进行倒计时。

当GTDNSR寄存器中的至少一位设置为1时，GTCNT计数器由该寄存器中设置为1的源进行计数。在这种情况下，GTCR.TPCS无效。

DSGTRGAR位（GTETRGA引脚上升沿输入源计数器倒计时使能）

DSGTRGAR位在GTETRGA引脚输入的上升沿启用或禁用GTCNT计数器倒计时。

DSGTRGAF bit (GTETRGA Pin Falling Input Source Counter Count Down Enable)

The DSGTRGAF bit enables or disables the GTCNT counter count down on the falling edge of GTETRGA pin input.

DSGTRGBR bit (GTETRGB Pin Rising Input Source Counter Count Down Enable)

The DSGTRGBR bit enables or disables the GTCNT counter count down on the rising edge of GTETRGB pin input.

DSGTRGBF bit (GTETRGB Pin Falling Input Source Counter Count Down Enable)

The DSGTRGBF bit enables or disables the GTCNT counter count down on the falling edge of GTETRGB pin input.

DSGTRGCR bit (GTETRGC Pin Rising Input Source Counter Count Down Enable)

The DSGTRGCR bit enables or disables the GTCNT counter count down on the rising edge of GTETRGC pin input.

DSGTRGCF bit (GTETRGC Pin Falling Input Source Counter Count Down Enable)

The DSGTRGCF bit enables or disables the GTCNT counter count down on the falling edge of GTETRGC pin input.

DSGTRGDR bit (GTETRGD Pin Rising Input Source Counter Count Down Enable)

The DSGTRGDR bit enables or disables the GTCNT counter count down on the rising edge of GTETRGD pin input.

DSGTRGDF bit (GTETRGD Pin Falling Input Source Counter Count Down Enable)

The DSGTRGDF bit enables or disables the GTCNT counter count down on the falling edge of GTETRGD pin input.

DSCARBL bit (GTIOCA Pin Rising Input during GTIOCB Value Low Source Counter Count Down Enable)

The DSCARBL bit enables or disables the GTCNT counter count down on the rising edge of GTIOCA pin input, when GTIOCB input is 0.

DSCARBH bit (GTIOCA Pin Rising Input during GTIOCB Value High Source Counter Count Down Enable)

The DSCARBH bit enables or disables the GTCNT counter count down on the rising edge of GTIOCA pin input, when GTIOCB input is 1.

DSCAFBL bit (GTIOCA Pin Falling Input during GTIOCB Value Low Source Counter Count Down Enable)

The DSCAFBL bit enables or disables the GTCNT counter count down on the falling edge of GTIOCA pin input, when GTIOCB input is 0.

DSCAFBH bit (GTIOCA Pin Falling Input during GTIOCB Value High Source Counter Count Down Enable)

The DSCAFBH bit enables or disables the GTCNT counter count down on the falling edge of GTIOCA pin input, when GTIOCB input is 1.

DSCBRAL bit (GTIOCB Pin Rising Input during GTIOCA Value Low Source Counter Count Down Enable)

The DSCBRAL bit enables or disables the GTCNT counter count down on the rising edge of GTIOCB pin input, when GTIOCA input is 0.

DSCBRAH bit (GTIOCB Pin Rising Input during GTIOCA Value High Source Counter Count Down Enable)

The DSCBRAH bit enables or disables the GTCNT counter count down on the rising edge of GTIOCB pin input, when GTIOCA input is 1.

DSGTRGAF位（GTETRGA引脚下降输入源计数器倒计时使能）

DSGTRGAF位在GTETRGA引脚输入的下降沿启用或禁用GTCNT计数器倒计时。

DSGTRGBR位（GTETRGB引脚上升输入源计数器倒计时使能）

DSGTRGBR位在GTETRGB引脚输入的上升沿启用或禁用GTCNT计数器倒计时。

DSGTRGBF位（GTETRGB引脚下降输入源计数器倒计时使能）

DSGTRGBF位在GTETRGB引脚输入的下降沿启用或禁用GTCNT计数器倒计时。

DSGTRGCR位（GTETRGC引脚上升输入源计数器倒计时使能）

DSGTRGCR位在GTETRGC引脚输入的上升沿启用或禁用GTCNT计数器倒计时。

DSGTRGCF位（GTETRGC引脚下降输入源计数器倒计时使能）

DSGTRGCF位在GTETRGC引脚输入的下降沿启用或禁用GTCNT计数器倒计时。

DSGTRGDR位（GTETRGD引脚上升输入源计数器倒计时使能）

DSGTRGDR位在GTETRGD引脚输入的上升沿启用或禁用GTCNT计数器倒计时。

DSGTRGDF位（GTETRGD引脚下降输入源计数器倒计时使能）

DSGTRGDF位在GTETRGD引脚输入的下降沿启用或禁用GTCNT计数器倒计时。

DSCARBL位（GTIOCB值低源计数器倒计时期间GTIOCA引脚上升沿输入Enable）

DSCARBL位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器倒计时，当GTIOCB输入为0。

DSCARBH位（GTIOCB值高电平期间的GTIOCA引脚上升沿输入源计数器向下计数Enable）

DSCARBH位在GTIOCA引脚输入的上升沿启用或禁用GTCNT计数器倒计时，当GTIOCB输入为1。

DSCAFBL位（GTIOCB值低源计数器向下计数期间GTIOCA引脚下降输入Enable）

DSCAFBL位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器倒计时，当GTIOCB输入为0。

DSCAFBH位（GTIOCB值高源计数器倒计时期间GTIOCA引脚下降输入Enable）

DSCAFBH位在GTIOCA引脚输入的下降沿启用或禁用GTCNT计数器倒计时，当GTIOCB输入为1。

DSCBRAL位（GTIOCA值低源计数器向下计数期间GTIOCB引脚上升沿输入Enable）

DSCBRAL位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器倒计时，当GTIOCA输入为0。

DSCBRAH位（GTIOCA值高源计数器倒计时期间GTIOCB引脚上升沿输入Enable）

DSCBRAH位在GTIOCB引脚输入的上升沿启用或禁用GTCNT计数器倒计时，当GTIOCA输入为1。

DSCBFAL bit (GTIOCB Pin Falling Input during GTIOCA Value Low Source Counter Count Down Enable)

The DSCBFAL bit enables or disables the GTCNT counter count down on the falling edge of GTIOCB pin input, when GTIOCA input is 0.

DSCBFAH bit (GTIOCB Pin Falling Input during GTIOCA Value High Source Counter Count Down Enable)

The DSCBFAH bit enables or disables the GTCNT counter count down on the falling edge of GTIOCB pin input, when GTIOCA input is 1.

DSELCm bit (ELC_GPTm Event Source Counter Count Down Enable) (m = A to H)

The DSELCm bit enables or disables the GTCNT counter count down at the ELC_GPTm event input.

22.2.10 General PWM Timer Input Capture Source Select Register A (GTICASR)

Address(es): GPT32EHm.GTICASR 4007 8024h + 0100h × m (m = 0 to 3)
GPT32Em.GTICASR 4007 8024h + 0100h × m (m = 4 to 7)
GPT32m.GTICASR 4007 8024h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	ASELCH	ASELCG	ASELCF	ASELCE	ASELCD	ASELCC	ASELCB	ASELCA
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ASCBFAH	ASCBFAL	ASCBRAH	ASCBRAL	ASCAFBH	ASCAFBL	ASCARBH	ASCARBL	ASGTRGDF	ASGTRGDR	ASGTRGCF	ASGTRGCR	ASGTRGBF	ASGTRGBR	ASGTRGAF	ASGTRGAR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	ASGTRGAR	GTETRGA Pin Rising Input Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the rising edge of GTETRGA input 1: GTCCRA input capture enabled on the rising edge of GTETRGA input.	R/W
b1	ASGTRGAF	GTETRGA Pin Falling Input Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the falling edge of GTETRGA input 1: GTCCRA input capture enabled on the falling edge of GTETRGA input.	R/W
b2	ASGTRGBR	GTETRGB Pin Rising Input Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the rising edge of GTETRGB input 1: GTCCRA input capture enabled on the rising edge of GTETRGB input.	R/W
b3	ASGTRGBF	GTETRGB Pin Falling Input Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the falling edge of GTETRGB input 1: GTCCRA input capture enabled on the falling edge of GTETRGB input.	R/W
b4	ASGTRGCR	GTETRGC Pin Rising Input Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the rising edge of GTETRGC input 1: GTCCRA input capture enabled on the rising edge of GTETRGC input.	R/W
b5	ASGTRGCF	GTETRGC Pin Falling Input Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the falling edge of GTETRGC input 1: GTCCRA input capture enabled on the falling edge of GTETRGC input.	R/W
b6	ASGTRGDR	GTETRGD Pin Rising Input Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the rising edge of GTETRGD input 1: GTCCRA input capture enabled on the rising edge of GTETRGD input.	R/W

DSCBFAL位（GTIOCA值低源计数器倒计时期间GTIOCB引脚下降输入Enable)

DSCBFAL位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器倒计时，当GTIOCA输入为0。

DSCBFAH位（GTIOCA值高源计数器倒计时期间GTIOCB引脚下降输入Enable)

DSCBFAH位在GTIOCB引脚输入的下降沿启用或禁用GTCNT计数器倒计时，当GTIOCA输入为1。

DSELCm位（ELC_GPTm事件源计数器倒计时启用）（m=A到H）

DSELCm位在ELC_GPTm事件输入处启用或禁用GTCNT计数器倒计时。

22.2.10 通用PWM定时器输入捕捉源选择寄存器A(GTICASR)

Address(es): GPT32EHm.GTICASR 4007 8024h + 0100h × m (m = 0 to 3)
GPT32Em.GTICASR 4007 8024h + 0100h × m (m = 4 to 7)
GPT32m.GTICASR 4007 8024h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	ASELCH	ASELCG	ASELCF	ASELCE	ASELCD	ASELCC	ASELCB	ASELCA
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ASCBFAH	ASCBFAL	ASCBRAH	ASCBRAL	ASCAFBH	ASCAFBL	ASCARBH	ASCARBL	ASGTRGDF	ASGTRGDR	ASGTRGCF	ASGTRGCR	ASGTRGBF	ASGTRGBR	ASGTRGAF	ASGTRGAR
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	ASGTRGAR	GTETRGA引脚上升输入源GTCCRA输入捕捉使能	0：在GTETRGA输入的上升沿禁用GTCCRA输入捕捉1：在GTETRGA输入的上升沿启用GTCCRA输入捕捉。	R/W
b1	ASGTRGAF	GTETRGA引脚下降输入源GTCCRA输入捕捉使能	0：在GTETRGA输入的下降沿禁用GTCCRA输入捕捉1：在GTETRGA输入的下降沿启用GTCCRA输入捕捉。	R/W
b2	ASGTRGBR	GTETRGB引脚上升输入源GTCCRA输入捕捉使能	0：在GTETRGB输入的上升沿禁用GTCCRA输入捕捉1：在GTETRGB输入的上升沿启用GTCCRA输入捕捉。	R/W
b3	ASGTRGBF	GTETRGB引脚下降输入源GTCCRA输入捕捉使能	0：在GTETRGB输入的下降沿禁用GTCCRA输入捕捉1：在GTETRGB输入的下降沿启用GTCCRA输入捕捉。	R/W
b4	ASGTRGCR	GTETRGC引脚上升沿输入源GTCCRA输入捕捉使能	0：在GTETRGC输入的上升沿禁用GTCCRA输入捕捉1：在GTETRGC输入的上升沿启用GTCCRA输入捕捉。	R/W
b5	ASGTRGCF	GTETRGC引脚下降输入源GTCCRA输入捕捉使能	0：在GTETRGC输入的下降沿禁用GTCCRA输入捕捉1：在GTETRGC输入的下降沿启用GTCCRA输入捕捉。	R/W
b6	ASGTRGDR	GTETRGD引脚上升输入源GTCCRA输入捕捉使能	0：在GTETRGD输入的上升沿禁用GTCCRA输入捕捉1：在GTETRGD输入的上升沿启用GTCCRA输入捕捉。	R/W

Bit	Symbol	Bit name	Description	R/W
b7	ASGTRGDF	GTETRGD Pin Falling Input Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the falling edge of GTETRGD input 1: GTCCRA input capture enabled on the falling edge of GTETRGD input.	R/W
b8	ASCARBL	GTIOCA Pin Rising Input during GTIOCB Value Low Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the rising edge of GTIOCA input when GTIOCB input is 0 1: GTCCRA input capture enabled on the rising edge of GTIOCA input when GTIOCB input is 0.	R/W
b9	ASCARBH	GTIOCA Pin Rising Input during GTIOCB Value High Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the rising edge of GTIOCA input when GTIOCB input is 1 1: GTCCRA input capture enabled on the rising edge of GTIOCA input when GTIOCB input is 1.	R/W
b10	ASCAFBL	GTIOCA Pin Falling Input during GTIOCB Value Low Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the falling edge of GTIOCA input when GTIOCB input is 0 1: GTCCRA input capture enabled on the falling edge of GTIOCA input when GTIOCB input is 0.	R/W
b11	ASCAFBH	GTIOCA Pin Falling Input during GTIOCB Value High Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the falling edge of GTIOCA input when GTIOCB input is 1 1: GTCCRA input capture enabled on the falling edge of GTIOCA input when GTIOCB input is 1.	R/W
b12	ASCBRAL	GTIOCB Pin Rising Input during GTIOCA Value Low Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the rising edge of GTIOCB input when GTIOCA input is 0 1: GTCCRA input capture enabled on the rising edge of GTIOCB input when GTIOCA input is 0.	R/W
b13	ASCBRAH	GTIOCB Pin Rising Input during GTIOCA Value High Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the rising edge of GTIOCB input when GTIOCA input is 1 1: GTCCRA input capture enabled on the rising edge of GTIOCB input when GTIOCA input is 1.	R/W
b14	ASCBFAL	GTIOCB Pin Falling Input during GTIOCA Value Low Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the falling edge of GTIOCB input when GTIOCA input is 0 1: GTCCRA input capture enabled on the falling edge of GTIOCB input when GTIOCA input is 0.	R/W
b15	ASCBFAH	GTIOCB Pin Falling Input during GTIOCA Value High Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled on the falling edge of GTIOCB input when GTIOCA input is 1 1: GTCCRA input capture enabled on the falling edge of GTIOCB input when GTIOCA input is 1.	R/W
b16	ASELCA	ELC_GPTA Event Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled at the ELC_GPTA event input 1: GTCCRA input capture enabled at the ELC_GPTA event input.	R/W
b17	ASELCB	ELC_GPTB Event Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled at the ELC_GPTB event input 1: GTCCRA input capture enabled at the ELC_GPTB event input.	R/W
b18	ASELCC	ELC_GPTC Event Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled at the ELC_GPTC event input 1: GTCCRA input capture enabled at the ELC_GPTC event input.	R/W
b19	ASELCD	ELC_GPTD Event Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled at the ELC_GPTD event input 1: GTCCRA input capture enabled at the ELC_GPTD event input.	R/W
b20	ASELCE	ELC_GPTE Event Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled at the ELC_GPTE event input 1: GTCCRA input capture enabled at the ELC_GPTE event input.	R/W
b21	ASELCF	ELC_GPTF Event Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled at the ELC_GPTF event input 1: GTCCRA input capture enabled at the ELC_GPTF event input.	R/W

Bit	Symbol	位名称	Description	R/W
b7	ASGTRGDF	GTETRGD引脚下降输入源GTCCRA输入捕捉使能	0：在GTETRGD输入的下降沿禁用GTCCRA输入捕捉1：在GTETRGD输入的下降沿启用GTCCRA输入捕捉。	R/W
b8	ASCARBL	GTIOCB值低源期间的GTIOCA引脚上升输入 GTCCRA输入捕捉使能	0：当GTIOCB输入为0时，在GTIOCA输入的上升沿禁用GTCCRA输入捕捉1：当GTIOCB输入为0时，在GTIOCA输入的上升沿启用GTCCRA输入捕捉。	R/W
b9	ASCARBH	GTIOCB值高源期间的GTIOCA引脚上升输入 GTCCRA输入捕捉使能	0：当GTIOCB输入为1时，在GTIOCA输入上升沿禁用GTCCRA输入捕捉1：当GTIOCB输入为1时，在GTIOCA输入上升沿启用GTCCRA输入捕捉。	R/W
b10	ASCAFBL	GTIOCA引脚下降期间输入 GTIOCB价值低来源 GTCCRA输入捕捉使能	0：当GTIOCB输入为0时，在GTIOCA输入的下降沿禁用GTCCRA输入捕捉1：当GTIOCB输入为0时，在GTIOCA输入的下降沿启用GTCCRA输入捕捉。	R/W
b11	ASCAFBH	GTIOCA引脚下降期间输入 GTIOCB价值高来源 GTCCRA输入捕捉使能	0：当GTIOCB输入为1时，在GTIOCA输入的下降沿禁用GTCCRA输入捕捉1：当GTIOCB输入为1时，在GTIOCA输入的下降沿启用GTCCRA输入捕捉。	R/W
b12	ASCBRAL	GTIOCA值低源期间的GTIOCB引脚上升输入 GTCCRA输入捕捉使能	0：当GTIOCA输入为0时，在GTIOCB输入的上升沿禁用GTCCRA输入捕捉1：当GTIOCA输入为0时，在GTIOCB输入的上升沿启用GTCCRA输入捕捉。	R/W
b13	ASCBRAH	GTIOCA值高源期间的GTIOCB引脚上升输入 GTCCRA输入捕捉使能	0：当GTIOCA输入为1时，在GTIOCB输入的上升沿禁用GTCCRA输入捕捉1：当GTIOCA输入为1时，在GTIOCB输入的上升沿启用GTCCRA输入捕捉。	R/W
b14	ASCBFAL	在GTIOCB引脚下降输入GTIOCA价值低来源GTCCRA输入捕捉使能	0：当GTIOCA输入为0时，在GTIOCB输入的下降沿禁用GTCCRA输入捕捉1：当GTIOCA输入为0时，在GTIOCB输入的下降沿启用GTCCRA输入捕捉。	R/W
b15	ASCBFAH	在GTIOCB引脚下降输入GTIOCA价值高来源GTCCRA输入捕捉使能	0：当GTIOCA输入为1时，在GTIOCB输入的下降沿禁用GTCCRA输入捕捉1：当GTIOCA输入为1时，在GTIOCB输入的下降沿启用GTCCRA输入捕捉。	R/W
b16	ASELCA	ELC_GPTA事件源GTCCRA输入捕捉使能	0：在ELC_GPTA事件输入处禁用GTCCRA输入捕捉1：在ELC_GPTA事件输入处启用GTCCRA输入捕捉。	R/W
b17	ASELCB	ELC_GPTB事件源GTCCRA输入捕捉使能	0：在ELC_GPTB事件输入处禁用GTCCRA输入捕捉1：在ELC_GPTB事件输入处启用GTCCRA输入捕捉。	R/W
b18	ASELCC	ELC_GPTC事件源GTCCRA输入捕捉使能	0：在ELC_GPTC事件输入处禁用GTCCRA输入捕捉1：在ELC_GPTC事件输入处启用GTCCRA输入捕捉。	R/W
b19	ASELCD	ELC_GPTD事件源GTCCRA输入捕捉使能	0：在ELC_GPTD事件输入处禁用GTCCRA输入捕捉1：在ELC_GPTD事件输入处启用GTCCRA输入捕捉。	R/W
b20	ASELCE	ELC_GPTE事件源GTCCRA输入捕捉使能	0：在ELC_GPTE事件输入处禁用GTCCRA输入捕捉1：在ELC_GPTE事件输入处启用GTCCRA输入捕捉。	R/W
b21	ASELCF	ELC_GPTF事件源GTCCRA输入捕捉使能	0：在ELC_GPTF事件输入处禁用GTCCRA输入捕捉1：在ELC_GPTF事件输入处启用GTCCRA输入捕捉。	R/W

Bit	Symbol	Bit name	Description	R/W
b22	ASELCG	ELC_GPTG Event Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled at the ELC_GPTG event input 1: GTCCRA input capture enabled at the ELC_GPTG event input.	R/W
b23	ASELCH	ELC_GPTH Event Source GTCCRA Input Capture Enable	0: GTCCRA input capture disabled at the ELC_GPTH event input 1: GTCCRA input capture enabled at the ELC_GPTH event input.	R/W
b31 to b24	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTICASR sets the source of input capture for GTCCRA.

ASGTRGAR bit (GTETRGA Pin Rising Input Source GTCCRA Input Capture Enable)

The ASGTRGAR bit enables or disables the input capture for GTCCRA on the rising edge of GTETRGA pin input.

ASGTRGAF bit (GTETRGA Pin Falling Input Source GTCCRA Input Capture Enable)

The ASGTRGAF bit enables or disables the input capture for GTCCRA on the falling edge of GTETRGA pin input.

ASGTRGBR bit (GTETRGB Pin Rising Input Source GTCCRA Input Capture Enable)

The ASGTRGBR bit enables or disables the input capture for GTCCRA on the rising edge of GTETRGB pin input.

ASGTRGBF bit (GTETRGB Pin Falling Input Source GTCCRA Input Capture Enable)

The ASGTRGBF bit enables or disables the input capture for GTCCRA on the falling edge of GTETRGB pin input.

ASGTRGCR bit (GTETRGC Pin Rising Input Source GTCCRA Input Capture Enable)

The ASGTRGCR bit enables or disables the input capture for GTCCRA on the rising edge of GTETRGC pin input.

ASGTRGCF bit (GTETRGC Pin Falling Input Source GTCCRA Input Capture Enable)

The ASGTRGCF bit enables or disables the input capture for GTCCRA on the falling edge of GTETRGC pin input.

ASGTRGDR bit (GTETRGD Pin Rising Input Source GTCCRA Input Capture Enable)

The ASGTRGDR bit enables or disables the input capture for GTCCRA on the rising edge of GTETRGD pin input.

ASGTRGDF bit (GTETRGD Pin Falling Input Source GTCCRA Input Capture Enable)

The ASGTRGDF bit enables or disables the input capture for GTCCRA on the falling edge of GTETRGD pin input.

ASCARBL bit (GTIOCA Pin Rising Input during GTIOCB Value Low Source GTCCRA Input Capture Enable)

The ASCARBL bit enables or disables the input capture for GTCCRA on the rising edge of GTIOCA pin input, when GTIOCB input is 0.

ASCARBH bit (GTIOCA Pin Rising Input during GTIOCB Value High Source GTCCRA Input Capture Enable)

The ASCARBH bit enables or disables the input capture for GTCCRA on the rising edge of GTIOCA pin input, when GTIOCB input is 1.

ASCAFBL bit (GTIOCA Pin Falling Input during GTIOCB Value Low Source GTCCRA Input Capture Enable)

The ASCAFBL bit enables or disables the input capture for GTCCRA on the falling edge of GTIOCA pin input, when GTIOCB input is 0.

ASCAFBH bit (GTIOCA Pin Falling Input during GTIOCB Value High Source GTCCRA Input Capture Enable)

The ASCAFBH bit enables or disables the input capture for GTCCRA on the falling edge of GTIOCA pin input, when GTIOCB input is 1.

Bit	Symbol	位名称	Description	R/W
b22	ASELCG	ELC_GPTG事件源GTCCRA输入捕捉使能	0：在ELC_GPTG事件输入处禁用GTCCRA输入捕捉1：在ELC_GPTG事件输入处启用GTCCRA输入捕捉。	R/W
b23	ASELCH	ELC_GPTH事件源GTCCRA输入捕捉使能	0：在ELC_GPTH事件输入处禁用GTCCRA输入捕捉1：在ELC_GPTH事件输入处启用GTCCRA输入捕捉。	R/W
b31 to b24	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTICASR设置GTCCRA的输入捕获源。

ASGTRGAR位（GTETRGA引脚上升沿输入源GTCCRA输入捕捉使能）

ASGTRGAR位在GTETRGA引脚输入的上升沿启用或禁用GTCCRA的输入捕捉。

ASGTRGAF位（GTETRGA引脚下降输入源GTCCRA输入捕捉使能）

ASGTRGAF位在GTETRGA引脚输入的下降沿启用或禁用GTCCRA的输入捕捉。

ASGTRGBR位（GTETRGB引脚上升沿输入源GTCCRA输入捕捉使能）

ASGTRGBR位在GTETRGB引脚输入的上升沿启用或禁用GTCCRA的输入捕捉。

ASGTRGBF位（GTETRGB引脚下降输入源GTCCRA输入捕捉使能）

ASGTRGBF位在GTETRGB引脚输入的下降沿启用或禁用GTCCRA的输入捕捉。

ASGTRGCR位（GTETRGC引脚上升沿输入源GTCCRA输入捕捉使能）

ASGTRGCR位在GTETRGC引脚输入的上升沿启用或禁用GTCCRA的输入捕捉。

ASGTRGCF位（GTETRGC引脚下降输入源GTCCRA输入捕捉使能）

ASGTRGCF位在GTETRGC引脚输入的下降沿启用或禁用GTCCRA的输入捕捉。

ASGTRGDR位（GTETRGD引脚上升沿输入源GTCCRA输入捕捉使能）

ASGTRGDR位在GTETRGD引脚输入的上升沿启用或禁用GTCCRA的输入捕捉。

ASGTRGDF位（GTETRGD引脚下降输入源GTCCRA输入捕捉使能）

ASGTRGDF位在GTETRGD引脚输入的下降沿启用或禁用GTCCRA的输入捕捉。

ASCARBL位（GTIOCB值低电平期间GTIOCA引脚上升沿输入源GTCCRA输入捕捉Enable）

ASCARBL位在GTIOCA引脚输入的上升沿启用或禁用GTCCRA的输入捕捉，当GTIOCB输入为0。

ASCARBH位（GTIOCB值高电平期间GTIOCA引脚的上升沿输入源GTCCRA输入捕捉Enable）

ASCARBH位在GTIOCA引脚输入的上升沿启用或禁用GTCCRA的输入捕捉，当GTIOCB输入为1。

ASCAFBL位（GTIOCB值低电平期间GTIOCA引脚下降输入源GTCCRA输入捕捉Enable）

ASCAFBL位在GTIOCA引脚输入的下降沿启用或禁用GTCCRA的输入捕捉，当GTIOCB输入为0。

ASCAFBH位（GTIOCB值高电平期间GTIOCA引脚下降输入源GTCCRA输入捕捉Enable）

ASCAFBH位在GTIOCA引脚输入的下降沿启用或禁用GTCCRA的输入捕捉，当GTIOCB输入为1。

ASCBRAL bit (GTIOCB Pin Rising Input during GTIOCA Value Low Source GTCCRA Input Capture Enable)

The ASCBRAL bit enables or disables the input capture for GTCCRA on the rising edge of GTIOCB pin input, when GTIOCA input is 0.

ASCBRAH bit (GTIOCB Pin Rising Input during GTIOCA Value High Source GTCCRA Input Capture Enable)

The ASCBRAH bit enables or disables the input capture for GTCCRA on the rising edge of GTIOCB pin input, when GTIOCA input is 1.

ASCBFAL bit (GTIOCB Pin Falling Input during GTIOCA Value Low Source GTCCRA Input Capture Enable)

The ASCBFAL bit enables or disables the input capture for GTCCRA on the falling edge of GTIOCB pin input, when GTIOCA input is 0.

ASCBFAH bit (GTIOCB Pin Falling Input during GTIOCA Value High Source GTCCRA Input Capture Enable)

The ASCBFAH bit enables or disables the input capture for GTCCRA on the falling edge of GTIOCB pin input, when GTIOCA input is 1.

ASELCm bit (ELC_GPTm Event Source Counter GTCCRA Input Capture Enable) (m = A to H)

The ASELCm bit enables or disables the input capture for GTCCRA at the ELC_GPTm event input.

22.2.11 General PWM Timer Input Capture Source Select Register B (GTICBSR)

Address(es): GPT32EHm.GTICBSR 4007 8028h + 0100h × m (m = 0 to 3)
GPT32Em.GTICBSR 4007 8028h + 0100h × m (m = 4 to 7)
GPT32m.GTICBSR 4007 8028h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	BSELCH	BSELCG	BSELCF	BSELCE	BSELCD	BSELCC	BSELCB	BSELCA
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	BSCBFAH	BSCBFAL	BSCBRAH	BSCBRAL	BSCAFBH	BSCAFBL	BSCARBH	BSCARBL	BSGTRGDF	BSGTRGDR	BSGTRGCF	BSGTRGCR	BSGTRGBF	BSGTRGBR	BSGTRGAF	BSGTRGAR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	BSGTRGAR	GTETRGA Pin Rising Input Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the rising edge of GTETRGA input 1: GTCCRB input capture enabled on the rising edge of GTETRGA input.	R/W
b1	BSGTRGAF	GTETRGA Pin Falling Input Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the falling edge of GTETRGA input 1: GTCCRB input capture enabled on the falling edge of GTETRGA input.	R/W
b2	BSGTRGBR	GTETRGB Pin Rising Input Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the rising edge of GTETRGB input 1: GTCCRB input capture enabled on the rising edge of GTETRGB input.	R/W
b3	BSGTRGBF	GTETRGB Pin Falling Input Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the falling edge of GTETRGB input 1: GTCCRB input capture enabled on the falling edge of GTETRGB input.	R/W

ASCBRAL位（GTIOCA值低电平期间GTIOCB引脚上升沿输入源GTCCRA输入捕捉Enable)

ASCBRAL位在GTIOCB引脚输入的上升沿启用或禁用GTCCRA的输入捕捉，当GTIOCA输入为0。

ASCBRAH位（GTIOCA值高电平期间GTIOCB引脚的上升沿输入源GTCCRA输入捕捉Enable)

ASCBRAH位在GTIOCB引脚输入的上升沿启用或禁用GTCCRA的输入捕捉，当GTIOCA输入为1。

ASCBFAL位（GTIOCA值低电平期间GTIOCB引脚下降输入源GTCCRA输入捕捉Enable)

ASCBFAL位在GTIOCB引脚输入的下降沿启用或禁用GTCCRA的输入捕捉，当GTIOCA输入为0。

ASCBFAH位（GTIOCA值高电平期间GTIOCB引脚下降输入源GTCCRA输入捕捉Enable)

ASCBFAH位在GTIOCB引脚输入的下降沿启用或禁用GTCCRA的输入捕捉，当GTIOCA输入为1。

ASELCm位（ELC_GPTm事件源计数器GTCCRA输入捕捉使能）（m=A到H）

ASELCm位在ELC_GPTm事件输入处启用或禁用GTCCRA的输入捕捉。

22.2.11 通用PWM定时器输入捕捉源选择寄存器B(GTICBSR)

Address(es): GPT32EHm.GTICBSR 4007 8028h + 0100h × m (m = 0 to 3)
GPT32Em.GTICBSR 4007 8028h + 0100h × m (m = 4 to 7)
GPT32m.GTICBSR 4007 8028h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	BSELCH	BSELCG	BSELCF	BSELCE	BSELCD	BSELCC	BSELCB	BSELCA
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	BSCBFAH	BSCBFAL	BSCBRAH	BSCBRAL	BSCAFBH	BSCAFBL	BSCARBH	BSCARBL	BSGTRGDF	BSGTRGDR	BSGTRGCF	BSGTRGCR	BSGTRGBF	BSGTRGBR	BSGTRGAF	BSGTRGAR
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	BSGTRGAR	GTETRGA引脚上升输入源GTCCRB输入捕捉使能	0：在GTETRGA输入的上升沿禁用GTCCRB输入捕捉1：在GTETRGA输入的上升沿启用GTCCRB输入捕捉。	R/W
b1	BSGTRGAF	GTETRGA引脚下降输入源GTCCRB输入捕捉使能	0：在GTETRGA输入的下降沿禁用GTCCRB输入捕捉1：在GTETRGA输入的下降沿启用GTCCRB输入捕捉。	R/W
b2	BSGTRGBR	GTETRGB引脚上升输入源GTCCRB输入捕捉使能	0：在GTETRGB输入的上升沿禁用GTCCRB输入捕捉1：在GTETRGB输入的上升沿启用GTCCRB输入捕捉。	R/W
b3	BSGTRGBF	GTETRGB引脚下降输入源GTCCRB输入捕捉使能	0：在GTETRGB输入的下降沿禁用GTCCRB输入捕捉1：在GTETRGB输入的下降沿启用GTCCRB输入捕捉。	R/W

Bit	Symbol	Bit name	Description	R/W
b4	BSGTRGCR	GTETRGC Pin Rising Input Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the rising edge of GTETRGC input 1: GTCCRB input capture enabled on the rising edge of GTETRGC input.	R/W
b5	BSGTRGCF	GTETRGC Pin Falling Input Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the falling edge of GTETRGC input 1: GTCCRB input capture enabled on the falling edge of GTETRGC input.	R/W
b6	BSGTRGDR	GTETRGD Pin Rising Input Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the rising edge of GTETRGD input 1: GTCCRB input capture enabled on the rising edge of GTETRGD input.	R/W
b7	BSGTRGDF	GTETRGD Pin Falling Input Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the falling edge of GTETRGD input 1: GTCCRB input capture enabled on the falling edge of GTETRGD input.	R/W
b8	BSCARBL	GTIOCA Pin Rising Input during GTIOCB Value Low Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the rising edge of GTIOCA input when GTIOCB input is 0 1: GTCCRB input capture enabled on the rising edge of GTIOCA input when GTIOCB input is 0.	R/W
b9	BSCARBH	GTIOCA Pin Rising Input during GTIOCB Value High Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the rising edge of GTIOCA input when GTIOCB input is 1 1: GTCCRB input capture enabled on the rising edge of GTIOCA input when GTIOCB input is 1.	R/W
b10	BSCAFBL	GTIOCA Pin Falling Input during GTIOCB Value Low Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the falling edge of GTIOCA input when GTIOCB input is 0 1: GTCCRB input capture enabled on the falling edge of GTIOCA input when GTIOCB input is 0.	R/W
b11	BSCAFBH	GTIOCA Pin Falling Input during GTIOCB Value High Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the falling edge of GTIOCA input when GTIOCB input is 1 1: GTCCRB input capture enabled on the falling edge of GTIOCA input when GTIOCB input is 1.	R/W
b12	BSCBRAL	GTIOCB Pin Rising Input during GTIOCA Value Low Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the rising edge of GTIOCB input when GTIOCA input is 0 1: GTCCRB input capture enabled on the rising edge of GTIOCB input when GTIOCA input is 0.	R/W
b13	BSCBRAH	GTIOCB Pin Rising Input during GTIOCA Value High Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the rising edge of GTIOCB input when GTIOCA input is 1 1: GTCCRB input capture enabled on the rising edge of GTIOCB input when GTIOCA input is 1.	R/W
b14	BSCBFAL	GTIOCB Pin Falling Input during GTIOCA Value Low Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the falling edge of GTIOCB input when GTIOCA input is 0 1: Enable GTCCRB input capture on the falling edge of GTIOCB input when GTIOCA input is 0.	R/W
b15	BSCBFAH	GTIOCB Pin Falling Input during GTIOCA Value High Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled on the falling edge of GTIOCB input when GTIOCA input is 1 1: GTCCRB input capture enabled on the falling edge of GTIOCB input when GTIOCA input is 1.	R/W
b16	BSELCA	ELC_GPTA Event Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled at the ELC_GPTA event input 1: GTCCRB input capture enabled at the ELC_GPTA event input.	R/W
b17	BSELCB	ELC_GPTB Event Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled at the ELC_GPTB event input 1: GTCCRB input capture enabled at the ELC_GPTB event input.	R/W
b18	BSELCC	ELC_GPTC Event Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled at the ELC_GPTC event input 1: GTCCRB input capture enabled at the ELC_GPTC event input.	R/W

Bit	Symbol	位名称	Description	R/W
b4	BSGTRGCR	GTETRGC引脚上升沿输入源 GTCCRB输入捕捉使能	0：在GTETRGC输入的上升沿禁用GTCCRB输入捕捉1：在GTETRGC输入的上升沿启用GTCCRB输入捕捉。	R/W
b5	BSGTRGCF	GTETRGC引脚下降输入源 GTCCRB输入捕捉使能	0：在GTETRGC输入的下降沿禁用GTCCRB输入捕捉1：在GTETRGC输入的下降沿启用GTCCRB输入捕捉。	R/W
b6	BSGTRGDR	GTETRGD引脚上升输入源 GTCCRB输入捕捉使能	0：在GTETRGD输入的上升沿禁用GTCCRB输入捕捉1：在GTETRGD输入的上升沿启用GTCCRB输入捕捉。	R/W
b7	BSGTRGDF	GTETRGD引脚下降输入源 GTCCRB输入捕捉使能	0：在GTETRGD输入的下降沿禁用GTCCRB输入捕捉1：在GTETRGD输入的下降沿启用GTCCRB输入捕捉。	R/W
b8	BSCARBL	GTIOCB值低源期间的GTIOCA引脚上升输入 GTCCRB输入捕捉使能	0：当GTIOCB输入为0时，在GTIOCA输入上升沿禁用GTCCRB输入捕捉1：当GTIOCB输入为0时，在GTIOCA输入上升沿启用GTCCRB输入捕捉。	R/W
b9	BSCARBH	GTIOCB值高源期间的GTIOCA引脚上升输入 GTCCRB输入捕捉使能	0：当GTIOCB输入为1时，在GTIOCA输入上升沿禁用GTCCRB输入捕捉1：当GTIOCB输入为1时，在GTIOCA输入上升沿启用GTCCRB输入捕捉。	R/W
b10	BSCAFBL	GTIOCA引脚下降期间输入 GTIOCB价值低来源 GTCCRB输入捕捉使能	0：当GTIOCB输入为0时，在GTIOCA输入的下降沿禁用GTCCRB输入捕捉1：当GTIOCB输入为0时，在GTIOCA输入的下降沿启用GTCCRB输入捕捉。	R/W
b11	BSCAFBH	GTIOCA引脚下降期间输入 GTIOCB价值高来源 GTCCRB输入捕捉使能	0：当GTIOCB输入为1时，在GTIOCA输入的下降沿禁用GTCCRB输入捕捉1：当GTIOCB输入为1时，在GTIOCA输入的下降沿启用GTCCRB输入捕捉。	R/W
b12	BSCBRAL	GTIOCA值低源期间的GTIOCB引脚上升输入 GTCCRB输入捕捉使能	0：当GTIOCA输入为0时，在GTIOCB输入的上升沿禁用GTCCRB输入捕捉1：当GTIOCA输入为0时，在GTIOCB输入的上升沿启用GTCCRB输入捕捉。	R/W
b13	BSCBRAH	GTIOCA值高源期间的GTIOCB引脚上升输入 GTCCRB输入捕捉使能	0：当GTIOCA输入为1时，在GTIOCB输入的上升沿禁用GTCCRB输入捕捉1：当GTIOCA输入为1时，在GTIOCB输入的上升沿启用GTCCRB输入捕捉。	R/W
b14	BSCBFAL	在GTIOCB引脚下降输入 GTIOCA价值低来源 GTCCRB输入捕捉使能	0：当GTIOCA输入为0时，在GTIOCB输入下降沿禁用GTCCRB输入捕捉1：当GTIOCA输入为0时，在GTIOCB输入下降沿启用GTCCRB输入捕捉。	R/W
b15	BSCBFAH	在GTIOCB引脚下降输入 GTIOCA价值高来源 GTCCRB输入捕捉使能	0：当GTIOCA输入为1时，在GTIOCB输入的下降沿禁用GTCCRB输入捕捉1：当GTIOCA输入为1时，在GTIOCB输入的下降沿启用GTCCRB输入捕捉。	R/W
b16	BSELCA	ELC_GPTA事件源 GTCCRB输入捕捉使能	0：在ELC_GPTA事件输入处禁用GTCCRB输入捕捉1：在ELC_GPTA事件输入处启用GTCCRB输入捕捉。	R/W
b17	BSELCB	ELC_GPTB事件源 GTCCRB输入捕捉使能	0：在ELC_GPTB事件输入处禁用GTCCRB输入捕捉1：在ELC_GPTB事件输入处启用GTCCRB输入捕捉。	R/W
b18	BSELCC	ELC_GPTC事件源 GTCCRB输入捕捉使能	0：在ELC_GPTC事件输入处禁用GTCCRB输入捕捉1：在ELC_GPTC事件输入处启用GTCCRB输入捕捉。	R/W

Bit	Symbol	Bit name	Description	R/W
b19	BSELCD	ELC_GPTD Event Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled at the ELC_GPTD event input 1: GTCCRB input capture enabled at the ELC_GPTD event input.	R/W
b20	BSELCE	ELC_GPTE Event Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled at the ELC_GPTE event input 1: GTCCRB input capture enabled at the ELC_GPTE event input.	R/W
b21	BSELCF	ELC_GPTF Event Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled at the ELC_GPTF event input 1: GTCCRB input capture enabled at the ELC_GPTF event input.	R/W
b22	BSELCG	ELC_GPTG Event Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled at the ELC_GPTG event input 1: GTCCRB input capture enabled at the ELC_GPTG event input.	R/W
b23	BSELCH	ELC_GPTH Event Source GTCCRB Input Capture Enable	0: GTCCRB input capture disabled at the ELC_GPTH event input 1: GTCCRB input capture enabled at the ELC_GPTH event input.	R/W
b31 to b24	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTICBSR sets the source of input capture for GTCCRB.

BSGTRGAR bit (GTETRGA Pin Rising Input Source GTCCRB Input Capture Enable)

The BSGTRGAR bit enables or disables the input capture for GTCCRB on the rising edge of GTETRGA pin input.

BSGTRGAF bit (GTETRGA Pin Falling Input Source GTCCRB Input Capture Enable)

The BSGTRGAF bit enables or disables the input capture for GTCCRB on the falling edge of GTETRGA pin input.

BSGTRGBR bit (GTETRGB Pin Rising Input Source GTCCRB Input Capture Enable)

The BSGTRGBR bit enables or disables the input capture for GTCCRB on the rising edge of GTETRGB pin input.

BSGTRGBF bit (GTETRGB Pin Falling Input Source GTCCRB Input Capture Enable)

The BSGTRGBF bit enables or disables the input capture for GTCCRB on the falling edge of GTETRGB pin input.

BSGTRGCR bit (GTETRGC Pin Rising Input Source GTCCRB Input Capture Enable)

The BSGTRGCR bit enables or disables the input capture for GTCCRB on the rising edge of GTETRGC pin input.

BSGTRGCF bit (GTETRGC Pin Falling Input Source GTCCRB Input Capture Enable)

The BSGTRGCF bit enables or disables the input capture for GTCCRB on the falling edge of GTETRGC pin input.

BSGTRGDR bit (GTETRGD Pin Rising Input Source GTCCRB Input Capture Enable)

The BSGTRGDR bit enables or disables the input capture for GTCCRB on the rising edge of GTETRGD pin input.

BSGTRGDF bit (GTETRGD Pin Falling Input Source GTCCRB Input Capture Enable)

The BSGTRGDF bit enables or disables the input capture for GTCCRB on the falling edge of GTETRGD pin input.

BSCARBL bit (GTIOCA Pin Rising Input during GTIOCB Value Low Source GTCCRB Input Capture Enable)

The BSCARBL bit enables or disables the input capture for GTCCRB on the rising edge of GTIOCA pin input, when GTIOCB input is 0.

BSCARBH bit (GTIOCA Pin Rising Input during GTIOCB Value High Source GTCCRB Input Capture Enable)

The BSCARBH bit enables or disables the input capture for GTCCRB on the rising edge of GTIOCA pin input, when GTIOCB input is 1.

Bit	Symbol	位名称	Description	R/W
b19	BSELCD	ELC_GPTD事件源GTCCRB输入捕捉使能	0：在ELC_GPTD事件输入处禁用GTCCRB输入捕捉1：在ELC_GPTD事件输入处启用GTCCRB输入捕捉。	R/W
b20	BSELCE	ELC_GPTE事件源GTCCRB输入捕捉使能	0：在ELC_GPTE事件输入处禁用GTCCRB输入捕捉1：在ELC_GPTE事件输入处启用GTCCRB输入捕捉。	R/W
b21	BSELCF	ELC_GPTF事件源GTCCRB输入捕捉使能	0：在ELC_GPTF事件输入处禁用GTCCRB输入捕捉1：在ELC_GPTF事件输入处启用GTCCRB输入捕捉。	R/W
b22	BSELCG	ELC_GPTG事件源GTCCRB输入捕捉使能	0：在ELC_GPTG事件输入处禁用GTCCRB输入捕捉1：在ELC_GPTG事件输入处启用GTCCRB输入捕捉。	R/W
b23	BSELCH	ELC_GPTH事件源GTCCRB输入捕捉使能	0：在ELC_GPTH事件输入处禁用GTCCRB输入捕捉1：在ELC_GPTH事件输入处启用GTCCRB输入捕捉。	R/W
b31 to b24	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTICBSR设置GTCCRB的输入捕获源。

BSGTRGAR位（GTETRGA引脚上升沿输入源GTCCRB输入捕捉使能）

BSGTRGAR位在GTETRGA引脚输入的上升沿启用或禁用GTCCRB的输入捕捉。

BSGTRGAF位（GTETRGA引脚下降输入源GTCCRB输入捕捉使能）

BSGTRGAF位在GTETRGA引脚输入的下降沿启用或禁用GTCCRB的输入捕捉。

BSGTRGBR位（GTETRGB引脚上升沿输入源GTCCRB输入捕捉使能）

BSGTRGBR位在GTETRGB引脚输入的上升沿启用或禁用GTCCRB的输入捕捉。

BSGTRGBF位（GTETRGB引脚下降输入源GTCCRB输入捕捉使能）

BSGTRGBF位在GTETRGB引脚输入的下降沿启用或禁用GTCCRB的输入捕捉。

BSGTRGCR位（GTETRGC引脚上升沿输入源GTCCRB输入捕捉使能）

BSGTRGCR位在GTETRGC引脚输入的上升沿启用或禁用GTCCRB的输入捕捉。

BSGTRGCF位（GTETRGC引脚下降输入源GTCCRB输入捕捉使能）

BSGTRGCF位在GTETRGC引脚输入的下降沿启用或禁用GTCCRB的输入捕捉。

BSGTRGDR位（GTETRGD引脚上升沿输入源GTCCRB输入捕捉使能）

BSGTRGDR位在GTETRGD引脚输入的上升沿启用或禁用GTCCRB的输入捕捉。

BSGTRGDF位（GTETRGD引脚下降输入源GTCCRB输入捕捉使能）

BSGTRGDF位在GTETRGD引脚输入的下降沿启用或禁用GTCCRB的输入捕捉。

BSCARBL位（GTIOCB值低电平期间GTIOCA引脚上升沿输入源GTCCRB输入捕捉Enable）

BSCARBL位在GTIOCA引脚输入的上升沿启用或禁用GTCCRB的输入捕捉，当GTIOCB输入为0。

BSCARBH位（GTIOCB值高电平期间GTIOCA引脚的上升沿输入源GTCCRB输入捕捉Enable）

BSCARBH位在GTIOCA引脚输入的上升沿启用或禁用GTCCRB的输入捕捉，当GTIOCB输入为1。

BSCAFBL bit (GTIOCA Pin Falling Input during GTIOCB Value Low Source GTCCRB Input Capture Enable)

The BSCAFBL bit enables or disables the input capture for GTCCRB on the falling edge of GTIOCA pin input, when GTIOCB input is 0.

BSCAFBH bit (GTIOCA Pin Falling Input during GTIOCB Value High Source GTCCRB Input Capture Enable)

The BSCAFBH bit enables or disables the input capture for GTCCRB on the falling edge of GTIOCA pin input, when GTIOCB input is 1.

BSCBRAL bit (GTIOCB Pin Rising Input during GTIOCA Value Low Source GTCCRB Input Capture Enable)

The BSCBRAL bit enables or disables the input capture for GTCCRB on the rising edge of GTIOCB pin input, when GTIOCA input is 0.

BSCBRAH bit (GTIOCB Pin Rising Input during GTIOCA Value High Source GTCCRB Input Capture Enable)

The BSCBRAH bit enables or disables the input capture for GTCCRB on the rising edge of GTIOCB pin input, when GTIOCA input is 1.

BSCBFAL bit (GTIOCB Pin Falling Input during GTIOCA Value Low Source GTCCRB Input Capture Enable)

The BSCBFAL bit enables or disables the input capture for GTCCRB on the falling edge of GTIOCB pin input, when GTIOCA input is 0.

BSCBFAH bit (GTIOCB Pin Falling Input during GTIOCA Value High Source GTCCRB Input Capture Enable)

The BSCBFAH bit enables or disables the input capture for GTCCRB on the falling edge of GTIOCB pin input, when GTIOCA input is 1.

BSELCm bit (ELC_GPTm Event Source Counter GTCCRB Input Capture Enable) (m = A to H)

The BSELCm bit enables or disables the input capture for GTCCRB at the ELC_GPTm event input.

22.2.12 General PWM Timer Control Register (GTCR)

Address(es): GPT32EHm.GTCR 4007 802Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTCR 4007 802Ch + 0100h × m (m = 4 to 7)
GPT32m.GTCR 4007 802Ch + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	TPCS[2:0]			—	—	—	—	—	MD[2:0]		
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	CST
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CST	Count Start	0: Count operation is stopped 1: Count operation is performed.	R/W
b15 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

BSCAFBL位（GTIOCB值低电平期间GTIOCA引脚下降输入源GTCCRB输入捕捉Enable)

BSCAFBL位在GTIOCA引脚输入的下降沿启用或禁用GTCCRB的输入捕捉，当GTIOCB输入为0。

BSCAFBH位（GTIOCB值高电平期间GTIOCA引脚下降输入源GTCCRB输入捕捉Enable)

BSCAFBH位在GTIOCA引脚输入的下降沿启用或禁用GTCCRB的输入捕捉，当GTIOCB输入为1。

BSCBRAL位（GTIOCA值低电平期间GTIOCB引脚上升沿输入源GTCCRB输入捕捉Enable)

BSCBRAL位在GTIOCB引脚输入的上升沿启用或禁用GTCCRB的输入捕捉，当GTIOCA输入为0。

BSCBRAH位（GTIOCA值高电平期间GTIOCB引脚的上升沿输入源GTCCRB输入捕捉Enable)

BSCBRAH位在GTIOCB引脚输入的上升沿启用或禁用GTCCRB的输入捕捉，当GTIOCA输入为1。

BSCBFAL位（GTIOCA值低电平期间GTIOCB引脚下降输入源GTCCRB输入捕捉Enable)

BSCBFAL位在GTIOCB引脚输入的下降沿启用或禁用GTCCRB的输入捕捉，当GTIOCA输入为0。

BSCBFAH位（GTIOCA值高电平期间GTIOCB引脚下降输入源GTCCRB输入捕捉Enable)

BSCBFAH位在GTIOCB引脚输入的下降沿启用或禁用GTCCRB的输入捕捉，当GTIOCA输入为1。

BSELCm位（ELC_GPTm事件源计数器GTCCRB输入捕捉使能）（m=A到H）

BSELCm位在ELC_GPTm事件输入处启用或禁用GTCCRB的输入捕捉。

22.2.12 通用PWM定时器控制寄存器(GTCR)

Address(es): GPT32EHm.GTCR 4007 802Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTCR 4007 802Ch + 0100h × m (m = 4 to 7)
GPT32m.GTCR 4007 802Ch + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	TPCS[2:0]			—	—	—	—	—	MD[2:0]		
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	CST
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CST	计数开始	0：停止计数1：进行计数。	R/W
b15 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b18 to b16	MD[2:0]	Mode Select	b18 b16 0 0 0: Saw-wave PWM mode (single buffer or double buffer possible) 0 0 1: Saw-wave one-shot pulse mode (fixed buffer operation) 0 1 0: Setting prohibited 0 1 1: Setting prohibited 1 0 0: Triangle-wave PWM mode 1 (32-bit transfer at trough) (single buffer or double buffer is possible) 1 0 1: Triangle-wave PWM mode 2 (32-bit transfer at crest and trough) (single buffer or double buffer is possible) 1 1 0: Triangle-wave PWM mode 3 (64-bit transfer at trough) (fixed buffer operation) 1 1 1: Setting prohibited.	R/W
b23 to b19	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b26 to b24	TPCS[2:0]	Timer Prescaler Select	b26 b24 0 0 0: PCLKD/1 0 0 1: PCLKD/4 0 1 0: PCLKD/16 0 1 1: PCLKD/64 1 0 0: PCLKD/256 1 0 1: PCLKD/1024.	R/W
b31 to b27	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTCR controls GTCNT.

CST bit (Count Start)

The CST bit controls the GTCNT counter start and stop.

[Setting conditions]

- The GTSTR value where the channel number associated with the bit number is set to 1 with the GTSSR.CSTRT bit at 1
- The ELC event input or the GTIOCA/GTIOCB/GTETRGn port input event enabled by GTSSR as the counter start source, occurs
- 1 is written by software directly.

[Clearing conditions]

- The GTSTP value where the channel number associated with the bit number is set to 1 with the GTSSR.CSTOP bit at 1.
- The ELC event input or the GTIOCA/GTIOCB/GTETRGn port input event enabled by GTSSR as the counter stop source, occurs
- 0 is written by software directly.

MD[2:0] bits (Mode Select)

The MD[2:0] bits select the GPT operating mode. The MD[2:0] bits must be set while the GTCNT operation is stopped.

TPCS[2:0] bits (Timer Prescaler Select)

The TPCS[2:0] bits select the clock for GTCNT. A clock prescaler can be selected independently for each channel. The TPCS[2:0] bits must be set while the GTCNT operation is stopped.

Bit	Symbol	位名称	Description	R/W
b18 to b16	MD[2:0]	模式选择	b18b16000：Saw-wavePWM模式（单缓存或双缓存均可）001：Saw-waveone-shot脉冲模式（固定缓存操作）010：禁止设置011：禁止设置100：三角波PWM模式1（波谷32位传输）（可单缓冲区或双缓冲区）101：三角波PWM模式2（波峰和波谷32位传输）（单缓冲区或双缓冲区）缓冲是可能的）110：三角波PWM模式3（64位传输在谷）（固定缓冲操作）111：设置禁止。	R/W
b23 to b19	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b26 to b24	TPCS[2:0]	定时器预分频器选择	b26 b24 0 0 0: PCLKD/1 0 0 1: PCLKD/4 0 1 0: PCLKD/16 0 1 1: PCLKD/64 1 0 0: PCLKD/256 1 0 1: PCLKD/1024.	R/W
b31 to b27	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTCR控制GTCNT。

CST位（计数开始）

CST位控制GTCNT计数器的启动和停止。

[Setting conditions]

- GTSTR值，其中与位号关联的通道号设置为1，GTSSR.CSTRT位为1
- 发生由GTSSR作为计数器启动源启用的ELC事件输入或GTIOCAGTIOCBGTETRn端口输入事件
- 1由软件直接编写。

[Clearing conditions]

- GTSTP值，其中与位号关联的通道号设置为1，GTSSR.CSTOP位为1。
- 发生由GTSSR作为计数器停止源启用的ELC事件输入或GTIOCAGTIOCBGTETRn端口输入事件
- 0由软件直接写入。

MD[2:0]位（模式选择）

MD[2:0]位选择GPT操作模式。当GTCNT操作停止时，必须设置MD[2:0]位。

TPCS[2:0]位（定时器预分频器选择）

TPCS[2:0]位选择GTCNT的时钟。可为每个通道独立选择时钟预分频器。这
当GTCNT操作停止时，必须设置TPCS[2:0]位。

22.2.13 General PWM Timer Count Direction and Duty Setting Register (GTUDDTYC)

Address(es): GPT32EHm.GTUDDTYC 4007 8030h + 0100h × m (m = 0 to 3)
GPT32Em.GTUDDTYC 4007 8030h + 0100h × m (m = 4 to 7)
GPT32m.GTUDDTYC 4007 8030h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	OBDTYR	OBDTYF	OBDTY[1:0]		—	—	—	—	OADTYR	OADTYF	OADTY[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	UDF	UD
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Bit	Symbol	Bit name	Description	R/W
b0	UD	Count Direction Setting	0: GTCNT counts down 1: GTCNT counts up.	R/W
b1	UDF	Forcible Count Direction Setting	0: Not forcibly set 1: Forcibly set.	R/W
b15 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b17, 16	OADTY[1:0]	GTIOCA Output Duty Setting	b17 b16 0 x: GTIOCA pin duty depends on compare match 1 0: GTIOCA pin duty = 0% 1 1: GTIOCA pin duty = 100%.	R/W
b18	OADTYF	Forcible GTIOCA Output Duty Setting	0: Not forcibly set 1: Forcibly set.	R/W
b19	OADTYR	GTIOCA Output Value Selecting after Releasing 0%/100% Duty Setting	0: Apply output value set in 0%/100% duty to GTIOA[3:2] function after releasing 0%/100% duty setting 1: Apply masked compare match output value to GTIOA[3:2] function after releasing 0%/100% duty setting.	R/W
b23 to b20	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b25, b24	OBDTY[1:0]	GTIOCB Output Duty Setting	b25 b24 0 x: GTIOCB pin duty depends on compare match 1 0: GTIOCB pin duty = 0% 1 1: GTIOCB pin duty = 100%.	R/W
b26	OBDTYF	Forcible GTIOCB Output Duty Setting	0: Do not force setting 1: Force setting.	R/W
b27	OBDTYR	GTIOCB Output Value Selecting after Releasing 0%/100% Duty Setting	0: Apply output value set in 0%/100% duty to GTIOB[3:2] function after releasing 0%/100% duty setting 1: Apply masked compare match output value to GTIOB[3:2] function after releasing 0%/100% duty setting.	R/W
b31 to b28	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

x: Don't care

The GTUDDTYC sets the direction in which GTCNT counts (up-counting or down-counting) and sets the duty of the GTIOCA/GTIOCB pin output.

Count direction:

- In saw-wave mode.

When the UD value is set to 0 during up-counting, the count direction changes at an overflow (the timing synchronous with count clock after the GTCNT value becomes the GTPR value). When the UD value is set to 1 during down-counting, the count direction changes at an underflow (the timing synchronous with count clock after the GTCNT value becomes 0).

When the UD value changes from 1 to 0 with the UDF bit being 0 and while counting is stopped, the counter starts up-counting and the count direction changes at an overflow (the timing synchronous with count clock after the GTCNT

22.2.13 通用PWM定时器计数方向和占空比设置寄存器(GTUDDTYC)

Address(es): GPT32EHm.GTUDDTYC 4007 8030h + 0100h × m (m = 0 to 3)
GPT32Em.GTUDDTYC 4007 8030h + 0100h × m (m = 4 to 7)
GPT32m.GTUDDTYC 4007 8030h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	OBDTYR	OBDTYF	OBDTY[1:0]		—	—	—	—	OADTYR	OADTYF	OADTY[1:0]	
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	UDF	UD
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Bit	Symbol	位名称	Description	R/W
b0	UD	计数方向设置	0：GTCNT向下计数1： GTCNT向上计数。	R/W
b1	UDF	强制计数方向 Setting	0：不强制设置1 ：强制设置。	R/W
b15 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b17, 16	OADTY[1:0]	GTIOCA输出占空比设置	b17b160x：GTIOCA引脚占空比取决于比较匹配10： GTIOCA引脚占空比=0%11：GTIOCA引脚占空比=10 0%。	R/W
b18	OADTYF	强制GTIOCA输出占空比 Setting	0：不强制设置1 ：强制设置。	R/W
b19	OADTYR	解除0%100%占空比设置后GTIOCA输出值选择	0：在释放0%100%占空比设置后将0%100%占空比中设置的输出值应用到GTIOA[3:2]功能1：在释放0%100%后将屏蔽比较匹配输出值应用到GTIOA[3:2]功能职责设置。	R/W
b23 to b20	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b25, b24	OBDTY[1:0]	GTIOCB输出占空比设置	b25b240x：GTIOCB引脚占空比取决于比较匹配10： GTIOCB引脚占空比=0%11：GTIOCB引脚占空比=10 0%。	R/W
b26	OBDTYF	强制GTIOCB输出占空比 Setting	0：不强制设置1：强 制设置。	R/W
b27	OBDTYR	解除0%100%占空比设置后GTIOCB输出值选择	0：在释放0%100%duty设置后将0%100%duty中设置的输出值应用到GTIOB[3:2]功能1：在释放0%100%后将屏蔽比较匹配输出值应用到GTIOB[3:2]功能职责设置。	R/W
b31 to b28	—	Reserved	这些位被读取为0。写入值应为0。	R/W

x: Don't care

GTUDDTYC设置GTCNT计数的方向（向上计数或向下计数）并设置
GTIOCAGTIOCB引脚输出。

Count direction:

- 在锯齿波模式下。

如果在向上计数期间将UD值设置为0，则计数方向会在溢出时发生变化（GTCNT值变为GTPR值后与计数时钟同步的时序）。在递减计数期间将UD值设置为1时，计数方向会在下溢（GTCNT值变为0后与计数时钟同步的时序）下发生变化。

当UD值从1变为0且UDF位为0且计数停止时，计数器开始向上计数，并且计数方向在溢出时改变（与GTCNT之后的计数时钟同步的时序）

value becomes GTPR value). When the UD value changes from 0 to 1 with the UDF bit being 0 and while counting stops, the counter starts down-counting and the count direction changes at an underflow (the timing synchronous with count clock after the GTCNT value becomes 0).

When the UDF bit is set to 1 while counting stops, the UD bit value is reflected in the count direction when counting starts.

Count direction:

- In triangle-wave mode.

When the UD value changes during counting, the count direction does not change. When the UD value changes while the UDF bit is 0 and counting stops, the change is not reflected in the count direction when counting starts.

When the UDF bit is set to 1 while counting stops, the UD value is reflected in the count direction when counting starts.

UD bit (Count Direction Setting)

The UD bit sets the count direction (up-counting or down-counting) for GTCNT.

UDF bit (Forcible Count Direction Setting)

The UDF bit forcibly sets the count direction when GTCNT starts operation as the UD value. Only write 0 to this bit during counter operation. When 1 is written to the UDF bit while counting stops, return this bit to 0 before counting starts.

Output duty

- In saw-wave mode.

When the OADTY/OBDTY value changes during up-counting, the duty is reflected at an overflow (GTCNT = GTPR). When the OADTY/OBDTY value changes during down-counting, the duty is reflected at an underflow (GTCNT = 0).

When the OADTY/OBDTY value changes to 1 with the OADTYF/OBDTYF bit being 0 and while counting stops, the output duty is not reflected at the starting counter operation. When the count direction is up, the output duty is reflected at an overflow (GTCNT = GTPR). When the count direction is down, the output duty is reflected at an underflow (GTCNT = 0).

When the OADTY/OBDTY value changes to 0 with the OADTYF/OBDTYF bit being 1 and while counting stops, the output duty is reflected at the starting counter operation.

Output duty

- In triangle-wave mode.

When the OADTY/OBDTY value changes during counting, the duty is reflected at an underflow. When the OADTY/OBDTY value changes to 1 with the OADTYF/OBDTYF bit being 0 and while counting stops, the output duty is not reflected at the starting counter operation. The output duty is reflected at an underflow.

When the OADTY/OBDTY value changes to 0 with the OADTYF/OBDTYF bit being 1 and while counting stops, the output duty is reflected at the starting counter operation.

OmDTY[1:0] bits (GTIOCm Output Duty Setting) (m = A, B)

The OmDTY[1:0] bits set the output duty of the GTIOCm pin to either 0%, 100%, or compare match control.

OmDTYF bit (Forcible GTIOCm Output Duty Setting) (m = A, B)

The OmDTYF bit forcibly sets the output duty cycle to the OmDTY setting. Set this bit to 0 during counter operation. When OmDTYF bit is set to 1 while counting stops, return this bit to 0 until the first period ends after the counter starts.

OmDTYR bit (GTIOCm Output Value Selecting after Releasing 0%/100% Duty Setting) (m = A, B)

The OmDTYR bits select the value that is the object of output retained or toggled at cycle end, when the control changes from 0%/100% duty setting to compare match for the GTIOCm pin and GTIOR. The GTIOm[3:2] bits are set to 00b (output retained at cycle end) or the GTIOR.GTIOm[3:2] bits are set to 11b (output toggled at cycle end).

While the duty 0%/100% setting operation is running, the compare match operation continues inside the GPT32. When the OmDTYR bit is set to 1, the GTIOCm pin is in the output state selected by the GTIOR.GTIOm [3:2] bit at the end of

值变为GTPR值）。当UDF位为0且UD值从0变为1且计数停止时，计数器开始递减计数并且计数方向在下溢时改变（GTCNT值变为0后与计数时钟同步的时序）。

当计数停止时UDF位设置为1时，UD位值在计数开始时反映在计数方向上。

Count direction:

- 在三角波模式下。

计数过程中UD值变化时，计数方向不变。当UD值改变而UDF位为0且计数停止，计数开始时变化不反映在计数方向上。

如果在计数停止时UDF位设置为1，则UD值在计数开始时反映在计数方向上。

UD位（计数方向设置）

UD位设置GTCNT的计数方向（向上计数或向下计数）。

UDF位（强制计数方向设置）

当GTCNT开始操作时，UDF位将计数方向强制设置为UD值。仅在计数器操作期间向该位写入0。如果在计数停止时向UDF位写入1，则在计数开始前将该位返回0。

输出占空比

- 在锯齿波模式下。

当OADTYOBDTY值在递增计数期间发生变化时，占空比反映在溢出处(GTCNT=GTPR)。
当向下计数期间OADTYOBDTY值发生变化时，占空比反映为下溢(GTCNT=0)。

当OADTYFOBDTYF位为0且OADTYOBDTY值变为1且计数停止时，输出占空比不会反映在开始计数器操作中。
当计数方向向上时，输出占空比反映在溢出处(GTCNT=GTPR)。当计数方向向下时，输出占空比反映为下溢(GTCNT=0)。

当OADTYOBDTY值变为0且OADTYFOBDTYF位为1且计数停止时，输出占空比反映在开始计数器操作中。

输出占空比

- 在三角波模式下。

当计数期间OADTYOBDTY值发生变化时，占空比反映为下溢。当。。。的时候
OADTYOBDTY值在OADTYFOBDTYF位为0时变为1，并且当计数停止时，输出占空比不会反映在开始计数器操作中。输出占空比反映在下溢处。

当OADTYOBDTY值变为0且OADTYFOBDTYF位为1且计数停止时，输出占空比反映在开始计数器操作中。

OmDTY[1:0]位（GTIOCm输出占空比设置）（m=A，B）

OmDTY[1:0]位将GTIOCm引脚的输出占空比设置为0%、100%或比较匹配控制。

OmDTYF位（强制GTIOCm输出占空比设置）（m=A，B）

OmDTYF位强制将输出占空比设置为OmDTY设置。在计数器操作期间将此位设置为0。
如果在计数停止时将OmDTYF位设置为1，则将该位返回0，直到计数器开始后第一个周期结束。

OmDTYR位（释放0%100%占空比设置后选择GTIOCm输出值）（m=A、B）

当控制从0%100%占空比设置更改为GTIOCm引脚和GTIOR比较匹配时，OmDTYR位选择作为输出对象在周期结束时保留或切换的值。GTIOm[3:2]位设置为00b（输出在循环结束时保留）或GTIOR.GTIOm[3:2]位设置为11b（输出在循环结束时切换）。

在运行占空比0%100%设置操作时，比较匹配操作在GPT32内部继续进行。当OmDTYR位设置为1时，GTIOCm引脚处于输出状态，由GTIOR.GTIOm[3:2]位在结束时选择

the cycle in the compare match operation.

22.2.14 General PWM Timer I/O Control Register (GTIOR)

Address(es): GPT32EHm.GTIOR 4007 8034h + 0100h × m (m = 0 to 3)
GPT32Em.GTIOR 4007 8034h + 0100h × m (m = 4 to 7)
GPT32m.GTIOR 4007 8034h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	NFCSB[1:0]		NFBEN	—	—	OBDF[1:0]		OBE	OBHLD	OBDFLT	—	GTIOB[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	NFCSA[1:0]		NFAEN	—	—	OADF[1:0]		OAE	OAHLD	OADFLT	—	GTIOA[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	GTIOA[4:0]	GTIOCA Pin Function Select	See Table 22.5.	R/W
b5	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6	OADFLT	GTIOCA Pin Output Value Setting at the Count Stop	0: The GTIOCA pin outputs low when counting stops 1: The GTIOCA pin outputs high when counting stops.	R/W
b7	OAHLD	GTIOCA Pin Output Setting at the Start/Stop Count	0: The GTIOCA pin output level at the start or stop of counting depends on the register setting 1: The GTIOCA pin output level is retained at the start or stop of counting.	R/W
b8	OAE	GTIOCA Pin Output Enable	0: Output is disabled 1: Output is enabled.	R/W
b10, b9	OADF[1:0]	GTIOCA Pin Disable Value Setting	b10 b9 0 0: Output disable is prohibited 0 1: GTIOCA pin is set to Hi-Z on output disable 1 0: Set GTIOCA pin to 0 on output disable 1 1: Set GTIOCA pin to 1 on output disable.	R/W
b12, b11	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b13	NFAEN	Noise Filter A Enable	0: The noise filter for the GTIOCA pin is disabled 1: The noise filter for the GTIOCA pin is enabled.	R/W
b15, b14	NFCSA[1:0]	Noise Filter A Sampling Clock Select	b15 b14 0 0: PCLKD/1 0 1: PCLKD/4 1 0: PCLKD/16 1 1: PCLKD/64.	R/W
b20 to b16	GTIOB[4:0]	GTIOCB Pin Function Select	See Table 22.5.	R/W
b21	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b22	OBDFLT	GTIOCB Pin Output Value Setting at the Count Stop	0: The GTIOCB pin outputs low when counting stops 1: The GTIOCB pin outputs high when counting stops.	R/W
b23	OBHLD	GTIOCB Pin Output Setting at the Start/Stop Count	0: The GTIOCB pin output level at the start or stop of counting depends on the register setting 1: The GTIOCB pin output level is retained at the start or stop of counting.	R/W
b24	OBE	GTIOCB Pin Output Enable	0: Output is disabled 1: Output is enabled.	R/W
b26, b25	OBDF[1:0]	GTIOCB Pin Disable Value Setting	b26 b25 0 0: Output disable is prohibited 0 1: GTIOCB pin is set to Hi-Z on output disable 1 0: GTIOCB pin is set to 0 on output disable 1 1: GTIOCB pin is set to 1 on output disable.	R/W
b28, b27	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

比较匹配操作中的循环。

22.2.14 通用PWM定时器IO控制寄存器(GTIOR)

Address(es): GPT32EHm.GTIOR 4007 8034h + 0100h × m (m = 0 to 3)
GPT32Em.GTIOR 4007 8034h + 0100h × m (m = 4 to 7)
GPT32m.GTIOR 4007 8034h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	NFCSB[1:0]		NFBEN	—	—	OBDF[1:0]		OBE	OBHLD	OBDFLT	—	GTIOB[4:0]				
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	NFCSA[1:0]		NFAEN	—	—	OADF[1:0]		OAE	OAHLD	OADFLT	—	GTIOA[4:0]				
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	GTIOA[4:0]	GTIOCA引脚功能选择	见表22.5。	R/W
b5	—	Reserved	该位读取为0。写入值应为0。	R/W
b6	OADFLT	GTIOCA引脚输出值 在计数停止处设置	0：计数停止时GTIOCA引脚输出低电平1：计数停止时GTIOCA引脚输出高电平。	R/W
b7	OAHLD	开始停止计数时的GTIOCA引脚输出设置	0：计数开始或停止时GTIOCA引脚输出电平取决于寄存器设置 1：计数开始或停止时GTIOCA引脚输出电平保持不变。	R/W
b8	OAE	GTIOCA引脚输出使能	0：禁用输出1：启用输出。	R/W
b10, b9	OADF[1:0]	GTIOCA引脚禁用值 Setting	b10b900：禁止输出禁用01：GTIOCA引脚设置为Hi-Z，输出禁用10：GTIOCA引脚设置为0，输出禁用11：GTIOCA引脚设置为1，输出禁用。	R/W
b12, b11	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b13	NFAEN	噪声滤波器A启用	0：GTIOCA引脚的噪声滤波器禁用1：GTIOCA引脚的噪声滤波器启用。	R/W
b15, b14	NFCSA[1:0]	噪声滤波器A采样时钟 Select	b15 b14 0 0: PCLKD/1 0 1: PCLKD/4 1 0: PCLKD/16 1 1: PCLKD/64.	R/W
b20 to b16	GTIOB[4:0]	GTIOCB引脚功能选择	见表22.5。	R/W
b21	—	Reserved	该位读取为0。写入值应为0。	R/W
b22	OBDFLT	GTIOCB引脚输出值 在计数停止处设置	0：计数停止时GTIOCB引脚输出低电平1：计数停止时GTIOCB引脚输出高电平。	R/W
b23	OBHLD	开始停止计数时的GTIOCB引脚输出设置	0：计数开始或停止时GTIOCB引脚输出电平取决于寄存器设置 1：计数开始或停止时GTIOCB引脚输出电平保持不变。	R/W
b24	OBE	GTIOCB引脚输出使能	0：禁用输出1：启用输出。	R/W
b26, b25	OBDF[1:0]	GTIOCB引脚禁用值 Setting	b26b2500：禁止输出禁用01：GTIOCB引脚在输出禁用时设置为Hi-Z10：GTIOCB引脚在输出禁用时设置为011：GTIOCB引脚在输出禁用时设置为1。	R/W
b28, b27	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b29	NFBEN	Noise Filter B Enable	0: Noise filter for GTIOCB pin is disabled 1: Noise filter for GTIOCB pin is enabled.	R/W
b31, b30	NFCSB[1:0]	Noise Filter B Sampling Clock Select	b31 b30 0 0: PCLKD/1 0 1: PCLKD/4 1 0: PCLKD/16 1 1: PCLKD/64.	R/W

The GTIOR sets the functions of the GTIOCA and GTIOCB pins.

GTIOA[4:0] bits (GTIOCA Pin Function Select)

The GTIOA[4:0] bits select the GTIOCA pin function. For details, see Table 22.5.

OADFLT bit (GTIOCA Pin Output Value Setting at the Count Stop)

The OADFLT bit selects whether the GTIOCA pin outputs high or low when counting stops.

OAHLD bit (GTIOCA Pin Output Setting at the Start/Stop Count)

The OAHLD bit specifies whether the GTIOCA pin output level is retained or the level at the start/stop of counting depends on the register setting.

When the OAHLD bit is set to 0:

- The value specified in bit [4] of the GTIOA[4:0] bits is output when counting starts
- The value specified in the OADFLT bit is output when counting stops
- If the OADFLT bit is modified while counting stops, the new value is immediately reflected in the output.

When the OAHLD bit is set to 1:

- The output is retained when counting starts or stops.

OAE bit (GTIOCA Pin Output Enable)

The OAE bit disables or enables the GTIOCA pin output.

When GTCCRA register is used as the input capture register (at least one bit in the GTICASR register is set to 1), the GTIOCA pin does not output regardless of the OAE bit value.

OADF[1:0] bits (GTIOCA Pin Disable Value Setting)

The OADF[1:0] bits select the output value of GTIOCA pin when an output disable request occurs.

NFAEN bit (Noise Filter A Enable)

The NFAEN bit disables or enables the noise filter for input from the GTIOCA pin. Because changing the value of the bit might lead to internal generation of an unexpected edge, select the output compare function for the relevant pin in the GTIOR register before doing so.

NFCSA[1:0] bits (Noise Filter A Sampling Clock Select)

The NFCSA[1:0] bits set the sampling interval for the noise filter of the GTIOCA pin. When setting these bits, wait for 2 cycles of the selected sampling interval before setting the input capture function.

GTIOB[4:0] bits (GTIOCB Pin Function Select)

The GTIOB[4:0] bits select the GTIOCB pin function. For details, see Table 22.5.

OBDFLT bit (GTIOCB Pin Output Value Setting at the Count Stop)

The OBDFLT bit sets whether the GTIOCB pin outputs high or low when counting stops.

OBHLD bit (GTIOCB Pin Output Setting at the Start/Stop Count)

The OBHLD bit specifies whether the GTIOCB pin output level is retained or the level at the start/stop of counting depends on the register setting.

Bit	Symbol	位名称	Description	R/W
b29	NFBEN	噪声滤波器B启用	0：GTIOCB引脚的噪声滤波器禁用1：GTIOCB引脚的噪声滤波器启用。	R/W
b31, b30	NFCSB[1:0]	噪声滤波器B采样时钟Select	b31 b30 0 0: PCLKD/1 0 1: PCLKD/4 1 0: PCLKD/16 1 1: PCLKD/64.	R/W

GTIOR设置GTIOCA和GTIOCB引脚的功能。

GTIOA[4:0]位（GTIOCA引脚功能选择）

GTIOA[4:0]位选择GTIOCA引脚功能。详见表22.5。

OADFLT位（计数停止时GTIOCA引脚输出值设置）

OADFLT位选择当计数停止时GTIOCA引脚输出高电平还是低电平。

OAHLD位（开始停止计数时GTIOCA引脚输出设置）

OAHLD位指定是保留GTIOCA引脚输出电平还是计数开始停止时的电平取决于寄存器设置。

当OAHLD位设置为0时：

- 计数开始时输出GTIOA[4:0]位的位[4]中指定的值
- 计数停止时输出OADFLT位中指定的值
- 如果在计数停止时修改OADFLT位，则新值会立即反映在输出中。

当OAHLD位设置为1时：

- 当计数开始或停止时，输出保持不变。

OAE位（GTIOCA引脚输出使能）

OAE位禁用或启用GTIOCA引脚输出。

当GTCCRA寄存器用作输入捕捉寄存器时（GTICASR寄存器中至少有一位设置为1），
无论OAE位值如何，GTIOCA引脚都不输出。

OADF[1:0]位（GTIOCA引脚禁用值设置）

当输出禁用请求发生时，OADF[1:0]位选择GTIOCA引脚的输出值。

NFAEN位（噪声滤波器A使能）

NFAEN位禁用或启用来自GTIOCA引脚的输入的噪声滤波器。由于更改该位的值可能会导致内部产生意外边沿，因此在执行此操作之前，请在GTIOR寄存器中为相关引脚选择输出比较功能。

NFCSA[1:0]位（噪声滤波器A采样时钟选择）

NFCSA[1:0]位设置GTIOCA引脚噪声滤波器的采样间隔。设置这些位时，请等待所选采样间隔的2个周期，然后再设置输入捕捉功能。

GTIOB[4:0]位（GTIOCB引脚功能选择）

GTIOB[4:0]位选择GTIOCB引脚功能。详见表22.5。

OBDFLT位（计数停止时GTIOCB引脚输出值设置）

OBDFLT位设置当计数停止时GTIOCB引脚输出高电平还是低电平。

OBHLD位（开始停止计数时GTIOCB引脚输出设置）

OBHLD位指定是保留GTIOCB引脚输出电平还是计数开始停止时的电平取决于寄存器设置。

When the OBHLD bit is set to 0:

- The value specified in bit [4] of the GTIOB[4:0] bits is output when counting starts
- The value specified in the OBDFLT bit is output when counting stops
- If the OBDFLT bit is modified while counting stops, the new value is immediately reflected in the output.

When the OBHLD bit is set to 1:

- The output is retained when counting starts or stops.

OBE bit (GTIOCB Pin Output Enable)

The OBE bit disables or enables the GTIOCB pin output.

When GTCCRB register is used as the input capture register (at least one bit in GTICBSR register is set to 1), the GTIOCB pin does not output regardless of the OBE bit value.

OBDF[1:0] bits (GTIOCB Pin Disable Value Setting)

The OBDF[1:0] bits select the output value of GTIOCB pin when an output disable request occurs.

NFBEN bit (Noise Filter B Enable)

The NFBEN bit disables or enables the noise filter for input from the GTIOCB pin. Because changing the value of the bit might lead to internal generation of an unexpected edge, select the output compare function for the relevant pin in the GTIOR register before doing so.

NFCSB[1:0] bits (Noise Filter B Sampling Clock Select)

The NFCSB[1:0] bits set the sampling interval for the noise filter of the GTIOCB pin. When setting these bits, wait for 2 cycles of the selected sampling interval before setting the input capture function.

Table 22.5 Settings of GTIOA[4:0] and GTIOB[4:0] bits (1 of 2)

GTIOA/GTIOB[4:0] bits					Function		
b4	b3	b2	b1	b0	b4	b3, b2	b1, b0
0	0	0	0	0	Initial output is low	Output retained at cycle end	Output retained at GTCCRA/GTCCRB compare match
0	0	0	0	1			Low output at GTCCRA/GTCCRB compare match
0	0	0	1	0			High output at GTCCRA/GTCCRB compare match
0	0	0	1	1			Output toggled at GTCCRA/GTCCRB compare match
0	0	1	0	0		Low output at cycle end	Output retained at GTCCRA/GTCCRB compare match
0	0	1	0	1			Low output at GTCCRA/GTCCRB compare match
0	0	1	1	0			High output at GTCCRA/GTCCRB compare match
0	0	1	1	1			Output toggled at GTCCRA/GTCCRB compare match
0	1	0	0	0		High output at cycle end	Output retained at GTCCRA/GTCCRB compare match
0	1	0	0	1			Low output at GTCCRA/GTCCRB compare match
0	1	0	1	0			High output at GTCCRA/GTCCRB compare match
0	1	0	1	1			Output toggled at GTCCRA/GTCCRB compare match
0	1	1	0	0		Output toggled at cycle end	Output retained at GTCCRA/GTCCRB compare match
0	1	1	0	1			Low output at GTCCRA/GTCCRB compare match
0	1	1	1	0			High output at GTCCRA/GTCCRB compare match
0	1	1	1	1			Output toggled at GTCCRA/GTCCRB compare match

当OBHLD位设置为0时：

- 计数开始时输出GTIOB[4:0]位的位[4]中指定的值
- 计数停止时输出OBDFLT位中指定的值
- 如果在计数停止时修改了OBDFLT位，则新值会立即反映在输出中。

当OBHLD位设置为1时：

- 当计数开始或停止时，输出保持不变。

OBE位（GTIOCB引脚输出使能）

OBE位禁用或启用GTIOCB引脚输出。

当GTCCRB寄存器用作输入捕捉寄存器时（GTICBSR寄存器中至少有一位设置为1），
无论OBE位值如何，GTIOCB引脚都不输出。

OBDF[1:0]位（GTIOCB引脚禁用值设置）

当输出禁用请求发生时，OBDF[1:0]位选择GTIOCB引脚的输出值。

NFBEN位（噪声滤波器B启用）

NFBEN位禁用或启用来自GTIOCB引脚的输入的噪声滤波器。由于更改该位的值可能会导致内部产生意外边沿，因此在执行此操作之前，请在GTIOR寄存器中为相关引脚选择输出比较功能。

NFCSB[1:0]位（噪声滤波器B采样时钟选择）

NFCSB[1:0]位设置GTIOCB引脚噪声滤波器的采样间隔。设置这些位时，请等待所选采样间隔的2个周期，然后再设置输入捕捉功能。

Table 22.5 GTIOA[4:0]和GTIOB[4:0]位的设置(1of2)

GTIOA/GTIOB[4:0] bits					Function		
b4	b3	b2	b1	b0	b4	b3, b2	b1, b0
0	0	0	0	0	初始输出低	输出在循环结束时保留	GTCCRAGTCCRB比较匹配时保留的输出
0	0	0	0	1			GTCCRAGTCCRB比较匹配时的低输出
0	0	0	1	0			GTCCRAGTCCRB比较匹配时的高输出
0	0	0	1	1			在GTCCRAGTCCRB比较匹配时切换输出
0	0	1	0	0		循环结束时输出低	GTCCRAGTCCRB比较匹配时保留的输出
0	0	1	0	1			GTCCRAGTCCRB比较匹配时的低输出
0	0	1	1	0			GTCCRAGTCCRB比较匹配时的高输出
0	0	1	1	1			在GTCCRAGTCCRB比较匹配时切换输出
0	1	0	0	0		循环结束时的高输出	GTCCRAGTCCRB比较匹配时保留的输出
0	1	0	0	1			GTCCRAGTCCRB比较匹配时的低输出
0	1	0	1	0			GTCCRAGTCCRB比较匹配时的高输出
0	1	0	1	1			在GTCCRAGTCCRB比较匹配时切换输出
0	1	1	0	0		输出在循环结束时切换	GTCCRAGTCCRB比较匹配时保留的输出
0	1	1	0	1			GTCCRAGTCCRB比较匹配时的低输出
0	1	1	1	0			GTCCRAGTCCRB比较匹配时的高输出
0	1	1	1	1			在GTCCRAGTCCRB比较匹配时切换输出

Table 22.5 Settings of GTIOA[4:0] and GTIOB[4:0] bits (2 of 2)

GTIOA/GTIOB[4:0] bits					Function		
b4	b3	b2	b1	b0	b4	b3, b2	b1, b0
1	0	0	0	0	Set initial output high	Output retained at cycle end	Output retained at GTCCRA/GTCCRB compare match
1	0	0	0	1			Low output at GTCCRA/GTCCRB compare match
1	0	0	1	0			High output at GTCCRA/GTCCRB compare match
1	0	0	1	1			Output toggled at GTCCRA/GTCCRB compare match
1	0	1	0	0		Output low at cycle end	Output retained at GTCCRA/GTCCRB compare match
1	0	1	0	1			Low output at GTCCRA/GTCCRB compare match
1	0	1	1	0			High output at GTCCRA/GTCCRB compare match
1	0	1	1	1			Output toggled at GTCCRA/GTCCRB compare match
1	1	0	0	0		Output high at cycle end	Output retained at GTCCRA/GTCCRB compare match
1	1	0	0	1			Low output at GTCCRA/GTCCRB compare match
1	1	0	1	0			High output at GTCCRA/GTCCRB compare match
1	1	0	1	1			Output toggled at GTCCRA/GTCCRB compare match
1	1	1	0	0		Output toggled at cycle end	Output retained at GTCCRA/GTCCRB compare match
1	1	1	0	1			Low output at GTCCRA/GTCCRB compare match
1	1	1	1	0			High output at GTCCRA/GTCCRB compare match
1	1	1	1	1			Output toggled at GTCCRA/GTCCRB compare match

Note 1. The cycle end means an overflow (GTCNT changes from GTPR to 0 in up-counting) or underflow (GTCNT changes from 0 to GTPR in down-counting). The GTCNT counter is cleared for saw waves and for the trough (GTCNT changes from 0 to 1) for triangle waves.

Note 2. When the timing of a cycle end and the timing of a GTCCRA/GTCCRB compare match are the same in a compare-match operation, the b3 and b2 settings are given priority in saw-wave PWM mode, and the b1 and b0 settings are given priority in any other mode.

Note 3. In event count operation where at least one bit in GTUPSR or GTDNSR is set to 1, the setting of b3 and b2 is ignored.

Table 22.5 GTIOA[4:0]和GTIOB[4:0]位的设置(2of2)

GTIOA/GTIOB[4:0] bits					Function		
b4	b3	b2	b1	b0	b4	b3, b2	b1, b0
1	0	0	0	0	将初始输出设置为高	输出在循环结束时保留	GTCCRAGTCCRB比较匹配时保留的输出
1	0	0	0	1			GTCCRAGTCCRB比较匹配时的低输出
1	0	0	1	0			GTCCRAGTCCRB比较匹配时的高输出
1	0	0	1	1			在GTCCRAGTCCRB比较匹配时切换输出
1	0	1	0	0		循环结束时输出低	GTCCRAGTCCRB比较匹配时保留的输出
1	0	1	0	1			GTCCRAGTCCRB比较匹配时的低输出
1	0	1	1	0			GTCCRAGTCCRB比较匹配时的高输出
1	0	1	1	1			在GTCCRAGTCCRB比较匹配时切换输出
1	1	0	0	0		循环结束时输出高	GTCCRAGTCCRB比较匹配时保留的输出
1	1	0	0	1			GTCCRAGTCCRB比较匹配时的低输出
1	1	0	1	0			GTCCRAGTCCRB比较匹配时的高输出
1	1	0	1	1			在GTCCRAGTCCRB比较匹配时切换输出
1	1	1	0	0		输出在循环结束时切换	GTCCRAGTCCRB比较匹配时保留的输出
1	1	1	0	1			GTCCRAGTCCRB比较匹配时的低输出
1	1	1	1	0			GTCCRAGTCCRB比较匹配时的高输出
1	1	1	1	1			在GTCCRAGTCCRB比较匹配时切换输出

Note 1. 循环结束意味着上溢（向上计数时GTCNT从GTPR变为0）或下溢（向下计数时GTCNT从0变为GTPR）。锯齿波和波谷（GTCNT从0变为1）的三角波清除GTCNT计数器。

Note 2. 在比较匹配操作中，当周期结束的时序和GTCCRAGTCCRB比较匹配的时序相同时，在锯齿波PWM模式下，b3和b2设置优先，b1和b0设置优先在任何其他模式下。

Note 3. 在GTUPSR或GTDNSR中至少一位设置为1的事件计数操作中，忽略b3和b2的设置。

22.2.15 General PWM Timer Interrupt Output Setting Register (GTINTAD)

Address(es): GPT32EHm.GTINTAD 4007 8038h + 0100h × m (m = 0 to 3)
GPT32Em.GTINTAD 4007 8038h + 0100h × m (m = 4 to 7)
GPT32m.GTINTAD 4007 8038h + 0100h × m (m = 8 to 12)

- GPT32EH, GPT32E

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	GRPABL	GRPABH	GRPDTE	—	—	GRP[1:0]		—	—	—	—	ADTRBDEN	ADTRBUEN	ADTRADEN	ADTRAUEN
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- GPT32

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	GRPABL	GRPABH	—	—	—	GRP[1:0]		—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b15 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b16	ADTRAUEN	GTADTRA Compare Match (Up-Counting) A/D Converter Start Request Enable	0: A/D converter start request disabled 1: A/D converter start request enabled.	R/W
b17	ADTRADEN	GTADTRA Compare Match (Down-Counting) A/D Converter Start Request Enable	0: A/D converter start request disabled 1: A/D converter start request enabled.	R/W
b18	ADTRBUEN	GTADTRB Compare Match (Up-Counting) A/D Converter Start Request Enable	0: A/D converter start request disabled 1: A/D converter start request enabled.	R/W
b19	ADTRBDEN	GTADTRB Compare Match (Down-Counting) A/D Converter Start Request Enable	0: A/D converter start request disabled 1: A/D converter start request enabled.	R/W
b23 to b20	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b25, b24	GRP[1:0]	Output Disable Source Select	b25 b24 0 0: Group A output disable request 0 1: Group B output disable request 1 0: Group C output disable request 1 1: Group D output disable request.	R/W
b27, b26	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b28	GRPDTE	Dead Time Error Output Disable Request Enable	0: Dead time error output disable request disabled 1: Dead time error output disable request enabled.	R/W
b29	GRPABH	Same Time Output Level High Disable Request Enable	0: Same time output level high disable request disabled 1: Same time output level high disable request enabled.	R/W
b30	GRPABL	Same Time Output Level Low Disable Request Enable	0: Same time output level low disable request disabled 1: Same time output level low disable request enabled.	R/W

22.2.15 通用PWM定时器中断输出设置寄存器(GTINTAD)

Address(es): GPT32EHm.GTINTAD 4007 8038h + 0100h × m (m = 0 to 3)
GPT32Em.GTINTAD 4007 8038h + 0100h × m (m = 4 to 7)
GPT32m.GTINTAD 4007 8038h + 0100h × m (m = 8 to 12)

- GPT32EH, GPT32E

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	GRPABL	GRPABH	GRPDTE	—	—	GRP[1:0]		—	—	—	—	ADTRBDEN	ADTRBUEN	ADTRADEN	ADTRAUEN
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- GPT32

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	GRPABL	GRPABH	—	—	—	GRP[1:0]		—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b15 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b16	ADTRAUEN	GTADTRA比较匹配（上计数)AD转换器启动请求Enable	0：AD转换器启动请求无效1：AD转换器启动请求有效。	R/W
b17	ADTRADEN	GTADTRA比较匹配（下计数)AD转换器启动请求Enable	0：AD转换器启动请求无效1：AD转换器启动请求有效。	R/W
b18	ADTRBUEN	GTADTRB比较匹配（向上计数)AD转换器启动请求Enable	0：AD转换器启动请求无效1：AD转换器启动请求有效。	R/W
b19	ADTRBDEN	GTADTRB比较匹配（下计数)AD转换器启动请求Enable	0：AD转换器启动请求无效1：AD转换器启动请求有效。	R/W
b23 to b20	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b25, b24	GRP[1:0]	输出禁用源选择	b25b2400：A组输出禁止请求01：B组输出禁止请求10：C组输出禁止请求11：D组输出禁止请求。	R/W
b27, b26	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b28	GRPDTE	死区时间错误输出禁用请求启用	0：禁止死区错误输出禁用请求1：使能死区错误输出禁止请求。	R/W
b29	GRPABH	同时输出电平高禁用请求启用	0：禁止同时输出电平高禁止请求1：允许同时输出电平高禁止请求。	R/W
b30	GRPABL	同时输出电平低禁用请求启用	0：禁止同时输出电平低禁止请求1：允许同时输出电平低禁止请求。	R/W

Bit	Symbol	Bit name	Description	R/W
b31	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

The GTINTAD enables or disables interrupt requests, A/D converter start requests, and output disable requests.

ADTRAUEN bit (GTADTRA Compare Match (Up-Counting) A/D Converter Start Request Enable)

The ADTRAUEN bit enables or disables A/D converter start requests generated by GTADTRA compare matches during GTCNT up-counting. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

ADTRADEN bit (GTADTRA Compare Match (Down-Counting) A/D Converter Start Request Enable)

The ADTRADEN bit enables or disables A/D converter start requests generated by GTADTRA compare matches during GTCNT down-counting. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

ADTRBUEN bit (GTADTRB Compare Match (Up-Counting) A/D Converter Start Request Enable)

The ADTRBUEN bit enables or disables A/D converter start requests generated by GTADTRB compare matches during GTCNT up-counting. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

ADTRBDEN bit (GTADTRB Compare Match (Down-Counting) A/D Converter Start Request Enable)

The ADTRBDEN bit enables or disables A/D converter start requests generated by GTADTRB compare matches during GTCNT down-counting. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

GRP[1:0] bits (Output Disable Source Select)

The GRP[1:0] bits select the GTIOCA or GTIOCB pin output disable source.

The output disable request to POEG outputs to the group which is selected in the GRP[1:0] bits when dead time error, same time output level high, or same time output level low occurs based on the output disable request enable bit.

GTST.ODF shows the request of output disable source group that is selected in the GRP[1:0] bits. The GRP[1:0] bits should be set when both GTIOR.OAE and GTIOR.OBE are 0.

GRPDTE bit (Dead Time Error Output Disable Request Enable)

The GRPDTE bit enables or disables dead time error output disable request. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

GRPABH bit (Same Time Output Level High Disable Request Enable)

The GRPABH bit enables or disables output disable request when the GTIOCA and GTIOCB pins output 1 at the same time.

GRPABL bit (Same Time Output Level Low Disable Request Enable)

The GRPABL bit enables or disables output disable request when the GTIOCA and GTIOCB pins output 0 at the same time.

Bit	Symbol	位名称	Description	R/W
b31	—	Reserved	该位读取为0。写入值应为0。	R/W

GTINTAD启用或禁用中断请求、AD转换器启动请求和输出禁用请求。

ADTRAUEN位（GTADTRA比较匹配（向上计数）AD转换器启动请求使能）

ADTRAUEN位启用或禁用GTADTRA比较匹配期间生成的AD转换器启动请求GTCNT递增计数。只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

ADTRADEN位（GTADTRA比较匹配（递减计数）AD转换器启动请求使能）

ADTRADEN位启用或禁用GTADTRA比较匹配期间生成的AD转换器启动请求GTCNT递减计数。只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

ADTRBUEN位（GTADTRB比较匹配（向上计数）AD转换器启动请求使能）

ADTRBUEN位启用或禁用由GTADTRB比较匹配期间生成的AD转换器启动请求GTCNT递增计数。只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

ADTRBDEN位（GTADTRB比较匹配（递减计数）AD转换器启动请求使能）

ADTRBDEN位启用或禁用GTADTRB比较匹配期间生成的AD转换器启动请求GTCNT递减计数。只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

GRP[1:0]位（输出禁用源选择）

GRP[1:0]位选择GTIOCA或GTIOCB引脚输出禁用源。

当基于输出禁用请求使能位发生死区错误、同时输出电平高或同时输出电平低时，对POEG的输出禁用请求输出到在GRP[1:0]位中选择的组。

GTST.ODF显示在GRP[1:0]位中选择的输出禁用源组的请求。当GTIOR.OAE和GTIOR.OBE都为0时，应设置GRP[1:0]位。

GRPDTE位（死区错误输出禁用请求启用）

GRPDTE位启用或禁用死区错误输出禁用请求。只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

GRPABH位（同时输出电平高禁用请求启用）

当GTIOCA和GTIOCB引脚同时输出1时，GRPABH位启用或禁用输出禁用请求。

GRPABL位（同时输出电平低禁用请求启用）

当GTIOCA和GTIOCB引脚同时输出0时，GRPABL位启用或禁用输出禁用请求。

22.2.16 General PWM Timer Status Register (GTST)

Address(es): GPT32EHm.GTST 4007 803Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTST 4007 803Ch + 0100h × m (m = 4 to 7)
GPT32m.GTST 4007 803Ch + 0100h × m (m = 8 to 12)

- GPT32EH, GPT32E

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	OABLF	OABHF	DTEF	—	—	—	ODF	—	—	—	—	ADTRBDF	ADTRBUF	ADTRADF	ADTRAUF
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	TUCF	—	—	—	—	ITCNT[2:0]			TCFPU	TCFPO	TCFF	TCFE	TCFD	TCFC	TCFB	TCFA
Value after reset:	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- GPT32

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	OABLF	OABHF	—	—	—	—	ODF	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	TUCF	—	—	—	—	—	—	—	TCFPU	TCFPO	TCFF	TCFE	TCFD	TCFC	TCFB	TCFA
Value after reset:	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TCFA	Input Capture/Compare Match Flag A	0: No input capture/compare match of GTCCRA is generated 1: An input capture/compare match of GTCCRA is generated.	R/(W)*1
b1	TCFB	Input Capture/Compare Match Flag B	0: No input capture/compare match of GTCCRB is generated 1: An input capture/compare match of GTCCRB is generated.	R/(W)*1
b2	TCFC	Input Compare Match Flag C	0: No compare match of GTCCRC is generated 1: A compare match of GTCCRC is generated.	R/(W)*1
b3	TCFD	Input Compare Match Flag D	0: No compare match of GTCCRD is generated 1: A compare match of GTCCRD is generated.	R/(W)*1
b4	TCFE	Input Compare Match Flag E	0: No compare match of GTCCRE is generated 1: A compare match of GTCCRE is generated.	R/(W)*1
b5	TCFF	Input Compare Match Flag F	0: No compare match of GTCCRF is generated 1: A compare match of GTCCRF is generated.	R/(W)*1
b6	TCFPO	Overflow Flag	0: No overflow (crest) occurred 1: An overflow (crest) occurred.	R/(W)*1
b7	TCFPU	Underflow Flag	0: No underflow (trough) occurred 1: An underflow (trough) occurred.	R/(W)*1
b10 to b8	ITCNT[2:0]	GPTn_OVF/GPTn_UDF Interrupt Skipping Count Counter	Counter for counting the number of times a timer interrupt is skipped	R
b14 to b11	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15	TUCF	Count Direction Flag	0: GTCNT counter counts downward 1: GTCNT counter counts upward.	R
b16	ADTRAUF	GTADTRA Compare Match (Up-Counting) A/D Converter Start Request Flag	0: No compare match of GTADTRA at up-counting occurred 1: A compare match of GTADTRA at up-counting occurred.	R/(W)*1
b17	ADTRADF	GTADTRA Compare Match (Down-Counting) A/D Converter Start Request Flag	0: No compare match of GTADTRA at down-counting occurred 1: A compare match of GTADTRA at down-counting occurred.	R/(W)*1

22.2.16 通用PWM定时器状态寄存器(GTST)

Address(es): GPT32EHm.GTST 4007 803Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTST 4007 803Ch + 0100h × m (m = 4 to 7)
GPT32m.GTST 4007 803Ch + 0100h × m (m = 8 to 12)

- GPT32EH, GPT32E

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	OABLF	OABHF	DTEF	—	—	—	ODF	—	—	—	—	ADTRBDF	ADTRBUF	ADTRADF	ADTRAUF
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	TUCF	—	—	—	—	ITCNT[2:0]			TCFPU	TCFPO	TCFF	TCFE	TCFD	TCFC	TCFB	TCFA
重置后的值:	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- GPT32

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	OABLF	OABHF	—	—	—	—	ODF	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	TUCF	—	—	—	—	—	—	—	TCFPU	TCFPO	TCFF	TCFE	TCFD	TCFC	TCFB	TCFA
重置后的值:	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TCFA	输入捕捉比较匹配 Flag A	0：不生成GTCCRA的输入捕捉比较匹配1：生成GTCCRA的输入捕捉比较匹配。	R/(W)*1
b1	TCFB	输入捕捉比较匹配 Flag B	0：不生成GTCCRB的输入捕捉比较匹配1：生成GTCCRB的输入捕捉比较匹配。	R/(W)*1
b2	TCFC	输入比较匹配标志C	0：没有生成GTCCRC的比较匹配1：生成了GTCCRC的比较匹配。	R/(W)*1
b3	TCFD	输入比较匹配标志D	0：不产生GTCCRD的比较匹配1：产生GTCCRD的比较匹配。	R/(W)*1
b4	TCFE	输入比较匹配标志E	0：不产生GTCCRE的比较匹配1：产生GTCCRE的比较匹配。	R/(W)*1
b5	TCFF	输入比较匹配标志F	0：不产生GTCCRF的比较匹配1：产生GTCCRF的比较匹配。	R/(W)*1
b6	TCFPO	溢出标志	0：未发生溢出（波峰）1：发生溢出（波峰）。	R/(W)*1
b7	TCFPU	Underflow Flag	0：未发生下溢（谷）1：发生下溢（谷）。	R/(W)*1
b10 to b8	ITCNT[2:0]	GPTn_OVFGPTn_UDF中断跳过计数 Counter	用于计算跳过定时器中断次数的计数器	R
b14 to b11	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15	TUCF	计数方向标志	0：GTCNT计数器向下计数1：GTCNT计数器向上计数。	R
b16	ADTRAUF	GTADTRA比较匹配（向上计数）AD转换器启动请求标志	0：在递增计数时没有发生GTADTRA的比较匹配1：在递增计数时发生了GTADTRA的比较匹配。	R/(W)*1
b17	ADTRADF	GTADTRA比较匹配（递减计数）AD转换器启动请求标志	0：在递减计数时没有发生GTADTRA的比较匹配1：在递减计数时发生了GTADTRA的比较匹配。	R/(W)*1

Bit	Symbol	Bit name	Description	R/W
b18	ADTRBUF	GTADTRB Compare Match (Up-Counting) A/D Converter Start Request Flag	0: No compare match of GTADTRB at up-counting occurred 1: A compare match of GTADTRB at up-counting occurred.	R/(W)*1
b19	ADTRBDF	GTADTRB Compare Match (Down-Counting) A/D Converter Start Request Flag	0: No compare match of GTADTRB at down-counting occurred 1: A compare match of GTADTRB at down-counting occurred.	R/(W)*1
b23 to b20	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b24	ODF	Output Disable Flag	0: No output disable request is generated 1: An output disable request is generated.	R
b27 to b25	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b28	DTEF	Dead Time Error Flag	0: No dead time error occurred 1: Dead time error occurred.	R
b29	OABHF	Same Time Output Level High Flag	0: GTIOCA and GTIOCB pins do not output 1 at the same time 1: GTIOCA and GTIOCB pins output 1 at the same time.	R
b30	OABLF	Same Time Output Level Low Flag	0: GTIOCA and GTIOCB pins do not output 0 at the same time 1: GTIOCA and GTIOCB pins output 0 at the same time.	R
b31	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

Note 1. Only 0 can be written to this bit. Do not write 1.

The GTST register indicates the status of the GPT.

TCFA flag (Input Capture/Compare Match Flag A)

The TCFA flag indicates the status for the input capture or compare match of GTCCRA.

[Setting conditions]

- GTCNT = GTCCRA when the GTCCRA register functions as a compare match register
- GTCNT counter value is transferred to GTCCRA by the input capture signal when the GTCCRA register functions as an input capture register.

[Clearing condition]

- 0 is written to this flag.

TCFB flag (Input Capture/Compare Match Flag B)

The TCFB flag indicates the status for the input capture or compare match of GTCCRB.

[Setting conditions]

- GTCNT = GTCCRB when the GTCCRB register functions as a compare match register
- GTCNT counter value is transferred to GTCCRB by the input capture signal when the GTCCRB register function as an input capture register.

[Clearing condition]

- 0 is written to this flag.

TCFC flag (Input Compare Match Flag C)

The TCFC flag indicates the status for the compare match of GTCCRC.

[Setting condition]

- GTCNT = GTCCRC

[Clearing condition]

- 0 is written to this flag.

[Not comparing condition]

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)

Bit	Symbol	位名称	Description	R/W
b18	ADTRBUF	GTADTRB比较匹配（向上计数）AD转换器启动请求标志	0：在递增计数时没有发生GTADTRB的比较匹配1：在递增计数时发生了GTADTRB的比较匹配。	R/(W)*1
b19	ADTRBDF	GTADTRB比较匹配（递减计数）AD转换器启动请求标志	0：在向下计数时没有发生GTADTRB的比较匹配1：在向下计数时发生了GTADTRB的比较匹配。	R/(W)*1
b23 to b20	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b24	ODF	输出禁用标志	0：不产生输出禁止请求1：产生输出禁止请求。	R
b27 to b25	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b28	DTEF	死区错误标志	0：未发生死区错误1：发生死区错误。	R
b29	OABHF	同时输出电平高Flag	0：GTIOCA和GTIOCB引脚不同时输出11：GTIOCA和GTIOCB引脚同时输出1。	R
b30	OABLF	同时输出电平低Flag	0：GTIOCA和GTIOCB引脚不同时输出01：GTIOCA和GTIOCB引脚同时输出0。	R
b31	—	Reserved	该位读取为0。写入值应为0。	R/W

Note 1. 该位只能写入0。不要写1。

GTST寄存器指示GPT的状态。

TCFA标志（输入捕捉比较匹配标志A）

TCFA标志指示GTCCRA的输入捕获或比较匹配的状态。

[Setting conditions]

- 当GTCCRA寄存器用作比较匹配寄存器时GTCNT=GTCCRA
- 当GTCCRA寄存器用作输入捕捉寄存器时，GTCNT计数器值通过输入捕捉信号传送到GTCCRA。

[Clearing condition]

- 0写入该标志。

TCFB标志（输入捕捉比较匹配标志B）

TCFB标志指示GTCCRB的输入捕获或比较匹配的状态。

[Setting conditions]

- 当GTCCRB寄存器用作比较匹配寄存器时GTCNT=GTCCRB
- 当GTCCRB寄存器用作输入捕捉寄存器时，GTCNT计数器值通过输入捕捉信号传送到GTCCRB。

[Clearing condition]

- 0写入该标志。

TCFC标志（输入比较匹配标志C）

TCFC标志指示GTCCRC比较匹配的状态。

[Setting condition]

- GTCNT = GTCCRC

[Clearing condition]

- 0写入该标志。

[Not comparing condition]

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)

- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRA[1:0] = 01b, 10b, 11b (GTCCRC performs buffer operation).

TCFD flag (Input Compare Match Flag D)

The TCFD flag indicates the status for the compare match of GTCCRD.

[Setting condition]

- GTCNT = GTCCRD

[Clearing condition]

- 0 is written to this flag.

[Not comparing condition]

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRA[1:0] = 10b, 11b (GTCCRD performs buffer operation).

TCFE flag (Input Compare Match Flag E)

The TCFE flag indicates the status for the compare match of GTCCRE.

[Setting condition]

- GTCNT = GTCCRE

[Clearing condition]

- 0 is written to this flag.

[Not comparing condition]

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRB[1:0] = 01b, 10b, 11b (GTCCRE performs buffer operation).

TCFF flag (Input Compare Match Flag F)

The TCFF flag indicates the status for the compare match of GTCCRF.

[Setting condition]

- GTCNT = GTCCRF

[Clearing condition]

- 0 is written to this flag.

[Not comparing condition]

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRB[1:0] = 10b, 11b (GTCCRF performs buffer operation).

TCFPO flag (Overflow Flag)

The TCFPO flag indicates when an overflow or a crest has occurred.

[Setting conditions]

- In saw-wave mode, an overflow (GTCNT changes from GTPR to 0 in up-counting) has occurred
- In triangle-wave mode, a crest (GTCNT changes from GTPR to GTPR - 1) has occurred
- In counting by hardware sources, an overflow (GTCNT changes from GTPR to 0 in up-counting) has occurred.

- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRA[1:0]=01b 10b 11b（GTCCRC执行缓冲操作）。

TCFD标志（输入比较匹配标志D）

TCFD标志指示GTCCRD比较匹配的状态。

[Setting condition]

- GTCNT = GTCCRD

[Clearing condition]

- 0写入该标志。

[Not comparing condition]

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRA[1:0]=10b 11b（GTCCRD执行缓冲操作）。

TCFE标志（输入比较匹配标志E）

TCFE标志指示GTCCRE比较匹配的状态。

[Setting condition]

- GTCNT = GTCCRE

[Clearing condition]

- 0写入该标志。

[Not comparing condition]

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRB[1:0]=01b 10b 11b（GTCCRE执行缓冲操作）。

TCFF标志（输入比较匹配标志F）

TCFF标志表示GTCCRF比较匹配的状态。

[Setting condition]

- GTCNT = GTCCRF

[Clearing condition]

- 0写入该标志。

[Not comparing condition]

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRB[1:0]=10b 11b（GTCCRF执行缓冲操作）。

TCFPO标志（溢出标志）

TCFPO标志指示何时发生溢出或波峰。

[Setting conditions]

- 在锯齿波模式下，发生了溢出（GTCNT在递增计数中从GTPR变为0）
- 在三角波模式下，出现波峰（GTCNT从GTPR变为GTPR1）
- 在硬件源的计数中，发生了溢出（GTCNT在递增计数中从GTPR变为0）。

[Clearing condition]

- 0 is written to this flag.

TCFPU flag (Underflow Flag)

The TCFPU flag indicates when an underflow or a trough has occurred.

[Setting conditions]

- In saw-wave mode, an underflow (GTCNT changes from 0 to GTPR in down-counting) has occurred
- In triangle-wave mode, a trough (GTCNT changes from 0 to 1) has occurred
- In counting by hardware sources, an underflow (GTCNT changes from 0 to GTPR in down-counting) has occurred.

[Clearing condition]

- 0 is written to this flag.

ITCNT[2:0] bits (GPTn_OVF/GPTn_UDF Interrupt Skipping Count Counter)

When the GPTn_OVF/GPTn_UDF (n = 0 to 7) interrupt skipping function is used (the GTITC.IVTC[1:0] bits are set to a value other than 00b), the counter in the ITCNT[2:0] bits increments by 1 every time the GPTn_OVF/GPTn_UDF interrupt source that is selected in GTITC.IVTC[1:0] is generated.

Only GPT32EH and GPT32E have these bits. GPT32 does not have these bits.

[Clearing conditions]

- The GPTn_OVF/GPTn_UDF interrupt skipping function is not used (GTITC.IVTT[2:0] is 000b when GTITC.IVTC[1:0] is 00b)
- The GPTn_OVF/GPTn_UDF interrupt skipping count matches the specified count (ITCNT[2:0] matches the skipping count specified in GTITC.IVTT[2:0]).

TUCF flag (Count Direction Flag)

The TUCF flag indicates the count direction of GTCNT. In event count operation, this flag is set to 1 in up-counting and to 0 in down-counting.

ADTRAUF flag (GTADTRA Compare Match (Up-Counting) A/D Converter Start Request Flag)

The ADTRAUF flag indicates the status for the compare match of GTADTRA at up-counting.

[Setting condition]

- GTCNT = GTADTRA at up-counting.

[Clearing condition]

- 0 is written to this flag.

ADTRADF flag (GTADTRA Compare Match (Down-Counting) A/D Converter Start Request Flag)

The ADTRADF flag indicates the status for the compare match of GTADTRA at down-counting.

[Setting condition]

- GTCNT = GTADTRA at down-counting.

[Clearing condition]

- 0 is written to this flag.

ADTRBUF flag (GTADTRB Compare Match (Up-Counting) A/D Converter Start Request Flag)

The ADTRBUF flag indicates the status for the compare match of GTADTRB at up-counting.

[Setting condition]

- GTCNT = GTADTRB at up-counting.

[Clearing condition]

[Clearing condition]

- 0写入该标志。

TCFPU flag (Underflow Flag)

TCFPU标志指示何时发生下溢或波谷。

[Setting conditions]

- 在锯齿波模式下，发生下溢（向下计数时GTCNT从0变为GTPR）
- 在三角波模式下，出现了一个波谷（GTCNT从0变为1）
- 在硬件源的计数中，发生了下溢（向下计数时GTCNT从0变为GTPR）。

[Clearing condition]

- 0写入该标志。

ITCNT[2:0]位（GPTn_OVFGPTn_UDF中断跳过计数计数器）

当使用GPTn_OVFGPTn_UDF(n=0to7)中断跳过功能时（GTITC.IVTC[1:0]位设置为00b以外的值），ITCNT[2:0]位中的计数器递增每次在GTITC.IVTC[1:0]中选择的GPTn_OVFGPTn_UDF中断源产生时为1。

只有GPT32EH和GPT32E有这些位。GPT32没有这些位。

[Clearing conditions]

- 不使用GPTn_OVFGPTn_UDF中断跳过功能（GTITC.IVTT[2:0]为000b时 GTITC.IVTC[1:0] is 00b)
- GPTn_OVFGPTn_UDF中断跳过计数与指定计数匹配（ITCNT[2:0]与GTITC.IVTT[2:0]中指定的跳过计数匹配）。

TUCF标志（计数方向标志）

TUCF标志表示GTCNT的计数方向。在事件计数操作中，该标志在递增计数时设置为1，在递减计数时设置为0。

ADTRAUF标志（GTADTRA比较匹配（向上计数）AD转换器启动请求标志）

ADTRAUF标志指示在递增计数时GTADTRA比较匹配的状态。

[Setting condition]

- GTCNT = GTADTRA at up-counting.

[Clearing condition]

- 0写入该标志。

ADTRADF标志（GTADTRA比较匹配（递减计数）AD转换器启动请求标志）

ADTRADF标志指示向下计数时GTADTRA比较匹配的状态。

[Setting condition]

- GTCNT = GTADTRA at down-counting.

[Clearing condition]

- 0写入该标志。

ADTRBUF标志（GTADTRB比较匹配（向上计数）AD转换器启动请求标志）

ADTRBUF标志指示在递增计数时GTADTRB比较匹配的状态。

[Setting condition]

- GTCNT = GTADTRB at up-counting.

[Clearing condition]

- 0 is written to this flag.

ADTRBDF flag (GTADTRB Compare Match (Down-Counting) A/D Converter Start Request Flag)

The ADTRBDF flag indicates the status for the compare match of GTADTRB at down-counting.

[Setting condition]

- GTCNT = GTADTRB at down-counting.

[Clearing condition]

- 0 is written to this bit.

ODF flag (Output Disable Flag)

The ODF flag shows the request of the output disable source group that is selected in the GRP[1:0] bits. When output is disabled, an output disable control is not released within the same cycle in which an output disable request is negated. It is released in the next cycle.

DTEF flag (Dead Time Error Flag)

The DTEF flag indicates that the timer output toggle point after the automatic addition of dead time has exceeded the timer cycle.

This flag returns to 0 when the timer output toggle point after the automatic addition of dead time is within the timer cycle. This flag is read-only. Writing 0 to clear the flag is not allowed.

[Setting condition]

- The timer output toggle point after the automatic addition of dead time has exceeded the timer cycle.
  For triangle wave in up-counting: GTCCRA - GTDVU ≤ 0
  For triangle wave in down-counting: GTCCRA - GTDVD < 0
  For saw-wave one-shot pulse mode in up-counting:
  GTCCRA - GTDVU < 0 or GTCCRA + GTDVD > GTPR
  For saw-wave one-shot pulse mode in down-counting:
  GTCCRA + GTDVU > GTPR or GTCCRA - GTDVD < 0

[Clearing condition]

- The timer output toggle point after the automatic addition of dead time is within the timer cycle.
  Only GPT32EH and GPT32E have this flag. GPT32 does not have this flag.
  GPT32 has the automatic dead time setting function but it does not generate dead time error.

OABHF flag (Same Time Output Level High Flag)

The OABHF flag indicates that the GTIOCA and the GTIOCB pins output 1 at the same time.

When the GTIOCA or GTIOCB pin outputs 0, this flag returns to 0. This flag is read-only. Writing 0 to clear the flag is not allowed. When an interrupt by the OABHF flag is enabled (GTINTAD.GRPABH = 1), the OABHF flag is output to the POEG as an output disable request.

[Setting condition]

- GTIOCA and GTIOCB pins output 1 at the same time when both the OAE and OBE bits are set to 1.

[Clearing conditions]

- GTIOCA pin output value is different from GTIOCB pin output value when both the OAE and OBE bits are set to 1
- GTIOCA and GTIOCB pins output 0 at the same time when both the OAE and OBE bits are set to 1
- Either the OAE bit or OBE bit is set to 0.

OABLF flag (Same Time Output Level Low Flag)

The OABLF flag indicates that the GTIOCA and GTIOCB pins output 0 at the same time.

When the GTIOCA or GTIOCB pin outputs 1, this flag returns to 0. This flag is read-only. Writing 0 to clear the flag is not allowed. When an interrupt by the OABLF flag is enabled (GTINTAD.GRPABL = 1), the OABLF flag is output to

- 0写入该标志。

ADTRBDF标志（GTADTRB比较匹配（递减计数）AD转换器启动请求标志）

ADTRBDF标志指示向下计数时GTADTRB比较匹配的状态。

[Setting condition]

- GTCNT = GTADTRB at down-counting.

[Clearing condition]

- 0写入该位。

ODF标志（输出禁用标志）

ODF标志显示在GRP[1:0]位中选择的输出禁用源组的请求。当输出禁用时，输出禁用控制不会在输出禁用请求被否定的同一周期内释放。它在下一个周期中发布。

DTEF标志（死区错误标志）

DTEF标志表示自动添加死区时间后的定时器输出切换点已超过定时器周期。

当自动添加死区时间后的定时器输出切换点在定时器周期内时，该标志返回0。该标志是只读的。不允许写入0来清除标志。

[Setting condition]

- 自动添加死区时间后的定时器输出切换点已超过定时器周期。
  对于递增计数中的三角波：GTCCRAGTDVU≤0
  对于向下计数中的三角波：GTCCRAGTDVD<0对于向上计数中的锯波单次脉冲模式：
  GTCCRAGTDVU<0或GTCCRA+GTDVD>GTPR对于向下计数中的锯波单次脉冲模式：
  GTCCRA + GTDVU > GTPR or GTCCRA - GTDVD < 0

[Clearing condition]

- 自动添加死区时间后的定时器输出切换点在定时器周期内。
  只有GPT32EH和GPT32E有这个标志。GPT32没有这个标志。
  GPT32具有自动死区时间设置功能，但不会产生死区时间错误。

OABHF标志（同时输出电平高标志）

OABHF标志表示GTIOCA和GTIOCB管脚同时输出1。

当GTIOCA或GTIOCB引脚输出0时，该标志返回0。该标志为只读。不允许写入0来清除标志。当启用OABHF标志的中断时(GTINTAD.GRPABH=1)，OABHF标志作为输出禁用请求输出到POEG。

[Setting condition]

- 当OAE和OBE位都设置为1时，GTIOCA和GTIOCB引脚同时输出1。

[Clearing conditions]

- 当OAE和OBE位都设置为1时，GTIOCA引脚输出值与GTIOCB引脚输出值不同
- 当OAE和OBE位都设置为1时，GTIOCA和GTIOCB引脚同时输出0
- OAE位或OBE位设置为0。

OABLF标志（同时输出电平低标志）

OABLF标志表示GTIOCA和GTIOCB管脚同时输出0。

当GTIOCA或GTIOCB引脚输出1时，该标志返回0。该标志为只读。不允许写入0来清除标志。当启用OABLF标志的中断时（GTINTAD.GRPABL=1），OABLF标志输出到

the POEG as an output disable request.

[Setting condition]

- The GTIOCA and GTIOCB pins output 0 at the same time when both the OAE and OBE bits are set to 1.

[Clearing conditions]

- The GTIOCA pin output value is different from GTIOCB pin output value when both the OAE and OBE bits are set to 1
- The GTIOCA and GTIOCB pins output 1 at the same time when both the OAE and OBE bits are set to 1
- Either the OAE bit or OBE bit is set to 0.

The compare-target signals to generate the OABHF/OABLF flag are the compare match outputs (PWM outputs) signals before they are masked by the output disable function. When the output disable state is active, a compare match is performed continuously in the GPT and the OABHF/OABLF flag is updated in association with the result of the compared value.

22.2.17 General PWM Timer Buffer Enable Register (GTBER)

Address(es): GPT32EHm.GTBER 4007 8040h + 0100h × m (m = 0 to 3)
GPT32Em.GTBER 4007 8040h + 0100h × m (m = 4 to 7)
GPT32m.GTBER 4007 8040h + 0100h × m (m = 8 to 12)

- GPT32EH, GPT32E

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	ADTDB	ADTTB[1:0]		—	ADTDA	ADTTA[1:0]		—	CCRSWT	PR[1:0]		CCRB[1:0]		CCRA[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	BD[3]	BD[2]	BD[1]	BD[0]
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- GPT32

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—		—	—	—		—	CCRSWT	PR[1:0]		CCRB[1:0]		CCRA[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	BD[1]	BD[0]
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	BD[0]	GTCCR Buffer Operation Disable	0: Buffer operation is enabled 1: Buffer operation is disabled.	R/W
b1	BD[1]	GTPR Buffer Operation Disable		R/W
b2	BD[2]	GTADTR Buffer Operation Disable		R/W
b3	BD[3]	GTDV Buffer Operation Disable		R/W
b15 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b17, b16	CCRA[1:0]	GTCCRA Buffer Operation	b17 b16 0 0: No buffer operation 0 1: Single buffer operation (GTCCRA ↔ GTCCRC) 1 x: Double buffer operation (GTCCRA ↔ GTCCRC ↔ GTCCRD).	R/W

POEG作为输出禁用请求。

[Setting condition]

- 当OAE和OBE位都设置为1时，GTIOCA和GTIOCB引脚同时输出0。

[Clearing conditions]

- 当OAE和OBE位都设置为1时，GTIOCA引脚输出值与GTIOCB引脚输出值不同
- 当OAE和OBE位都设置为1时，GTIOCA和GTIOCB引脚同时输出1
- OAE位或OBE位设置为0。

生成OABHFOABLF标志的比较目标信号是比较匹配输出（PWM输出）信号，在它们被输出禁用功能屏蔽之前。当输出禁用状态激活时，在GPT中连续执行比较匹配，并根据比较值的结果更新OABHFOABLF标志。

22.2.17 通用PWM定时器缓冲器使能寄存器(GTBER)

Address(es): GPT32EHm.GTBER 4007 8040h + 0100h × m (m = 0 to 3)
GPT32Em.GTBER 4007 8040h + 0100h × m (m = 4 to 7)
GPT32m.GTBER 4007 8040h + 0100h × m (m = 8 to 12)

- GPT32EH, GPT32E

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	ADTDB	ADTTB[1:0]		—	ADTDA	ADTTA[1:0]		—	CCRSWT	PR[1:0]		CCRB[1:0]		CCRA[1:0]	
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	BD[3]	BD[2]	BD[1]	BD[0]
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- GPT32

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—		—	—	—		—	CCRSWT	PR[1:0]		CCRB[1:0]		CCRA[1:0]	
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	BD[1]	BD[0]
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	BD[0]	GTCCR缓冲区操作禁用	0：启用缓冲操作1：禁用缓冲操作。	R/W
b1	BD[1]	GTPR缓冲区操作禁用		R/W
b2	BD[2]	GTADTR缓冲区操作禁用		R/W
b3	BD[3]	GTDV缓冲区操作禁用		R/W
b15 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b17, b16	CCRA[1:0]	GTCCRA缓冲区操作	b17b1600：无缓存操作01：单缓存操作（GTCCRA↔GTCCRC）1x：双缓存操作（GTCCRA↔GTCCRC↔GTCCRD）。	R/W

Bit	Symbol	Bit name	Description	R/W
b19, b18	CCRB[1:0]	GTCCRB Buffer Operation	b19 b18 0 0: No buffer operation 0 1: Single buffer operation (GTCCRB ↔ GTCCRE) 1 x: Double buffer operation (GTCCRB ↔ GTCCRE ↔ GTCCRF).	R/W
b21, b20	PR[1:0]	GTPR Buffer Operation	b21 b20 0 0: No buffer operation 0 1: Single buffer operation (GTPBR → GTPR) 1 x: Double buffer operation (GTPDBR → GTPBR → GTPR).	R/W
b22	CCRSWT	GTCCRA and GTCCRB Forcible Buffer Operation	Writing 1 to this bit forces a buffer transfer of GTCCRA and GTCCRB. This bit automatically returns to 0 after 1 is written. This bit is read as 0.	R/W
b23	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b25, b24	ADTTA[1:0]	GTADTRA Buffer Transfer Timing Select	• Triangle waves b25 b24 0 0: No transfer 0 1: Transfer at crest 1 0: Transfer at trough 1 1: Transfer at both crest and trough. • Saw waves b25 b24 0 0: No transfer Values other than 0 0: Transfer on underflow (during down-counting) or on overflow (during up-counting).	R/W
b26	ADTDA	GTADTRA Double Buffer Operation	0: Single buffer operation (GTADTBRA → GTADTRA) 1: Double buffer operation (GTADTDBRA → GTADTBRA → GTADTDRA).	R/W
b27	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b29, b28	ADTTB[1:0]	GTADTRB Buffer Transfer Timing Select	• Triangle waves b29 b28 0 0: No transfer 0 1: Transfer at crest 1 0: Transfer at trough 1 1: Transfer at both crest and trough. • Saw waves b29 b28 0 0: No transfer Values other than 0 0: Transfer on underflow (in down-counting) or on overflow (in up-counting).	R/W
b30	ADTDB	GTADTRB Double Buffer Operation	0: Single buffer operation (GTADTBRB → GTADTRB) 1: Double buffer operation (GTADTDBRB → GTADTBRB → GTADTDRB).	R/W
b31	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

The GTBER provides settings for the buffer operation and must be set while the GTCNT operation is stopped.

BD[0] bit (GTCCR Buffer Operation Disable)

The BD[0] bit disables buffer operation using GTCCRA, GTCCRC, and GTCCRD combined and the buffer operation using GTCCRB, GTCCRE, and GTCCRF combined.

When GTDTCR.TDE is 1 and when BD [0] is set to 0, GTCCRB does not perform buffer operation and the GTCCRB register is automatically set to a compare match value for a negative-phase waveform with dead time.

BD[1] bit (GTPR Buffer Operation Disable)

The BD[1] bit disables buffer operation using GTPR, GTPBR, and GTPDBR combined.

BD[2] bit (GTADTR Buffer Operation Disable)

The BD[2] bit disables buffer operation using GTADTRA, GTADTBRA, and GTADTDBRA combined and buffer operation using GTADTRB, GTADTBRB, and GTADTDBRB combined. In event count operation, this bit is not

Bit	Symbol	位名称	Description	R/W
b19, b18	CCRB[1:0]	GTCCRB缓冲区操作	b19b1800：无缓冲操作01：单缓冲操作（GTCCRB↔GTCCRE）1x：双缓冲操作（GTCCRB↔GTCCRE↔GTCCRF）。	R/W
b21, b20	PR[1:0]	GTPR缓冲区操作	b21b2000：无缓冲操作01：单缓冲操作（GTPBR→GTPR）1x：双缓冲操作（GTPDBR→GTPBR→GTPR）。	R/W
b22	CCRSWT	GTCCRA和GTCCRB强制缓冲操作	向该位写入1会强制GTCCRA和GTCCRB进行缓冲区传输。该位在写入1后自动返回0。该位读为0。	R/W
b23	—	Reserved	该位读取为0。写入值应为0。	R/W
b25, b24	ADTTA[1:0]	GTADTRA缓冲区传输时序Select	三角波b25b2400：无转移01：在波峰转移10：在波谷转移11：在波峰和波谷转移。 锯齿波b25b2400：无传输0以外的值0：在下溢（向下计数期间）或在溢出时（向上计数期间）传输。	R/W
b26	ADTDA	GTADTRA双缓冲操作	0：单缓冲操作（GTADTBRA→GTADTRA）1：双缓冲操作（GTADTBRA→GTADTBRA→GTADTDRA）。	R/W
b27	—	Reserved	该位读取为0。写入值应为0。	R/W
b29, b28	ADTTB[1:0]	GTADTRB缓冲区传输时序Select	三角波b29b2800：无转移01：在波峰转移10：在波谷转移11：在波峰和波谷转移。 锯齿波b29b2800：不传输0以外的值0：在下溢（向下计数）或溢出（向上计数）时传输。	R/W
b30	ADTDB	GTADTRB双缓冲操作	0：单缓冲操作（GTADTBRB→GTADTRB）1：双缓冲操作（GTADTDBRB→GTADTBRB→GTADTDRB）。	R/W
b31	—	Reserved	该位读取为0。写入值应为0。	R/W

GTBER为缓冲操作提供设置，并且必须在GTCNT操作停止时进行设置。

BD[0]位（GTCCR缓冲区操作禁用）

BD[0]位禁用使用GTCCRA、GTCCRC和GTCCRD组合的缓冲器操作以及使用GTCCRB、GTCCRE和GTCCRF组合的缓冲器操作。

当GTDTCR.TDE为1且BD[0]设置为0时，GTCCRB不执行缓冲操作，并且GTCCRB寄存器自动设置为具有死区时间的反相波形的比较匹配值。

BD[1]位（GTPR缓冲区操作禁用）

BD[1]位禁用使用GTPR、GTPBR和GTPDBR组合的缓冲区操作。

BD[2]位（GTADTR缓冲区操作禁用）

BD[2]位禁用使用GTADTRA、GTADTBRA和GTADTBRA组合的缓冲区操作以及使用GTADTRB、GTADTBRB和GTADTDBRB组合的缓冲区操作。在事件计数操作中，该位不

available and the GTADTR buffer operation is not performed. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

BD[3] bit (GTDV Buffer Operation Disable)

The BD[3] bit disables buffer operation using GTDVU and GTDBU combined and buffer operation using GTDVD and GTDBD combined.

When the GTDTCR.TDFER bit is set to 1, even if BD[3] is set to 0, buffer operation is not performed and the GTDVD value is set as a value of GTDVU automatically. In event count operation, this bit is not available and the GTDV buffer operation is not performed. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

CCRA[1:0] bits (GTCCRA Buffer Operation)

The CCRA[1:0] bits set buffer operation using GTCCRA, GTCCRC, and GTCCRD combined. When buffer operation is restricted by the operating mode set in GTCR, the GTCR setting is given priority.*1

CCRB[1:0] bits (GTCCRB Buffer Operation)

The CCRB[1:0] bits set buffer operation using GTCCRB, GTCCRE, and GTCCRF combined. When buffer operation is restricted by the operating mode set in GTCR, the GTCR setting is given priority.*1

PR[1:0] bits (GTPR Buffer Operation)

The PR[1:0] bits set buffer operation using GTPR, GTPBR, and GTPDBR combined. GPT32 does not have the PR[1] bit. Only single buffer operation setting by PR[0] bit is available for GPT32.

CCRSWT bit (GTCCRA and GTCCRB Forcible Buffer Operation)

Writing 1 to the CCRSWT bit forces a buffer transfer of GTCCRA and GTCCRB. This bit automatically returns to 0 after 1 is written. This bit is read as 0 and is only valid when counting is stopped with a specified compare match operation.

ADTTA[1:0] bits (GTADTRA Buffer Transfer Timing Select)

The ADTTA[1:0] bits set the transfer timing for buffer operation of GTADTRA, GTADTBRA, and GTADTDBRA. These bits are not available in event count operation. Only GPT32EH and GPT32E have these bits. GPT32 does not have these bits.

ADTDA bit (GTADTRA Double Buffer Operation)

The ADTDA bit sets buffer operation using GTADTRA, GTADTBRA, and GTADTDBRA combined. This bit is not available in event count operation. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

ADTTB[1:0] bits (GTADTRB Buffer Transfer Timing Select)

The ADTTB[1:0] bits set the transfer timing for buffer operation of GTADTRB, GTADTBRB, and GTADTDBRB. These bits are not available in event count operation. Only GPT32EH and GPT32E have these bits. GPT32 does not have these bits.

ADTDB bit (GTADTRB Double Buffer Operation)

The ADTDB bit sets buffer operation using GTADTRB, GTADTBRB, and GTADTDBRB combined. This bit is not available in event count operation. Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

Note 1. The buffer operation mode is fixed in saw-wave one-shot pulse mode or triangle-wave PWM mode 3 (64-bit transfer at trough).

可用且不执行GTADTR缓冲区操作。只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

BD[3]位（GTDV缓冲区操作禁用）

BD[3]位禁用使用GTDVU和GTDBU组合的缓冲区操作以及使用GTDVD和
GTDBD combined.

当GTDTCR.TDFER位设置为1时，即使BD[3]设置为0，也不执行缓冲操作，并且GTDVD值自动设置为GTDVU的值。在事件计数操作中，该位不可用且不执行GTDV缓冲区操作。只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

CCRA[1:0]位（GTCCRA缓冲区操作）

CCRA[1:0]位使用GTCCRA、GTCCRC和GTCCRD组合设置缓冲区操作。当缓冲操作受到GTCR中设置的操作模式限制时，GTCR设置优先。*1

CCRB[1:0]位（GTCCRB缓冲区操作）

CCRB[1:0]位使用GTCCRB、GTCCRE和GTCCRF组合设置缓冲区操作。当缓冲操作受到GTCR中设置的操作模式限制时，GTCR设置优先。*1

PR[1:0]位（GTPR缓冲区操作）

PR[1:0]位设置使用GTPR、GTPBR和GTPDBR组合的缓冲区操作。GPT32没有PR[1]位。GPT32只能通过PR[0]位设置单个缓冲区操作。

CCRSWT位（GTCCRA和GTCCRB强制缓冲操作）

向CCRSWT位写入1会强制GTCCRA和GTCCRB进行缓冲区传输。该位在写入1后自动返回0。该位读为0，仅在使用指定的比较匹配操作停止计数时有效。

ADTTA[1:0]位（GTADTRA缓冲区传输时序选择）

ADTTA[1:0]位设置GTADTRA、GTADTBRA和GTADTBRA的缓冲区操作的传输时序。
这些位在事件计数操作中不可用。只有GPT32EH和GPT32E有这些位。GPT32没有这些位。

ADTDA位（GTADTRA双缓冲器操作）

ADTDA位设置使用GTADTRA、GTADTBRA和GTADTBRA组合的缓冲区操作。该位在事件计数操作中不可用。
只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

ADTTB[1:0]位（GTADTRB缓冲区传输时序选择）

ADTTB[1:0]位设置GTADTRB、GTADTBRB和GTADTDRBB的缓冲区操作的传输时序。
这些位在事件计数操作中不可用。只有GPT32EH和GPT32E有这些位。GPT32没有这些位。

ADTDB位（GTADTRB双缓冲操作）

ADTDB位使用GTADTRB、GTADTBRB和GTADTDRBB组合设置缓冲区操作。该位在事件计数操作中不可用。
只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

注1.缓冲操作模式固定为锯齿波单次脉冲模式或三角波PWM模式3（64位低谷传输）。

22.2.18 General PWM Timer Interrupt and A/D Converter Start Request Skipping Setting Register (GTITC)

Address(es): GPT32EHm.GTITC 4007 8044h + 0100h × m (m = 0 to 3)
GPT32Em.GTITC 4007 8044h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	ADTBL	—	ADTAL	—	IVTT[2:0]			IVTC[1:0]		ITLF	ITLE	ITLD	ITLC	ITLB	ITLA
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	ITLA	GTCCRA Compare Match/Input Capture Interrupt Link	0: GPTn_OVF/GPTn_UDF interrupt skipping function is not linked 1: GPTn_OVF/GPTn_UDF interrupt skipping function is linked	R/W
b1	ITLB	GTCCRB Compare Match/Input Capture Interrupt Link	0: GPTn_OVF/GPTn_UDF interrupt skipping function is not linked 1: GPTn_OVF/GPTn_UDF interrupt skipping function is linked.	R/W
b2	ITLC	GTCCRC Compare Match Interrupt Link	0: GPTn_OVF/GPTn_UDF interrupt skipping function is not linked 1: GPTn_OVF/GPTn_UDF interrupt skipping function is linked.	R/W
b3	ITLD	GTCCRD Compare Match Interrupt Link	0: GPTn_OVF/GPTn_UDF interrupt skipping function is not linked 1: GPTn_OVF/GPTn_UDF interrupt skipping function is linked.	R/W
b4	ITLE	GTCCRE Compare Match Interrupt Link	0: GPTn_OVF/GPTn_UDF interrupt skipping function is not linked 1: GPTn_OVF/GPTn_UDF interrupt skipping function is linked.	R/W
b5	ITLF	GTCCRF Compare Match Interrupt Link	0: GPTn_OVF/GPTn_UDF interrupt skipping function is not linked 1: GPTn_OVF/GPTn_UDF interrupt skipping function is linked.	R/W
b7, b6	IVTC[1:0]	GPTn_OVF/GPTn_UDF Interrupt Skipping Function Select	b7 b6 0 0: Do not perform skipping 0 1: Count and skip both overflow and underflow for saw waves and crest for triangle waves 1 0: Count and skip both overflow and underflow for saw waves and trough for triangle waves 1 1: Count and skip both overflow and underflow for saw waves and both crest and trough for triangle waves.	R/W
b10 to b8	IVTT[2:0]	GPTn_OVF/GPTn_UDF Interrupt Skipping Count Select	b10 b8 0 0 0: No skipping 0 0 1: Skipping count of 1 0 1 0: Skipping count of 2 0 1 1: Skipping count of 3 1 0 0: Skipping count of 4 1 0 1: Skipping count of 5 1 1 0: Skipping count of 6 1 1 1: Skipping count of 7.	R/W
b11	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

22.2.18 通用PWM定时器中断和AD转换器启动请求跳过设置寄存器(GTITC)

Address(es): GPT32EHm.GTITC 4007 8044h + 0100h × m (m = 0 to 3)
GPT32Em.GTITC 4007 8044h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	ADTBL	—	ADTAL	—	IVTT[2:0]			IVTC[1:0]		ITLF	ITLE	ITLD	ITLC	ITLB	ITLA
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	ITLA	GTCCRA Compare Match/Input 捕获中断链接	0：GPTn_OVFGPTn_UDF中断跳过函数未链接1：GPTn_OVFGPTn_UDF中断跳过函数已链接	R/W
b1	ITLB	GTCCRB Compare Match/Input 捕获中断链接	0：GPTn_OVFGPTn_UDF中断跳过函数未链接1：GPTn_OVFGPTn_UDF中断跳过函数已链接。	R/W
b2	ITLC	GTCCRC比较匹配中断 Link	0：GPTn_OVFGPTn_UDF中断跳过函数未链接1：GPTn_OVFGPTn_UDF中断跳过函数已链接。	R/W
b3	ITLD	GTCCRD比较匹配中断 Link	0：GPTn_OVFGPTn_UDF中断跳过函数未链接1：GPTn_OVFGPTn_UDF中断跳过函数已链接。	R/W
b4	ITLE	GTCCRE比较匹配中断 Link	0：GPTn_OVFGPTn_UDF中断跳过函数未链接1：GPTn_OVFGPTn_UDF中断跳过函数已链接。	R/W
b5	ITLF	GTCCRF比较匹配中断 Link	0：GPTn_OVFGPTn_UDF中断跳过函数未链接1：GPTn_OVFGPTn_UDF中断跳过函数已链接。	R/W
b7, b6	IVTC[1:0]	GPTn_OVF/GPTn_UDF Interrupt 跳过功能选择	b7b600：不执行跳过01：计数并跳过锯齿波的上溢和下溢以及三角波的波峰10：计数并跳过锯齿波的上溢和下溢以及三角波的波谷11：计数并跳过跳过锯齿波的上溢和下溢以及三角波的波峰和波谷。	R/W
b10 to b8	IVTT[2:0]	GPTn_OVF/GPTn_UDF Interrupt 跳过计数选择	b10b8000：不跳过001：跳过计数1010：跳过计数2011：跳过计数3100：跳过计数4101：跳过计数5110：跳过计数6111：跳过计数7。	R/W
b11	—	Reserved	该位读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b12	ADTAL	GTADTRA A/D Converter Start Request Link	0: GPTn_OVF/GPTn_UDF interrupt skipping function is not linked 1: GPTn_OVF/GPTn_UDF interrupt skipping function is linked.	R/W
b13	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b14	ADTBL	GTADTRB A/D Converter Start Request Link	0: GPTn_OVF/GPTn_UDF interrupt skipping function is not linked 1: GPTn_OVF/GPTn_UDF interrupt skipping function is linked.	R/W
b31 to b15	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTITC register sets the skipping function for the GTCNT counter overflow (GTPR compare match) interrupt (GPTn_OVF) and underflow interrupt (GPTn_UDF). It also specifies whether to link other interrupts and A/D converter start requests with the GPTn_OVF/GPTn_UDF interrupt skipping function. The output disable request to POEG cannot be linked with the GPTn_OVF/GPTn_UDF interrupt skipping function. This register is not available in event count operation. Only GPT32EH and GPT32E have this register. GPT32 does not have this register and it is read as 0.

ITLA bit (GTCCRA Compare Match/Input Capture Interrupt Link)

The ITLA bit specifies whether to link the GTCCRA compare match/input capture interrupt (GTCIA) with the GPTn_OVF/GPTn_UDF interrupt skipping function.

ITLB bit (GTCCRB Compare Match/Input Capture Interrupt Link)

The ITLB bit specifies whether to link the GTCCRB compare match/input capture interrupt (GTCIB) with the GPTn_OVF/GPTn_UDF interrupt skipping function.

ITLC bit (GTCCRC Compare Match Interrupt Link)

The ITLC bit specifies whether to link the GTCCRC compare match interrupt (GTCIC) with the GPTn_OVF/GPTn_UDF interrupt skipping function.

ITLD bit (GTCCRD Compare Match Interrupt Link)

The ITLD bit specifies whether to link the GTCCRD compare match interrupt (GTCID) with the GPTn_OVF/GPTn_UDF interrupt skipping function.

ITLE bit (GTCCRE Compare Match Interrupt Link)

The ITLE bit specifies whether to link the GTCCRE compare match interrupt (GTCIE) with the GPTn_OVF/GPTn_UDF interrupt skipping function.

ITLF bit (GTCCRF Compare Match Interrupt Link)

The ITLF bit specifies whether to link the GTCCRF compare match interrupt (GTCIF) with the GPTn_OVF/GPTn_UDF interrupt skipping function.

IVTC[1:0] bits (GPTn_OVF/GPTn_UDF Interrupt Skipping Function Select)

The IVTC[1:0] bits set the skipping function for the GTPR compare match (GTCNT overflow) interrupt (GPTn_OVF) and GTCNT counter underflow interrupt (GPTn_UDF).

IVTT[2:0] bits (GPTn_OVF/GPTn_UDF Interrupt Skipping Count Select)

The IVTT[2:0] bits set the skipping count for the GTPR compare match (GTCNT overflow) interrupt (GPTn_OVF) and GTCNT counter underflow interrupt (GPTn_UDF). When modifying the IVTT[2:0] bits, first set the IVTC[1:0] bits to 00b.

ADTAL bit (GTADTRA A/D Converter Start Request Link)

The ADTAL bit specifies whether to link the GTADTRA A/D converter start request with GPTn_OVF/GPTn_UDF interrupt skipping function.

Bit	Symbol	位名称	Description	R/W
b12	ADTAL	GTADTRAAD转换器启动请求链接	0：GPTn_OVFGPTn_UDF中断跳过函数未链接1：GPTn_OVFGPTn_UDF中断跳过函数已链接。	R/W
b13	—	Reserved	该位读取为0。写入值应为0。	R/W
b14	ADTBL	GTADTRBAD转换器启动请求链接	0：GPTn_OVFGPTn_UDF中断跳过函数未链接1：GPTn_OVFGPTn_UDF中断跳过函数已链接。	R/W
b31 to b15	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTITC寄存器设置GTCNT计数器溢出（GTPR比较匹配）中断（GPTn_OVF）和下溢中断（GPTn_UDF）的跳过功能。它还指定是否将其他中断和AD转换器启动请求与GPTn_OVFGPTn_UDF中断跳过功能联系起来。对POEG的输出禁用请求不能与GPTn_OVFGPTn_UDF中断跳过函数链接。该寄存器在事件计数操作中不可用。只有GPT32EH和GPT32E有这个寄存器。GPT32没有这个寄存器，读为0。

ITLA位（GTCCRA比较匹配输入捕捉中断链接）

ITLA位指定是否将GTCCRA比较匹配输入捕捉中断(GTCIA)与GPTn_OVFGPTn_UDF中断跳过函数。

ITLB位（GTCCRB比较匹配输入捕捉中断链接）

ITLB位指定是否将GTCCRB比较匹配输入捕捉中断(GTCIB)与GPTn_OVFGPTn_UDF中断跳过函数。

ITLC位（GTCCRC比较匹配中断链接）

ITLC位指定是否将GTCCRC比较匹配中断(GTCIC)与GPTn_OVFGPTn_UDF中断跳过函数。

ITLD位（GTCCRD比较匹配中断链接）

ITLD位指定是否将GTCCRD比较匹配中断(GTCID)与GPTn_OVFGPTn_UDF中断跳过函数。

ITLE位（GTCCRE比较匹配中断链接）

ITLE位指定是否将GTCCRE比较匹配中断(GTCIE)与GPTn_OVFGPTn_UDF中断跳过函数。

ITLF位（GTCCRF比较匹配中断链接）

ITLF位指定是否将GTCCRF比较匹配中断(GTCIF)与GPTn_OVFGPTn_UDF中断跳过功能链接。

IVTC[1:0]位（GPTn_OVFGPTn_UDF中断跳过功能选择）

IVTC[1:0]位设置GTPR比较匹配（GTCNT上溢）中断（GPTn_OVF）和GTCNT计数器下溢中断（GPTn_UDF）的跳过功能。

IVTT[2:0]位（GPTn_OVFGPTn_UDF中断跳过计数选择）

IVTT[2:0]位设置GTPR比较匹配（GTCNT上溢）中断（GPTn_OVF）和GTCNT计数器下溢中断（GPTn_UDF）的跳过计数。修改IVTT[2:0]位时，首先将IVTC[1:0]位设置为00b。

ADTAL位（GTADTRAAD转换器启动请求链接）

ADTAL位指定是否将GTADTRAAD转换器启动请求与GPTn_OVFGPTn_UDF中断跳过功能联系起来。

ADTBL bit (GTADTRB A/D Converter Start Request Link)

The ADTBL bit specifies whether to link the GTADTRB A/D converter start request with GPTn_OVF/GPTn_UDF interrupt skipping function.

22.2.19 General PWM Timer Counter (GTCNT)

Address(es): GPT32EHm.GTCNT 4007 8048h + 0100h × m (m = 0 to 3)
GPT32Em.GTCNT 4007 8048h + 0100h × m (m = 4 to 7)
GPT32m.GTCNT 4007 8048h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GTCNT is a 32-bit read/write counter and can only be written to after counting is stopped. GTCNT must be accessed in 32-bit units. Access in 8-bit/16-bit units is prohibited. GTCNT must be set within the range of 0 ≤ GTCNT ≤ GTPR.

22.2.20 General PWM Timer Compare Capture Register n (GTCCRn) (n = A to F)

Address(es): GPT32EHm.GTCCRA 4007 804Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRA 4007 804Ch + 0100h × m (m = 4 to 7)
GPT32m.GTCCRA 4007 804Ch + 0100h × m (m = 8 to 12)
GPT32EHm.GTCCRB 4007 8050h + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRB 4007 8050h + 0100h × m (m = 4 to 7)
GPT32m.GTCCRB 4007 8050h + 0100h × m (m = 8 to 12)
GPT32EHm.GTCCRC 4007 8054h + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRC 4007 8054h + 0100h × m (m = 4 to 7)
GPT32m.GTCCRC 4007 8054h + 0100h × m (m = 8 to 12)
GPT32EHm.GTCCRE 4007 8058h + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRE 4007 8058h + 0100h × m (m = 4 to 7)
GPT32m.GTCCRE 4007 8058h + 0100h × m (m = 8 to 12)
GPT32EHm.GTCCRD 4007 805Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRD 4007 805Ch + 0100h × m (m = 4 to 7)
GPT32m.GTCCRD 4007 805Ch + 0100h × m (m = 8 to 13)
GPT32EHm.GTCCRF 4007 8060h + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRF 4007 8060h + 0100h × m (m = 4 to 7)
GPT32m.GTCCRF 4007 8060h + 0100h × m (m = 8 to 13)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTCCRn registers are read/write registers.

GTCCRA and GTCCRB are registers used for both output compare and input capture.

GTCCRC and GTCCRE are compare match registers that can also function as buffer registers for GTCCRA and GTCCRB.

GTCCRD and GTCCRF are compare match registers that can also function as buffer registers for GTCCRC and GTCCRE (double-buffer registers for GTCCRA and GTCCRB).

ADTBL位（GTADTRBAD转换器启动请求链接）

ADTBL位指定是否将GTADTRBAD转换器启动请求与GPTn_OVFGPTn_UDF中断跳过功能链接。

22.2.19 通用PWM定时器计数器(GTCNT)

Address(es): GPT32EHm.GTCNT 4007 8048h + 0100h × m (m = 0 to 3)
GPT32Em.GTCNT 4007 8048h + 0100h × m (m = 4 to 7)
GPT32m.GTCNT 4007 8048h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GTCNT是一个32位读写计数器，只有在停止计数后才能写入。GTCNT必须以32位单元访问。禁止以8位16位为单位进行访问。GTCNT必须设置在0≤GTCNT≤GTPR的范围内。

22.2.20 通用PWM定时器比较捕捉寄存器n(GTCCRn)(n=AtoF)

Address(es): GPT32EHm.GTCCRA 4007 804Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRA 4007 804Ch + 0100h × m (m = 4 to 7)
GPT32m.GTCCRA 4007 804Ch + 0100h × m (m = 8 to 12)
GPT32EHm.GTCCRB 4007 8050h + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRB 4007 8050h + 0100h × m (m = 4 to 7)
GPT32m.GTCCRB 4007 8050h + 0100h × m (m = 8 to 12)
GPT32EHm.GTCCRC 4007 8054h + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRC 4007 8054h + 0100h × m (m = 4 to 7)
GPT32m.GTCCRC 4007 8054h + 0100h × m (m = 8 to 12)
GPT32EHm.GTCCRE 4007 8058h + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRE 4007 8058h + 0100h × m (m = 4 to 7)
GPT32m.GTCCRE 4007 8058h + 0100h × m (m = 8 to 12)
GPT32EHm.GTCCRD 4007 805Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRD 4007 805Ch + 0100h × m (m = 4 to 7)
GPT32m.GTCCRD 4007 805Ch + 0100h × m (m = 8 to 13)
GPT32EHm.GTCCRF 4007 8060h + 0100h × m (m = 0 to 3)
GPT32Em.GTCCRF 4007 8060h + 0100h × m (m = 4 to 7)
GPT32m.GTCCRF 4007 8060h + 0100h × m (m = 8 to 13)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTCCRn寄存器是读写寄存器。

GTCCRA和GTCCRB是用于输出比较和输入捕捉的寄存器。

GTCCRC和GTCCRE是比较匹配寄存器，也可以用作GTCCRA的缓冲寄存器和GTCCRB.

GTCCRD和GTCCRF是比较匹配寄存器，也可以用作GTCCRC的缓冲寄存器和GTCCRE（GTCCRA和GTCCRB的双缓冲寄存器）。

22.2.21 General PWM Timer Cycle Setting Register (GTPR)

Address(es): GPT32EHm.GTPR 4007 8064h + 0100h × m (m = 0 to 3)
GPT32Em.GTPR 4007 8064h + 0100h × m (m = 4 to 7)
GPT32m.GTPR 4007 8064h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTPR is a read/write register that sets the maximum count value of GTCNT. For saw waves, the value of (GTPR + 1) is the cycle. For triangle waves, the value of (GTPR value × 2) is the cycle.

22.2.22 General PWM Timer Cycle Setting Buffer Register (GTPBR)

Address(es): GPT32EHm.GTPBR 4007 8068h + 0100h × m (m = 0 to 3)
GPT32Em.GTPBR 4007 8068h + 0100h × m (m = 4 to 7)
GPT32m.GTPBR 4007 8068h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTPBR is a read/write register that functions as a buffer register for GTPR.

22.2.23 General PWM Timer Cycle Setting Double-Buffer Register (GTPDBR)

Address(es): GPT32EHm.GTPDBR 4007 806Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTPDBR 4007 806Ch + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTPDBR is a 32-bit read/write register that functions as a buffer register for GTPBR (double-buffer register for GTPR). Only GPT32EH and GPT32E have this register. GPT32 does not have this register. This register is read with the value after reset.

22.2.21 通用PWM定时器周期设置寄存器(GTPR)

Address(es): GPT32EHm.GTPR 4007 8064h + 0100h × m (m = 0 to 3)
GPT32Em.GTPR 4007 8064h + 0100h × m (m = 4 to 7)
GPT32m.GTPR 4007 8064h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTPR是一个读写寄存器，设置GTCNT的最大计数值。对于锯齿波，(GTPR+1)的值就是周期。对于三角波，（GTPR值 2）的值就是周期。

22.2.22 通用PWM定时器周期设置缓冲寄存器(GTPBR)

Address(es): GPT32EHm.GTPBR 4007 8068h + 0100h × m (m = 0 to 3)
GPT32Em.GTPBR 4007 8068h + 0100h × m (m = 4 to 7)
GPT32m.GTPBR 4007 8068h + 0100h × m (m = 8 to 12)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTPBR是一个读写寄存器，用作GTPR的缓冲寄存器。

22.2.23 通用PWM定时器周期设置双缓冲寄存器(GTPDBR)

Address(es): GPT32EHm.GTPDBR 4007 806Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTPDBR 4007 806Ch + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTPDBR是一个32位读写寄存器，用作GTPBR的缓冲寄存器（GTPR的双缓冲寄存器）。
只有GPT32EH和GPT32E有这个寄存器。GPT32没有这个寄存器。用复位后的值读取该寄存器。

22.2.24 A/D Converter Start Request Timing Register n (GTADTRn) (n = A, B)

Address(es): GPT32EHm.GTADTRA 4007 8070h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTRA 4007 8070h + 0100h × m (m = 4 to 7)

GPT32EHm.GTADTRB 4007 807Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTADTRB 4007 807Ch + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The GTADTRn registers are 32-bit read/write registers that set the timing of A/D converter start request generation. When the GTADTRn value matches the GTCNT counter value, an A/D converter start request is generated. GTADTRm must be accessed in 32-bit units. Access in 8-bit/16-bit units is prohibited. Only GPT32EH and GPT32E have this register. GPT32 does not have this register. This register is read with the value after reset.

22.2.25 A/D Converter Start Request Timing Buffer Register n (GTADTBRn) (n = A, B)

Address(es): GPT32EHm.GTADTBRA 4007 8074h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTBRA 4007 8074h + 0100h × m (m = 4 to 7)

GPT32EHm.GTADTBRB 4007 8080h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTBRB 4007 8080h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The GTADTBRn registers are 32-bit read/write registers that function as buffer registers for GTADTRn. GTADTBRn must be accessed in 32-bit units. Access in 8-bit/16-bit units is prohibited. Only GPT32EH and GPT32E have this register. GPT32 does not have this register. This register is read with the value after reset.

22.2.24 AD转换器启动请求时序寄存器n(GTADTRn)(n=A B)

Address(es): GPT32EHm.GTADTRA 4007 8070h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTRA 4007 8070h + 0100h × m (m = 4 to 7)

GPT32EHm.GTADTRB 4007 807Ch + 0100h × m (m = 0 to 3)
GPT32Em.GTADTRB 4007 807Ch + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTADTRn寄存器是32位读写寄存器，用于设置AD转换器启动请求生成的时序。
当GTADTRn值与GTCNT计数器值匹配时，将产生AD转换器启动请求。GTADTRm必须以32位单元访问。禁止以8位16位为单位进行访问。只有GPT32EH和GPT32E有这个寄存器。GPT32没有这个寄存器。用复位后的值读取该寄存器。

22.2.25 AD转换器启动请求时序缓冲寄存器n(GTADTBRn)(n=A B)

Address(es): GPT32EHm.GTADTBRA 4007 8074h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTBRA 4007 8074h + 0100h × m (m = 4 to 7)

GPT32EHm.GTADTBRB 4007 8080h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTBRB 4007 8080h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTADTRn寄存器是32位读写寄存器，用作GTADTRn的缓冲寄存器。GTADTBRn必须以32位单元访问。禁止以8位16位为单位进行访问。只有GPT32EH和GPT32E有这个寄存器。GPT32没有这个寄存器。用复位后的值读取该寄存器。

22.2.26 A/D Converter Start Request Timing Double-Buffer Register n (GTADTDBRn) (n = A, B)

Address(es): GPT32EHm.GTADTDBRA 4007 8078h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTDBRA 4007 8078h + 0100h × m (m = 4 to 7)

GPT32EHm.GTADTDBRB 4007 8084h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTDBRB 4007 8084h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The GTADTDBRn registers are 32-bit read/write registers that function as buffer registers for GTADTBRn (double-buffer registers for GTADTR). GTADTDBRn must be accessed in 32-bit units. Access in 8-bit/16-bit units is prohibited. Only GPT32EH and GPT32E have this register. GPT32 does not have this register. This register is read with the value after reset.

22.2.27 General PWM Timer Dead Time Control Register (GTDTCR)

Address(es): GPT32EHm.GTDTCR 4007 8088h + 0100h × m (m = 0 to 3)
GPT32Em.GTDTCR 4007 8088h + 0100h × m (m = 4 to 7)
GPT32m.GTDTCR 4007 8088h + 0100h × m (m = 8 to 12)

• GPT32EH, GPT32E

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	TDFER	—	—	TDBDE	TDBUE	—	—	—	TDE
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

• GPT32

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	TDE
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TDE	Negative-Phase Waveform Setting	0: GTCCRB is set without using GTDVU and GTDVD 1: GTDVU and GTDVD set the compare match value for negative-phase waveform with automatic dead time in GTCCRB.	R/W
b3 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	TDBUE	GTDVU Buffer Operation Enable	0: GTDVU buffer operation disabled 1: GTDVU buffer operation enabled.	R/W

22.2.26 AD转换器启动请求时序双缓冲寄存器n(GTADTDBRn)(n=A B)

Address(es): GPT32EHm.GTADTDBRA 4007 8078h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTDBRA 4007 8078h + 0100h × m (m = 4 to 7)

GPT32EHm.GTADTDBRB 4007 8084h + 0100h × m (m = 0 to 3)
GPT32Em.GTADTDBRB 4007 8084h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTADTDBRn寄存器是32位读写寄存器，用作GTADTBRn的缓冲寄存器（GTADTR的双缓冲寄存器）。GTADTDBRn必须以32位单元访问。禁止以8位16位为单位进行访问。只有GPT32EH和GPT32E有这个寄存器。GPT32没有这个寄存器。用复位后的值读取该寄存器。

22.2.27 通用PWM定时器死区控制寄存器(GTDTCR)

Address(es): GPT32EHm.GTDTCR 4007 8088h + 0100h × m (m = 0 to 3)
GPT32Em.GTDTCR 4007 8088h + 0100h × m (m = 4 to 7)
GPT32m.GTDTCR 4007 8088h + 0100h × m (m = 8 to 12)

• GPT32EH, GPT32E

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	TDFER	—	—	TDBDE	TDBUE	—	—	—	TDE
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

• GPT32

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	TDE
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TDE	负相位波形设置	0：不使用GTDVU和GTDVD设置GTCCRB1：GTDVU和GTDVD在GTCCRB中设置带自动死区时间的负相波形的比较匹配值。	R/W
b3 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	TDBUE	GTDVU缓冲区操作使能	0：禁止GTDVU缓冲操作1：使能GTDVU缓冲操作。	R/W

Bit	Symbol	Bit name	Description	R/W
b5	TDBDE	GTDVD Buffer Operation Enable	0: GTDVD buffer operation disabled 1: GTDVD buffer operation enabled.	R/W
b7, b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b8	TDFER	GTDVD Setting	0: GTDVU and GTDVD are set separately 1: The value written to GTDVU to GTDVD is automatically set.	R/W
b31 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTDTCR enables automatic setting of a compare match value for negative-phase waveform with dead time.

GPT32EH, GPT32E and GPT32 have dead time control function. GPT32 does not have the dead time buffer function and only GTDVU register is used for setting dead time value.

TDE bit (Negative-Phase Waveform Setting)

The TDE bit specifies whether to use GTDVU and GTDVD. When GTDVU and GTDVD are used, the compare match value for a negative-phase waveform with dead time obtained by the compare match value of a positive-phase waveform (GTCCRA) and the dead time value (GTDVU and GTDVD), is automatically set in GTCCRB. The TDE bit setting is ignored in saw-wave PWM mode, and automatic setting does not take place.

The GTCCRB value is automatically set and has the following upper and lower limit values. If the obtained GTCCRB value is not within the upper or lower limit, the following limit value is set in GTCCRB and the GTST.DTEF flag is set to 1. However, in triangle waves, when the obtained GTCCRB value exceeds the upper limit value, the GTST.DTEF flag is set to 0.

- Triangle waves:
  Upper limit value: GTPR - 1
  Lower limit value: 1 in up-counting, 0 in down-counting
- Saw-wave one-shot pulse mode:

  Upper limit value: GTPR
  Lower limit value: 0.

TDBUE bit (GTDVU Buffer Operation Enable)

The TDBUE bit enables buffer operation with GTDVU and GTDBU combined. The buffer transfer timing is the trough for triangle waves, and an overflow or underflow for saw waves.

Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

TDBDE bit (GTDVD Buffer Operation Enable)

The TDBDE bit enables buffer operation with GTDVD and GTDBD combined. The buffer transfer timing is the trough for triangle waves, and an overflow or underflow for saw waves. When this bit and the TDFER bit are set to 1 simultaneously, the TDFER bit setting is given priority.

Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

TDFER bit (GTDVD Setting)

The TDFER bit selects whether the value written to GTDVU is also set to GTDVD automatically.

Only GPT32EH and GPT32E have this bit. GPT32 does not have this bit.

Bit	Symbol	位名称	Description	R/W
b5	TDBDE	GTDVD缓冲区操作使能	0：禁用GTDVD缓冲区操作1：启用GTDVD缓冲区操作。	R/W
b7, b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b8	TDFER	GTDVD Setting	0：GTDVU和GTDVD分别设置1：自动设置写入GTDVU到GTDVD的值。	R/W
b31 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTDTCR可以自动设置带死区时间的负相位波形的比较匹配值。

GPT32EH、GPT32E和GPT32具有死区时间控制功能。GPT32没有死区缓冲功能，只有GTDVU寄存器用于设置死区值。

TDE位（负相位波形设置）

TDE位指定是否使用GTDVU和GTDVD。使用GTDVU和GTDVD时，通过正相波形的比较匹配值(GTCCRA)和死区时间值(GTDVU和GTDVD)获得的带死区时间的负相波形的比较匹配值自动设置在GTCCRB。TDE位设置在锯齿波PWM模式下被忽略，并且不会进行自动设置。

GTCCRB值是自动设置的，具有以下上下限值。如果获得的GTCCRB值不在上限或下限内，则在GTCCRB中设置以下限值并将GTST.DTEF标志设置为1。但是，在三角波中，当获得的GTCCRB值超过上限值时，GTST.DTEF标志设置为0。

- Triangle waves:
  上限值：GTPR1
  下限值：加1，减0
- Saw-wave one-shot pulse mode:

  上限值：GTPR
  下限值：0。

TDBUE位（GTDVU缓冲区操作使能）

TDBUE位使　　能结合GTDVU和GTDBU的缓冲器操作。缓冲传输时间是三角波的波谷，锯齿波的上溢或下溢。

只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

TDBDE位（GTDVD缓冲区操作使能）

TDBDE位使能结合GTDVD和GTDBD的缓冲操作。缓冲传输时间是三角波的波谷，锯齿波的上溢或下溢。当该位和TDFER位同时设置为1时，TDFER位设置优先。

只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

TDFER位（GTDVD设置）

TDFER位选择写入GTDVU的值是否也自动设置为GTDVD。

只有GPT32EH和GPT32E有这个位。GPT32没有这个位。

22.2.28 General PWM Timer Dead Time Value Register n (GTDVn) (n = U, D)

Address(es): GPT32EHm.GTDVU 4007 808Ch + 0100h x m (m = 0 to 3)
GPT32Em.GTDVU 4007 808Ch + 0100h x m (m = 4 to 7)
GPT32m.GTDVU 4007 808Ch + 0100h x m (m = 8 to 12)
GPT32EHm.GTDVD 4007 8090h + 0100h x m (m = 0 to 3)
GPT32Em.GTDVD 4007 8090h + 0100h x m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTDVn is a 32-bit read/write register that sets the dead time for generating PWM waveforms with dead time. Dead time for the transition in the first half is set in GTDVU and that in the second half is set in GTDVD.

Setting a GTDVn value greater than or equal to GTPR is prohibited. Setting a dead time value that exceeds the cycle is prohibited. The compare match value set by the automatic dead time setting function for a negative waveform can be confirmed by reading from GTCCRB.

When GTDVn is used, writing to GTCCRB is not allowed. When this register is set to 0, waveforms without dead time are output. GTDVn must be accessed in 32-bit units. Access in 8-bit/16-bit units is prohibited. The way to rewrite GTDVn differs by GPT channel number.

GPT32EH0 to GPT32EH3 and GPT32E4 to GPT32E7

When GTDVm buffer operation is enabled, GTDBm can be written at anytime. GTDBm is transferred to GTDVm at the cycle end. When GTDVm buffer operation is disabled, stop the GPT using the CST bit in the GTCR register before changing GTDVm to a new value.

GPT328 to GPT3212

While the GPT is running, changing the GTDVU values is prohibited. To change GTDVU to a new value, stop the GPT with the CST bit in the GTCR register.

Only GPT32EH and GPT32E have the GTDVD register. GPT32 does not have the GTDVD register. This register is read with the value after reset.

22.2.29 General PWM Timer Dead Time Buffer Register n (GTDBn) (n = U, D)

Address(es): GPT32EHm.GTDBU 4007 8094h + 0100h × m (m = 0 to 3)
GPT32Em.GTDBU 4007 8094h + 0100h × m (m = 4 to 7)

GPT32EHm.GTDBD 4007 8098h + 0100h × m (m = 0 to 3)
GPT32Em.GTDBD 4007 8098h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTDBn is a 32-bit read/write register that functions as a buffer register for GTDVn.

Only GPT32EH and GPT32E have this register. GPT32 does not have this register. This register is read with the value after reset.

22.2.28 通用PWM定时器死区值寄存器n(GTDVn)(n=U D)

Address(es): GPT32EHm.GTDVU 4007 808Ch + 0100h x m (m = 0 to 3)
GPT32Em.GTDVU 4007 808Ch + 0100h x m (m = 4 to 7)
GPT32m.GTDVU 4007 808Ch + 0100h x m (m = 8 to 12)
GPT32EHm.GTDVD 4007 8090h + 0100h x m (m = 0 to 3)
GPT32Em.GTDVD 4007 8090h + 0100h x m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTDVn是一个32位读写寄存器，用于设置死区时间，以生成带死区时间的PWM波形。前半段过渡的死区时间在GTDVU中设置，后半段在GTDVD中设置。

禁止将GTDVn值设置为大于或等于GTPR。禁止设置超过周期的死区时间值。通过读取GTCCRB可以确认负波形的自动死区时间设置功能设置的比较匹配值。

使用GTDVn时，不允许写入GTCCRB。当该寄存器设置为0时，输出无死区时间的波形。GTDVn必须以32位单元访问。禁止以8位16位为单位进行访问。重写GTDVn的方式因GPT通道号而异。

GPT32EH0到GPT32EH3和GPT32E4到GPT32E7

当启用GTDVm缓冲区操作时，可以随时写入GTDBm。GTDBm在循环结束时转移到GTDVm。当GTDVm缓冲区操作被禁用时，在将GTDVm更改为新值之前，使用GTCR寄存器中的CST位停止GPT。

GPT328 to GPT3212

在GPT运行时，禁止更改GTDVU值。要将GTDVU更改为新值，请使用GTCR寄存器中的CST位停止GPT。

只有GPT32EH和GPT32E有GTDVD寄存器。GPT32没有GTDVD寄存器。用复位后的值读取该寄存器。

22.2.29 通用PWM定时器死区缓冲寄存器n(GTDBn)(n=U D)

Address(es): GPT32EHm.GTDBU 4007 8094h + 0100h × m (m = 0 to 3)
GPT32Em.GTDBU 4007 8094h + 0100h × m (m = 4 to 7)

GPT32EHm.GTDBD 4007 8098h + 0100h × m (m = 0 to 3)
GPT32Em.GTDBD 4007 8098h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

GTDBn是一个32位读写寄存器，用作GTDVn的缓冲寄存器。

只有GPT32EH和GPT32E有这个寄存器。GPT32没有这个寄存器。用复位后的值读取该寄存器。

22.2.30 General PWM Timer Output Protection Function Status Register (GTSOS)

Address(es): GPT32EHm.GTSOS 4007 809Ch + 0100h x m (m = 0 to 3)
GPT32Em.GTSOS 4007 809Ch + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	SOS[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	SOS[1:0]	Output Protection Function Status	b1 b0 0 0: Normal operation 0 1: Protected state (set GTCCRA = 0 during transfer at trough or crest) 1 0: Protected state (set GTCCRA ≥ GTPR during transfer at trough) 1 1: Protected state (set GTCCRA ≥ GTPR during transfer at crest).	R
b31 to b2	—	Reserved	These bits are read as 0. Writing to these bits is ignored.	R

GTSOS is a register that indicates the status of the output protection function. The output protection function is enabled only when the dead time is automatically set (GTDTCR.TDE bit = 1) in triangle-wave mode.

Only GPT32EH and GPT32E have this register. GPT32 does not have this register. This register is read as 0000 0000h.

SOS[1:0] bits (Output Protection Function Status)

The SOS[1:0] bits indicate the status of the output protection function in triangle-wave PWM mode.

22.2.31 General PWM Timer Output Protection Function Temporary Release Register (GTSOTR)

Address(es): GPT32EHm.GTSOTR 4007 80A0h + 0100h x m (m = 0 to 3)
GPT32Em.GTSOTR 4007 80A0h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	SOTR
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SOTR	Output Protection Function Temporary Release	0: Protected state is not released 1: Protected state is released.	R/W
b31 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTSOTR temporarily releases the protected state of GTIOCB pin output when output protection is set. The protected state can be released only when GTSOS.SOS[1:0] bits = 10b (protected state in which GTCCRA ≥ GTPR has occurred during transfer at trough). The protected state cannot be released in any other case.

22.2.30 通用PWM定时器输出保护功能状态寄存器(GTSOS)

Address(es): GPT32EHm.GTSOS 4007 809Ch + 0100h x m (m = 0 to 3)
GPT32Em.GTSOS 4007 809Ch + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	SOS[1:0]	
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	SOS[1:0]	输出保护功能状态	b1b000：正常运行01：保护状态（在波谷或波峰转移期间设置GTCCRA=0）10：保护状态（在波谷转移期间设置GTCCRA≥GTPR）11：保护状态（在波谷或波峰转移期间设置GTCCRA≥GTPR）在波峰转移）。	R
b31 to b2	—	Reserved	这些位被读取为0。写入这些位被忽略。	R

GTSOS是指示输出保护功能状态的寄存器。只有在三角波模式下自动设置死区时间（GTDTCR.TDE位=1）时，才会启用输出保护功能。

只有GPT32EH和GPT32E有这个寄存器。GPT32没有这个寄存器。该寄存器读为00000000h。

SOS[1:0]位（输出保护功能状态）

SOS[1:0]位指示三角波PWM模式下输出保护功能的状态。

22.2.31 通用PWM定时器输出保护功能临时释放寄存器(GTSOTR)

Address(es): GPT32EHm.GTSOTR 4007 80A0h + 0100h x m (m = 0 to 3)
GPT32Em.GTSOTR 4007 80A0h + 0100h × m (m = 4 to 7)

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	SOTR
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SOTR	输出保护功能 临时释放	0：不解除保护状态1：解除保护状态。	R/W
b31 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

当设置输出保护时，GTSOTR会暂时解除GTIOCB引脚输出的保护状态。仅当GTSOS.SOS[1:0]位=10b时才能解除保护状态（在低谷传输期间发生GTCCRA≥GTPR的保护状态）。在任何其他情况下都不能释放受保护的状态。

Only GPT32EH and GPT32E have this register. GPT32 does not have this register. This register is read as 0000 0000h.

SOTR bit (Output Protection Function Temporary Release)

The SOTR bit specifies whether to temporarily release the protected state of GTIOCB pin output in an output protected state. When the SOTR bit is set to 1, the output protection function is canceled from the first trough. When the SOTR bit is set to 0, output protection resumes from the first trough.

22.2.32 Output Phase Switching Control Register (OPSCR)

Address(es): GPT_OPS.OPSCR 4007 8FF0h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	NFCS[1:0]		NFEN	—	—	GODF	GRP[1:0]		—	—	ALIGN	—	INV	N	P	FB
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	EN	—	W	V	U	—	WF	VF	UF
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	UF	Input Phase Soft Setting	These bits set the input phase from the software settings. Setting these bits is valid when the OPSCR.FB bit = 1.	R/W
b1	VF			R/W
b2	WF			R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	U	Input U-Phase Monitor	These bits monitor the state of the input phase: OPSCR.FB = 0: External inputs that are synchronized by PCLKD OPSCR.FB = 1: The OPSCR.U, OPSCR.V, and OPSCR.W bits can read the OPSCR.UF. OPSCR.VF, and OPSCR.WF bits.	R
b5	V	Input V-Phase Monitor		R
b6	W	Input W-Phase Monitor		R
b7	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b8	EN	Enable-Phase Output Control	0: Do not output (Hi-Z on external pin) 1: Output.*1	R/W
b15 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b16	FB	External Feedback Signal Enable	This bit selects the input phase from the software settings or external input: 0: Select the external input 1: Select the software settings (OPSCR.UF, VF, WF).	R/W
b17	P	Positive-Phase Output (P) Control	0: Output level signal 1: Output level signal (PWM of GPT32EH0).	R/W
b18	N	Negative-Phase Output (N) Control	0: Output level signal 1: Output PWM signal (PWM of GPT32EH0).	R/W
b19	INV	Invert-Phase Output Control	0: Output positive logic (active-high) 1: Output negative logic (active-low).	R/W
b20	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b21	ALIGN	Input Phase Alignment	0: Input phase aligned to PCLKD 1: Input phase aligned to PWM.	R/W
b23, b22	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b25, b24	GRP[1:0]	Output Disabled Source Selection	b25 b24 0 0: Select group A output disable source 0 1: Select group B output disable source 1 0: Select group C output disable source 1 1: Select group D output disable source.	R/W

只有GPT32EH和GPT32E有这个寄存器。GPT32没有这个寄存器。该寄存器读为00000000h。

SOTR位（输出保护功能临时释放）

SOTR位指定是否在输出保护状态下暂时解除GTIOCB引脚输出的保护状态。当SOTR位设置为1时，输出保护功能从第一个波谷取消。当SOTR位设置为0时，输出保护从第一个波谷恢复。

22.2.32 输出相位切换控制寄存器(OPSCR)

Address(es): GPT_OPS.OPSCR 4007 8FF0h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	NFCS[1:0]		NFEN	—	—	GODF	GRP[1:0]		—	—	ALIGN	—	INV	N	P	FB
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	EN	—	W	V	U	—	WF	VF	UF
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	UF	输入相位软设置	这些位通过软件设置设置输入相位。 当OPSCR.FB位=1时，设置这些位有效。	R/W
b1	VF			R/W
b2	WF			R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	U	输入U相监视器	这些位监控输入相位的状态： OPSCR.FB=0：同步的外部输入 PCLKD	R
b5	V	输入V相监视器		R
b6	W	输入W相监视器	OPSCR.FB=1：OPSCR.U、OPSCR.V和OPSCR.W位可以读取OPSCR.UF。OPSCR.VF和OPSCR.WF位。	R
b7	—	Reserved	该位读取为0。写入值应为0。	R/W
b8	EN	使能相输出控制	0：不输出（外部引脚上的Hi-Z）1： 输出。*1	R/W
b15 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b16	FB	外部反馈信号使能	该位从软件设置或外部输入中选择输入相位：0：选择外部输入1：选择软件设置（OPSCR.UF、VF、WF）。	R/W
b17	P	正相输出(P)控制	0：输出电平信号1：输出电平信号（GPT32EH0的PWM）。	R/W
b18	N	负相输出(N)控制	0：输出电平信号1：输出PWM信号（GPT32EH0的PWM）。	R/W
b19	INV	反相输出控制	0：输出正逻辑（高电平有效）1： 输出负逻辑（低电平有效）。	R/W
b20	—	Reserved	该位读取为0。写入值应为0。	R/W
b21	ALIGN	输入相位对齐	0：输入相位与PCLKD对齐1：输入相位与PWM对齐。	R/W
b23, b22	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b25, b24	GRP[1:0]	输出禁用源选择	b25b2400：选择A组输出禁用源01：选择B组输出禁用源10：选择C 组输出禁用源11：选择D组输出禁用源。	R/W

Bit	Symbol	Bit name	Description	R/W
b26	GODF	Group Output Disable Function	0: This bit function is ignored 1: Group disable clears the OPSCR.EN bit.*1	R/W
b28, b27	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b29	NFEN	External Input Noise Filter Enable	0: Do not use a noise filter on the external input 1: Use a noise filter on the external input.	R/W
b31, b30	NFCS[1:0]	External Input Noise Filter Clock Selection	Noise filter sampling clock setting of the external input: b31 b30 0 0: PCLKD/1 0 1: PCLKD/4 1 0: PCLKD/16 1 1: PCLKD/64.	R/W

Note 1. When OPSCR.GODF = 1 and the signal value selected by the OPSCR.GRP[1:0] bits is high, the OPSCR.EN bit is set to 0.

The OPSCR sets the output of the signal waveform required for brushless DC motor control.

UF, VF, WF bits (Input Phase Soft Setting)

The UF, VF, and WF bits set the input phase from the software settings. When OPSCR.FB bit is 1, these bits are valid. The set value of the UF/VF/WF bits takes the place of the U/V/W external input.

U, V, W bits (Input Phase Monitor)

When the OPSCR.FB bit is 0, external inputs that are synchronized by PCLKD are monitored by these bits. When the OPSCR.FB bit is 1, the OPSCR.U, OPSCR.V, and OPSCR.W bits can read the OPSCR.UF, OPSCR.VF, and OPSCR.WF bits.

EN bit (Enable-Phase Output Control)

The EN bit controls the output enable signal output phase (positive phase/reverse phase).

When the OPSCR.EN bit is 1, the signal waveform is output.

When the OPSCR.EN bit is 0, first set OPSCR.FB, OPSCR.UF/VF/WF (software setting is selected), OPSCR.P/N, OPSCR.INV, OPSCR.RV, OPSCR.ALIGN, OPSCR.GRP, OPSCR.GODF, OPSCR.NFEN, and OPSCR.NFCS. Then, set the EN bit to 1. Also, when OPSCR.GODF is 1 and the signal value selected by the OPSCR.GRP bit is high, the OPSCR.EN bit is set to 0.

FB bit (External Feedback Signal Enable)

The FB bit selects the input phase from the software settings (OPSCR.UF, VF, WF) and external input such as a Hall element.

P bit (Positive-Phase Output (P) Control)

The P bit selects one of the level signal output (PWM of GPT32EH0) or PWM signal output for the positive-phase output (GTOUUP pin, GTOVUP pin, GTOWUP pin).

N bit (Negative-Phase Output (N) Control)

The N bit selects one of the level signal output (PWM of GPT32EH0) or PWM signal output for the negative-phase output (GTOULO pin, GTOVLO pin, GTOWLO pin).

INV bit (Invert-Phase Output Control)

The INV bit selects either positive logic (active-high) output or negative logic (active-low) output for the output phase.

ALIGN bit (Input Phase Alignment)

The ALIGN bit selects the PCLKD or PWM for the sampling of the input phase (input phase is specified in the OPSCR.FB bit). When OPSCR.ALIGN bit is 0, input phase is aligned to PCLKD.

Note: When PWM output is selected (OPSCR.P/N is 1) and the PCLKD input phase is aligned, the PWM pulse might be short-pulsed.

Note: When OPSCR.ALIGN bit is 1, input phase is aligned with PWM output.

Bit	Symbol	位名称	Description	R/W
b26	GODF	组输出禁用功能	0：忽略该位功能1：组禁用清除OPSCR.EN位。*1	R/W
b28, b27	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b29	NFEN	外部输入噪声滤波器启用	0：外部输入不使用噪声滤波器1：外部输入使用噪声滤波器。	R/W
b31, b30	NFCS[1:0]	外部输入噪声滤波器时钟Selection	外部输入的噪声滤波器采样时钟设置：b31b3000：PCLKD101：PCLKD410：PCLKD1611：PCLKD64。	R/W

Note 1. 当OPSCR.GODF=1且OPSCR.GRP[1:0]位选择的信号值为高时，OPSCR.EN位设置为0。

OPSCR设置无刷直流电机控制所需的信号波形输出。

UF VF WF位（输入相位软设置）

UF、VF和WF位通过软件设置设置输入相位。当OPSCR.FB位为1时，这些位有效。UFVFWF位的设定值代替了UVW外部输入。

U V W位（输入相位监视器）

当OPSCR.FB位为0时，由PCLKD同步的外部输入由这些位监控。当。。。的时候OPSCR.FB位为1，OPSCR.U、OPSCR.V和OPSCR.W位可以读取OPSCR.UF、OPSCR.VF和OPSCR.WF bits.

EN位（使能相位输出控制）

EN位控制输出使能信号的输出相位（正相反相）。

当OPSCR.EN位为1时，输出信号波形。

当OPSCR.EN位为0时，先设置OPSCR.FB、OPSCR.UFVFWF（选择软件设置）、OPSCR.PN、OPSCR.INV、OPSCR.RV、OPSCR.ALIGN、OPSCR.GRP、OPSCR.GODF、OPSCR.NFEN和OPSCR.NFCS。然后，将EN位设置为1。此外，当OPSCR.GODF为1且OPSCR.GRP位选择的信号值为高时，OPSCR.EN位设置为0。

FB位（外部反馈信号使能）

FB位从软件设置（OPSCR.UF、VF、WF）和霍尔元件等外部输入中选择输入相位。

P位（正相输出（P）控制）

P位选择电平信号输出（GPT32EH0的PWM）或正相输出（GTOUUP引脚、GTOVUP引脚、GTOWUP引脚）的PWM信号输出之一。

N位（负相输出（N）控制）

N位选择电平信号输出（GPT32EH0的PWM）或负相输出（GTOULO引脚、GTOVLO引脚、GTOWLO引脚）的PWM信号输出之一。

INV位（反相输出控制）

INV位为输出相位选择正逻辑（高电平有效）输出或负逻辑（低电平有效）输出。

ALIGN位（输入相位对齐）

ALIGN位选择PCLKD或PWM用于输入相位的采样（输入相位在OPSCR.FB位）。当OPSCR.ALIGN位为0时，输入相位与PCLKD对齐。

Note: WhenPWMoutputisselected(OPSCR.PNis1)andthePCLKDinputphaseisaligned thePWMpulsemightbeshort-pulsed.

Note: 当OPSCR.ALIGN位为1时，输入相位与PWM输出对齐。

GRP[1:0] bits (Output Disabled Source Selection)

The GRP[1:0] bits select the output disable source (A to D).

GODF bit (Group Output Disable Function)

When the GODF bit is 1 and the signal value selected by the OPSCR.GRP bit is high, the OPSCR.EN bit is set to 0. When the GODF bit is 0, the bit is ignored.

NFEN bit (External Input Noise Filter Enable)

The NFEN bit selects the noise filter for external input. When OPSCR.NFEN bit is 0, a noise filter is not used for the external input.

Note: When this bit is switched because of an unintentional internal edge, set the OPSCR.EN bit to 0.

NFCS[1:0] bits (External Input Noise Filter Clock Selection)

The NFCS[1:0] bits select the clock for the external input noise filter. When the OPSCR.NFEN bit is 1, noise filter sampling clock setting for external input is enabled.

1. Set the NFCS[1:0].
2. Wait for 2 cycles.
3. Set the OPSCR.EN bit to 1.

22.3 Operation

22.3.1 Basic Operation

Each channel has a 32-bit timer that performs a periodic count operation using the count clock and hardware sources. The count function provides both up-counting and down-counting. The GTPR controls the count cycle.

When the GTCNT counter value matches the value in GTCCRA or GTCCRB, the output from the associated pin GTIOCA or GTIOCB can be changed. GTCCRA or GTCCRB can be used as an input capture register with hardware resources.

GTCCRC and GTCCRD can function as buffer registers for GTCCRA. GTCCRE and GTCCRF can function as buffer registers for GTCCRB.

22.3.1.1 Counter operation

(1) Counter start and stop

The counter for each channel starts the count operation when GTCR.CST is set to 1. The GTCR.CST bit value is changed by the following sources:

- Writing to GTCR register
- Writing 1 to the bit in GTSTR associated with the GPT channel number when the GTSSR.CSTRT bit is set to 1
- Writing 1 to the bit in GTSTP associated with the GPT channel number when the GTPSR.CSTOP bit is set to 1
- The hardware source selected in the GTSSR register
- The hardware source selected in the GTPSR register.

(2) Periodic count operation in up-counting by count clock

The GTCNT counter in each channel starts up-counting when the associated GTCR.CST bit is set to 1 with the GTUPSR and GTDNSR registers set to 0000 0000h. When the GTCNT value changes from the GTPR value to 0 (overflow), the GTST.TCFPO flag is set to 1. When GTCNT overflows, up-counting resumes from 0000 0000h.

Figure 22.3 shows an example of a periodic count operation in up-counting.

GRP[1:0]位（输出禁用源选择）

GRP[1:0]位选择输出禁用源（A到D）。

GODF位（组输出禁用功能）

当GODF位为1且OPSCR.GRP位选择的信号值为高时，OPSCR.EN位设置为0。
当GODF位为0时，该位被忽略。

NFEN位（外部输入噪声滤波器使能）

NFEN位选择外部输入的噪声滤波器。当OPSCR.NFEN位为0时，外部输入不使用噪声滤波器。

Note: 由于无意的内部边沿而切换该位时，将OPSCR.EN位设置为0。

NFCS[1:0]位（外部输入噪声滤波器时钟选择）

NFCS[1:0]位选择外部输入噪声滤波器的时钟。当OPSCR.NFEN位为1时，外部输入的噪声滤波器采样时钟设置使能。

1. 设置NFCS[1:0]。
2. 等待2个周期。
3. 将OPSCR.EN位设置为1。

22.3 Operation

22.3.1 基本操作

每个通道都有一个32位定时器，它使用计数时钟和硬件源执行周期性计数操作。
计数功能提供向上计数和向下计数。GTPR控制计数周期。

当GTCNT计数器值与GTCCRA或GTCCRB中的值匹配时，相关引脚的输出
GTIOCA或GTIOCB可以更改。GTCCRA或GTCCRB可用作具有硬件资源的输入捕捉寄存器。

GTCCRC和GTCCRD可以作为GTCCRA的缓冲寄存器。GTCCRE和GTCCRF可以作为GTCCRB的缓冲寄存器。

22.3.1.1 计数器操作

(1) 计数器启动和停止

当GTCR.CST设置为1时，每个通道的计数器开始计数操作。GTCR.CST位值由以下来源更改：

- 写入GTCR寄存器
- 当GTSSR.CSTRT位设置为1时，将1写入GTSTR中与GPT通道号相关的位
- 当GTPSR.CSTOP位设置为1时，将1写入GTSTP中与GPT通道号相关联的位
- GTSSR寄存器中选择的硬件源
- 在GTPSR寄存器中选择的硬件源。

(2) 计数时钟递增计数中的周期计数操作

当相关的GTCR.CST位设置为1且GTUPSR和GTDNSR寄存器设置为00000000h时，每个通道中的GTCNT计数器开始向上计数。当GTCNT值从GTPR值变为0（溢出）时，GTST.TCFPO标志设置为1。当GTCNT溢出时，向上计数从00000000h恢复。

图22.3显示了递增计数中的周期性计数操作的示例。

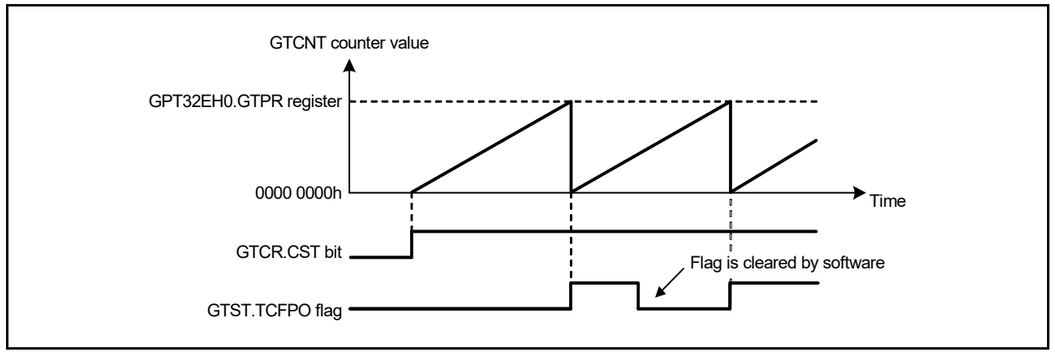


Figure 22.3 Example of periodic count operation in up-counting by the count clock

Figure 22.4 shows an example for setting periodic count operation in up-counting.

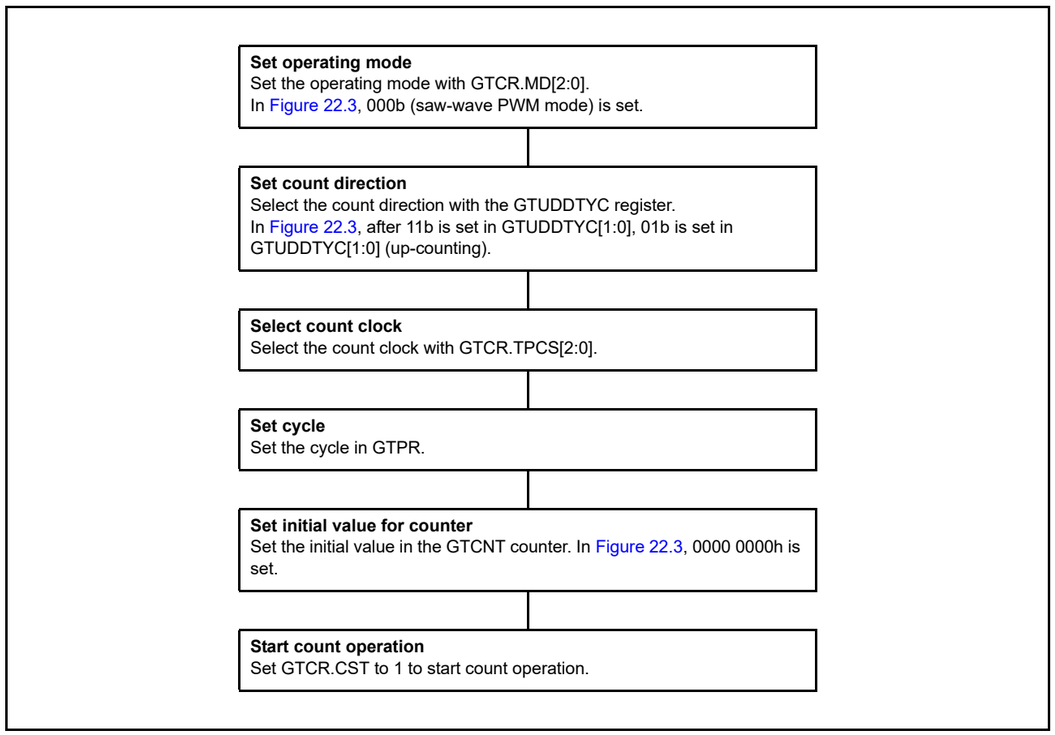


Figure 22.4 Example setting for a periodic count operation in up-counting by the count clock

(3) Periodic count operation in down-counting by count clock

The GTCNT counter in each channel can perform down-counting by setting GTUDDTYC.UD with the GTUPSR and GTDNSR registers set to 0000 0000h. When GTCNT changes from 0 to the GTPR value (underflow), GTST.TCFPU is set to 1. When the GTCNT counter underflows, down-counting resumes from the GTPR value.

Figure 22.5 shows an example of periodic count operation in down-counting by the count clock.

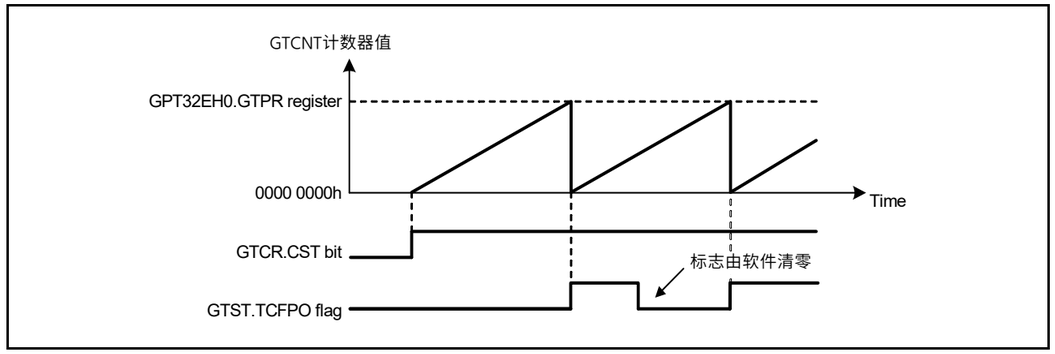


Figure 22.3 计数时钟递增计数中的周期计数操作示例

图22.4显示了在递增计数中设置周期性计数操作的示例。

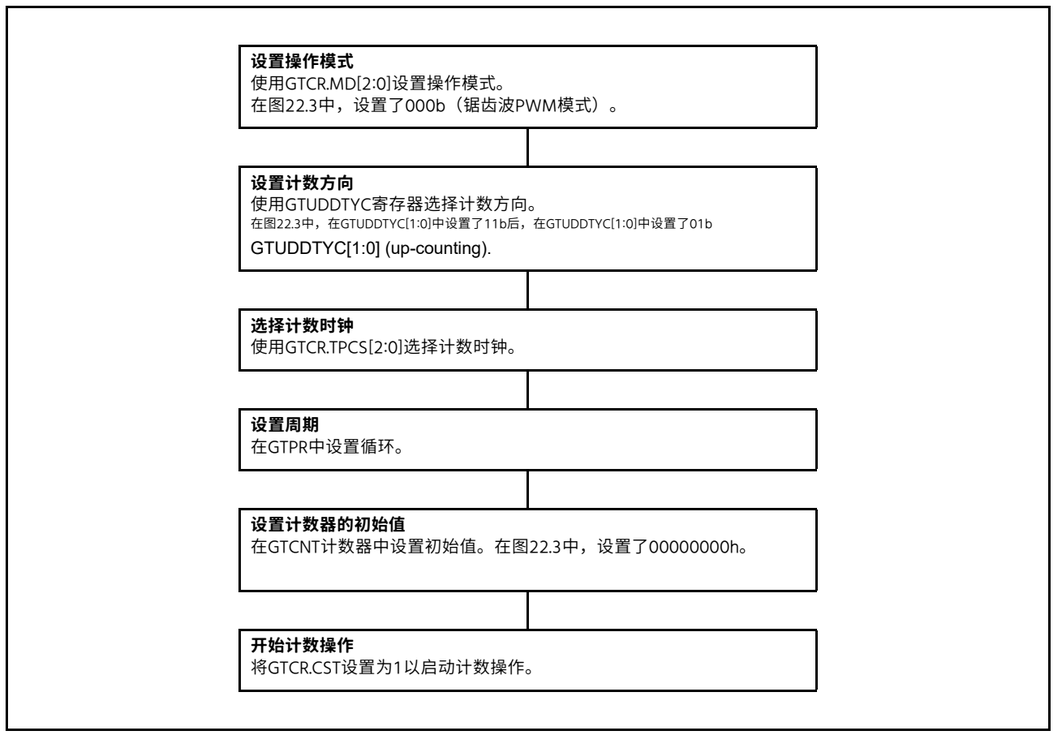


Figure 22.4 计数时钟递增计数中周期性计数操作的示例设置

(3) 计数时钟递减计数中的周期计数操作

每个通道中的GTCNT计数器可以通过使用GTUPSR设置GTUDDTYC.UD和GTDNSR寄存器设置为00000000h。当GTCNT从0变为GTPR值（下溢）时，GTST.TCFPU设置为1。当GTCNT计数器下溢时，从GTPR值开始向下计数。

图22.5显示了计数时钟递减计数中的周期性计数操作示例。

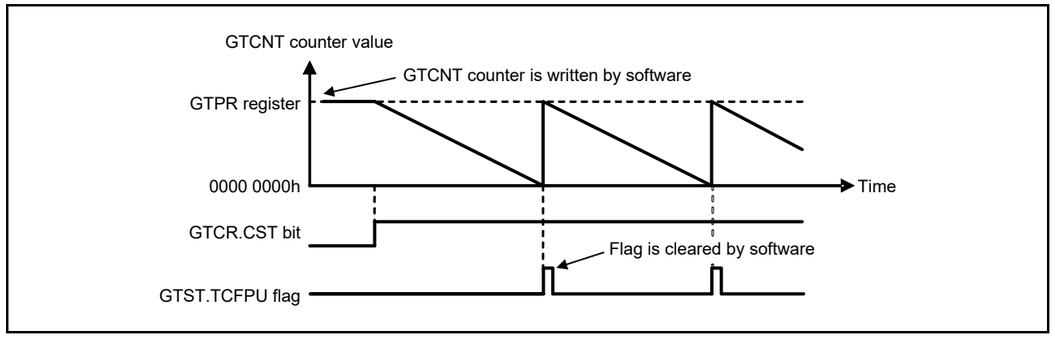


Figure 22.5 Example of periodic count operation in down-counting by the count clock

Figure 22.6 shows an example setting for periodic count operation in down-counting by the count clock.

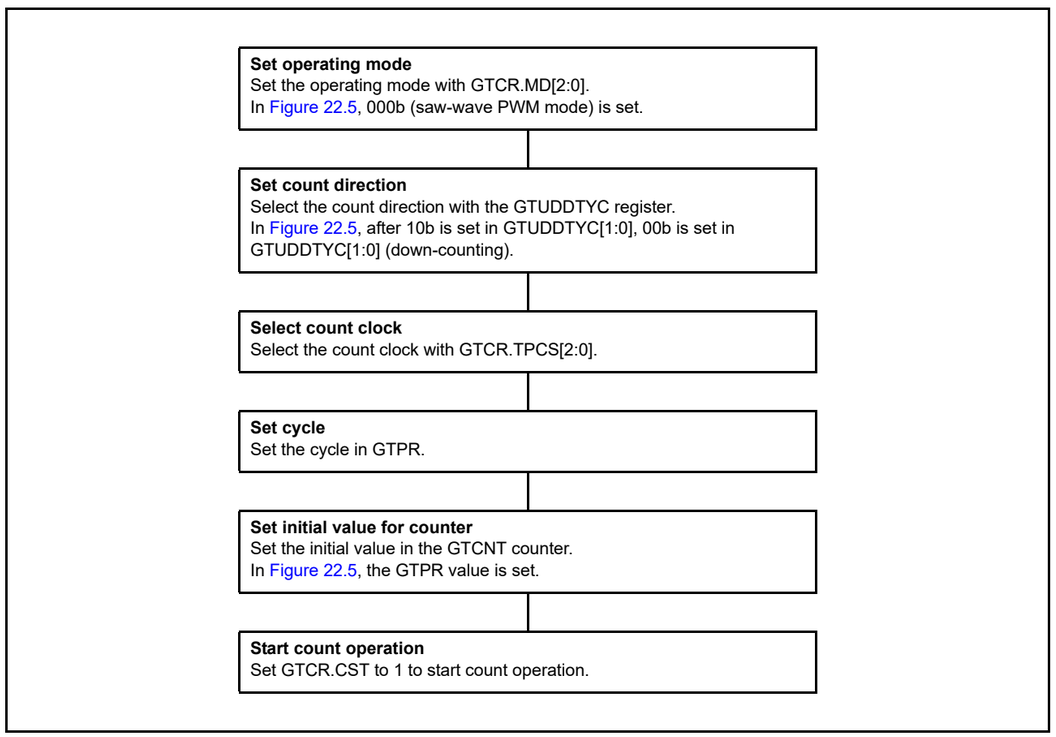


Figure 22.6 Example setting for periodic count operation in down-counting by count clock

(4) Event count operation in up-counting using hardware sources

The GTCNT counter in each channel can perform up-counting using hardware sources as set in GTUPSR.

When GTUPSR is set to enable, the count clock selected in GTCR.TPCS[2:0] and the count direction selected in GTUDDTYC.UD are ignored. If up-counting and down-counting using hardware sources occur at the same time, the GTCNT counter value does not change. The overflow behavior for up-counting using hardware sources is the same as for up-counting by the count clock.

When GTCR.CST bit is set to 1 to count up using hardware sources, the count operation is enabled. When GTCR.CST is set to 1, the counter cannot count up for 1 clock cycle as specified in GTCR.TPCS[2:0] because the count operation is

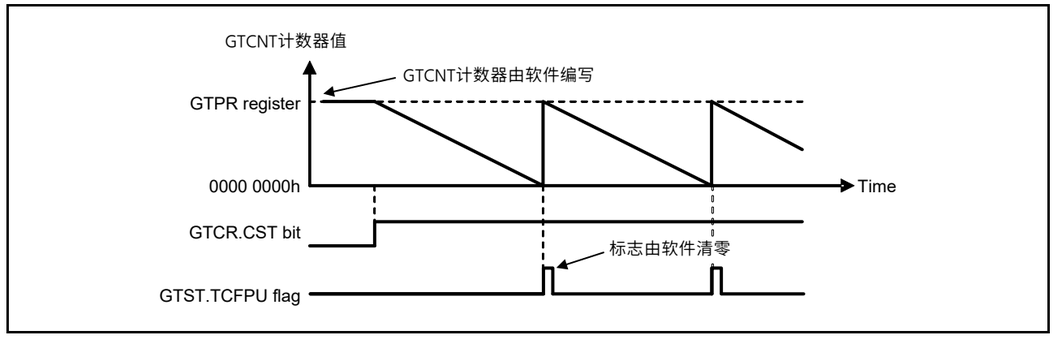


Figure 22.5 计数时钟递减计数中的周期计数操作示例

图22.6显示了计数时钟递减计数中周期性计数操作的示例设置。

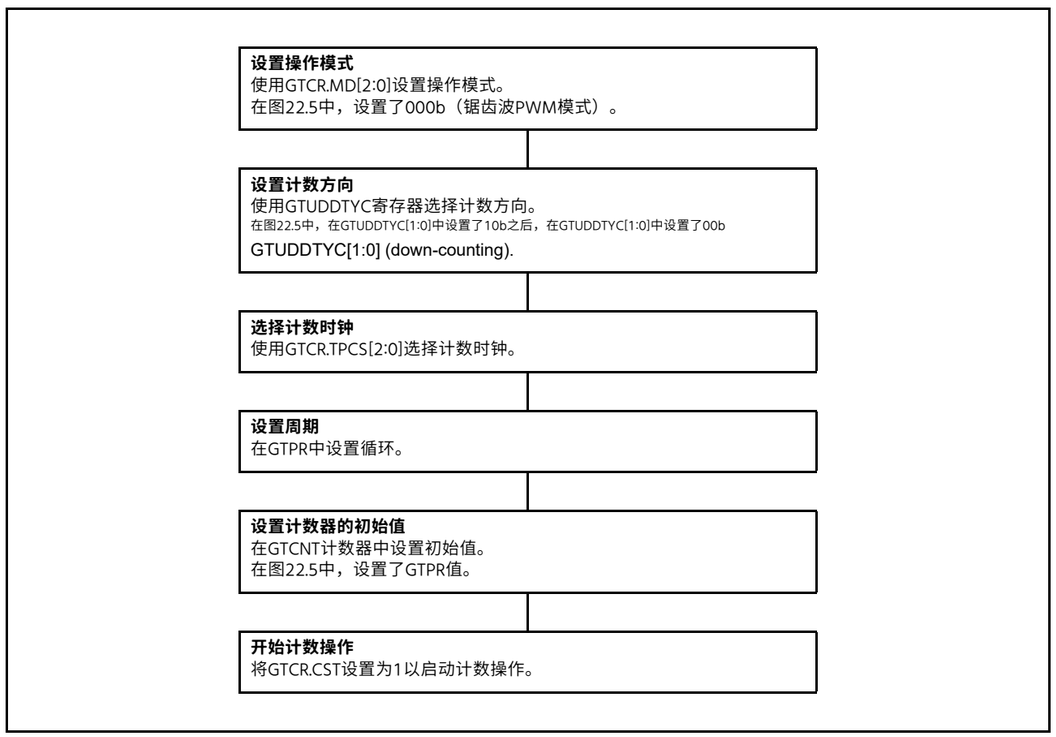


Figure 22.6 计数时钟递减计数中的周期计数操作设置示例

(4) 使用硬件源的递增计数中的事件计数操作

每个通道中的GTCNT计数器可以使用GTUPSR中设置的硬件源执行递增计数。

当GTUPSR设置为使能时，在GTCR.TPCS[2:0]中选择的计数时钟和在GTUDDTYC.UD被忽略。如果同时使用硬件源进行向上计数和向下计数，则GTCNT计数器值不会改变。使用硬件源进行向上计数的溢出行为与使用计数时钟进行向上计数的溢出行为相同。

当GTCR.CST位设置为1以使用硬件源进行计数时，计数操作被启用。当GTCR.CST设置为1时，计数器不能按GTCR.TPCS[2:0]中的规定向上计数1个时钟周期，因为计数操作是

synchronized by the count clock selected in GTCR.TPCS[2:0]. When count up with 1 PCLKD clock delay, set GTCR.TPCS[2:0] to 000b.

Figure 22.7 shows an example of a periodic count operation in up-counting by a hardware source (rising edge of the GTETRGA pin).

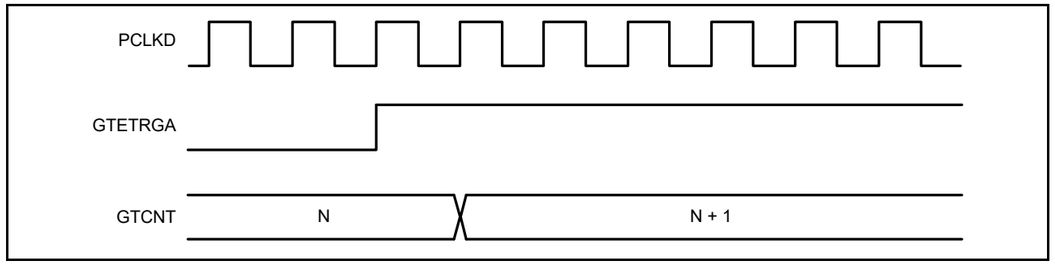


Figure 22.7 Example of periodic count operation in up-counting using hardware sources

Figure 22.8 shows an example setting for periodic count operation in up-counting by a hardware source.

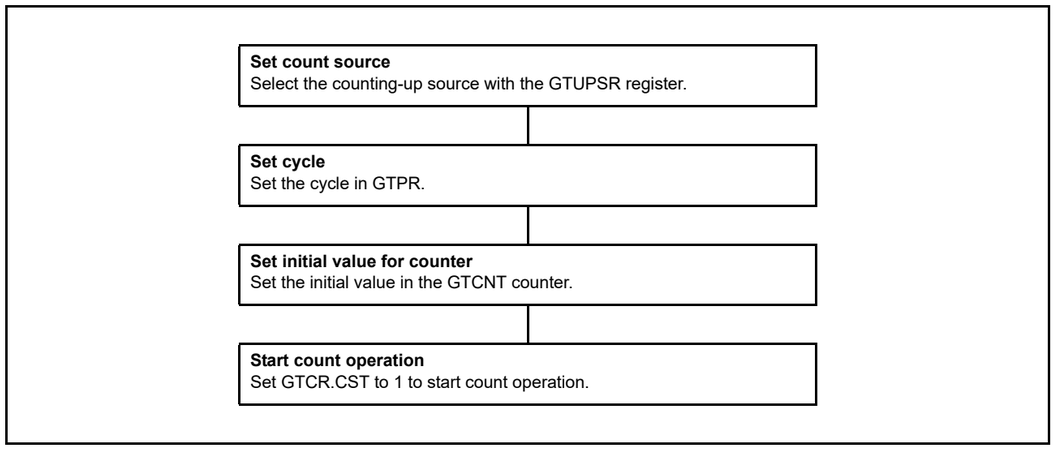


Figure 22.8 Example setting for an event count operation in up-counting using hardware sources

(5) Event count operation in down-counting using hardware sources

The GTCNT counter in each channel can perform down-counting using hardware sources set in the GTDNSR register.

When GTDNSR is set to enable, the count clock selected in GTCR.TPCS[2:0] and the count direction selected in GTUDDTYC.UD are ignored. If up-counting and down-counting using hardware sources occur at the same time, the GTCNT counter value does not change. The underflow behavior for down-counting using hardware sources is the same as for down-counting by the count clock.

When GTCR.CST bit is set to 1 to count down using hardware sources, the count operation is enabled. When GTCR.CST is set to 1, the counter cannot count down for 1 clock cycle as specified in GTCR.TPCS[2:0] because the count operation is synchronized with the count clock selected in GTCR.TPCS[2:0]. When count down with 1 PCLKD clock delay, set GTCR.TPCS[2:0] to 000b.

Figure 22.9 shows an example of a periodic count operation in down-counting by a hardware source (rising edge of the GTETRGA pin).

由GTCR.TPCS[2:0]中选择的计数时钟同步。当以1个PCLKD时钟延迟向上计数时，将GTCR.TPCS[2:0]设置为000b。

图22.7显示了一个由硬件源进行递增计数的周期性计数操作示例（上升沿
GTETRGA pin).

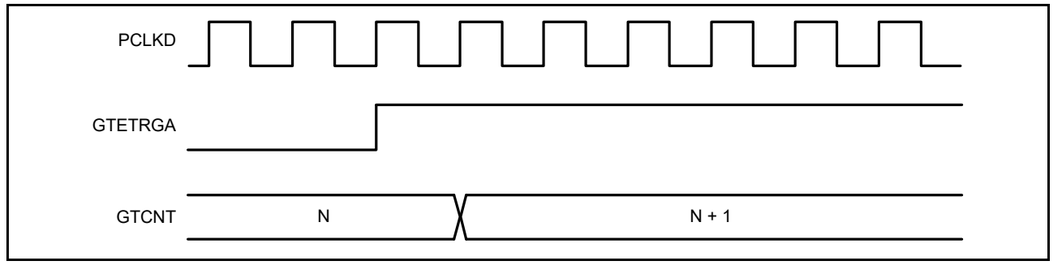


Figure 22.7 使用硬件源进行递增计数的周期性计数操作示例

图22.8显示了硬件源递增计数中周期性计数操作的示例设置。

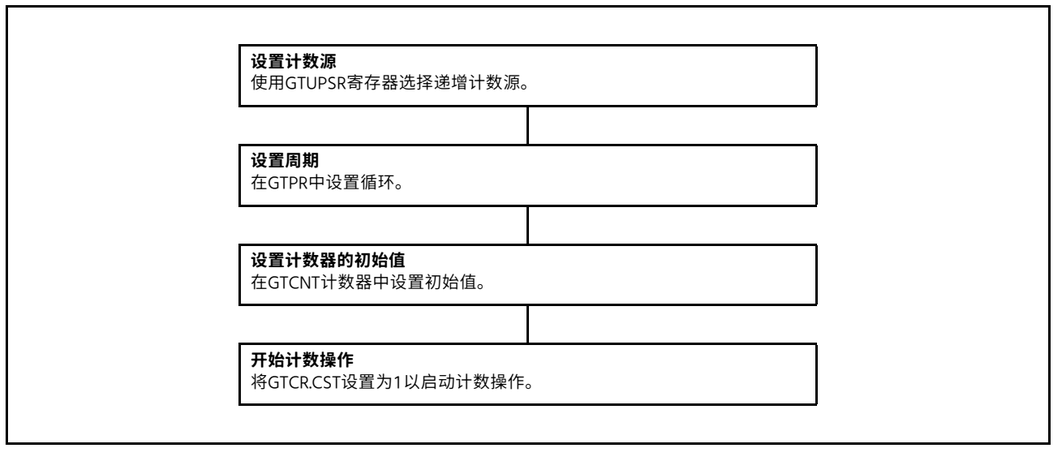


Figure 22.8 使用硬件源的递增计数中的事件计数操作设置示例

(5) 使用硬件源的递减计数中的事件计数操作

每个通道中的GTCNT计数器可以使用GTDNSR寄存器中设置的硬件源进行递减计数。

当GTDNSR设置为使能时，在GTCR.TPCS[2:0]中选择的计数时钟和在
GTUDDTYC.UD被忽略。如果同时使用硬件源进行向上计数和向下计数，则
GTCNT计数器值不会改变。使用硬件源向下计数的下溢行为与使用计数时钟向下计数的相同。

当GTCR.CST位设置为1以使用硬件源进行递减计数时，启用计数操作。什么时候
GTCR.CST设置为1，因为计数操作与GTCR.TPCS[2:0]中选择的计数时钟同步，所以计数器不能按GTCR.TPCS[2:0]中的规定递减1个时钟周期。当以1个PCLKD时钟延迟递减计数时，将GTCR.TPCS[2:0]设置为000b。

图22.9显示了一个由硬件源进行递减计数的周期性计数操作示例（时钟的上升沿）
GTETRGA pin).

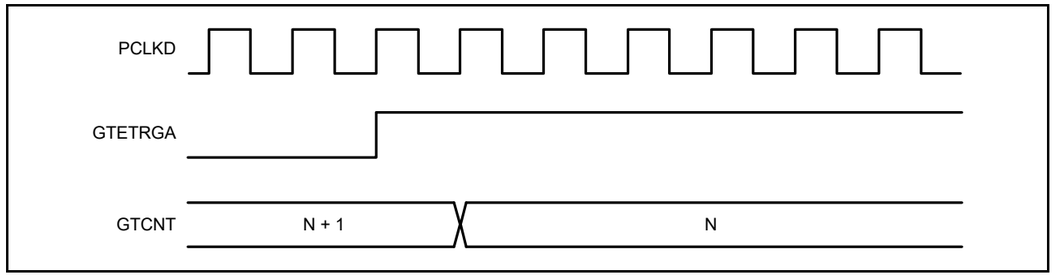


Figure 22.9 Example of event count operation in down-counting using hardware sources

Figure 22.10 shows an example setting for a periodic count operation in down-counting using a hardware source.

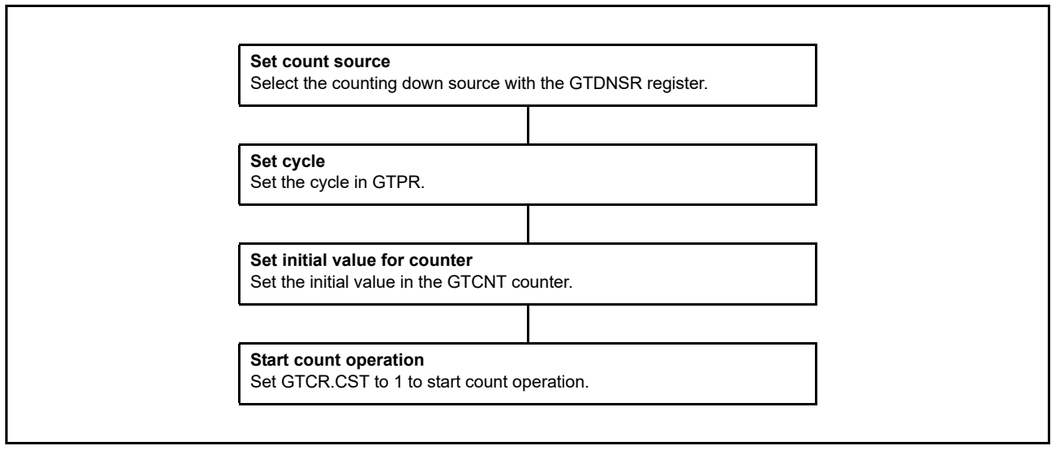


Figure 22.10 Example setting for an event count operation in down-counting using hardware sources

(6) Counter clear operation

The counter of each channel is cleared by the following sources:

- Writing 0 to GTCNT register
- Writing 1 to the bit in GTCLR associated with the GPT channel number when the GTCSR.CCLR bit is set to 1
- The hardware source selected in GTCSR register.

Writing to the GTCNT register is prohibited during count operation. The GTCNT counter can be cleared both by writing 1 to the GTCLR and by the clear request of hardware sources, whether GTCNT is counting (GTCR.CST is 1) or not (GTCR.CST is 0).

For saw waves selected by setting GTCR.MD[2:0] and the count direction flag showing down-counting (GTST.TUCF is 0), the GTCNT register is set to the value of the GTPR register when writing 1 to the GTCLR register or when clearing by hardware sources is performed.

When not in saw wave mode and down-counting, the GTCNT register is set to 0 when writing 1 to the GTCLR register and when clearing by hardware sources is performed.

In event count operation when at least 1 bit in the GTUPSR or GTDNSR is set to 1, after clear sources occur, both writing to the GTCLR register and clearing by hardware sources are performed immediately to synchronize with PCLKD. If other settings are used, clear is synchronized with the counter clock selected in GTCR.TPCS[2:0].

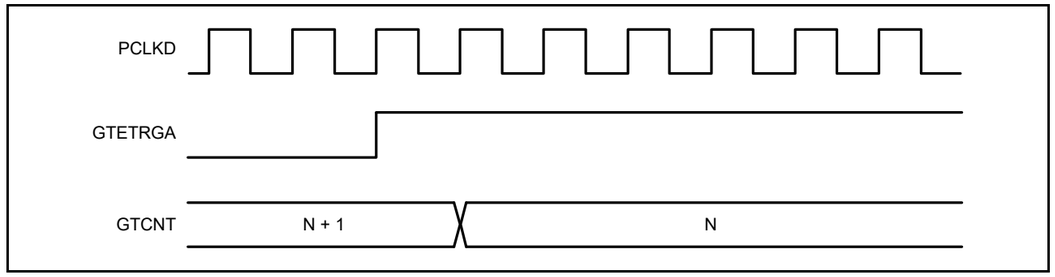


Figure 22.9 使用硬件源递减计数中的事件计数操作示例

图22.10显示了使用硬件源进行递减计数中的周期性计数操作的示例设置。

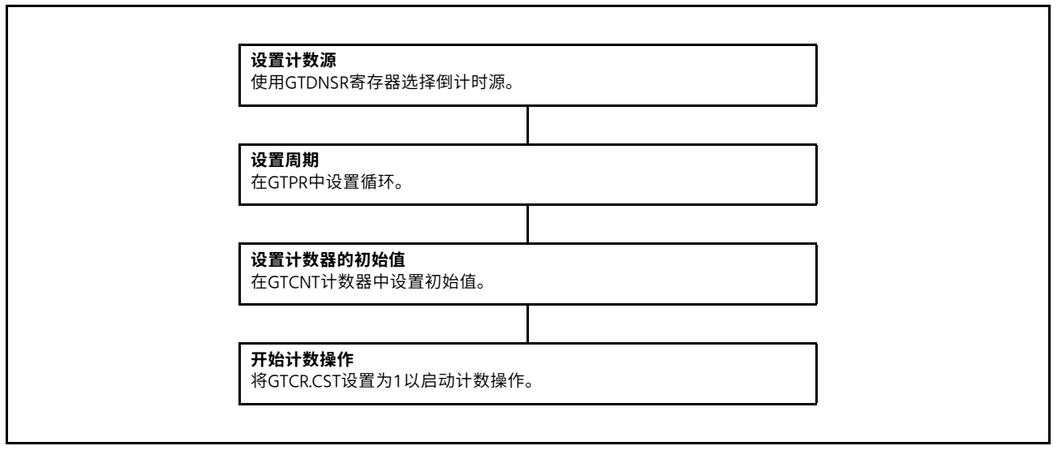


Figure 22.10 使用硬件源的递减计数中的事件计数操作设置示例

(6) 计数器清零操作

每个通道的计数器由以下源清除：

- 将0写入GTCNT寄存器
- 当GTCSR.CCLR位设置为1时，将1写入GTCLR中与GPT通道号相关的位
- 在GTCSR寄存器中选择的硬件源。

计数操作期间禁止写入GTCNT寄存器。GTCNT计数器可以通过向GTCLR写入1和硬件源的清除请求来清除，无论GTCNT正在计数（GTCR.CST为1）还是不计数（GTCR.CST为0）。

对于通过设置GTCR.MD[2:0]和显示递减计数的计数方向标志（GTST.TUCF为0）选择的锯齿波，当向GTCLR寄存器写入1时，GTCNT寄存器设置为GTPR寄存器的值或执行硬件源清除时。

当不处于锯齿波模式和递减计数时，当向GTCLR寄存器写入1并执行硬件源清零时，GTCNT寄存器设置为0。

在GTUPSR或GTDNSR中至少有1位设置为1的事件计数操作中，发生清除源后，立即执行写入GTCLR寄存器和通过硬件源清除以与PCLKD同步。如果使用其他设置，则清除与GTCR.TPCS[2:0]中选择的计数器时钟同步。

22.3.1.2 Waveform output by compare match

Compare match means that the GTCNT counter value matches the value of GTCCRA or GTCCRB. When a compare match occurs, the compare match flag is generated synchronously with the count clock, including the event count. At the same time the GPT can output low, high, or toggle output from the associated GTIOCA or GTIOCB output pin. In addition, the GTIOCA or GTIOCB pin output can be low, high, or toggled at the cycle end, which is determined by GTPR.

The cycle end is:

- For saw waves in up-counting — when GTCNT changes from the GTPR value to 0 (overflow)
- For saw waves in down-counting — when GTCNT changes from 0 to the GTPR value (underflow)
- For saw waves — when the GTCNT counter is cleared
- For triangle waves — when the GTCNT changes from 0 to 1 (trough).

(1) Low output and high output

Figure 22.11 shows an example of low output and high output operation by a compare match of GTCCRA and GTCCRB.

In this example, the GPT32EH0.GTCNT counter performs up-counting, and settings are made so that high is output from the GTIOC0A pin by a GPT32EH0.GTCCRA compare match, and low is output from the GTOC0B pin by a GPT32EH0.GTCCRB compare match. The pin level does not change when the specified level and pin level match.

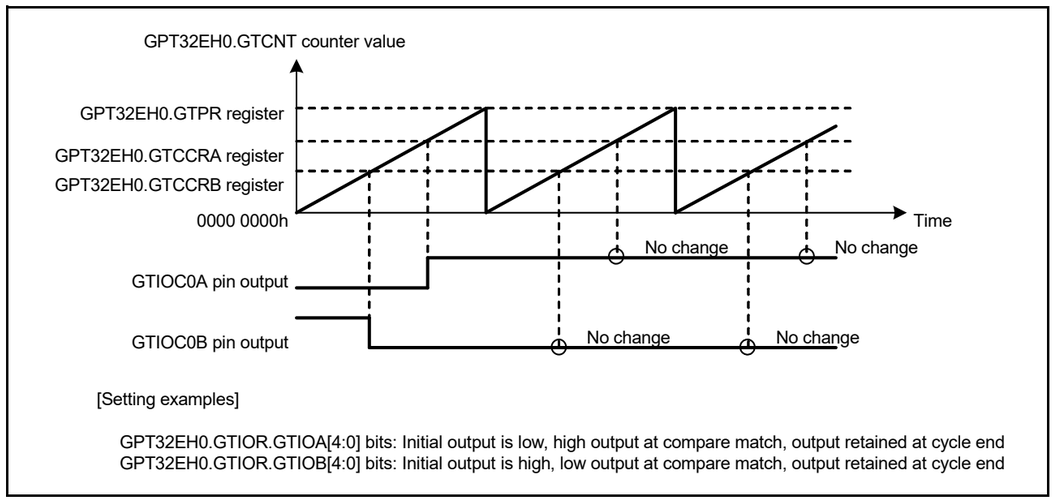


Figure 22.11 Example of low output and high output operation

Figure 22.12 shows an example setting for low output and high output operation.

22.3.1.2 比较匹配的波形输出

比较匹配意味着GTCNT计数器值与GTCCRA或GTCCRB的值匹配。当比较匹配发生时，比较匹配标志与计数时钟同步生成，包括事件计数。同时，GPT可以从相关的GTIOCA或GTIOCB输出引脚输出低、高或切换输出。此外，GTIOCA或GTIOCB引脚输出可以是低电平、高电平或在周期结束时切换，这由GTPR决定。

循环结束为：

- 对于向上计数中的锯齿波——当GTCNT从GTPR值变为0（溢出）时
- 对于向下计数中的锯齿波——当GTCNT从0变为GTPR值时（下溢）
- 对于锯齿波——当GTCNT计数器清零时
- 对于三角波——当GTCNT从0变为1（波谷）时。

(1) 低输出和高输出

图22.11显示了通过GTCCRA和比较匹配的低输出和高输出操作示例
GTCCRB.

在本例中，GPT32EH0.GTCNT计数器进行递增计数，设置为通过GPT32EH0.GTCCRA比较匹配从GTIOC0A引脚输出高电平，通过GPT32EH0.GTCCRB比较匹配从GTOC0B引脚输出低电平.当指定电平和引脚电平匹配时，引脚电平不会改变。

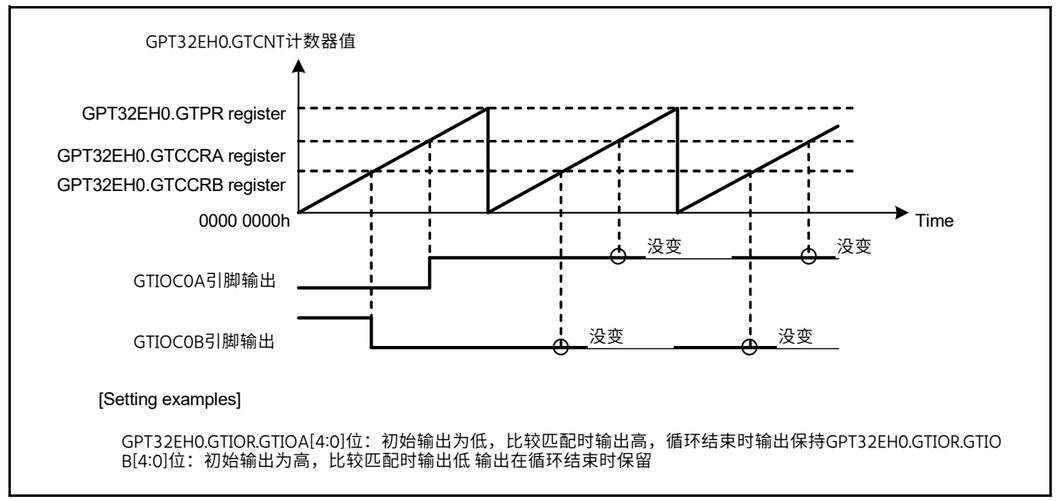
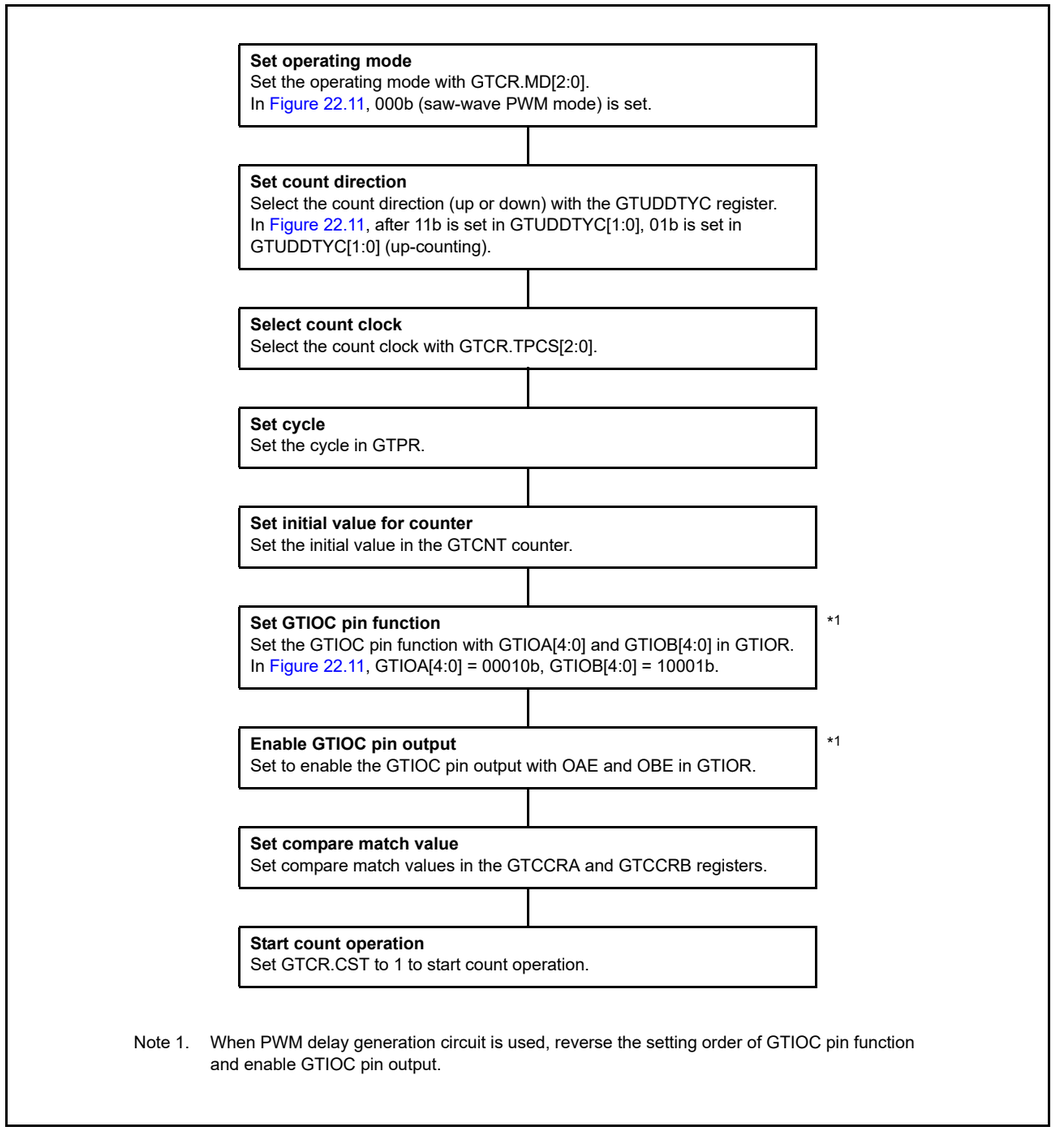


Figure 22.11 低输出和高输出操作示例

图22.12显示了低输出和高输出操作的示例设置。



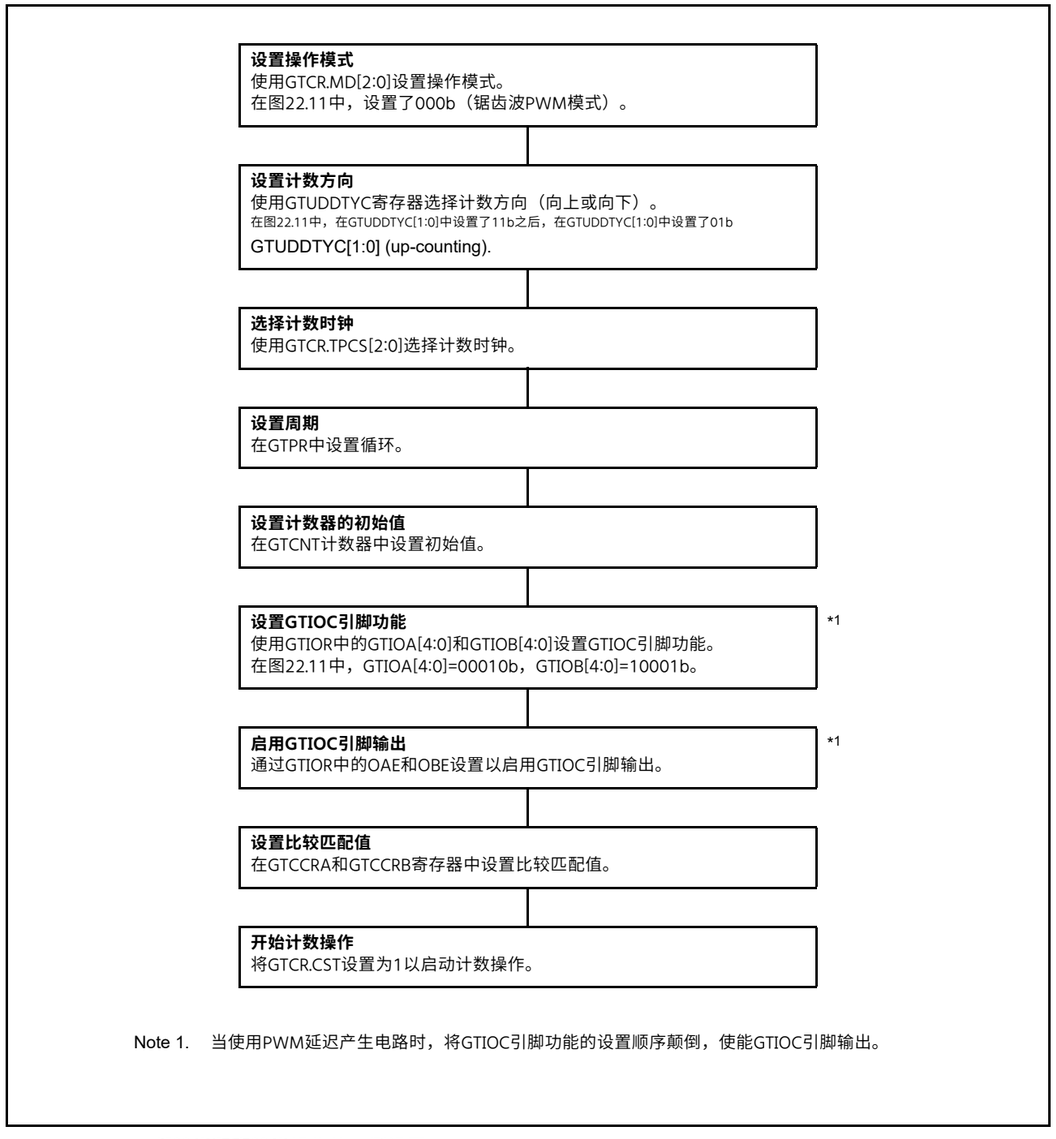
Note 1. When PWM delay generation circuit is used, reverse the setting order of GTIOC pin function and enable GTIOC pin output.

Figure 22.12 Example setting for low output and high output operation

(2) Toggled output

Figure 22.13 and Figure 22.14 show examples of toggled output operation by compare matches of GTCCRA and GTCCRB. In Figure 22.13, the GPT32EH0.GTCNT counter performs up-counting, and settings are made so that the GTIOC0A pin output by a GPT32EH0.GTCCRA compare match and GTIOC0B pin output by a GPT32EH0.GTCCRB compare match are toggled.

In Figure 22.14, the GPT32EH0.GTCNT counter performs up-counting, and settings are made so that the GTIOC0A output is toggled by a compare match of GPT32EH0.GTCCRA and the GTIOC0B output is toggled at the cycle end.



Note 1. 当使用PWM延迟产生电路时，将GTIOC引脚功能的设置顺序颠倒，使能GTIOC引脚输出。

Figure 22.12 低输出和高输出操作的示例设置

(2) Toggled output

图22.13和图22.14显示了通过比较匹配GTCCRA和
GTCCRB。在图22.13中，GPT32EH0.GTCNT计数器执行递增计数，并进行设置以使
GPT32EH0.GTCCRA比较匹配的GTIOC0A引脚输出和GPT32EH0.GTCCRB比较匹配的GTIOC0B引脚输出被切换。

在图22.14中，GPT32EH0.GTCNT计数器执行递增计数，并进行设置，以便通过GPT32EH0.GTCCRA的比较匹配来切换GTIOC0A输出，并在周期结束时切换GTIOC0B输出。

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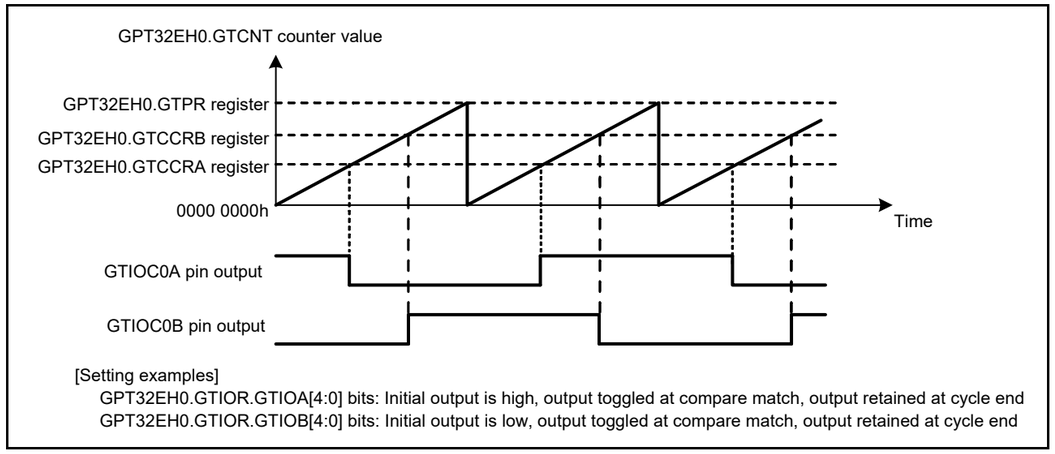


Figure 22.13 Example of toggled output operation (1)

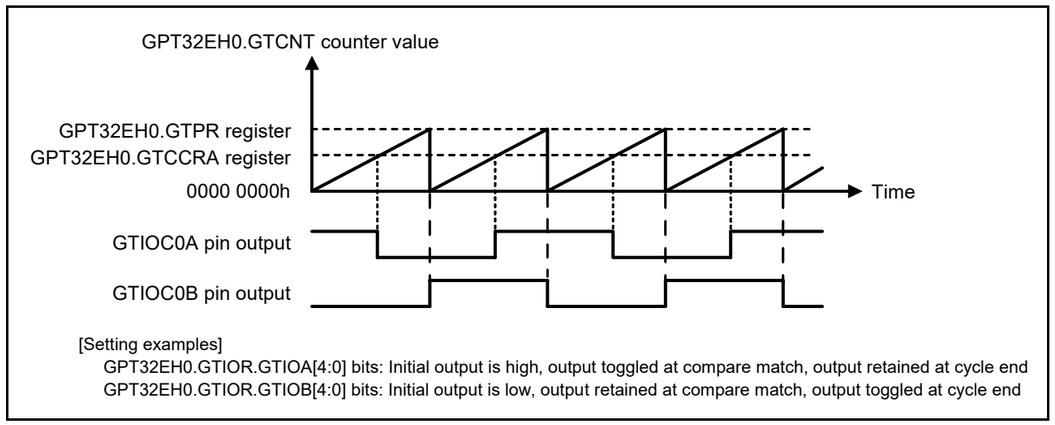


Figure 22.14 Example of toggled output operation (2)

Figure 22.15 shows an example setting for toggled output operation.

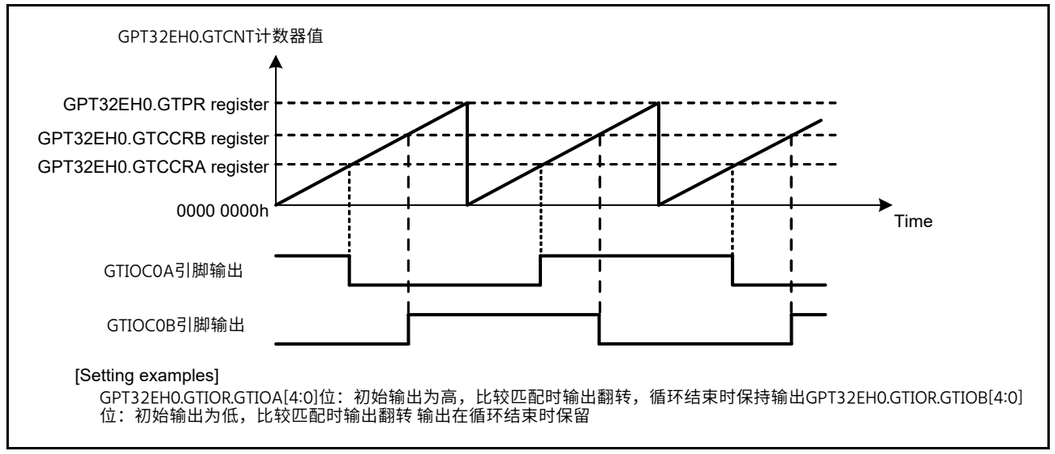


Figure 22.13 切换输出操作示例(1)

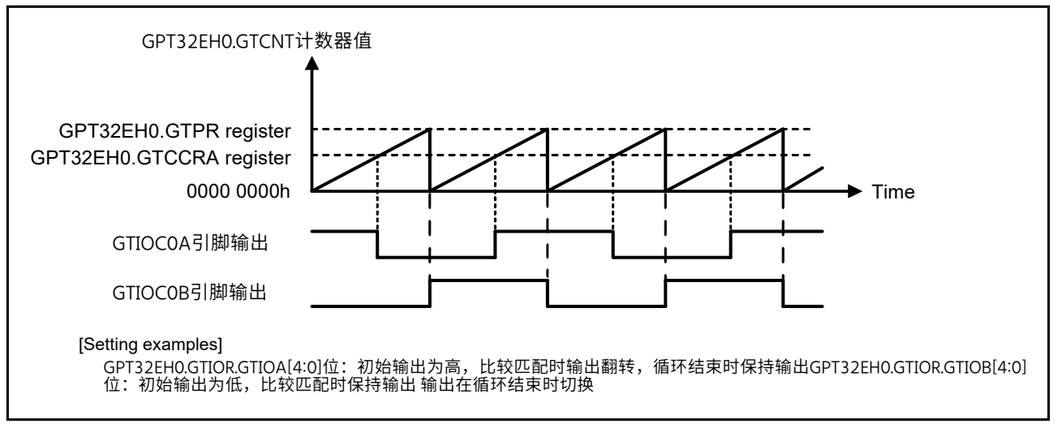
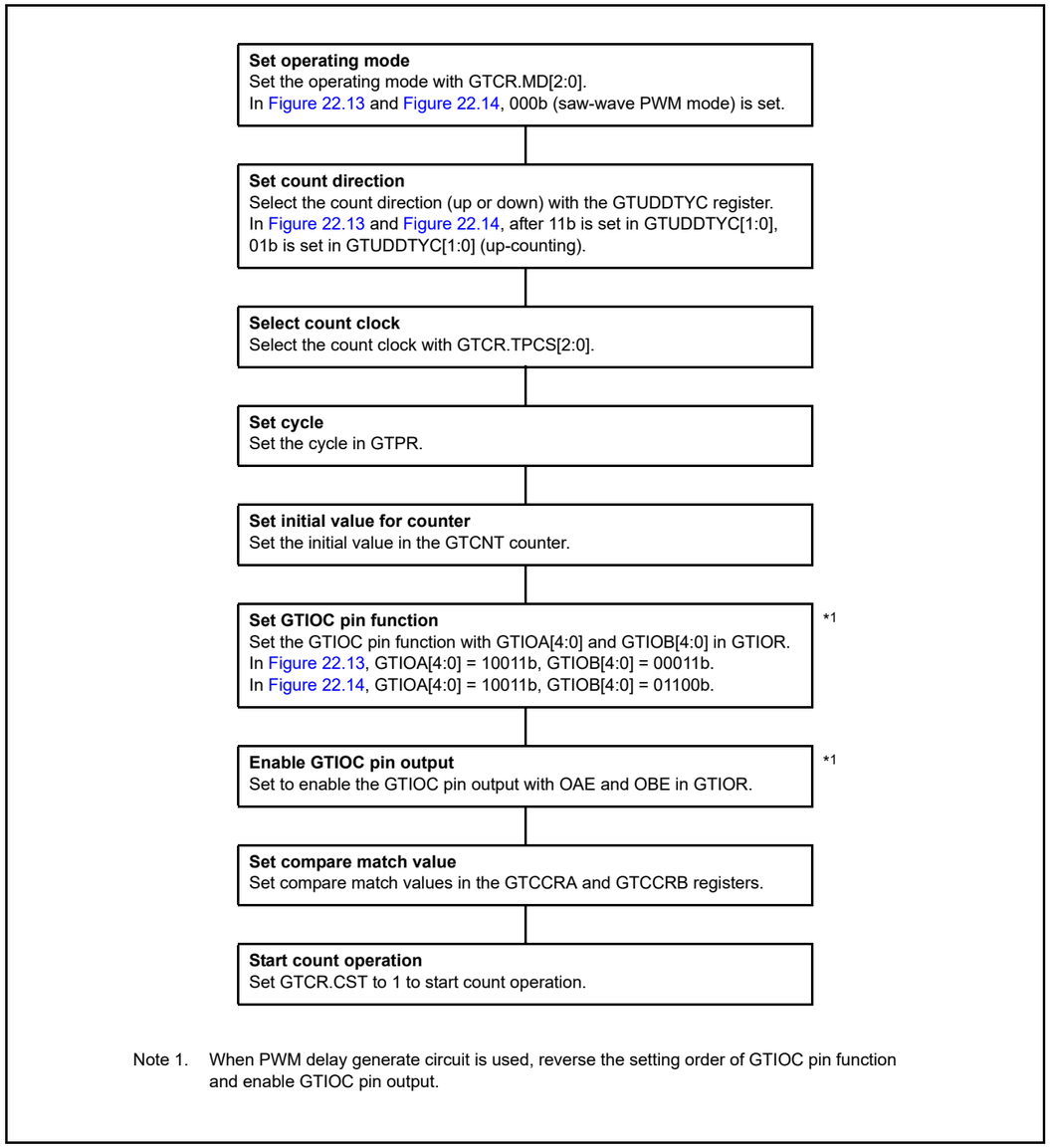


Figure 22.14 切换输出操作示例(2)

图22.15显示了切换输出操作的示例设置。



Note 1. When PWM delay generate circuit is used, reverse the setting order of GTIOC pin function and enable GTIOC pin output.

Figure 22.15 Example setting for toggled output operation

22.3.1.3 Input capture function

The GTCNT counter value can be transferred to either GTCCRA or GTCCRB on detection of the hardware source that is set in GTICASR and GTICBSR.

Figure 22.16 shows an example of the input capture function.

In this example, the GPT32EH0.GTCNT counter performs up-counting by the count clock, and settings are made so that an input capture is performed to GTICCRA at both edges of the GTIOC0A input pin and to GTICCRB on the rising edge of the GTIOC0B input pin.

Note 1. 当使用PWM延迟产生电路时，将GTIOC引脚功能的设置顺序颠倒，使能GTIOC引脚输出。

Figure 22.15 切换输出操作的示例设置

22.3.1.3 输入捕捉功能

在检测到在GTICASR和GTICBSR中设置的硬件源时，可以将GTCNT计数器值传输到GTCCRA或GTCCRB。

图22.16显示了输入捕获函数的示例。

在本例中，GPT32EH0.GTCNT计数器通过计数时钟进行递增计数，并设置为在GTIOC0A输入引脚的两个边沿对GTICCRA进行输入捕捉，在GTIOC0B输入的上升沿对GTICCRB进行输入捕捉别针。

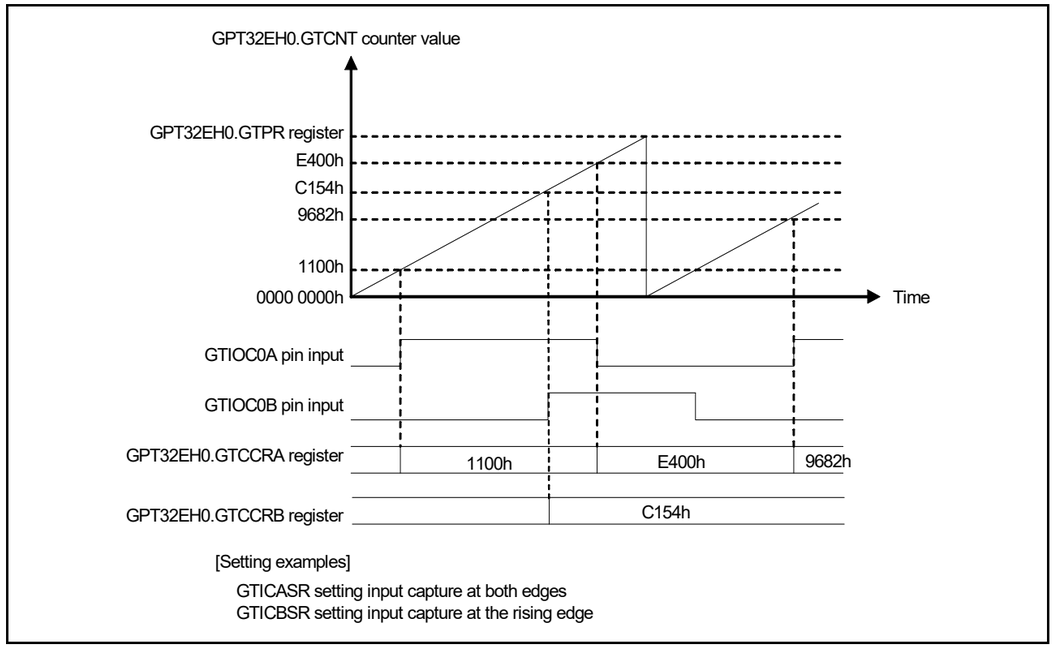


Figure 22.16 Example of input capture operation

Figure 22.17 shows an example setting for an input capture operation with count operation by the count clock.

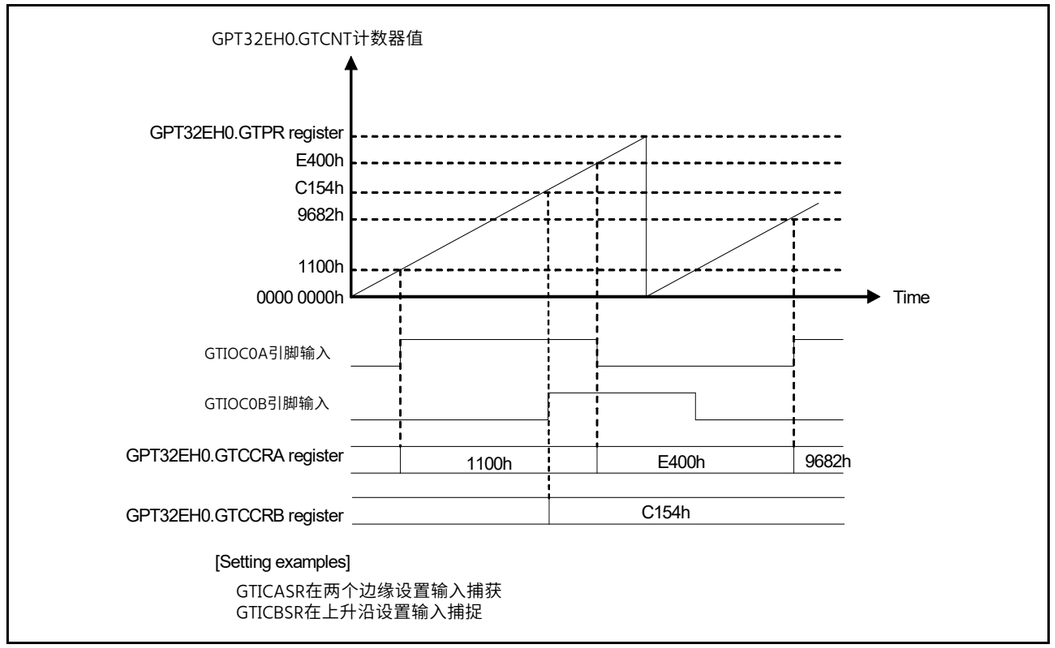


Figure 22.16 输入捕捉操作示例

图22.17显示了通过计数时钟进行计数操作的输入捕捉操作的示例设置。

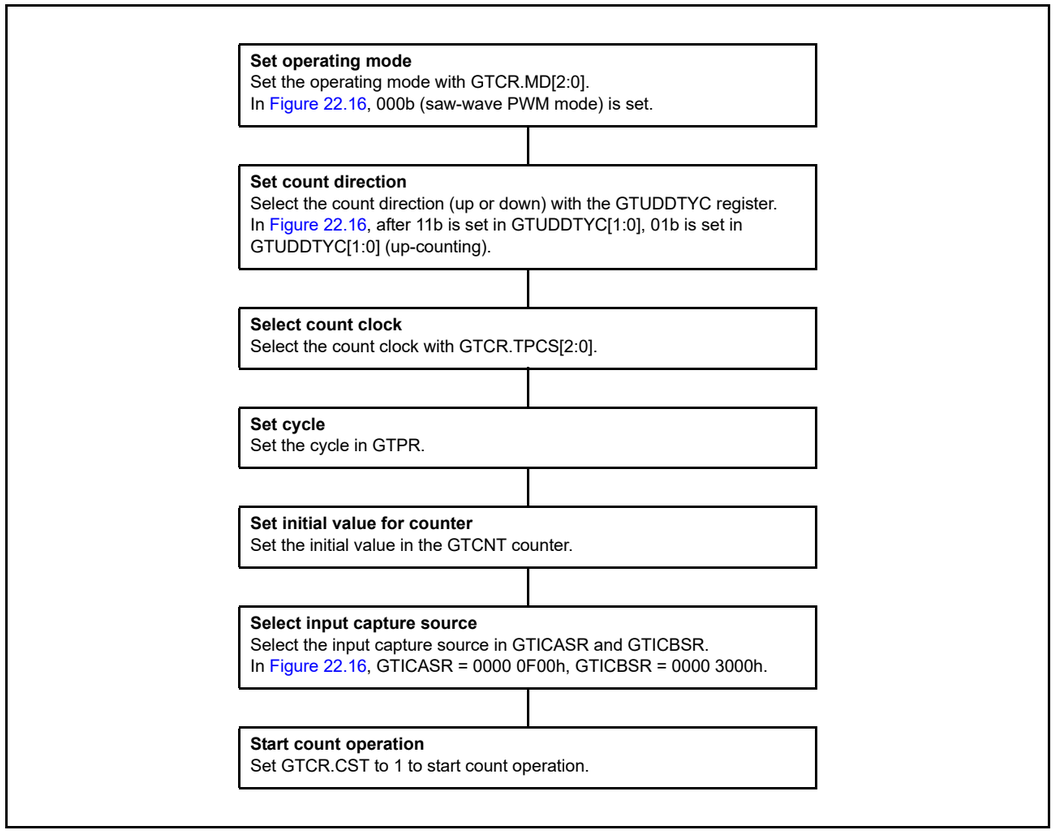


Figure 22.17 Example setting for input capture operation

22.3.2 Buffer Operation

The following buffer operations can be set with GTBER:

- GTPR, GTPBR, and GTPDBR
- GTCCRA, GTCCRC, and GTCCRD
- GTCCRB, GTCCRE, and GTCCRF
- GTADTRA, GTADTBRA, and GTADTDBRA
- GTADTRB, GTADTBRB, and GTADTDBRB.

The following buffer operations can be set with GTDTCR:

- GTDVU and GTDBU
- GTDVD and GTDBD.

22.3.2.1 GTPR register buffer operation

GTPBR can function as a buffer register for GTPR, and GTPDBR can function as a buffer register for GTPBR (double-buffer register for GTPR). The buffer transfer is performed at an overflow (during up-counting) or an underflow (during down-counting) in saw-wave mode or in event count, and at a trough in triangle-wave mode.

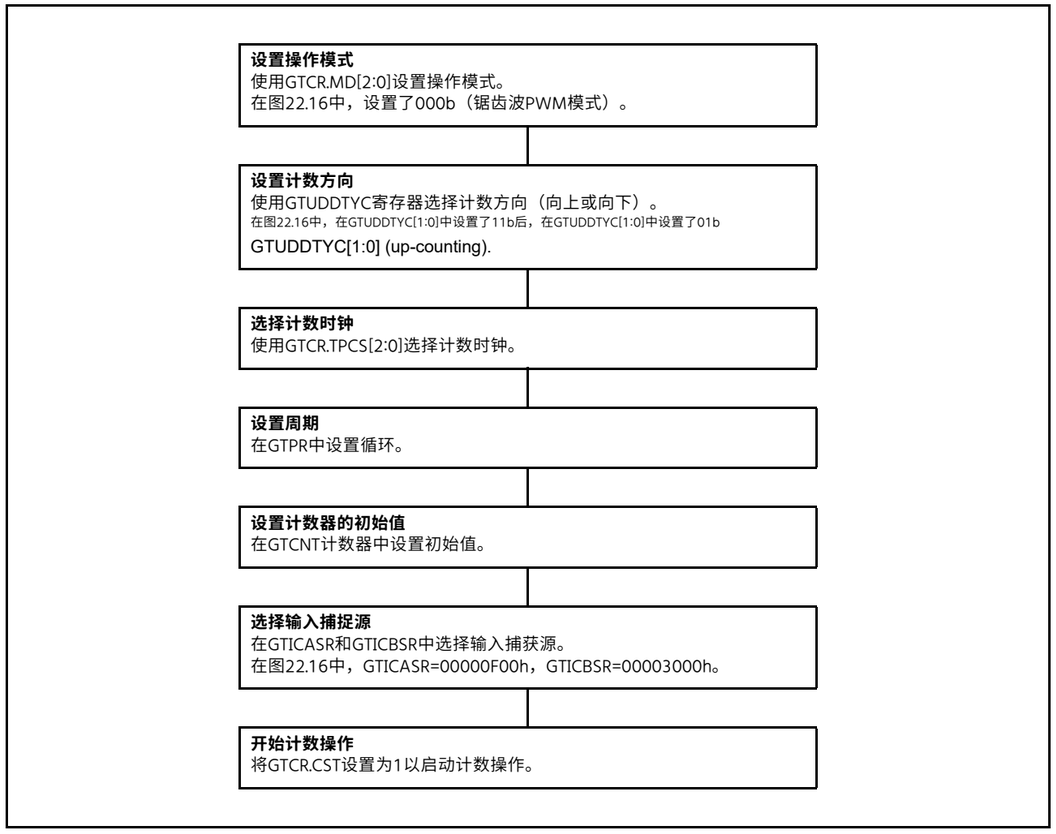


Figure 22.17 输入捕捉操作的示例设置

22.3.2 缓冲操作

可以使用GTBER设置以下缓冲区操作：

- GTPR, GTPBR, and GTPDBR
- GTCCRA, GTCCRC, and GTCCRD
- GTCCRB, GTCCRE, and GTCCRF
- GTADTRA, GTADTBRA, and GTADTDBRA
- GTADTRB, GTADTBRB, and GTADTDBRB.

可以使用GTDTCR设置以下缓冲区操作：

- GTDVU and GTDBU
- GTDVD and GTDBD.

22.3.2.1 GTPR寄存器缓冲操作

GTPBR可以作为GTPR的缓冲寄存器，GTPDBR可以作为GTPBR的缓冲寄存器（GTPR的双缓冲寄存器）。缓冲区传输在锯齿波模式或事件计数中的上溢（向上计数期间）或下溢（向下计数期间）以及三角波模式的波谷处执行。

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In saw-wave mode or in event count, the buffer transfer is performed when the following counter clear operations occur during counting:

- Clear by hardware sources (the clear source is selected in GTCSR[23:0])
- Clear by software (when GTCSR.CCLR bit is 1 and GTCLR[n] bit is set to 1, n = channel number).

To set GTPR to function as double buffer, set GTBER.PR[1:0] to 10b or 11b. To set GTPR to not function as a buffer, set GTBER.PR[1:0] to 00b.

Figure 22.18 to Figure 22.20 show examples of GTPR buffer operation, and Figure 22.21 shows an example setting for GTPR buffer operation.

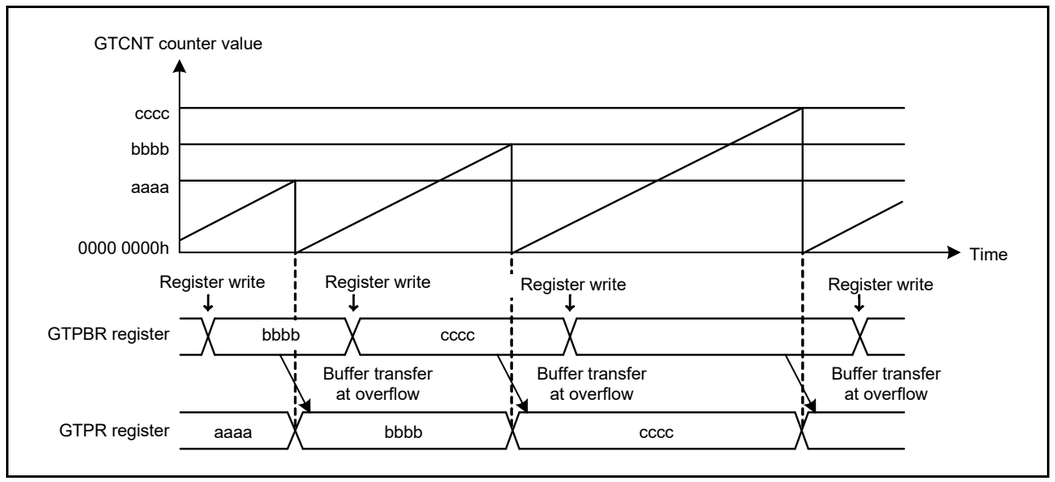

Figure 22.18 Example of GTPR buffer operation with saw waves in up-counting

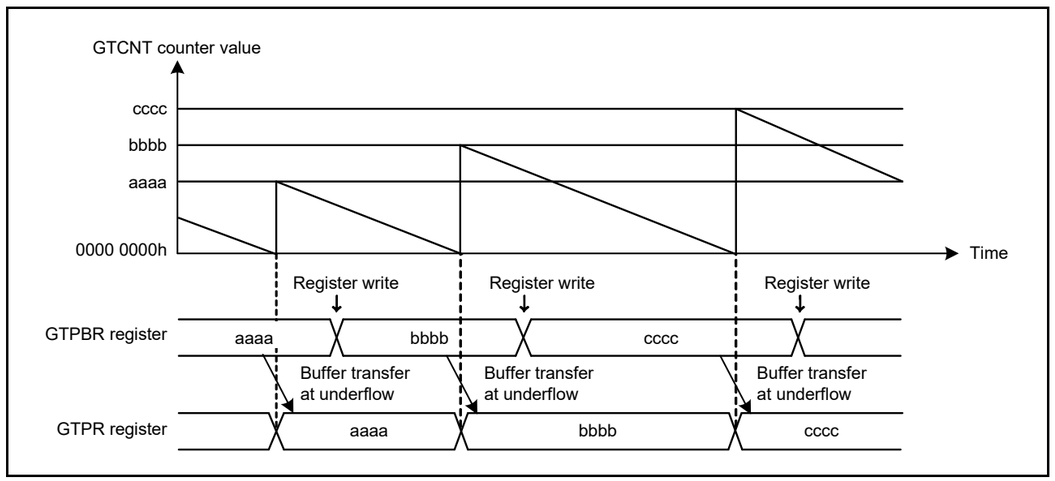

Figure 22.19 Example of GTPR buffer operation with saw waves in down-counting

在锯齿波模式或事件计数中，当计数期间发生以下计数器清零操作时，将执行缓冲区传输：

- 通过硬件源清除（清除源在GTCSR[23:0]中选择）
- 由软件清零（当GTCSR.CCLR位为1且GTCLR[n]位设置为1时，n=通道号）。

要将GTPR设置为双缓冲区，请将GTBER.PR[1:0]设置为10b或11b。要将GTPR设置为不用作缓冲区，请设置GTBER.PR[1:0] to 00b.

图22.18至图22.20显示了GTPR缓冲区操作的示例，图22.21显示了示例设置GTPR缓冲区操作。

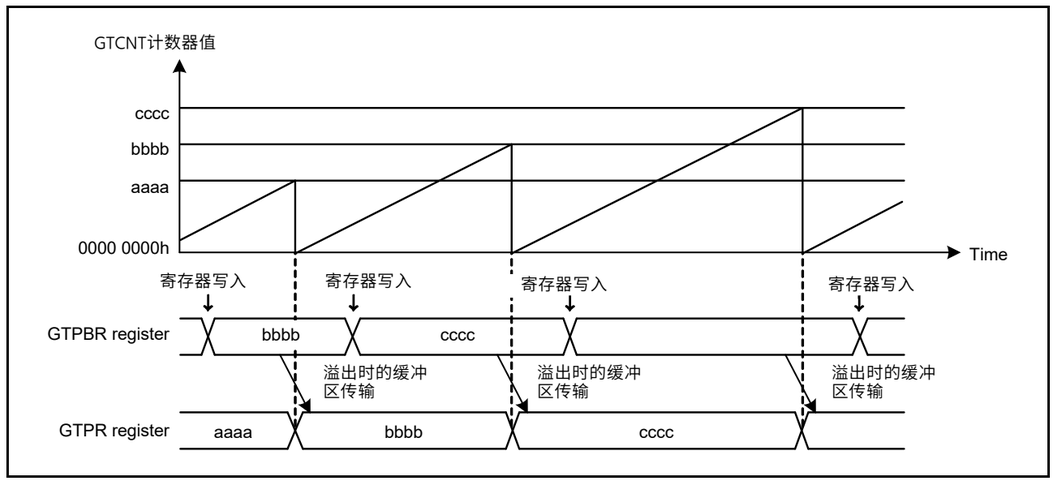

Figure 22.18 GTPR缓冲区操作示例，在向上计数中使用锯齿波

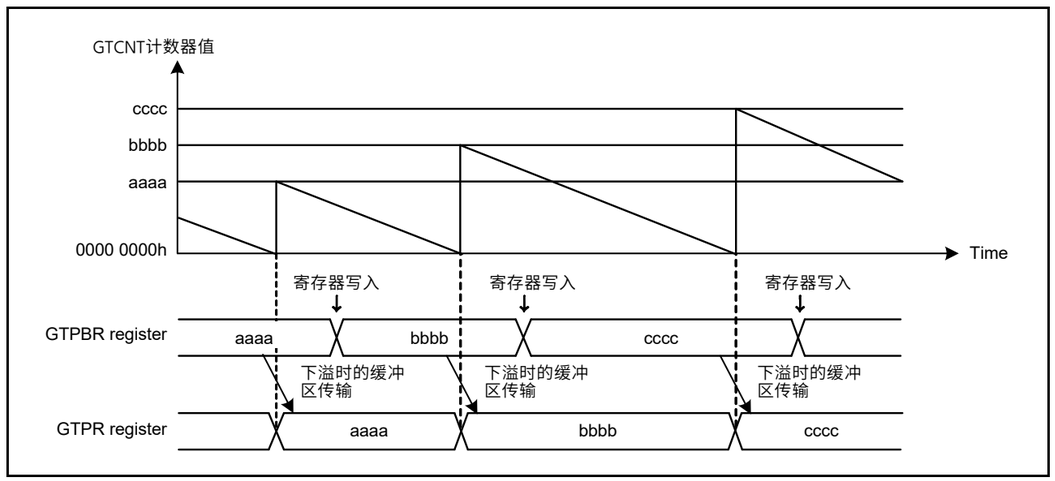

Figure 22.19 向下计数中锯波的GTPR缓冲区操作示例

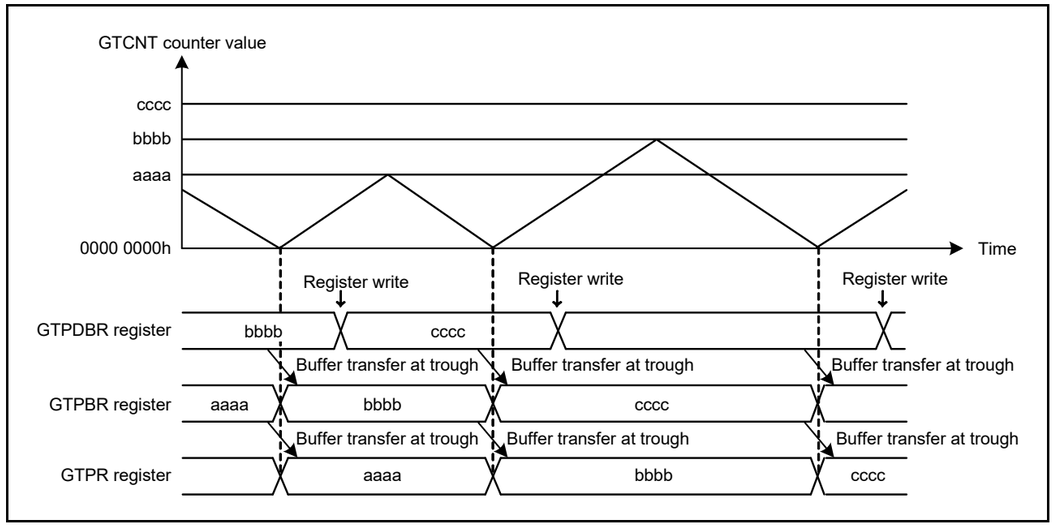

Figure 22.20 Example of GTPR double buffer operation with triangle waves

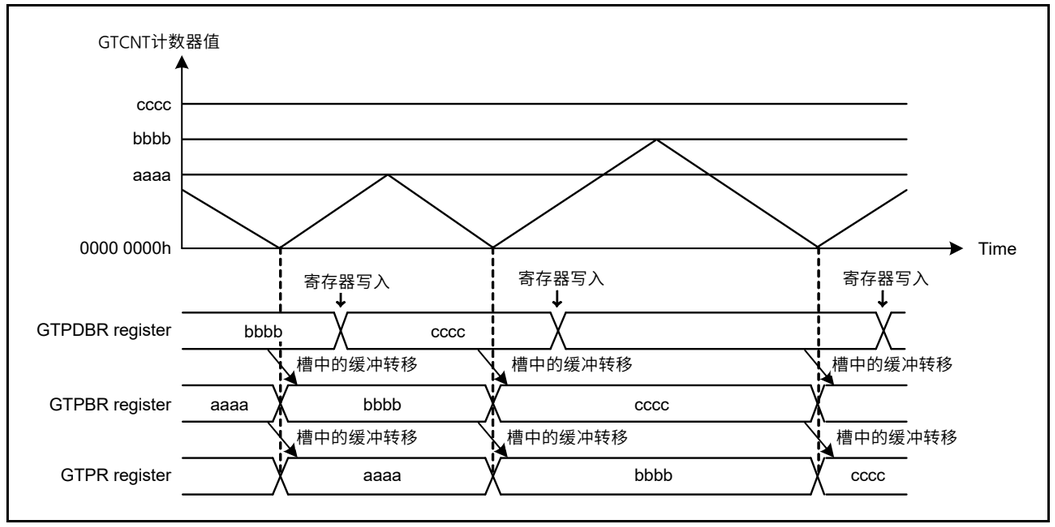

Figure 22.20 使用三角波的GTPR双缓冲操作示例

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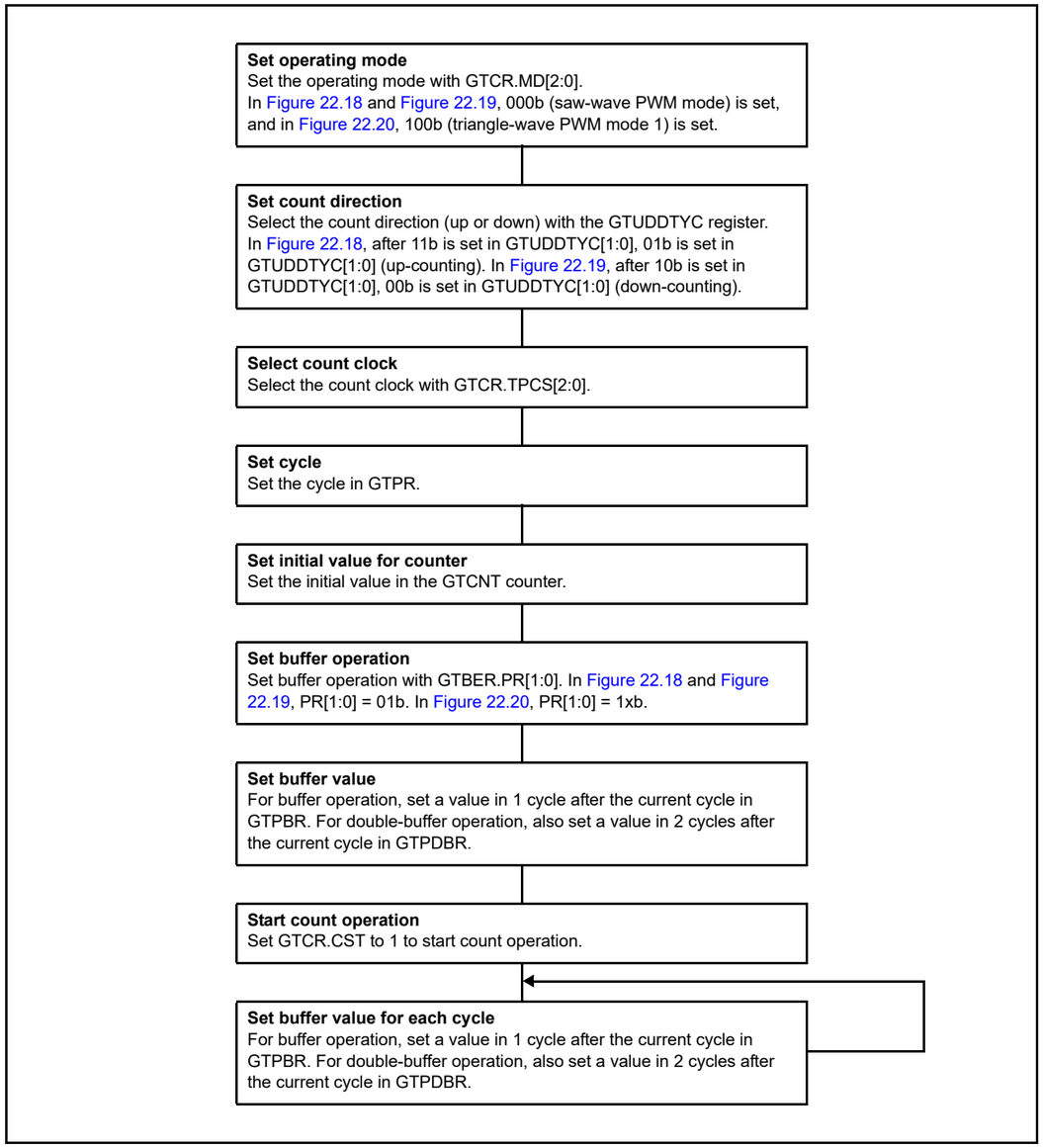

Figure 22.21 Example setting for GTPR buffer operation

22.3.2.2 Buffer operation for GTCCRA and GTCCRB

GTCCRC can function as the GTCCRA buffer register and GTCCRD can function as the GTCCRC buffer register (double-buffer register for GTCCRA). Similarly, GTCCRE can function as the GTCCRB buffer register and GTCCRF can function as the GTCCRE buffer register (double-buffer register for GTCCRB).

To set GTCCRA or GTCCRB to function as a double buffer, set GTBER.CCRA[1:0] or GTBER.CCRB[1:0] to 10b or 11b. For single-buffer operation, set GTBER.CCRA[1:0] or GTBER.CCRB[1:0] to 01b. To set GTCCRA or GTCCRB to not function as a buffer, set GTBER.CCRA[1:0] or GTBER.CCRB[1:0] to 00b.

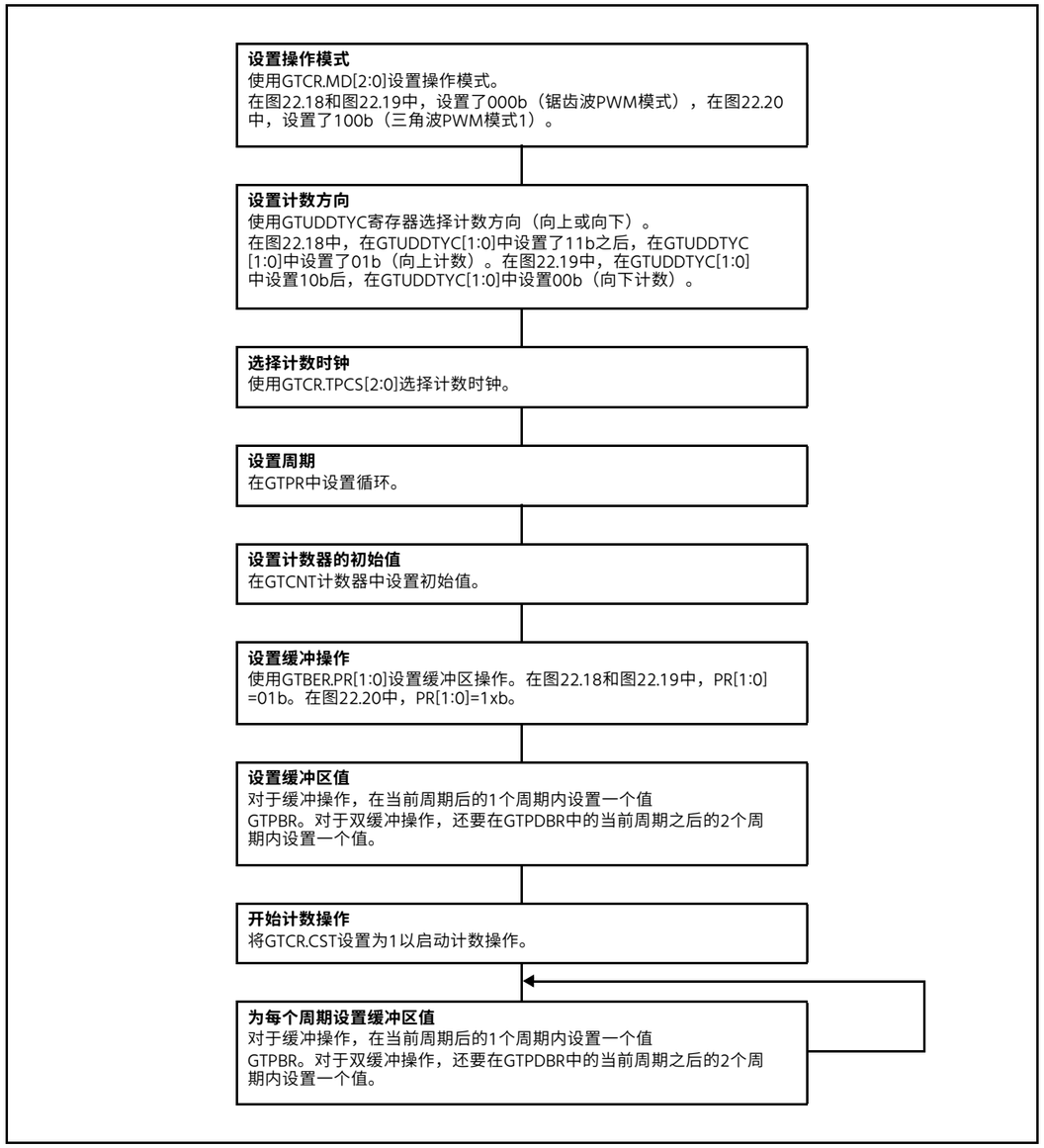

Figure 22.21 GTPR缓冲区操作的示例设置

22.3.2.2 GTCCRA和GTCCRB的缓冲操作

GTCCRC可以作为GTCCRA缓冲寄存器，GTCCRD可以作为GTCCRC缓冲寄存器（GTCCRA的双缓冲寄存器）。同样，GTCCRE可以作为GTCCRB缓冲寄存器，GTCCRF可以作为GTCCRE缓冲寄存器（GTCCRB的双缓冲寄存器）。

要将GTCCRA或GTCCRB设置为双缓冲区，请将GTBER.CCRA[1:0]或GTBER.CCRB[1:0]设置为10b或11b。对于单缓冲区操作，将GTBER.CCRA[1:0]或GTBER.CCRB[1:0]设置为01b。要将GTCCRA或GTCCRB设置为不用作缓冲区，请将GTBER.CCRA[1:0]或GTBER.CCRB[1:0]设置为00b。

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(1) When GTCCRA or GTCCRB functions as an output compare register

Buffer transfer occurs in the following situations:

- Buffer transfer by overflow or underflow
  Buffer transfer is performed at an overflow (during up-counting) or an underflow (during down-counting) in saw-wave mode or in event count operation. In triangle-wave mode, buffer transfer is performed at a trough (triangle-wave PWM mode 1) or a crest and trough (triangle-wave PWM mode 2).
- Buffer transfer by counter clear
  In saw-wave mode or in event count operation, during counting, buffer transfer (which is the same as an overflow during up-counting or an underflow during down-counting) is performed by the counter clear sources similar to the case shown in section 22.3.2.1, GTPR register buffer operation. In triangle-wave mode, buffer transfer is not performed by the counter clear.
- Forcible buffer transfer
  When GTBER.CCRSWT bit is set to 1 while the count operation is stopped, the GTCCRA and the GTCCRB register buffer transfers are performed forcibly in saw-wave mode, in event count operation, and in triangle-wave mode. Additionally, buffer transfer from the GTCCRD register to temporary register A and from the GTCCRF register to temporary register B are performed in saw-wave one-shot pulse mode or triangle-wave PWM mode 3.

Figure 22.22 to Figure 22.24 show examples of GTCCRA and GTCCRB buffer operation and Figure 22.25 shows an example setting for GTCCRA and GTCCRB buffer operation.

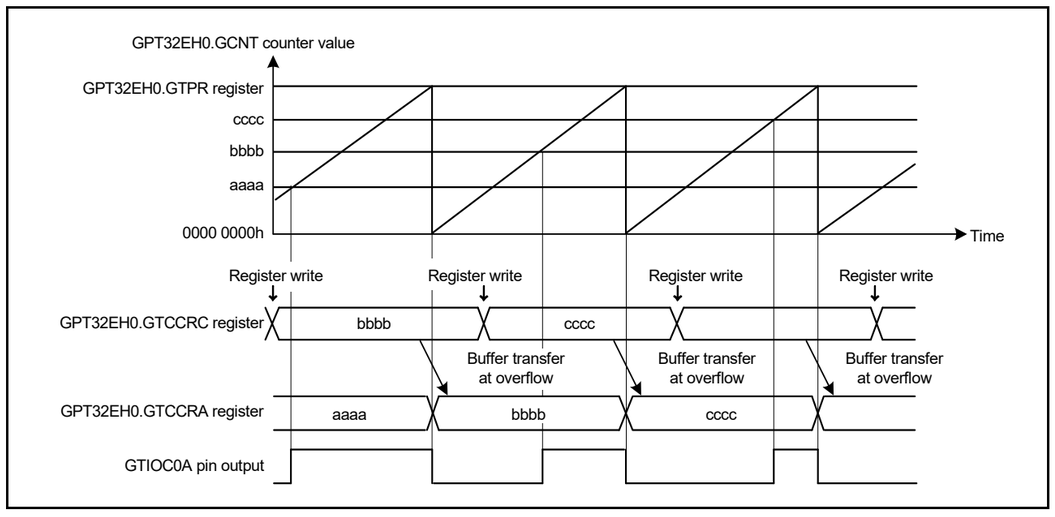

Figure 22.22 Example of GTCCRA and GTCCRB buffer operation with output compare, saw waves in up-counting, high output at GTCCRA compare match, and low output at cycle end

(1) 当GTCCRA或GTCCRB用作输出比较寄存器时

缓冲区传输发生在以下情况：

- 通过上溢或下溢进行缓冲区传输
  在锯齿波模式或事件计数操作中，在溢出（向上计数期间）或下溢（向下计数期间）时执行缓冲区传输。在三角波模式中，缓冲区传输在波谷（三角波PWM模式1）或波峰和波谷（三角波PWM模式2）处执行。
- 通过计数器清除缓冲区传输
  在锯齿波模式或事件计数操作中，在计数期间，缓冲区传输（与向上计数期间的溢出或向下计数期间的下溢相同）由计数器清零源执行，类似于章节中所示的情况22.3.2.1、GTPR寄存器缓冲操作。在三角波模式下，计数器清零不执行缓冲区传输。
- 强制缓冲转移
  如果在计数操作停止时将GTBER.CCRSWT位设置为1，则在锯齿波模式、事件计数操作和三角波模式下强制执行GTCCRA和GTCCRB寄存器缓冲传输。此外，从GTCCRD寄存器到临时寄存器A和从GTCCRF寄存器到临时寄存器B的缓冲区传输是在锯齿波一次性脉冲模式或三角波PWM模式3中执行的。

图22.22至图22.24显示了GTCCRA和GTCCRB缓冲操作的示例，图22.25显示了GTCCRA和GTCCRB缓冲操作的示例设置。

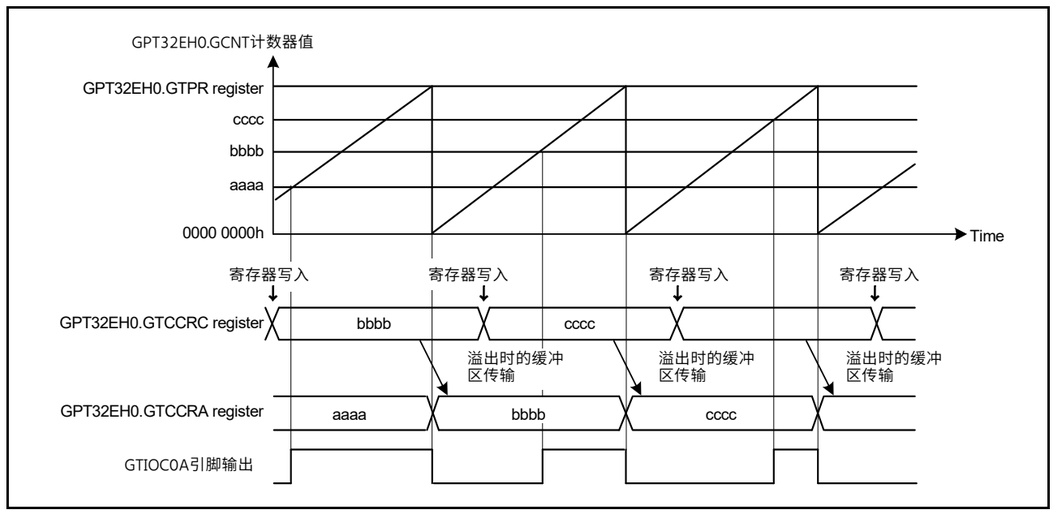

Figure 22.22 GTCCRA和GTCCRB缓冲器操作示例，输出比较、递增计数中的锯齿波、GTCCRA比较匹配时的高输出和周期结束时的低输出

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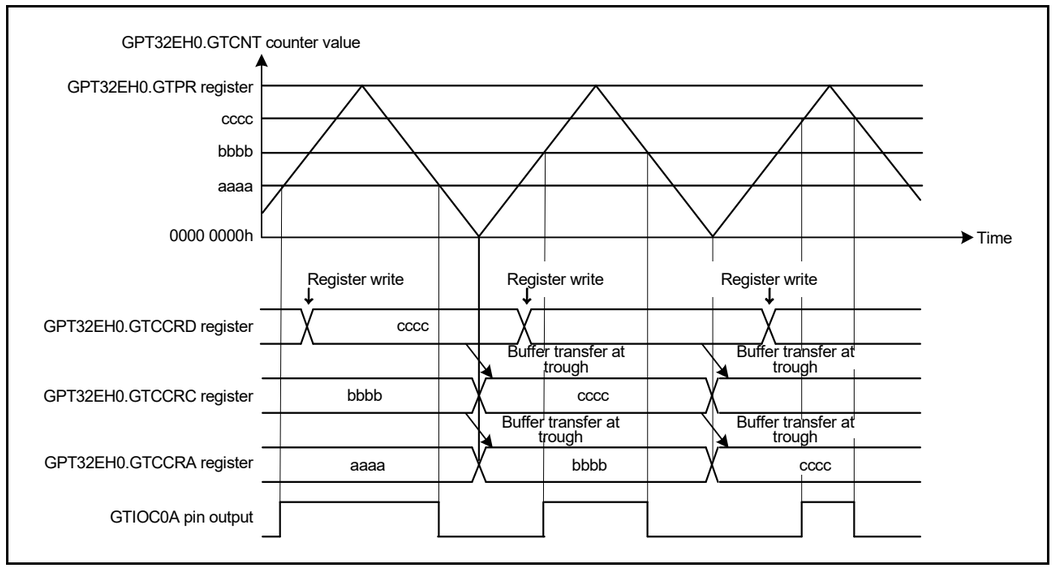

Figure 22.23 Example of GTCCRA and GTCCRB double buffer operation with output compare, triangle waves, buffer operation at trough, output toggled at GTCCRA compare match, and output retained at cycle end

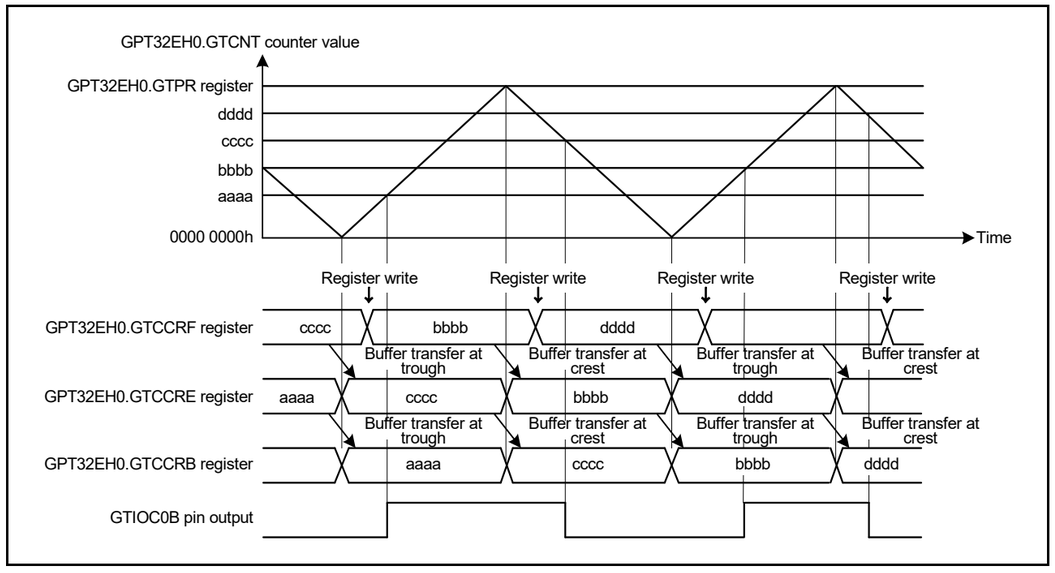

Figure 22.24 Example of GTCCRA and GTCCRB double buffer operation with output compare, triangle waves, buffer operation at both troughs and crests, output toggled at GTCCRB compare match, and output retained at cycle end

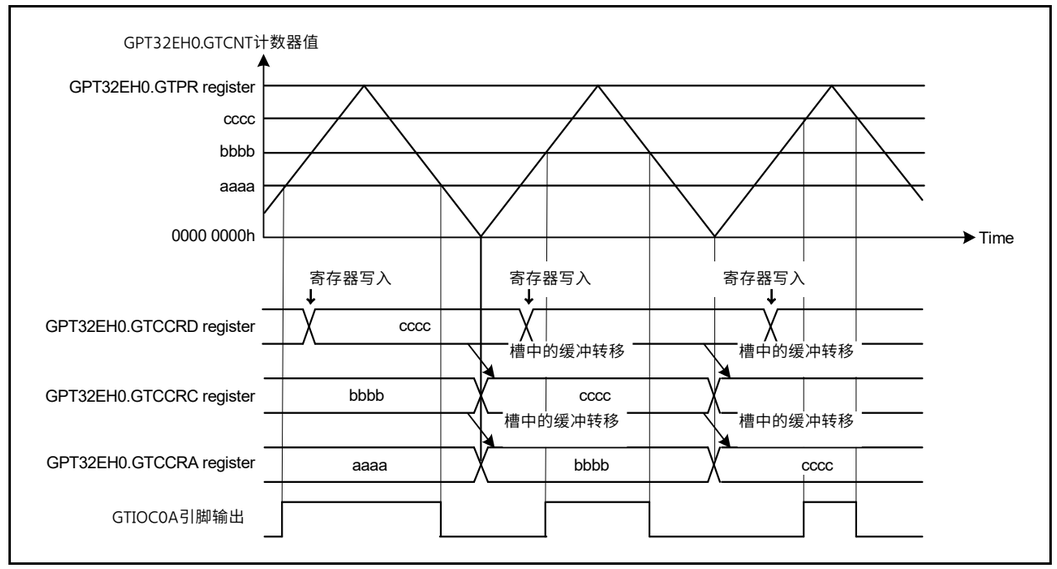

Figure 22.23 GTCCRA和GTCCRB双缓冲操作示例，输出比较、三角波、波谷缓冲操作、GTCCRA比较匹配时切换输出、循环结束时保留输出

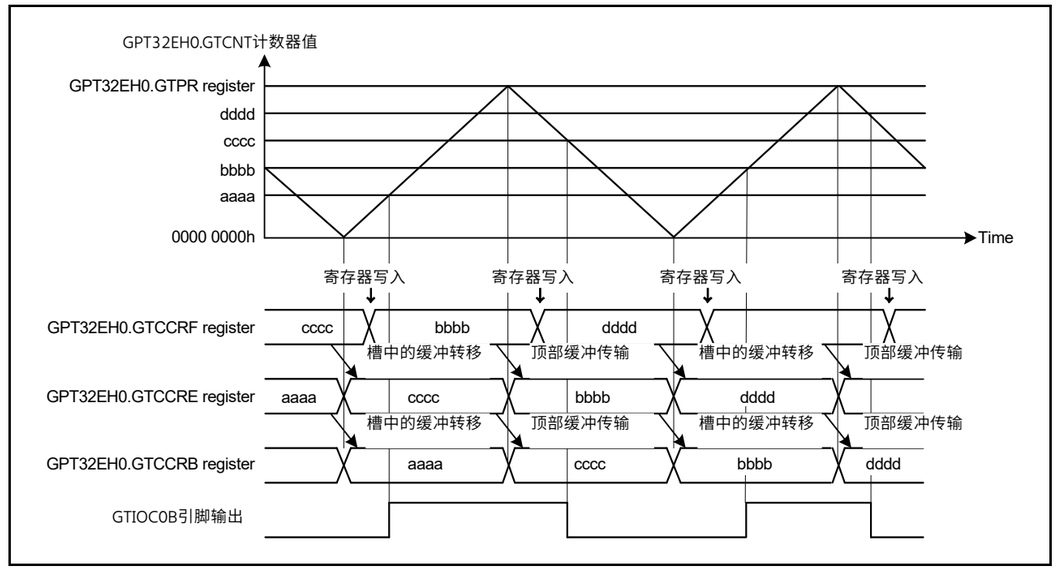

Figure 22.24 GTCCRA和GTCCRB双缓冲操作示例，输出比较、三角波、波谷和波峰缓冲操作、在GTCCRB比较匹配时切换输出以及在周期结束时保留输出

Set operating mode
Set the operating mode with GTCR.MD[2:0].
In Figure 22.22, 000b (saw-wave PWM mode) is set, in Figure 22.23, 100b (triangle-wave PWM mode 1) is set, and in Figure 22.24, 101b (triangle-wave PWM mode 2) is set.

Set count direction
Select the count direction (up or down) with the GTUDDTYC register.
In Figure 22.22, after 11b is set in GTUDDTYC[1:0], 01b is set in GTUDDTYC[1:0] (up-counting).

Select count clock
Select the count clock with GTCR.TPCS[2:0].

Set cycle
Set the cycle in GTPR.

Set initial value for counter
Set the initial value in the GTCNT counter.

Set GTIOC pin function
Set the GTIOC pin function with GTIOA[4:0] and GTIOB[4:0] in GTIOR.
In Figure 22.22, GTIOA[4:0] = 00110b, in Figure 22.23, GTIOA[4:0] = 00011b, and in Figure 22.24, GTIOB[4:0] = 00011b.

Enable GTIOC pin output *1
Set to enable the GTIOC pin output with OAE and OBE in GTIOR.

Set buffer operation
Set buffer operation with CCRA and CCRB in GTBER.
In Figure 22.22, CCRA = 01b, in Figure 22.23, CCRA = 1xb, and in Figure 22.24, CCRB = 1xb.

Set compare match value *1
Set the GTIOCA pin transition in GTCCRA and GTIOCB pin transition in GTCCRB.

Set buffer value
For buffer operation, set the GTIOCA pin and GTIOCB pin transitions in 1 cycle after the current cycle (in saw-wave mode or triangle-wave mode with buffer transfer at trough) or 1/2 cycle after the current cycle (in triangle-wave mode with buffer transfer at both trough and crest) in GTCCRC and GTCCRE, respectively.
For double buffer operation, also set the GTIOCA pin and GTIOCB pin transitions in 2 cycles after the current cycle (in saw-wave mode or triangle-wave mode with buffer transfer at trough) or 1 cycle after the current cycle (in triangle-wave mode with buffer transfer at both trough and crest) in GTCCRD and GTCCRF, respectively.

Start count operation
Set GTCR.CST to 1 to start count operation.

Set buffer value for each cycle
For buffer operation, set the GTIOCA pin and GTIOCB pin transitions in 1 cycle after the current cycle (in saw-wave mode or triangle-wave mode with buffer transfer at trough) or 1/2 cycle after the current cycle (in triangle-wave mode with buffer transfer at both trough and crest) in GTCCRC and GTCCRE, respectively.
For double buffer operation, also set the GTIOCA pin and GTIOCB pin transitions in 2 cycles after the current cycle (in saw-wave mode or triangle-wave mode with buffer transfer at trough) or 1 cycle after the current cycle (in triangle-wave mode with buffer transfer at both trough and crest) in GTCCRD and GTCCRF, respectively.

Note 1. When the PWM delay generation circuit is used, exchange the sequence of the step for Enable GTIOC pin output and the step for Set compare-match value.

Figure 22.25 Example setting for GTCCRA and GTCCRB buffer operation with output compare

设置操作模式
使用GTCR.MD[2:0]设置操作模式。
在图22.22中，设置了000b（锯齿波PWM模式），在图22.23中，设置了100b（三角波PWM模式1），在图22.24、101b（三角波PWM模式2）设置。

设置计数方向
使用GTUDDTYC寄存器选择计数方向（向上或向下）。
在图22.22中，在GTUDDTYC[1:0]中设置11b后，在GTUDDTYC[1:0]中设置01b（向上计数）。

选择计数时钟
使用GTCR.TPCS[2:0]选择计数时钟。

设置周期
在GTPR中设置循环。

设置计数器的初始值
在GTCNT计数器中设置初始值。

设置GTIOC引脚功能
使用GTIOR中的GTIOA[4:0]和GTIOB[4:0]设置GTIOC引脚功能。
在图22.22中，GTIOA[4:0]=00110b，在图22.23中，GTIOA[4:0]=00011b，在图22.24中，GTIOB[4:0]=00011b。

启用GTIOC引脚输出 *1
通过GTIOR中的OAE和OBE设置以启用GTIOC引脚输出。

设置缓冲操作
在GTBER中使用CCRA和CCRB设置缓冲区操作。
在图22.22中，CCRA=01b，在图22.23中，CCRA=1xb，在图22.24中，CCRB=1xb。

设置比较匹配值 *1
在GTCCRA中设置GTIOCA引脚转换，在GTCCRB中设置GTIOCB引脚转换。

设置缓冲区值
对于缓冲操作，设置GTIOCA引脚和GTIOCB引脚在当前周期后1个周期（在锯齿波模式或在波谷处缓冲传输的三角波模式）或当前周期后的12个周期（在三角波模式分别在GTCCRC和GTCCRE中的波谷和波峰处进行缓冲区传输。对于双缓冲器操作，还设置GTIOCA引脚和GTIOCB引脚在当前周期后的2个周期（在锯齿波模式或在波谷处缓冲传输的三角波模式）或当前周期后的1个周期（在三角波模式分别在GTCCRD和GTCCRF中的波谷和波峰处进行缓冲转移。

开始计数操作
将GTCR.CST设置为1以启动计数操作。

为每个周期设置缓冲区值
对于缓冲操作，设置GTIOCA引脚和GTIOCB引脚在当前周期后1个周期（在锯齿波模式或在波谷处缓冲传输的三角波模式）或当前周期后的12个周期（在三角波模式分别在GTCCRC和GTCCRE中的波谷和波峰处进行缓冲区传输。对于双缓冲器操作，还设置GTIOCA引脚和GTIOCB引脚在当前周期后的2个周期（在锯齿波模式或在波谷处缓冲传输的三角波模式）或当前周期后的1个周期（在三角波GTCCRD和GTCCRF中的波谷和波峰缓冲传输模式，分别。

Note 1. 当使用PWM延迟产生电路时，交换EnableGTIOCpinoutput的step和Setcompare-matchvalue的step。

Figure 22.25 带输出比较的GTCCRA和GTCCRB缓冲区操作设置示例

(2) When GTCCRA or GTCCRB functions as an Input Capture Register

When an input capture is generated, the GTCNT counter value is transferred to GTCCRA and GTCCRB and the stored GTCCRA and GTCCRB register values are transferred to the buffer registers. In input capture operation, the buffer transfer is not performed by the counter clear.

Figure 22.26 and Figure 22.27 show examples of GTCCRA and GTCCRB buffer operation, and Figure 22.28 shows an example setting for GTCCRA and GTCCRB buffer operation.

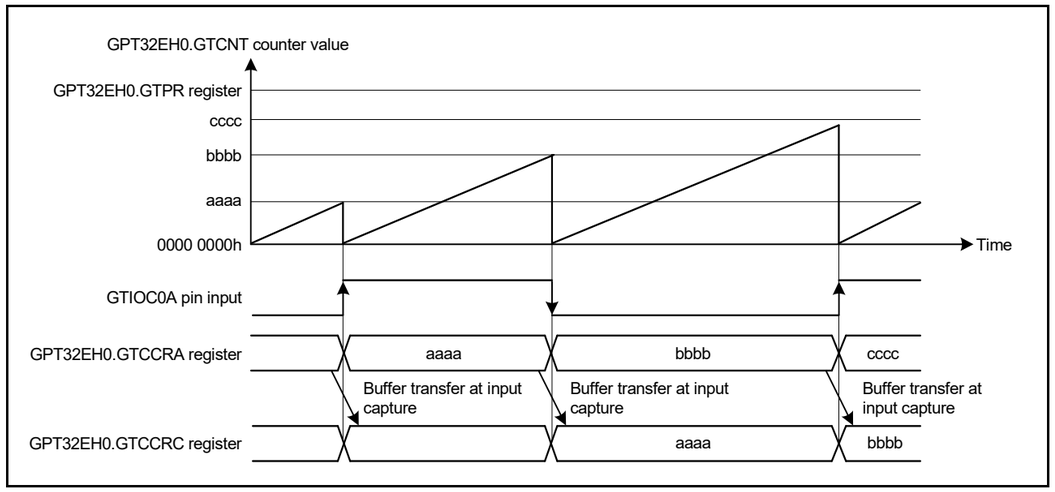

Figure 22.26 Example of GTCCRA and GTCCRB buffer operation with input capture at both edges of GTIOC0A input, saw waves in up-counting, and GTCNT counter cleared at both edges of GTIOC0A input

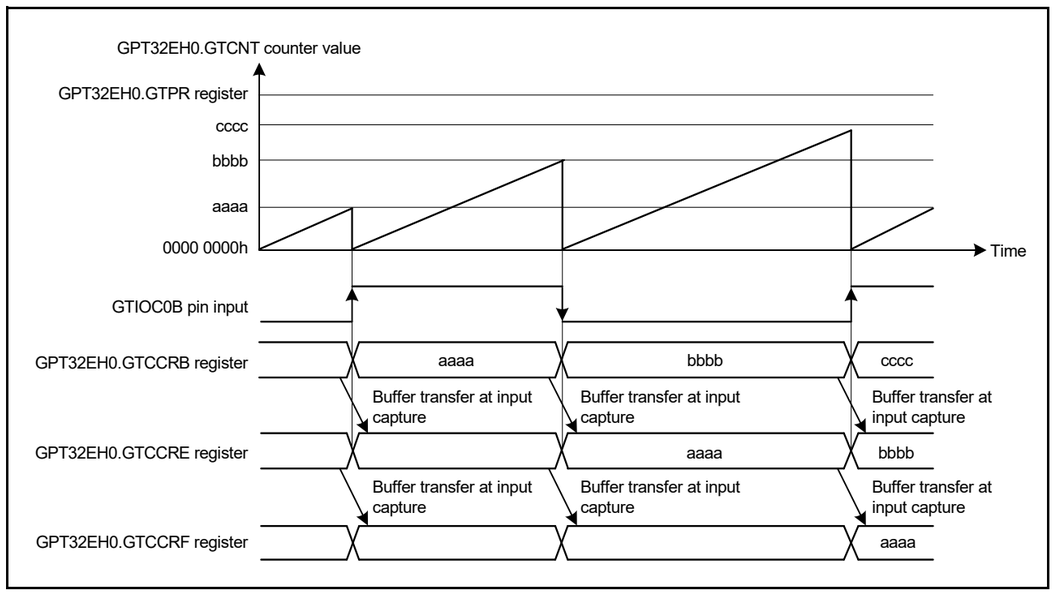

Figure 22.27 Example of GTCCRA and GTCCRB double buffer operation with input capture at both edges of GTIOC0B input, saw waves in up-counting, and GTCNT counter cleared at both edges of GTIOC0B input

(2) 当GTCCRA或GTCCRB用作输入捕捉寄存器时

当产生输入捕捉时，GTCNT计数器值被传送到GTCCRA和GTCCRB并存储GTCCRA和GTCCRB寄存器值被传送到缓冲寄存器。在输入捕捉操作中，缓冲区传输不是由计数器清零来执行的。

图22.26和图22.27显示了GTCCRA和GTCCRB缓冲操作的示例，图22.28显示了GTCCRA和GTCCRB缓冲操作的示例设置。

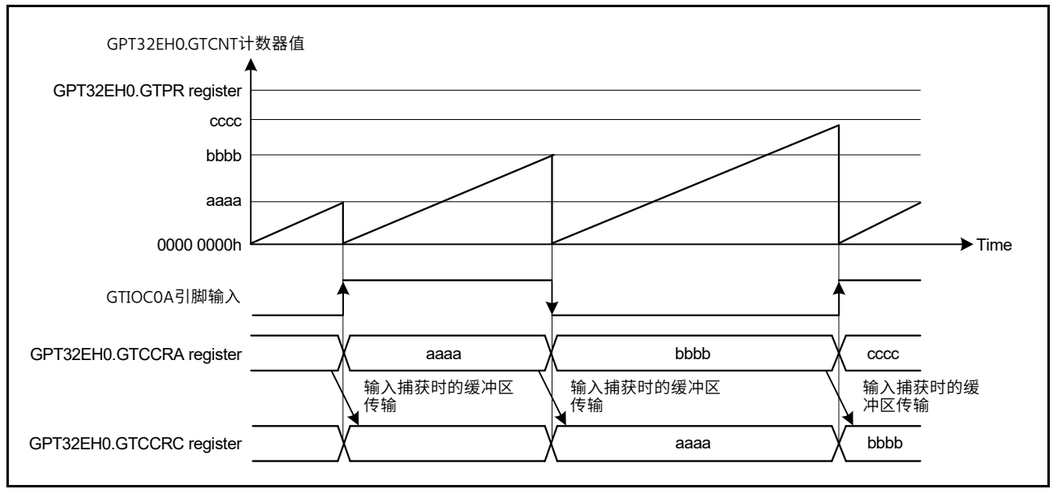

Figure 22.26 GTCCRA和GTCCRB缓冲器操作示例，在GTIOC0A输入的两个边沿进行输入捕获，在向上计数时看到锯齿波，并且在GTIOC0A输入的两个边沿清除GTCNT计数器

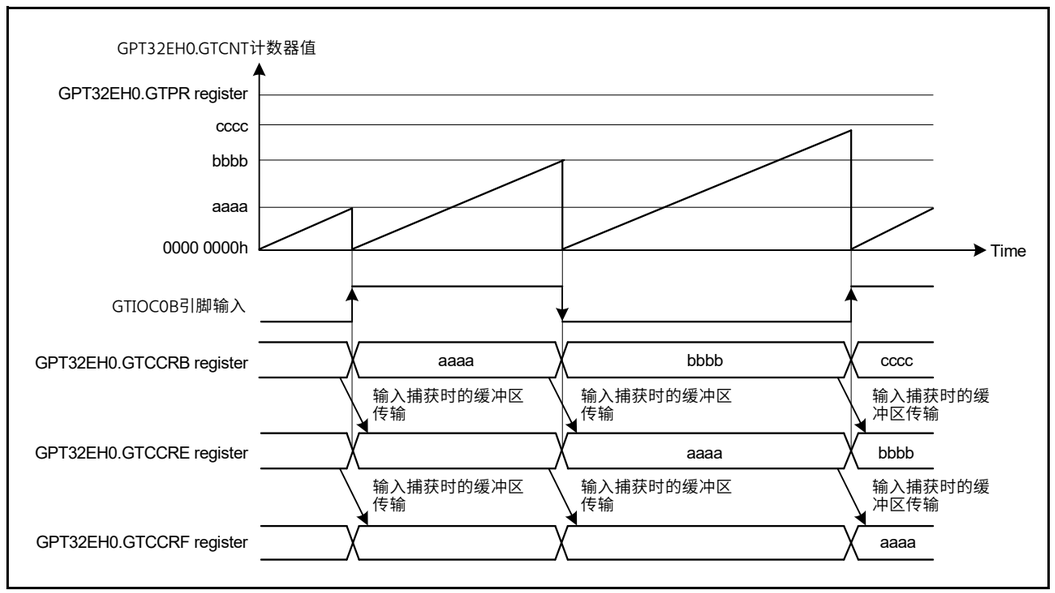

Figure 22.27 GTCCRA和GTCCRB双缓冲操作示例，在两个边沿进行输入捕获GTIOC0B输入，递增计数中的锯齿波，并且GTCNT计数器在GTIOC0B input

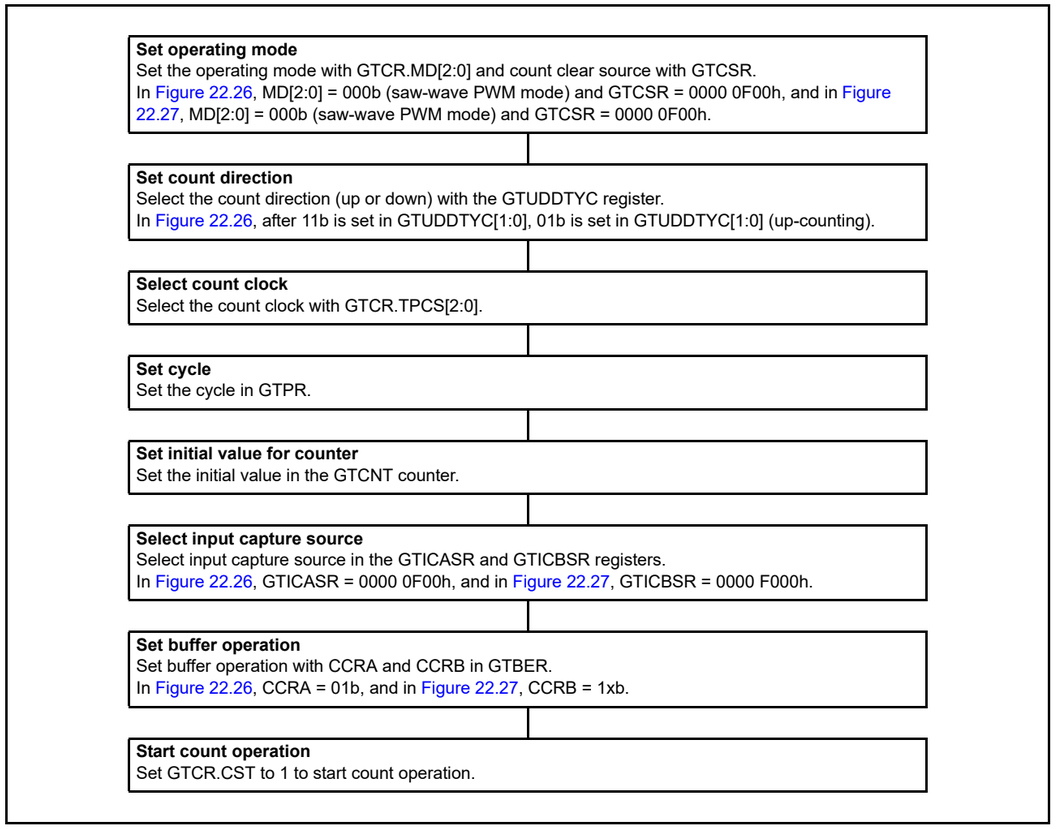

Figure 22.28 Example setting for GTCCRA and GTCCRB buffer operation with input capture

22.3.2.3 Buffer operation for GTADTRA and GTADTRB

GTADTBRA can function as the GTADTRA buffer register and GTADTDBRA can function as the GTADTBRA buffer register (double-buffer register for GTADTRA). Similarly, GTADTBRB can function as the GTADTRB buffer register and GTADTDBRB can function as the GTADTBRB buffer register (double-buffer register for GTADTRB).

To set GTADTRA or GTADTRB to function as a double buffer, set GTBER.ADTDA or GTBER.ADTDB to 1. For single-buffer operation, set GTBER.ADTDA or GTBER.ADTDB to 0. To set GTADTRA or GTADTRB to not function as a buffer, set GTBER.ADTTA[1:0] or GTBER.ADTTB[1:0] to 00b.

The buffer transfer timing can be set with the GTBER.ADTTA[1:0] bits. For saw waves, overflows (during up-counting) or underflows (during down-counting) can be selected. For triangle waves, crests are selected when GTBER.ADTTA[1:0] = 01b, troughs are selected when GTBER.ADTTA[1:0] = 10b, and both crests and troughs are selected when GTBER.ADTTA[1:0] = 11b.

Figure 22.29 to Figure 22.31 show examples of GTADTRA and GTADTRB buffer operation and Figure 22.32 shows an example setting for GTDTRA and GTADTRB buffer operation.

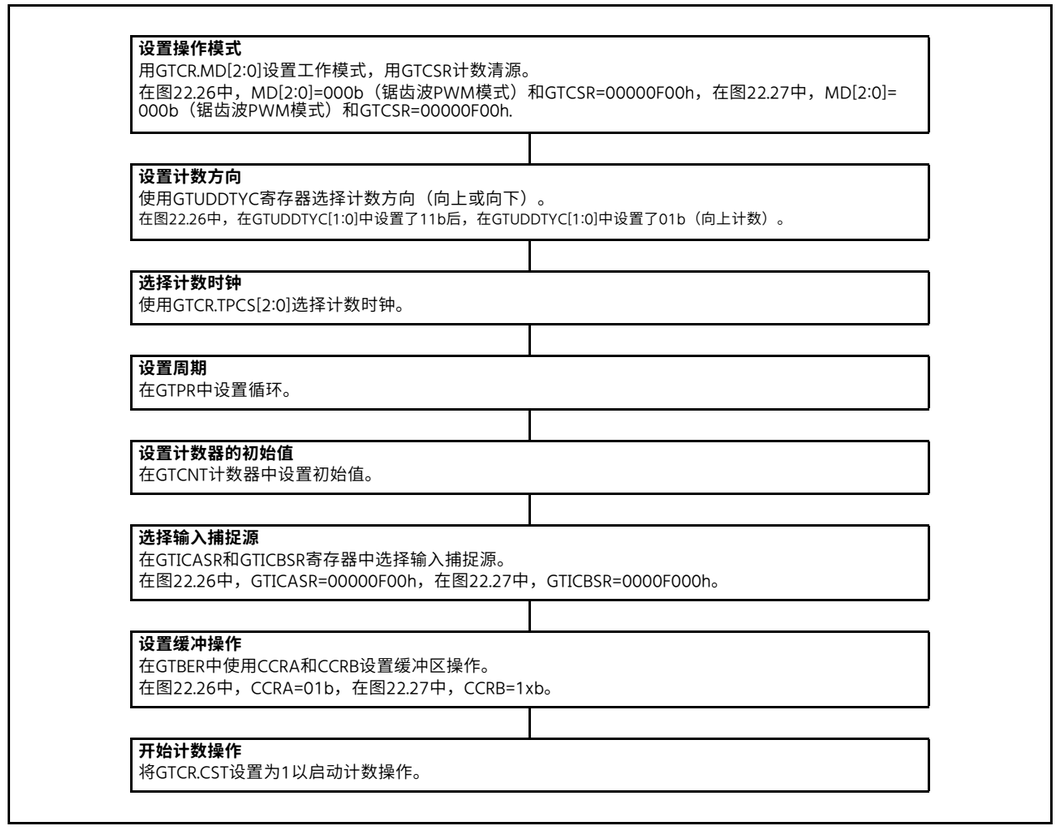

Figure 22.28 带输入捕获的GTCCRA和GTCCRB缓冲区操作设置示例

22.3.2.3 GTADTRA和GTADTRB的缓冲操作

GTADTBRA可以用作GTADTRA缓冲寄存器，GTADTBRA可以用作GTADTBRA缓冲寄存器（GTADTRA的双缓冲寄存器）。同样，GTADTBRB可以作为GTADTRB缓冲寄存器，GTADTDRBB可以作为GTADTBRB缓冲寄存器（GTADTRB的双缓冲寄存器）。

要将GTADTRA或GTADTRB设置为双缓冲区，请将GTBER.ADTDA或GTBER.ADTDB设置为1。对于单缓冲区操作，将GTBER.ADTDA或GTBER.ADTDB设置为0。要将GTADTRA或GTADTRB设置为不作为缓冲区，将GTBER.ADTTA[1:0]或GTBER.ADTTB[1:0]设置为00b。

可以使用GTBER.ADTTA[1:0]位设置缓冲区传输时序。对于锯齿波，可以选择上溢（向上计数期间）或下溢（向下计数期间）。对于三角波，当GTBER.ADTTA[1:0]=01b时选择波峰，当GTBER.ADTTA[1:0]=10b时选择波谷，当GTBER.ADTTA[1:0]时选择波峰和波谷=11b。

图22.29至图22.31显示了GTADTRA和GTADTRB缓冲操作的示例，图22.32显示了GTDTRA和GTADTRB缓冲操作的示例设置。

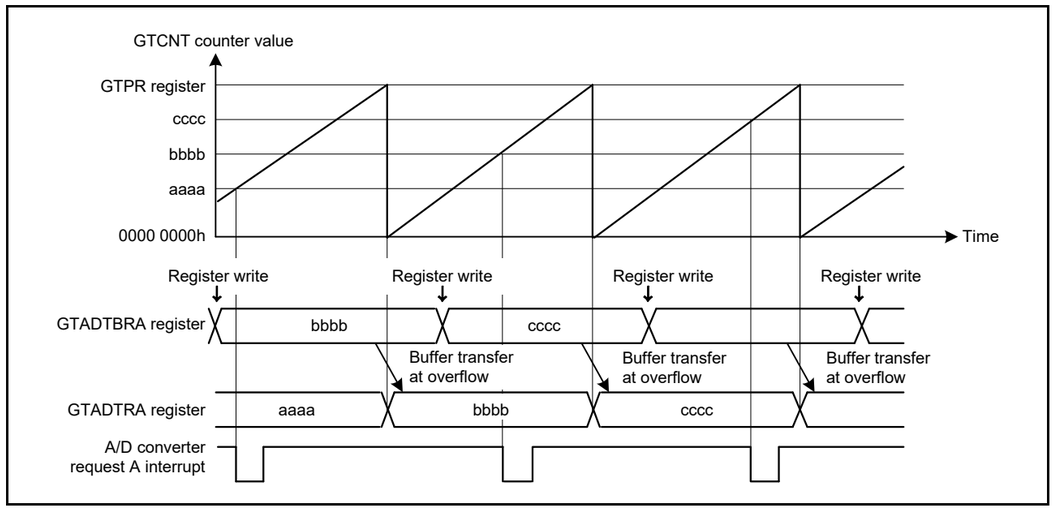

Figure 22.29 Example of GTADTRA and GTADTRB buffer operation with saw waves in up-counting and A/D converter start request interrupt generated by up-counting

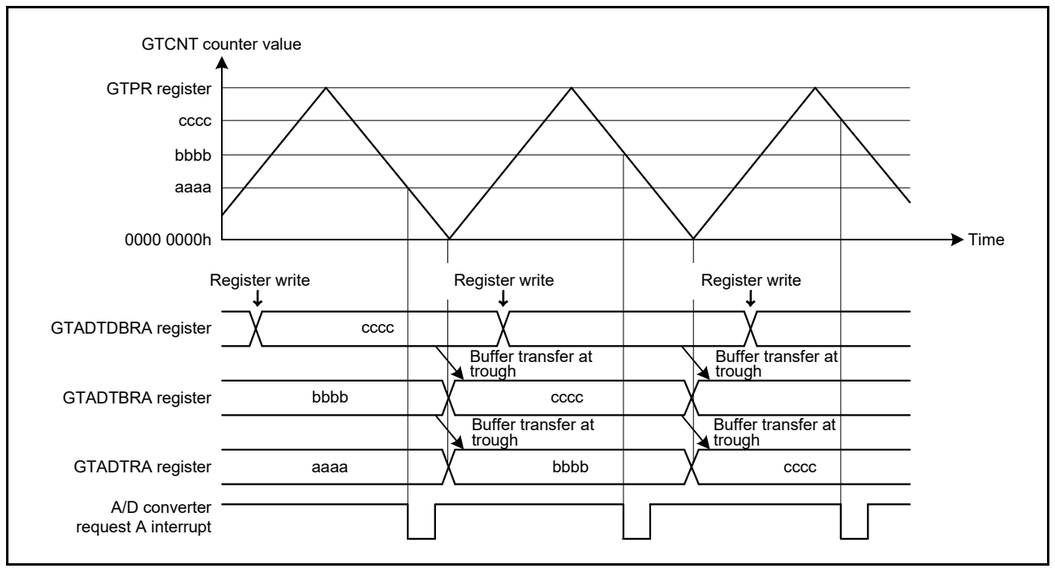

Figure 22.30 Example of GTADTRA and GTADTRB double buffer operation with triangle waves, buffer transfer at troughs, and A/D converter start request interrupt generated by down-counting

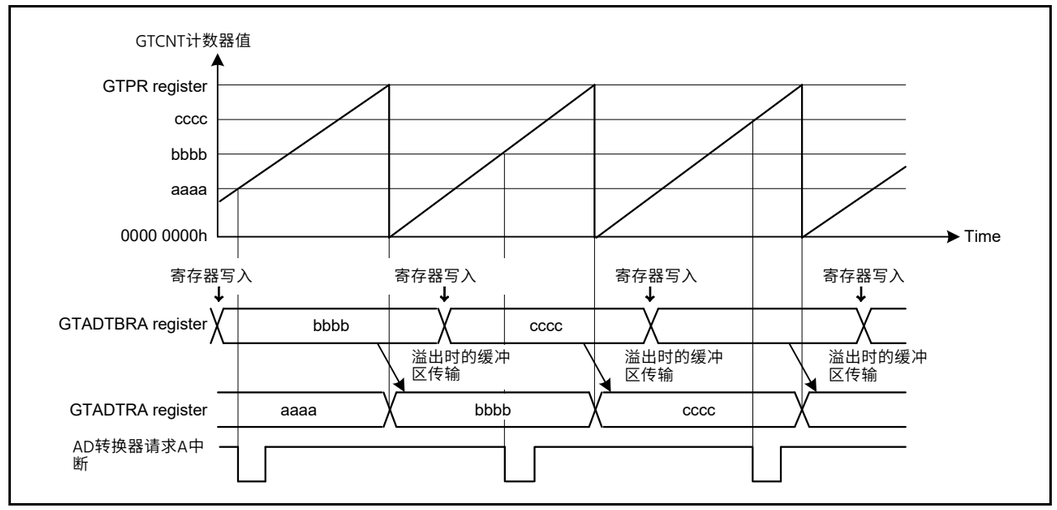

Figure 22.29 GTADTRA和GTADTRB缓冲器操作示例，在递增计数中使用锯齿波和递增计数产生的AD转换器启动请求中断

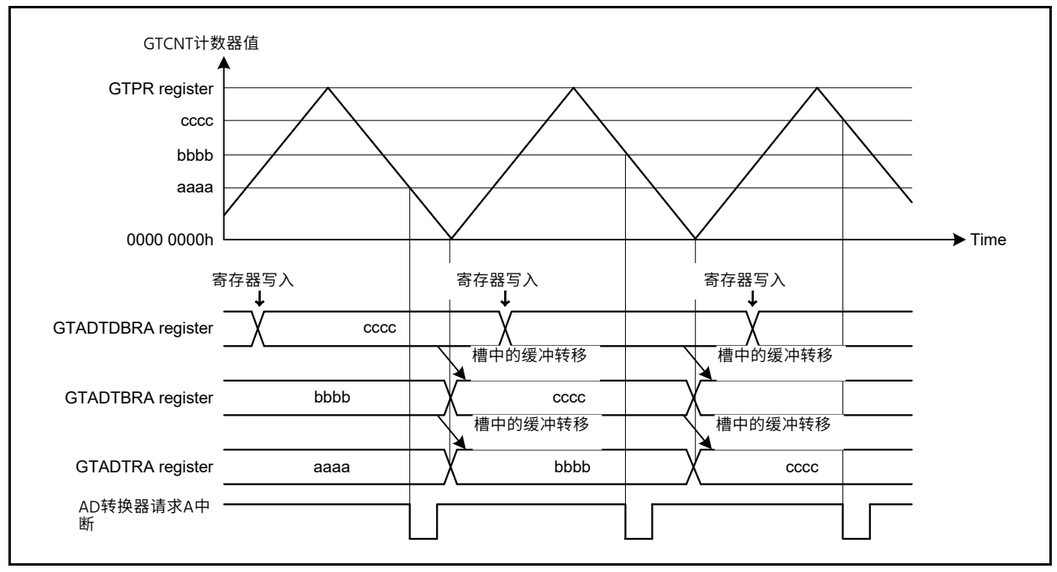

Figure 22.30 三角波的GTADTRA和GTADTRB双缓冲操作示例，波谷处的缓冲传输，以及由递减计数产生的AD转换器启动请求中断

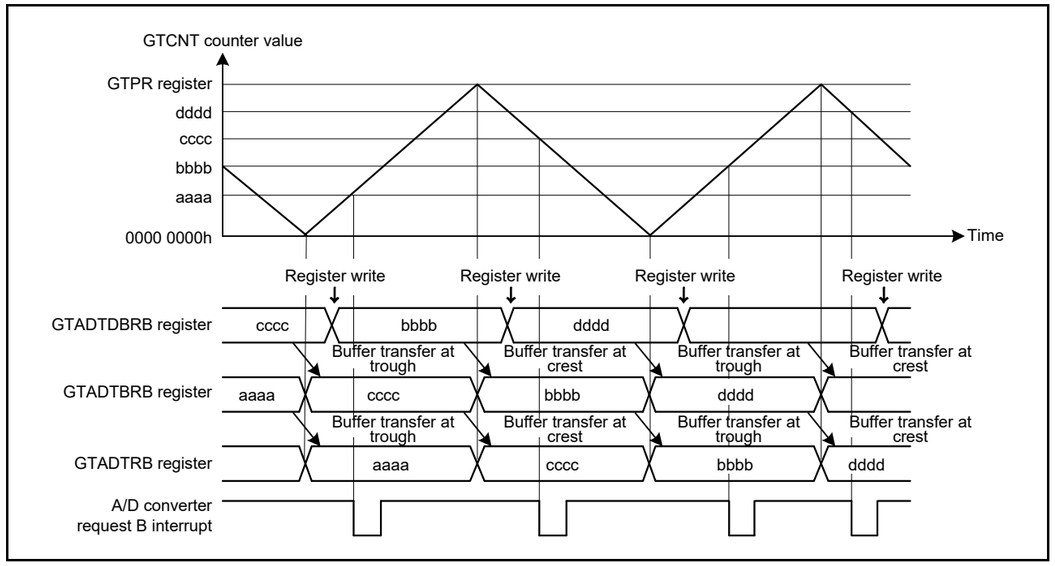

Figure 22.31 Example of GTADTRA and GTADTRB double buffer operation with triangle waves, buffer transfer at both troughs and crests, and A/D converter start request interrupt generated by both up- and down-counting

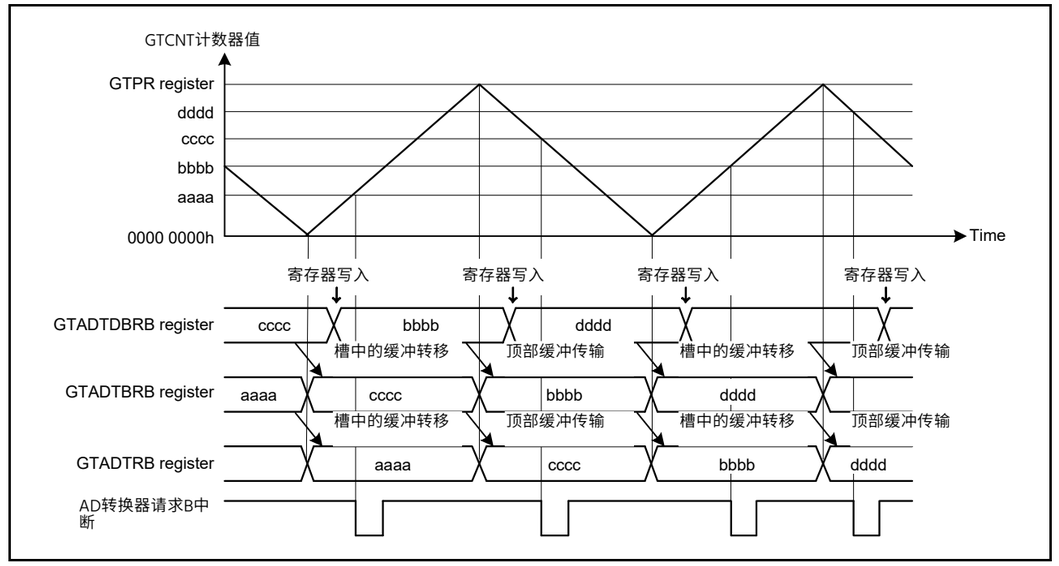

Figure 22.31 三角波的GTADTRA和GTADTRB双缓冲操作示例，波谷和波峰的缓冲传输，以及由加减计数产生的AD转换器启动请求中断

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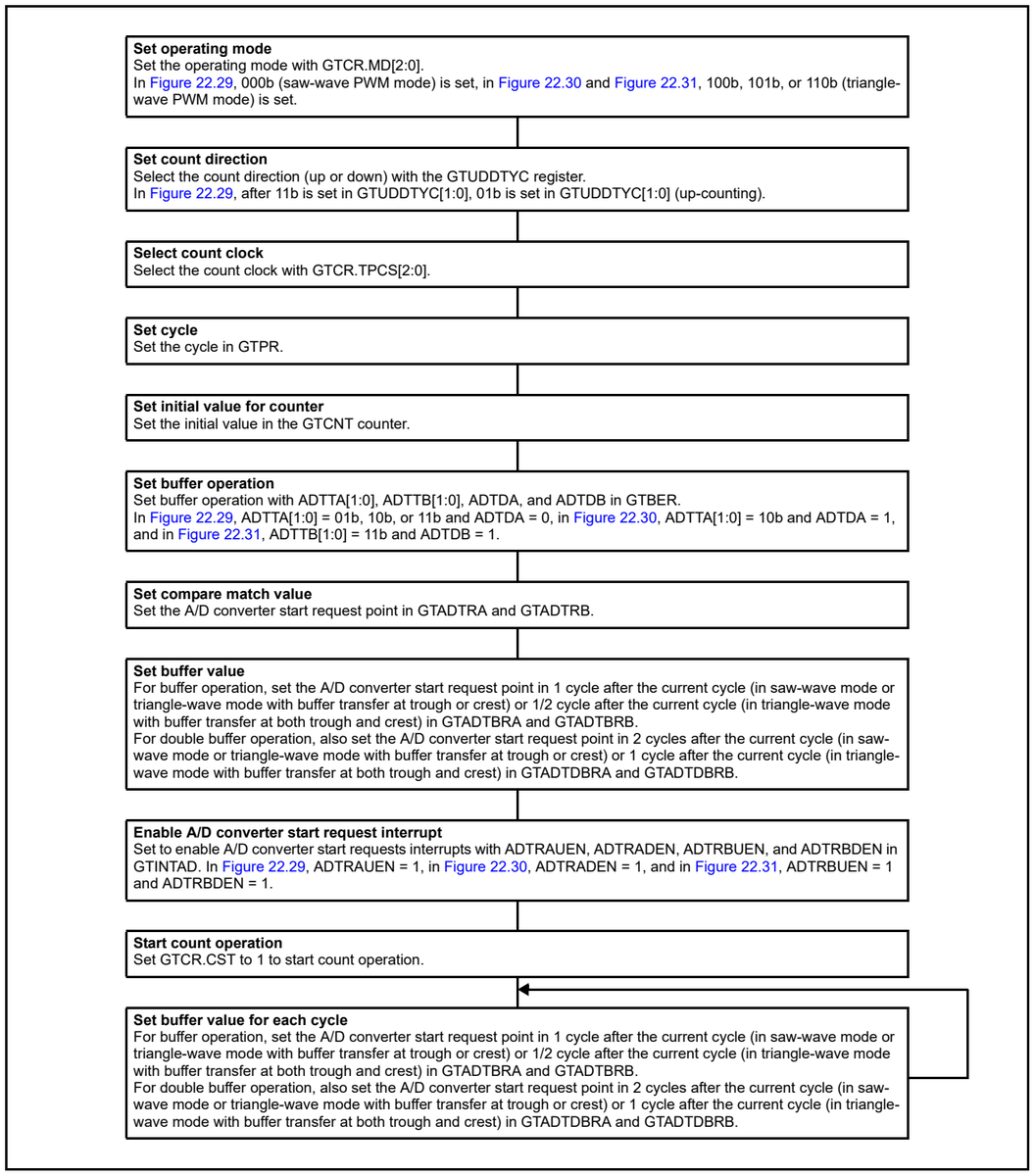

Figure 22.32 Example setting for GTADTRA and GTADTRB buffer operation

22.3.3 PWM Output Operating Mode

The GPT can output PWM waveforms to the GTIOCA or GTIOCB pin by a compare match between the GTCNT counter and GTCCRA or GTCCRB. By setting GTDTCR, GTDVU, and GTDVD, the compare match value for a negative-phase waveform with dead time can be automatically set to GTCCRB.

Figure 22.32 GTADTRA和GTADTRB缓冲操作的示例设置

22.3.3 PWM输出工作模式

通过GTCNT计数器与GTCCRA或GTCCRB之间的比较匹配，GPT可以将PWM波形输出到GTIOCA或GTIOCB引脚。通过设置GTDTCR、GTDVU和GTDVD，可以自动将带死区时间的负相位波形的比较匹配值设置为GTCCRB。

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22.3.3.1 Saw-wave PWM mode

In saw-wave PWM mode, GTCNT performs saw-wave (half-wave) operation by setting the cycle in GTPR. A PWM waveform is output to the GTIOCA or GTIOCB pin when a GTCCRA or GTCCRB compare match occurs. The pin output value can be selected from low output, high output, or toggle output separately for a compare match and for the cycle end according to the GTIOR setting.

Figure 22.33 shows an example of saw-wave PWM mode operation, and Figure 22.34 shows an example setting for saw-wave PWM mode.

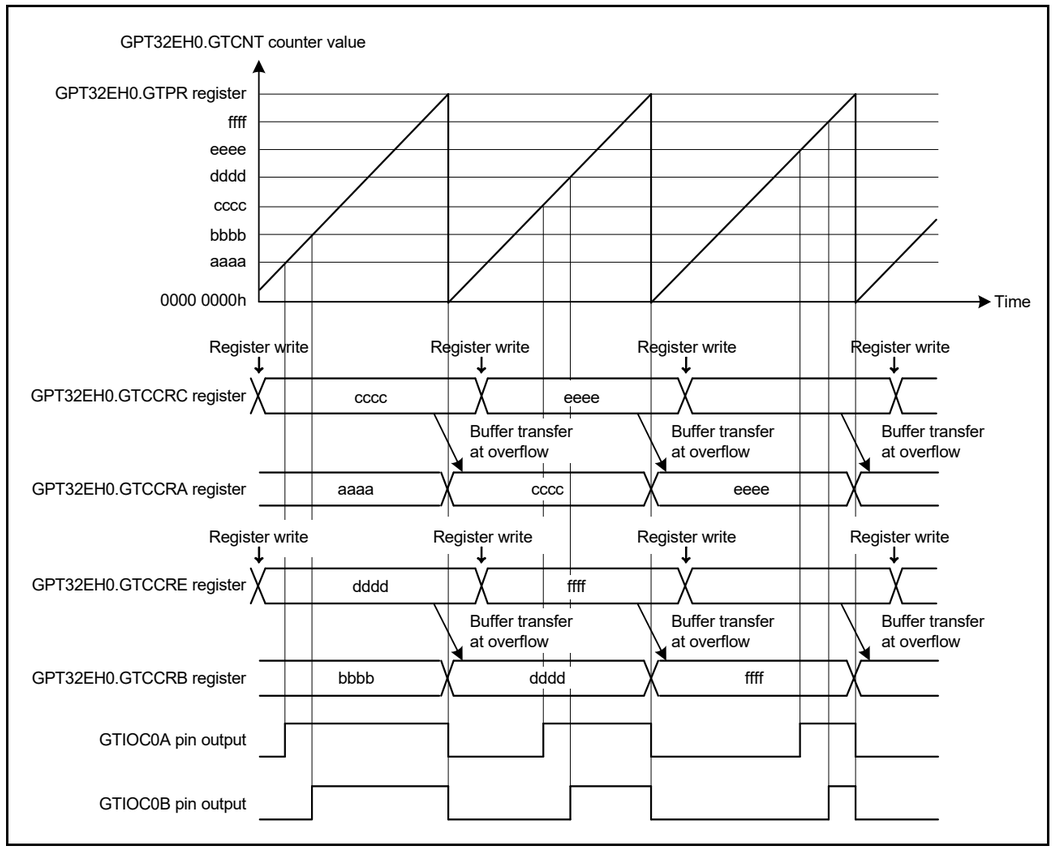


Figure 22.33 Example of saw-wave PWM mode operation with up-counting, buffer operation, high output at GTCCRA/GTCCRB compare match, and low output at cycle end

22.3.3.1 Saw-wave PWM mode

在锯齿波PWM模式下，GTCNT通过在GTPR中设置周期来执行锯齿波（半波）操作。当GTCCRA或GTCCRB比较匹配发生时，PWM波形输出到GTIOCA或GTIOCB引脚。引脚输出值可以根据GTIOR设置分别从低输出、高输出或切换输出中选择，用于比较匹配和循环结束。

图22.33显示了锯波PWM模式操作的示例，图22.34显示了锯波PWM模式设置的示例。

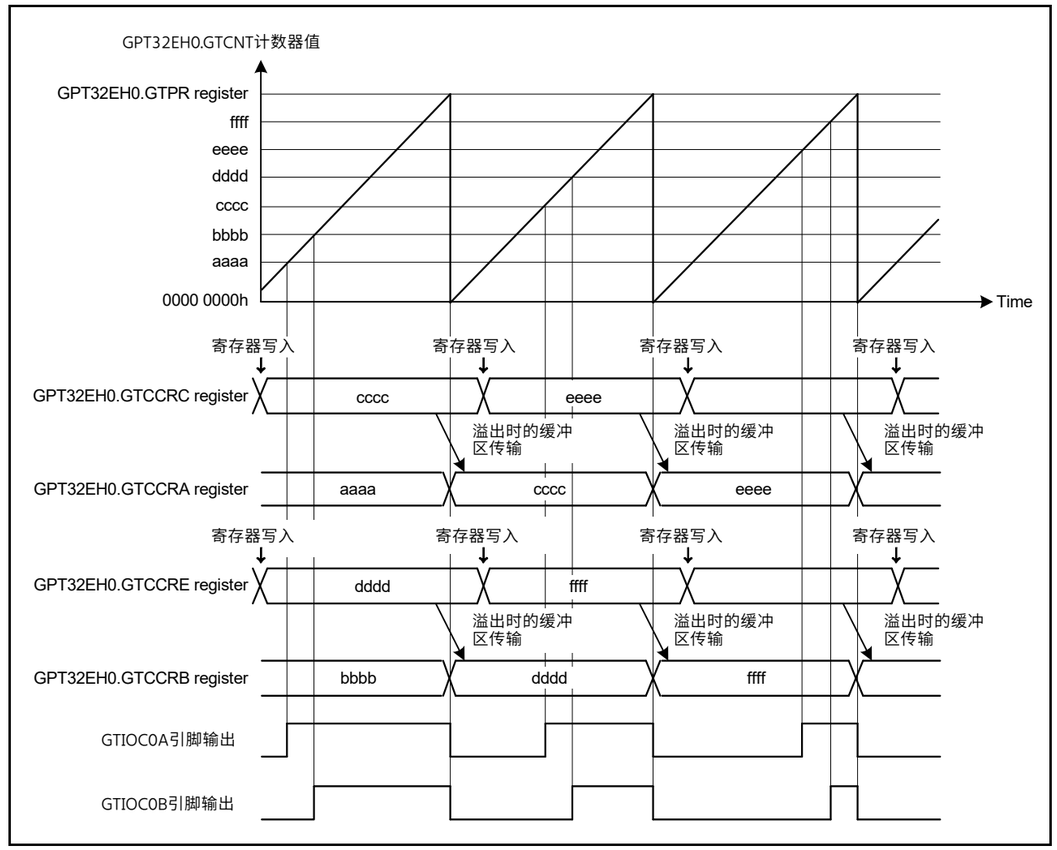
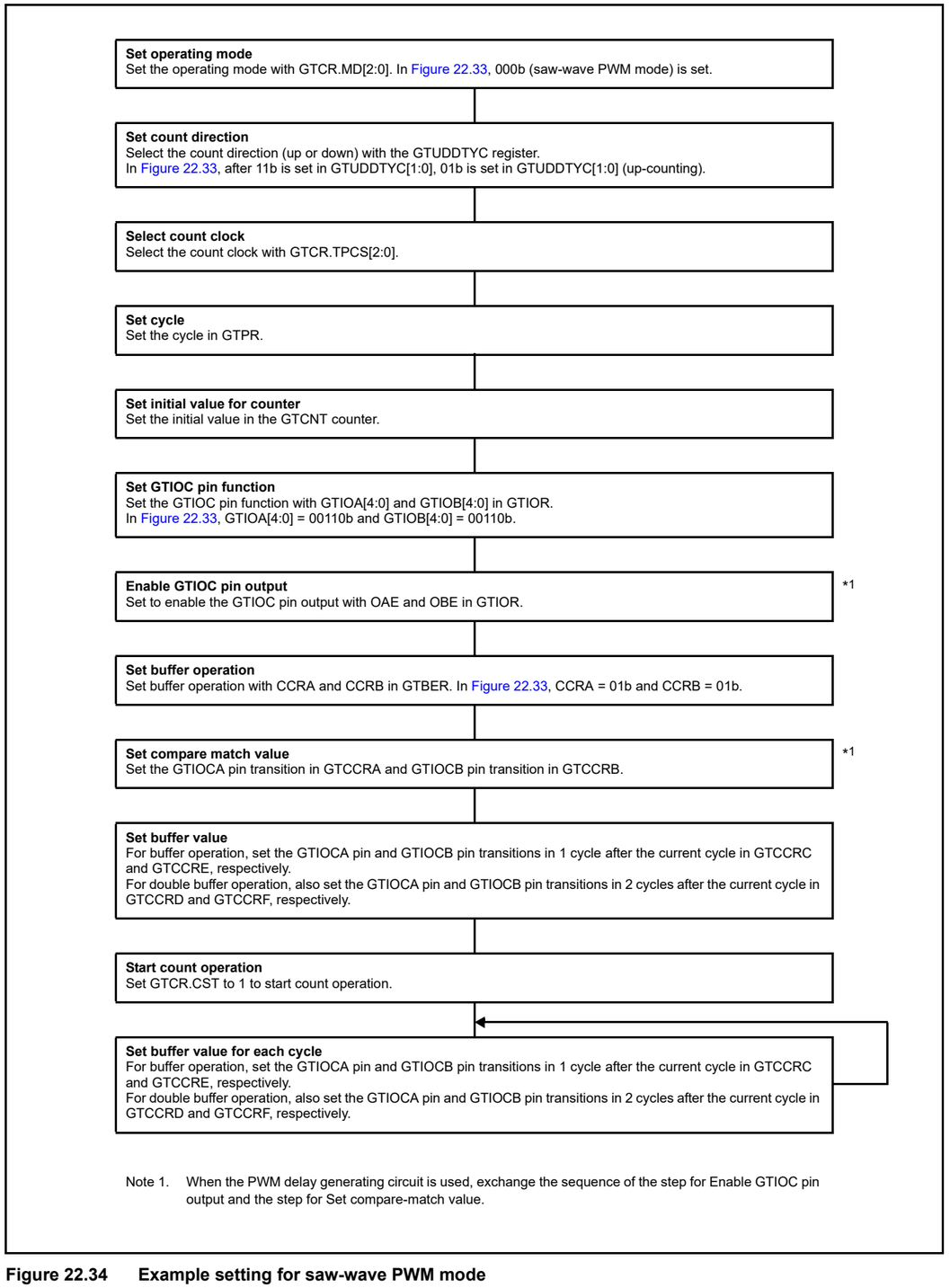
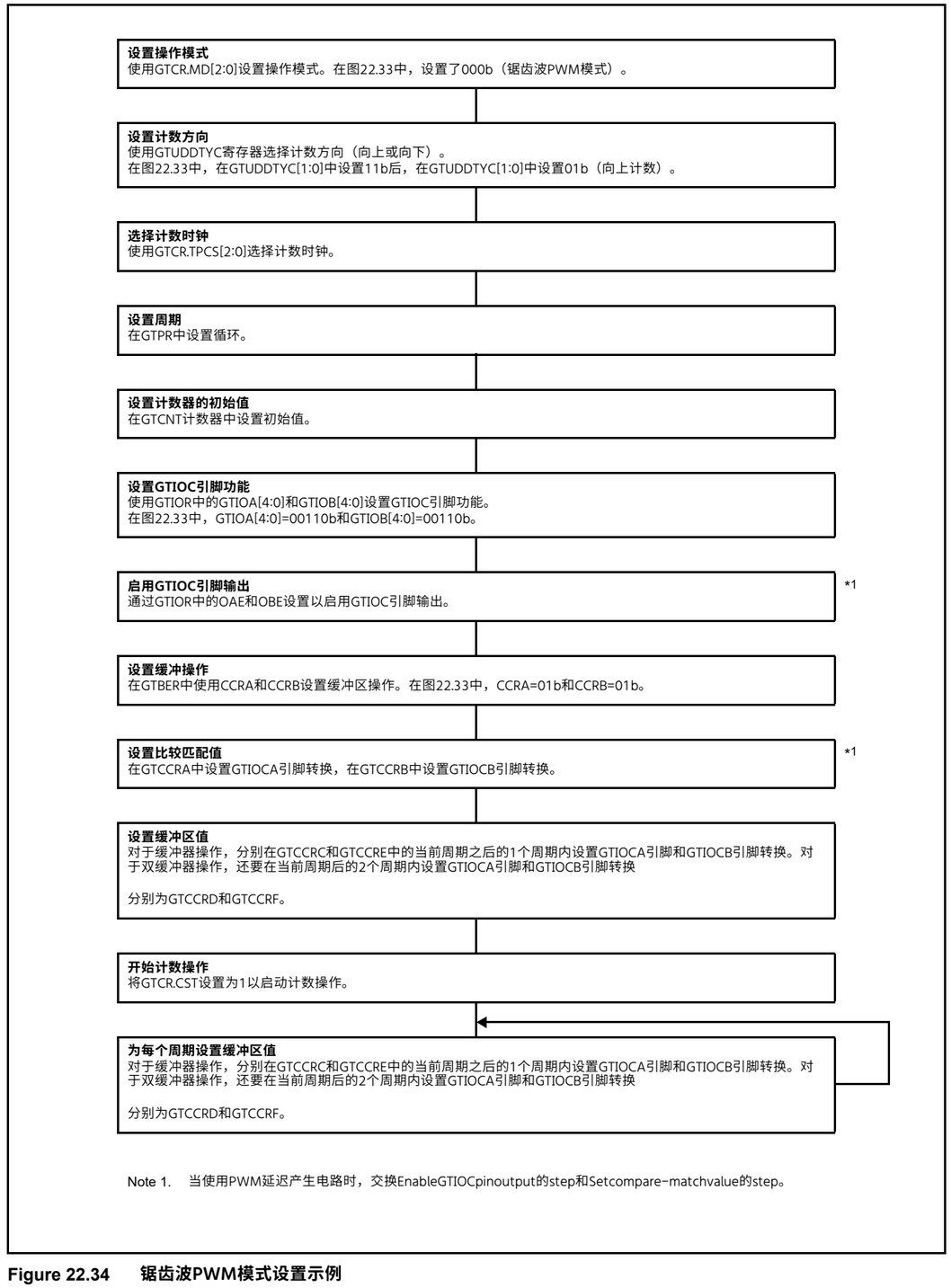


Figure 22.33 具有递增计数、缓冲操作、高输出的锯齿波PWM模式操作示例 GTCCRAGTCCRB比较匹配，循环结束时输出低



Note 1. When the PWM delay generating circuit is used, exchange the sequence of the step for Enable GTIOC pin output and the step for Set compare-match value.

Figure 22.34 Example setting for saw-wave PWM mode



Note 1. 当使用PWM延迟产生电路时，交换EnableGTIOCpinoutput的step和Setcompare-matchvalue的step。

Figure 22.34 锯齿波PWM模式设置示例

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22.3.3.2 Saw-wave one-shot pulse mode

The saw-wave one-shot pulse mode is a mode in which the cycle is set in GTPR. The GTCNT counter performs saw-wave (half-wave) operation and a PWM waveform is output to the GTIOCA or GTIOCB pin at a compare match of GTCCRA or GTCCRB with buffer operation fixed.

Buffer operation in saw-wave one-shot pulse mode is different from the usual buffer operation. Buffer transfer is performed from:

- GTCCRC to GTCCRA at the cycle end
- GTCCRE to GTCCRB at the cycle end
- GTCCRD to temporary register A at the cycle end
- GTCCRF to temporary register B at the cycle end
- Temporary register A to GTCCRA at a GTCCRA compare match
- Temporary register B to GTCCRB at a GTCCRB compare match.

The pin output value can be selected from low output, high output, or toggle output separately for a compare match and the cycle end according to the GTIOR setting. When the GTBER.CCRSWT bit is set to 1 while the count operation is stopped, the buffer is transferred forcibly from the GTCCRD register to temporary register A and from the GTCCRF register to temporary register B. By setting GTDTCR, GTDVU, and GTDVD, a compare match value for a negative-phase waveform with dead time can automatically be set to GTCCRB.

Figure 22.35 shows an example of saw-wave one-shot pulse mode operation, and Figure 22.36 shows an example setting for saw-wave one-shot pulse mode.

22.3.3.2 锯波单发脉冲模式

锯齿波单发脉冲模式是在GTPR中设置周期的模式。GTCNT计数器执行锯齿波（半波）操作，并且在GTCCRA或GTCCRB的比较匹配时将PWM波形输出到GTIOCA或GTIOCB引脚，且缓冲器操作固定。

锯波单次脉冲模式中的缓冲操作不同于通常的缓冲操作。缓冲区传输从以下位置执行：

- 循环结束时GTCCRC到GTCCRA
- 循环结束时GTCCRE到GTCCRB
- GTCCRD在循环结束时到临时寄存器A
- GTCCRF在循环结束时到临时寄存器B
- 在GTCCRA比较匹配时将临时寄存器A发送到GTCCRA
- 在GTCCRB比较匹配时，临时寄存器B到GTCCRB。

引脚输出值可以根据GTIOR设置分别从低输出、高输出或切换输出中选择，以进行比较匹配和循环结束。当在计数操作停止时GTBER.CCRSWT位设置为1时，缓冲区被强制从GTCCRD寄存器传送到临时寄存器A，并从GTCCRF寄存器传送到临时寄存器B。通过设置GTDTCR、GTDVU和GTDVD，a带有死区时间的负相位波形的比较匹配值可以自动设置为GTCCRB。

图22.35显示了锯齿波单次脉冲模式操作的示例，图22.36显示了锯齿波单次脉冲模式设置的示例。

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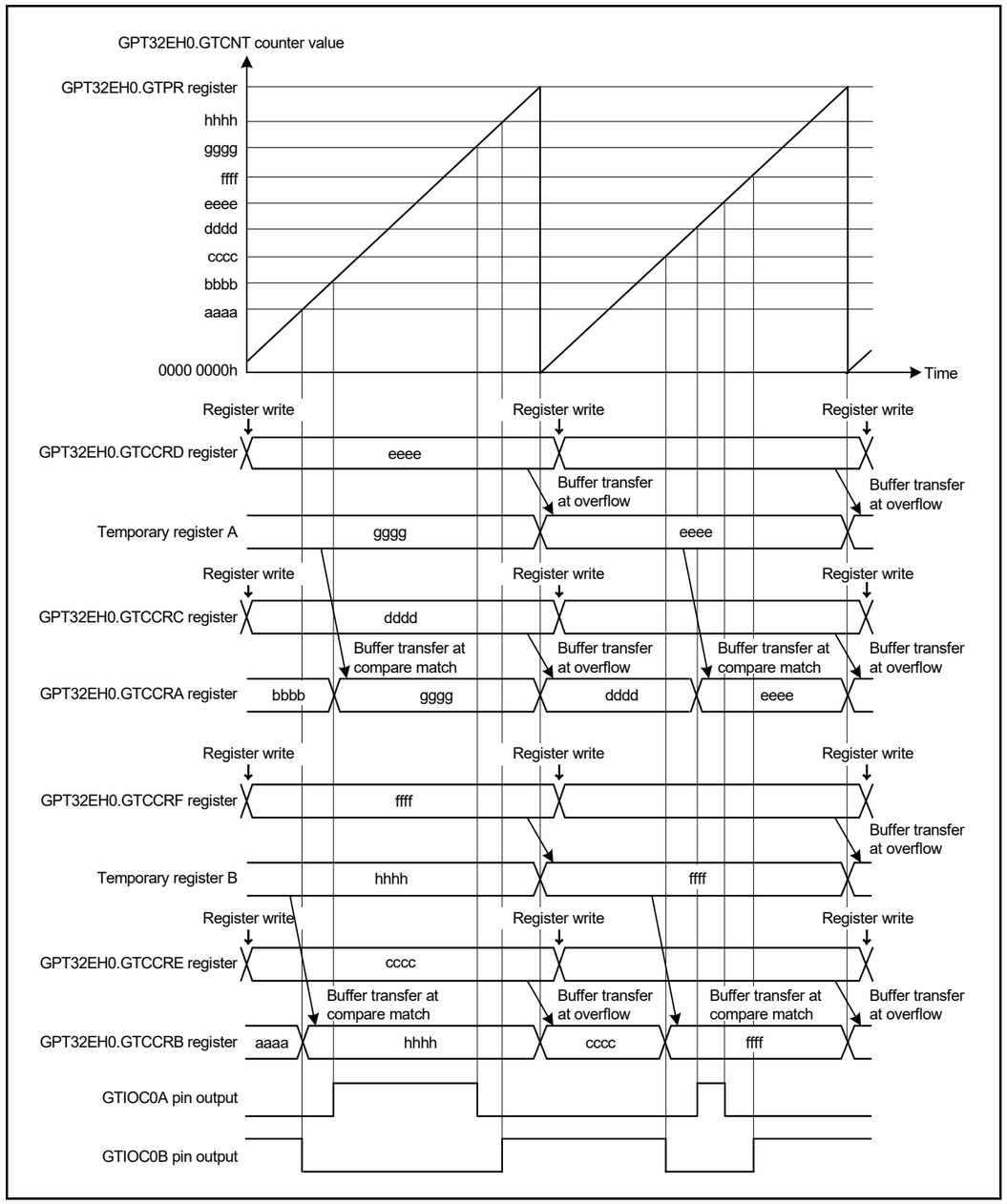


Figure 22.35 Example of saw-wave one-shot pulse mode operation with up-counting, low output from the GTIOC0A pin and high output from the GTIOC0B pin at count start, output toggled at GTCCRA/GTCCRB compare match, and output retained at cycle end

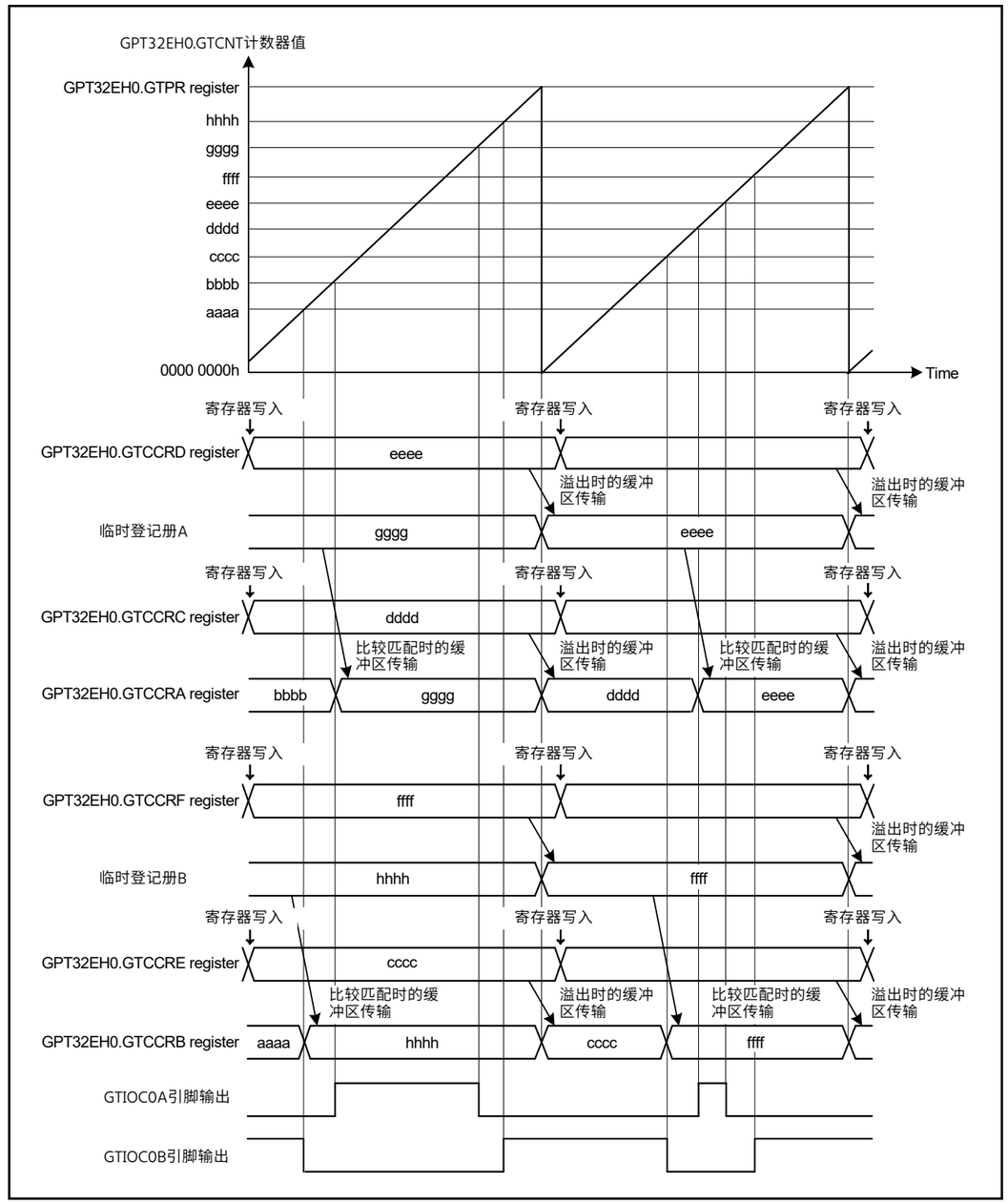
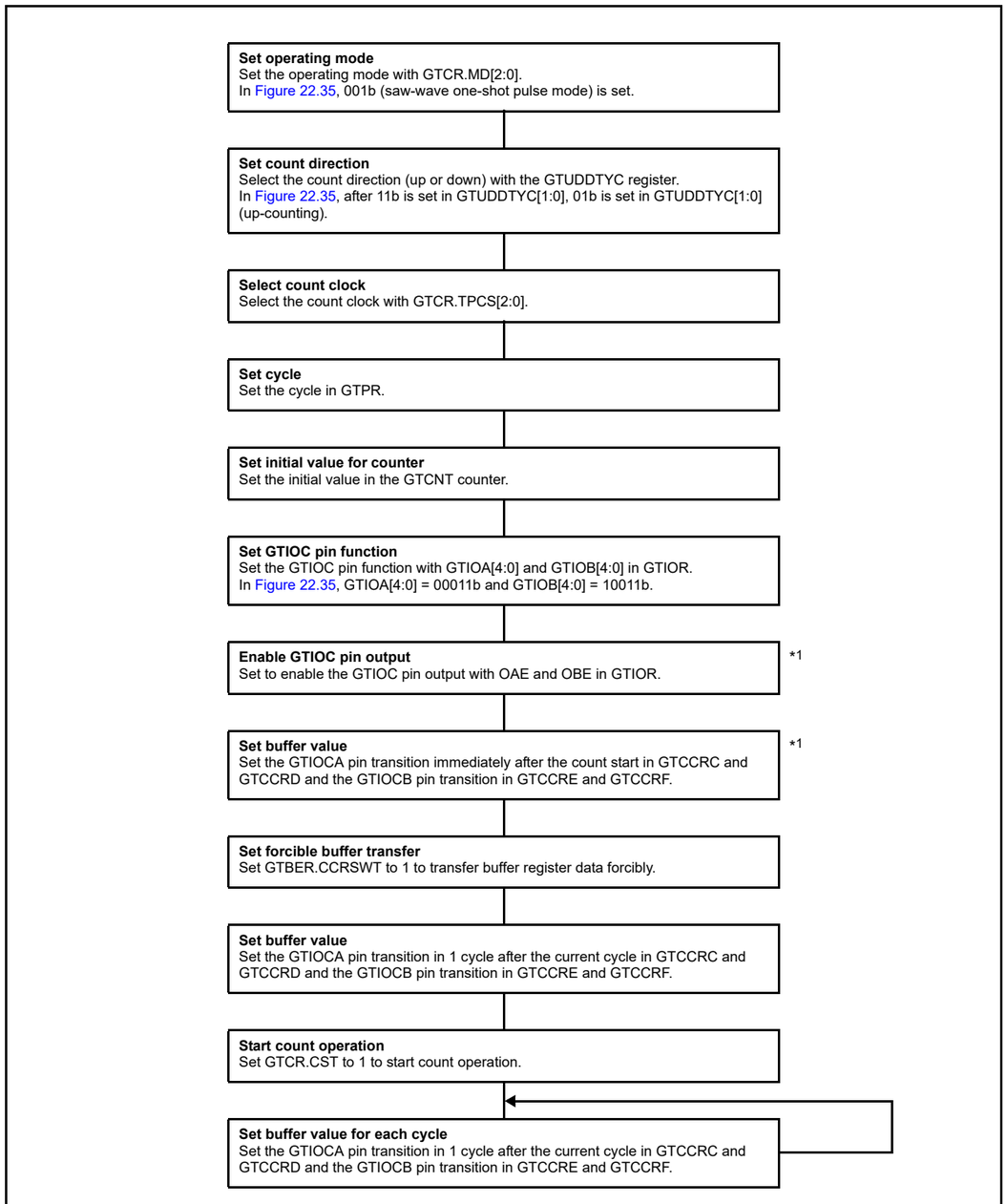


Figure 22.35 具有递增计数、低输出的锯齿波单次脉冲模式操作示例 GTIOC0A引脚和GTIOC0B引脚在计数开始时的高电平输出，输出在 GTCCRAGTCCRB比较匹配，并在循环结束时保留输出



Note 1. When the PWM delay generating circuit is used, exchange the sequence of the step for Enable GTIOC pin output and the step for Set buffer value.

Figure 22.36 Example setting for saw-wave one-shot pulse mode

Note 1. 当使用PWM延迟产生电路时，交换EnableGTIOCpinoutput的step和Setbuffervalue的step。

Figure 22.36 锯波单发脉冲模式设置示例

22.3.3.3 Triangle-wave PWM mode 1 (32-bit transfer at trough)

The triangle-wave PWM mode 1 is a mode in which the cycle is set in GTPR. The GTCNT counter performs triangle-wave (full-wave) operation, and a PWM waveform is output to the GTIOCA or GTIOCB pin when a GTCCRA or GTCCRB compare match occurs. Buffer transfer is performed at the trough. The pin output value can be selected from low output, high output, or toggle output separately for a compare match and for the cycle end based on the GTIOR setting.

By setting GTDTCR, GTDVU, and GTDVD, a compare match value for a negative-phase waveform with dead time can automatically be set to GTCCRB.

Figure 22.37 shows an example of a triangle-wave PWM mode 1 operation, and Figure 22.38 shows an example setting for a triangle-wave PWM mode 1.

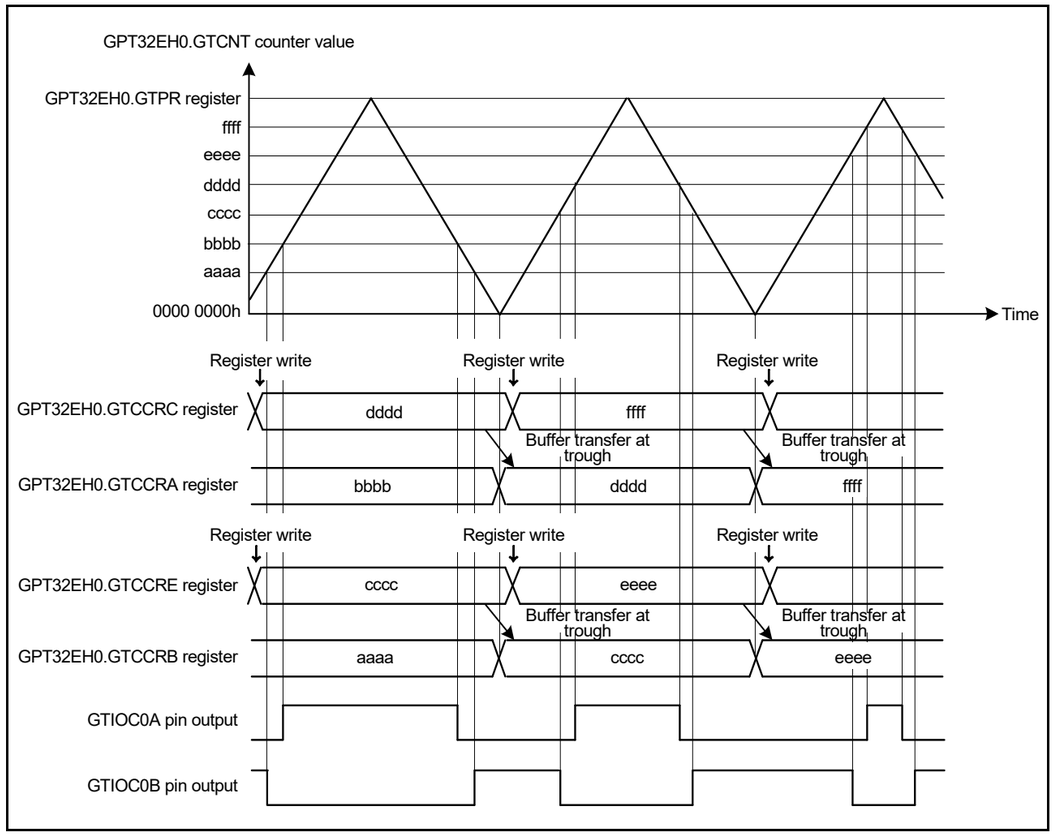


Figure 22.37 Example of triangle-wave PWM mode 1 operation with buffer operation, low output from the GTIOC0A pin and high output from the GTIOC0B pin at count start, output toggled at GTCCRA/GTCCRB register compare match, and output retained at cycle end

22.3.3.3 三角波PWM模式1（波谷32位传输）

三角波PWM模式1是在GTPR中设定周期的模式。GTCNT计数器执行三角波（全波）操作，当发生GTCCRA或GTCCRB比较匹配时，PWM波形将输出到GTIOCA或GTIOCB引脚。在槽中进行缓冲转移。引脚输出值可以根据GTIOR设置分别从低输出、高输出或切换输出中选择，用于比较匹配和循环结束。

通过设置GTDTCR、GTDVU和GTDVD，可以自动将带死区时间的负相位波形的比较匹配值设置为GTCCRB。

图22.37显示了三角波PWM模式1操作的示例，图22.38显示了三角波PWM模式1的示例设置。

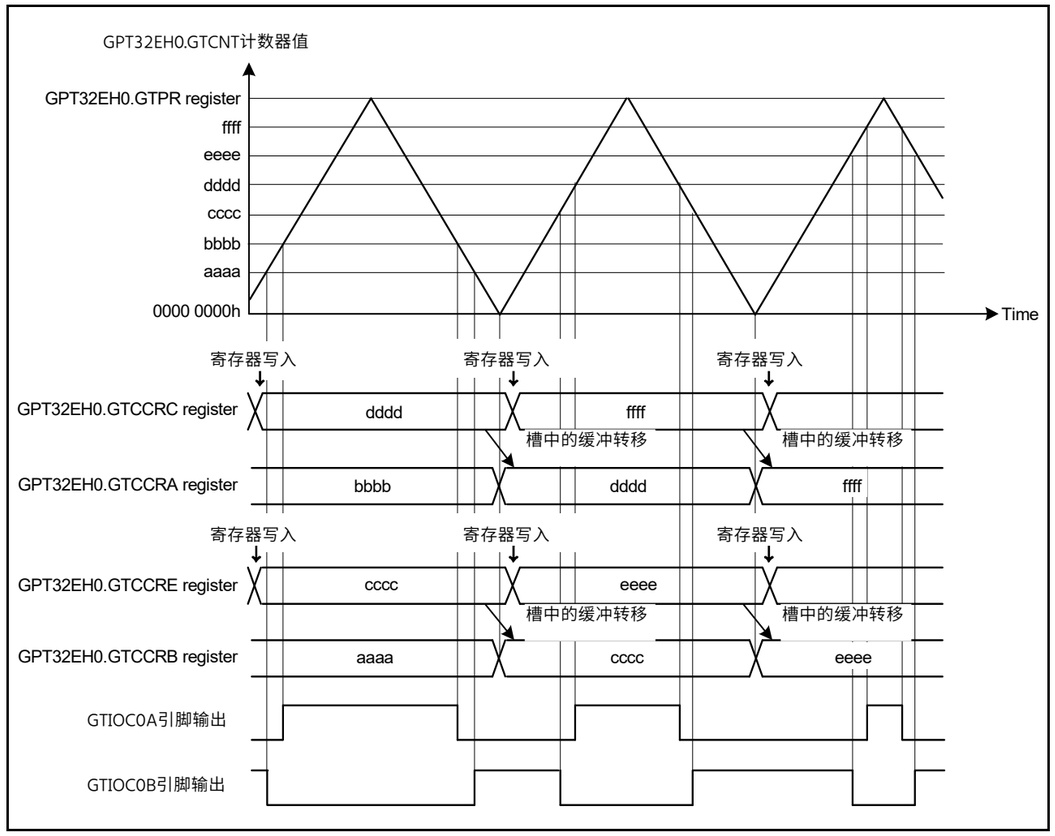
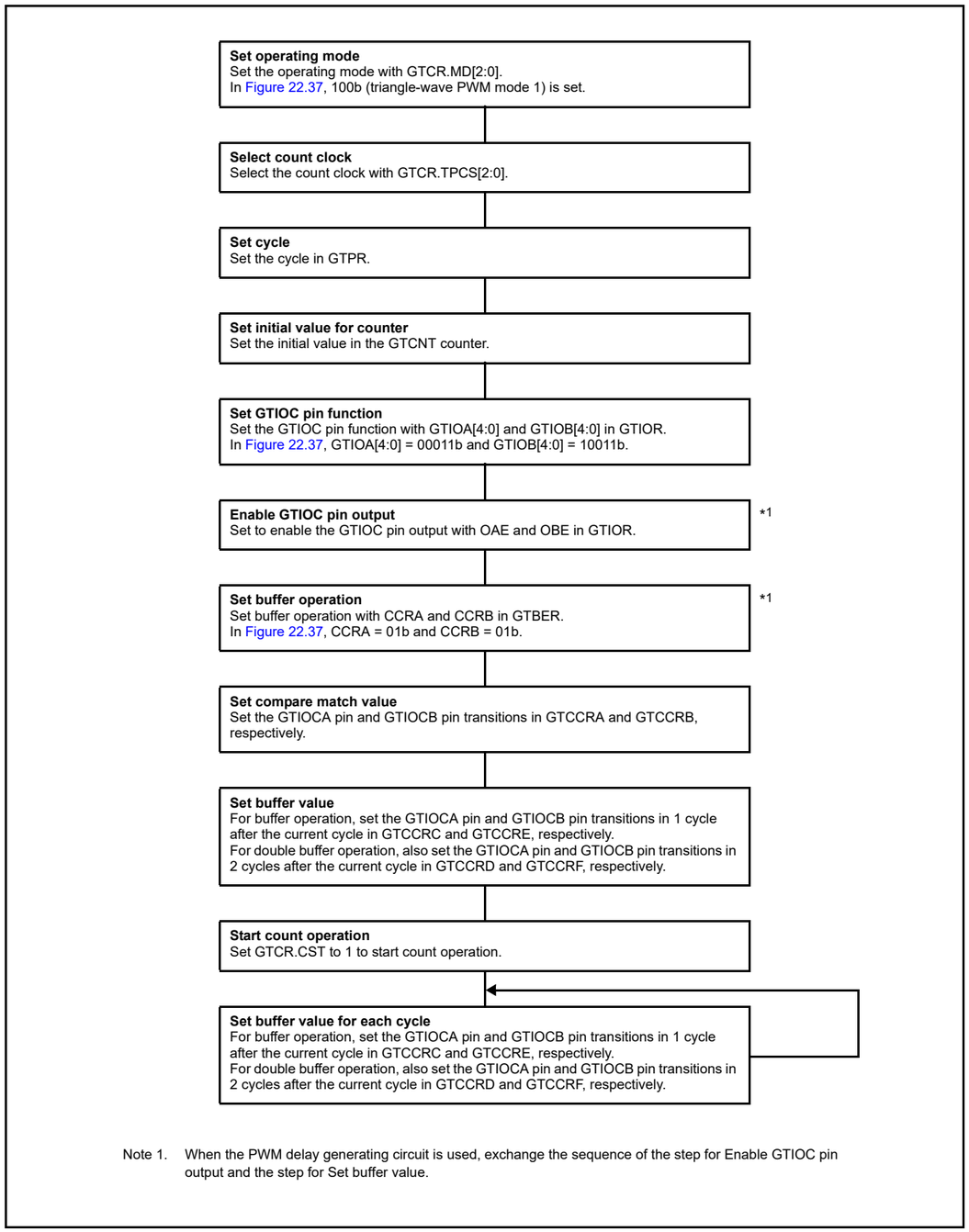
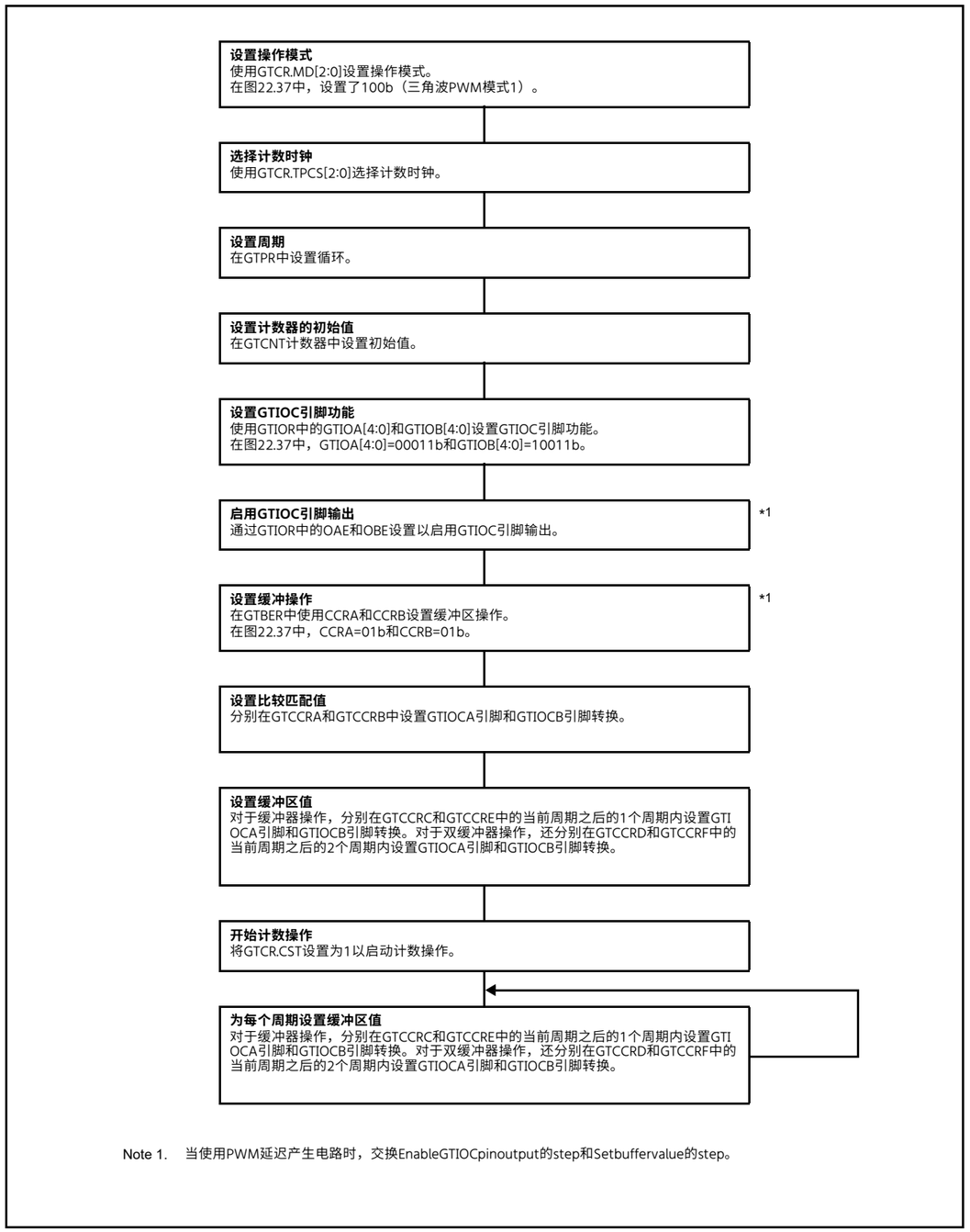


Figure 22.37 带缓冲操作的三角波PWM模式1操作示例，从GTIOC0A引脚和GTIOC0B引脚在计数开始时的高电平输出，输出在GTCCRAGTCCRB寄存器比较匹配，并在循环结束时保留输出



Note 1. When the PWM delay generating circuit is used, exchange the sequence of the step for Enable GTIOC pin output and the step for Set buffer value.

Figure 22.38 Example setting for triangle-wave PWM mode 1



Note 1. 当使用PWM延迟产生电路时，交换EnableGTIOCpinoutput的step和Setbuffervalue的step。

Figure 22.38 三角波PWM模式1的设置示例

22.3.3.4 Triangle-wave PWM mode 2 (32-bit transfer at crest and trough)

Similarly to triangle-wave PWM mode 1, in triangle-wave PWM mode 2 the cycle is set in GTPR. The GTCNT counter performs triangle-wave (full-wave) operation, and a PWM waveform is output to the GTIOCA or GTIOCB pin when a GTCCRA or GTCCRB compare match occurs. The buffer transfer is performed at both crests and troughs. The pin output value can be selected from low output, high output, or toggle output separately for a compare match and for the cycle end according to the GTIOR setting.

By setting GTDTCR, GTDVU, and GTDVD, a compare match value for a negative-phase waveform with dead time can automatically be set to GTCCRB.

Figure 22.39 shows an example of triangle-wave PWM mode 2 operation, and Figure 22.40 shows an example setting for triangle-wave PWM mode 2.

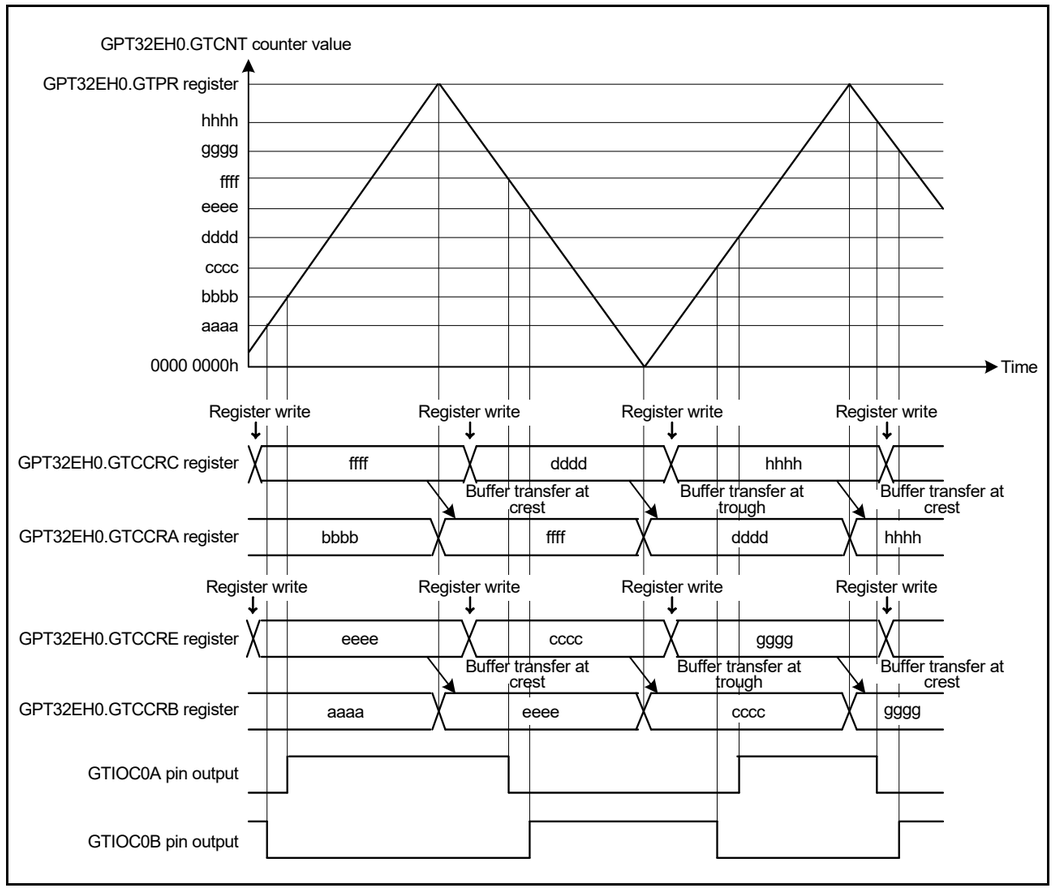


Figure 22.39 Example of triangle-wave PWM mode 2 operation with buffer operation, low output from the GTIOC0A pin and high output from the GTIOC0B pin at count start, output toggled at GTCCRA/GTCCRB compare match, and output retained at cycle end

22.3.3.4 三角波PWM模式2（波峰和波谷32位传输）

与三角波PWM模式1类似，在三角波PWM模式2中，周期在GTPR中设置。GTCNT计数器执行三角波（全波）操作，当发生GTCCRA或GTCCRB比较匹配时，PWM波形将输出到GTIOCA或GTIOCB引脚。缓冲转移在波峰和波谷进行。引脚输出值可以根据GTIOR设置分别从低输出、高输出或切换输出中选择，用于比较匹配和循环结束。

通过设置GTDTCR、GTDVU和GTDVD，可以自动将带死区时间的负相位波形的比较匹配值设置为GTCCRB。

图22.39显示了三角波PWM模式2操作的示例，图22.40显示了三角波PWM模式2的示例设置。

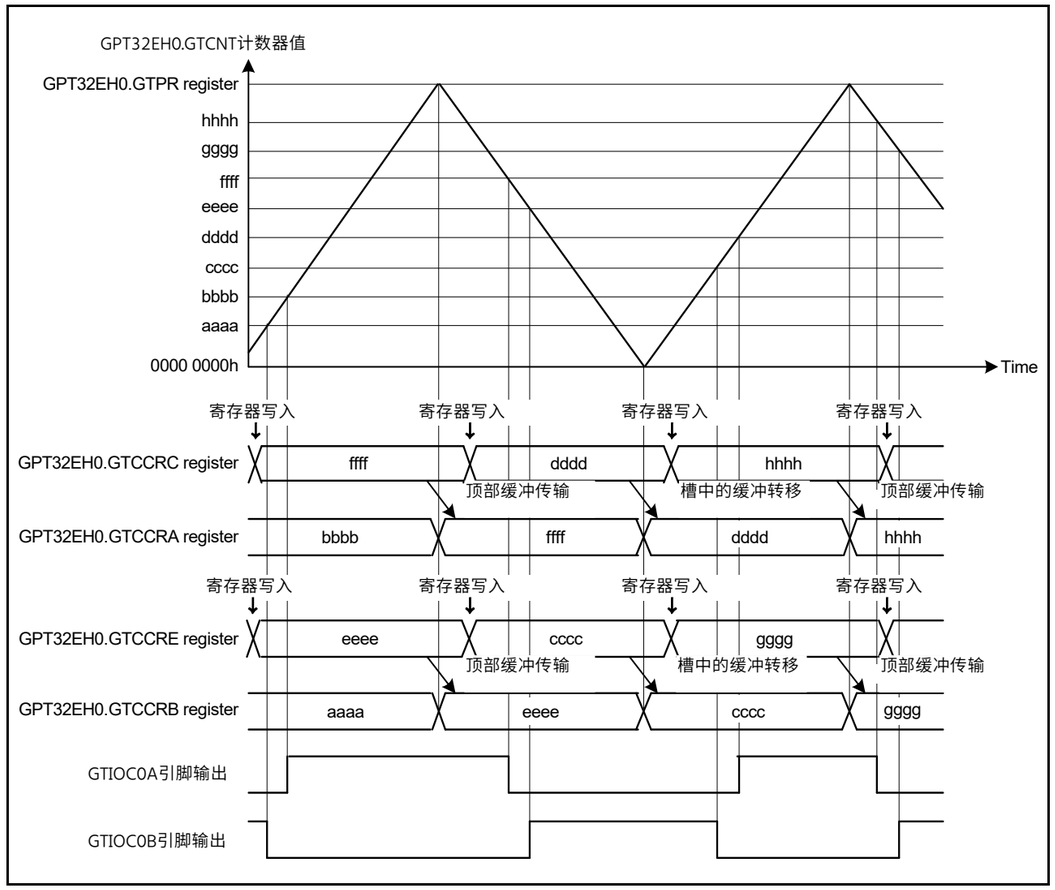
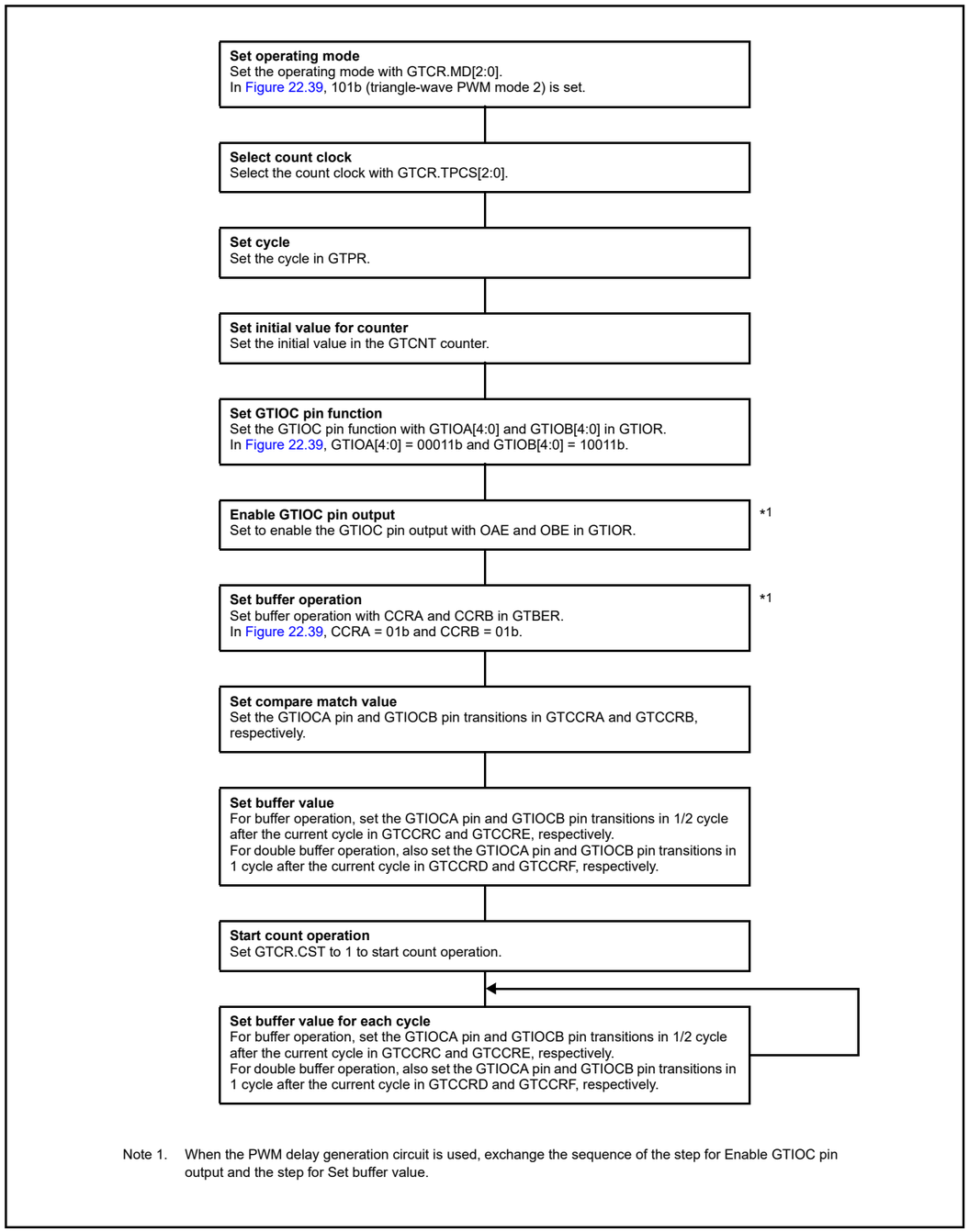
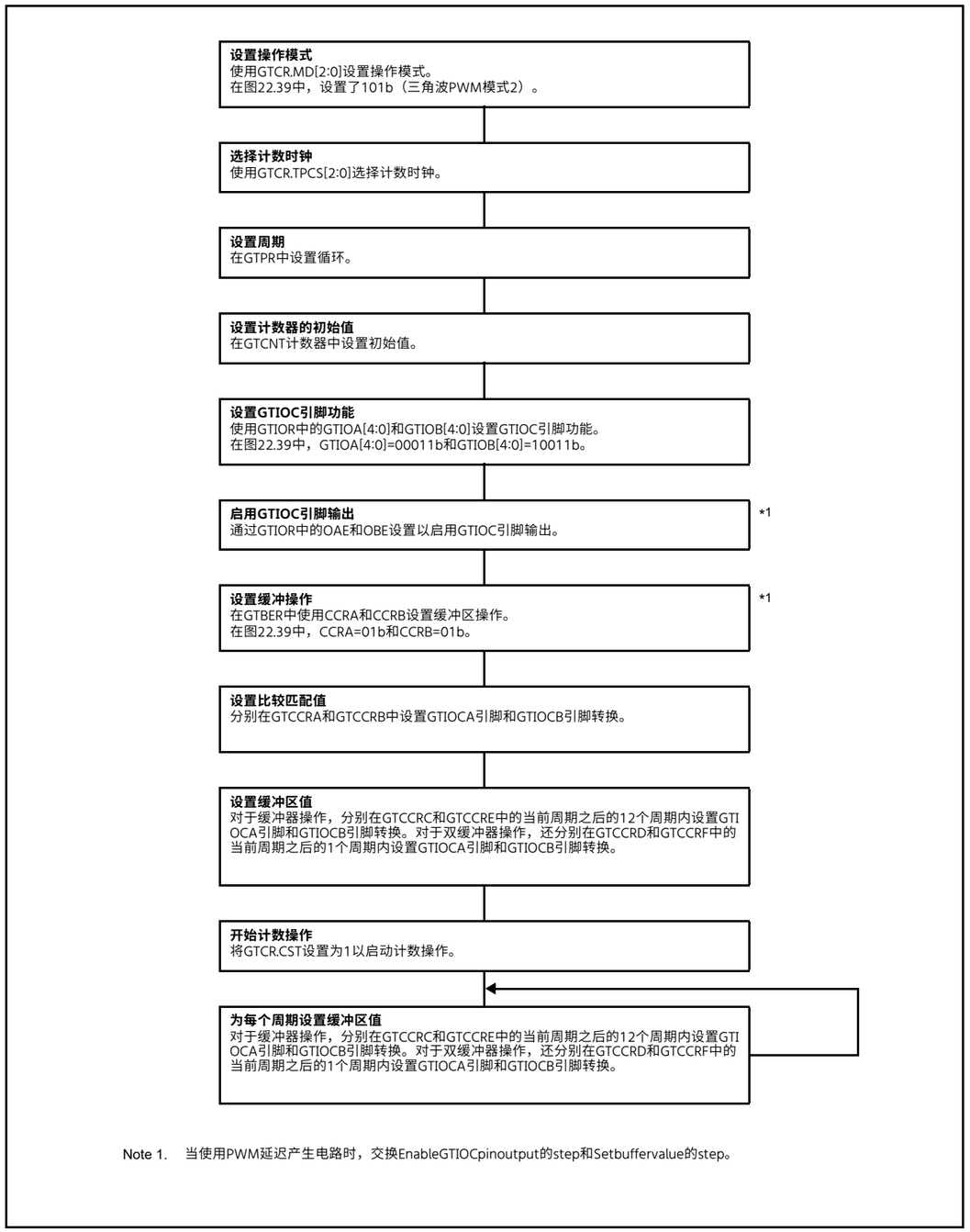


Figure 22.39 带缓冲操作的三角波PWM模式2操作示例，从GTIOC0A引脚和GTIOC0B引脚在计数开始时的高电平输出，输出在GTCCRAGTCCRB比较匹配，并在循环结束时保留输出



Note 1. When the PWM delay generation circuit is used, exchange the sequence of the step for Enable GTIOC pin output and the step for Set buffer value.

Figure 22.40 Example setting for triangle-wave PWM mode 2



Note 1. 当使用PWM延迟产生电路时，交换EnableGTIOCpinoutput的step和Setbuffervalue的step。

Figure 22.40 三角波PWM模式2的设置示例

22.3.3.5 Triangle-wave PWM mode 3 (64-bit transfer at trough)

The triangle-wave PWM mode 3 is a mode in which the cycle is set in GTPR. The GTCNT counter performs triangle-wave (full-wave) operation, and a PWM waveform is output to the GTIOCA or GTIOCB pin at a compare match of GTCCRA or GTCCRB with buffer operation fixed. Buffer operation in triangle-wave PWM mode 3 is different from the usual buffer operation. Buffer transfer is performed from:

- GTCCRC to GTCCRA at the trough
- GTCCRE to GTCCRB at the trough
- GTCCRD to temporary register A at the trough
- GTCCRF to temporary register B at the trough
- Temporary register A to GTCCRA at the crest
- Temporary register B to GTCCRB at the crest.

The pin output value can be selected from low output, high output, or toggle output separately for a compare match and for the cycle end according to the GTIOR setting.

By setting GTDTCR, GTDVU, and GTDVD, a compare match value for a negative-phase waveform with dead time can automatically be set to GTCCRB.

Figure 22.41 shows an example of triangle-wave PWM mode 3 operation, and Figure 22.42 shows an example setting for triangle-wave PWM mode 3.

22.3.3.5 三角波PWM模式3（波谷64位传输）

三角波PWM模式3是在GTPR中设定周期的模式。GTCNT计数器执行三角波（全波）操作，并且在固定缓冲操作的GTCCRA或GTCCRB比较匹配时将PWM波形输出到GTIOCA或GTIOCB引脚。三角波PWM模式3中的缓冲操作与通常的缓冲操作不同。缓冲区传输从以下位置执行：

- GTCCRC到GTCCRA在低谷
- GTCCRE到GTCCRB在低谷
- GTCCRD到谷底临时寄存器A
- GTCCRF到波谷临时寄存器B
- 顶部GTCCRA的临时注册A
- 在顶部的GTCCRB临时寄存器B。

引脚输出值可以根据GTIOR设置分别从低输出、高输出或切换输出中选择，用于比较匹配和循环结束。

通过设置GTDTCR、GTDVU和GTDVD，可以自动将带死区时间的负相位波形的比较匹配值设置为GTCCRB。

图22.41显示了三角波PWM模式3操作的示例，图22.42显示了三角波PWM模式3的示例设置。

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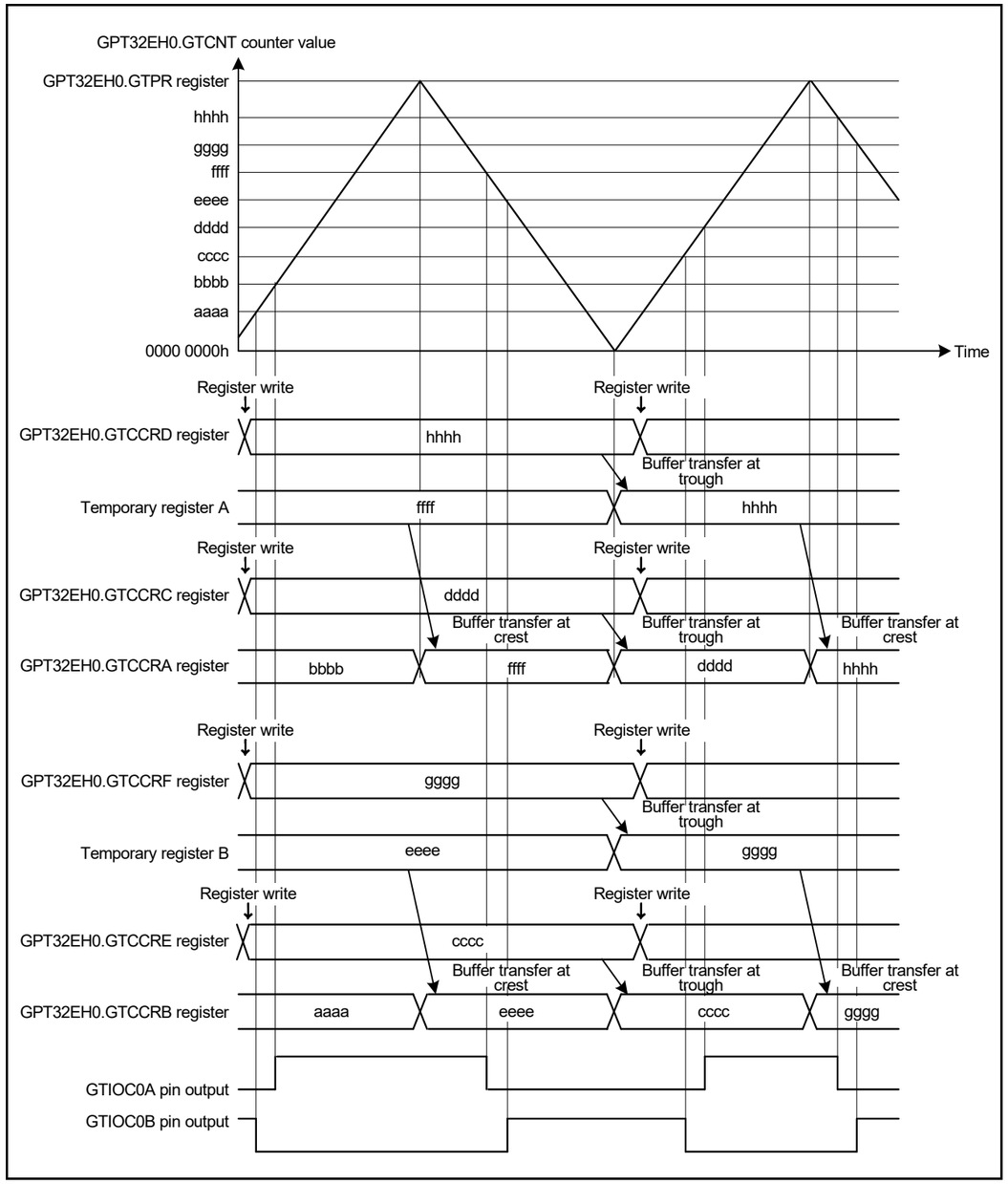


Figure 22.41 Example of triangle-wave PWM mode 3 operation with low output from the GTIOC0A pin and high output from the GTIOC0B pin at count start, output toggled at GTCCRA/GTCCRB compare match, and output retained at cycle end

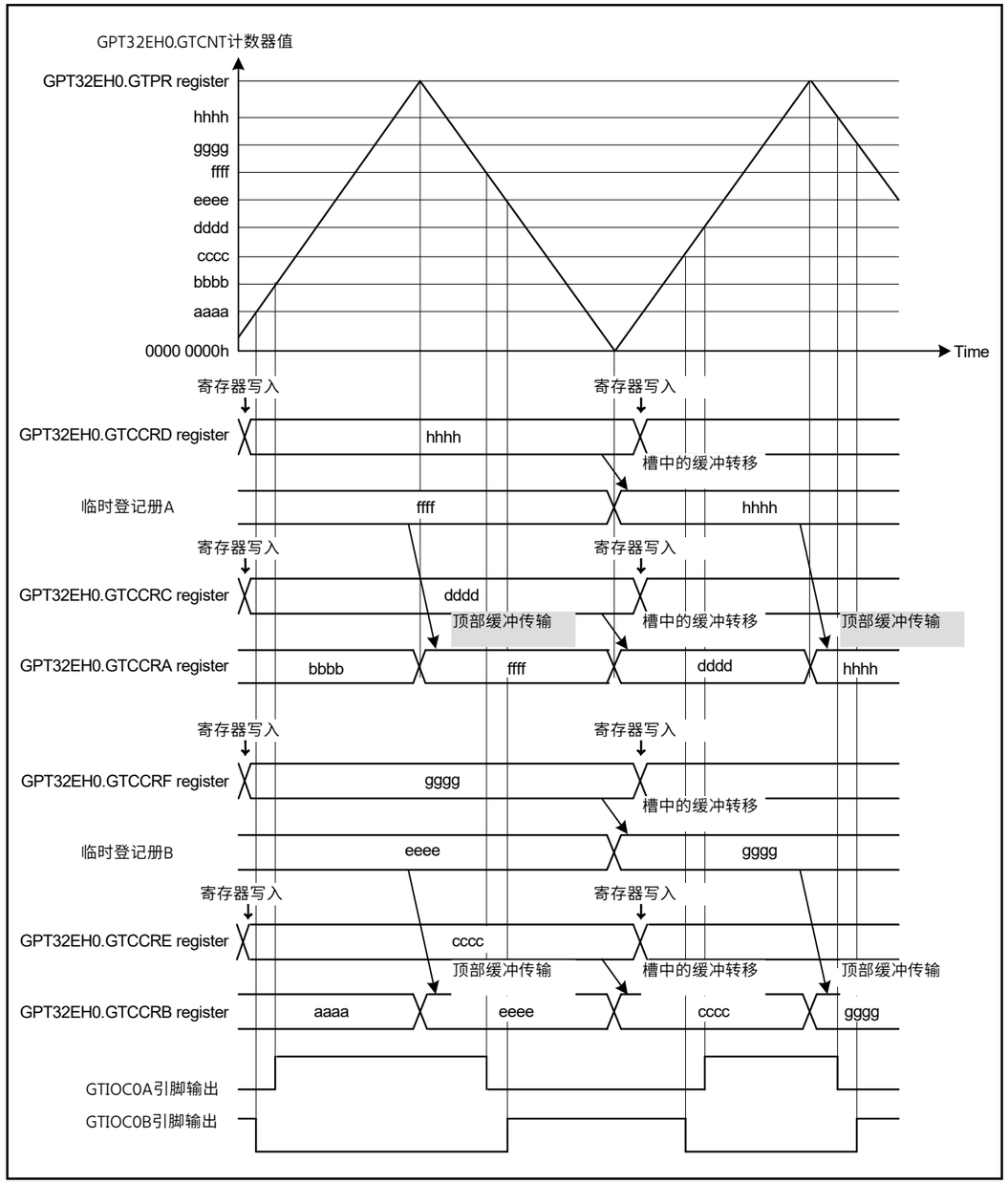
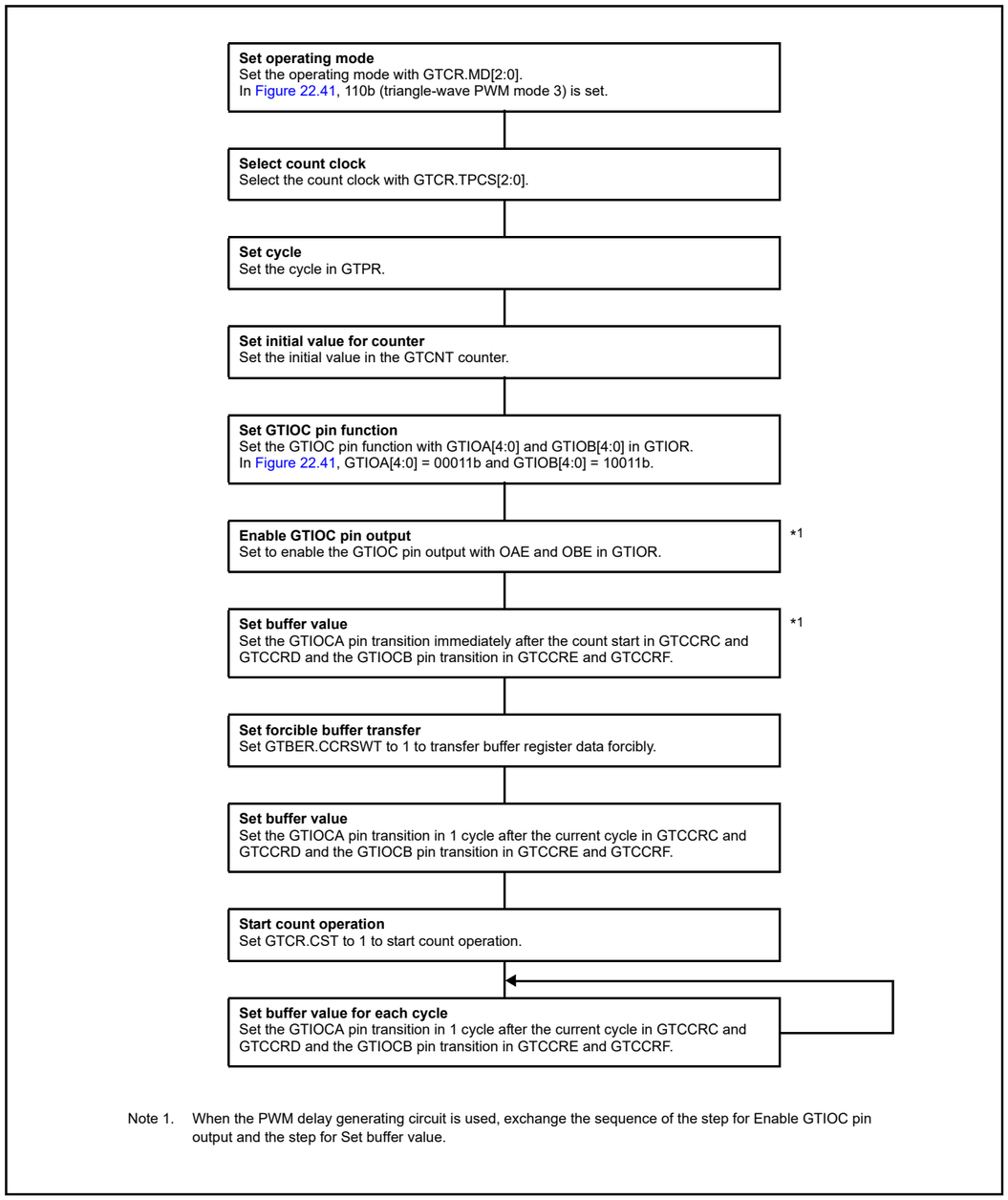
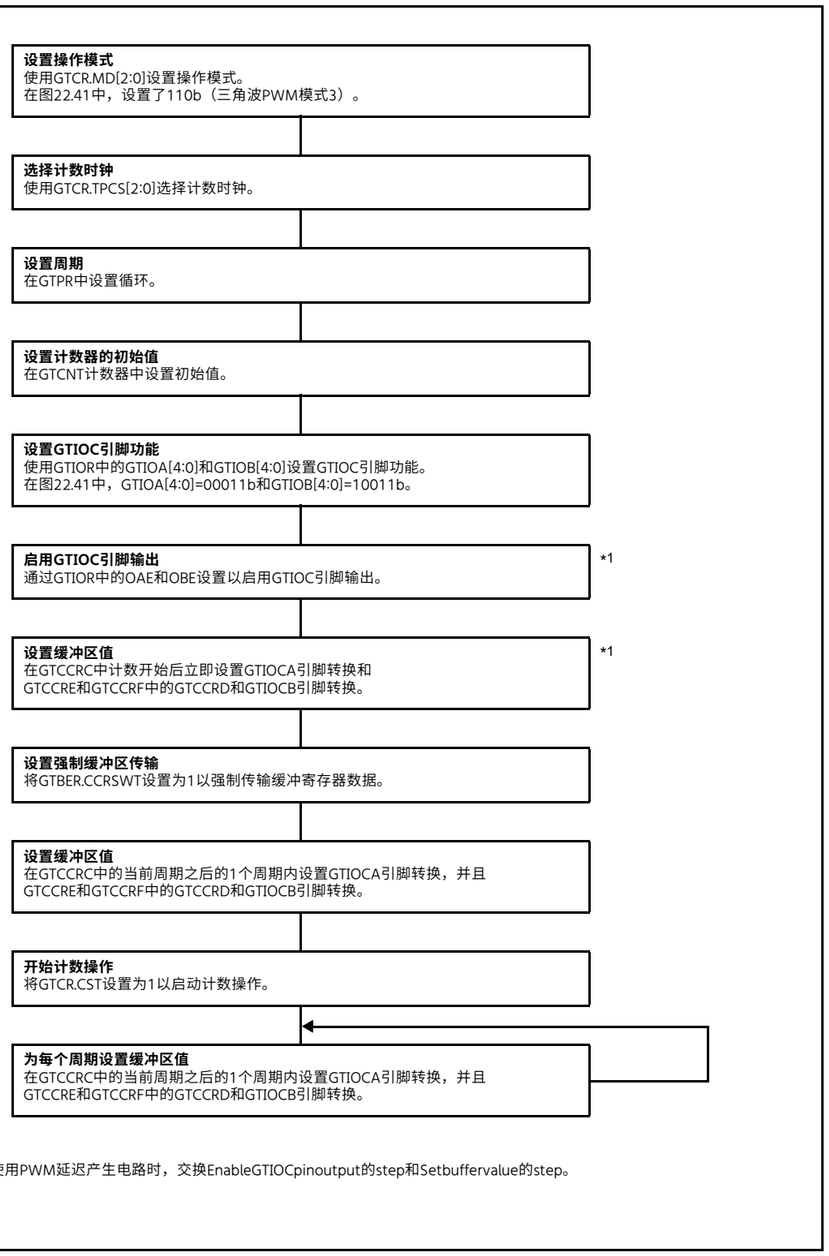


Figure 22.41 三角波PWM模式3操作示例，计数开始时GTIOC0A引脚输出低电平，GTIOC0B引脚输出高电平，在GTCCRAGTCCRB比较匹配时切换输出，在周期结束时保持输出



Note 1. When the PWM delay generating circuit is used, exchange the sequence of the step for Enable GTIOC pin output and the step for Set buffer value.

Figure 22.42 Example setting for triangle-wave PWM mode 3



Note 1. 当使用PWM延迟产生电路时，交换EnableGTIOCpinoutput的step和Setbuffervalue的step。

Figure 22.42 三角波PWM模式3的设置示例

22.3.4 Automatic Dead Time Setting Function

By setting GTDTCR, a compare match value for a negative waveform with dead time obtained by a compare match value for a positive waveform (GTCCRA value) and specified dead time values (GTDVU and GTDVD values) can automatically be set to GTCCRB. The automatic dead time setting function can be used in saw-wave one-shot pulse mode and all the triangle PWM modes.

Dead time can be separately set for the first half and second half of a waveform. Dead time for the transition in the first half of a negative waveform is set in GTDVU and that in the second half is set in GTDVD. The same dead time can also be set for the first and second halves by setting the GTDTCR.TDFER bit to 1.

GTDBU can be used as a buffer register of GTDVU, and GTDBD can be used as a buffer register of GTDVD. Buffer transfer is performed at a GTCNT overflow (during up-counting), an underflow (during down-counting), or at a GTCNT counter clear for saw waves and at the trough for triangle waves.

The compare match value set by automatic dead time setting function can be confirmed by reading from GTCCRB. Writing to GTCCRB is prohibited when the automatic dead time setting function is used.

Dead time setting beyond the cycle is prohibited. When a dead time error occurs, the compare match values for positive and negative waveforms are adjusted to generate the waveforms with the dead time as shown in Table 22.6. The adjusted value for the negative waveform is set for GTCCRB automatically. The adjusted value for the positive waveform is used as internal signal and not set for GTCCRA.

In saw-wave one-shot pulse mode, when the adjusted value is beyond the cycle or the adjusted waveform toggle points are in disorder, the complementarity of the waveforms is not guaranteed.

In triangle-wave mode, when the dead time is beyond the cycle by setting the value GTCCR = 0 or GTCCRA ≥ GTPR for GTCCRA, the output protection function keeps the level of output. For details, see section 22.8.4, Output Protection Function for GTIOC Pin Output. When the GTCCRA is GTCCRA ≥ GTPR + GTDVm, GTPR-1 is set for GTCCRB as the upper limit value. The automatic dead time value setting to GTCCRB is performed at the next clock cycle count when registers used for calculating the automatic dead time value are updated.

The way to rewrite GTDVm differs by GPT channel number.

Table 22.6 Compare match value after adjusting for dead time error

PWM output operating mode	Count direction	First half/ Second half	Condition of dead time error	Compare match value after adjusting	
				Positive waveform	Negative waveform
Saw-wave one-shot pulse mode	Up	First half	GTCCRA - GTDVU < 0	GTDVU	0
		Second half	GTCCRA + GTDVD > GTPR	GTPR - GTDVD	GTPR
	Down	First half	GTCCRA + GTDVU > GTPR	GTPR - GTDVU	GTPR
		Second half	GTCCRA - GTDVD < 0	GTDVD	0
Triangle-wave PWM mode 1/2/3	Up	First half	GTCCRA - GTDVU ≤ 0	GTDVU + 1	1
	Down	Second half	GTCCRA - GTDVD < 0	GTDVD	0

GPT32EH0 to GPT32EH3 and GPT32E4 to GPT32E7

When GTDVm buffer operation is enabled, GTDBm can be written at anytime. GTDBm is transferred to GTDVm at the cycle end.

When GTDVm buffer operation is disabled, stop the GPT using the CST bit in the GTCR register before changing GTDVm to a new value.

GPT328 to GPT3212

While GPT is running, changing the GTDVU values is prohibited. To change GTDVU to a new value, first stop the GPT using the CST bit in the GTCR register.

Figure 22.43 to Figure 22.46 show examples of automatic dead time setting function operation for GPT32EH and GPT32E. Figure 22.47 and Figure 22.48 show the setting examples.

22.3.4 自动死区时间设置功能

通过设置GTDTCR，通过正波形的比较匹配值（GTCCRA值）和指定的死区时间值（GTDVU和GTDVD值）获得的负波形与死区时间的比较匹配值可以自动设置为GTCCRB。自动死区时间设置功能可用于锯齿波一次性脉冲模式和所有三角PWM模式。

可以为波形的前半部分和后半部分分别设置死区时间。在GTDVU中设置负波形前半部分的过渡的死区时间，在GTDVD中设置后半部分的过渡时间。通过将GTDTCR.TDFER位设置为1，也可以为前半部分和后半部分设置相同的死区时间。

GTDBU可以作为GTDVU的缓冲寄存器，GTDBD可以作为GTDVD的缓冲寄存器。在GTCNT上溢（向上计数期间）、下溢（向下计数期间）或GTCNT计数器清除锯齿波和三角波波谷时执行缓冲区传输。

自动死区时间设置功能设置的比较匹配值可以通过读取GTCCRB来确认。
使用自动死区时间设置功能时，禁止写入GTCCRB。

禁止设置超出周期的死区时间。当出现死区时间错误时，调整正负波形的比较匹配值以生成具有死区时间的波形，如表22.6所示。负波形的调整值自动为GTCCRB设置。正波形的调整值用作内部信号，而不是为GTCCRA设置的。

在锯齿波单发脉冲模式下，当调整值超出周期或调整后的波形切换点混乱时，波形的互补性无法保证。

在三角波模式下，当通过设置GTCCRA=0或GTCCRA≥GTCCRA的值使死区时间超出周期时，输出保护功能保持输出电平。有关详细信息，请参见第22.8.4节，GTIOC引脚输出的输出保护功能。当GTCCRA为GTCCRA≥GTPR+GTDVm时，将GTPR−1设置为GTCCRB作为上限值。当用于计算自动死区时间值的寄存器被更新时，在下一个时钟周期计数时执行GTCCRB的自动死区时间值设置。

重写GTDVm的方式因GPT通道号而异。

Table 22.6 调整死区时间误差后比较匹配值

PWM输出工作模式	计数方向	First half/ 下半场	死区时间错误的条件	调整后比较匹配值	
				正波形	负波形
锯波单发脉冲模式	Up	上半场	GTCCRA - GTDVU < 0	GTDVU	0
		下半场	GTCCRA + GTDVD > GTPR	GTPR - GTDVD	GTPR
	Down	上半场	GTCCRA + GTDVU > GTPR	GTPR - GTDVU	GTPR
		下半场	GTCCRA - GTDVD < 0	GTDVD	0
Triangle-wave PWM mode 1/2/3	Up	上半场	GTCCRA - GTDVU ≤ 0	GTDVU + 1	1
	Down	下半场	GTCCRA - GTDVD < 0	GTDVD	0

GPT32EH0到GPT32EH3和GPT32E4到GPT32E7

当启用GTDVm缓冲区操作时，可以随时写入GTDBm。GTDBm在循环结束时转移到GTDVm。

当GTDVm缓冲区操作被禁用时，在更改之前使用GTCR寄存器中的CST位停止GPT
GTDVm到一个新的值。

GPT328 to GPT3212

在GPT运行时，禁止更改GTDVU值。要将GTDVU更改为新值，首先使用GTCR寄存器中的CST位停止GPT。

图22.43至图22.46显示了GPT32EH和自动死区时间设置功能操作示例
GPT32E。图22.47和图22.48显示了设置示例。

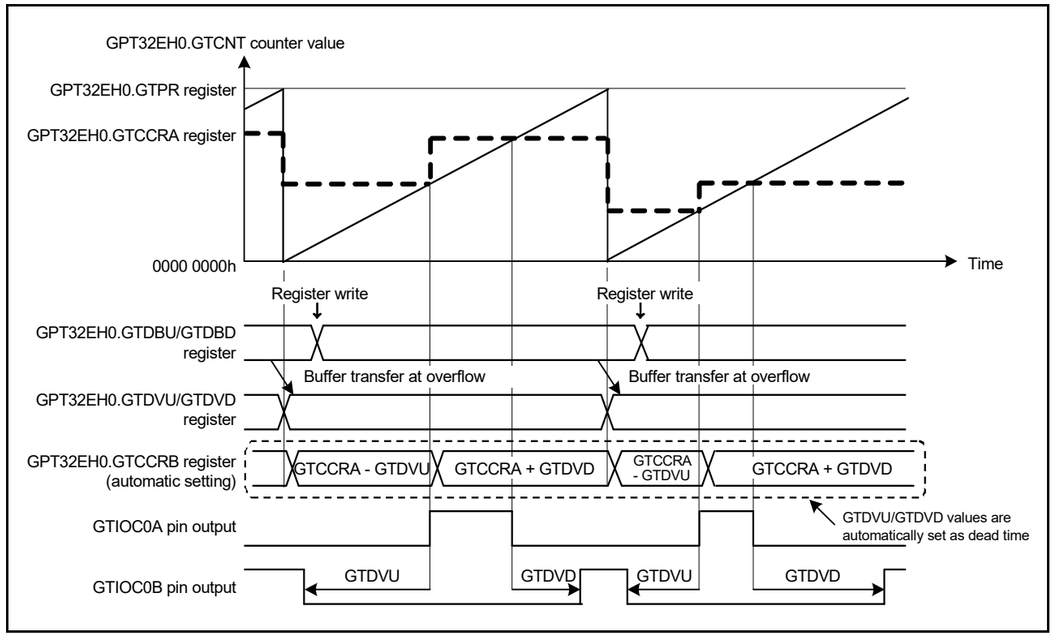


Figure 22.43 Example of automatic dead time setting function operation with saw-wave one-shot pulse mode, up-counting, GTDVU and GTDVD set to buffer operation, and active-high

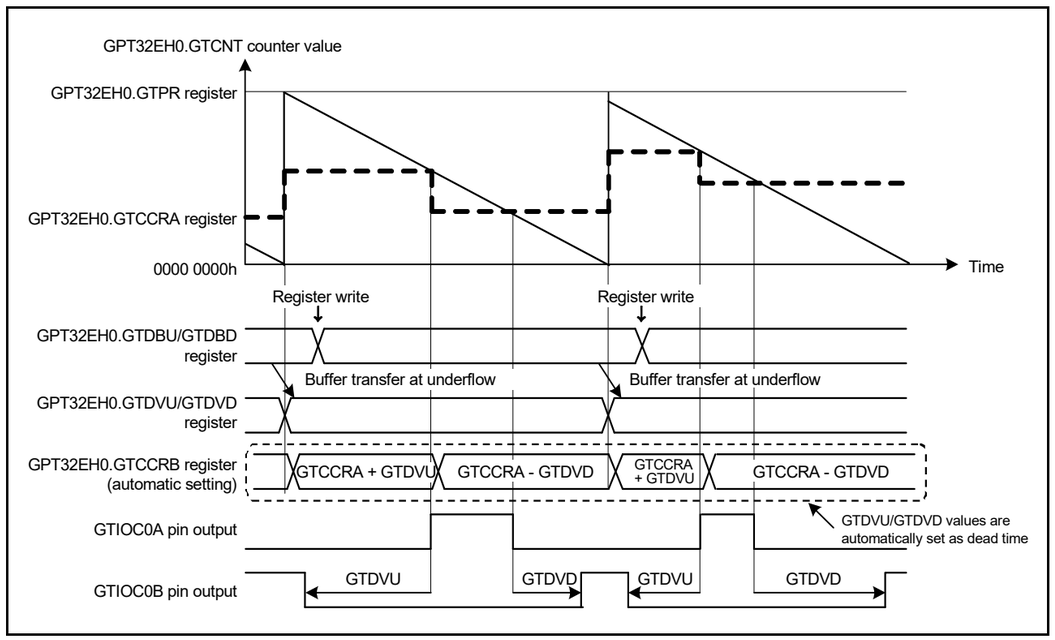


Figure 22.44 Example of automatic dead time setting function operation with saw-wave one-shot pulse mode, down-counting, GTDVU and GTDVD set to buffer operation, and active-high

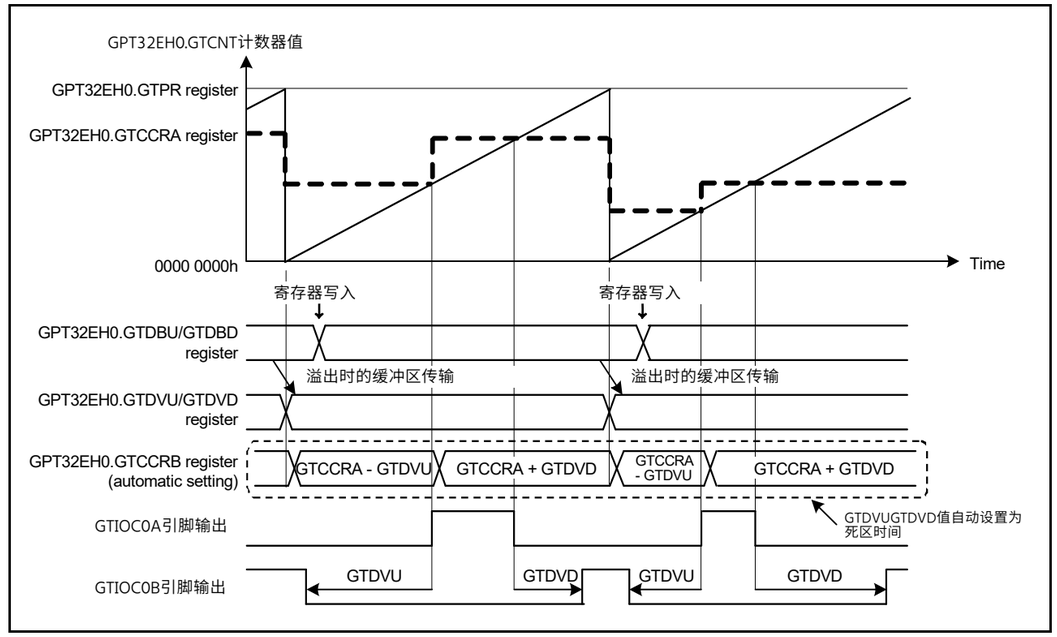


Figure 22.43 自动死区时间设置功能操作示例，锯齿波单次脉冲模式、递增计数、GTDVU和GTDVD设置为缓冲操作以及高电平有效

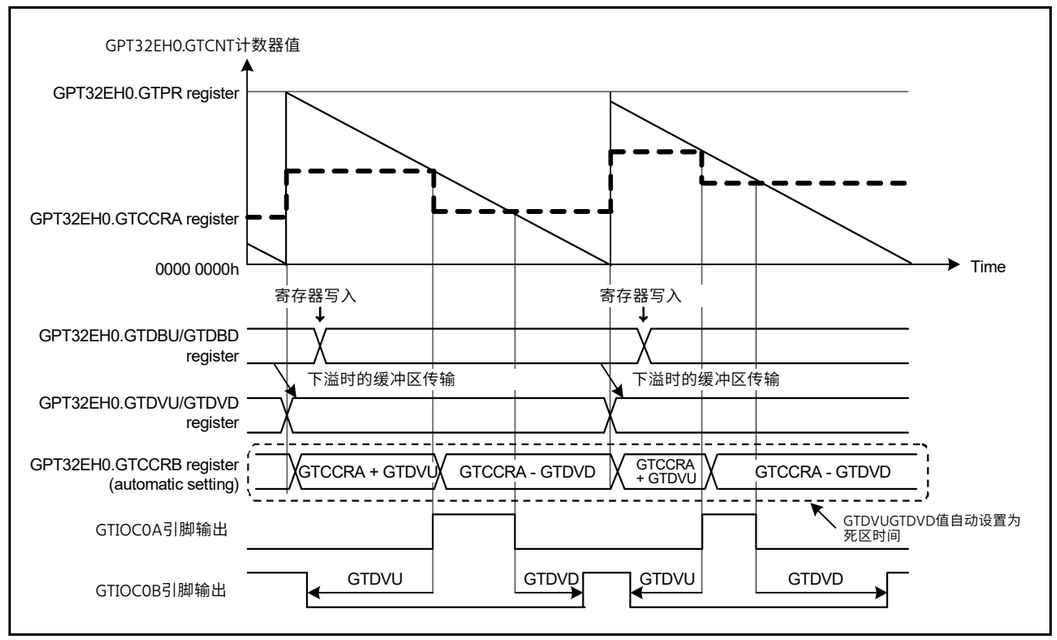


Figure 22.44 自动死区时间设置功能操作示例，锯齿波单次脉冲模式、递减计数、GTDVU和GTDVD设置为缓冲操作以及高电平有效

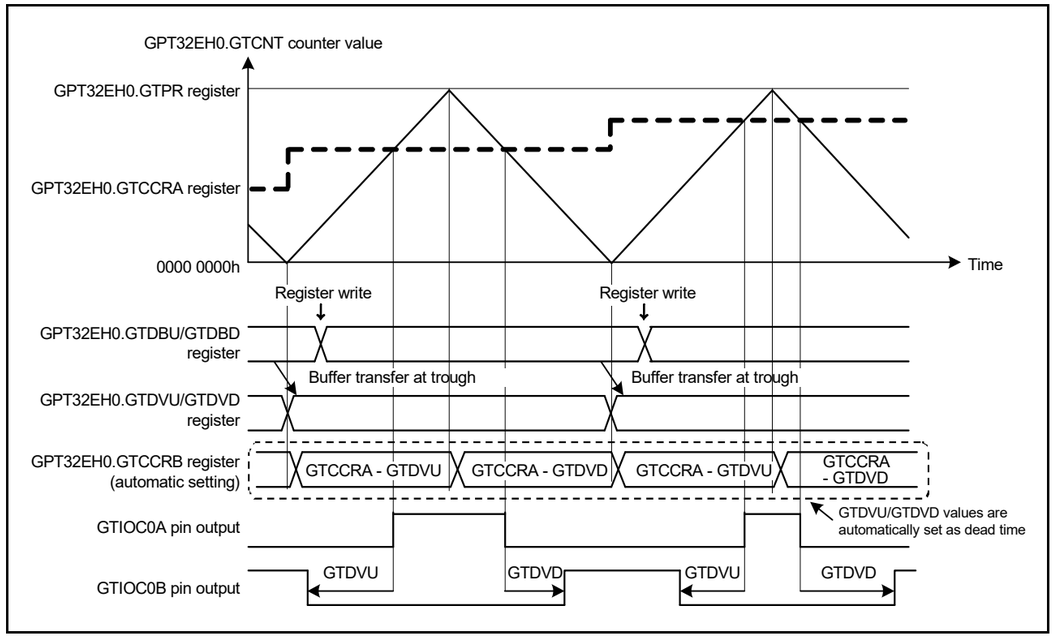


Figure 22.45 Example of automatic compare-match value setting function with dead time, triangle-wave PWM mode 1, GTDVU and GTDVD set to buffer operation, active-high

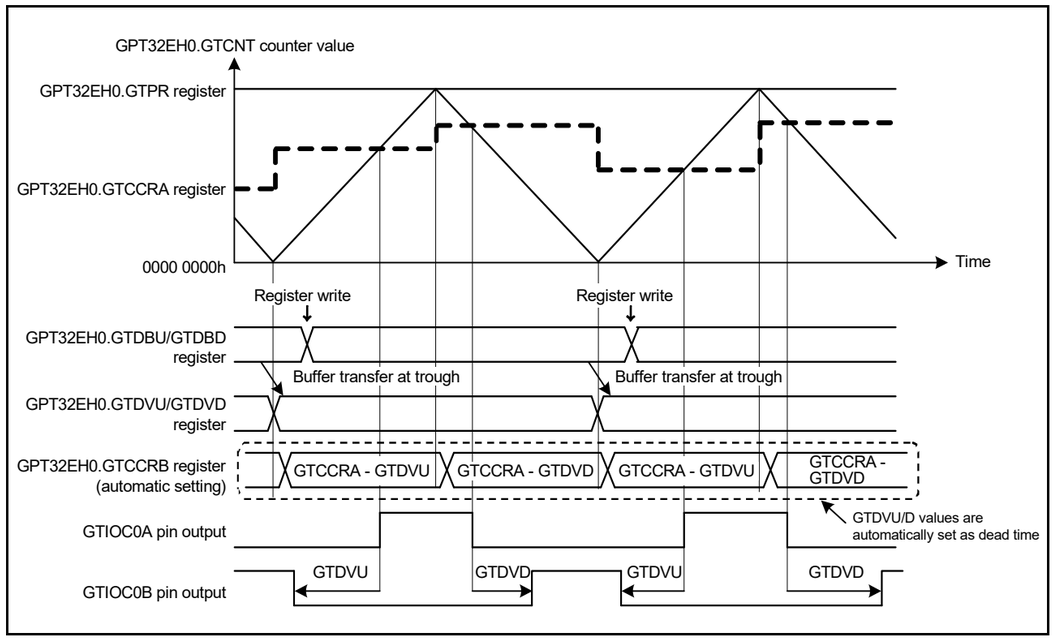


Figure 22.46 Example of automatic compare-match value setting function with dead time, triangle-wave PWM mode 2 or 3, GTDVU and GTDVD set to buffer operation, and active-high

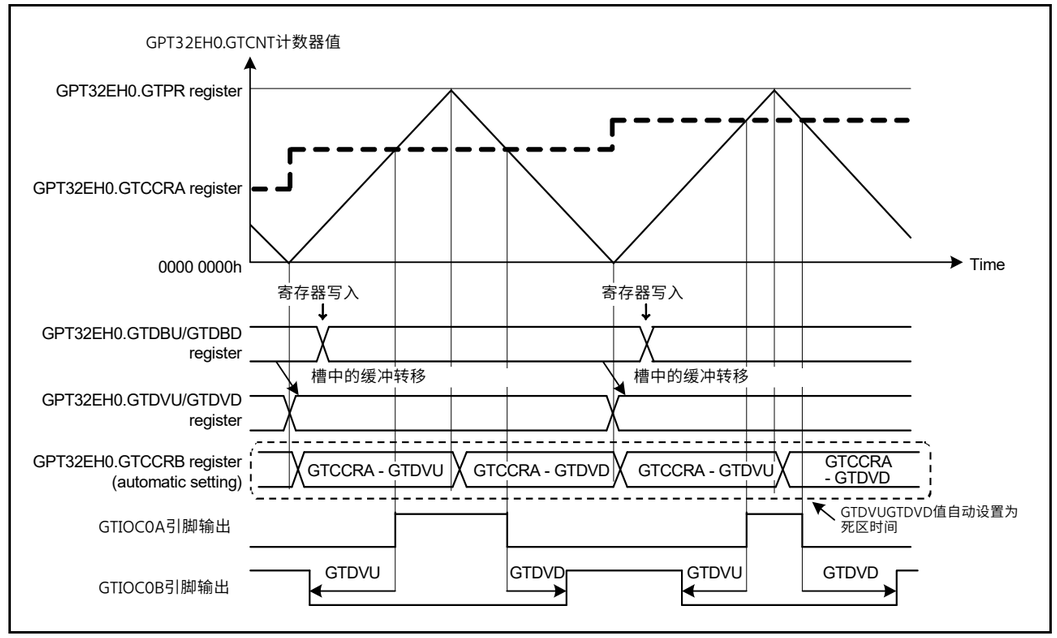


Figure 22.45 具有死区时间、三角波PWM模式1、GTDVU和GTDVD设置为缓冲操作、高电平有效的自动比较匹配值设置功能示例

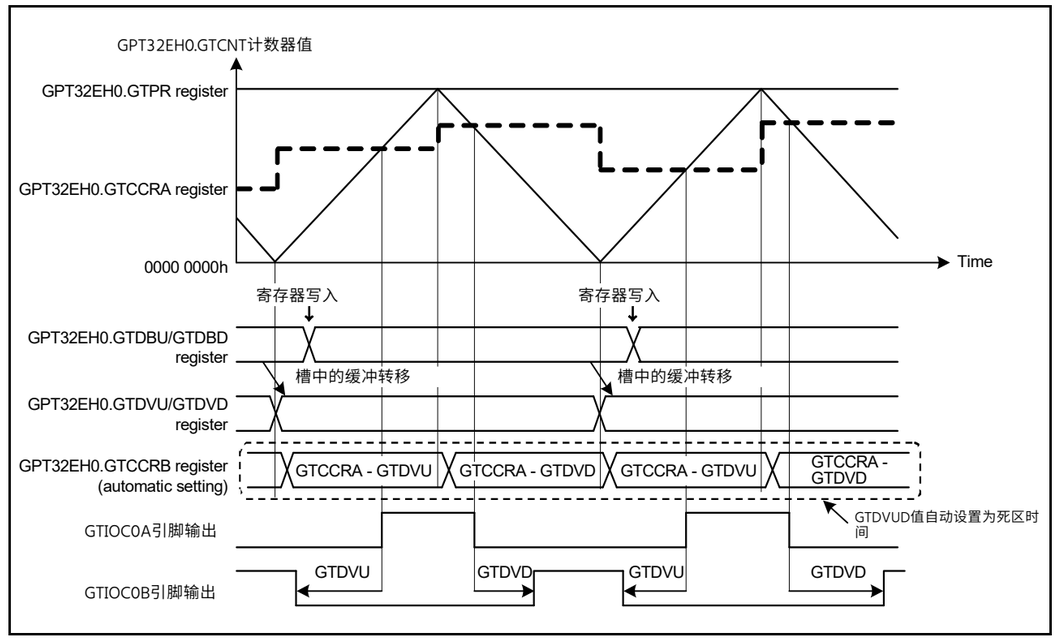
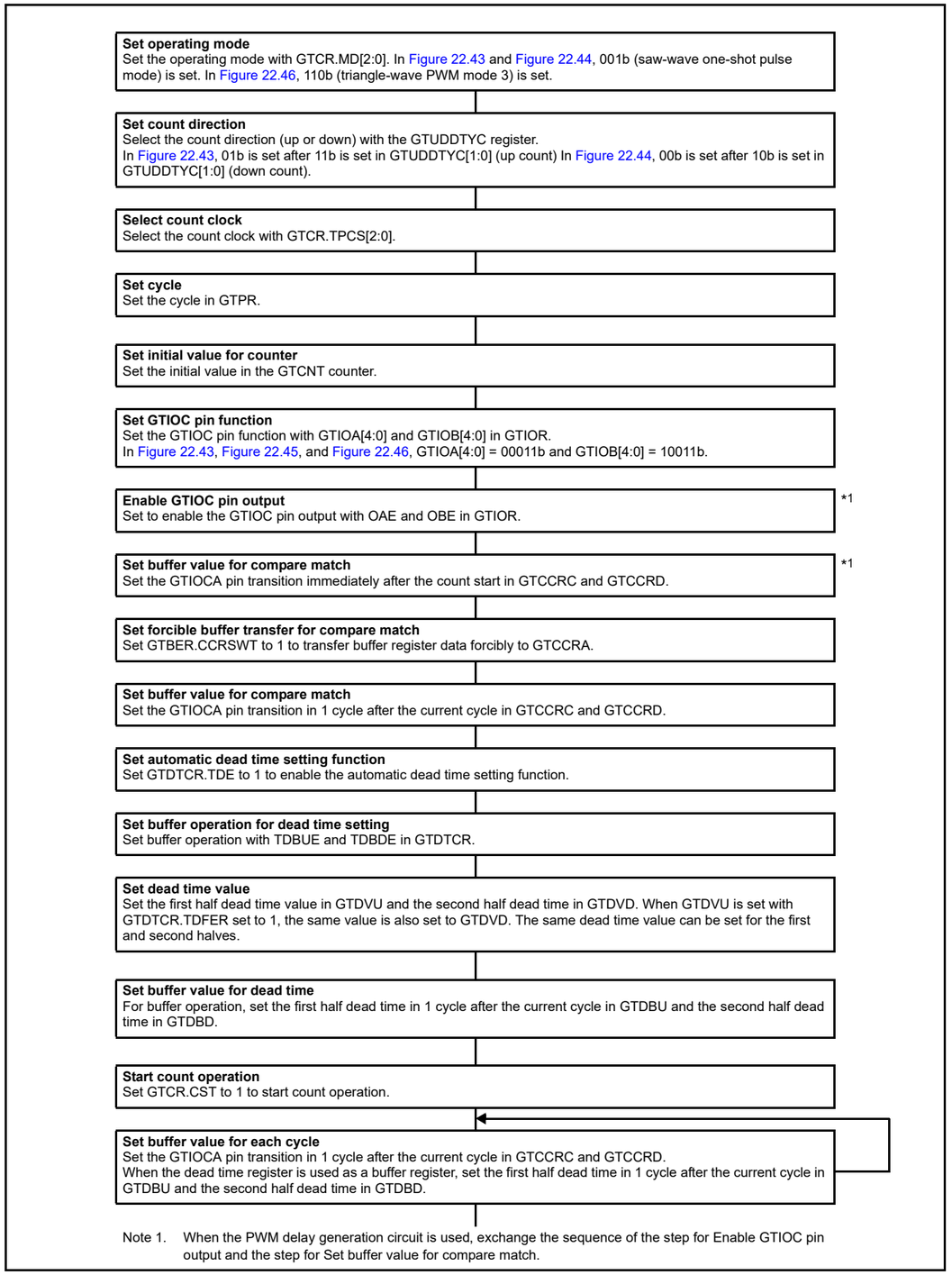
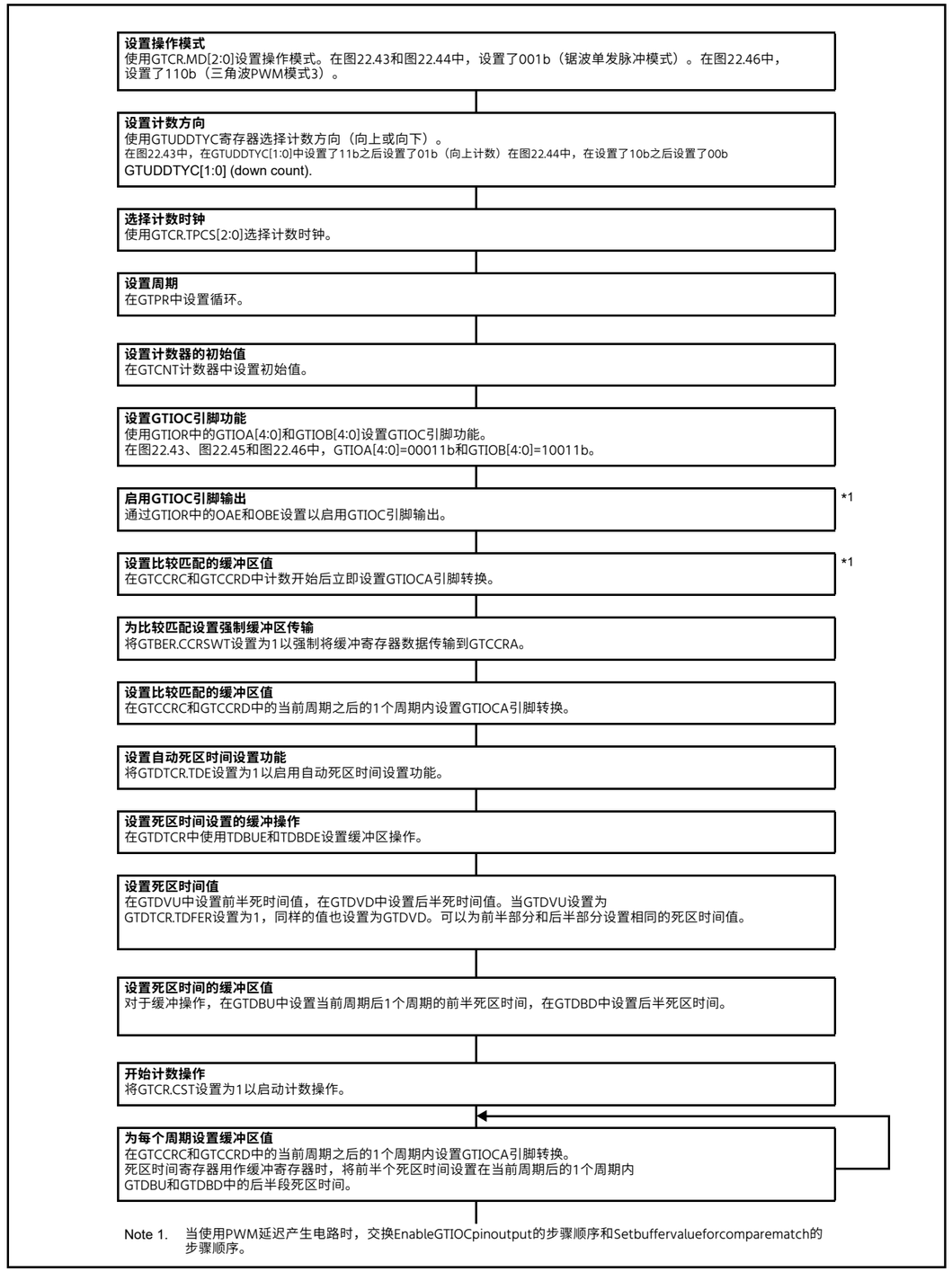


Figure 22.46 具有死区时间、三角波PWM模式2或3、GTDVU和GTDVD设置为缓冲操作和高电平有效的自动比较匹配值设置功能示例



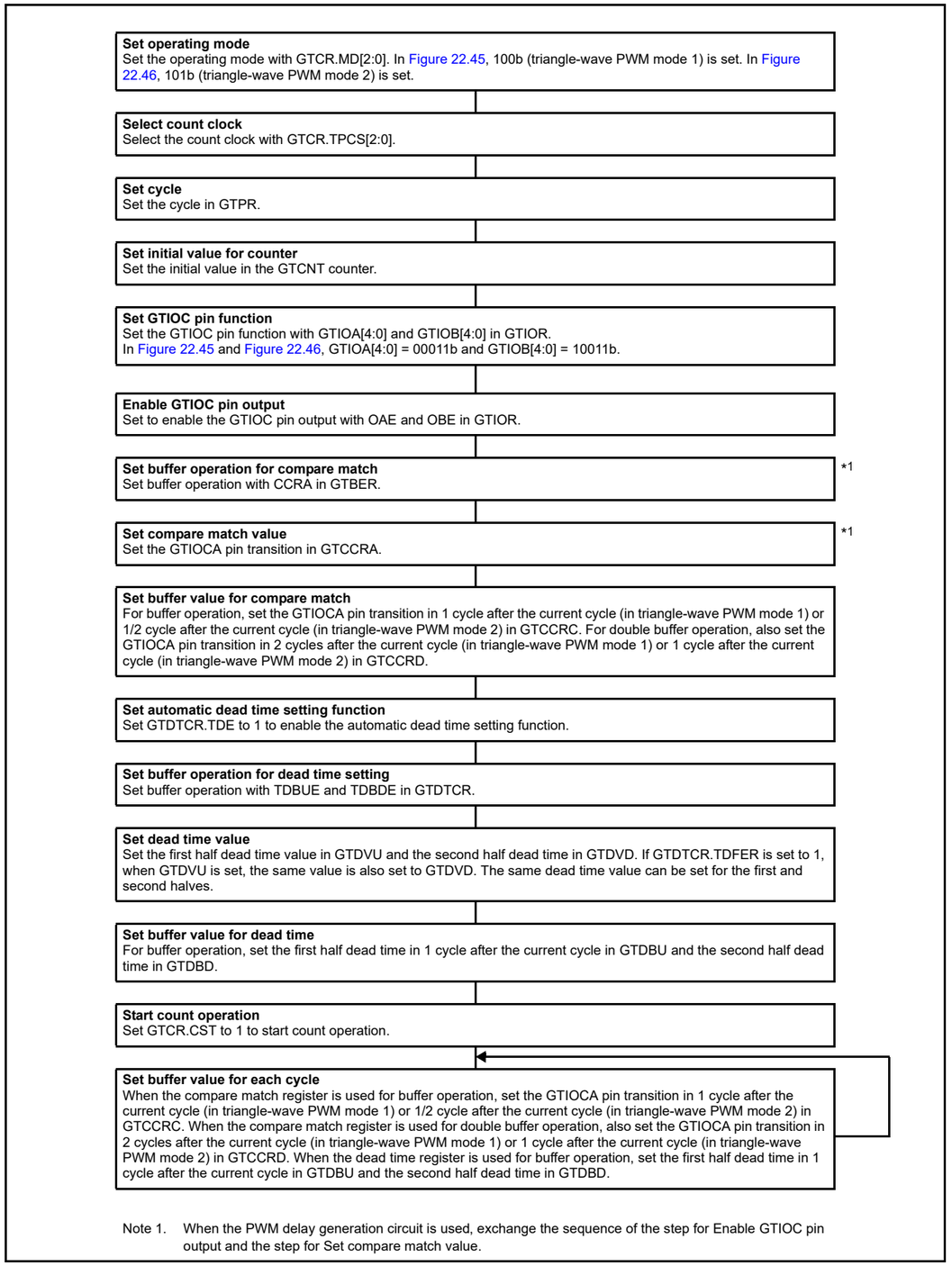
Note 1. When the PWM delay generation circuit is used, exchange the sequence of the step for Enable GTIOC pin output and the step for Set buffer value for compare match.

Figure 22.47 Example setting for automatic dead time setting function with saw-wave one-shot pulse mode, and triangle-wave PWM mode 3



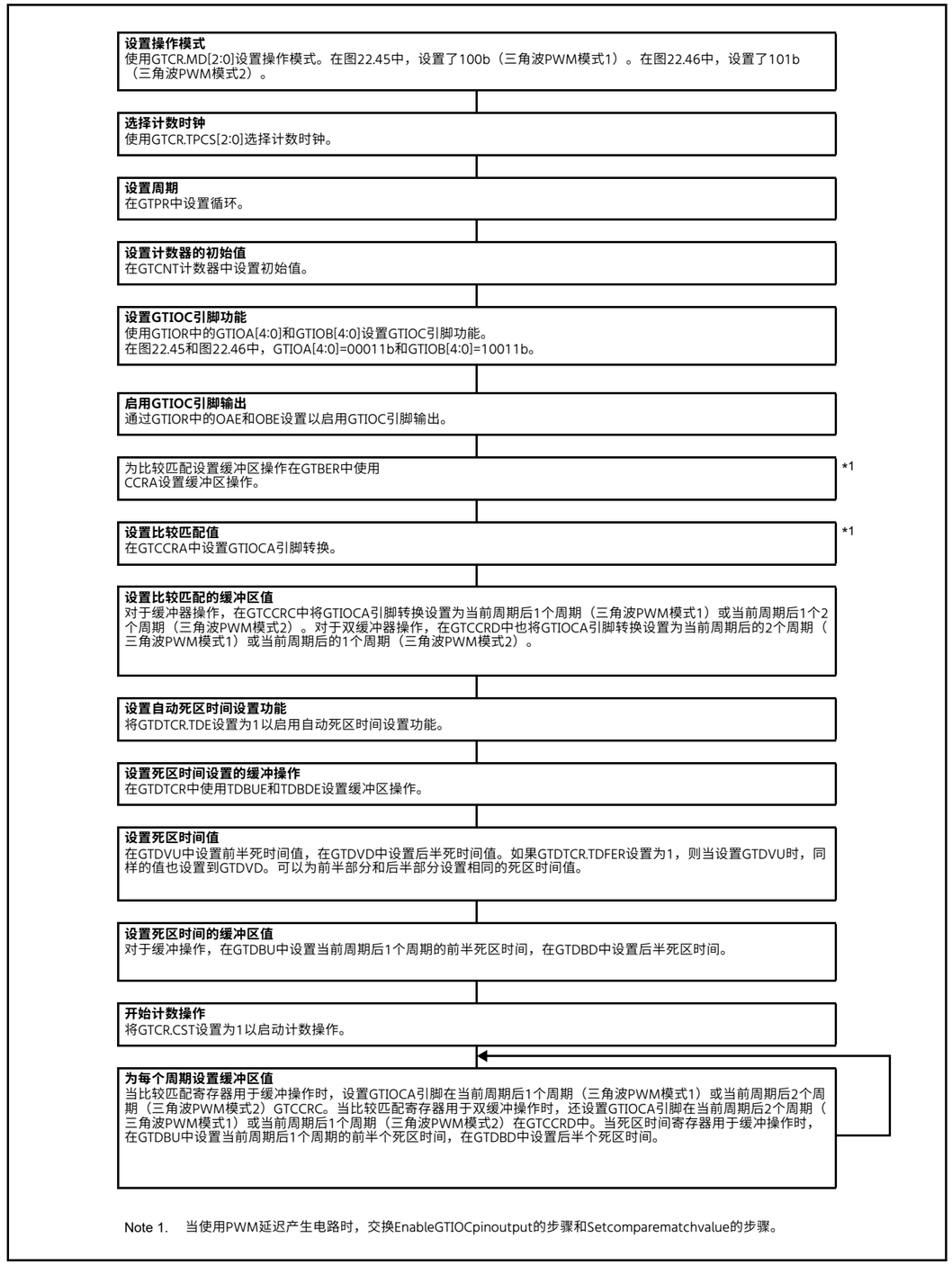
Note 1. 当使用PWM延迟产生电路时，交换EnableGTIOCpinoutput的步骤顺序和Setbuffervalueforcomparematch的步骤顺序。

Figure 22.47 锯齿波一次性脉冲模式和三角波PWM模式的自动死区时间设置功能示例3



Note 1. When the PWM delay generation circuit is used, exchange the sequence of the step for Enable GTIOC pin output and the step for Set compare match value.

Figure 22.48 Example setting for automatic dead time setting function with triangle-wave PWM mode 1 or 2



Note 1. 当使用PWM延迟产生电路时，交换EnableGTIOCpinoutput的步骤和Setcomparematchvalue的步骤。

Figure 22.48 三角波PWM模式1或2的自动死区时间设置功能设置示例

22.3.5 Count Direction Changing Function

The count direction of the GTCNT counter can be changed by modifying the UD bit in GTUDDTYC.

In saw-wave mode, if the UD bit in GTUDDTYC is modified during count operation, the count direction is changed at an overflow (when modified during up-counting) or an underflow (when modified during down-counting). If the GTUDDTYC.UD bit is modified while the count operation is stopped and the GTUDDTYC.UDF bit is 0, the GTUDDTYC.UD bit modification is not reflected at the start of counting and the count direction is changed at an overflow or an underflow. If the UDF bit is set to 1 while the count operation is stopped, the GTUDDTYC.UD bit value at that time is reflected at the start of counting.

In triangle-wave mode, the count direction does not change when the UD bit in GTUDDTYC is modified during the count operation. Similarly, when the GTUDDTYC.UD bit is modified while the count operation is stopped and GTUDDTYC.UDF bit is 0, the GTUDDTYC.UD bit value is not reflected in the count operation. If the GTUDDTYC.UDF bit is set to 1 while the count operation is stopped, the GTUDDTYC.UD bit value at that time is reflected at the start of counting.

If the count direction changes during a saw-wave count operation, the GTPR value after the start of up-counting is reflected in the count cycle during up-counting, and the GTPR value before the start of down-counting is reflected during down-counting.

Figure 22.49 shows an example operation of count direction changing function.

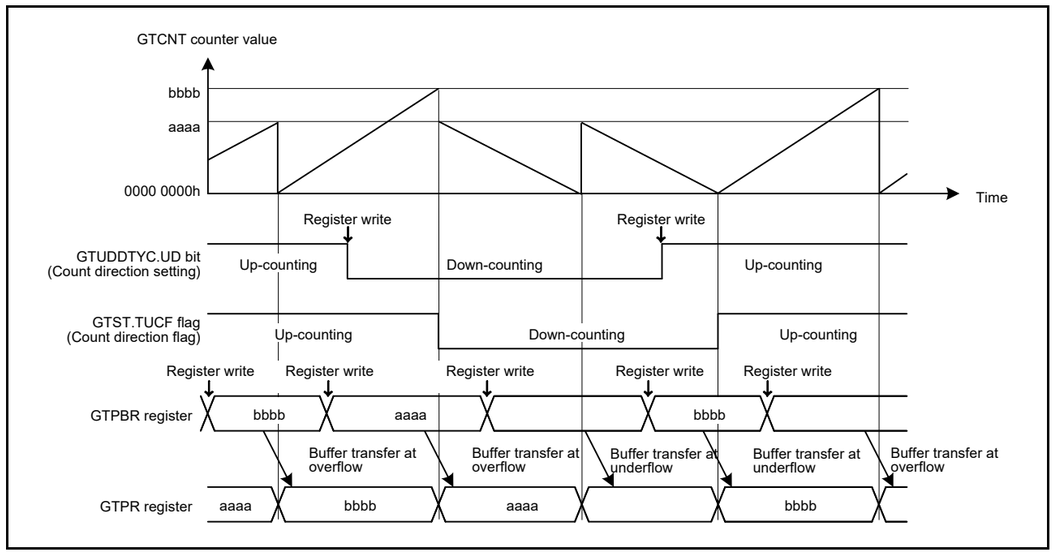


Figure 22.49 Example operation of count direction changing function during buffer operation

22.3.5 计数方向改变功能

GTCNT计数器的计数方向可以通过修改GTUDDTYC中的UD位来改变。

在锯齿波模式下，如果在计数操作期间修改GTUDDTYC中的UD位，则计数方向会在溢出（在向上计数期间修改时）或下溢（在向下计数期间修改时）改变。如果在计数操作停止且GTUDDTYC.UDF位为0时修改GTUDDTYC.UD位，则

GTUDDTYC.UD位修改不会反映在计数开始时，计数方向会在上溢或下溢时改变。如果在计数操作停止时UDF位设置为1，则此时的GTUDDTYC.UD位值将反映在计数开始时。

在三角波模式下，在计数操作期间修改GTUDDTYC中的UD位不会改变计数方向。同样，当计数操作停止且GTUDDTYC.UDF位为0时修改GTUDDTYC.UD位时，GTUDDTYC.UD位值不会反映在计数操作中。如果

计数操作停止时GTUDDTYC.UDF位设置为1，此时的GTUDDTYC.UD位值反映在计数开始时。

如果在锯波计数操作期间计数方向发生变化，则递增计数开始后的GTPR值在递增计数期间反映在计数周期中，递减计数开始前的GTPR值在递减期间反映数数。

图22.49显示了计数方向改变功能的示例操作。

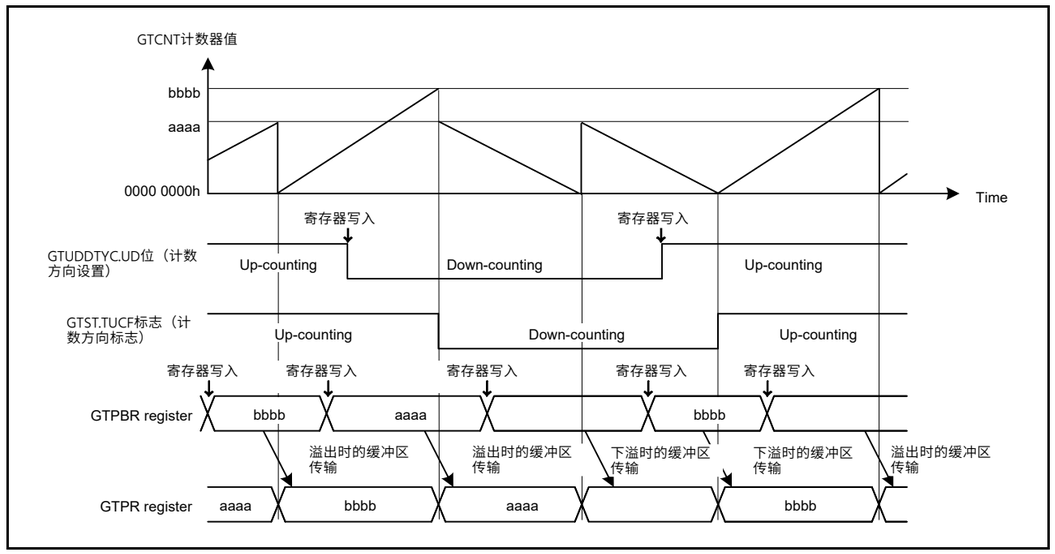


Figure 22.49 缓冲操作期间计数方向改变功能的示例操作

22.3.6 Function of Output Duty 0% and 100%

The output duty of the GTIOCA and GTIOCB pins are set to 0% or 100% by changing the GTUDDTYC.OADTY bit or GTUDDTYC.OBDTY bit.

In saw-wave mode, if the GTUDDTYC.OADTY or GTUDDTYC.OBDTY bit is modified during the count operation, the output duty setting is reflected at an overflow (when modified during up-counting) or an underflow (when modified during down-counting). If the GTUDDTYC.OADTY or GTUDDTYC.OBDTY bit is modified while the count operation is stopped and the GTUDDTYC.OADTYF or GTUDDTYC.OBDTYF bit is 0, the output duty modification is not reflected at the start of counting. The output duty changes at an overflow or an underflow. If the GTUDDTYC.OADTYF or GTUDDTYC.OBDTYF bit is set to 1 while the count operation is stopped, the GTUDDTYC.OADTY or GTUDDTYC.OBDTY bit value at that time is reflected at the start of counting.

In triangle-wave mode, if the GTUDDTYC.OADTY or GTUDDTYC.OBDTY bit is modified during the count operation, the output duty setting is reflected at an underflow.

If the GTUDDTYC.OADTY or GTUDDTYC.OBDTY bit is modified while the count operation is stopped and the GTUDDTYC.OADTYF or GTUDDTYC.OBDTYF bit is 0, the output duty modification is not reflected at the start of counting. The output duty changes at an underflow. If the GTUDDTYC.OADTY or GTUDDTYC.OBDTY bit is modified while the count operation is stopped and the GTUDDTYC.OADTYF or GTUDDTYC.OBDTYF bit is 1, the output duty modification is reflected at the start of counting.

In performing 0%/100% duty operation, GPT internally continues to:

- Perform compare match operation
- Set compare match flag
- Output interrupt
- Perform buffer operation.

When the control is changed from 0% or 100% duty setting to compare match, the output value of GTIOCA pin at cycle end is determined by GTIOR.GTIOA[3:2] and GTUDDTYC.OADTYR. The output value of GTIOCB pin at cycle end is determined by GTIOR.GTIOB[3:2] and GTUDDTYC.OBDTYR.

When GTIOR.GTIOA[3:2] and GTIOR.GTIOB[3:2] are set to 01b, the output pins output low at cycle end. When GTIOR.GTIOA[3:2] and GTIOR.GTIOB[3:2] are set to 10b, the output pins output high at cycle end.

GTUDDTYC.OADTYR selects the value that is the object of output retained/toggled at cycle end, when GTIOR.GTIOm[3:2] are set to 00b (output retained at cycle end) or when GTIOR.GTIOm[3:2] are set to 11b (output toggled at cycle end). Table 22.7 shows the values of GTIOCA/GTIOCB pin output at cycle end.

Table 22.7 Output values after releasing 0% or 100% duty setting (m = A, B)

GTIOR.GTIOm[3:2]	Compare match value at cycle end masked by 0% or 100% duty setting	GTUDDTYC.OmDTYR in duty 0% setting		GTUDDTYC.OmDTYR in duty 100% setting	
		0	1	0	1
00 (output retained at cycle end)	0	0	0	1	0
	1	0	1	1	1
01 (low output at cycle end)	-	0	0	0	0
10 (high output at cycle end)	-	1	1	1	1
11 (output toggled at cycle end)	0	1	1	0	1
	1	1	0	0	0

Figure 22.50 shows an example of output duty 0% and 100% function.

22.3.6 输出占空比0%和100%的功能

GTIOCA和GTIOCB引脚的输出占空比通过更改GTUDDTYC.OADTY位设置为0%或100%或GTUDDTYC.OBDTY bit.

在锯齿波模式下，如果在计数操作期间修改GTUDDTYC.OADTY或GTUDDTYC.OBDTY位，则输出占空比设置反映在溢出（在向上计数期间修改时）或下溢（在向下计数期间修改时）。如果在计数操作停止且GTUDDTYC.OADTYF或GTUDDTYC.OBDTYF位为0时修改GTUDDTYC.OADTY或GTUDDTYC.OBDTY位，则在计数开始时不反映输出占空比修改。输出占空比在上溢或下溢时发生变化。如果在计数操作停止时将GTUDDTYC.OADTYF或GTUDDTYC.OBDTYF位设置为1，则此时的GTUDDTYC.OADTY或GTUDDTYC.OBDTY位值将反映在计数开始时。

在三角波模式下，如果在计数操作期间修改GTUDDTYC.OADTY或GTUDDTYC.OBDTY位，则输出占空比设置会在下溢时反映。

如果GTUDDTYC.OADTY或GTUDDTYC.OBDTY位在计数操作停止并且GTUDDTYC.OADTYF或GTUDDTYC.OBDTYF位为0，输出占空比修改在计数开始时不反映。输出占空比在下溢时发生变化。如果在计数操作停止且GTUDDTYC.OADTYF或GTUDDTYC.OBDTYF位为1时修改GTUDDTYC.OADTY或GTUDDTYC.OBDTY位，则输出占空比修改反映在计数开始时。

在执行0%100%占空比操作时，GPT在内部继续：

- 执行比较匹配操作
- 设置比较匹配标志
- 输出中断
- 执行缓冲操作。

当控制从0%或100%占空比设置更改为比较匹配时，循环结束时GTIOCA引脚的输出值由GTIOR.GTIOA[3:2]和GTUDDTYC.OADTYR确定。周期结束时GTIOCB引脚的输出值由GTIOR.GTIOB[3:2]和GTUDDTYC.OBDTYR决定。

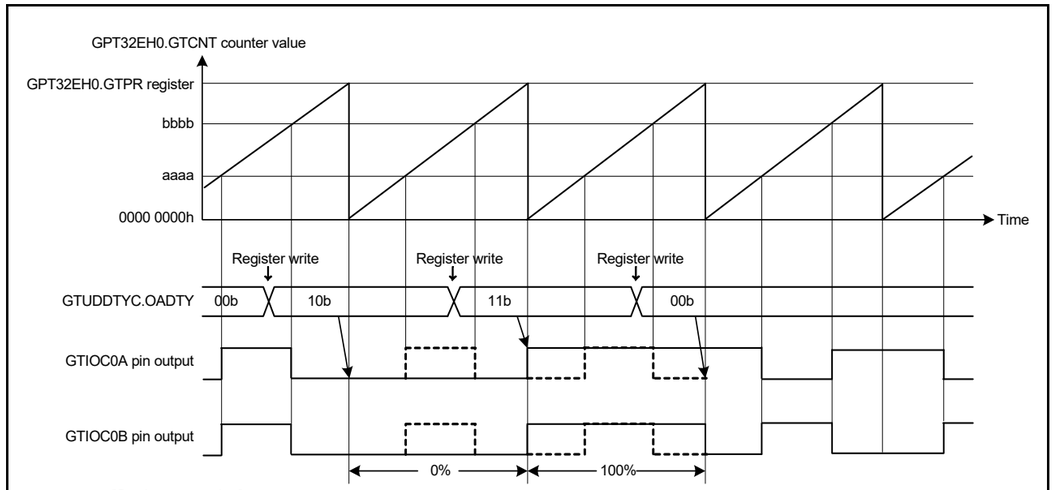
当GTIOR.GTIOA[3:2]和GTIOR.GTIOB[3:2]设置为01b时，输出引脚在周期结束时输出低电平。什么时候GTIOR.GTIOA[3:2]和GTIOR.GTIOB[3:2]设置为10b，输出引脚在周期结束时输出高电平。

GTUDDTYC.OADTYR选择在循环结束时作为输出保持切换的对象的值，当GTIOR.GTIOm[3:2]设置为00b（输出在循环结束时保留）或GTIOR.GTIOm[3:2]设置为11b（输出在循环结束时切换）。表22.7显示了循环结束时GTIOCAGTIOCB引脚输出的值。

Table 22.7 释放0%或100%占空比设置后的输出值(m=A B)

GTIOR.GTIOm[3:2]	比较被0%或100%占空比设置屏蔽的循环结束时的匹配值	GTUDDTYC.OmDTYR在占空比0%设置		GTUDDTYC.OmDTYR占空比100%设置	
		0	1	0	1
00（循环结束时保留输出）	0	0	0	1	0
	1	0	1	1	1
01（循环结束时输出低）	-	0	0	0	0
10（循环结束时的高输出）	-	1	1	1	1
11（循环结束时切换输出）	0	1	1	0	1
	1	1	0	0	0

图22.50显示了输出占空比0%和100%功能的示例。



[Setting examples]

GPT32EH0.GTIOR.GTIOA[4:0] bits: 00011b
Initial low output, output toggled at compare match, output retained at cycle end

GPT32EH0.GTUDDTYC.OADTYR bit: 0b
Applied the value of duty 0%/100% output to GTIOA[3:2] bits function after 0%/100% duty setting is released

GPT32EH0.GTIOR.GTIOB[4:0] bits: 00011b
Initial low output, output toggled at compare match, output retained at cycle end

GPT32EH0.GTUDDTYC.OBDTYR bit: 1
Applied the value of masked compare match output to GTIOB[3:2] bits function after 0%/100% duty setting is released

Figure 22.50 Example of output duty 0% and 100% functions

22.3.7 Hardware Count Start/Count Stop and Clear Operation

The GTCNT counter can be started, stopped, or cleared by the following hardware sources:

- External trigger input
- ELC event input
- GTIOCA/GTIOCB pin input.

22.3.7.1 Hardware start operation

The GTCNT counter can be started by selecting a hardware source using GTSSR.

Figure 22.51 shows an example of a count start operation by a hardware source. Figure 22.52 shows the setting example.

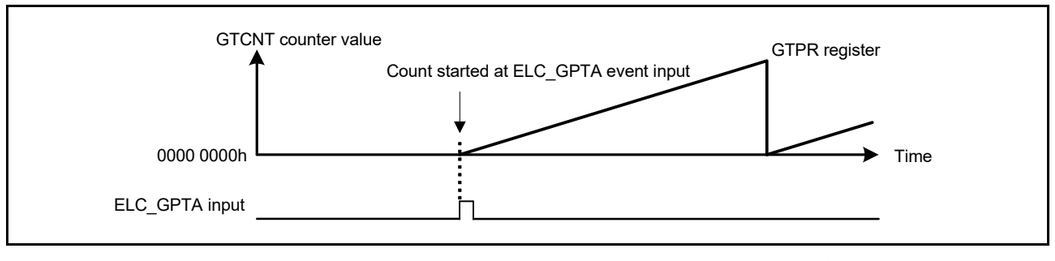
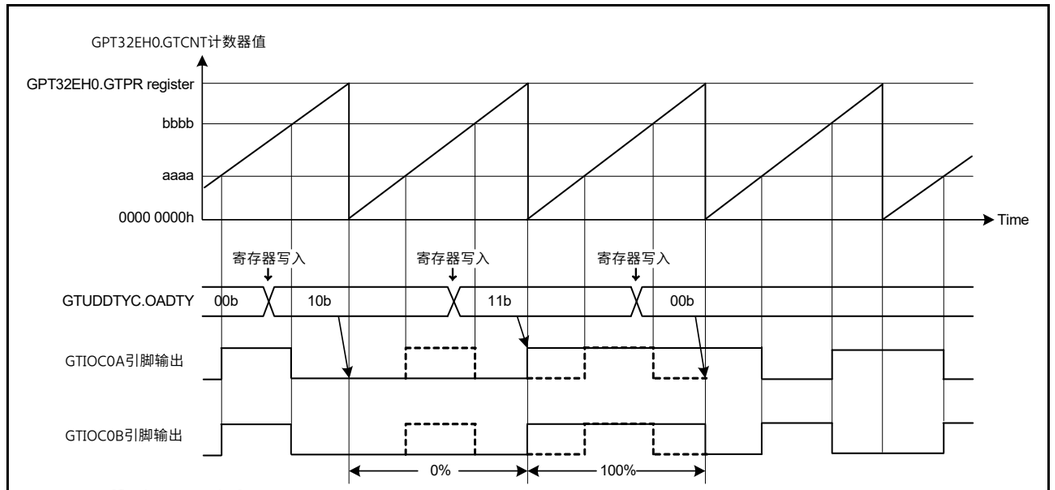


Figure 22.51 Example of count start operation by hardware source, started at the input of the signal from the ELC_GPTA event



[Setting examples]

GPT32EH0.GTIOR.GTIOA[4:0] bits: 00011b
初始低输出，比较匹配时切换输出，循环结束时保持输出

GPT32EH0.GTUDDTYC.OADTYR bit: 0b
在释放0%100%占空比设置后，将占空比0%100%输出的值应用于GTIOA[3:2]位功能GPT32EH0.GTIOR.GTIOB[4:0]位：00011b

初始低输出，比较匹配时切换输出，循环结束时保持输出

GPT32EH0.GTUDDTYC.OBDTYR bit: 1
在释放0%100%占空比设置后，将屏蔽比较匹配输出的值应用于GTIOB[3:2]位功能

Figure 22.50 输出占空比0%和100%功能示例

22.3.7 硬件计数开始计数停止和清除操作

GTCNT计数器可以由以下硬件源启动、停止或清除：

- 外部触发输入
- ELC事件输入
- GTIOCAGTIOCB引脚输入。

22.3.7.1 硬件启动操作

GTCNT计数器可以通过使用GTSSR选择硬件源来启动。

图22.51显示了一个硬件源的计数开始操作示例。图22.52显示了设置示例。

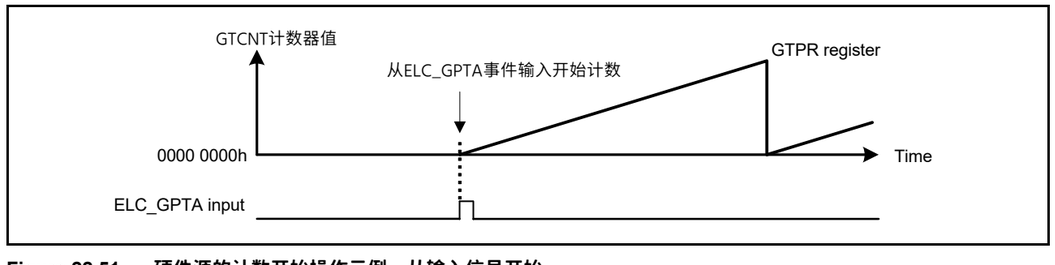


Figure 22.51 硬件源的计数开始操作示例，从输入信号开始 ELC_GPTA event

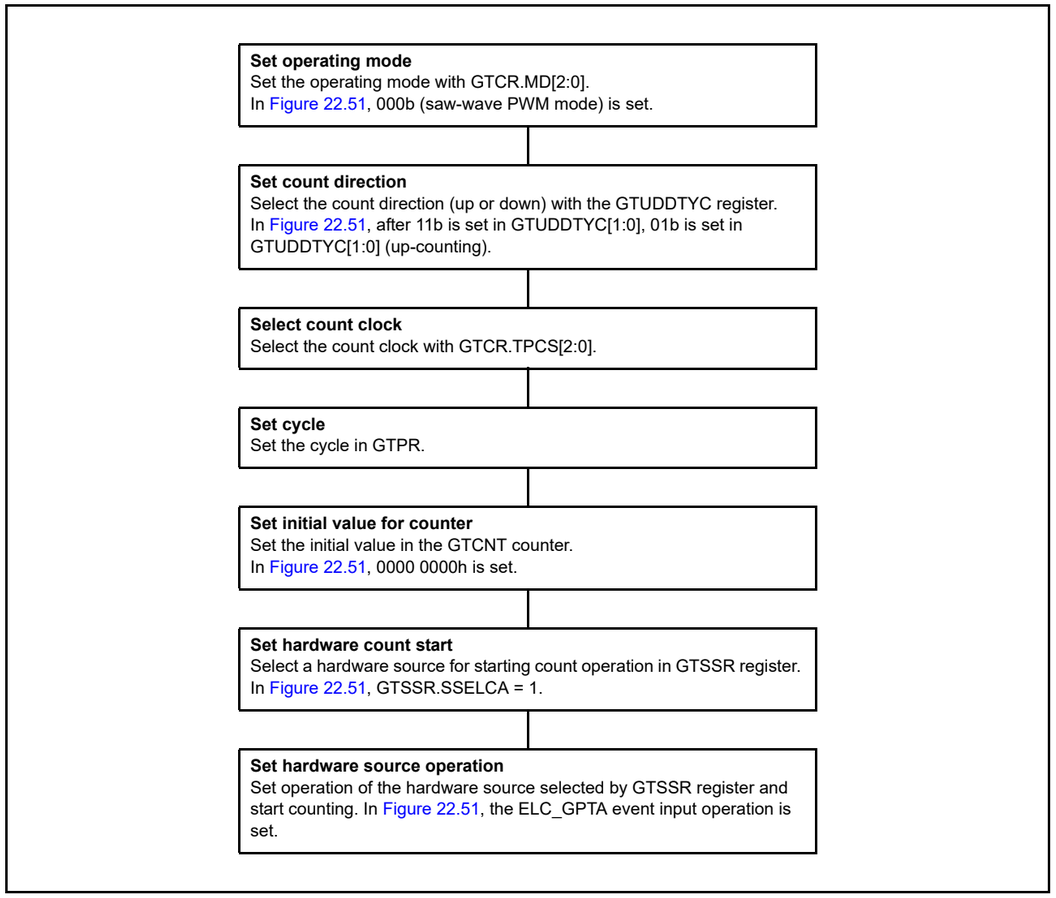


Figure 22.52 Example setting for count start operation by a hardware source

22.3.7.2 Hardware stop operation

The GTCNT counter can be stopped by selecting a hardware source using GTPSR.

Figure 22.53 shows an example of a count stop operation by a hardware source. Figure 22.54 shows the setting example. In this example, the count operation stops at the edge of the ELC_GPTA event input, and restarts at the edge of the ELC_GPTB event input.

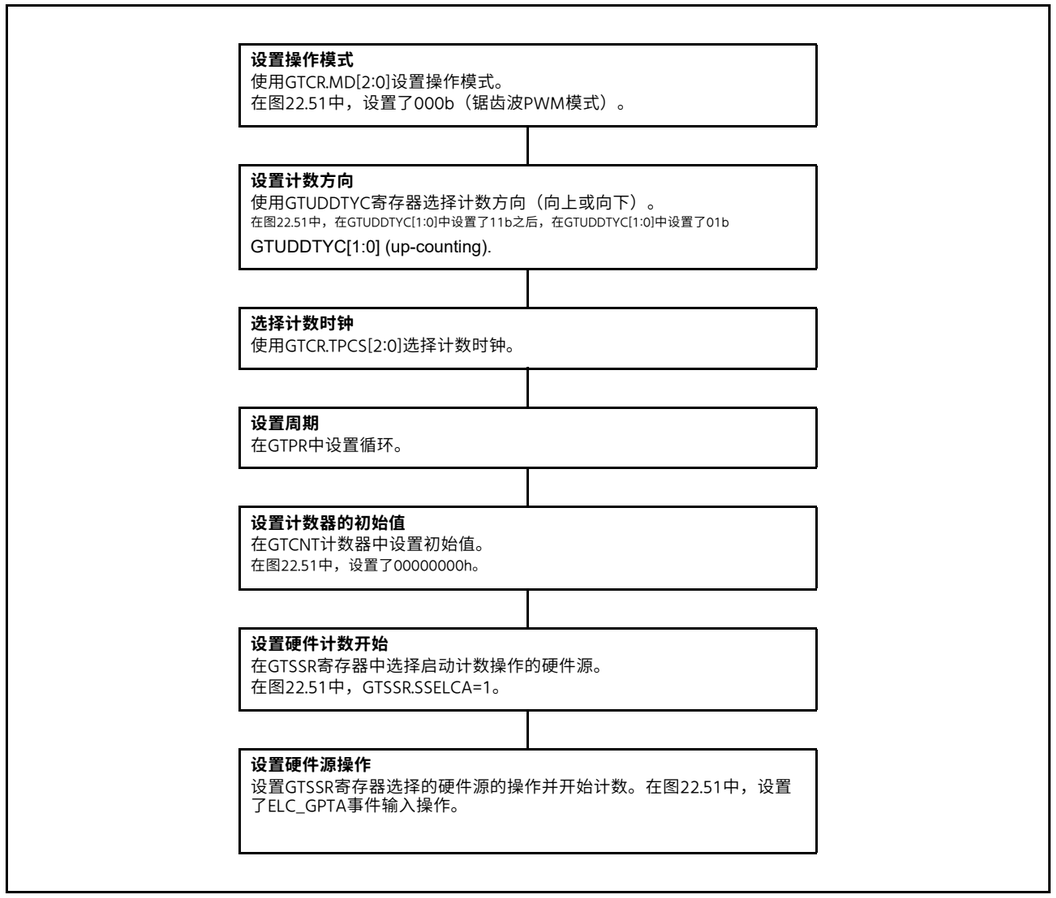


Figure 22.52 硬件源的计数开始操作设置示例

22.3.7.2 硬件停止操作

GTCNT计数器可以通过使用GTPSR选择硬件源来停止。

图22.53显示了一个硬件源的计数停止操作示例。图22.54显示了设置示例。
在此示例中，计数操作在ELC_GPTA事件输入的边缘停止，并在
ELC_GPTB事件输入。

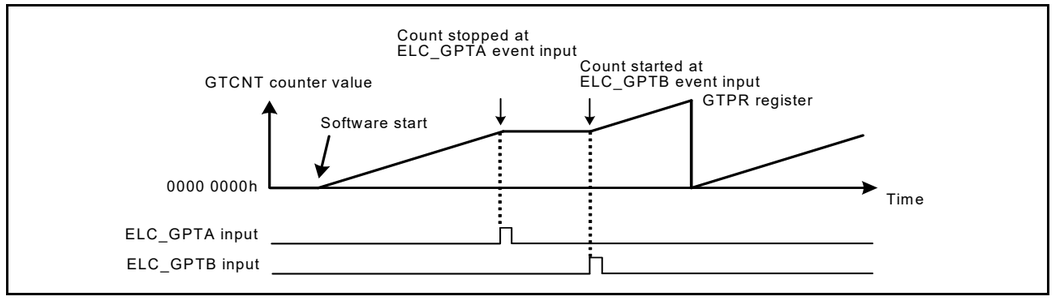


Figure 22.53 Example of count stop operation by a hardware source, started by software, stopped at ELC_GPTA event input, and restarted at ELC_GPTB event input

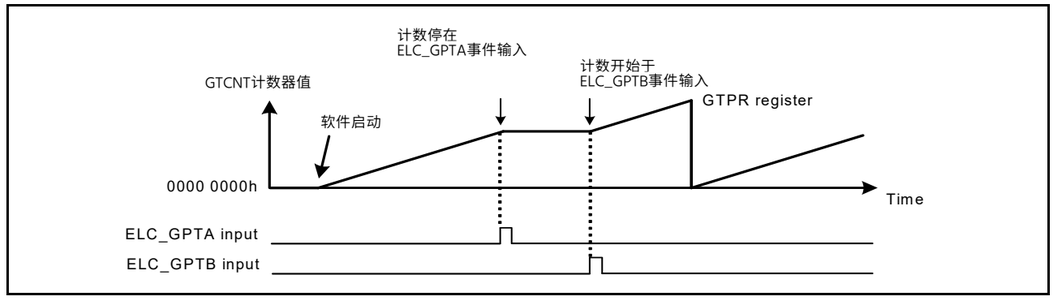


Figure 22.53 硬件源的计数停止操作示例，由软件启动，在ELC_GPTA事件输入，并在ELC_GPTB事件输入处重新启动

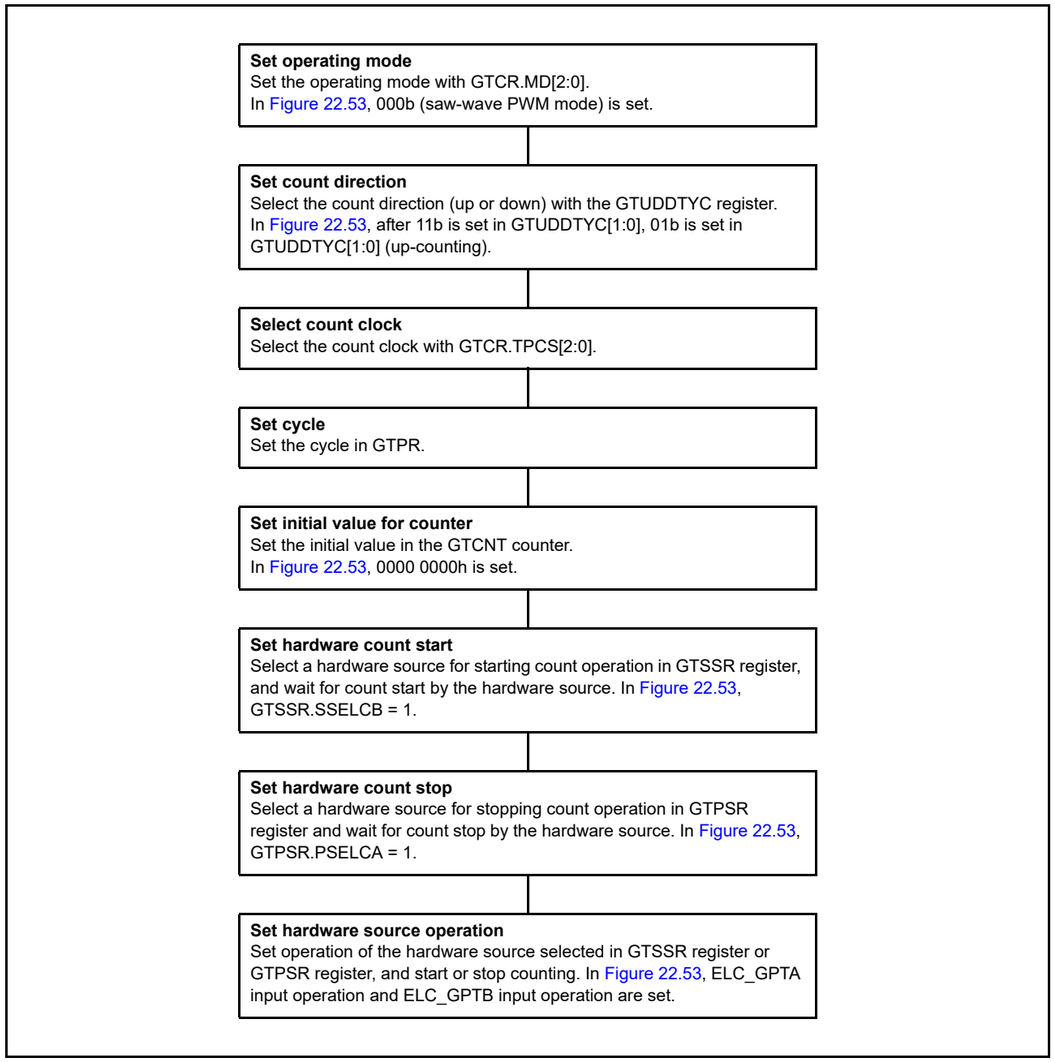


Figure 22.54 Example setting for count stop operation by a hardware source

Figure 22.55 shows an example of a count start/stop operation by a hardware source. Figure 22.56 shows the setting example. In this example, the counter operates during the high-level periods of the external trigger input GTETRGA.

Figure 22.54 硬件源的计数停止操作设置示例

图22.55显示了一个硬件源的计数开始停止操作示例。图22.56显示了设置示例。在本例中，计数器在外部触发输入GTETRGA的高电平期间运行。

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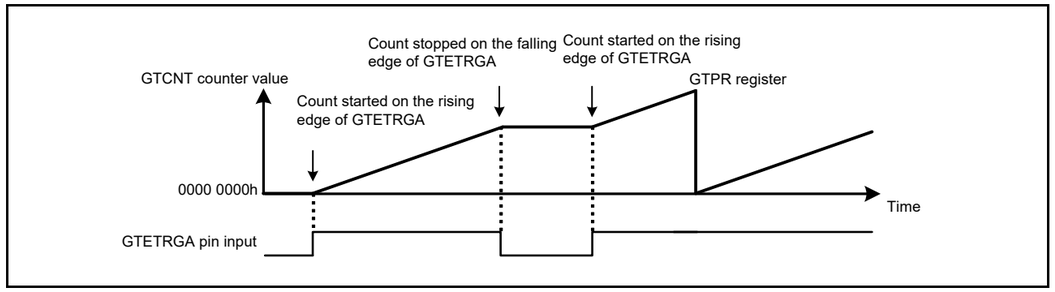

Figure 22.55 Example of count start/stop operation by hardware source, started on the rising edge of GTETRGA pin input, and stopped on the falling edge of GTETRGA pin input

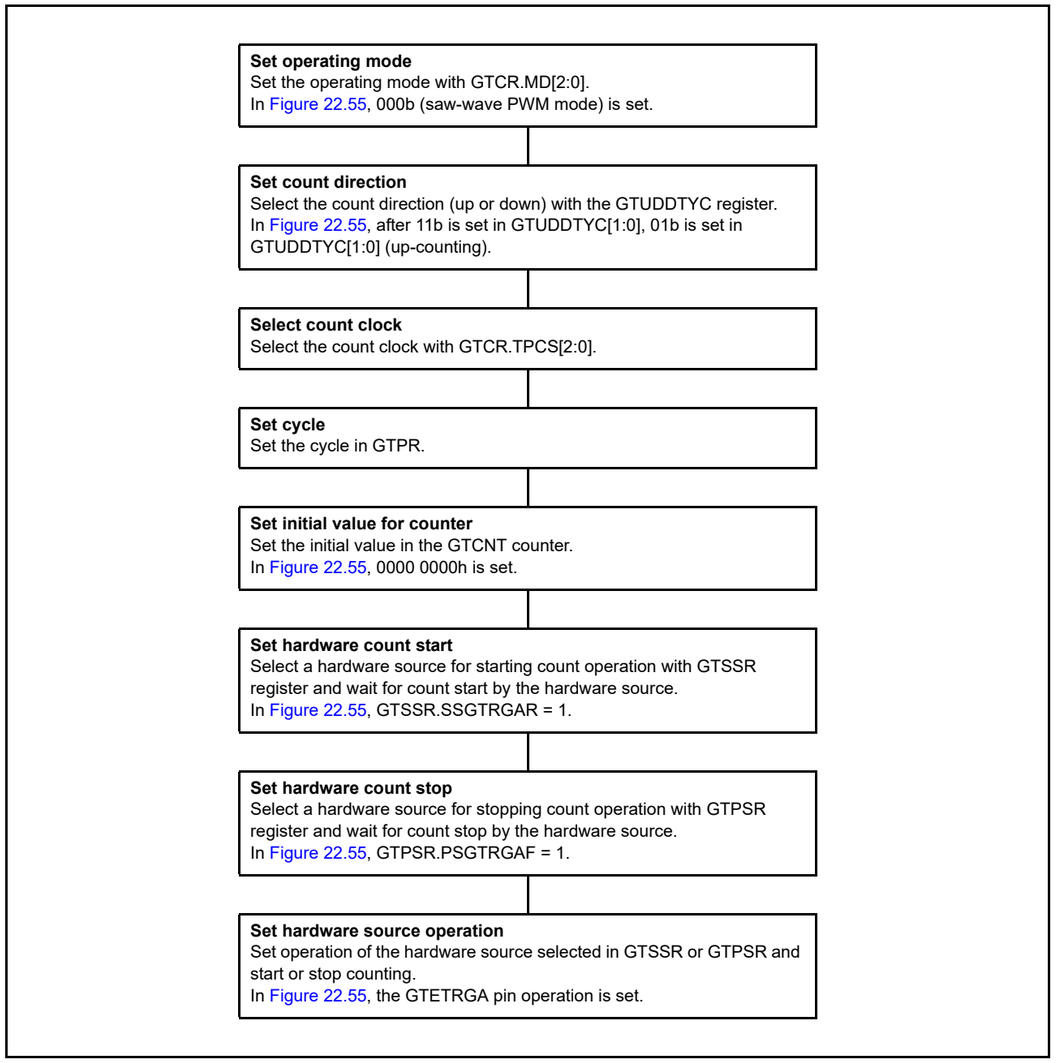

Figure 22.56 Example setting for count start/stop operation by a hardware source

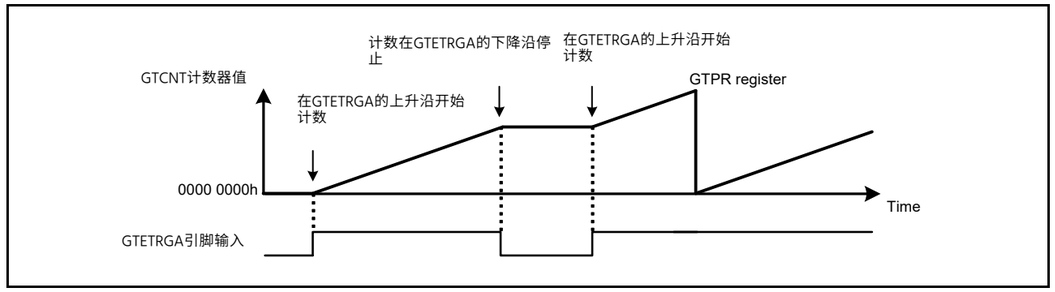

Figure 22.55 硬件源的计数开始停止操作示例，在计数的上升沿开始GTETRGA引脚输入，并在GTETRGA引脚输入的下降沿停止

Figure 22.56 硬件源的计数开始停止操作设置示例

22.3.7.3 Hardware clear operation

The GTCNT counter can be cleared by selecting a hardware source using GTCSR. The GPTn_OVF/GPTn_UDF (n = 0 to 12) interrupt (overflow/underflow interrupt) is not generated when the GTCNT counter is cleared by a hardware source or by software.

Figure 22.57 and Figure 22.58 show examples of the GTCNT counter clearing operation by a hardware source. Figure 22.59 shows the setting example. In this example, the GTCNT counter starts at the edge of the ELC_GPTA event input, and the counter stops and clears at the edge of the ELC_GPTB event input.

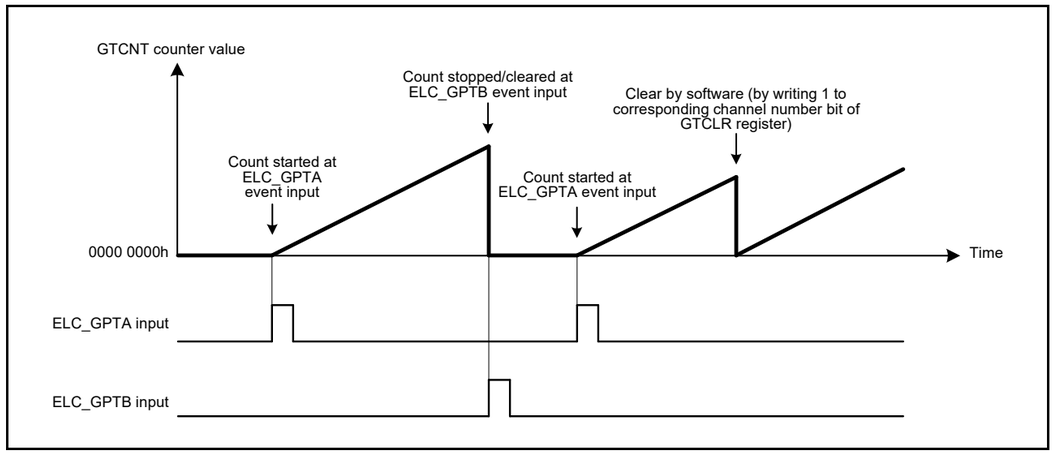

Figure 22.57 Examples of count clearing operation by hardware source in saw-wave up-counting, started at ELC_GPTA event input, and stopped/cleared at ELC_GPTB event input

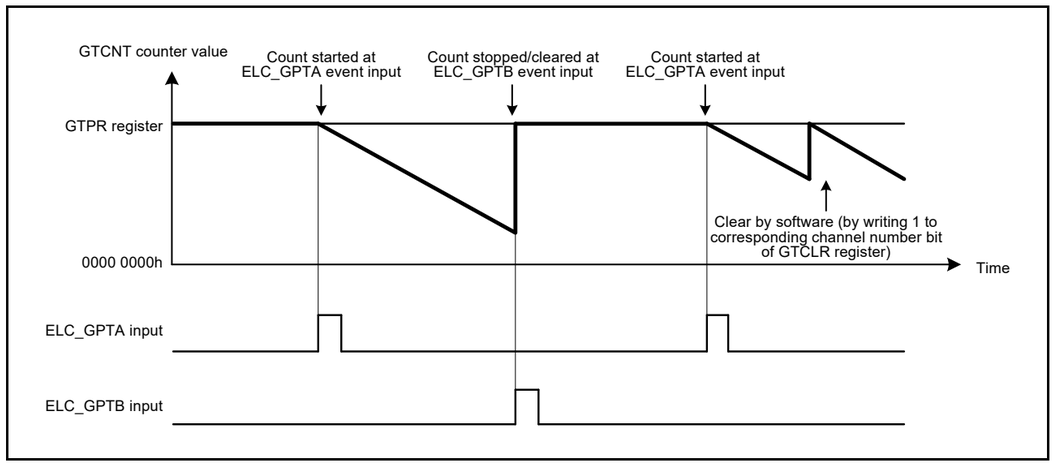

Figure 22.58 Examples of count clearing operation by hardware source in saw-wave down-counting, started at ELC_GPTA event input, and stopped/cleared at ELC_GPTB event input

22.3.7.3 硬件清除操作

GTCNT计数器可以通过使用GTCSR选择硬件源来清除。当GTCNT计数器被硬件或软件清零时，不会产生GPTn_OVFGPTn_UDF（n=0到12）中断（上溢下溢中断）。

图22.57和图22.58显示了通过硬件源清除GTCNT计数器操作的示例。图22.59显示了设置示例。在本例中，GTCNT计数器在ELC_GPTA事件输入的边沿开始，计数器在ELC_GPTB事件输入的边沿停止并清零。

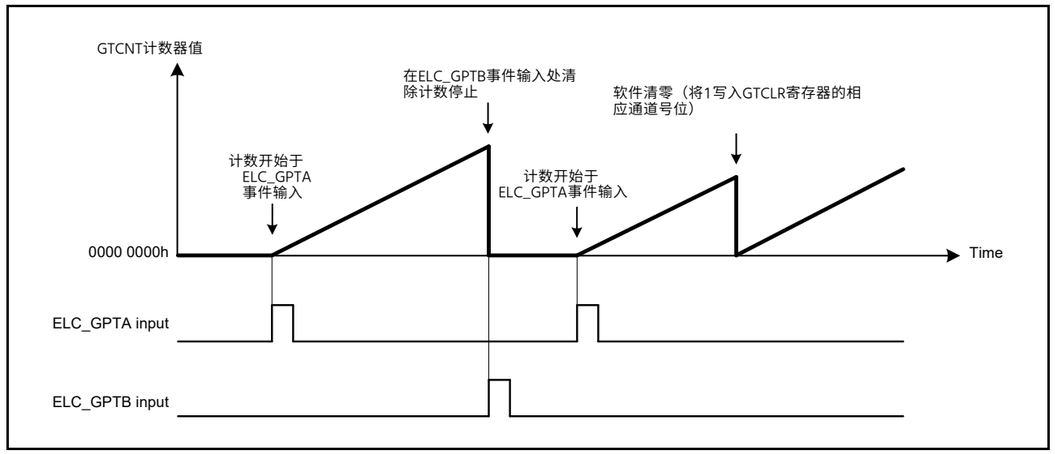

Figure 22.57 锯波递增计数中硬件源的计数清除操作示例，开始于ELC_GPTA事件输入，并在ELC_GPTB事件输入处停止清除

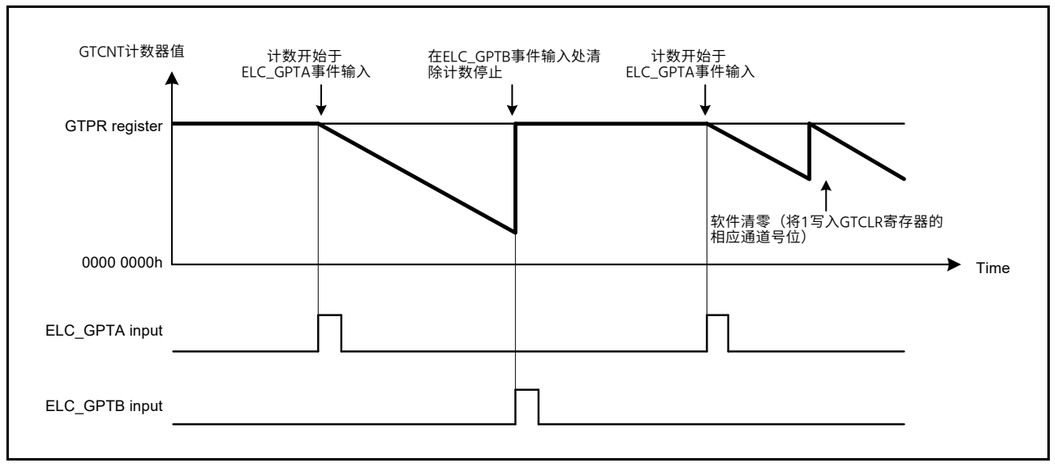

Figure 22.58 锯波递减计数中硬件源的计数清除操作示例，开始于ELC_GPTA事件输入，并在ELC_GPTB事件输入处停止清除

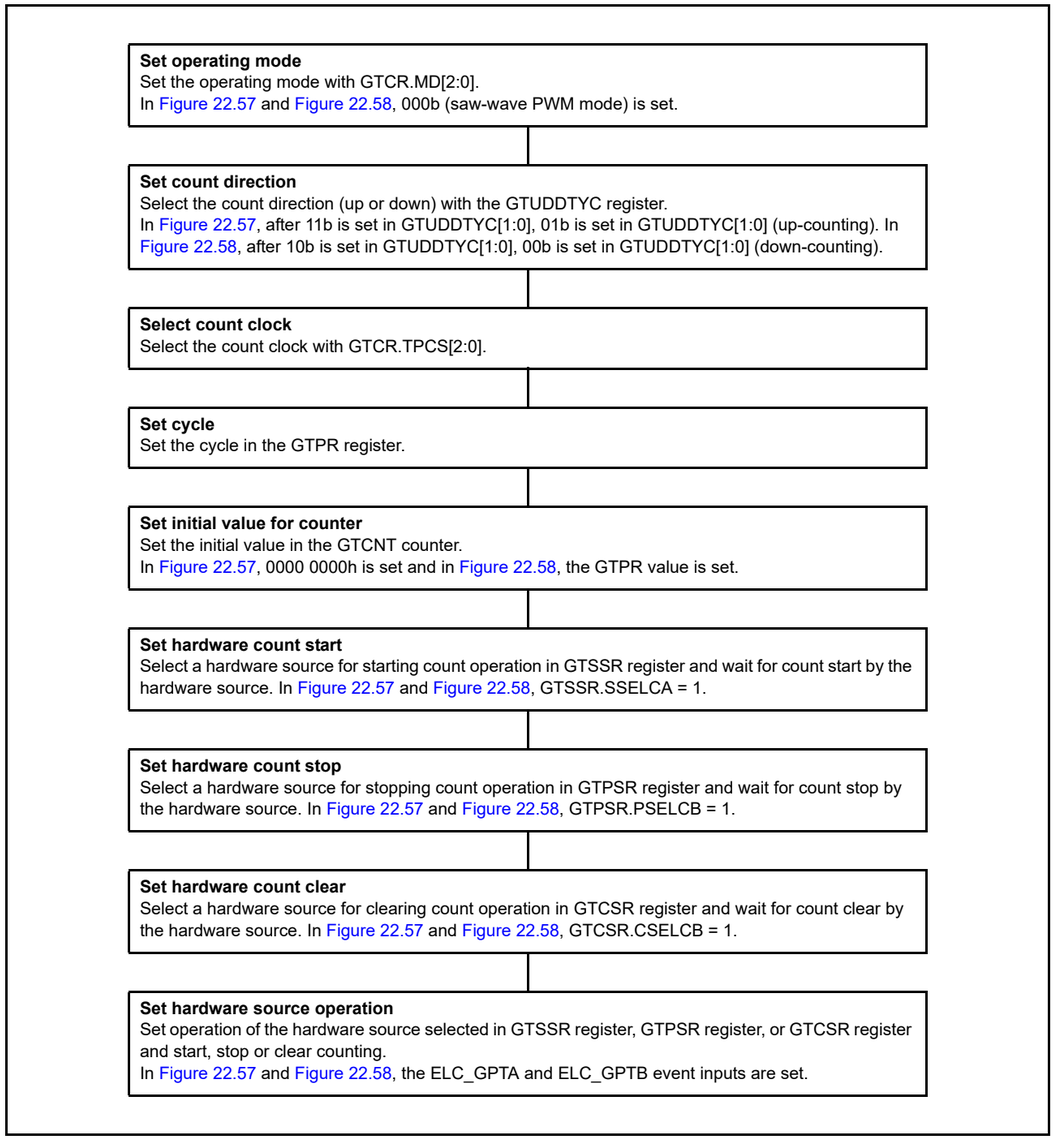

Figure 22.59 Example setting for count clearing operation by a hardware source

The GPTn_OVF/GPTn_UDF (n = 0 to 12) interrupt (overflow/underflow interrupt) is not generated when the counter is cleared by a hardware source or by software.

Figure 22.60 shows the relationship between the counter clearing by a hardware source and the GPTn_OVF (n = 0 to 12) interrupt.

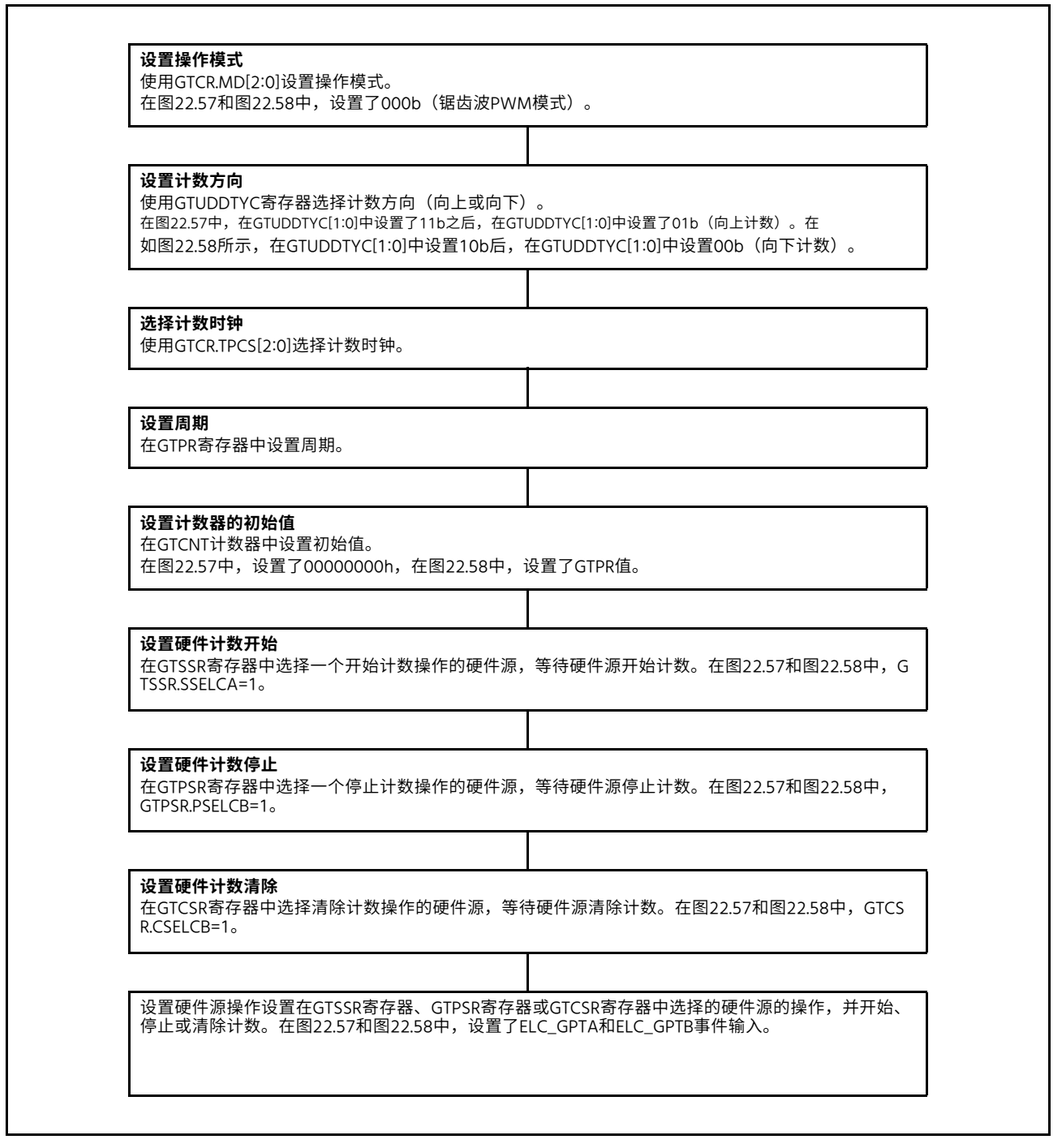

Figure 22.59 通过硬件源进行计数清除操作的示例设置

GPTn_OVFGPTn_UDF（n=0到12）中断（溢出下溢中断）不会在计数器被硬件源或软件清零时产生。

图22.60显示了通过硬件源清除计数器和GPTn_OVF（n=0到12）中断之间的关系。

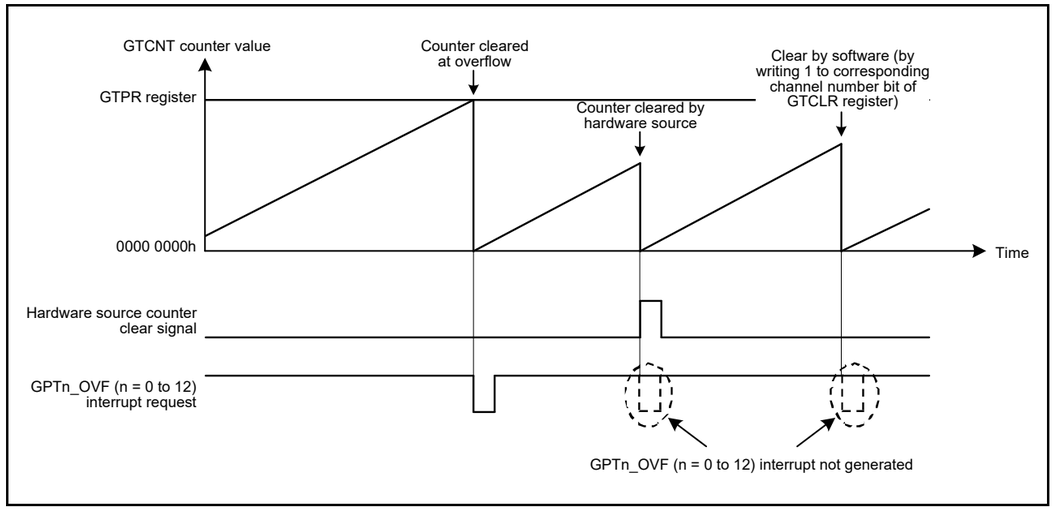

Figure 22.60 Relationship between counter clearing by hardware source and GPTn_OVF (n = 0 to 12) interrupt

22.3.8 Synchronized Operation

Synchronized operation on channels such as a synchronized start, stop, and clear operation can be performed.

22.3.8.1 Synchronized operation by software

The GTCNT counters can be started, stopped, and cleared on multiple channels by setting the associated GTSTR, GTSTP, or GTCLR bits simultaneously to 1.

Count start with a phase difference is possible by setting the initial value in the GTCNT counter and setting the associated GTSTR bits simultaneously to 1.

Figure 22.61 shows an example of a simultaneous start, stop, and clear by software. Figure 22.62 shows an example of phase start operation by software.

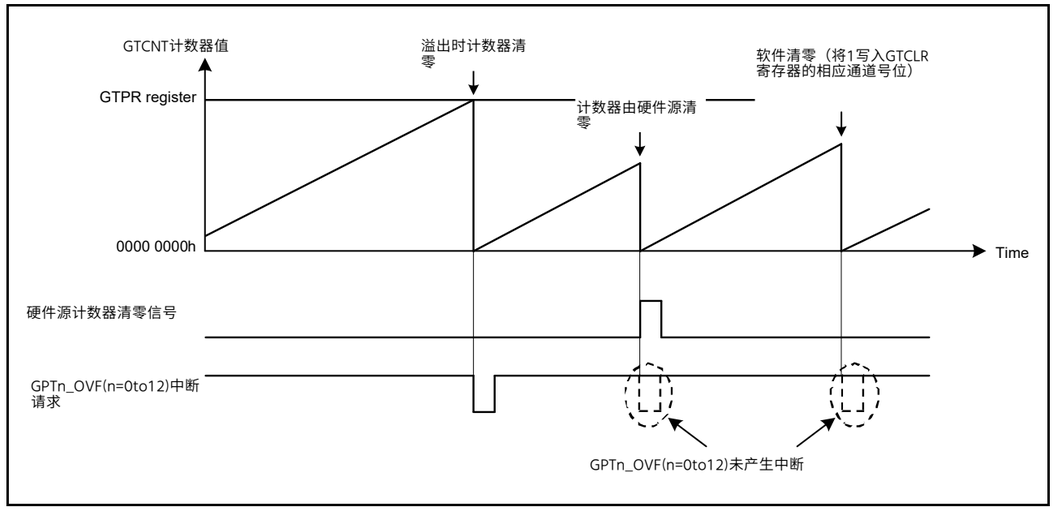

Figure 22.60 硬件源计数器清零与GPTn_OVF(n=0to12)中断之间的关系

22.3.8 同步操作

可以对通道进行同步操作，例如同步启动、停止和清除操作。

22.3.8.1 软件同步操作

通过设置相关的GTSTR，可以在多个通道上启动、停止和清除GTCNT计数器，GTSTP或GTCLR位同时为1。

通过在GTCNT计数器中设置初始值并同时将相关的GTSTR位设置为1，可以从相位差开始计数。

图22.61显示了通过软件同时启动、停止和清除的示例。图22.62显示了通过软件进行相位启动操作的示例。

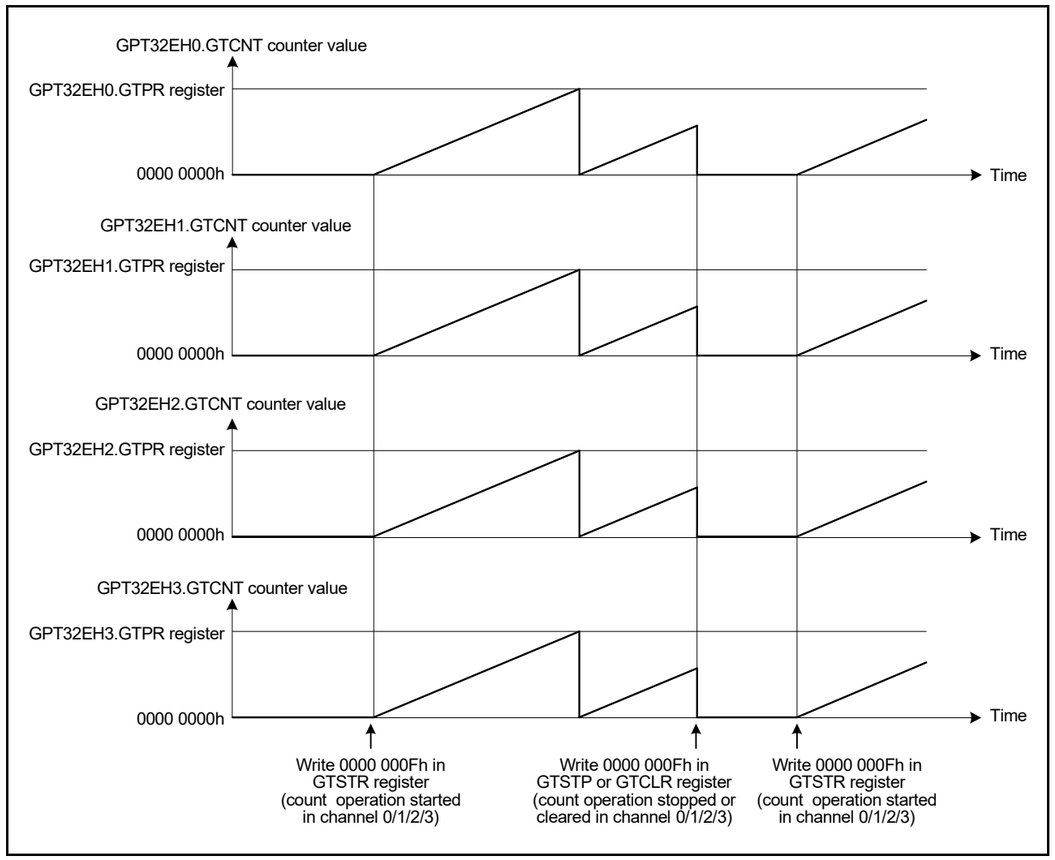

Figure 22.61 Example of a simultaneous start, stop, and clear by software, with the same count cycle (GTPR register value)

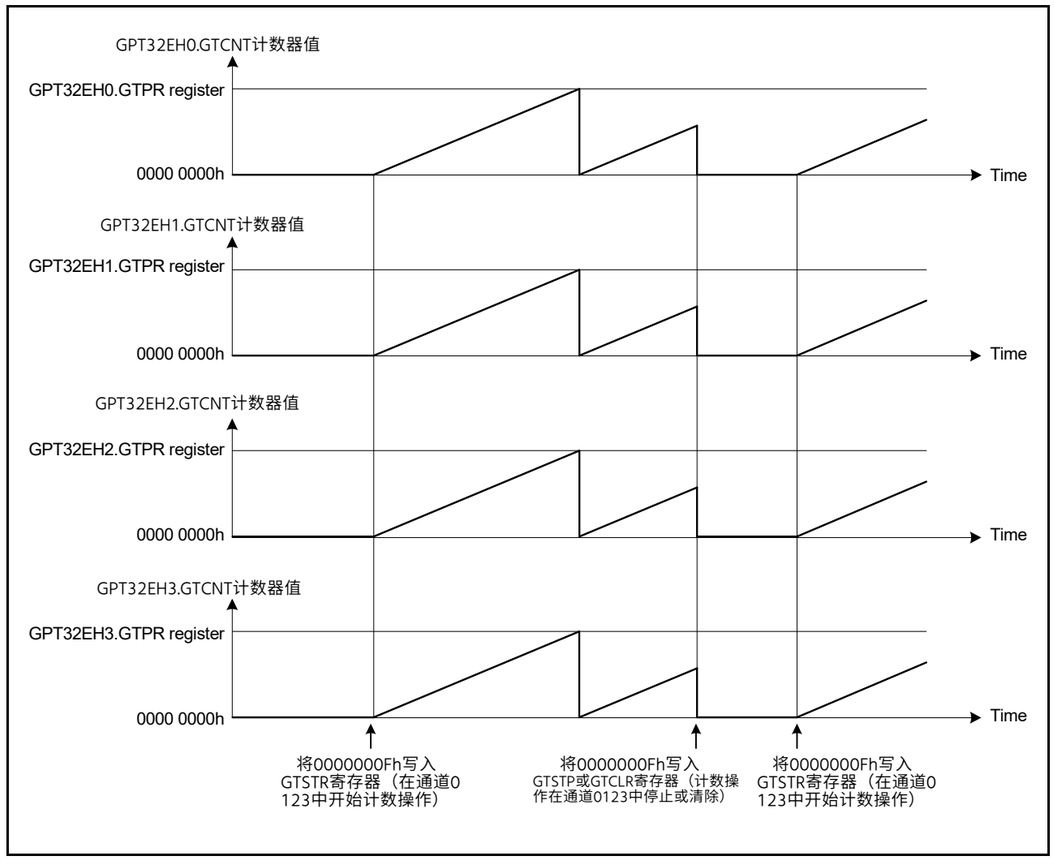

Figure 22.61 通过软件同时启动、停止和清除的示例，具有相同的计数周期（GTPR寄存器值）

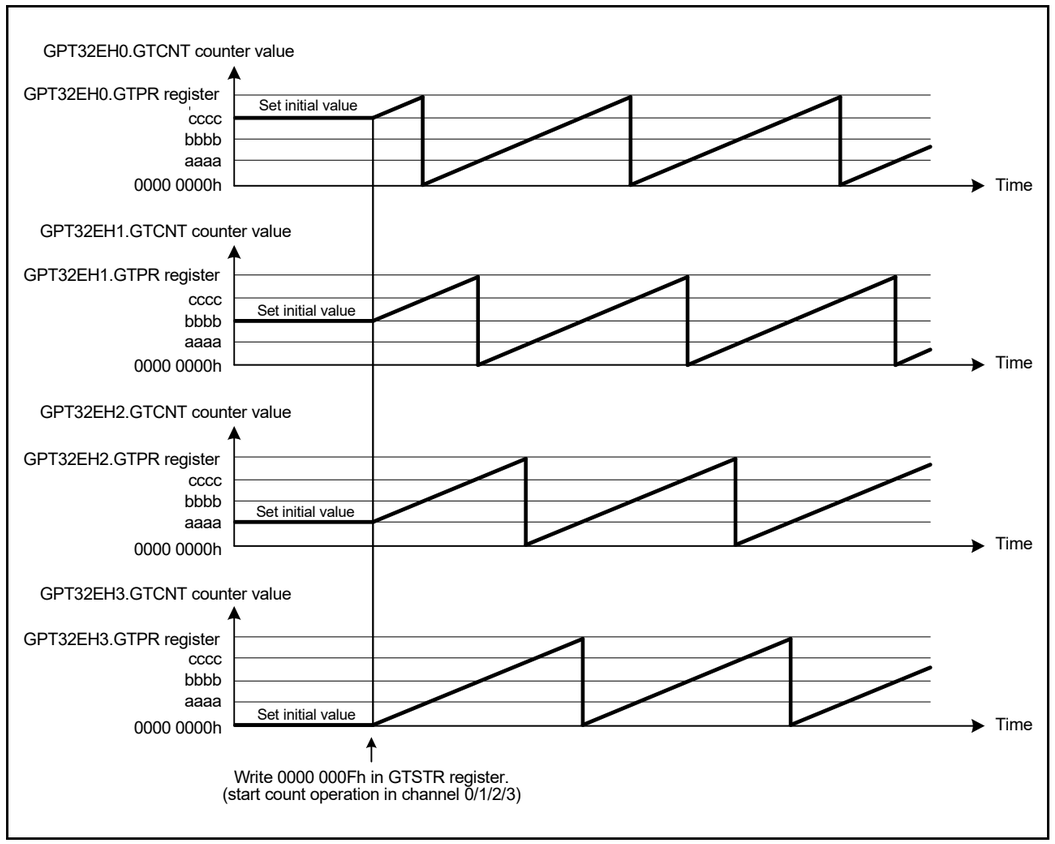

Figure 22.62 Example of software phase start with the same count cycle (GTPR register value)

22.3.8.2 Synchronized operation by hardware

The GTCNT counters can be started simultaneously by the following hardware sources:

- External trigger input
- ELC event input.

Figure 22.63 shows an example of a simultaneous start, stop, and clear operation by a hardware source. Figure 22.64 shows the setting example.

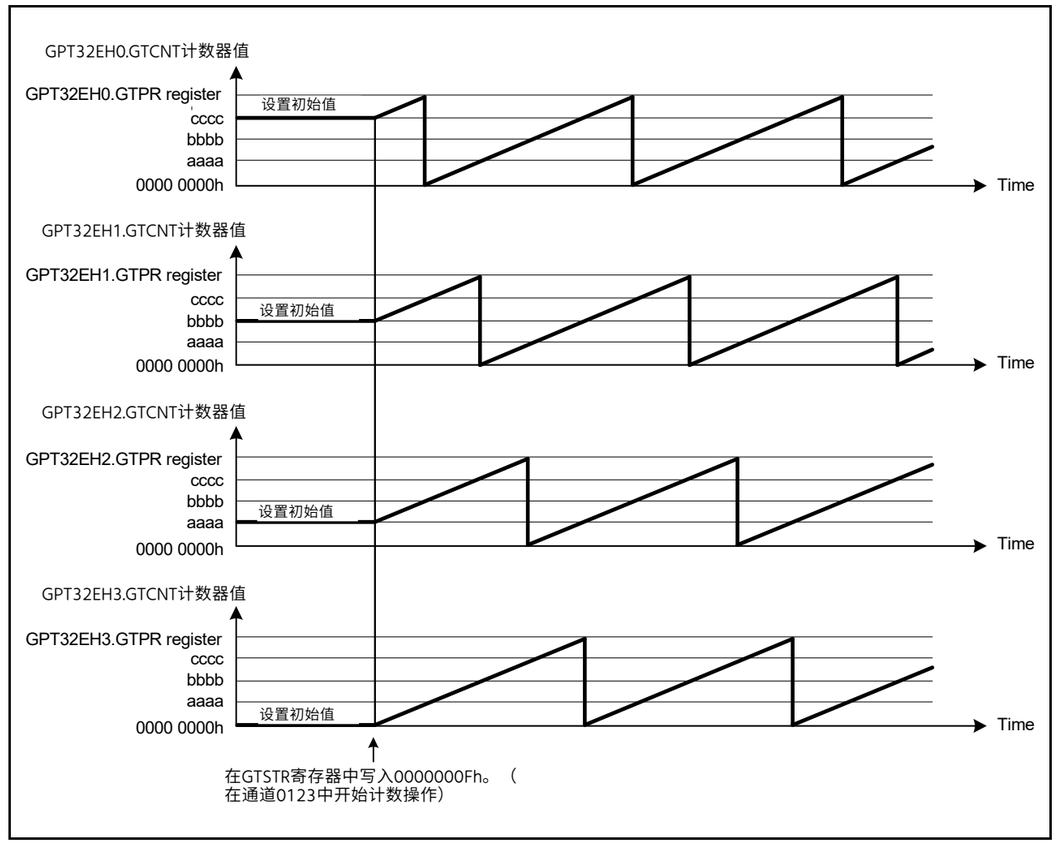

Figure 22.62 以相同计数周期开始的软件阶段示例（GTPR寄存器值）

22.3.8.2 硬件同步操作

GTCNT计数器可以由以下硬件源同时启动：

- 外部触发输入
- ELC事件输入。

图22.63显示了一个硬件源同时启动、停止和清除操作的示例。图22.64显示了设置示例。

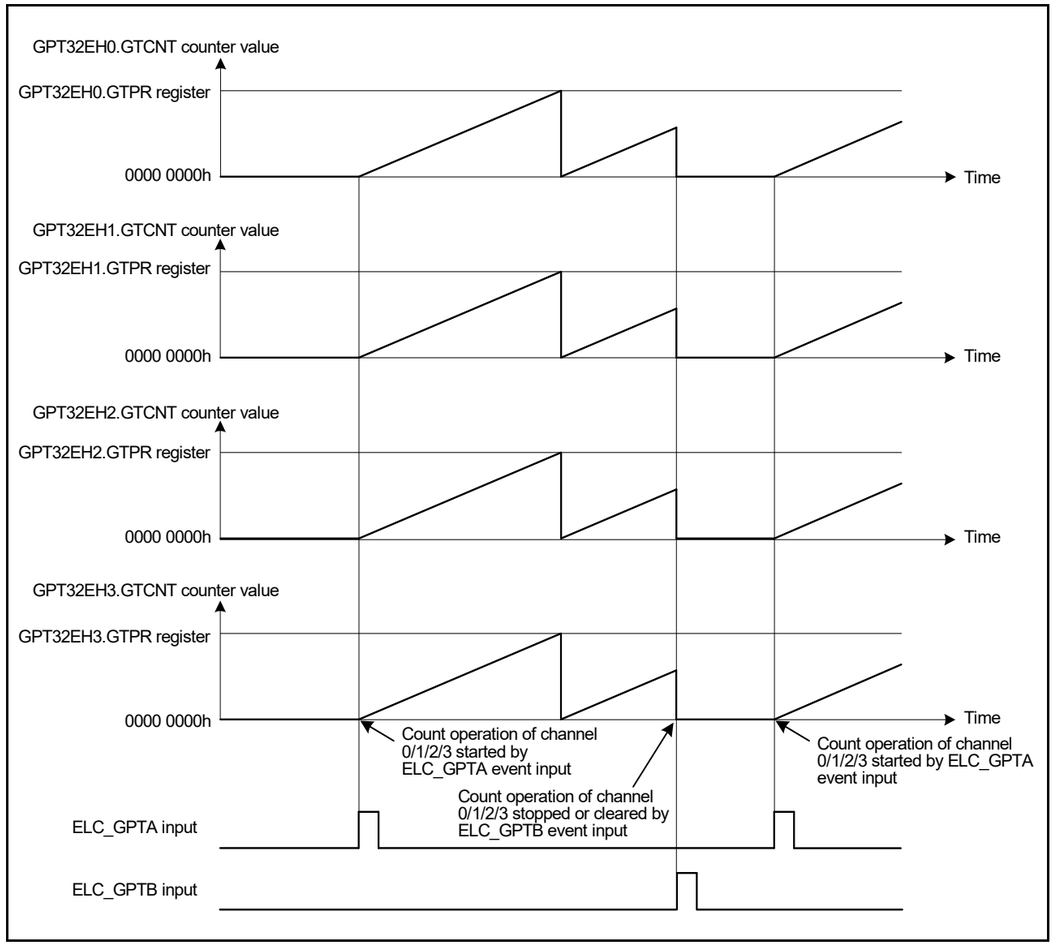

Figure 22.63 Example of a simultaneous start, stop, and clear by hardware source with the same count cycle (GTPR register value)

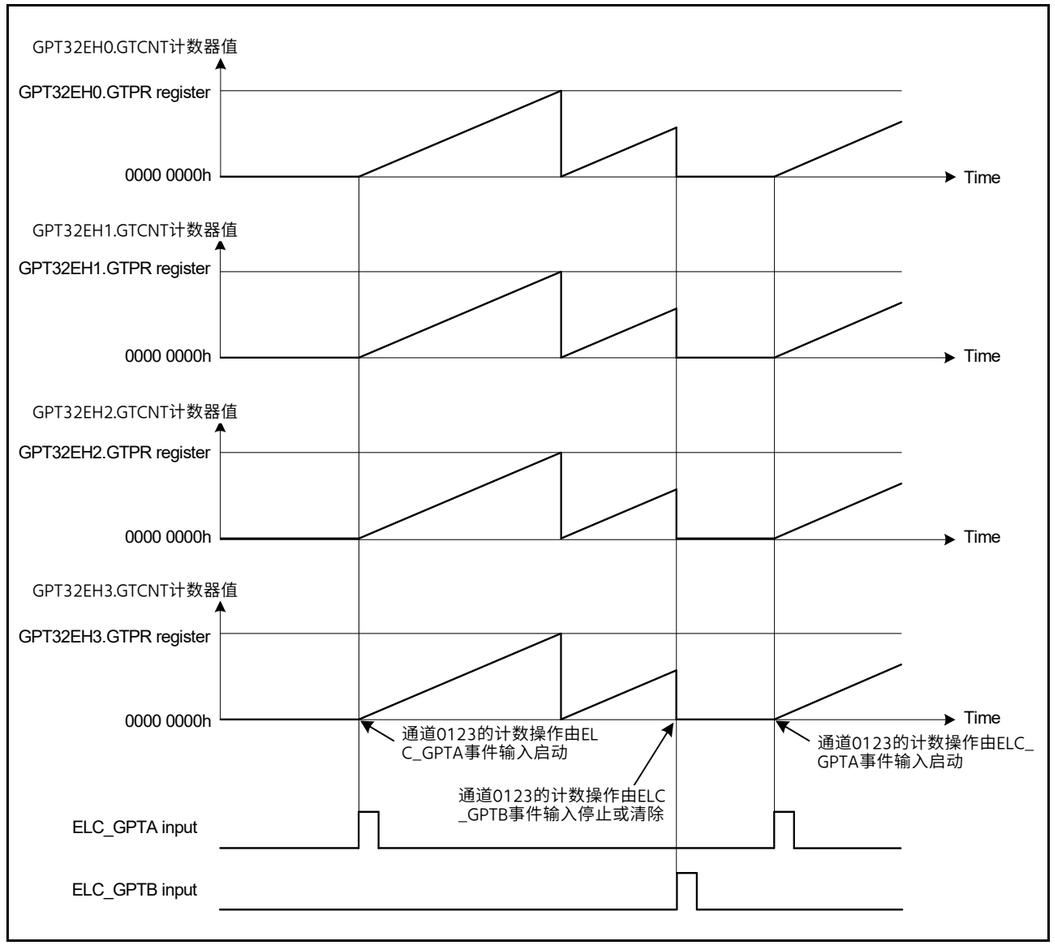

Figure 22.63 具有相同计数周期（GTPR寄存器值）的硬件源同时启动、停止和清除的示例

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Set operating mode
Set the operating mode with GTCR.MD[2:0]
In Figure 22.63, 000b (saw-wave PWM mode) is set.

Set count direction
Select the count direction (up or down) with the GTUDDTYC register.
In Figure 22.63, after 11b is set in GTUDDTYC[1:0], 01b is set in GTUDDTYC[1:0] (up-counting).

Select count clock
Select the count clock with GTCR.TPCS[2:0].

Set cycle
Set the cycle in the GTPR register.

Set initial value for counter
Set the initial value in the GTCNT counter.
In Figure 22.63, 0000 0000h is set.

Set hardware count start
Select a hardware source for starting count operation with GTSSR register and wait for count start by the hardware source. In Figure 22.63, GTSSR.SSELCA = 1.

Set hardware count stop
Select a hardware source for stopping count operation with GTPSR register and wait for count stop by the hardware source. In Figure 22.63, GTPSR.PSELCB = 1.

Set hardware count clear
Select a hardware source for clearing count operation with GTCSR register and wait for count clear by the hardware source. In Figure 22.63, GTCSR.CSELCB = 1.

Set hardware source operation
Set operation of the hardware source selected in GTSSR or GTPSR or GTCSR and start or stop or clear counting. In Figure 22.63, ELC_GPTA and ELC_GPTB event inputs are set.

Figure 22.64 Example setting for simultaneous start by a hardware source

22.3.9 PWM Output Operation Examples

(1) Synchronized PWM output

The GPT outputs 26 phases of linked PWM waveforms for a maximum of 13 channels by multiple GPTs.

Figure 22.65 shows an example in which four channels perform synchronized operation in saw-wave PWM mode and eight phases of PWM waveforms are output. The GTIOCA is set so that it outputs low as the initial value, high at a GTCCRA compare match, and low at the cycle end. The GTIOCB is set so that it outputs low as the initial value, high at a GTCCRB compare match, and low at the cycle end.

设置操作模式
使用GTCR.MD[2:0]设置操作模式
在图22.63中，设置了000b（锯齿波PWM模式）。

设置计数方向
使用GTUDDTYC寄存器选择计数方向（向上或向下）。
在图22.63中，在GTUDDTYC[1:0]中设置了11b之后，在GTUDDTYC[1:0]中设置了01b（向上计数）。

选择计数时钟
使用GTCR.TPCS[2:0]选择计数时钟。

设置周期
在GTPR寄存器中设置周期。

设置计数器的初始值
在GTCNT计数器中设置初始值。
在图22.63中，设置了00000000h。

设置硬件计数开始
使用GTSSR寄存器选择开始计数操作的硬件源，并等待硬件源开始计数。在图22.63中，GTSSR.SSELCA=1。

设置硬件计数停止
使用GTPSR寄存器选择停止计数操作的硬件源，并等待硬件源停止计数。在图22.63中，GTPSR.PSELCB=1。

设置硬件计数清除
使用GTCSR寄存器选择清除计数操作的硬件源，并等待硬件源清除计数。在图22.63中，GTCSR.CSELCB=1。

设置硬件源操作
设置在GTSSR或GTPSR或GTCSR中选择的硬件源的操作并开始或停止或清除计数。在图22.63中，设置了ELC_GPTA和ELC_GPTB事件输入。

Figure 22.64 通过硬件源同时启动的示例设置

22.3.9 PWM输出操作示例

(1) 同步PWM输出

GPT通过多个GPT为最多13个通道输出26相链接的PWM波形。

图22.65显示了一个示例，其中4个通道在锯齿波PWM模式下执行同步操作并输出8相PWM波形。GTIOCA设置为输出低作为初始值，在GTCCRA比较匹配时输出高，在循环结束时输出低。GTIOCB设置为输出低作为初始值，在GTCCRB比较匹配时输出高，在循环结束时输出低。

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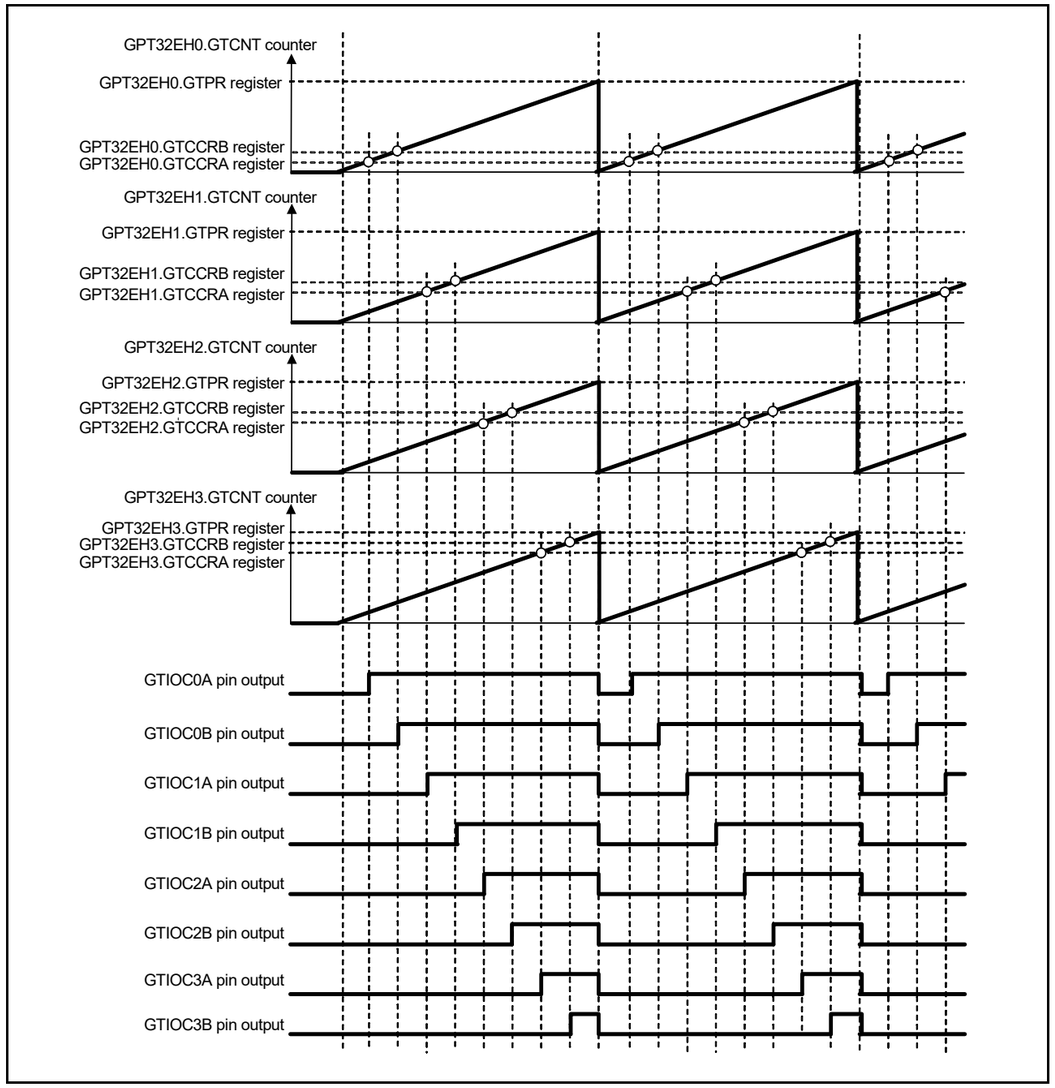

Figure 22.65 Example of synchronized PWM output

(2) 3-phase saw-wave complementary PWM output

Figure 22.66 shows an example in which three channels perform synchronized operation in saw-wave PWM mode and 3-phase complementary PWM waveforms are output. The GTIOCA pin is set so that it outputs low as the initial value, high at a GTCCRA compare match, and low at the cycle end. The GTIOCB pin is set so that it outputs high as the initial value, low at a GTCCRB compare match, and high at the cycle end.

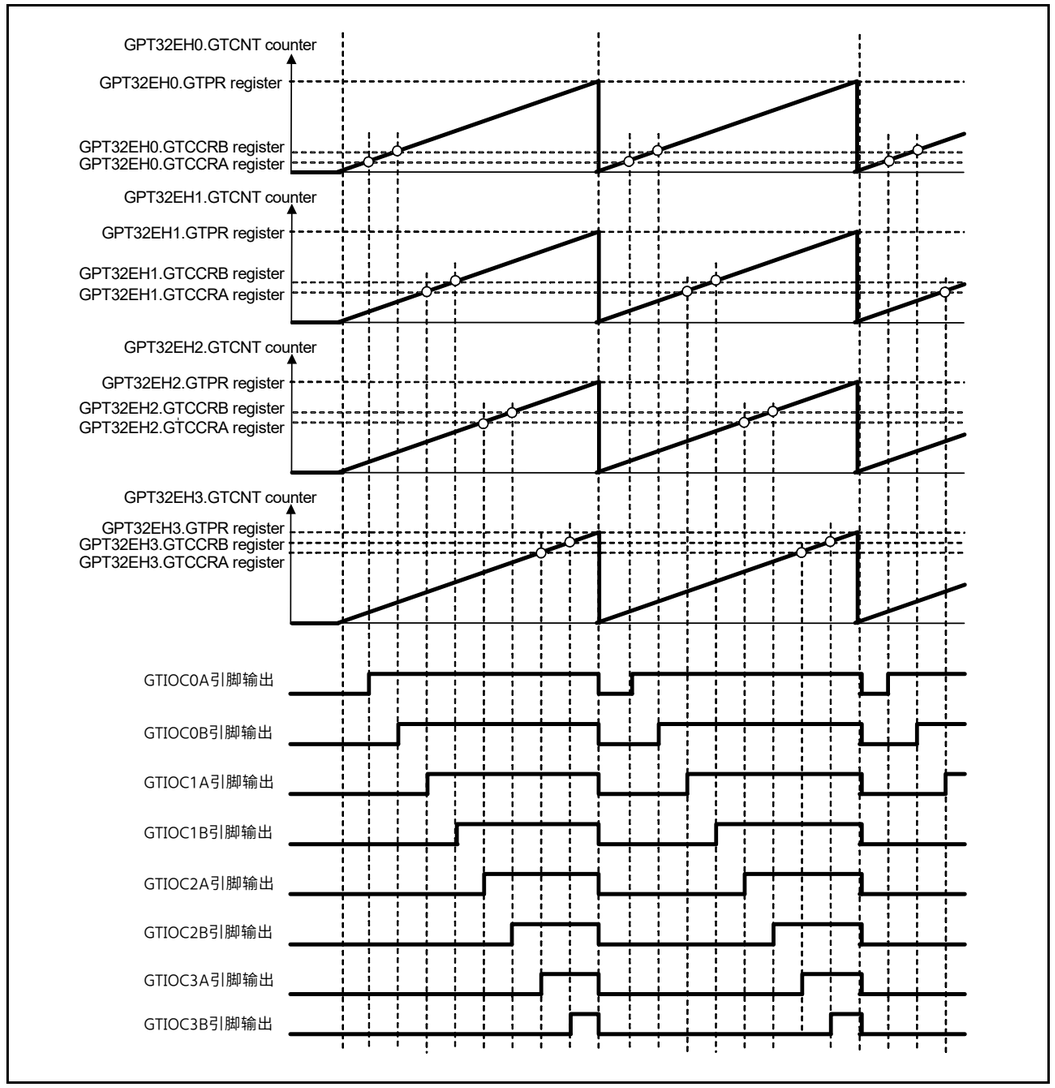

Figure 22.65 同步PWM输出示例

(2) 三相锯齿波互补PWM输出

图22.66显示了一个示例，其中三个通道在锯齿波PWM模式下执行同步操作并输出三相互补PWM波形。GTIOCA引脚设置为输出低作为初始值，在GTCCRA比较匹配时输出高，在循环结束时输出低。GTIOCB引脚设置为输出高作为初始值，在GTCCRB比较匹配时输出低，在周期结束时输出高。

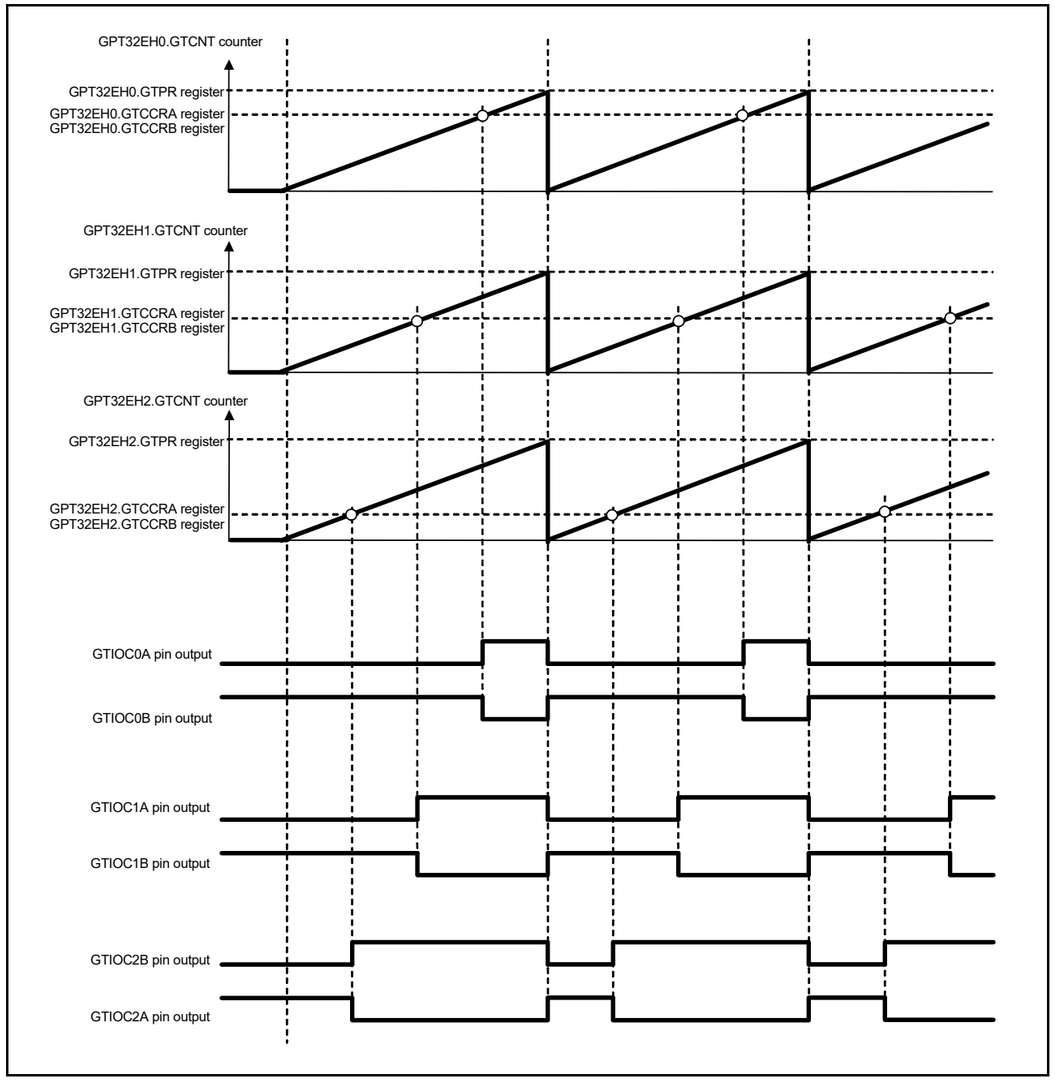

Figure 22.66 Example of 3-phase saw-wave complementary PWM output

(3) 3-phase saw-wave complementary PWM output with automatic dead time setting

Figure 22.67 shows an example in which three channels perform synchronized operation in saw-wave one-shot pulse mode with automatic dead time setting and 3-phase complementary PWM waveforms are output. The GTIOCA pin is set so that it outputs low as the initial value, toggles the output at a GTCCRA compare match, and retains the output at the cycle end. The GTIOCB pin is set so that it outputs high as the initial value, toggles the output at a GTCCRB compare match, and retains the output at the cycle end.

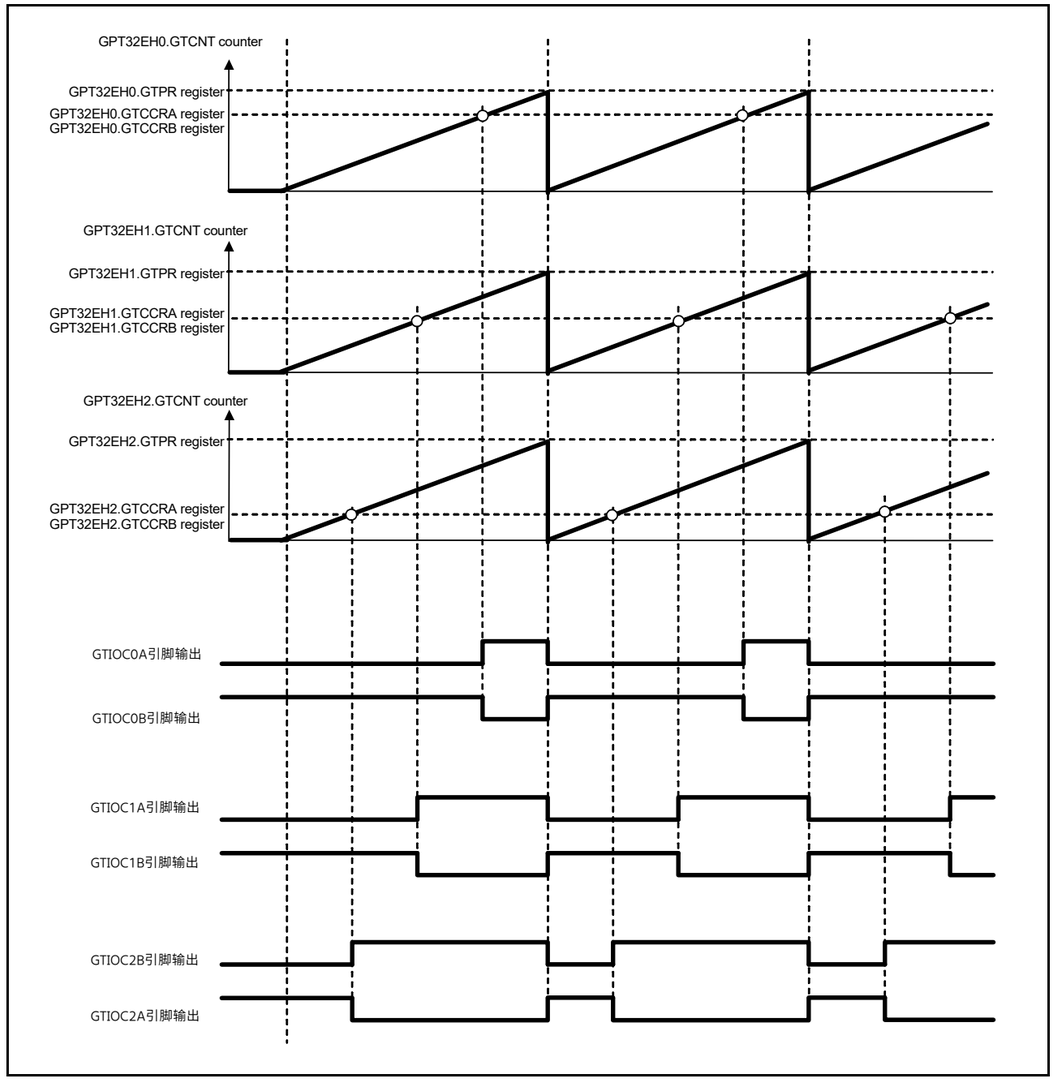

Figure 22.66 三相锯齿波互补PWM输出示例

(3) 具有自动死区时间设置的三相锯齿波互补PWM输出

图22.67显示了一个示例，其中三个通道在具有自动死区时间设置的锯齿波一次性脉冲模式下执行同步操作并输出三相互补PWM波形。GTIOCA引脚设置为输出低作为初始值，在GTCCRA比较匹配时切换输出，并在周期结束时保持输出。GTIOCB引脚设置为输出高电平作为初始值，在GTCCRB比较匹配时切换输出，并在周期结束时保持输出。

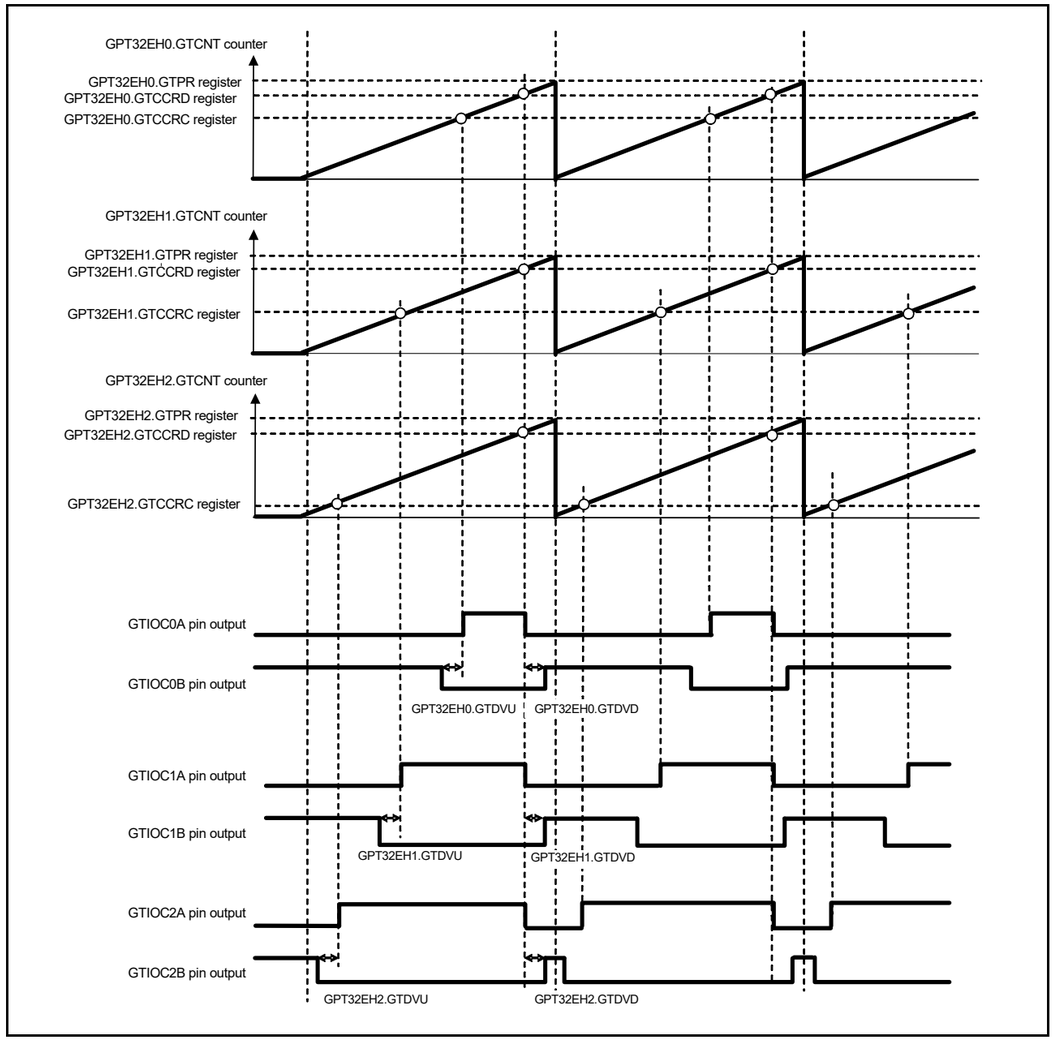

Figure 22.67 Example of 3-phase saw-wave complementary PWM output with automatic dead time setting

(4) 3-phase triangle-wave complementary PWM output

Figure 22.68 shows an example in which three channels perform synchronized operation in triangle-wave PWM mode 1 and 3-phase complementary PWM waveforms are output. The GTIOCA pin is set so that it outputs low as the initial value, toggles the output at a GTCCRA compare match, and retains the output at the cycle end. The GTIOCB pin is set so that it outputs high as the initial value, toggles the output at a GTCCRB compare match, and retains the output at the cycle end.

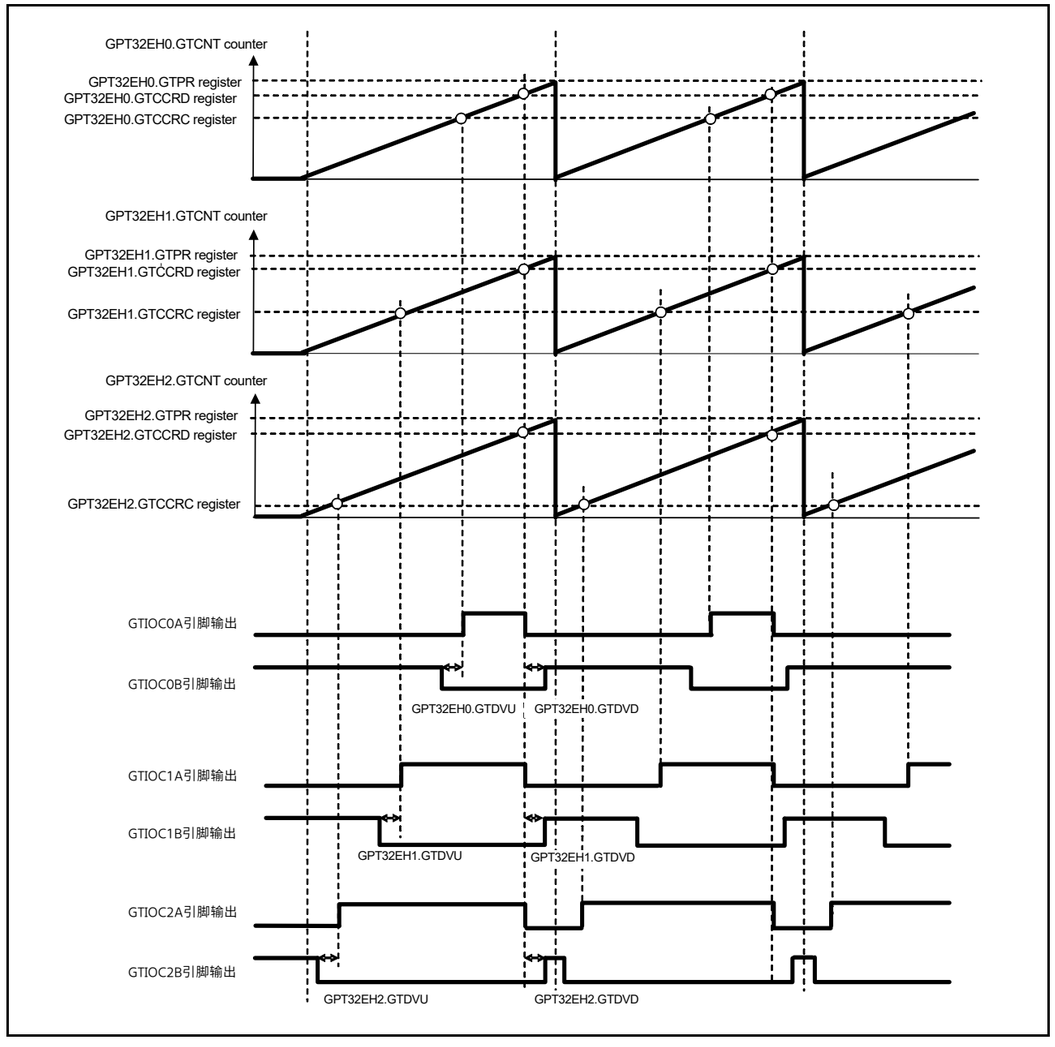

Figure 22.67 具有自动死区时间设置的三相锯齿波互补PWM输出示例

(4) 三相三角波互补PWM输出

图22.68显示了一个示例，其中三个通道在三角波PWM模式1中执行同步操作并输出三相互补PWM波形。GTIOCA引脚设置为输出低作为初始值，在GTCCRA比较匹配时切换输出，并在周期结束时保持输出。GTIOCB引脚设置为输出高电平作为初始值，在GTCCRB比较匹配时切换输出，并在周期结束时保持输出。

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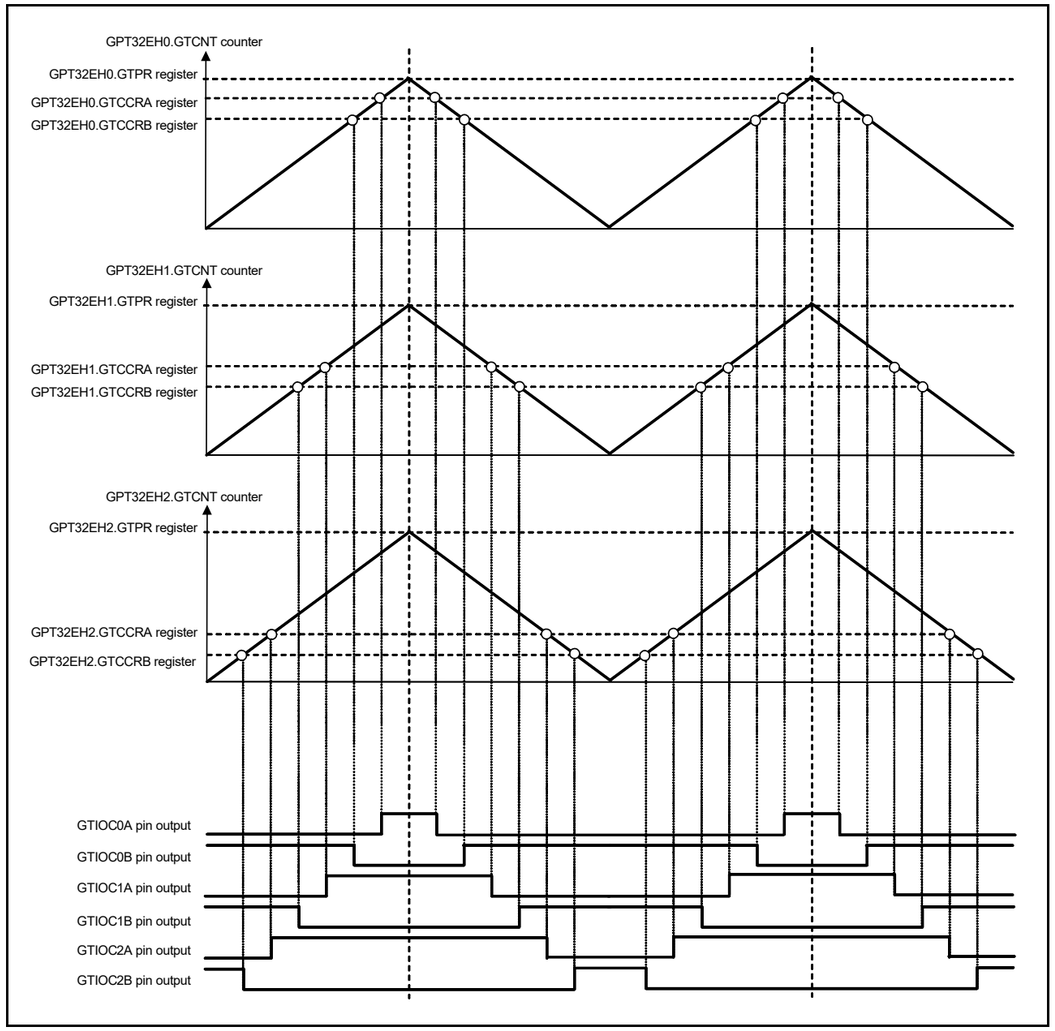

Figure 22.68 Example of 3-phase triangle-wave complementary PWM output

(5) 3-phase triangle-wave complementary PWM output with automatic dead time setting

Figure 22.69 shows an example in which three channels perform synchronized operation in triangle-wave PWM mode 1 with automatic dead time setting and 3-phase complementary PWM waveforms are output. The GTIOCA pin is set so that it outputs low as the initial value, toggles the output at a GTCCRA compare match, and retains the output at the cycle end. The GTIOCB pin is set so that it outputs high as the initial value, toggles the output at a GTCCRB compare match, and retains the output at the cycle end.

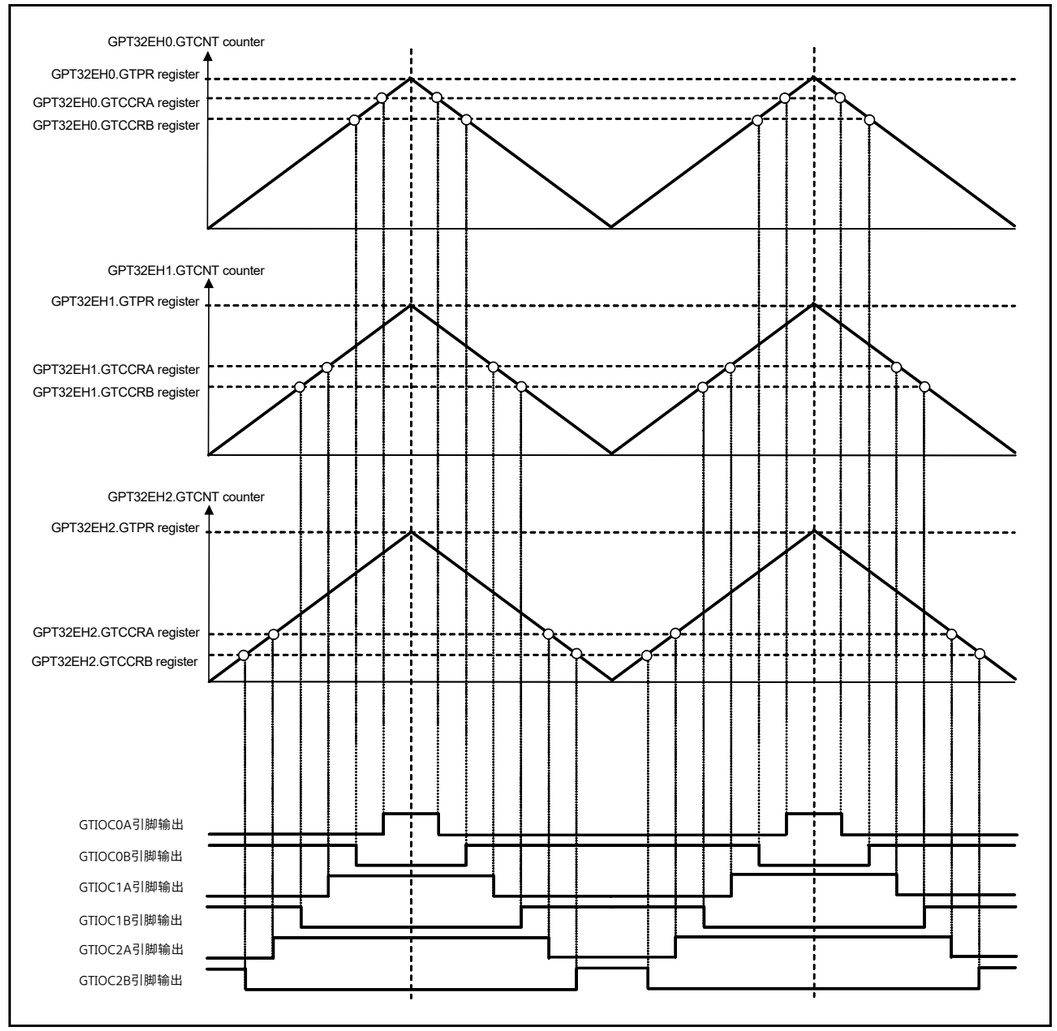

Figure 22.68 三相三角波互补PWM输出示例

(5) 具有自动死区时间设置的三相三角波互补PWM输出

图22.69显示了一个示例，其中三个通道在三角波PWM模式1下执行同步操作，自动设置死区时间并输出三相互补PWM波形。GTIOCA引脚设置为输出低作为初始值，在GTCCRA比较匹配时切换输出，并在周期结束时保持输出。GTIOCB引脚设置为输出高电平作为初始值，在GTCCRB比较匹配时切换输出，并在周期结束时保持输出。

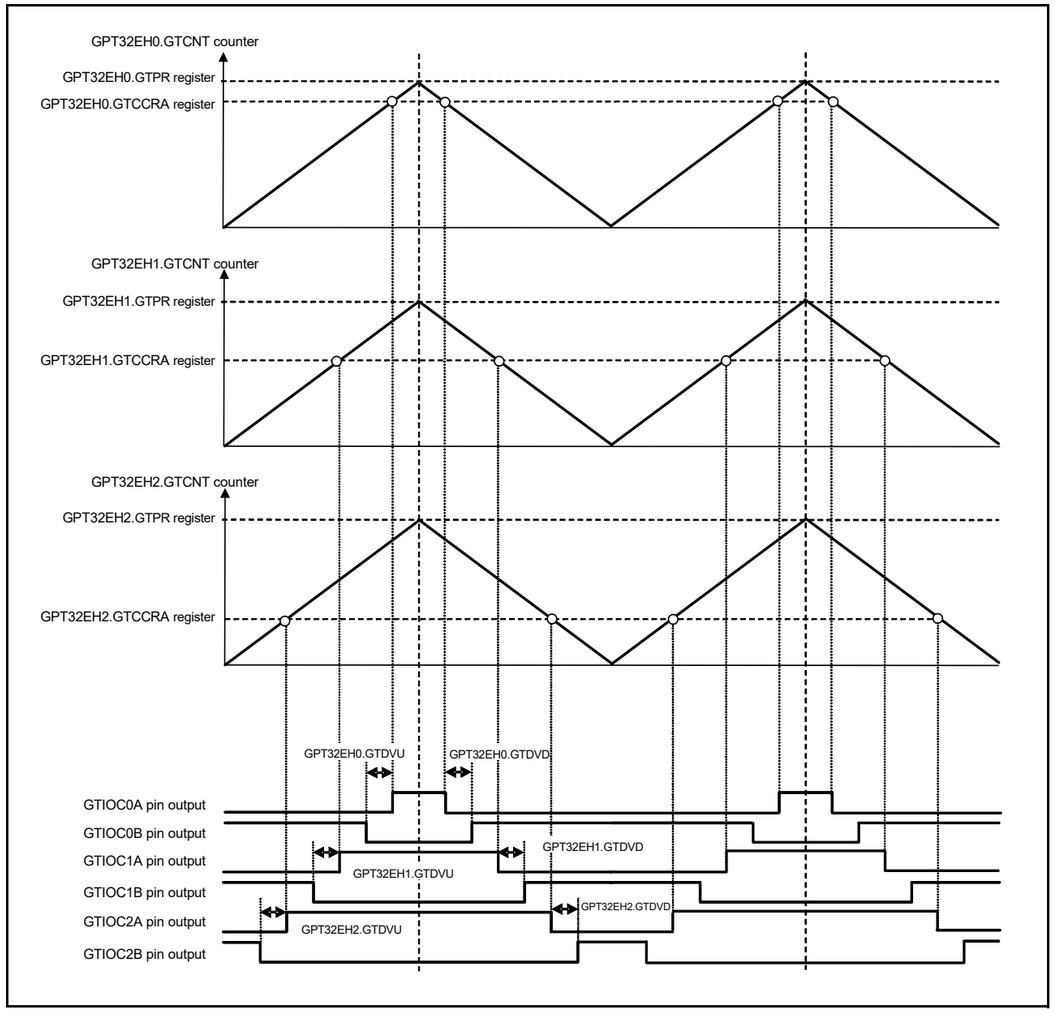

Figure 22.69 Example of 3-phase triangle-wave complementary PWM output with automatic dead time setting

(6) 3-phase asymmetric triangle-wave complementary PWM output with automatic dead time setting

Figure 22.70 shows an example in which three channels perform synchronized operation in triangle-wave PWM mode 3 with automatic dead time setting and 3-phase complementary PWM waveforms are output. The GTIOCA is set so that it outputs low as the initial value, toggles the output at a GTCCRA compare match, and retains the output at the cycle end. The GTIOCB is set so that it outputs high as the initial value, toggles the output at a GTCCRB compare match, and retains the output at the cycle end.

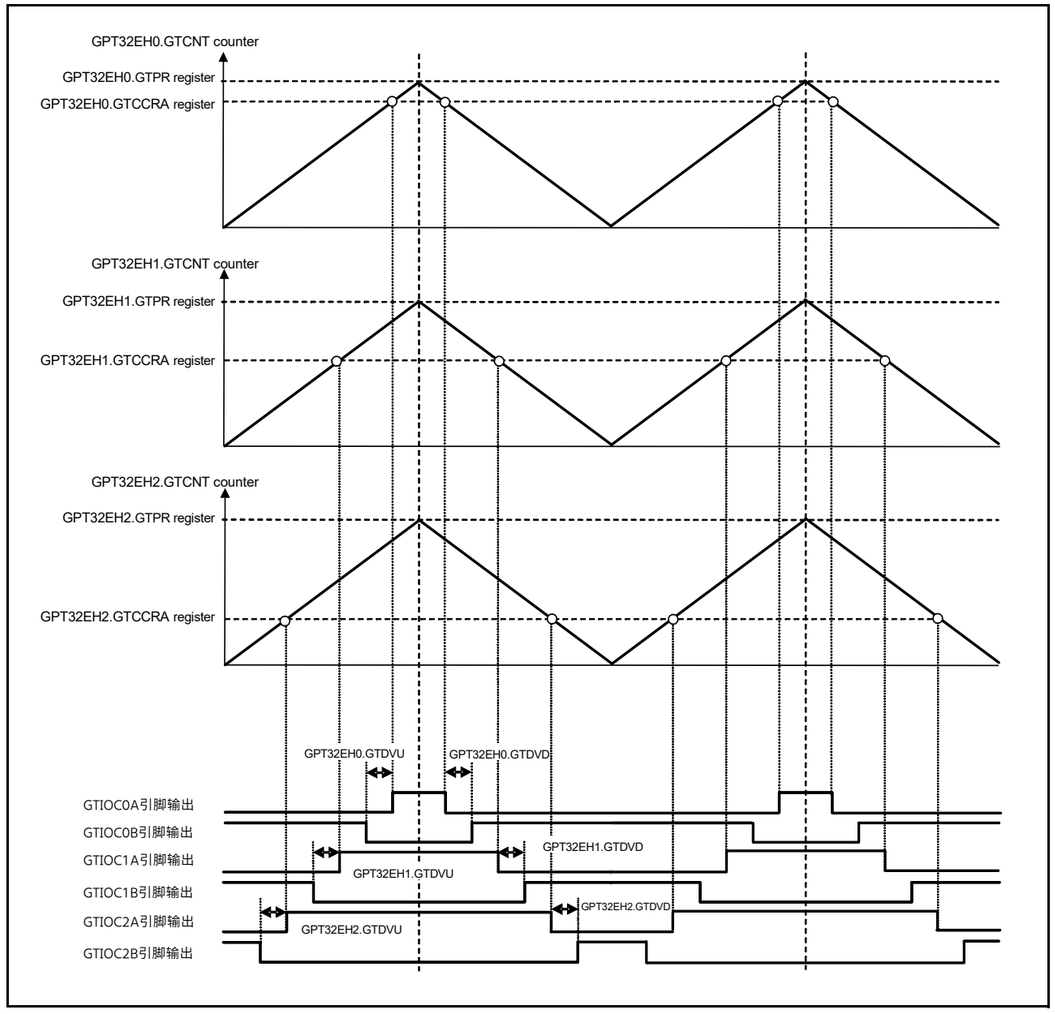

Figure 22.69 具有自动死区时间设置的三相三角波互补PWM输出示例

(6) 具有自动死区时间设置的三相不对称三角波互补PWM输出

图22.70显示了一个示例，其中三个通道在三角波PWM模式3下执行同步操作，自动设置死区时间并输出三相互补PWM波形。GTIOCA设置为输出低作为初始值，在GTCCRA比较匹配时切换输出，并在循环结束时保留输出。GTIOCB设置为输出高电平作为初始值，在GTCCRB比较匹配时切换输出，并在循环结束时保留输出。

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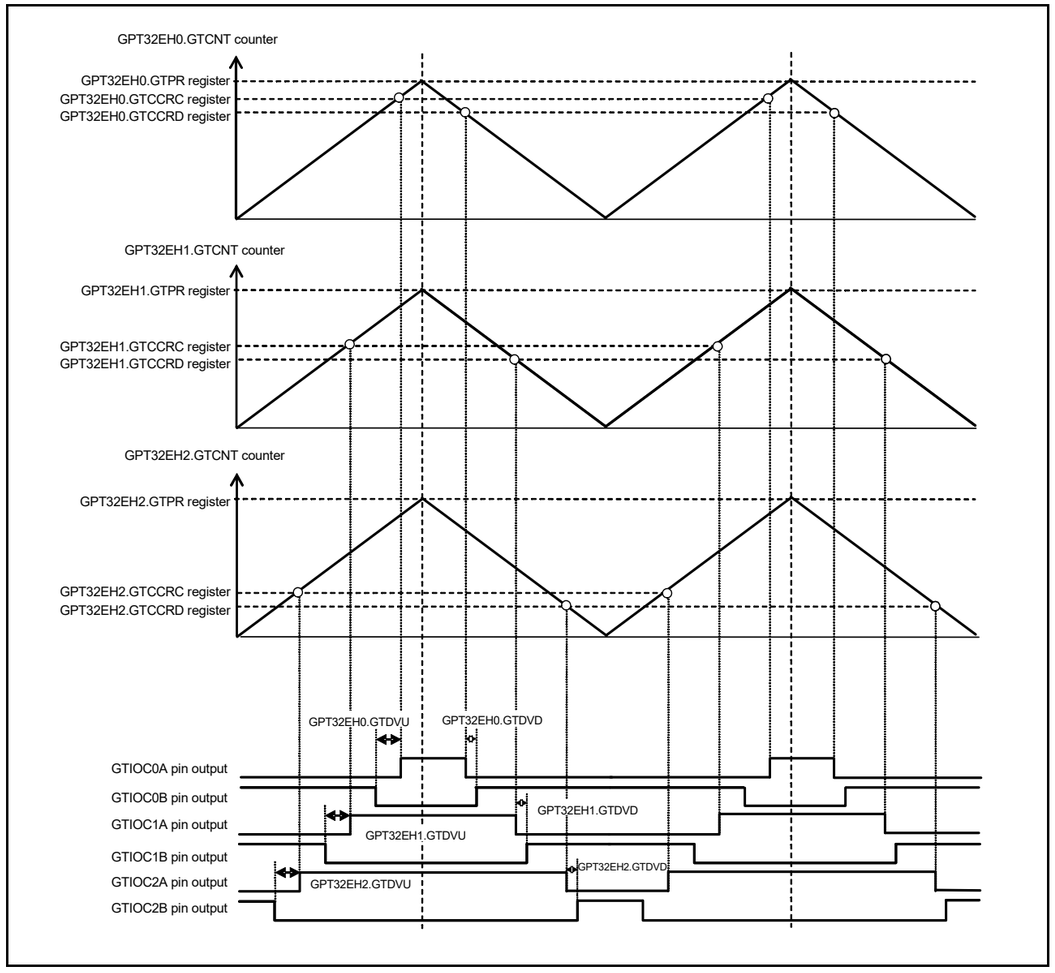

Figure 22.70 Example of 3-phase asymmetric triangle-wave complementary PWM output with automatic dead time setting

22.3.10 Phase Counting Function

The phase difference between the GTIOCA and GTIOCB pin inputs is detected and the associated GTCNT counts up or counts down. The detectable phase difference is available in any combination with the relationship between the edge and the level of GTIOCA and GTIOCB pin inputs being set in the GTUPSR and GTDNSR registers. For details on count operation, see section 22.3.1.1, Counter operation.

Figure 22.71 to Figure 22.80 show phase counting functions 1 to 5. Table 22.8 to Table 22.17 show conditions of up-counting or down-counting and list settings for the GTUPSR and GTDNSR registers.

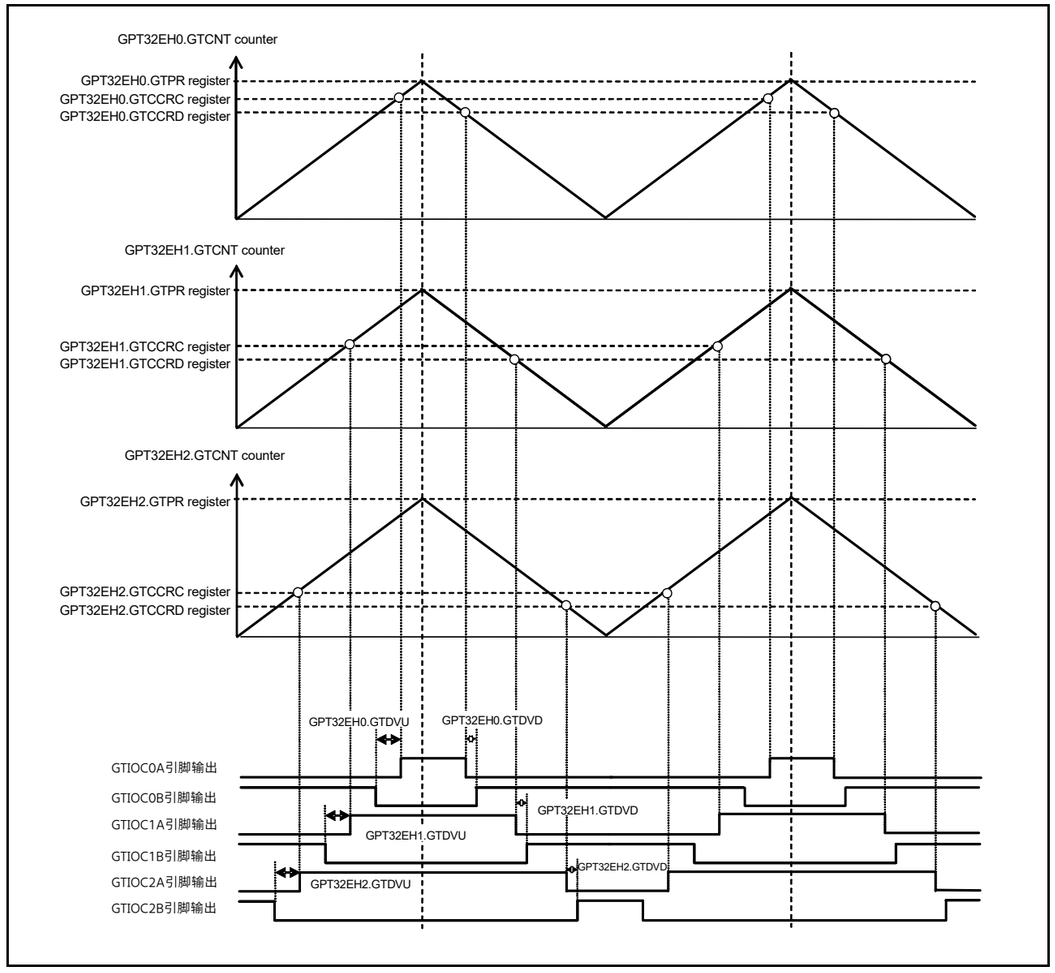

Figure 22.70 具有自动死区时间设置的三相不对称三角波互补PWM输出示例

22.3.10 相位计数功能

检测到GTIOCA和GTIOCB引脚输入之间的相位差，并且相关的GTCNT向上计数或向下计数。可检测的相位差可与在GTUPSR和GTDNSR寄存器中设置的GTIOCA和GTIOCB引脚输入的边沿和电平之间的关系任意组合。有关计数操作的详细信息，请参阅第22.3.1.1节，计数器操作。

图22.71至图22.80显示了相位计数功能1至5。表22.8至表22.17显示了GTUPSR和GTDNSR寄存器的递增或递减计数条件和列表设置。

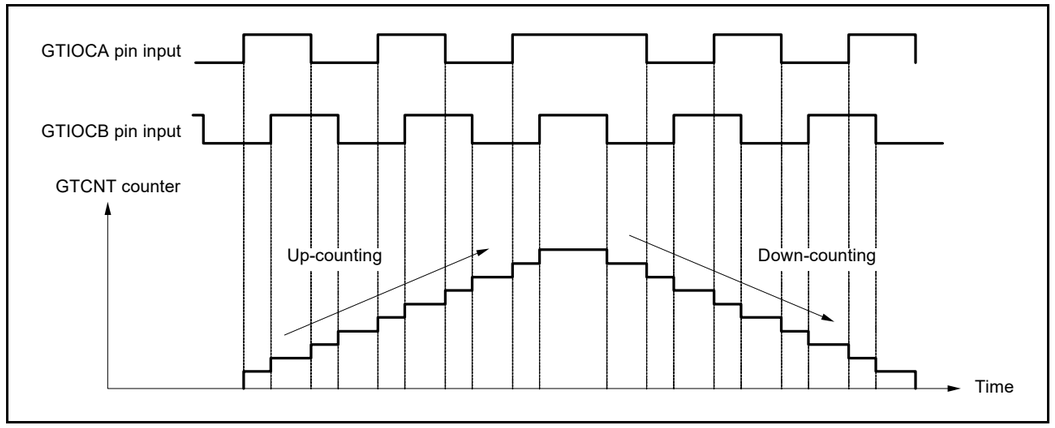

Figure 22.71 Example of phase counting function 1

Table 22.8 Conditions of up-counting/down-counting in phase counting function 1

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Up-counting	GTUPSR = 0000 6900h GTDNSR = 0000 9600h
Low	↓		
↑	Low		
↓	High		
High	↓	Down-counting	
Low	↑		
↑	High		
↓	Low		

↑ : Rising edge

↓ : Falling edge

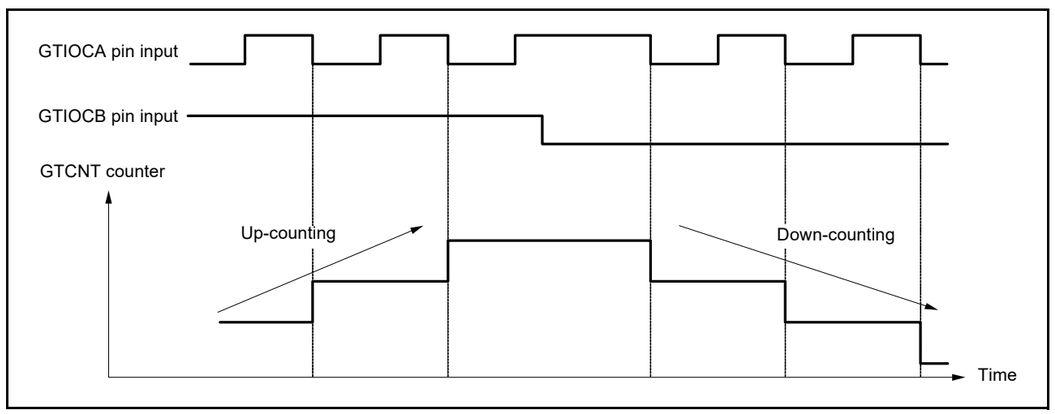

Figure 22.72 Example of phase counting function 2 (A)

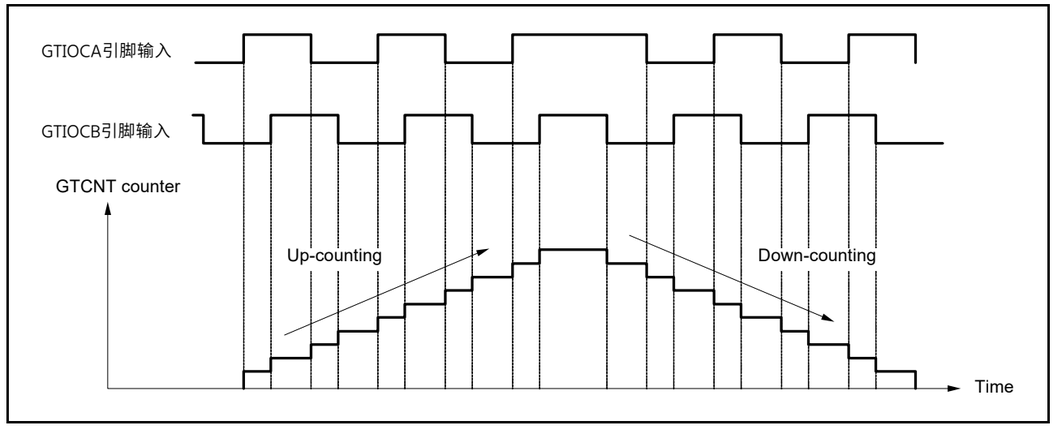

Figure 22.71 相位计数功能示例1

Table 22.8 相位计数功能加减计数条件1

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Up-counting	GTUPSR = 0000 6900h GTDNSR = 0000 9600h
Low	↓		
↑	Low		
↓	High		
High	↓	Down-counting	
Low	↑		
↑	High		
↓	Low		

↑ :上升沿

↓ :下降沿

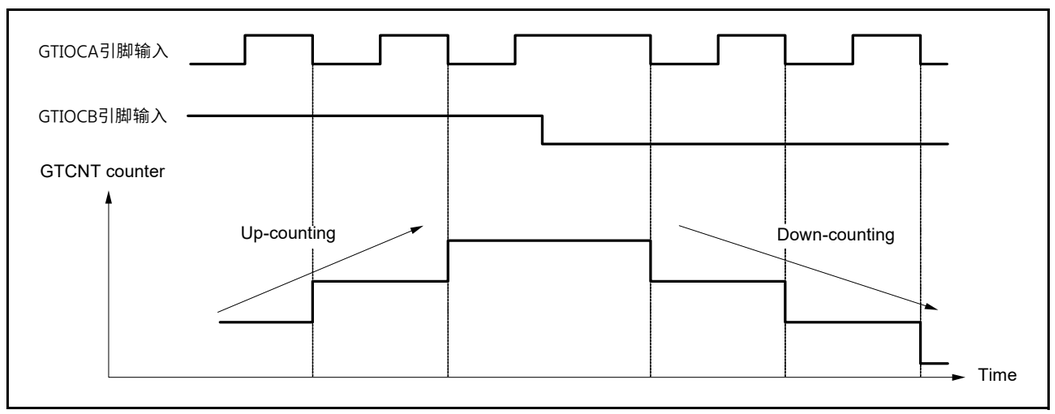

Figure 22.72 相位计数功能示例2(A)

Table 22.9 Conditions of up-counting/down-counting in phase counting function 2 (A)

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Don't care	GTUPSR = 0000 0800h GTDNSR = 0000 0400h
Low	↓		
↑	Low		
↓	High	Up-counting	
High	↓	Don't care	
Low	↑		
↑	High		
↓	Low	Down-counting	

↑ : Rising edge

↓ : Falling edge

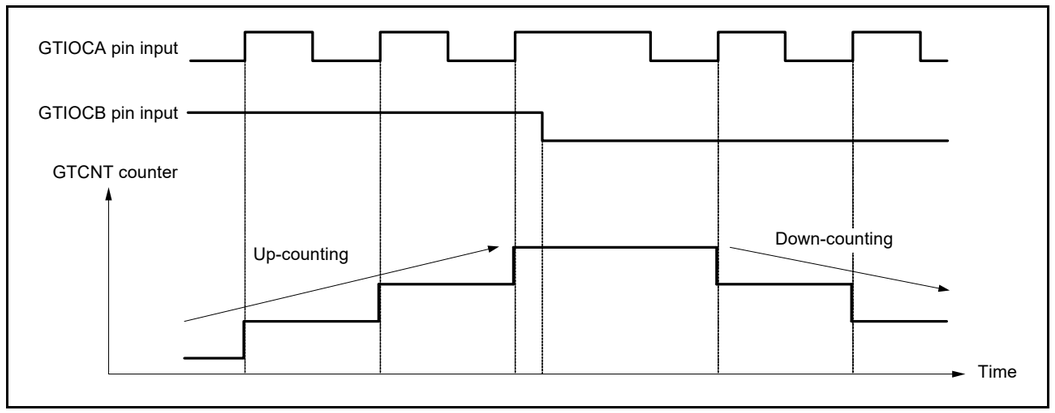

Figure 22.73 Example of phase counting function 2 (B)

Table 22.10 Conditions of up-counting/down-counting in phase counting function 2 (B)

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Don't care	GTUPSR = 0000 0200h GTDNSR = 0000 0100h
Low	↓		
↑	Low	Down-counting	
↓	High	Don't care	
High	↓		
Low	↑		
↑	High	Up-counting	
↓	Low	Don't care	

↑ : Rising edge

↓ : Falling edge

Table 22.9 相位计数功能2(A)中加减计数的条件

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Don't care	GTUPSR = 0000 0800h GTDNSR = 0000 0400h
Low	↓		
↑	Low		
↓	High	Up-counting	
High	↓	Don't care	
Low	↑		
↑	High		
↓	Low	Down-counting	

↑ :上升沿

↓ :下降沿

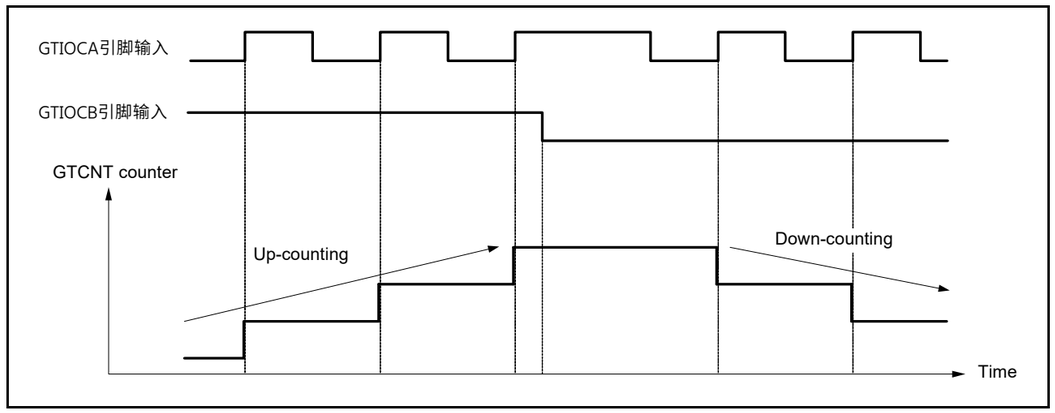

Figure 22.73 相位计数功能示例2(B)

Table 22.10 相位计数功能2(B)中加减计数的条件

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Don't care	GTUPSR = 0000 0200h GTDNSR = 0000 0100h
Low	↓		
↑	Low	Down-counting	
↓	High	Don't care	
High	↓		
Low	↑		
↑	High	Up-counting	
↓	Low	Don't care	

↑ :上升沿

↓ :下降沿

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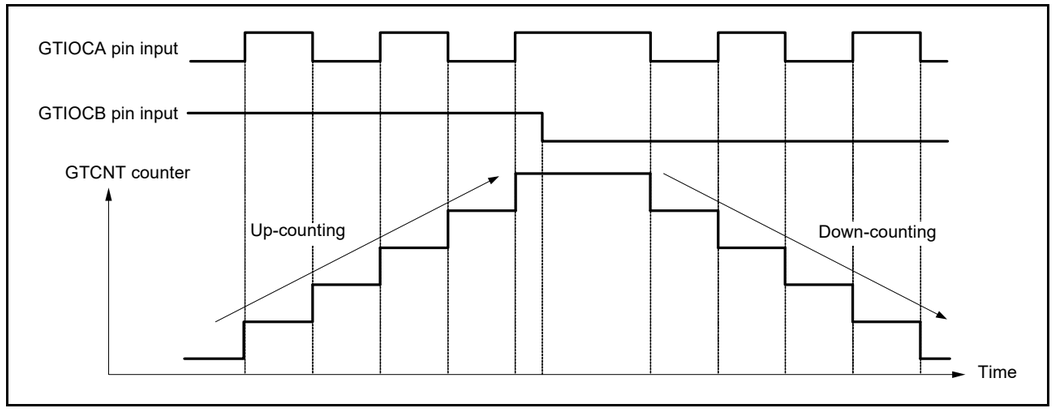

Figure 22.74 Example of phase counting function 2 (C)

Table 22.11 Conditions of up-counting/down-counting in phase counting function 2 (C)

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Don't care	GTUPSR = 0000 0A00h GTDNSR = 0000 0500h
Low	↓		
↑	Low	Down-counting	
↓	High	Don't care	
Low	↑		
↑	High	Up-counting	
↓	Low	Down-counting	

↑ : Rising edge

↓ : Falling edge

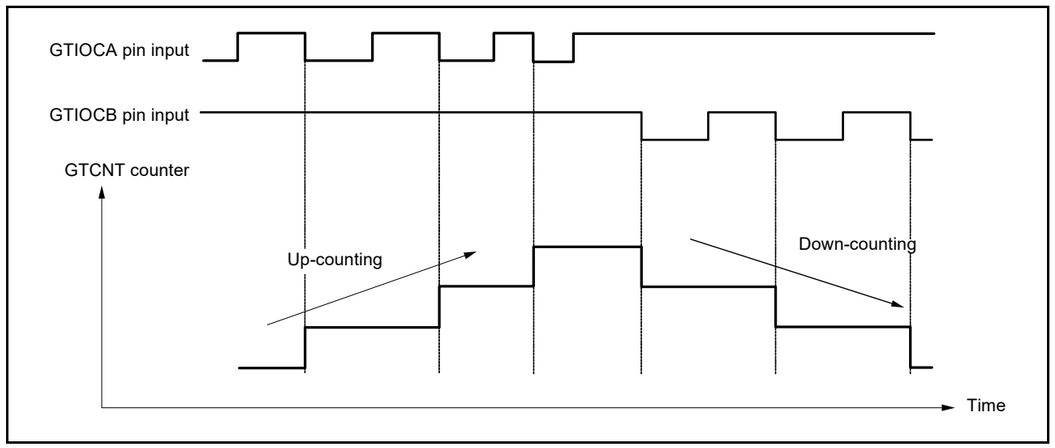

Figure 22.75 Example of phase counting function 3 (A)

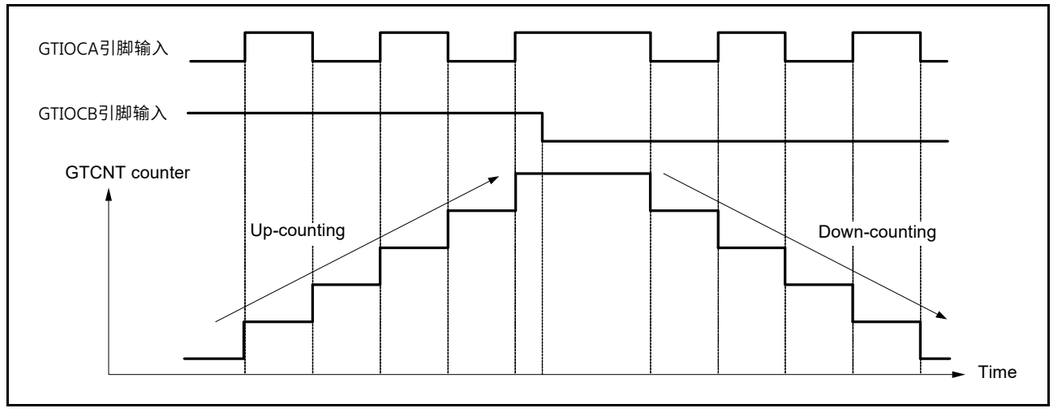

Figure 22.74 相位计数功能示例2(C)

Table 22.11 相位计数功能2(C)中加减计数的条件

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Don't care	GTUPSR = 0000 0A00h GTDNSR = 0000 0500h
Low	↓		
↑	Low	Down-counting	
↓	High	Don't care	
Low	↑		
↑	High	Up-counting	
↓	Low	Down-counting	

↑ :上升沿

↓ :下降沿

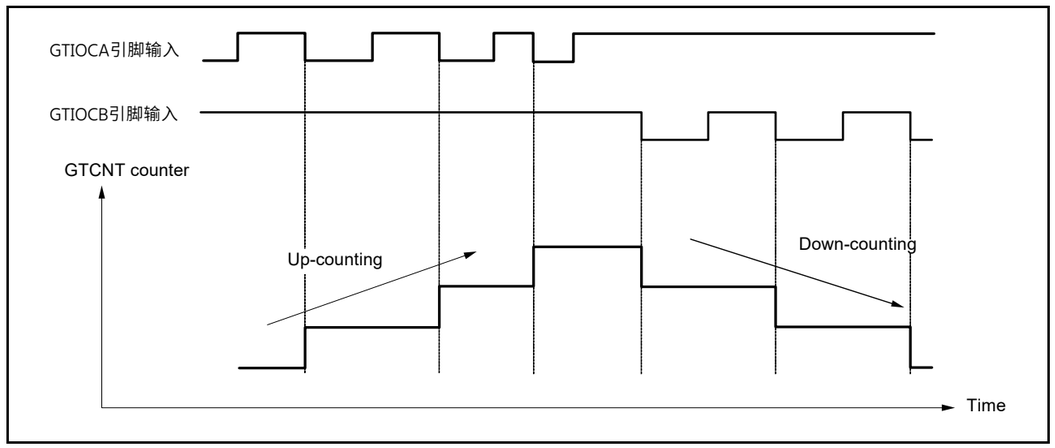

Figure 22.75 相位计数功能示例3(A)

Table 22.12 Conditions of up-counting/down-counting in phase counting function 3 (A)

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Don't care	GTUPSR = 0000 0800h GTDNSR = 0000 8000h
Low	↓		
↑	Low		
↓	High	Up-counting	
High	↓	Down-counting	
Low	↑	Don't care	
↑	High		
↓	Low		

↑ : Rising edge

↓ : Falling edge

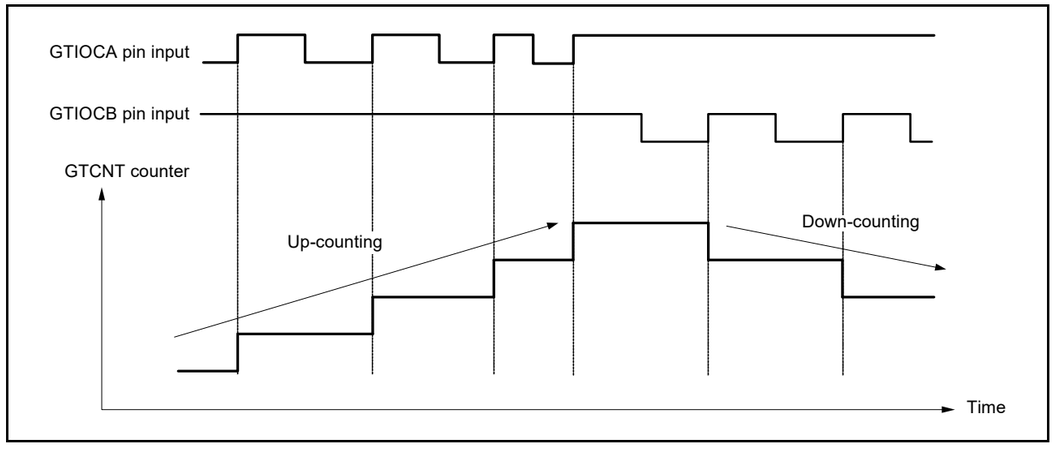

Figure 22.76 Example of phase counting function 3 (B)

Table 22.13 Conditions of up-counting/down-counting in phase counting function 3 (B)

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Down-counting	GTUPSR = 0000 0200h GTDNSR = 0000 2000h
Low	↓	Don't care	
↑	Low		
↓	High		
High	↓		
Low	↑		
↑	High	Up-counting	
↓	Low	Don't care	

↑ : Rising edge

↓ : Falling edge

Table 22.12 相位计数功能3(A)中加减计数的条件

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Don't care	GTUPSR = 0000 0800h GTDNSR = 0000 8000h
Low	↓		
↑	Low		
↓	High	Up-counting	
High	↓	Down-counting	
Low	↑	Don't care	
↑	High		
↓	Low		

↑ :上升沿

↓ :下降沿

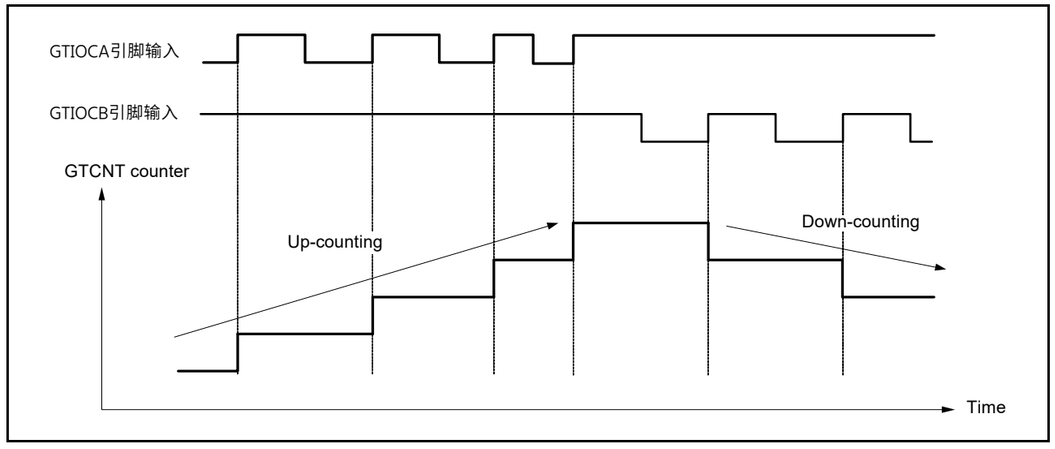

Figure 22.76 相位计数功能示例3(B)

Table 22.13 相位计数功能3(B)中加减计数的条件

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Down-counting	GTUPSR = 0000 0200h GTDNSR = 0000 2000h
Low	↓	Don't care	
↑	Low		
↓	High		
High	↓		
Low	↑		
↑	High	Up-counting	
↓	Low	Don't care	

↑ :上升沿

↓ :下降沿

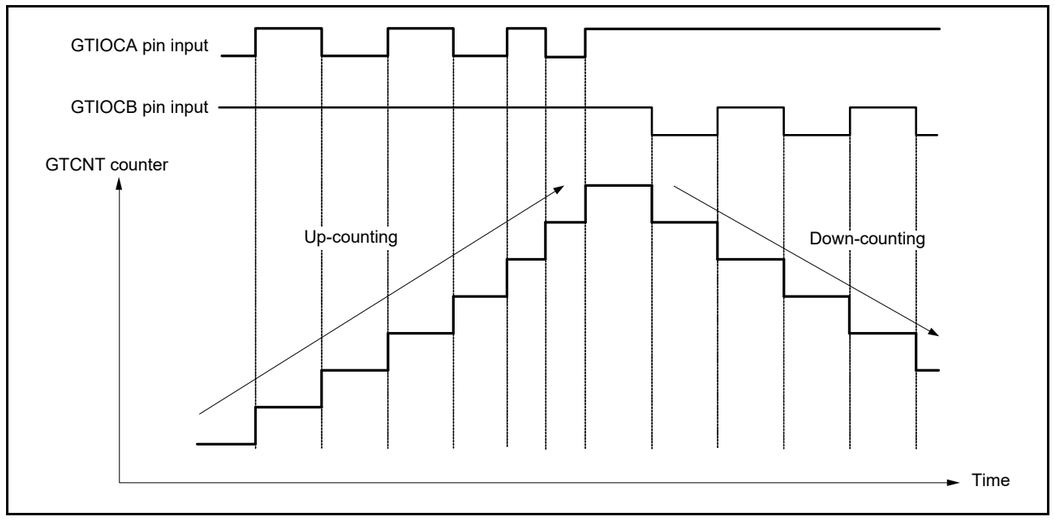

Figure 22.77 Example of phase counting function 3 (C)

Table 22.14 Conditions of up-counting/down-counting in phase counting function 3 (C)

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Down-counting	GTUPSR = 0000 0A00h GTDNSR = 0000 A000h
Low	↓	Don't care	
↑	Low		
↓	High	Up-counting	
High	↓	Down-counting	
Low	↑	Don't care	
↑	High	Up-counting	
↓	Low	Don't care	

↑ : Rising edge

↓ : Falling edge

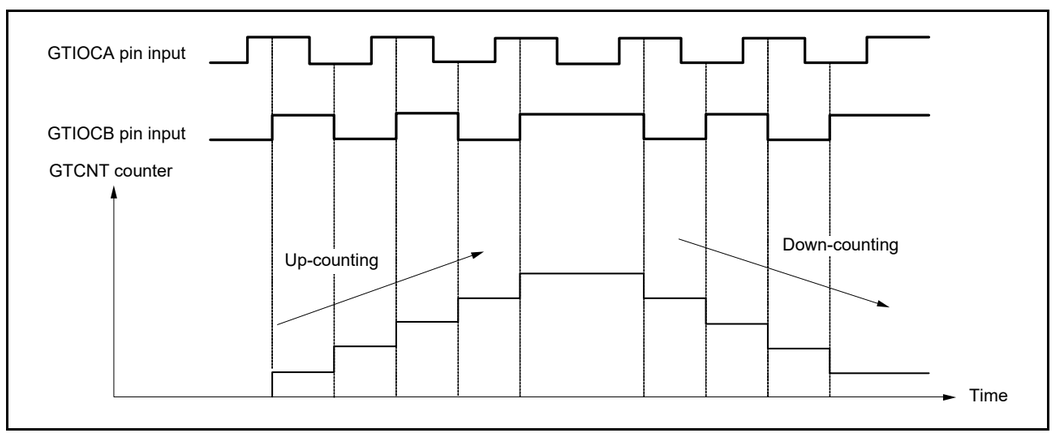

Figure 22.78 Example of phase counting function 4

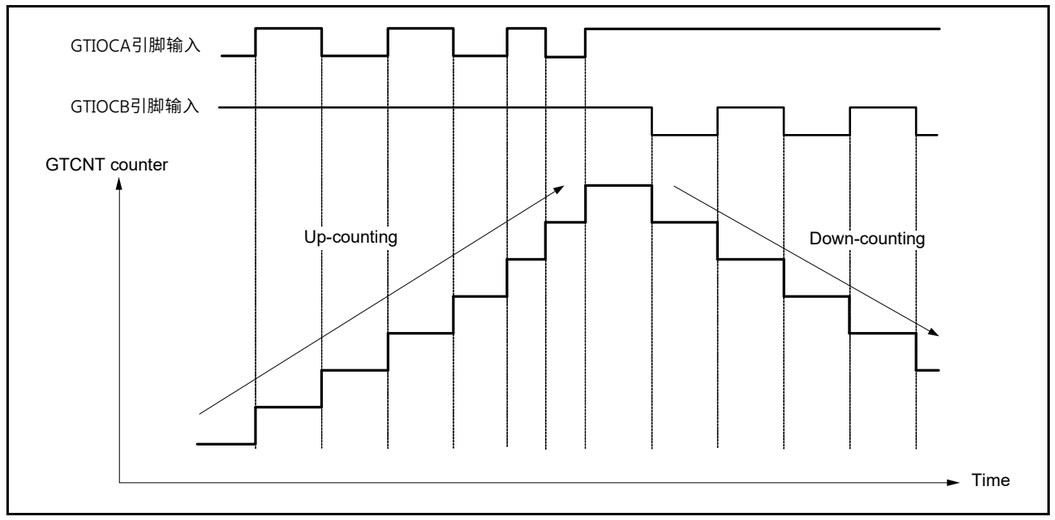

Figure 22.77 相位计数功能示例3(C)

Table 22.14 相位计数功能3(C)中加减计数的条件

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Down-counting	GTUPSR = 0000 0A00h GTDNSR = 0000 A000h
Low	↓	Don't care	
↑	Low		
↓	High	Up-counting	
High	↓	Down-counting	
Low	↑	Don't care	
↑	High	Up-counting	
↓	Low	Don't care	

↑ :上升沿

↓ :下降沿

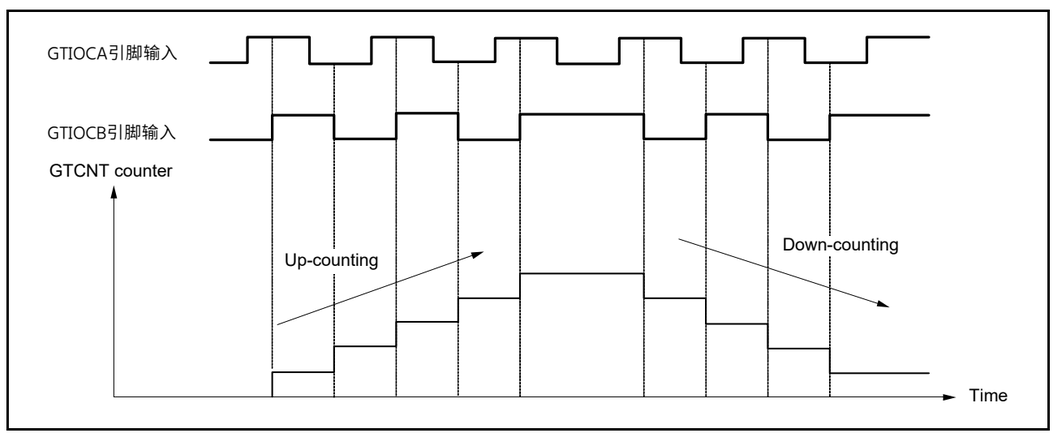

Figure 22.78 相位计数功能示例4

Table 22.15 Conditions of up-counting/down-counting in phase counting function 4

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Up-counting	GTUPSR = 0000 6000h GTDNSR = 0000 9000h
Low	↓		
↑	Low	Don't care	
↓	High		
High	↓	Down-counting	
Low	↑		
↑	High	Don't care	
↓	Low		

↑ : Rising edge

↓ : Falling edge

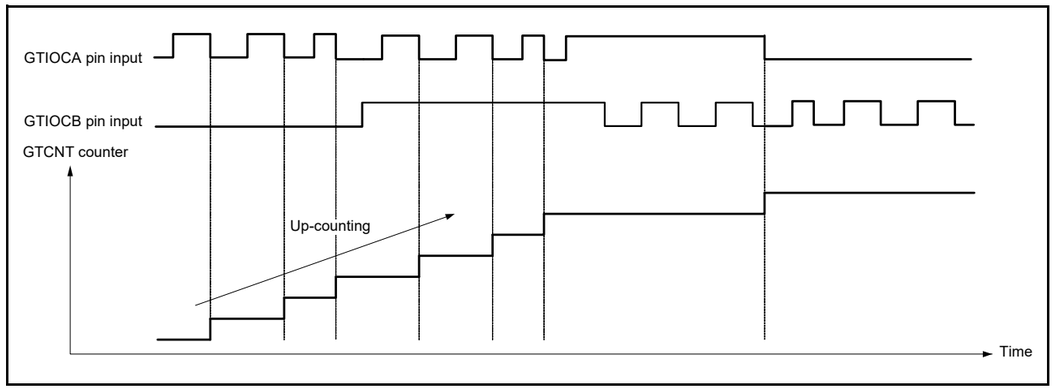

Figure 22.79 Example of phase counting function 5 (A)

Table 22.16 Conditions of up-counting/down-counting in phase counting function 5 (A)

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Don't care	GTUPSR = 0000 0C00h GTDNSR = 0000 0000h
Low	↓		
↑	Low		
↓	High	Up-counting	
High	↓	Don't care	
Low	↑		
↑	High		
↓	Low	Up-counting	

↑ : Rising edge

↓ : Falling edge

Table 22.15 相位计数功能中加减计数条件4

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Up-counting	GTUPSR = 0000 6000h GTDNSR = 0000 9000h
Low	↓		
↑	Low	Don't care	
↓	High		
High	↓	Down-counting	
Low	↑		
↑	High	Don't care	
↓	Low		

↑ :上升沿

↓ :下降沿

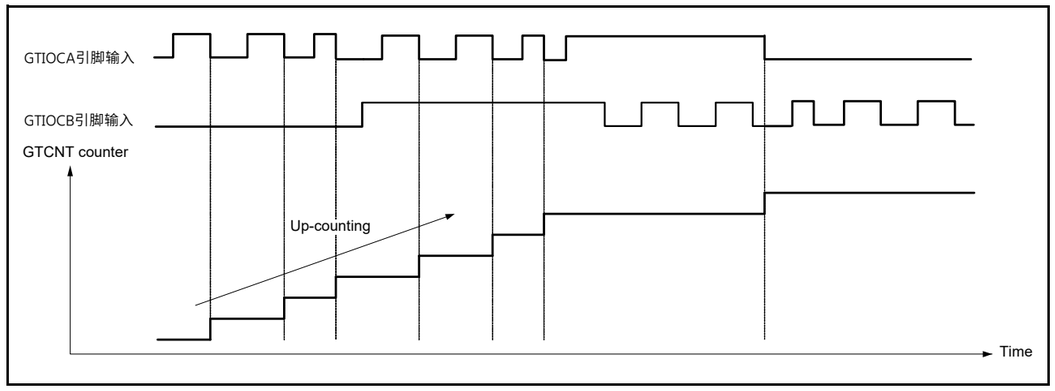

Figure 22.79 相位计数功能示例5(A)

Table 22.16 相位计数功能5(A)中加减计数的条件

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Don't care	GTUPSR = 0000 0C00h GTDNSR = 0000 0000h
Low	↓		
↑	Low		
↓	High	Up-counting	
High	↓	Don't care	
Low	↑		
↑	High		
↓	Low	Up-counting	

↑ :上升沿

↓ :下降沿

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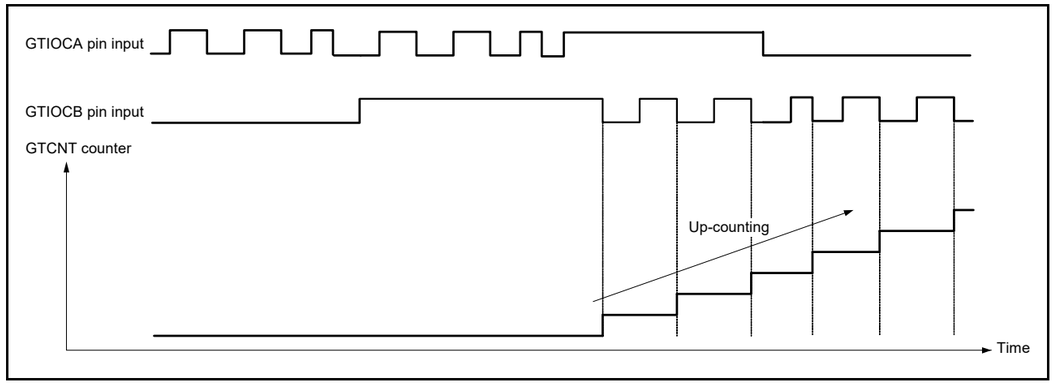


Figure 22.80 Example of phase counting function 5 (B)

Table 22.17 Conditions of up-counting/down-counting in phase counting function 5 (B)

GTIOCA pin input	GTIOCB pin input	Operation	Register setting
High	↑	Don't care	GTUPSR = 0000 0C00h GTDNSR = 0000 0000h
Low	↓	Up-counting	
↑	Low	Don't care	
↓	High		
High	↓	Up-counting	
Low	↑	Don't care	
↑	High		
↓	Low		

↑ : Rising edge

↓ : Falling edge

22.3.11 Output Phase Switching (GPT_OPS)

GPT_OPS provides a function for easy control of brushless DC motor operation using the Output Phase Switching Control Register (OPSCR).

GPT_OPS outputs a PWM signal to be used for chopper control or level signal for each phase (U-positive phase/negative phase, V-positive phase/negative phase, W-positive phase/negative phase) of the 6-phase motor control. This function uses a soft setting value (OPSCR.UF, VF, WF) set by software or external signals detected by the Hall element, a PWM waveform of GPT32EH0.GTIOCA.

Figure 22.81 shows the conceptual diagram of GPT_OPS control flow.

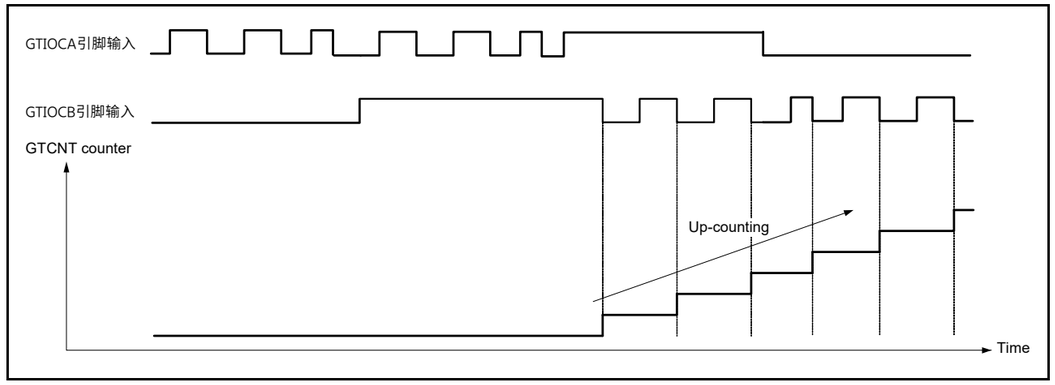


Figure 22.80 相位计数功能示例5(B)

Table 22.17 相位计数功能5(B)中加减计数的条件

GTIOCA引脚输入	GTIOCB引脚输入	Operation	注册设置
High	↑	Don't care	GTUPSR = 0000 0C00h GTDNSR = 0000 0000h
Low	↓	Up-counting	
↑	Low	Don't care	
↓	High		
High	↓	Up-counting	
Low	↑	Don't care	
↑	High		
↓	Low		

↑ :上升沿

↓ :下降沿

22.3.11 输出相位切换(GPT_OPS)

GPT_OPS提供使用输出相位切换轻松控制无刷直流电机运行的功能
控制寄存器(OPSCR)。

GPT_OPS输出用于斩波控制的PWM信号或6相电机控制的每一相（U正相负相、V正相负相、W正相负相）的电平信号。该功能使用软件设置的软设置值（OPSCR.UF、VF、WF）或霍尔元件检测到的外部信号，GPT32EH0.GTIOCA的PWM波形。

图22.81显示了GPT_OPS控制流程的概念图。

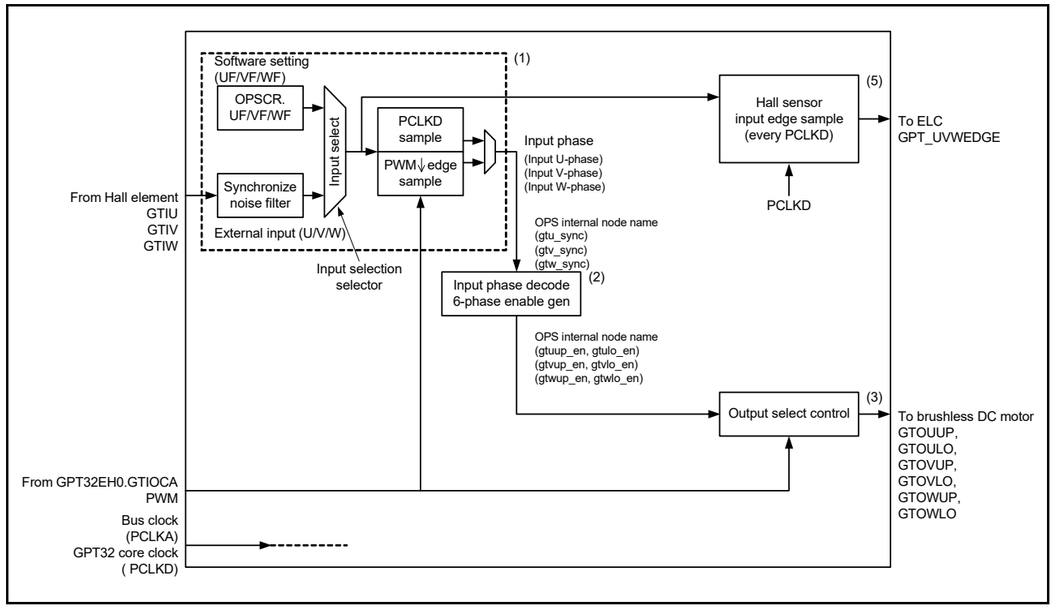


Figure 22.81 Conceptual diagram of GPT_OPS control flow

Figure 22.82 shows a 6-phase level signals output example of a GPT_OPS operation.

The GPT_UVWEDGE signal in Figure 22.82 is the Hall sensor input edge to ELC output.

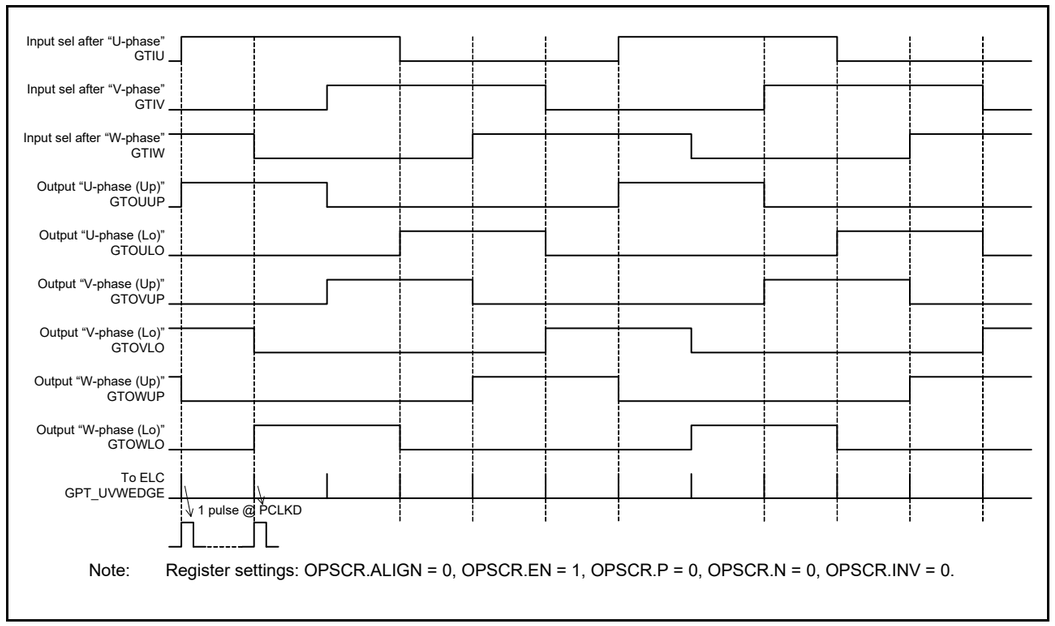


Figure 22.82 Example of 6-phase level output operation

Figure 22.83 shows a 6-phase PWM output example of a GPT_OPS operation with chopper control.

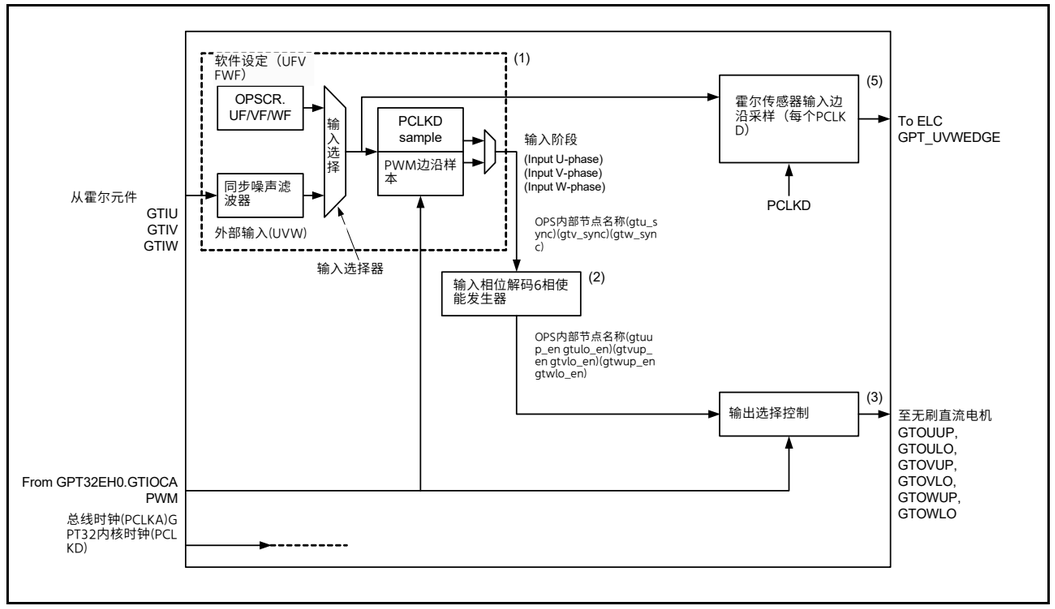


Figure 22.81 GPT_OPS控制流程概念图

图22.82显示了GPT_OPS操作的6相电平信号输出示例。

图22.82中的GPT_UVWEDGE信号是霍尔传感器输入边沿到ELC输出。

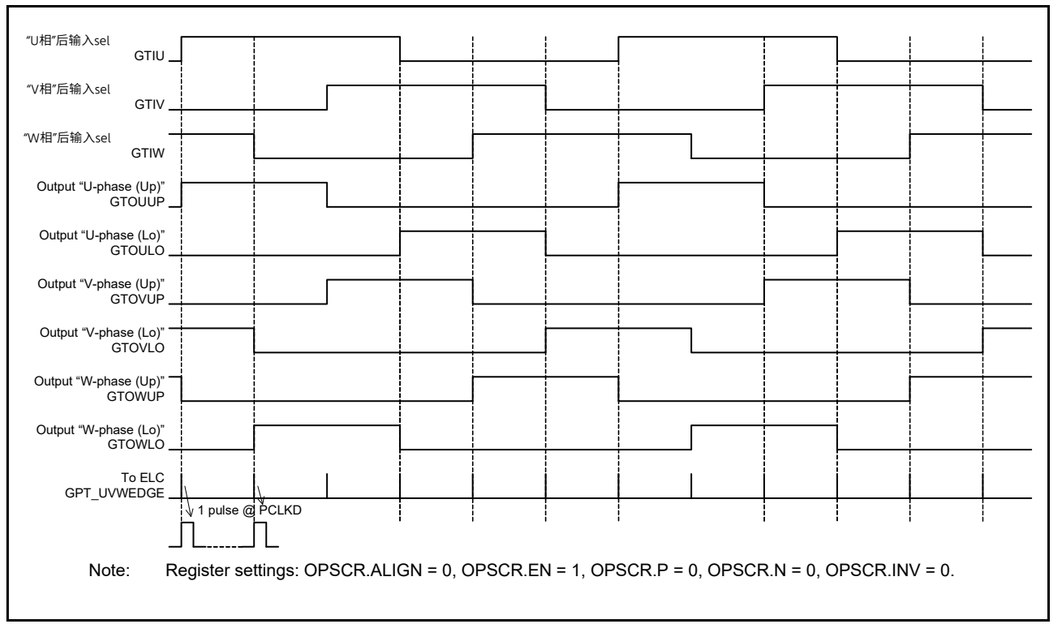
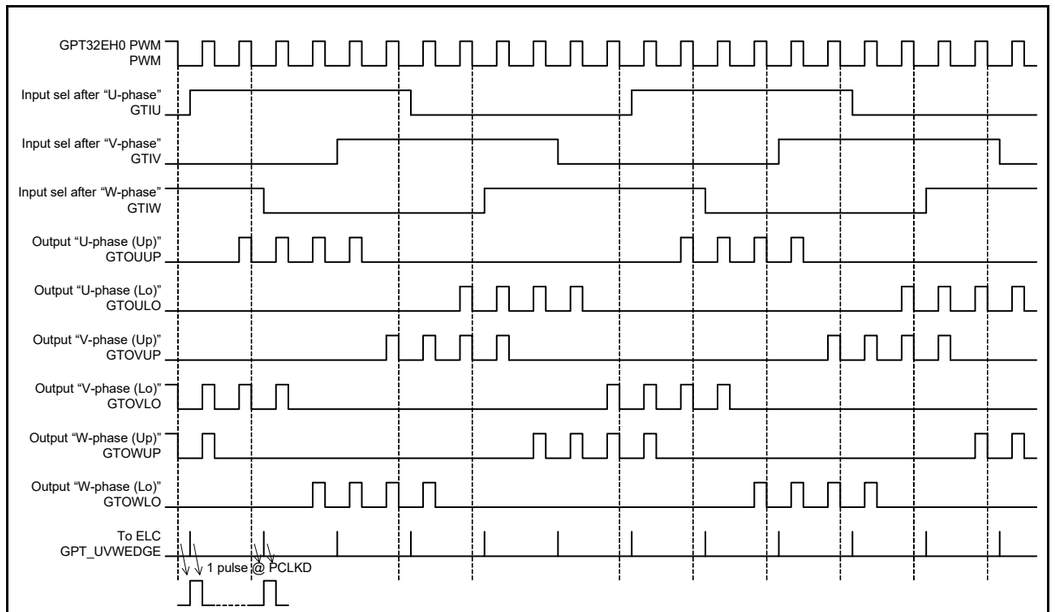


Figure 22.82 6相电平输出动作示例

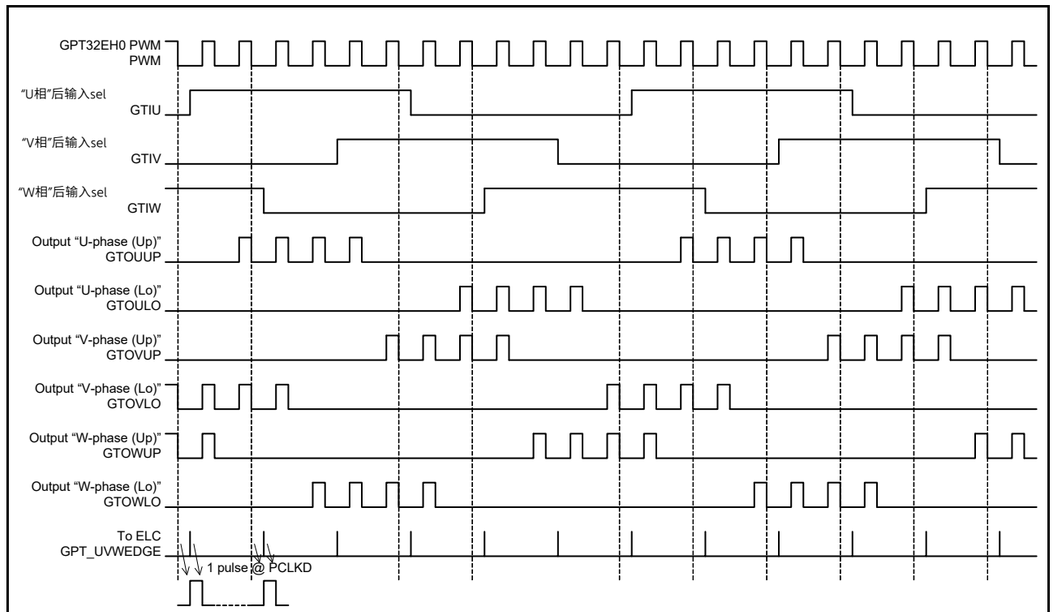
图22.83显示了带斩波器控制的GPT_OPS操作的6相PWM输出示例。



Note: Register settings: OPSCR.ALIGN = 1, OPSCR.EN = 1, OPSCR.P = 1, OPSCR.N = 1, OPSCR.INV = 0

Figure 22.83 Example of 6-phase PWM output operation with chopper control

Figure 22.84 shows a 6-phase PWM output example of an output disable control operation.



Note: Register settings: OPSCR.ALIGN = 1, OPSCR.EN = 1, OPSCR.P = 1, OPSCR.N = 1, OPSCR.INV = 0

Figure 22.83 带斩波器控制的6相PWM输出操作示例

图22.84显示了输出禁用控制操作的6相PWM输出示例。

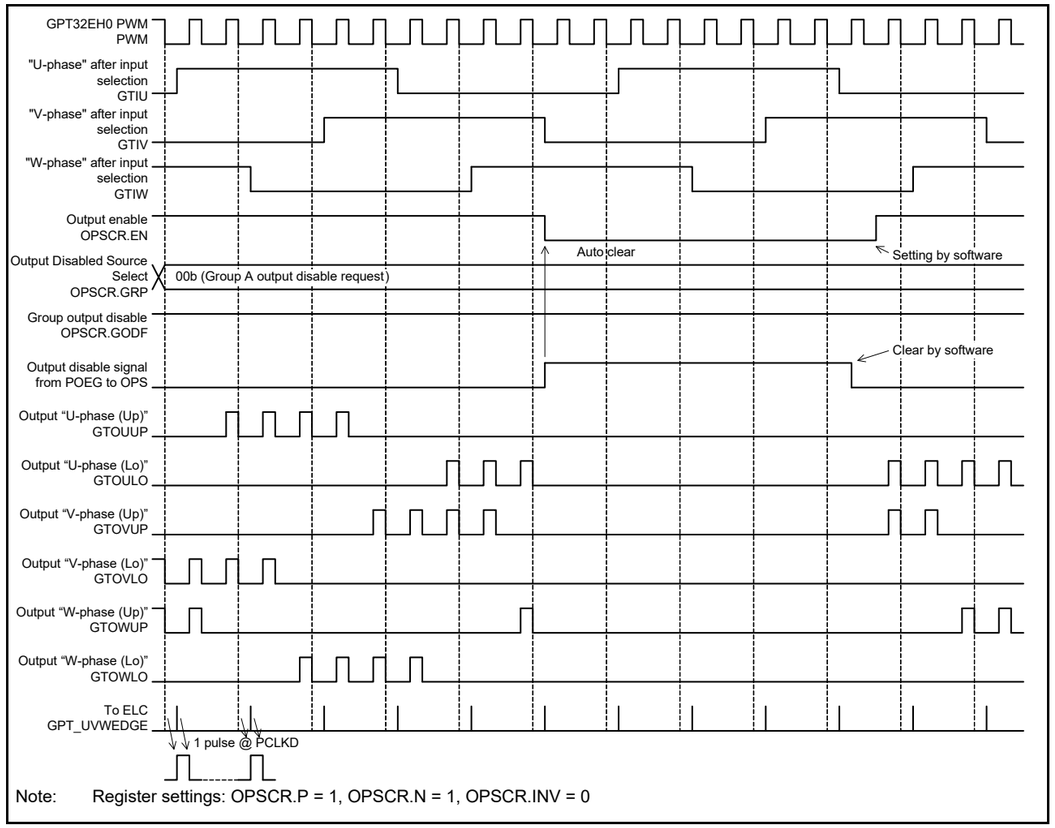


Figure 22.84 Example of group output disable control operation

22.3.11.1 Input selection and synchronization of external input signal

In the GPT_OPS control flow conceptual diagram shown in Figure 22.81, (1) is a selection of input phase from the software settings and external input by the OPSCR.FB bit.

When OPSCR.FB bit is 0, select the external input. Enable the input signal after synchronization with the GPT core clock (PCLKD). After carrying out noise filtering (optional), set the external input to the input phase of PWM (PWM of GPT32EH0.GTIOCA) using falling edge sampling with OPSCR.ALIGN bit set to 1.

When OPSCR.FB bit is 1, select the software setting (OPSCR.UF, VF, WF) with the value of the input phase of PWM (PWM of GPT32EH0.GTIOCA) using falling edge sampling with OPSCR.ALIGN bit set to 1.

When OPSCR.ALIGN bit is 0, GPT_OPS operates with the input phase of PCLKD synchronization with either OPSCR.FB bit set to 0 or OPSCR.FB bit set to 1. However, in some situations, the PWM pulse width of the output U/V/W phases (PWM output mode) of switch timing (just before or just after) is shortened.

Table 22.18 shows the input selection process and setting of associated OPSCR bits.

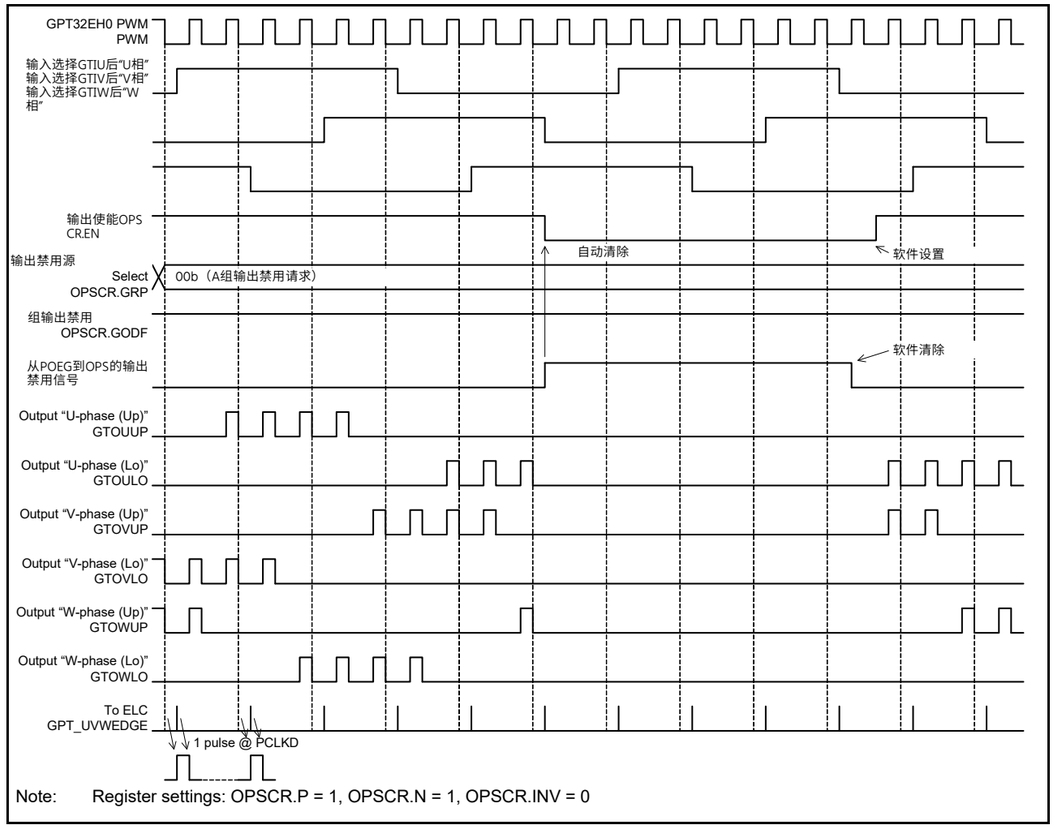


Figure 22.84 组输出禁用控制操作示例

22.3.11.1 外部输入信号的输入选择和同步

在图22.81所示的GPT_OPS控制流程概念图中，(1)是通过OPSCR.FB位从软件设置和外部输入中选择输入相位。

当OPSCR.FB位为0时，选择外部输入。与GPT内核时钟(PCLKD)同步后启用输入信号。执行噪声过滤（可选）后，使用下降沿采样将外部输入设置为PWM的输入相位（GPT32EH0.GTIOCA），并将OPSCR.ALIGN位设置为1。

当OPSCR.FB位为1时，使用OPSCR.ALIGN位设置为1的下降沿采样选择PWM输入相位值（GPT32EH0.GTIOCA的PWM）的软件设置（OPSCR.UF、VF、WF）。

当OPSCR.ALIGN位为0时，GPT_OPS以PCLKD同步的输入相位与任一OPSCR.FB位设置为0或OPSCR.FB位设置为1。但是，在某些情况下，输出的PWM脉冲宽度UVW相位（PWM输出模式）的开关时序（恰好在之前或之后）被缩短。

表22.18显示了输入选择过程和相关OPSCR位的设置。

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Table 22.18 Input selection processing method

OPSCR register		Selection of input phase sampling method (U/V/W-phase)	Synchronization input/output selection process (GPT_OPS internal node name)
FB bit	ALIGN bit		
0	1	External Input at PWM Falling Edge Sampling (PCLKD synchronization + falling edge sample)	Input Phase Input U-Phase (gtu_sync) Input V-Phase (gtv_sync) Input W-Phase (gtw_sync)
	0	External Input at PCLKD Synchronization Output (PCLKD synchronization + through mode)	
1	1	Software Settings at PWM Falling Edge Sampling (OPSCR.UF, VF, WF of falling edge sample)	
	0	Software Setting Value Selection (= OPSCR.UF/VF/WF value) (= PCLKD synchronization)	

22.3.11.2 Input sampling

The OPSCR.U, V, W bits indicate the PCLKD sampling results of the input selected by the OPSCR.FB bit.

When OPSCR.FB bit is 0 and after synchronization with the GPT core clock (PCLKD) and noise filtering (optional), OPSCR.U, V, W bits indicate the sampling results of the external input. When OPSCR.FB bit is 1, OPSCR.U, V, W bits have the value (OPSCR.UF, VF, WF) of the software setting.

22.3.11.3 Input phase decode

In the GPT_OPS control flow conceptual diagram shown in Figure 22.81, (2) enables the 6-phase signals by decoding the input phase selected by the OPSCR.FB bit. The 6-phase enable signal is used for internal processing of GPT_OPS.

Table 22.19 shows the decode table of input phase.

Table 22.19 Decode table of input phase

Input phase (U/V/W) (GPT_OPS internal node name)			6-phase enable {U/V/W (Up/Lo)} by decoding input phase (GPT_OPS internal node name)					
Input U-phase	Input V-phase	Input W-phase	U-phase (Up)	U-phase (Lo)	V-phase (Up)	V-phase (Lo)	W-phase (Up)	W-phase (Lo)
(gtu_sync)	(gtv_sync)	(gtw_sync)	(gtuup_en)	(gtulo_en)	(gtvup_en)	(gtvlo_en)	(gtwup_en)	(gtwlo_en)
1	0	1	1	0	0	1	0	0
1	0	0	1	0	0	0	0	1
1	1	0	0	0	1	0	0	1
0	1	0	0	1	1	0	0	0
0	1	1	0	1	0	0	1	0
0	0	1	0	0	0	1	1	0
0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0

Table 22.18 输入选择处理方法

OPSCR register		输入相位采样方式的选择（UVW−phase）	同步输入输出选择过程（GPT_OPS内部节点名）
FB bit	对齐位		
0	1	PWM下降沿采样的外部输入（PCLKD同步+下降沿采样）	输入相位 Input U-Phase (gtu_sync) Input V-Phase (gtv_sync) Input W-Phase (gtw_sync)
	0	PCLKD同步输出端的外部输入（PCLKD同步+直通模式）	
1	1	PWM下降沿采样的软件设置（下降沿采样的OPSCR.UF、VF、WF）	
	0	软件设置值选择（=OPSCR.UFVFWF值）（=PCLKD同步）	

22.3.11.2 输入采样

OPSCR.U、V、W位指示由OPSCR.FB位选择的输入的PCLKD采样结果。

当OPSCR.FB位为0并与GPT内核时钟(PCLKD)和噪声过滤（可选）同步后，OPSCR.U、V、W位表示外部输入的采样结果。当OPSCR.FB位为1时，OPSCR.U、V、W位具有软件设置的值（OPSCR.UF、VF、WF）。

22.3.11.3 输入相位解码

在图22.81所示的GPT_OPS控制流程概念图中，(2)通过解码OPSCR.FB位选择的输入相位来启用6相位信号。6相使能信号用于GPT_OPS的内部处理。

表22.19显示了输入相位的解码表。

Table 22.19 输入相位解码表

输入相位(UVW)（GPT_OPS内部节点名称）			6−phaseenable{UVW(UpLo) 通过解码输入相位（GPT_OPS内部节点名称）					
输入U相	输入V相	输入W相	U-phase (Up)	U-phase (Lo)	V-phase (Up)	V-phase (Lo)	W-phase (Up)	W-phase (Lo)
(gtu_sync)	(gtv_sync)	(gtw_sync)	(gtuup_en)	(gtulo_en)	(gtvup_en)	(gtvlo_en)	(gtwup_en)	(gtwlo_en)
1	0	1	1	0	0	1	0	0
1	0	0	1	0	0	0	0	1
1	1	0	0	0	1	0	0	1
0	1	0	0	1	1	0	0	0
0	1	1	0	1	0	0	1	0
0	0	1	0	0	0	1	1	0
0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0

22.3.11.4 Output selection control

In the GPT_OPS control flow conceptual diagram in Figure 22.81, (3) represents the selection of the output waveform by setting the OPSCR register bit.

For output selection, the following bits are relevant:

- The OPSCR.EN bit controls whether to output the 6-phase output, or to stop
- The OPSCR.P and OPSCR.N bits can select from the level signal or PWM signal (chopper output) for the output phase
- The polarity of the output phase can be set to positive logic or negative logic by the OPSCR.INV bit.

Table 22.20 and Table 22.21 show the output selection control method using the OPSCR register bit.

Table 22.20 Output selection control method (positive phase)

Enable-phase output control	Positive-phase output (P) control	Invert-phase output control	Output port name (positive phase = up) (output selection internal node allocation)	
OPSCR.EN bit	OPSCR.P bit	OPSCR.INV bit	GTOUUP GTOVUP GTOWUP	Mode
0	x	x	0	Output Stop (External pin: Hi-Z) GPT_OPS => 0 output
1	0	0	Level signal (gtuup_en) (gtvup_en) (gtwup_en)	Level Output Mode (Positive phase) (Positive logic)
1	0	1	Level signal (~gtuup_en) (~gtvup_en) (~gtwup_en)	Level Output Mode (Positive phase) (Negative logic)
1	1	0	PWM signal (PWM & gtuup_en) (PWM & gtvup_en) (PWM & gtwup_en)	PWM Output Mode (Positive phase) (Positive logic)
1	1	1	PWM signal (~(PWM & gtuup_en)) (~(PWM & gtvup_en)) (~(PWM & gtwup_en))	PWM Output Mode (Positive phase) (Negative logic)

Table 22.21 Output selection control method (negative phase) (1 of 2)

Enable-phase output control	Negative-phase output (N) control	Invert-phase output control	Output port name (negative phase = Lo) (output selection internal node allocation)	
OPSCR.EN bit	OPSCR.N bit	OPSCR.INV bit	GTOULO GTOVLO GTOWLO	Mode
0	x	x	0	Output Stop (External pin: Hi-Z) GPT_OPS → 0 output
1	0	0	Level signal (gtulo_en) (gtvlo_en) (gtwlo_en)	Level Output Mode (Negative phase) (Positive logic)
1	0	1	Level signal (~gtulo_en) (~gtvlo_en) (~gtwlo_en)	Level Output Mode (Negative phase) (Negative logic)

22.3.11.4 输出选择控制

在图22.81的GPT_OPS控制流程概念图中，(3)表示通过设置OPSCR寄存器位来选择输出波形。

对于输出选择，以下位是相关的：

- OPSCR.EN位控制是输出6相输出，还是停止
- OPSCR.P和OPSCR.N位可以选择输出相位的电平信号或PWM信号（斩波器输出）
- 输出相位的极性可通过OPSCR.INV位设置为正逻辑或负逻辑。

表22.20和表22.21显示了使用OPSCR寄存器位的输出选择控制方法。

Table 22.20 输出选择控制方式（正相）

使能相位输出控制	正相输出(P)控制	反相输出控制	输出端口名称（正相=向上）（输出选择内部节点分配）	
OPSCR.EN bit	OPSCR.P bit	OPSCR.INV bit	GTOUUP GTOVUP GTOWUP	Mode
0	x	x	0	输出停止（外部引脚：Hi-Z）GPT_OPS=>0输出
1	0	0	电平信号(gtuup_en)(gtvup_en)(gtwup_en)	电平输出模式（正相）（正逻辑）
1	0	1	电平信号(~gtuup_en)(~gtvup_en)(~gtwup_en)	电平输出模式（正相）（负逻辑）
1	1	0	PWM signal (PWM & gtuup_en) (PWM & gtvup_en) (PWM & gtwup_en)	PWM输出模式（正相）（正逻辑）
1	1	1	PWM signal (~(PWM & gtuup_en)) (~(PWM & gtvup_en)) (~(PWM & gtwup_en))	PWM输出模式（正相）（负逻辑）

Table 22.21 输出选择控制方式（负相）（1of2）

使能相位输出控制	负相输出(N)控制	反相输出控制	输出端口名称（负相=Lo）（输出选择内部节点分配）	
OPSCR.EN bit	OPSCR.N bit	OPSCR.INV bit	GTOULO GTOVLO GTOWLO	Mode
0	x	x	0	输出停止（外部引脚：Hi-Z）GPT_OPS→0输出
1	0	0	电平信号(gtulo_en)(gtvlo_en)(gtwlo_en)	电平输出模式（负相）（正逻辑）
1	0	1	电平信号(~gtulo_en)(~gtvlo_en)(~gtwlo_en)	电平输出模式（负相）（负逻辑）

Table 22.21 Output selection control method (negative phase) (2 of 2)

Enable-phase output control	Negative-phase output (N) control	Invert-phase output control	Output port name (negative phase = Lo) (output selection internal node allocation)	
OPSCR.EN bit	OPSCR.N bit	OPSCR.INV bit	GTOULO GTOVLO GTOWLO	Mode
1	1	0	PWM signal (PWM & gtulo_en) (PWM & gtvlo_en) (PWM & gtwlo_en)	PWM Output Mode (Negative phase) (Positive logic)
1	1	1	PWM signal (~(PWM & gtulo_en)) (~(PWM & gtvlo_en)) (~(PWM & gtwlo_en))	PWM Output Mode (Negative phase) (Negative logic)

22.3.11.5 Output selection control (group output disable function)

When OPSCR.GODF is 1 and the signal value selected by the OPSCR.GRP bit is high (output disable request), the GPT_OPS output pins change to Hi-Z asynchronously and the OPSCR.EN bit is set to 0 by the output disable request signal synchronized with PCLKD. For the return, set the OPSCR.EN bit to 1 after clearing the output disable request with software.

The timing of OPSCR.EN bit cleared to 0 is 3 PCLKD cycles after generating the output disable request. To perform output disable control reliably, allow at least 4 PCLKD cycles after generating the output disable request (by clearing the output disable request flag in POEG) until the output disable request is terminated. For an example of the operation of group output disable control, see Figure 22.84.

22.3.11.6 Event Link Controller (ELC) output

In the GPT_OPS control flow conceptual diagram shown in Figure 22.81, (5) outputs the Hall sensor input signal edge to the ELC.

The Hall sensor input edge signal is the logical OR of the rising and falling edge signals of each U-phase/V-phase/W-phase input sampled at PCLKD. That is, if the high period of each of the U-phase/V-phase/W-phase input is short in duration, the Hall sensor edge input signal is not output at that time.

When OPSCR.FB bit is 0, the Hall sensor input edge signal is the logical OR of the edge signals of the external input phase sampled at PCLKD.

When OPSCR.FB bit is 1, the Hall sensor input edge signal is the logical OR of the edge of the software setting (OPSCR.UF, VF, WF) sampled at PCLKD.

See Figure 22.82 to Figure 22.84 for examples of the output signal to the ELC.

Table 22.21 输出选择控制方式（负相）(2of2)

使能相位输出控制	负相输出(N)控制	反相输出控制	输出端口名称（负相=Lo）（输出选择内部节点分配）	
OPSCR.EN bit	OPSCR.N bit	OPSCR.INV bit	GTOULO GTOVLO GTOWLO	Mode
1	1	0	PWM signal (PWM & gtulo_en) (PWM & gtvlo_en) (PWM & gtwlo_en)	PWM输出模式（负相）（正逻辑）
1	1	1	PWM signal (~(PWM & gtulo_en)) (~(PWM & gtvlo_en)) (~(PWM & gtwlo_en))	PWM输出模式（负相）（负逻辑）

22.3.11.5 输出选择控制（组输出禁用功能）

当OPSCR.GODF为1且OPSCR.GRP位选择的信号值为高（输出禁用请求）时，GPT_OPS输出引脚异步变为Hi-Z，并且通过与PCLKD同步的输出禁用请求信号将OPSCR.EN位设置为0。对于返回，请在用软件清除输出禁用请求后将OPSCR.EN位设置为1。

OPSCR.EN位清零的时序是在产生输出禁用请求后的3个PCLKD周期。为了可靠地执行输出禁用控制，在生成输出禁用请求后（通过清除POEG中的输出禁用请求标志）至少允许4个PCLKD周期，直到输出禁用请求终止。组输出禁用控制的操作示例见图22.84。

22.3.11.6 事件链接控制器(ELC)输出

在图22.81所示的GPT_OPS控制流程概念图中，(5)将霍尔传感器输入信号沿输出到ELC。

霍尔传感器输入边沿信号是在PCLKD采样的每个U相V相W相输入的上升沿和下降沿信号的逻辑或。即，如果U相V相W相输入中的每一个的高电平时段持续时间短，则此时不输出霍尔传感器边沿输入信号。

当OPSCR.FB位为0时，霍尔传感器输入边沿信号是在PCLKD采样的外部输入相位边沿信号的逻辑或。

当OPSCR.FB位为1时，霍尔传感器输入边沿信号是在PCLKD采样的软件设置（OPSCR.UF、VF、WF）边沿的逻辑或。

有关ELC的输出信号示例，请参见图22.82至图22.84。

22.3.11.7 GPT_OPS start operation setting flow

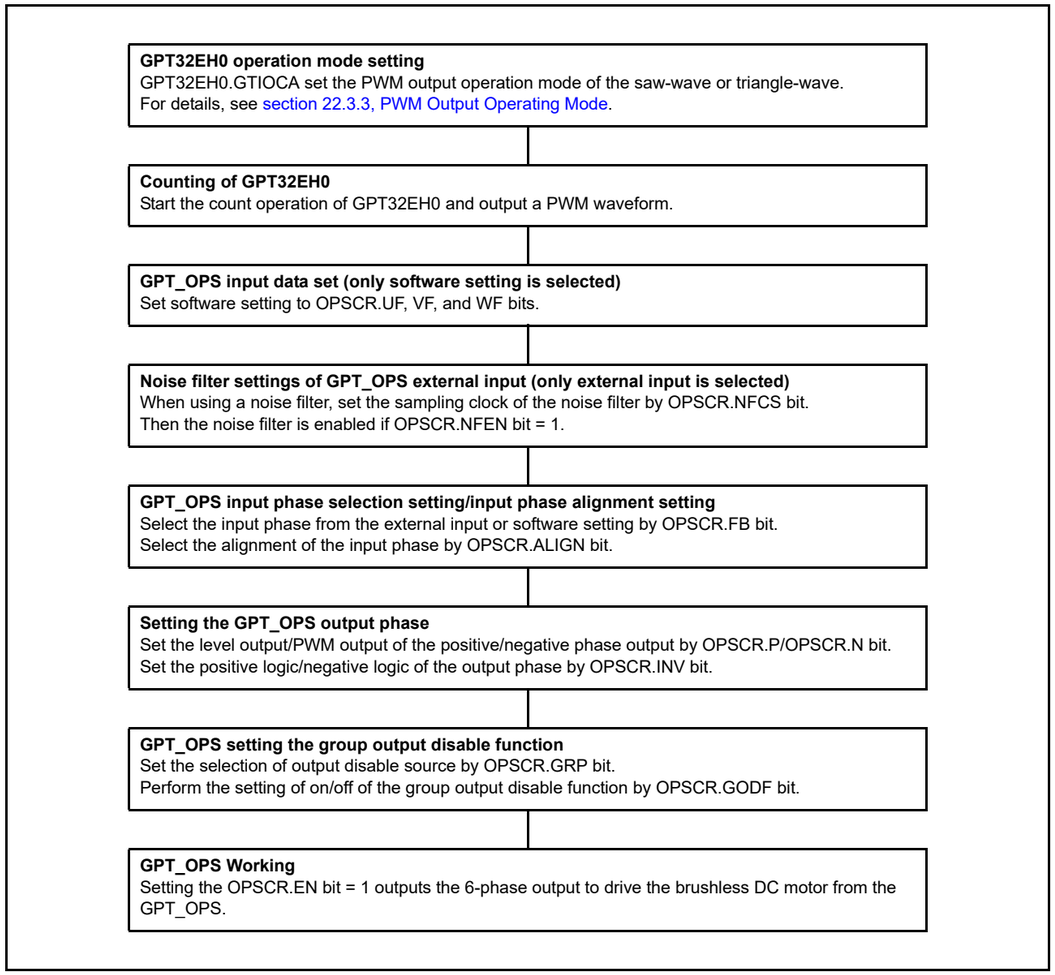

Figure 22.85 Example setting of GPT_OPS start operation

22.4 Interrupt Sources

The GPT provides the following interrupt sources:

- GTCCR input capture/compare match
- GTADTR compare match
- GTCNT counter overflow (GTPR compare match)/underflow.

Each interrupt source has its own status flag. When an interrupt source signal is generated, the associated status flag in GTST is set to 1. The associated status flag in GTST can be cleared by writing 0. If flag set and flag clear occur at the same time, flag clear takes priority over flag set. These flags are automatically updated by the internal state.

Table 22.22 lists the GPT interrupt sources.

22.3.11.7 GPT_OPS启动操作设置流程

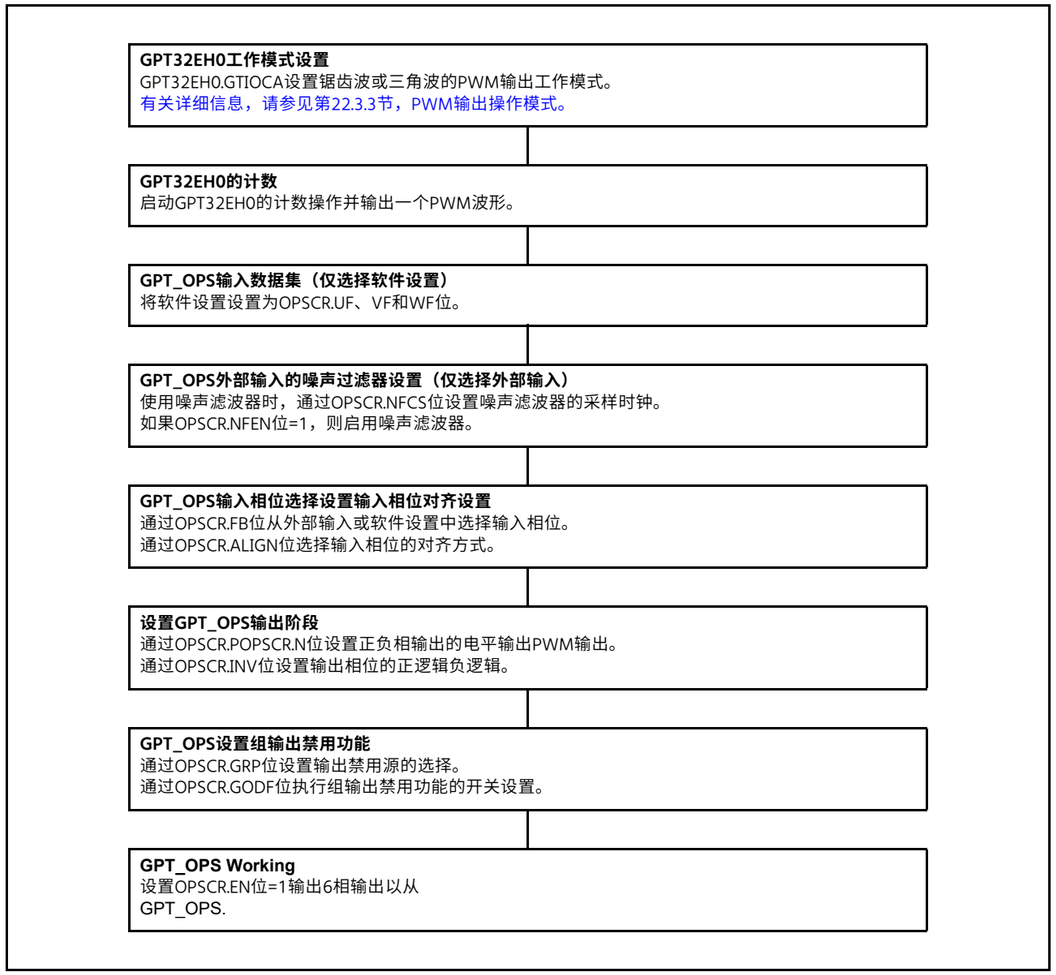

Figure 22.85 GPT_OPS启动操作的示例设置

22.4 中断源

GPT提供以下中断源：

- GTCCR输入捕获比较匹配
- GTADTR比较匹配
- GTCNT计数器上溢（GTPR比较匹配）下溢。

每个中断源都有自己的状态标志。当产生中断源信号时，GTST中的相关状态标志设置为1。GTST中的相关状态标志可以通过写入0来清除。如果标志设置和标志清除同时发生，则标志清除优先于标志放。这些标志由内部状态自动更新。

表22.22列出了GPT中断源。

Table 22.22 Interrupt sources (1 of 4)

Channel	Name	Interrupt source	Interrupt flag	DMAC/DTC activation
0	GPT0_CCMPA	GPT32EH0.GTCCRA input capture/compare match	TCFA	Possible
	GPT0_CCMPB	GPT32EH0.GTCCRB input capture/compare match	TCFB	Possible
	GPT0_CMPC	GPT32EH0.GTCCRC compare match	TCFC	Possible
	GPT0_CMPD	GPT32EH0.GTCCRD compare match	TCFD	Possible
	GPT0_CMPE	GPT32EH0.GTCCRE compare match	TCFE	Possible
	GPT0_CMPF	GPT32EH0.GTCCRF compare match	TCFF	Possible
	GPT0_ADTRGA	GPT32EH0.GTADTRA compare match	ADTRAUF ADRTADF	Possible
	GPT0_ADTRGB	GPT32EH0.GTADTRB compare match	ADTRBUF ADRTBDF	Possible
	GPT0_OVF	GPT32EH0.GTCNT overflow (GPT32EH0.GTPR compare match)	TCFPO	Possible
	GPT0_UDF	GPT32EH0.GTCNT underflow	TCFPU	Possible
1	GPT1_CCMPA	GPT32EH1.GTCCRA input capture/compare match	TCFA	Possible
	GPT1_CCMPB	GPT32EH1.GTCCRB input capture/compare match	TCFB	Possible
	GPT1_CMPC	GPT32EH1.GTCCRC compare match	TCFC	Possible
	GPT1_CMPD	GPT32EH1.GTCCRD compare match	TCFD	Possible
	GPT1_CMPE	GPT32EH1.GTCCRE compare match	TCFE	Possible
	GPT1_CMPF	GPT32EH1.GTCCRF compare match	TCFF	Possible
	GPT1_ADTRGA	GPT32EH1.GTADTRA compare match	ADTRAUF ADRTADF	Possible
	GPT1_ADTRGB	GPT32EH1.GTADTRB compare match	ADTRBUF ADRTBDF	Possible
	GPT1_OVF	GPT32EH1.GTCNT overflow (GPT32EH1.GTPR compare match)	TCFPO	Possible
	GPT1_UDF	GPT32EH1.GTCNT underflow	TCFPU	Possible
2	GPT2_CCMPA	GPT32EH2.GTCCRA input capture/compare match	TCFA	Possible
	GPT2_CCMPB	GPT32EH2.GTCCRB input capture/compare match	TCFB	Possible
	GPT2_CMPC	GPT32EH2.GTCCRC compare match	TCFC	Possible
	GPT2_CMPD	GPT32EH2.GTCCRD compare match	TCFD	Possible
	GPT2_CMPE	GPT32EH2.GTCCRE compare match	TCFE	Possible
	GPT2_CMPF	GPT32EH2.GTCCRF compare match	TCFF	Possible
	GPT2_ADTRGA	GPT32EH2.GTCCRE compare match	ADTRAUF ADRTADF	Possible
	GPT2_ADTRGB	GPT32EH2.GTCCRF compare match	ADTRBUF ADRTBDF	Possible
	GPT2_OVF	GPT32EH2.GTCNT overflow (GPT32EH2.GTPR compare match)	TCFPO	Possible
	GPT2_UDF	GPT32EH2.GTCNT underflow	TCFPU	Possible

Table 22.22 中断源（4个中的1个）

Channel	Name	中断源	中断标志	DMAC/DTC activation
0	GPT0_CCMPA	GPT32EH0.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT0_CCMPB	GPT32EH0.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT0_CMPC	GPT32EH0.GTCCRC比较匹配	TCFC	Possible
	GPT0_CMPD	GPT32EH0.GTCCRD比较匹配	TCFD	Possible
	GPT0_CMPE	GPT32EH0.GTCCRE比较匹配	TCFE	Possible
	GPT0_CMPF	GPT32EH0.GTCCRF比较匹配	TCFF	Possible
	GPT0_ADTRGA	GPT32EH0.GTADTRA比较匹配	ADTRAUF ADRTADF	Possible
	GPT0_ADTRGB	GPT32EH0.GTADTRB比较匹配	ADTRBUF ADRTBDF	Possible
	GPT0_OVF	GPT32EH0.GTCNT溢出（GPT32EH0.GTPR比较匹配）	TCFPO	Possible
	GPT0_UDF	GPT32EH0.GTCNT underflow	TCFPU	Possible
1	GPT1_CCMPA	GPT32EH1.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT1_CCMPB	GPT32EH1.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT1_CMPC	GPT32EH1.GTCCRC比较匹配	TCFC	Possible
	GPT1_CMPD	GPT32EH1.GTCCRD比较匹配	TCFD	Possible
	GPT1_CMPE	GPT32EH1.GTCCRE比较匹配	TCFE	Possible
	GPT1_CMPF	GPT32EH1.GTCCRF比较匹配	TCFF	Possible
	GPT1_ADTRGA	GPT32EH1.GTADTRA比较匹配	ADTRAUF ADRTADF	Possible
	GPT1_ADTRGB	GPT32EH1.GTADTRB比较匹配	ADTRBUF ADRTBDF	Possible
	GPT1_OVF	GPT32EH1.GTCNT溢出（GPT32EH1.GTPR比较匹配）	TCFPO	Possible
	GPT1_UDF	GPT32EH1.GTCNT underflow	TCFPU	Possible
2	GPT2_CCMPA	GPT32EH2.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT2_CCMPB	GPT32EH2.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT2_CMPC	GPT32EH2.GTCCRC比较匹配	TCFC	Possible
	GPT2_CMPD	GPT32EH2.GTCCRD比较匹配	TCFD	Possible
	GPT2_CMPE	GPT32EH2.GTCCRE比较匹配	TCFE	Possible
	GPT2_CMPF	GPT32EH2.GTCCRF比较匹配	TCFF	Possible
	GPT2_ADTRGA	GPT32EH2.GTCCRE比较匹配	ADTRAUF ADRTADF	Possible
	GPT2_ADTRGB	GPT32EH2.GTCCRF比较匹配	ADTRBUF ADRTBDF	Possible
	GPT2_OVF	GPT32EH2.GTCNT溢出（GPT32EH2.GTPR比较匹配）	TCFPO	Possible
	GPT2_UDF	GPT32EH2.GTCNT underflow	TCFPU	Possible

Table 22.22 Interrupt sources (2 of 4)

Channel	Name	Interrupt source	Interrupt flag	DMAC/DTC activation
3	GPT3_CCMPA	GPT32EH3.GTCCRA input capture/compare match	TCFA	Possible
	GPT3_CCMPB	GPT32EH3.GTCCRB input capture/compare match	TCFB	Possible
	GPT3_CMPC	GPT32EH3.GTCCRC compare match	TCFC	Possible
	GPT3_CMPD	GPT32EH3.GTCCRD compare match	TCFD	Possible
	GPT3_CMPE	GPT32EH3.GTCCRE compare match	TCFE	Possible
	GPT3_CMPF	GPT32EH3.GTCCRF compare match	TCFF	Possible
	GPT3_ADTRGA	GPT32EH3.GTADTRA compare match	ADTRAUF ADRTADF	Possible
	GPT3_ADTRGB	GPT32EH3.GTADTRB compare match	ADTRBUF ADRTBDF	Possible
	GPT3_OVF	GPT32EH3.GTCNT overflow (GPT32EH3.GTPR compare match)	TCFPO	Possible
	GPT3_UDF	GPT32EH3.GTCNT underflow	TCFPU	Possible
4	GPT4_CCMPA	GPT32E4.GTCCRA input capture/compare match	TCFA	Possible
	GPT4_CCMPB	GPT32E4.GTCCRB input capture/compare match	TCFB	Possible
	GPT4_CMPC	GPT32E4.GTCCRC compare match	TCFC	Possible
	GPT4_CMPD	GPT32E4.GTCCRD compare match	TCFD	Possible
	GPT4_CMPE	GPT32E4.GTCCRE compare match	TCFE	Possible
	GPT4_CMPF	GPT32E4.GTCCRF compare match	TCFF	Possible
	GPT4_ADTRGA	GPT32E4.GTADTRA compare match	ADTRAUF ADRTADF	Possible
	GPT4_ADTRGB	GPT32E4.GTADTRB compare match	ADTRBUF ADRTBDF	Possible
	GPT4_OVF	GPT32E4.GTCNT overflow (GPT32E4.GTPR compare match)	TCFPO	Possible
	GPT4_UDF	GPT32E4.GTCNT underflow	TCFPU	Possible
5	GPT5_CCMPA	GPT32E5.GTCCRA input capture/compare match	TCFA	Possible
	GPT5_CCMPB	GPT32E5.GTCCRB input capture/compare match	TCFB	Possible
	GPT5_CMPC	GPT32E5.GTCCRC compare match	TCFC	Possible
	GPT5_CMPD	GPT32E5.GTCCRD compare match	TCFD	Possible
	GPT5_CMPE	GPT32E5.GTCCRE compare match	TCFE	Possible
	GPT5_CMPF	GPT32E5.GTCCRF compare match	TCFF	Possible
	GPT5_ADTRGA	GPT32E5.GTADTRA compare match	ADTRAUF ADRTADF	Possible
	GPT5_ADTRGB	GPT32E5.GTADTRB compare match	ADTRBUF ADRTBDF	Possible
	GPT5_OVF	GPT32E5.GTCNT overflow (GPT32E5.GTPR compare match)	TCFPO	Possible
	GPT5_UDF	GPT32E5.GTCNT underflow	TCFPU	Possible

Table 22.22 中断源（4个中的2个）

Channel	Name	中断源	中断标志	DMAC/DTC activation
3	GPT3_CCMPA	GPT32EH3.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT3_CCMPB	GPT32EH3.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT3_CMPC	GPT32EH3.GTCCRC比较匹配	TCFC	Possible
	GPT3_CMPD	GPT32EH3.GTCCRD比较匹配	TCFD	Possible
	GPT3_CMPE	GPT32EH3.GTCCRE比较匹配	TCFE	Possible
	GPT3_CMPF	GPT32EH3.GTCCRF比较匹配	TCFF	Possible
	GPT3_ADTRGA	GPT32EH3.GTADTRA比较匹配	ADTRAUF ADRTADF	Possible
	GPT3_ADTRGB	GPT32EH3.GTADTRB比较匹配	ADTRBUF ADRTBDF	Possible
	GPT3_OVF	GPT32EH3.GTCNT溢出（GPT32EH3.GTPR比较匹配）	TCFPO	Possible
	GPT3_UDF	GPT32EH3.GTCNT underflow	TCFPU	Possible
4	GPT4_CCMPA	GPT32E4.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT4_CCMPB	GPT32E4.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT4_CMPC	GPT32E4.GTCCRC比较匹配	TCFC	Possible
	GPT4_CMPD	GPT32E4.GTCCRD比较匹配	TCFD	Possible
	GPT4_CMPE	GPT32E4.GTCCRE比较匹配	TCFE	Possible
	GPT4_CMPF	GPT32E4.GTCCRF比较匹配	TCFF	Possible
	GPT4_ADTRGA	GPT32E4.GTADTRA比较匹配	ADTRAUF ADRTADF	Possible
	GPT4_ADTRGB	GPT32E4.GTADTRB比较匹配	ADTRBUF ADRTBDF	Possible
	GPT4_OVF	GPT32E4.GTCNT溢出（GPT32E4.GTPR比较匹配）	TCFPO	Possible
	GPT4_UDF	GPT32E4.GTCNT underflow	TCFPU	Possible
5	GPT5_CCMPA	GPT32E5.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT5_CCMPB	GPT32E5.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT5_CMPC	GPT32E5.GTCCRC比较匹配	TCFC	Possible
	GPT5_CMPD	GPT32E5.GTCCRD比较匹配	TCFD	Possible
	GPT5_CMPE	GPT32E5.GTCCRE比较匹配	TCFE	Possible
	GPT5_CMPF	GPT32E5.GTCCRF比较匹配	TCFF	Possible
	GPT5_ADTRGA	GPT32E5.GTADTRA比较匹配	ADTRAUF ADRTADF	Possible
	GPT5_ADTRGB	GPT32E5.GTADTRB比较匹配	ADTRBUF ADRTBDF	Possible
	GPT5_OVF	GPT32E5.GTCNT溢出（GPT32E5.GTPR比较匹配）	TCFPO	Possible
	GPT5_UDF	GPT32E5.GTCNT underflow	TCFPU	Possible

Table 22.22 Interrupt sources (3 of 4)

Channel	Name	Interrupt source	Interrupt flag	DMAC/DTC activation
6	GPT6_CCMPA	GPT32E6.GTCCRA input capture/compare match	TCFA	Possible
	GPT6_CCMPB	GPT32E6.GTCCRB input capture/compare match	TCFB	Possible
	GPT6_CMPC	GPT32E6.GTCCRC compare match	TCFC	Possible
	GPT6_CMPD	GPT32E6.GTCCRD compare match	TCFD	Possible
	GPT6_CMPE	GPT32E6.GTCCRE compare match	TCFE	Possible
	GPT6_CMPF	GPT32E6.GTCCRF compare match	TCFF	Possible
	GPT6_ADTRGA	GPT32E6.GTADTRA compare match	ADTRAUF ADRTADF	Possible
	GPT6_ADTRGB	GPT32E6.GTADTRB compare match	ADTRBUF ADRTBDF	Possible
	GPT6_OVF	GPT32E6.GTCNT overflow (GPT32E6.GTPR compare match)	TCFPO	Possible
	GPT6_UDF	GPT32E6.GTCNT underflow	TCFPU	Possible
7	GPT7_CCMPA	GPT32E7.GTCCRA input capture/compare match	TCFA	Possible
	GPT7_CCMPB	GPT32E7.GTCCRB input capture/compare match	TCFB	Possible
	GPT7_CMPC	GPT32E7.GTCCRC compare match	TCFC	Possible
	GPT7_CMPD	GPT32E7.GTCCRD compare match	TCFD	Possible
	GPT7_CMPE	GPT32E7.GTCCRE compare match	TCFE	Possible
	GPT7_CMPF	GPT32E7.GTCCRF compare match	TCFF	Possible
	GPT7_ADTRGA	GPT32E7.GTADTRA compare match	ADTRAUF ADRTADF	Possible
	GPT7_ADTRGB	GPT32E7.GTADTRB compare match	ADTRBUF ADRTBDF	Possible
	GPT7_OVF	GPT32E7.GTCNT overflow (GPT32E7.GTPR compare match)	TCFPO	Possible
	GPT7_UDF	GPT32E7.GTCNT underflow	TCFPU	Possible
8	GPT8_CCMPA	GPT328.GTCCRA input capture/compare match	TCFA	Possible
	GPT8_CCMPB	GPT328.GTCCRB input capture/compare match	TCFB	Possible
	GPT8_CMPC	GPT328.GTCCRC compare match	TCFC	Possible
	GPT8_CMPD	GPT328.GTCCRD compare match	TCFD	Possible
	GPT8_CMPE	GPT328.GTCCRE compare match	TCFE	Possible
	GPT8_CMPF	GPT328.GTCCRF compare match	TCFF	Possible
	GPT8_OVF	GPT328.GTCNT overflow (GPT328.GTPR compare match)	TCFPO	Possible
	GPT8_UDF	GPT328.GTCNT underflow	TCFPU	Possible
9	GPT9_CCMPA	GPT329.GTCCRA input capture/compare match	TCFA	Possible
	GPT9_CCMPB	GPT329.GTCCRB input capture/compare match	TCFB	Possible
	GPT9_CMPC	GPT329.GTCCRC compare match	TCFC	Possible
	GPT9_CMPD	GPT329.GTCCRD compare match	TCFD	Possible
	GPT9_CMPE	GPT329.GTCCRE compare match	TCFE	Possible
	GPT9_CMPF	GPT329.GTCCRF compare match	TCFF	Possible
	GPT9_OVF	GPT329.GTCNT overflow (GPT329.GTPR compare match)	TCFPO	Possible
	GPT9_UDF	GPT329.GTCNT underflow	TCFPU	Possible

Table 22.22 中断源（4个中的3个）

Channel	Name	中断源	中断标志	DMAC/DTC activation
6	GPT6_CCMPA	GPT32E6.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT6_CCMPB	GPT32E6.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT6_CMPC	GPT32E6.GTCCRC比较匹配	TCFC	Possible
	GPT6_CMPD	GPT32E6.GTCCRD比较匹配	TCFD	Possible
	GPT6_CMPE	GPT32E6.GTCCRE比较匹配	TCFE	Possible
	GPT6_CMPF	GPT32E6.GTCCRF比较匹配	TCFF	Possible
	GPT6_ADTRGA	GPT32E6.GTADTRA比较匹配	ADTRAUF ADRTADF	Possible
	GPT6_ADTRGB	GPT32E6.GTADTRB比较匹配	ADTRBUF ADRTBDF	Possible
	GPT6_OVF	GPT32E6.GTCNT溢出（GPT32E6.GTPR比较匹配）	TCFPO	Possible
	GPT6_UDF	GPT32E6.GTCNT underflow	TCFPU	Possible
7	GPT7_CCMPA	GPT32E7.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT7_CCMPB	GPT32E7.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT7_CMPC	GPT32E7.GTCCRC比较匹配	TCFC	Possible
	GPT7_CMPD	GPT32E7.GTCCRD比较匹配	TCFD	Possible
	GPT7_CMPE	GPT32E7.GTCCRE比较匹配	TCFE	Possible
	GPT7_CMPF	GPT32E7.GTCCRF比较匹配	TCFF	Possible
	GPT7_ADTRGA	GPT32E7.GTADTRA比较匹配	ADTRAUF ADRTADF	Possible
	GPT7_ADTRGB	GPT32E7.GTADTRB比较匹配	ADTRBUF ADRTBDF	Possible
	GPT7_OVF	GPT32E7.GTCNT溢出（GPT32E7.GTPR比较匹配）	TCFPO	Possible
	GPT7_UDF	GPT32E7.GTCNT underflow	TCFPU	Possible
8	GPT8_CCMPA	GPT328.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT8_CCMPB	GPT328.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT8_CMPC	GPT328.GTCCRC比较匹配	TCFC	Possible
	GPT8_CMPD	GPT328.GTCCRD比较匹配	TCFD	Possible
	GPT8_CMPE	GPT328.GTCCRE比较匹配	TCFE	Possible
	GPT8_CMPF	GPT328.GTCCRF比较匹配	TCFF	Possible
	GPT8_OVF	GPT328.GTCNT溢出（GPT328.GTPR比较匹配）	TCFPO	Possible
	GPT8_UDF	GPT328.GTCNT underflow	TCFPU	Possible
9	GPT9_CCMPA	GPT329.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT9_CCMPB	GPT329.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT9_CMPC	GPT329.GTCCRC比较匹配	TCFC	Possible
	GPT9_CMPD	GPT329.GTCCRD比较匹配	TCFD	Possible
	GPT9_CMPE	GPT329.GTCCRE比较匹配	TCFE	Possible
	GPT9_CMPF	GPT329.GTCCRF比较匹配	TCFF	Possible
	GPT9_OVF	GPT329.GTCNT溢出（GPT329.GTPR比较匹配）	TCFPO	Possible
	GPT9_UDF	GPT329.GTCNT underflow	TCFPU	Possible

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Table 22.22 Interrupt sources (4 of 4)

Channel	Name	Interrupt source	Interrupt flag	DMAC/DTC activation
10	GPT10_CCMPA	GPT3210.GTCCRA input capture/compare match	TCFA	Possible
	GPT10_CCMPB	GPT3210.GTCCRB input capture/compare match	TCFB	Possible
	GPT10_CMPC	GPT3210.GTCCRC compare match	TCFC	Possible
	GPT10_CMPD	GPT3210.GTCCRD compare match	TCFD	Possible
	GPT10_CMPE	GPT3210.GTCCRE compare match	TCFE	Possible
	GPT10_CMPF	GPT3210.GTCCRF compare match	TCFF	Possible
	GPT10_OVF	GPT3210.GTCNT overflow (GPT3210.GTPR compare match)	TCFPO	Possible
	GPT10_UDF	GPT3210.GTCNT underflow	TCFPU	Possible
11	GPT11_CCMPA	GPT3211.GTCCRA input capture/compare match	TCFA	Possible
	GPT11_CCMPB	GPT3211.GTCCRB input capture/compare match	TCFB	Possible
	GPT11_CMPC	GPT3211.GTCCRC compare match	TCFC	Possible
	GPT11_CMPD	GPT3211.GTCCRD compare match	TCFD	Possible
	GPT11_CMPE	GPT3211.GTCCRE compare match	TCFE	Possible
	GPT11_CMPF	GPT3211.GTCCRF compare match	TCFF	Possible
	GPT11_OVF	GPT3211.GTCNT overflow (GPT3211.GTPR compare match)	TCFPO	Possible
	GPT11_UDF	GPT3211.GTCNT underflow	TCFPU	Possible
12	GPT12_CCMPA	GPT3212.GTCCRA input capture/compare match	TCFA	Possible
	GPT12_CCMPB	GPT3212.GTCCRB input capture/compare match	TCFB	Possible
	GPT12_CMPC	GPT3212.GTCCRC compare match	TCFC	Possible
	GPT12_CMPD	GPT3212.GTCCRD compare match	TCFD	Possible
	GPT12_CMPE	GPT3212.GTCCRE compare match	TCFE	Possible
	GPT12_CMPF	GPT3212.GTCCRF compare match	TCFF	Possible
	GPT12_OVF	GPT3212.GTCNT overflow (GPT3212.GTPR compare match)	TCFPO	Possible
	GPT12_UDF	GPT3212.GTCNT underflow	TCFPU	Possible

(1) GPTn_ADTRGA interrupt (n = 0 to 7)

When the GTCNT counter value matches with the GTADTRA register, an interrupt request is generated under the following conditions:

- In up-counting, the interrupt enable bit (ADTRAUEN) in the GTINTAD register is 1
- In down-counting, the interrupt enable bit (ADTRADEN) in the GTINTAD register is 1.

In event count operation, this interrupt request is not generated.

(2) GPTn_ADTRGB interrupt (n = 0 to 7)

When the GTCNT counter value matches with the GTADTRB register, an interrupt request is generated under the following conditions:

- In up-counting, the interrupt enable bit (ADTRBUEN) in the GTINTAD register is 1
- In down-counting, the interrupt enable bit (ADTRBDEN) in the GTINTAD register is 1.

In event count operation, this interrupt request is not generated.

(3) GPTn_CCMPA interrupt (n = 0 to 12)

An interrupt request is generated under the following conditions:

- When the GTCCRA register functions as a compare match register, the GTCNT counter value matches with the GTCCRA register.
- When the GTCCRA register functions as an input capture register, the input-capture signal causes transfer of the GTCNT counter value to the GTCCRA register.

Table 22.22 中断源（4个中的4个）

Channel	Name	中断源	中断标志	DMAC/DTC activation
10	GPT10_CCMPA	GPT3210.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT10_CCMPB	GPT3210.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT10_CMPC	GPT3210.GTCCRC比较匹配	TCFC	Possible
	GPT10_CMPD	GPT3210.GTCCRD比较匹配	TCFD	Possible
	GPT10_CMPE	GPT3210.GTCCRE比较匹配	TCFE	Possible
	GPT10_CMPF	GPT3210.GTCCRF比较匹配	TCFF	Possible
	GPT10_OVF	GPT3210.GTCNT溢出（GPT3210.GTPR比较匹配）	TCFPO	Possible
	GPT10_UDF	GPT3210.GTCNT underflow	TCFPU	Possible
11	GPT11_CCMPA	GPT3211.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT11_CCMPB	GPT3211.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT11_CMPC	GPT3211.GTCCRC比较匹配	TCFC	Possible
	GPT11_CMPD	GPT3211.GTCCRD比较匹配	TCFD	Possible
	GPT11_CMPE	GPT3211.GTCCRE比较匹配	TCFE	Possible
	GPT11_CMPF	GPT3211.GTCCRF比较匹配	TCFF	Possible
	GPT11_OVF	GPT3211.GTCNT溢出（GPT3211.GTPR比较匹配）	TCFPO	Possible
	GPT11_UDF	GPT3211.GTCNT underflow	TCFPU	Possible
12	GPT12_CCMPA	GPT3212.GTCCRA输入捕捉比较匹配	TCFA	Possible
	GPT12_CCMPB	GPT3212.GTCCRB输入捕捉比较匹配	TCFB	Possible
	GPT12_CMPC	GPT3212.GTCCRC比较匹配	TCFC	Possible
	GPT12_CMPD	GPT3212.GTCCRD比较匹配	TCFD	Possible
	GPT12_CMPE	GPT3212.GTCCRE比较匹配	TCFE	Possible
	GPT12_CMPF	GPT3212.GTCCRF比较匹配	TCFF	Possible
	GPT12_OVF	GPT3212.GTCNT溢出（GPT3212.GTPR比较匹配）	TCFPO	Possible
	GPT12_UDF	GPT3212.GTCNT underflow	TCFPU	Possible

(1) GPTn_ADTRGA中断（n=0到7）

当GTCNT计数器值与GTADTRA寄存器匹配时，会在以下条件下产生中断请求：

- 在递增计数中，GTINTAD寄存器中的中断使能位（ADTRAUEN）为1
- 在递减计数中，GTINTAD寄存器中的中断使能位（ADTRADEN）为1。

在事件计数操作中，不会产生此中断请求。

(2) GPTn_ADTRGB中断（n=0到7）

当GTCNT计数器值与GTADTRB寄存器匹配时，会在以下情况下产生中断请求：

- 在递增计数中，GTINTAD寄存器中的中断使能位（ADTRBUEN）为1
- 在递减计数中，GTINTAD寄存器中的中断使能位（ADTRBDEN）为1。

在事件计数操作中，不会产生此中断请求。

(3) GPTn_CCMPA中断（n=0到12）

在以下情况下会产生中断请求：

- 当GTCCRA寄存器用作比较匹配寄存器时，GTCNT计数器值与GTCCRA register.
- 当GTCCRA寄存器用作输入捕捉寄存器时，输入捕捉信号会导致传输GTCNT计数器值到GTCCRA寄存器。

(4) GPTn_CCMPB interrupt (n = 0 to 12)

An interrupt request is generated under the following conditions:

- When the GTCCRB register functions as a compare match register, the GTCNT counter value matches with the GTCCRB register
- When the GTCCRB register functions as an input capture register, the input-capture signal causes transfer of the GTCNT counter value to the GTCCRB register.

(5) GPTn_CMPC interrupt (n = 0 to 12)

An interrupt request is generated under the following condition:

- When the GTCCRC register functions as a compare match register, the GTCNT counter value matches with the GTCCRC register.

A compare match is not performed and an interrupt is not requested under the following conditions:

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRA[1:0] = 01b, 10b, 11b (buffer operation with the GTCCRC register).

(6) GPTn_CMPD interrupt (n = 0 to 12)

An interrupt request is generated under the following condition:

- When the GTCCRD register functions as a compare match register, the GTCNT counter value matches with the GTCCRD register.

A compare match is not performed and an interrupt is not requested under the following conditions:

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRA[1:0] = 10b, 11b (buffer operation with the GTCCRD register).

(7) GPTn_CMPE interrupt (n = 0 to 12)

An interrupt request is generated under the following condition.

- When the GTCCRE register functions as a compare match register, the GTCNT counter value matches with the GTCCRE register.

A compare match is not performed and an interrupt is not requested under the following conditions:

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRB[1:0] = 01b, 10b, 11b (buffer operation with the GTCCRE register).

(8) GPTn_CMPF interrupt (n = 0 to 12)

An interrupt request is generated under the following condition:

- When the GTCCRF register functions as a compare match register, the GTCNT counter value matches with the GTCCRF register.

A compare match is not performed and an interrupt is not requested under the following conditions:

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRB[1:0] = 10b, 11b (buffer operation with the GTCCRF register).

(9) GPTn_OVF interrupt (n = 0 to 12)

An interrupt request is generated under the following conditions:

(4) GPTn_CCMPB中断（n=0到12）

在以下情况下会产生中断请求：

- 当GTCCRB寄存器用作比较匹配寄存器时，GTCNT计数器值与GTCCRB register
- 当GTCCRB寄存器用作输入捕捉寄存器时，输入捕捉信号会导致GTCNT计数器值到GTCCRB寄存器。

(5) GPTn_CMPC中断（n=0到12）

在以下情况下会产生中断请求：

- 当GTCCRC寄存器用作比较匹配寄存器时，GTCNT计数器值与GTCCRC register.

在以下情况下不执行比较匹配并且不请求中断：

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRA[1:0]=01b 10b 11b（使用GTCCRC寄存器进行缓冲操作）。

(6) GPTn_CMPD中断（n=0到12）

在以下情况下会产生中断请求：

- 当GTCCRD寄存器用作比较匹配寄存器时，GTCNT计数器值与GTCCRD register.

在以下情况下不执行比较匹配并且不请求中断：

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRA[1:0]=10b 11b（使用GTCCRD寄存器进行缓冲操作）。

(7) GPTn_CMPE中断（n=0到12）

在以下条件下会产生中断请求。

- 当GTCCRE寄存器用作比较匹配寄存器时，GTCNT计数器值与GTCCRE register.

在以下情况下不执行比较匹配并且不请求中断：

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRB[1:0]=01b 10b 11b（使用GTCCRE寄存器进行缓冲操作）。

(8) GPTn_CMPF中断（n=0到12）

在以下情况下会产生中断请求：

- 当GTCCRF寄存器用作比较匹配寄存器时，GTCNT计数器值与GTCCRF register.

在以下情况下不执行比较匹配并且不请求中断：

- GTCR.MD[2:0] = 001b (saw-wave one-shot pulse mode)
- GTCR.MD[2:0] = 110b (triangle-wave PWM mode 3)
- GTBER.CCRB[1:0]=10b 11b（使用GTCCRF寄存器进行缓冲操作）。

(9) GPTn_OVF中断（n=0到12）

在以下情况下会产生中断请求：

- In saw-wave mode, interrupt requests are enabled at overflows (when the GTCNT counter value changes from GTPR to 0 during up-counting)
- In triangle-wave mode, interrupt requests are enabled at crests (GTCNT changes from GTPR to GTPR - 1)
- In counting by hardware sources, overflow (GTCNT changes from GTPR to 0 in up count) has occurred.

(10) GPTn_UDF interrupt (n = 0 to 12)

An interrupt request is generated under the following conditions:

- In saw-wave mode, interrupt requests are enabled at underflows (when the GTCNT counter value changes from 0 to GTPR during down-counting)
- In triangle-wave mode, interrupt requests are enabled at troughs (GTCNT changes from 0 to 1)
- In counting by hardware sources, underflow (GTCNT changes from 0 to GTPR in down count) has occurred.

Table 22.23 Interrupt signals, interrupt permission bits, and interrupt status flags

Interrupt signal	Interrupt permission bit	Interrupt status flag
GPTn_UDF	- *1	GTST[7] (TCFPU)
GPTn_OVF		GTST[6] (TCFPO)
GPTn_ADTRGB	GTINTAD[19] (ADTRBDEN) GTINTAD[18] (ADTRBUEN)	GTST[19] (ADTRBDF) GTST[18] (ADTRBUF)
GPTn_ADTRGA	GTINTAD[17] (ADTRADEN) GTINTAD[16] (ADTRAUEN)	GTST[17] (ADTRADF) GTST[16] (ADTRAUF)
GPTn_CMPF	- *1	GTST[5] (TCFF)
GPTn_CMPE		GTST[4] (TCFE)
GPTn_CMPD		GTST[3] (TCFD)
GPTn_CMPC		GTST[2] (TCFC)
GPTn_CCMPB		GTST[1] (TCFB)
GPTn_CCMPA		GTST[0] (TCFA)

Note 1. Interrupt is always permitted.

22.4.1 DMAC/DTC Activation

The DMAC and DTC can be activated by the interrupt in each channel. For details, see section 13, Interrupt Controller Unit (ICU), and section 17, Data Transfer Controller (DTC).

22.4.2 Interrupt and A/D Conversion Request Skipping Function

By setting the GTITC register, the GTCNT counter overflow (GTPR compare match) interrupt (GPTn_OVF) and underflow interrupt (GPTn_UDF) can be skipped. Other interrupts and A/D converter start request signals can be skipped in coordination with the GPTn_OVF/GPTn_UDF skipping function.

The interrupt request skipping function only depends on the setting of GTITC register and is independent of the setting of interrupt permission bits in the GTINTAD register.

When both troughs and crests are counted and skipped in triangle-wave mode, if the number of times for skipping is odd, GPTn_OVF/GPTn_UDF interrupt requests cannot be generated at troughs only or at crests only depending on the skipping counter start timing. To count both troughs and crests and generate the GPTn_OVF/GPTn_UDF interrupts at troughs only or crests only in triangle-wave mode, you must set an even number of skips.

Similarly, in saw-wave mode, when both overflows and underflows are counted and skipped with the count direction changed, GPTn_OVF interrupt requests cannot be generated on either overflows or underflows only. To count both overflows and underflows with the count direction changed and generate the GPTn_OVF/GPTn_UDF interrupts on either overflows or underflows only in saw wave mode, you must first check the skipping state.

Before changing the skipping count, you must release the skipping count setting (GTITC.IVTC[1:0] bits = 00b).

Figure 22.86 to Figure 22.91 show examples of skipping function operation.

- 在锯齿波模式下，中断请求在溢出时启用（当GTCNT计数器值从向上计数期间GTPR为0）
- 在三角波模式下，在波峰处启用中断请求（GTCNT从GTPR变为GTPR1）
- 在硬件源的计数中，发生了溢出（GTCNT在向上计数中从GTPR变为0）。

(10)GPTn_UDF中断（n=0到12）

在以下情况下会产生中断请求：

- 在锯齿波模式下，中断请求在下溢时启用（当GTCNT计数器值从0变为GTPR during down-counting)
- 在三角波模式下，在波谷处启用中断请求（GTCNT从0变为1）
- 在硬件源的计数中，发生了下溢（向下计数时GTCNT从0变为GTPR）。

Table 22.23 中断信号、中断许可位和中断状态标志

中断信号	中断许可位	中断状态标志
GPTn_UDF	- *1	GTST[7] (TCFPU)
GPTn_OVF		GTST[6] (TCFPO)
GPTn_ADTRGB	GTINTAD[19] (ADTRBDEN) GTINTAD[18] (ADTRBUEN)	GTST[19] (ADTRBDF) GTST[18] (ADTRBUF)
GPTn_ADTRGA	GTINTAD[17] (ADTRADEN) GTINTAD[16] (ADTRAUEN)	GTST[17] (ADTRADF) GTST[16] (ADTRAUF)
GPTn_CMPF	- *1	GTST[5] (TCFF)
GPTn_CMPE		GTST[4] (TCFE)
GPTn_CMPD		GTST[3] (TCFD)
GPTn_CMPC		GTST[2] (TCFC)
GPTn_CCMPB		GTST[1] (TCFB)
GPTn_CCMPA		GTST[0] (TCFA)

Note 1. 总是允许中断。

22.4.1 DMAC/DTC Activation

DMAC和DTC可以通过每个通道中的中断来激活。有关详细信息，请参阅第13节，中断控制器单元(ICU)和第17节，数据传输控制器(DTC)。

22.4.2 中断和AD转换请求跳过功能

通过设置GTITC寄存器，可以跳过GTCNT计数器溢出（GTPR比较匹配）中断（GPTn_OVF）和下溢中断（GPTn_UDF）。其他中断和AD转换器启动请求信号可以与GPTn_OVFGPTn_UDF跳过功能配合跳过。

中断请求跳过功能仅取决于GTITC寄存器的设置，与GTINTAD寄存器中中断允许位的设置无关。

在三角波模式下同时计算波谷和波峰并跳过时，如果跳过的次数是奇数，GPTn_OVFGPTn_UDF中断请求不能仅在波谷或波峰产生，具体取决于跳跃计数器的开始时间。要同时计算波谷和波峰，并在三角波模式下仅在波谷或波峰处生成GPTn_OVFGPTn_UDF中断，您必须设置偶数个跳过。

类似地，在锯齿波模式下，当计数方向改变同时计数和跳过上溢和下溢时，GPTn_OVF中断请求不能仅在上溢或下溢时产生。要在计数方向改变的情况下计算上溢和下溢，并仅在锯齿波模式下在上溢或下溢时生成GPTn_OVFGPTn_UDF中断，您必须首先检查跳过状态。

在更改跳过计数之前，您必须释放跳过计数设置（GTITC.IVTC[1:0]位=00b）。

图22.86至图22.91显示了跳过函数操作的示例。

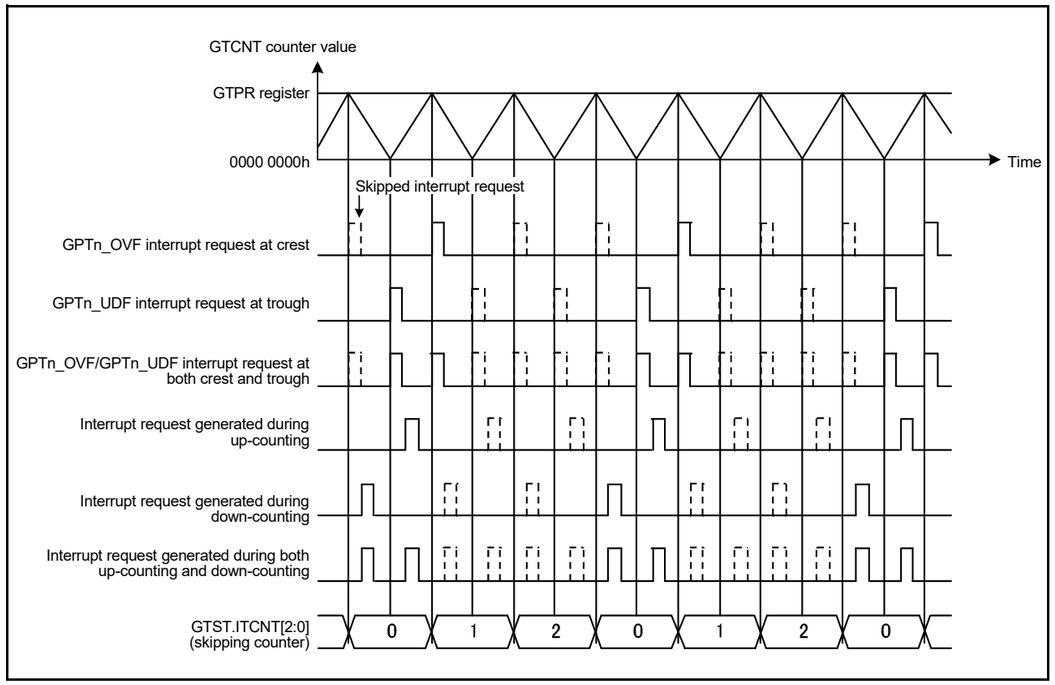


Figure 22.86 Example of interrupt skipping function operation with triangle waves, counting and skipping crests, and skipping count = 2

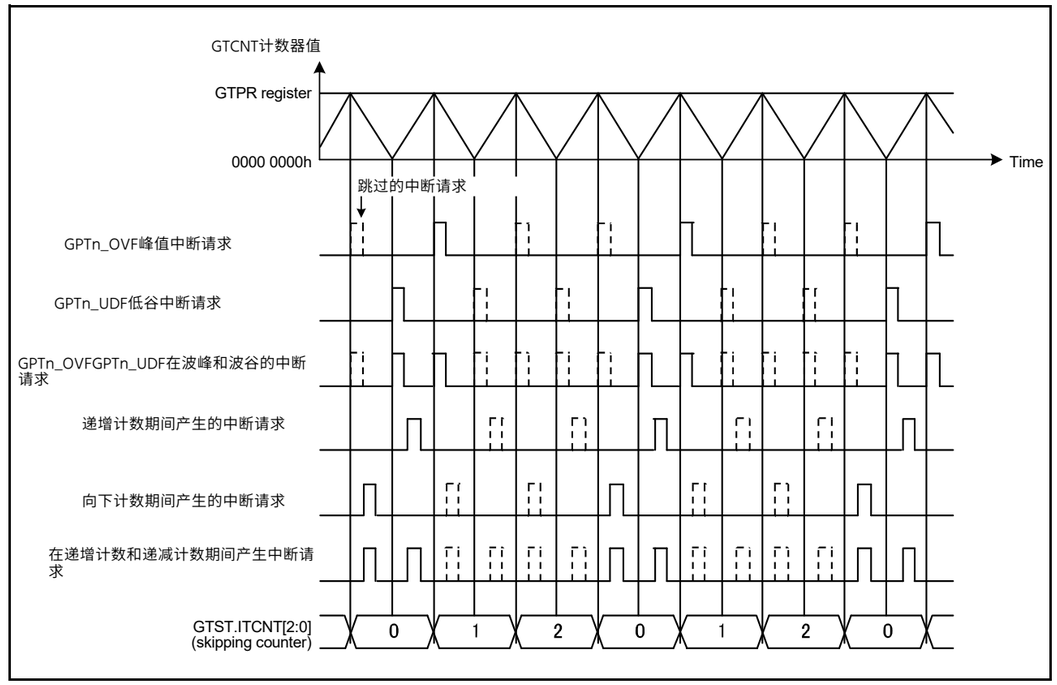


Figure 22.86 使用三角波、计数和跳过波峰以及跳过计数=2的中断跳过函数操作示例

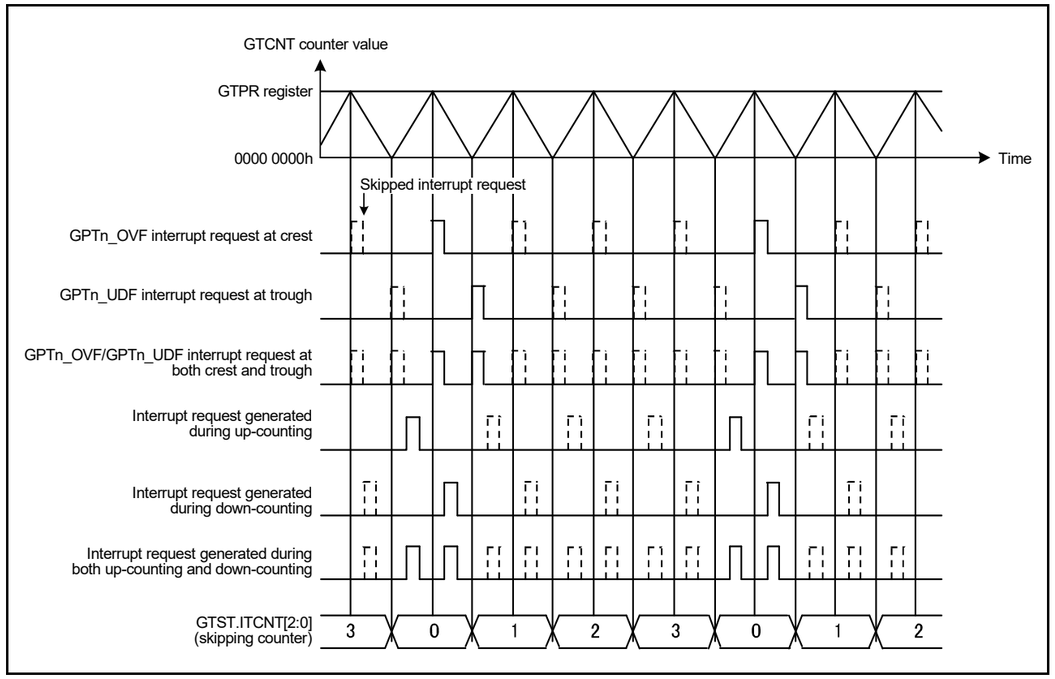


Figure 22.87 Example of interrupt skipping function operation with triangle waves, counting and skipping troughs, and skipping count = 3

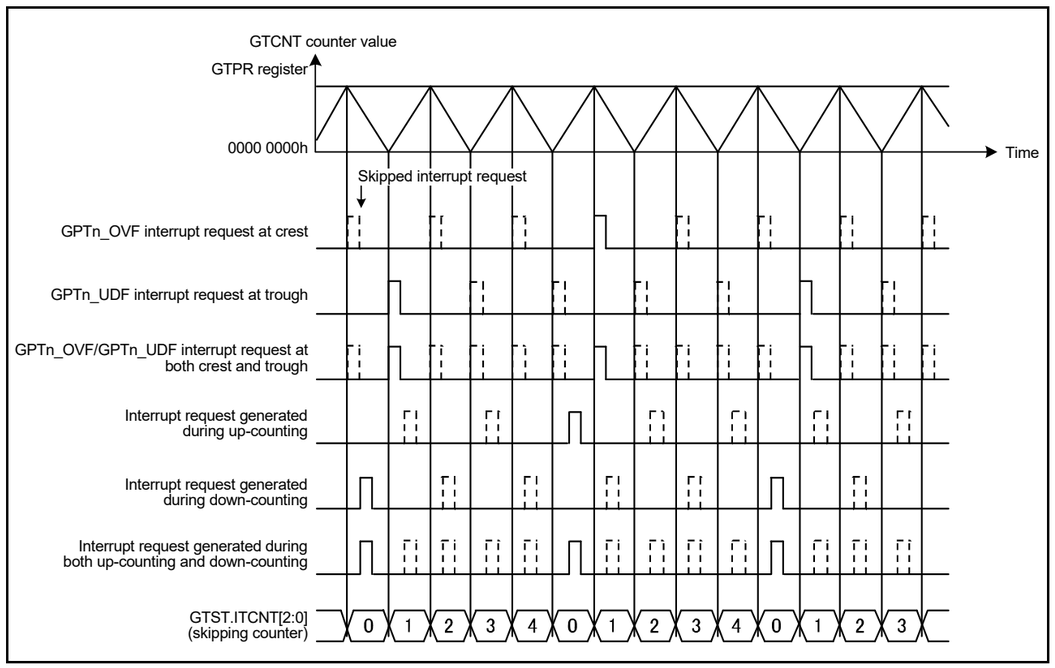


Figure 22.88 Example of interrupt skipping function operation with triangle waves, counting and skipping both troughs and crests, and skipping count = 4

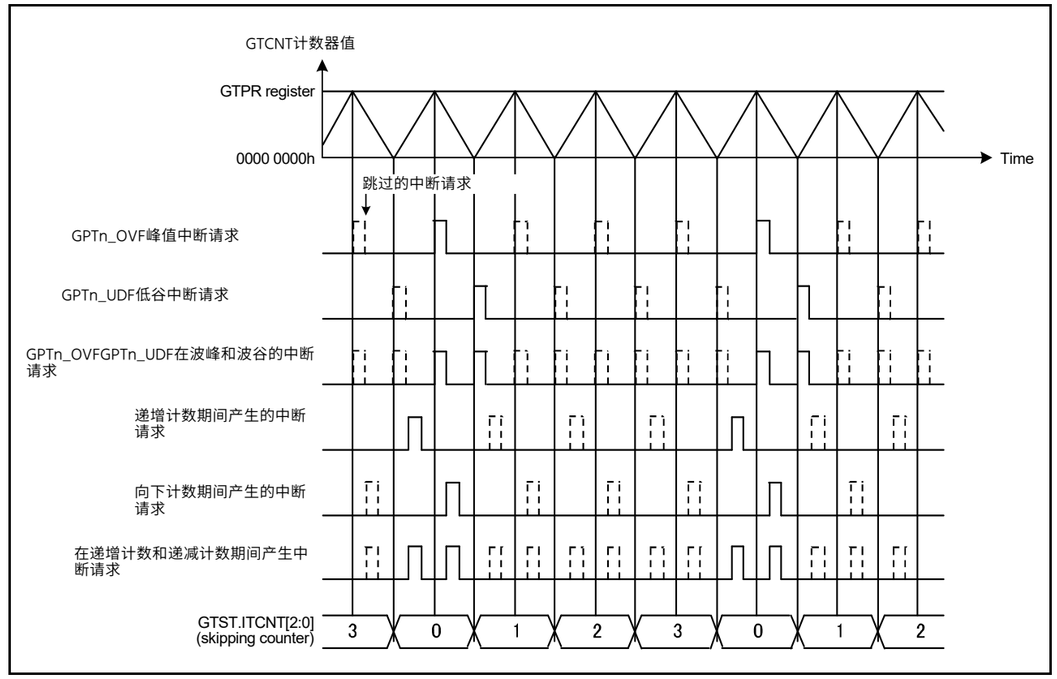


Figure 22.87 带有三角波的中断跳跃函数操作示例，计数和跳跃波谷，跳跃计数=3

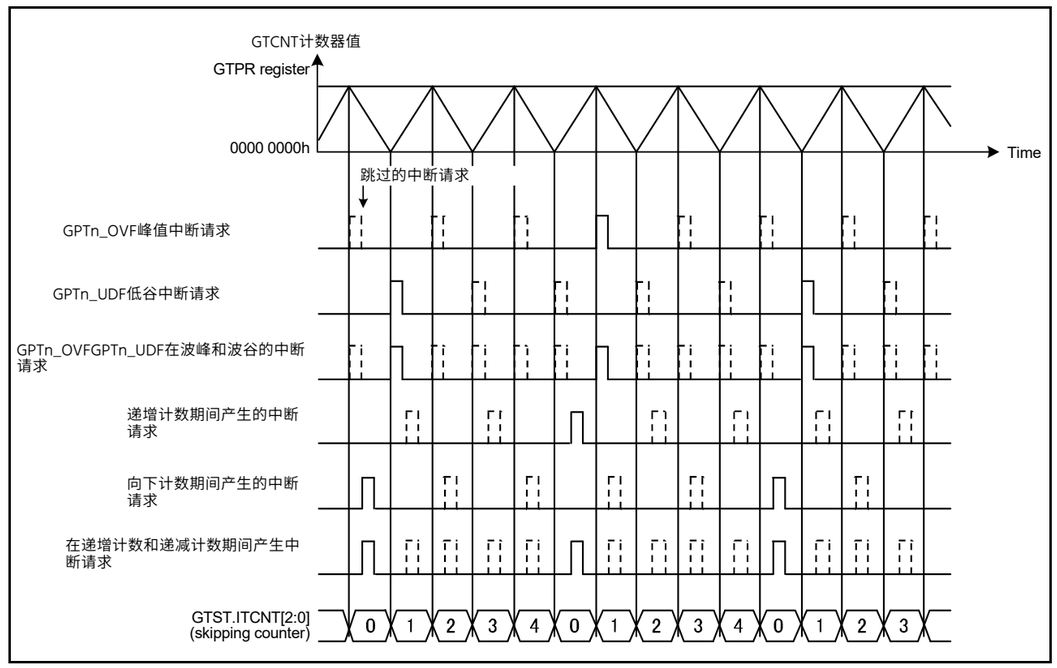


Figure 22.88 使用三角波的中断跳跃函数操作示例，计数和跳跃波谷和波峰，跳跃计数=4

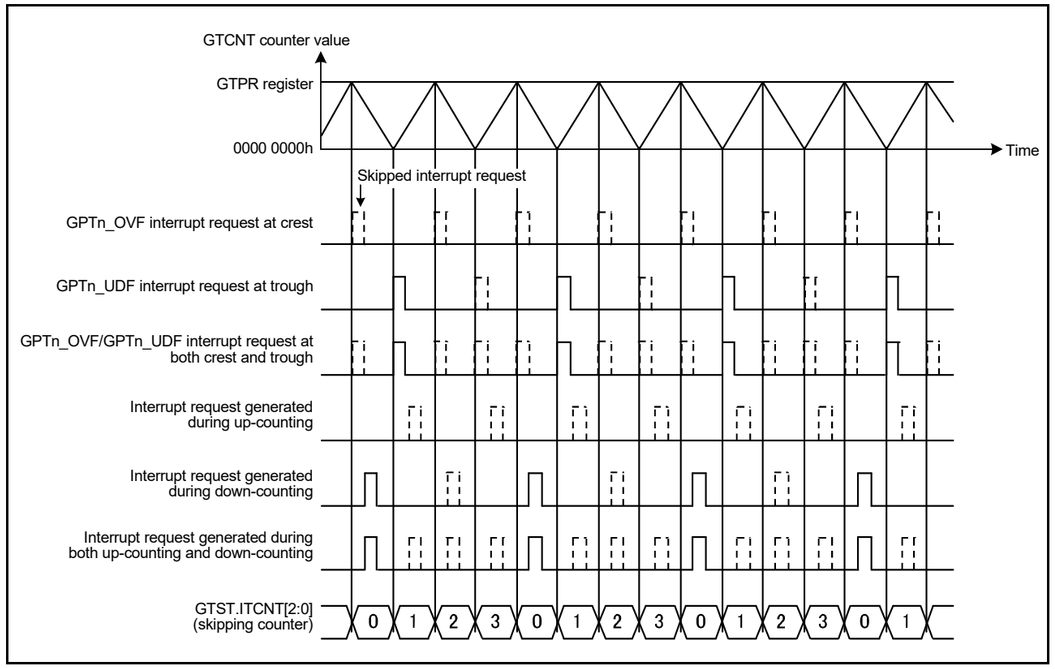


Figure 22.89 Example of interrupt skipping function operation with triangle waves, counting and skipping both troughs and crests, skipping count = 3, and skipping started at up-counting

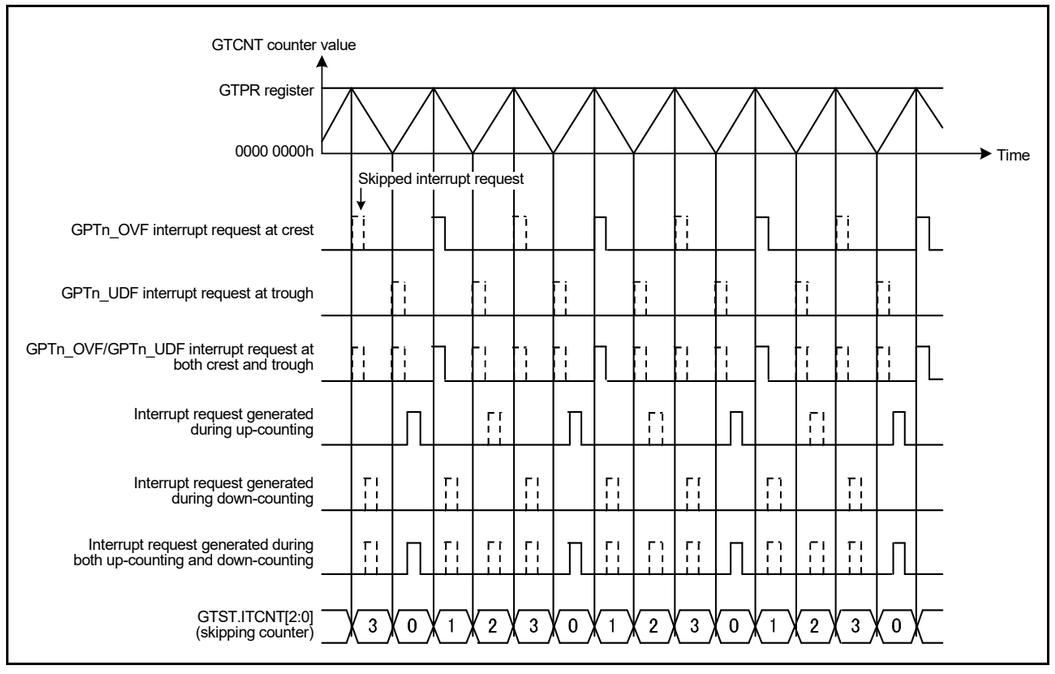


Figure 22.90 Example of interrupt skipping function operation with triangle waves, counting and skipping both troughs and crests, skipping count = 3, and skipping started at down-counting

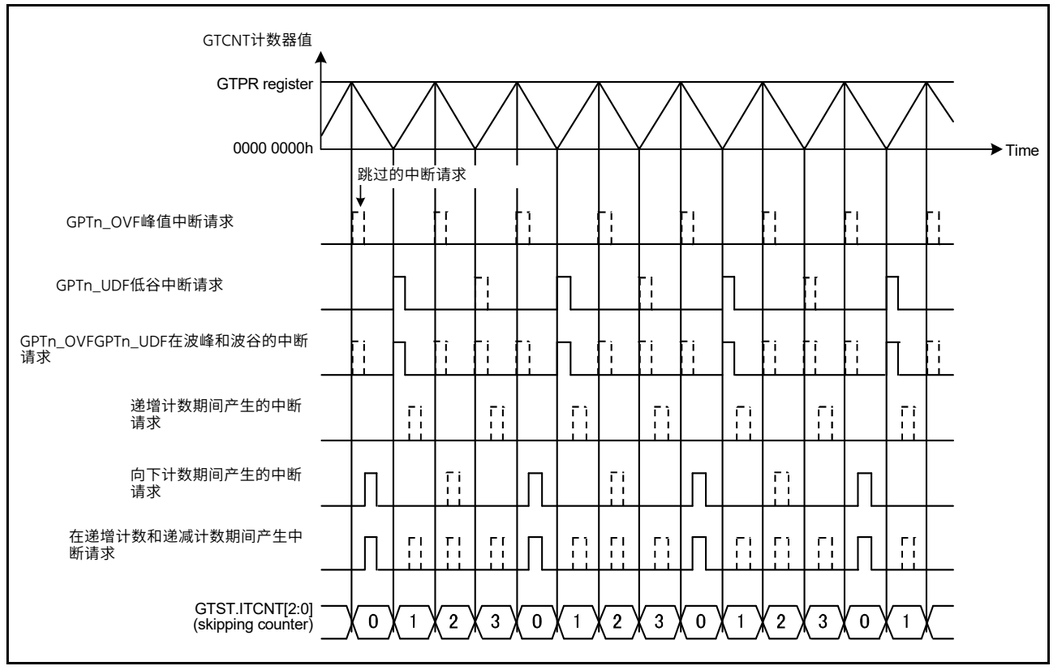


Figure 22.89 使用三角波的中断跳跃函数操作示例，计数和跳跃波谷和波峰，跳跃计数=3，跳跃从向上计数开始

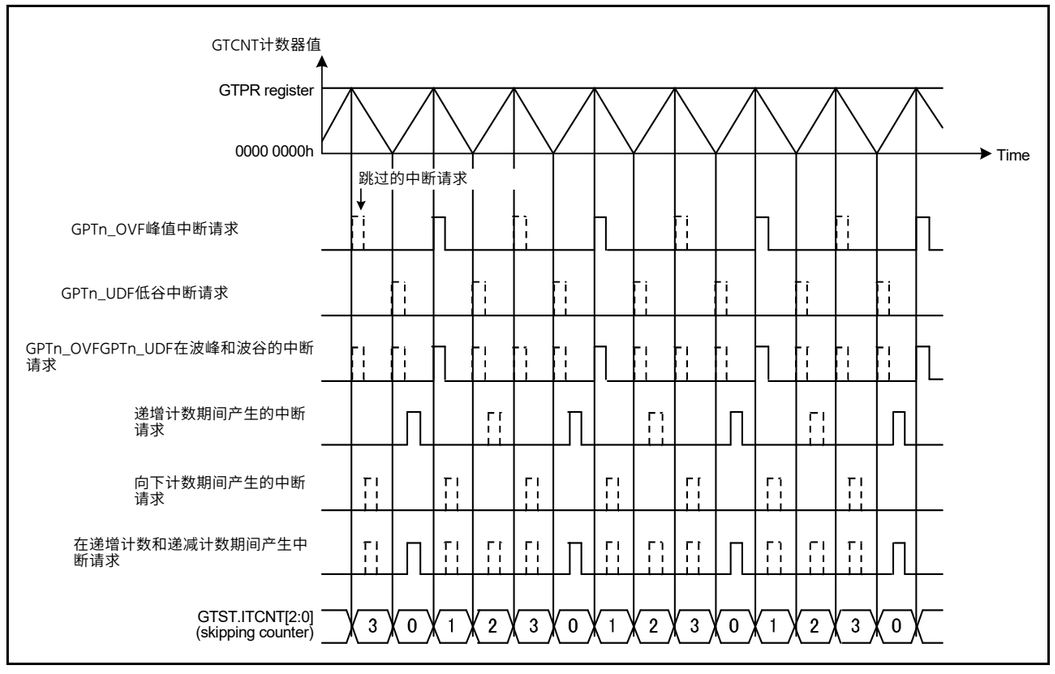


Figure 22.90 使用三角波的中断跳跃函数操作示例，计数和跳跃波谷和波峰，跳跃计数=3，跳跃从向下计数开始

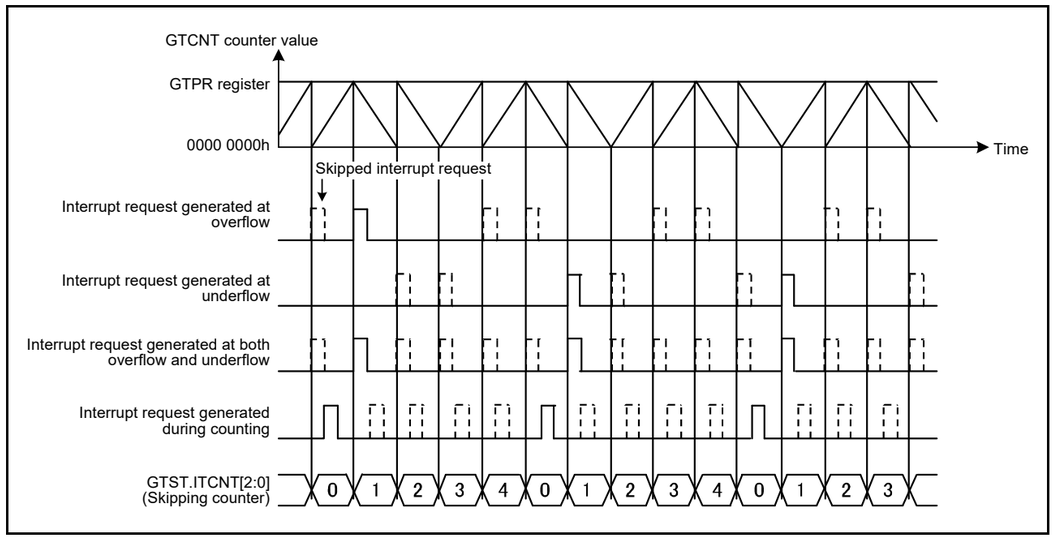


Figure 22.91 Example of interrupt skipping function operation with saw waves, operation with count direction changed, counting and skipping both overflows and underflows, and skipping count = 4

22.5 A/D Converter Start Request

An A/D converter start request can be issued at a compare match between the GTCNT counter and GTADTRA or GTADTRB, and up-counting only, down-counting only, or both up-counting and down-counting can be specified.

In event count operation performing, A/D converter start requests interrupt cannot be generated. An A/D converter start request does not direct output to the A/D converter module but results in output to ELC as event signals.

GTADTRA and GTADTRB each have two buffer registers. Buffer operation with GTADTRA combined with GTADTBRA and GTADTDBRA, and buffer operation with GTADTRB combined with GTADTBRB and GTADTDBRB can be performed.

Figure 22.92 shows an example of A/D converter start request operation, and Figure 22.93 shows an example setting for A/D converter start request operation.

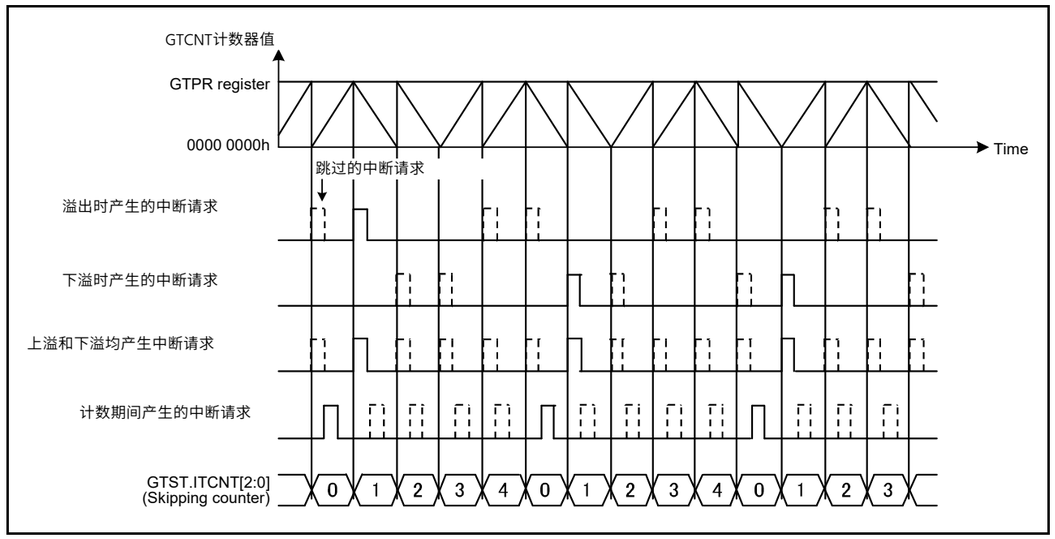


Figure 22.91 使用锯齿波的中断跳过功能操作示例，改变计数方向的操作，计数和跳过上溢和下溢，以及跳过计数=4

22.5 AD转换器启动请求

可以在GTCNT计数器和GTADTRA或GTADTRB之间的比较匹配时发出AD转换器启动请求，并且可以指定仅递增计数、仅递减计数或同时递增计数和递减计数。

在执行事件计数操作时，不能产生AD转换器启动请求中断。AD转换器启动请求不会直接输出到AD转换器模块，而是导致作为事件信号输出到ELC。

GTADTRA和GTADTRB各有两个缓冲寄存器。与GTADTRA相结合的缓冲操作GTADTBRA和GTADTBRA，以及将GTADTRB与GTADTBRB和可以执行GTADTDRBB。

图22.92显示AD转换器启动请求操作示例，图22.93显示示例设置AD转换器启动请求操作。

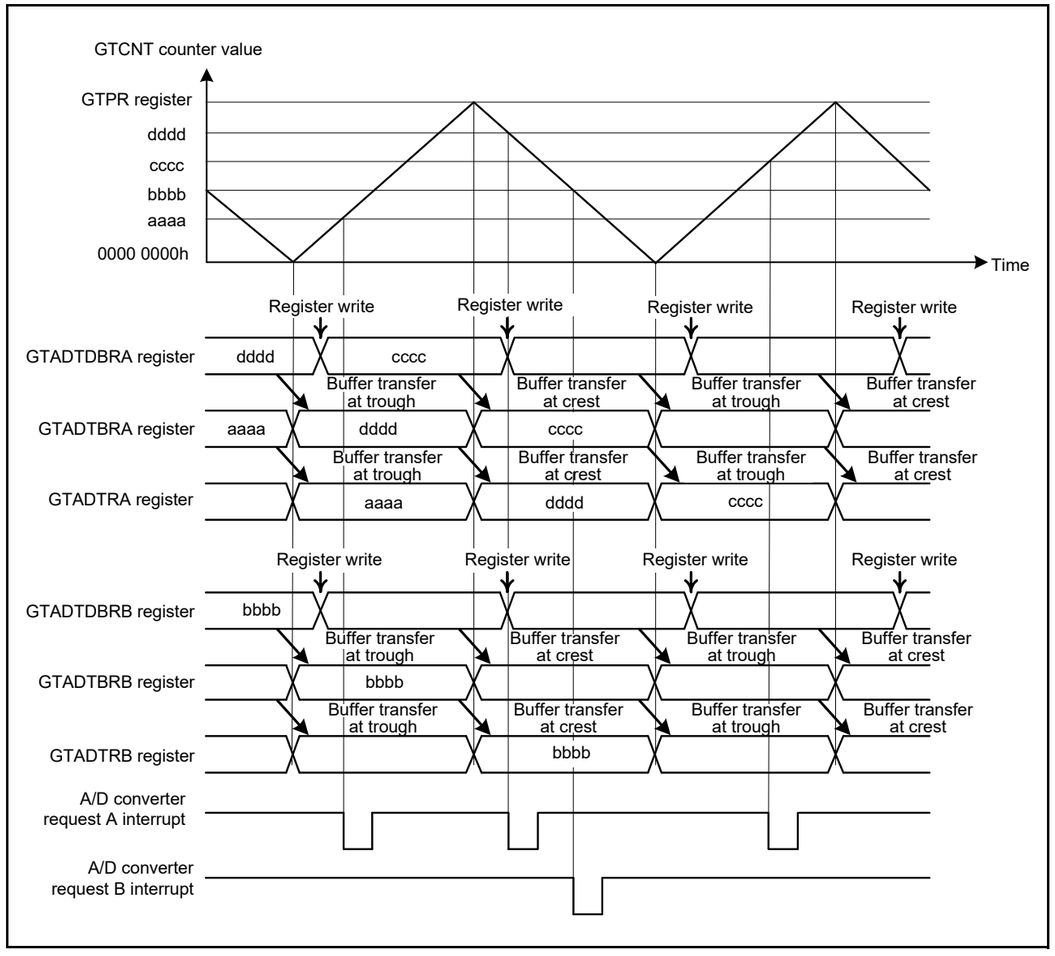


Figure 22.92 **Example of A/D converter start request timing operation with triangle waves, double buffer operation, buffer transfer at both troughs and crests, A/D converter start request interrupt by GTADTRA at both up-counting and down-counting, and A/D converter start request interrupt by GTADTRB at down-counting**

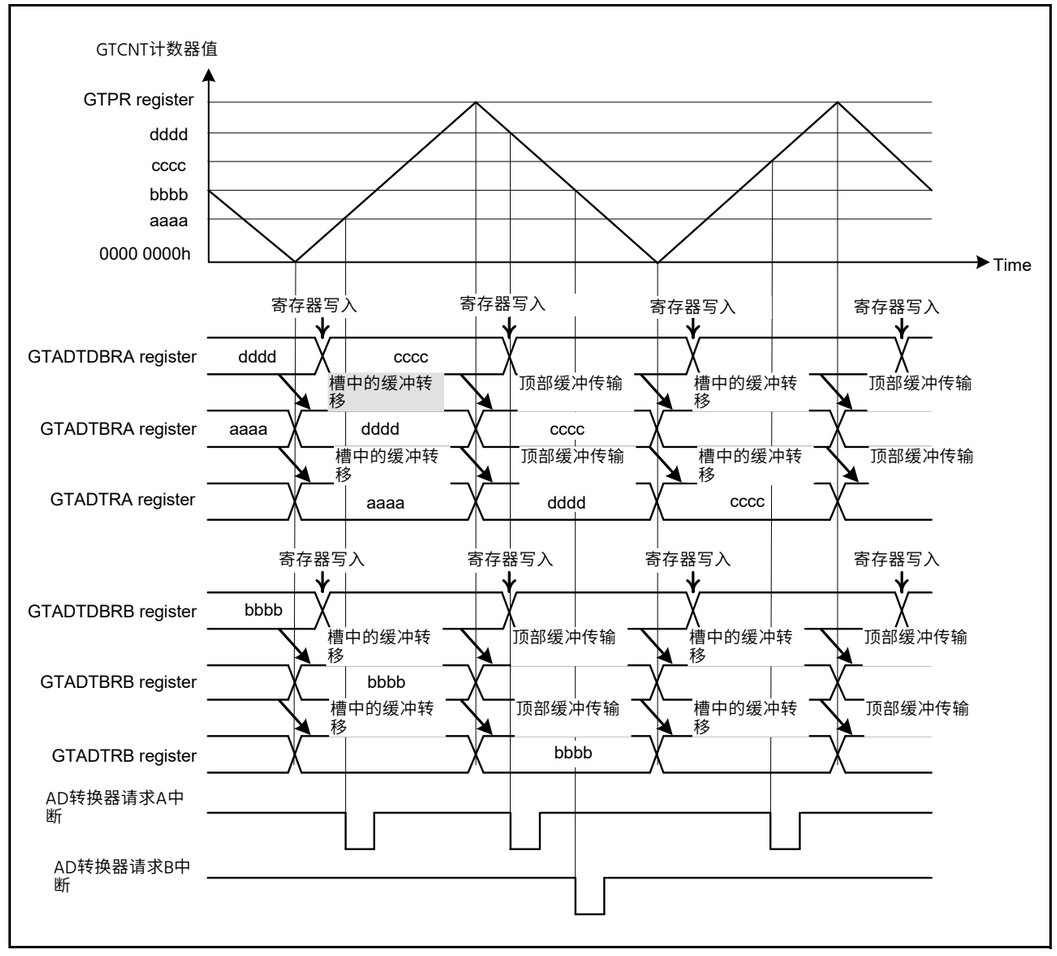


Figure 22.92 **带三角波的AD转换器启动请求时序操作示例、双缓冲器操作、波谷和波峰的缓冲器传输、递增计数和递减计数时GTADTRA的AD转换器启动请求中断以及AD转换器启动请求中断的示例**

GTADTRB at down-counting

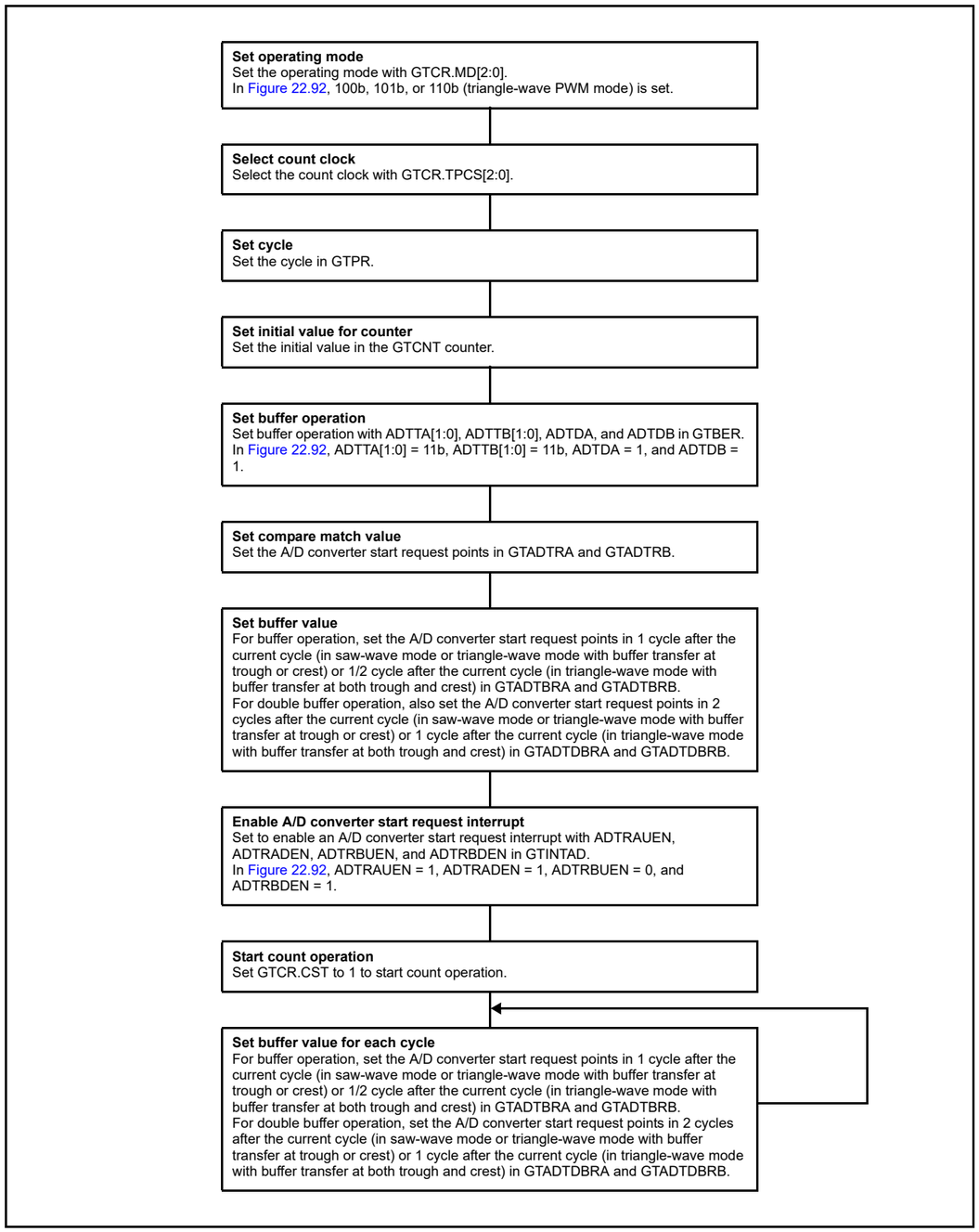


Figure 22.93 Example setting for A/D converter start request timing operation

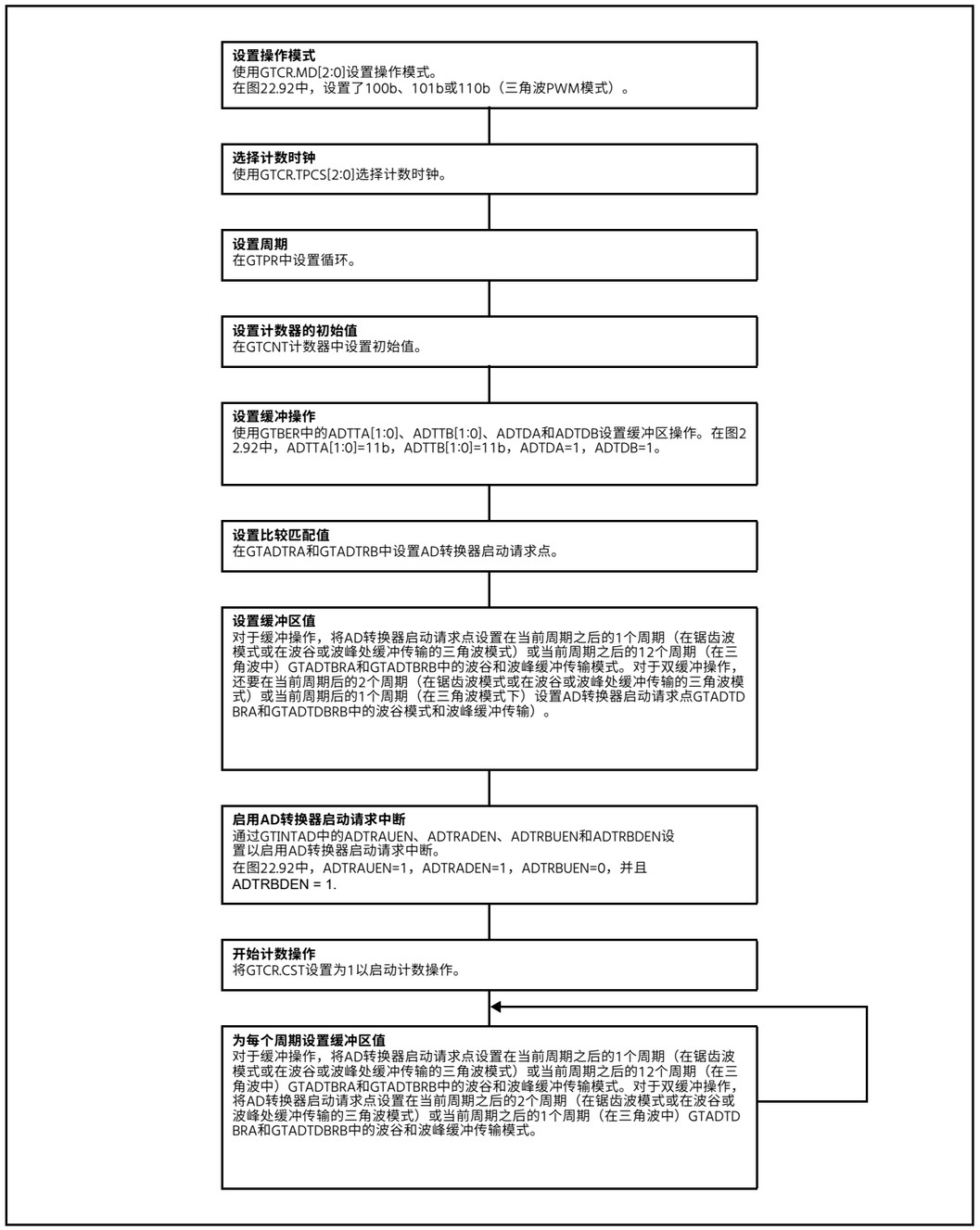


Figure 22.93 AD转换器启动请求时序操作的示例设置

22.6 Operations Linked by the ELC

22.6.1 Event Signal Output to the ELC

The GPT can perform operation linked with another module set in advance when its interrupt request signal is used as an event signal by the Event Link Controller (ELC).

A/D converter start requests can be enabled and disabled individually with each up-counting and down-counting for both interrupts and events output to ELC by enable bits of the interrupt request.

The GPT has the following ELC event signals:

- Generation of compare match A interrupt (GPTn_CCMPA (n = 0 to 12))
- Generation of compare match B interrupt (GPTn_CCMPB (n = 0 to 12))
- Generation of compare match C interrupt (GPTn_CMPC (n = 0 to 12))
- Generation of compare match D interrupt (GPTn_CMPD (n = 0 to 12))
- Generation of compare match E interrupt (GPTn_CMPE (n = 0 to 12))
- Generation of compare match F interrupt (GPTn_CMPF (n = 0 to 12))
- Generation of overflow interrupt (GPTn_OVF (n = 0 to 12))
- Generation of underflow interrupt (GPTn_UDF (n = 0 to 12))
- A/D converter start request A interrupt (GPTn_ADTRGA (n = 0 to 7))
- A/D converter start request B interrupt (GPTn_ADTRGB (n = 0 to 7)).

22.6.2 Event Signal Inputs from the ELC

The GPT can perform the following operations in response to a maximum of eight events from the ELC:

- Start counting, stop counting, clear counting
- Up-counting, down counting
- Input capture.

See section 22.3, Operation for detail on hardware resources.

22.7 Noise Filter Function

Each pin for use in input capture and Hall sensor input to the GPT is equipped with a noise filter. The noise filter samples input signals at the sampling clock and removes the pulses whose length is less than 3 sampling cycles.

The noise filter functionality includes enabling and disabling the noise filter for each pin and setting of the sampling clock for each channel.

Figure 22.94 shows the timing of noise filtering.

22.6 由ELC关联的操作

22.6.1 事件信号输出到ELC

当GPT的中断请求信号被事件链接控制器(ELC)用作事件信号时，GPT可以执行与预先设置的另一个模块链接的操作。

D转换器启动请求可以通过中断请求的使能位单独启用和禁用，每次递增和递减中断和事件输出到ELC。

GPT具有以下ELC事件信号：

- 产生比较匹配A中断(GPTn_CCMPA(n=0to12))
- 产生比较匹配B中断(GPTn_CCMPB(n=0to12))
- 产生比较匹配C中断(GPTn_CMPC(n=0to12))
- 产生比较匹配D中断(GPTn_CMPD(n=0to12))
- 产生比较匹配E中断(GPTn_CMPE(n=0to12))
- 产生比较匹配F中断(GPTn_CMPF(n=0to12))
- 产生溢出中断(GPTn_OVF(n=0to12))
- 产生下溢中断(GPTn_UDF(n=0to12))
- AD转换器启动请求A中断(GPTn_ADTRGA(n=0to7))
- AD转换器启动请求B中断(GPTn_ADTRGB(n=0to7))。

22.6.2 来自ELC的事件信号输入

GPT最多可以执行以下操作以响应来自ELC的八个事件：

- 开始计数，停止计数，清除计数
- 递增计数、递减计数
- 输入捕获。

有关硬件资源的详细信息，请参见第22.3节，操作。

22.7 噪音过滤功能

用于GPT的输入捕捉和霍尔传感器输入的每个引脚都配备了噪声滤波器。噪声滤波器以采样时钟对输入信号进行采样，并去除长度小于3个采样周期的脉冲。

噪声过滤器功能包括为每个引脚启用和禁用噪声过滤器以及为每个通道设置采样时钟。

图22.94显示了噪声过滤的时序。

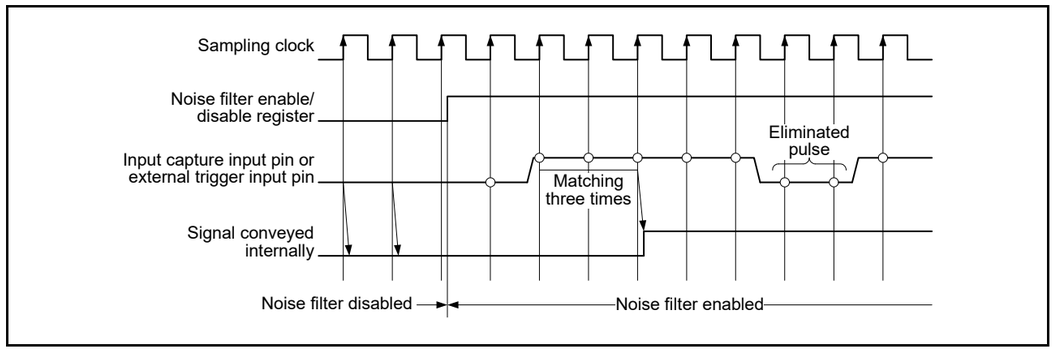


Figure 22.94 Timing of noise filtering

If noise filtering is enabled, the input capture operation or external trigger operation performs on the edges of the noise filtered signal after a delay of a sampling interval × 3 + PCLKD. This is caused by the noise filtering for the input capture input or external trigger operation.

22.8 Protection Function

22.8.1 Write-Protection for Registers

To prevent registers from being accidentally modified, registers can be write-protected in channel units by setting GTWP.WP. Write-protection can be set for the following registers:

GTSSR, GTPSR, GTCSR, GTUPSR, GTDNSR, GTICASR, GTICBSR, GTCR, GTUDDTYC, GTIOR, GTINTAD,GTST, GTBER, GTITC, GTCNT, GTCCRA, GTCCRB, GTCCRC, GTCCRD, GTCCRE, GTCCRF, GTPR, GTPBR, GTPDBR, GTADTRA, GTADTBRA, GTADTDBRA, GTADTRB, GTADTBRB, GTADTDBRB, GTDTCR, GTDVU, GTDVD, GTDBU, GTDBD, GTSOS, GTSOTR.

22.8.2 Disabling of Buffer Operation

If the timing of buffer register write is delayed relative to the timing for the buffer transfer, buffer operation can be suspended with the GTBER.BD bit setting. Specifically, buffer transfer can be temporarily disabled even when a buffer transfer condition is generated during a buffer register write. This can be done by setting the associated GTBER.BD bit to 1 (buffer operation disabled) before a buffer register write and clearing the bit to 0 (buffer operation enabled) after completion of writing to all the buffer registers.

Figure 22.95 shows an example of operation for disabling buffer operation.

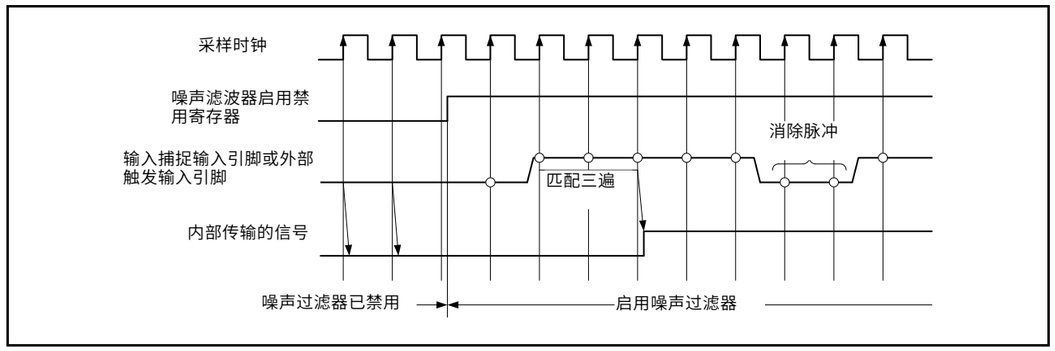


Figure 22.94 噪声过滤的时序

如果噪声过滤使能，输入捕捉操作或外部触发操作在经过一个采样间隔×3+PCLKD的延迟后在噪声过滤信号的边沿上执行。这是由输入捕捉输入或外部触发操作的噪声过滤引起的。

22.8 保护功能

22.8.1 寄存器的写保护

为了防止寄存器被意外修改，可以通过设置以通道为单位对寄存器进行写保护GTWP.WP。可以为以下寄存器设置写保护：

GTSSR, GTPSR, GTCSR, GTUPSR, GTDNSR, GTICASR, GTICBSR, GTCR, GTUDDTYC, GTIOR, GTINTAD,GTST, GTBER, GTITC, GTCNT, GTCCRA, GTCCRB, GTCCRC, GTCCRD, GTCCRE, GTCCRF, GTPR, GTPBR, GTPDBR, GTADTRA, GTADTBRA, GTADTDBRA, GTADTRB, GTADTBRB, GTADTDBRB, GTDTCR, GTDVU, GTDVD, GTDBU, GTDBD, GTSOS, GTSOTR.

22.8.2 禁用缓冲区操作

如果缓冲寄存器写入的时序相对于缓冲传输的时序延迟，则可以通过GTBER.BD位设置暂停缓冲操作。具体而言，即使在缓冲寄存器写入期间产生了缓冲传送条件，也可以暂时禁用缓冲传送。这可以通过在写入缓冲寄存器之前将关联的GTBER.BD位设置为1（禁用缓冲操作）并在完成对所有缓冲寄存器的写入后将该位清除为0（启用缓冲操作）来完成。

图22.95显示了禁用缓冲区操作的操作示例。

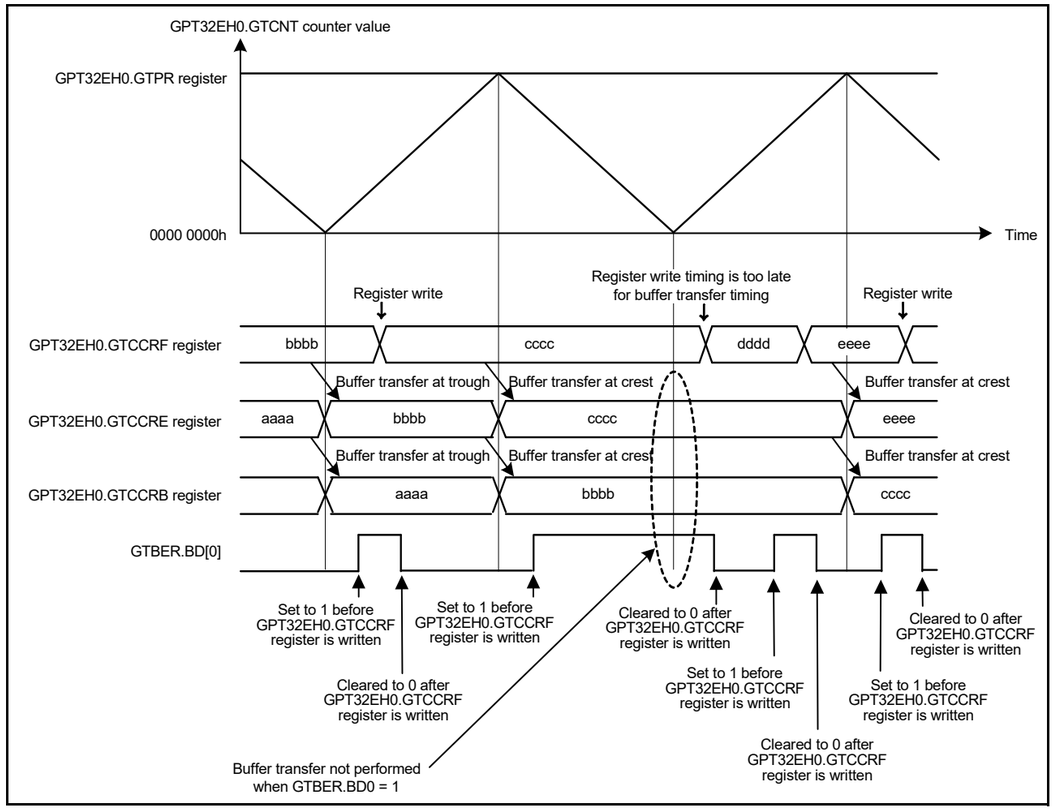


Figure 22.95 Example of operation for disabling buffer operation with triangle waves, double buffer operation, and buffer transfer at both troughs and crests

22.8.3 GTIOC Pin Output Negate Control

For protection from system failure, the output disable control that changes the GTIOC pin output value forcibly is provided for GTIOC pin output by the request of output disable from POEG.

When dead time error occurs or the GTIOCA pin output value is the same as the GTIOCB pin output value, output protection is required. The GPT detects this condition and generates output disable requests to POEG according to the settings in the output disable request permission bits, such as GTINTAD.GRPDTE, GTINTAD.GRPABH, and GTINTAD.GRPABL. After the POEG receives output disable requests from each channel and calculates external input using an OR operation, the POEG generates output disable requests to GPT.

One output disable signal (representing the shared output disable request signal of the GTIOCA pin and the GTIOCB pin) out of four output disable requests generated by the POEG is selected by setting GTINTAD.GRP[1:0]. The status of the selected disable output request is monitored by reading the GTST.ODF bit. The output level during output disable is based on the GTIOR.OADF[1:0] setting for the GTIOCA pin and the GTIOR.OBDF[1:0] setting for the GTIOCB pin.

The change to the output disable state is performed asynchronously by generating the output disable request from the POEG. The release of the output disable state is performed at end of cycle by terminating the output disable request. The timing of release of the output disable state is a minimum of 3 PCLKD cycles after terminating the output disable request. To perform output disable control reliably, allow at least 4 PCLKD cycles after generating the output disable request (by clearing the output disable request flag in POEG) until the output disable request is terminated.

When event count is performed or when the output disable state is to be released immediately without waiting for an end of cycle, GTIOR.OADF[1:0] must be set to 00b (for GTIOCA pin) or GTIOR.OBDF[1:0] must be set to 00b (for GTIOCB pin).

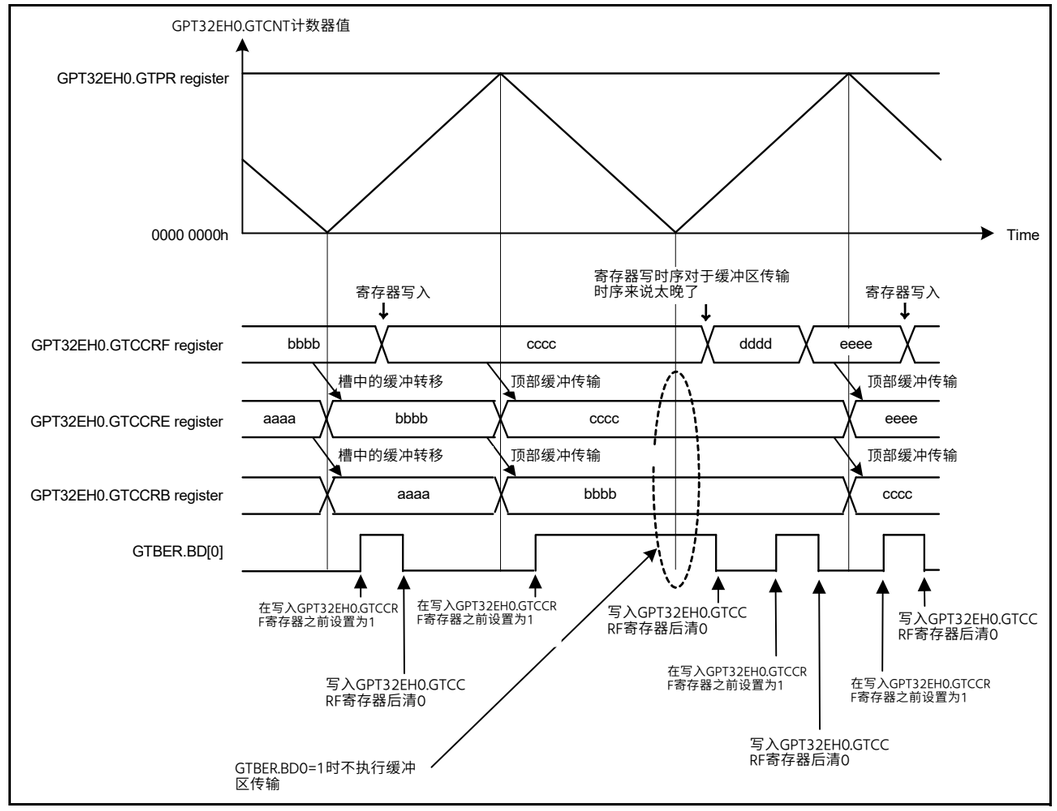


Figure 22.95 三角波缓冲操作、双缓冲操作、波谷和波峰缓冲转移的禁用操作示例

22.8.3 GTIOC引脚输出负控制

为防止系统故障，根据POEG的输出禁用请求，为GTIOC引脚输出提供强制改变GTIOC引脚输出值的输出禁用控制。

当发生死区错误或GTIOCA引脚输出值与GTIOCB引脚输出值相同时，需要输出保护。GPT检测到这种情况并根据输出禁用请求权限位中的设置（例如GTINTAD.GRPDTE、GTINTAD.GRPABH和GTINTAD.GRPABL）向POEG生成输出禁用请求。在POEG接收到来自每个通道的输出禁用请求并使用OR运算计算外部输入后，POEG向GPT生成输出禁用请求。

通过设置GTINTAD.GRP[1:0]，在POEG产生的四个输出禁止请求中选择一个输出禁止信号（代表GTIOCA引脚和GTIOCB引脚的共享输出禁止请求信号）。通过读取GTST.ODF位来监控所选禁用输出请求的状态。输出禁用期间的输出电平基于GTIOCA引脚的GTIOR.OADF[1:0]设置和GTIOCB引脚的GTIOR.OBDF[1:0]设置。

对输出禁用状态的更改是通过从
POEG。通过终止输出禁用请求，在循环结束时执行输出禁用状态的释放。输出禁用状态的释放时间是在终止输出禁用请求后至少3个PCLKD周期。为了可靠地执行输出禁用控制，在生成输出禁用请求后（通过清除POEG中的输出禁用请求标志）至少允许4个PCLKD周期，直到输出禁用请求终止。

当执行事件计数或不等待周期结束而立即释放输出禁用状态时，必须将GTIOR.OADF[1:0]设置为00b（对于GTIOCA引脚）或GTIOR.OBDF[1:0]必须设置为00b（对于GTIOCB引脚）。

Figure 22.96 shows an example of the GTIOC pin output disable control operation.

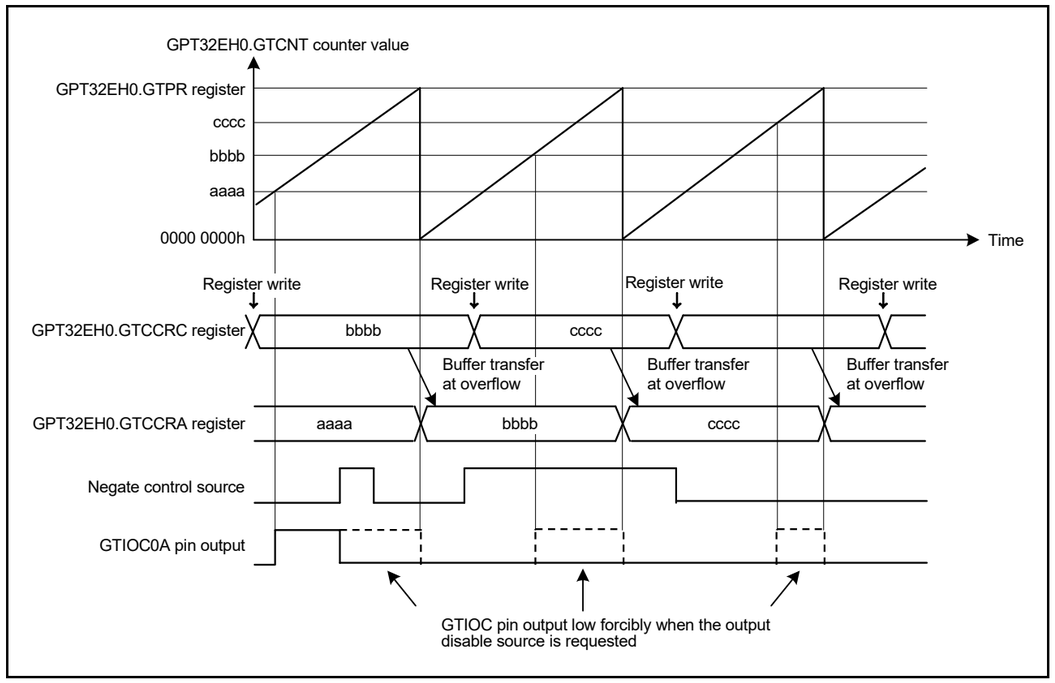


Figure 22.96 Example of GTIOC pin output disable control operation with saw-wave up-counting, buffer operation, active level 1, high output at GTCCRA compare match, low output at cycle end, and low output at output disable

22.8.4 Output Protection Function for GTIOC Pin Output

In preparation for incorrect settings of the GTCCRA register (settings outside the range of 0 < GTCCRA < GTPR), the output protection function for the GTIOC pin output (disabling function) is activated when the automatic dead time setting (GTDTCR.TDE = 1) is made in triangle-wave mode. The status of the output protection function can be read from GTSOS.SOS[1:0].

Figure 22.97 shows the state transition of the output protection function.

图22.96显示了GTIOC引脚输出禁用控制操作的示例。

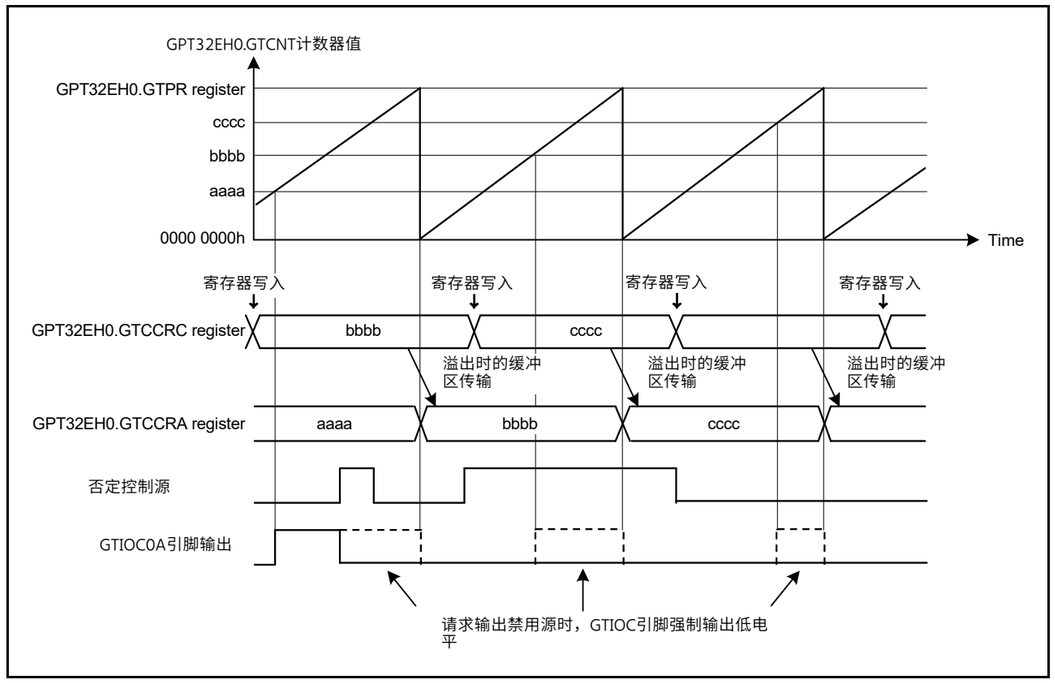


Figure 22.96 GTIOC引脚输出禁用控制操作示例，锯波递增计数、缓冲器操作、有效电平1、GTCCRA比较匹配时的高输出、周期结束时的低输出和输出禁用时的低输出

22.8.4 GTIOC引脚输出的输出保护功能

为防止GTCCRA寄存器的错误设置（设置超出0<GTCCRA<GTPR的范围），当自动死区时间设置(GTDTCR.TDE=1)时，将激活GTIOC引脚输出的输出保护功能（禁用功能）是在三角波模式下制作的。输出保护功能的状态可以从GTSOS.SOS[1:0]中读取。

图22.97显示了输出保护功能的状态转换。

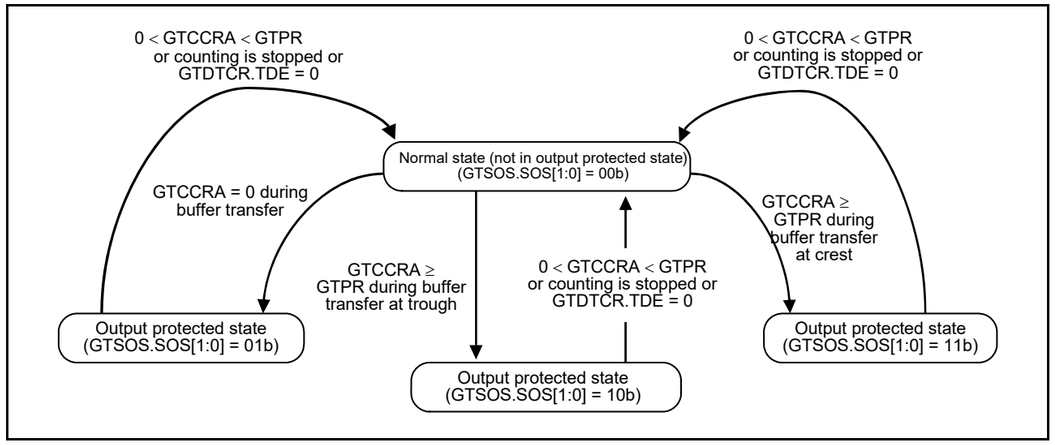
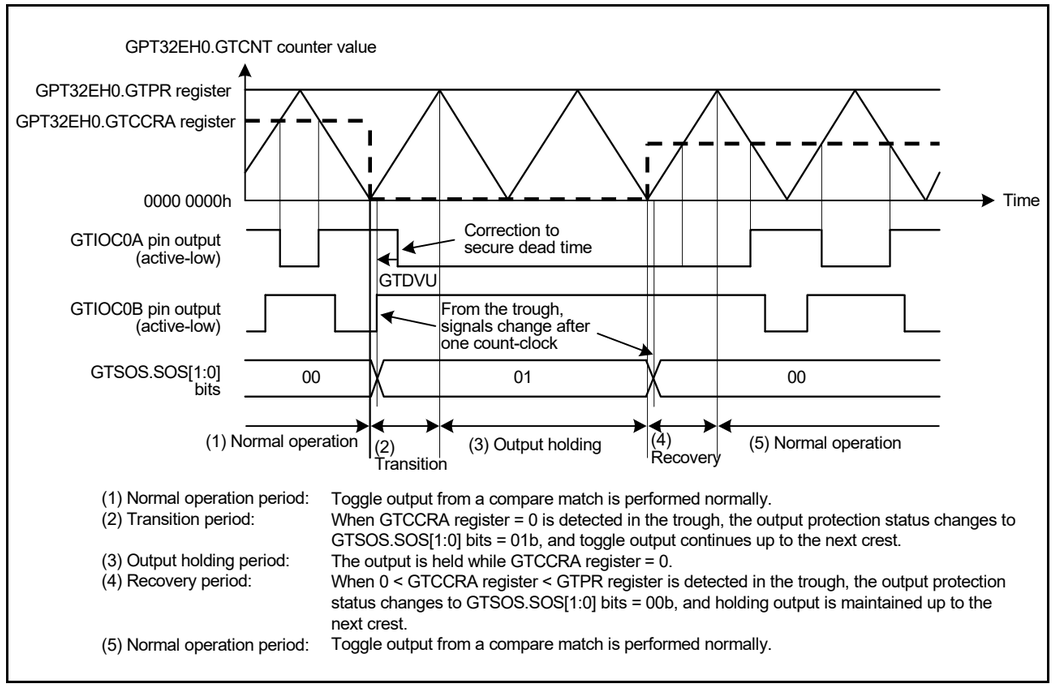


Figure 22.97 Output protection function

22.8.4.1 Output protection function when the GTCCRA register is set to 0 during buffer transfer

Figure 22.98 and Figure 22.99 show examples of output protection function operation when the GTCCRA register is set to 0 during buffer transfer at troughs, and Figure 22.100 and Figure 22.101 show examples when the GTCCRA register is set to 0 during buffer transfer at crests.



(1) Normal operation period: Toggle output from a compare match is performed normally.
(2) Transition period: When GTCCRA register = 0 is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 01b, and toggle output continues up to the next crest.
(3) Output holding period: The output is held while GTCCRA register = 0.
(4) Recovery period: When 0 < GTCCRA register < GTPR register is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 00b, and holding output is maintained up to the next crest.
(5) Normal operation period: Toggle output from a compare match is performed normally.

Figure 22.98 Example of output protection operation when GTCCRA is set to 0 during buffer transfer at troughs, with 0 < GTCCRA < GTPR restored during buffer transfer at troughs, and active-low

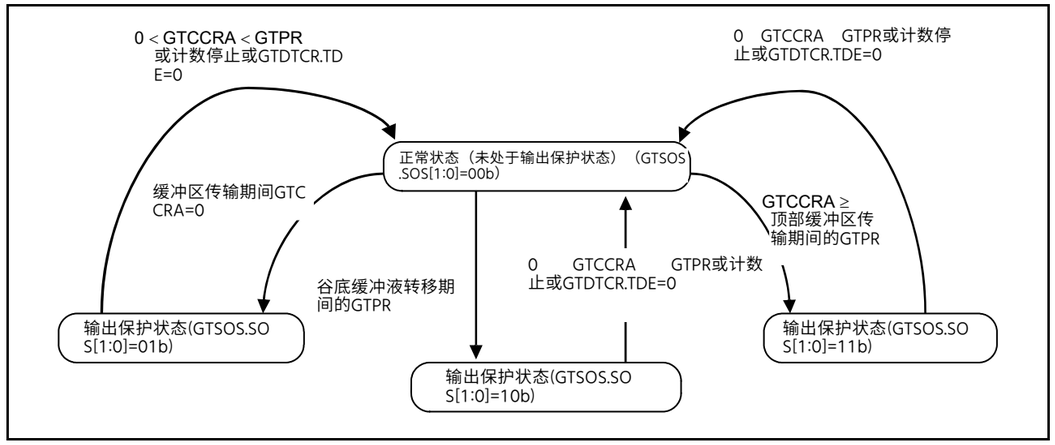
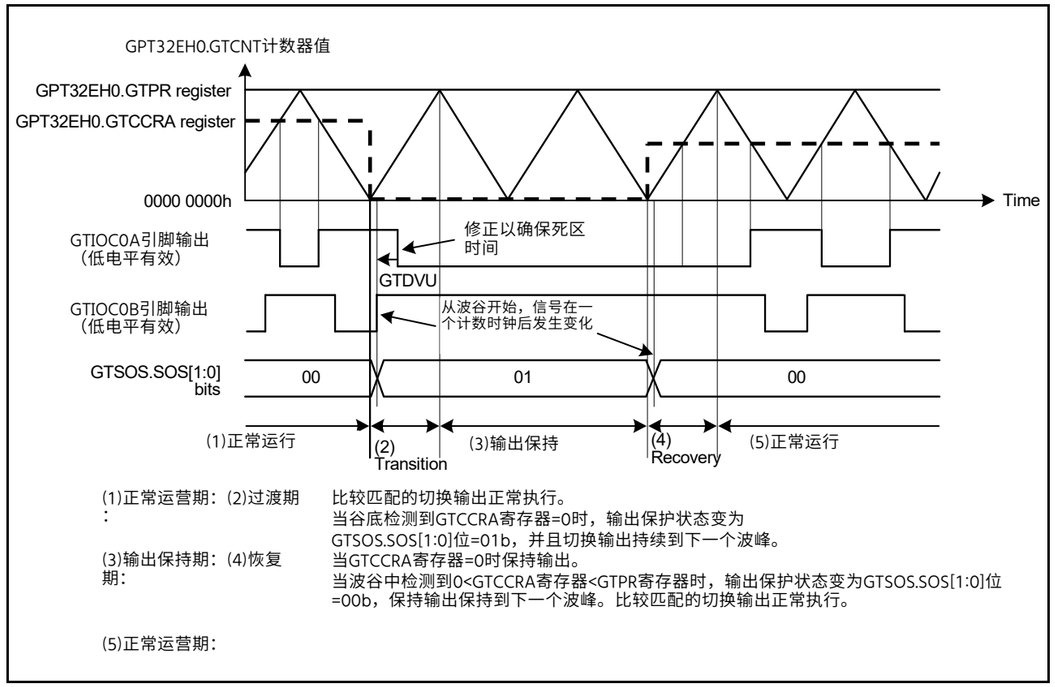


Figure 22.97 输出保护功能

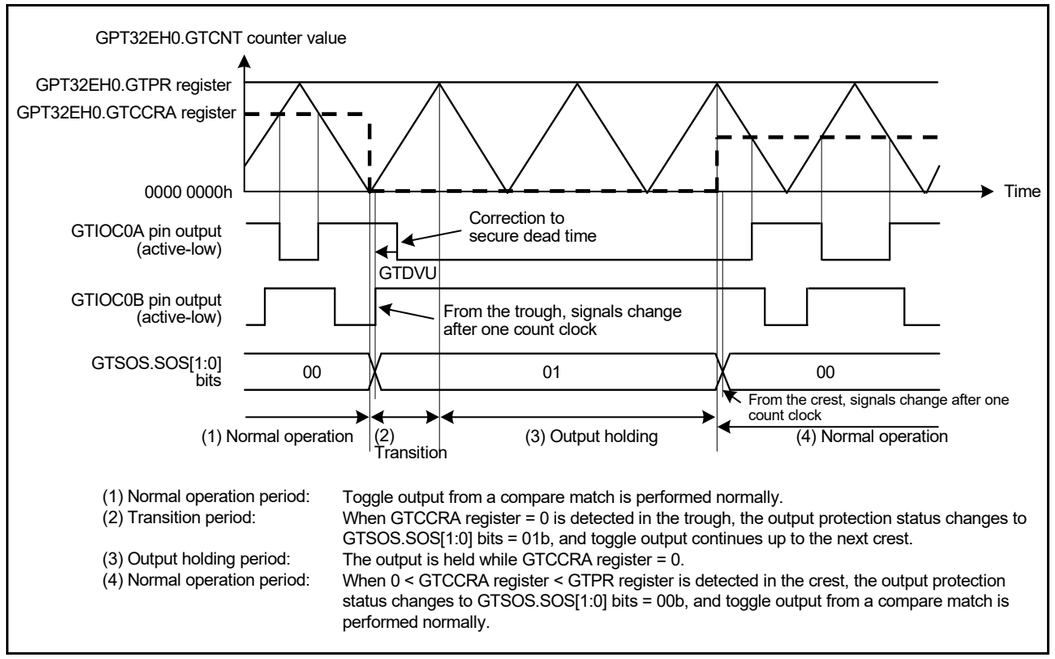
22.8.4.1 缓冲区传输期间GTCCRA寄存器设置为0时的输出保护功能

图22.98和图22.99显示了在波谷缓冲传输期间GTCCRA寄存器设置为0时的输出保护功能操作示例，图22.100和图22.101显示了在波峰缓冲传输期间GTCCRA寄存器设置为0的示例。



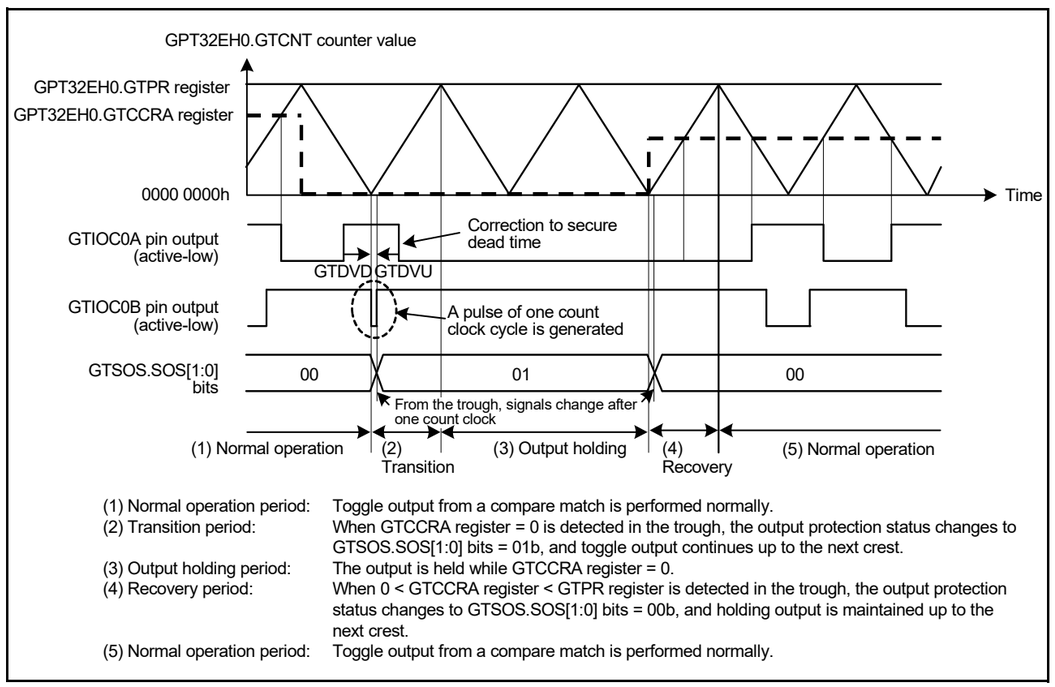
(1)正常运营期：(2)过渡期：比较匹配的切换输出正常执行。当谷底检测到GTCCRA寄存器=0时，输出保护状态变为GTSOS.SOS[1:0]位=01b，并且切换输出持续到下一个波峰。
(3)输出保持期：(4)恢复期：当GTCCRA寄存器=0时保持输出。当波谷中检测到0<GTCCRA寄存器<GTPR寄存器时，输出保护状态变为GTSOS.SOS[1:0]位=00b，保持输出保持到下一个波峰。比较匹配的切换输出正常执行。
(5)正常运营期：

Figure 22.98 输出保护操作示例，当GTCCRA在谷底缓冲区传输期间设置为0，0<GTCCRA<GTPR在谷底缓冲区传输期间恢复，低电平有效



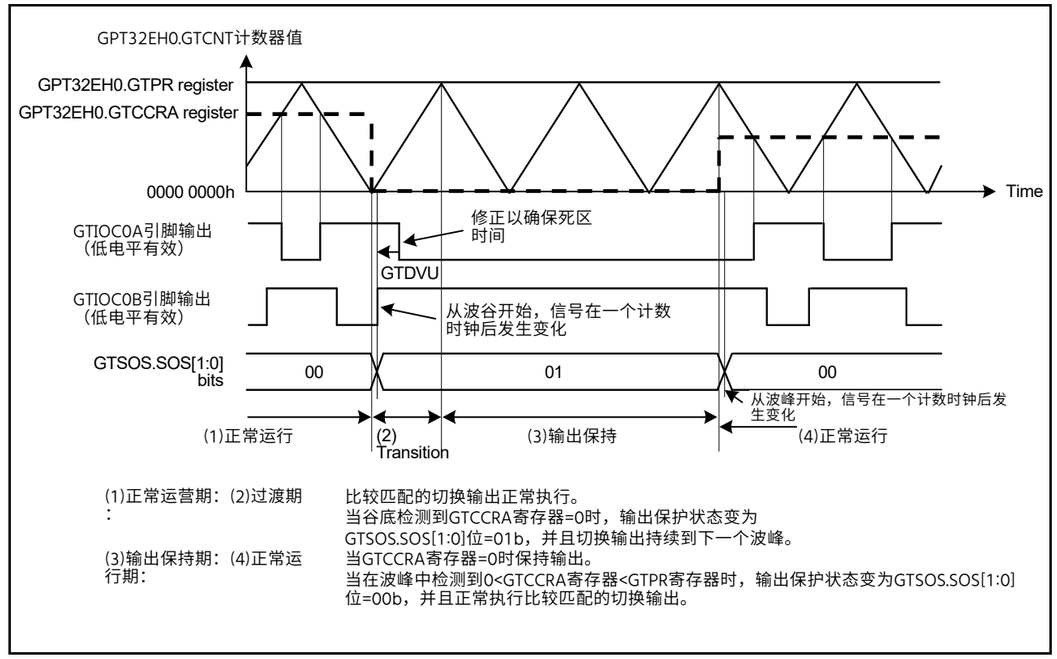
(1) Normal operation period: Toggle output from a compare match is performed normally.
(2) Transition period: When GTCCRA register = 0 is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 01b, and toggle output continues up to the next crest.
(3) Output holding period: The output is held while GTCCRA register = 0.
(4) Normal operation period: When 0 < GTCCRA register < GTPR register is detected in the crest, the output protection status changes to GTSOS.SOS[1:0] bits = 00b, and toggle output from a compare match is performed normally.

Figure 22.99 Example of output protection operation when GTCCRA is set to 0 during buffer transfer at troughs, with 0 < GTCCRA < GTPR restored during buffer transfer at crests, and active-low



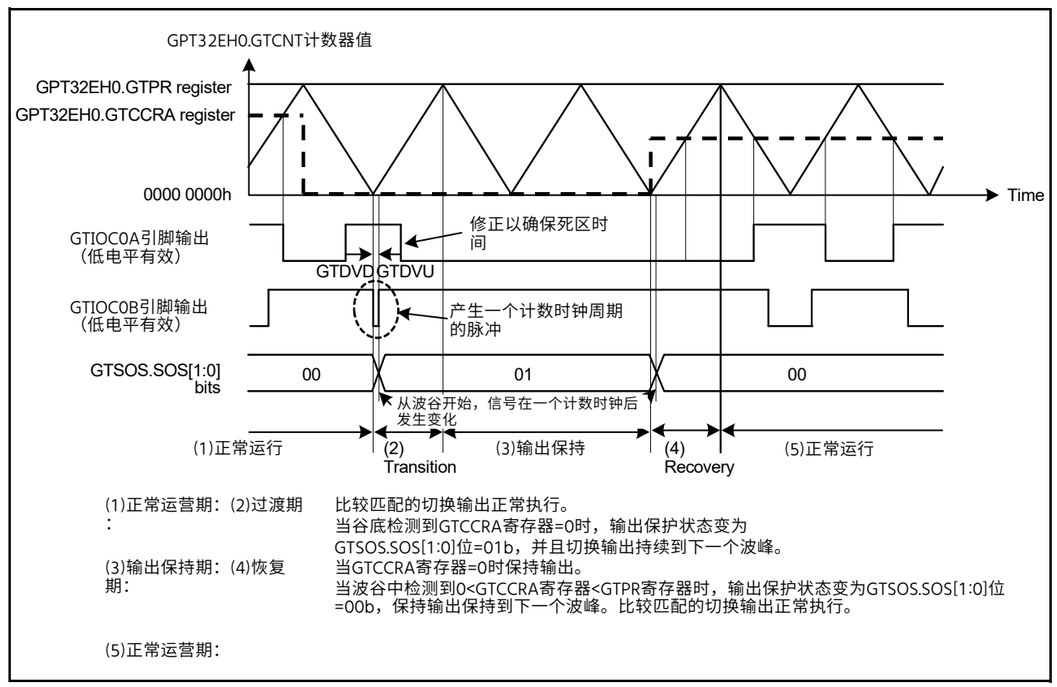
(1) Normal operation period: Toggle output from a compare match is performed normally.
(2) Transition period: When GTCCRA register = 0 is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 01b, and toggle output continues up to the next crest.
(3) Output holding period: The output is held while GTCCRA register = 0.
(4) Recovery period: When 0 < GTCCRA register < GTPR register is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 00b, and holding output is maintained up to the next crest.
(5) Normal operation period: Toggle output from a compare match is performed normally.

Figure 22.100 Example of output protection operation when GTCCRA is set to 0 during buffer transfer at crests, with 0 < GTCCRA < GTPR restored during buffer transfer at troughs, and active-low



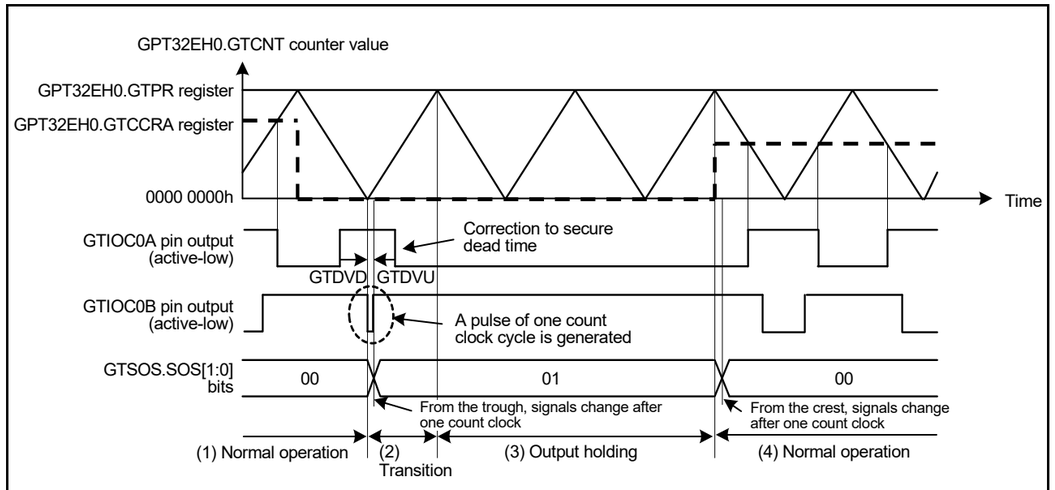
(1)正常运营期：(2)过渡期：比较匹配的切换输出正常执行。
当谷底检测到GTCCRA寄存器=0时，输出保护状态变为GTSOS.SOS[1:0]位=01b，并且切换输出持续到下一个波峰。
(3)输出保持期：(4)正常运行期：当GTCCRA寄存器=0时保持输出。
当在波峰中检测到0<GTCCRA寄存器<GTPR寄存器时，输出保护状态变为GTSOS.SOS[1:0]位=00b，并且正常执行比较匹配的切换输出。

Figure 22.99 输出保护操作示例，当GTCCRA在波谷缓冲传输期间设置为0，0<GTCCRA<GTPR在波峰缓冲传输期间恢复，低电平有效



(1)正常运营期：(2)过渡期：比较匹配的切换输出正常执行。
当谷底检测到GTCCRA寄存器=0时，输出保护状态变为GTSOS.SOS[1:0]位=01b，并且切换输出持续到下一个波峰。
(3)输出保持期：(4)恢复期：当GTCCRA寄存器=0时保持输出。
当波谷中检测到0<GTCCRA寄存器<GTPR寄存器时，输出保护状态变为GTSOS.SOS[1:0]位=00b，保持输出保持到下一个波峰。比较匹配的切换输出正常执行。
(5)正常运营期：

Figure 22.100 在波峰缓冲传输期间GTCCRA设置为0时输出保护操作示例，在波谷缓冲传输期间0<GTCCRA<GTPR恢复，低电平有效

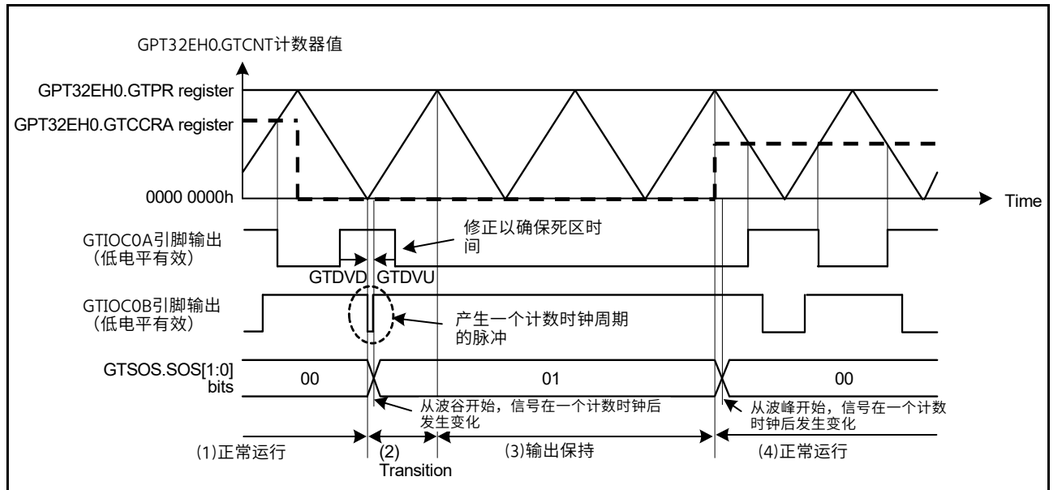


(1) Normal operation period: Toggle output from a compare match is performed normally.
(2) Transition period: When GTCCRA register = 0 is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 01b, and toggle output continues up to the next crest.
(3) Output holding period: The output is held while GTCCRA register = 0.
(4) Normal operation period: When 0 < GTCCRA register < GTPR register Is detected in the crest, the output protection status changes to GTSOS.SOS[1:0] bits = 00b, and toggle output from a compare match is performed normally.

Figure 22.101 Example of output protection operation when GTCCRA is set to 0 during buffer transfer at crests, with 0 < GTCCRA < GTPR restored during buffer transfer at crests, and active-low

22.8.4.2 Output protection function when GTCCRA ≥ GTPR is set during buffer transfer at troughs

Figure 22.102 and Figure 22.103 show examples of output protection function operation when GTCCRA ≥ GTPR is set during buffer transfer at troughs.

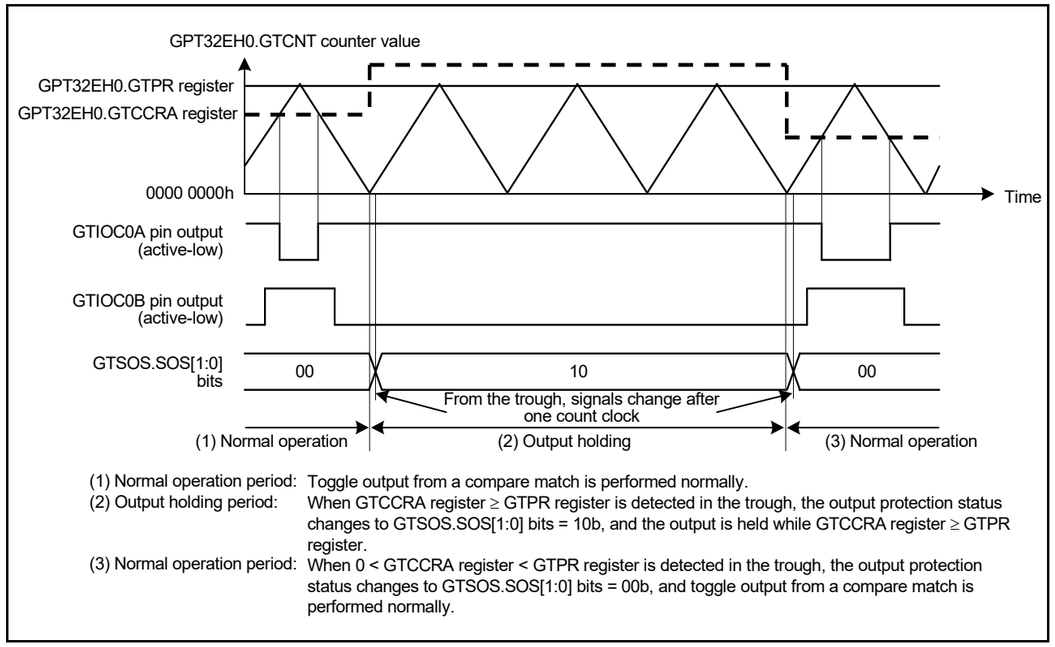


(1)正常运营期：(2)过渡期：比较匹配的切换输出正常执行。
当谷底检测到GTCCRA寄存器=0时，输出保护状态变为GTSOS.SOS[1:0]位=01b，并且切换输出持续到下一个波峰。
(3)输出保持期：(4)正常运行期：当GTCCRA寄存器=0时保持输出。
当波峰中检测到0<GTCCRA寄存器<GTPR寄存器时，输出保护状态变为GTSOS.SOS[1:0]位=00b，并且正常执行比较匹配的切换输出。

Figure 22.101 峰值缓冲传输期间GTCCRA设置为0时的输出保护操作示例，0<GTCCRA<GTPR在峰值缓冲传输期间恢复，低电平有效

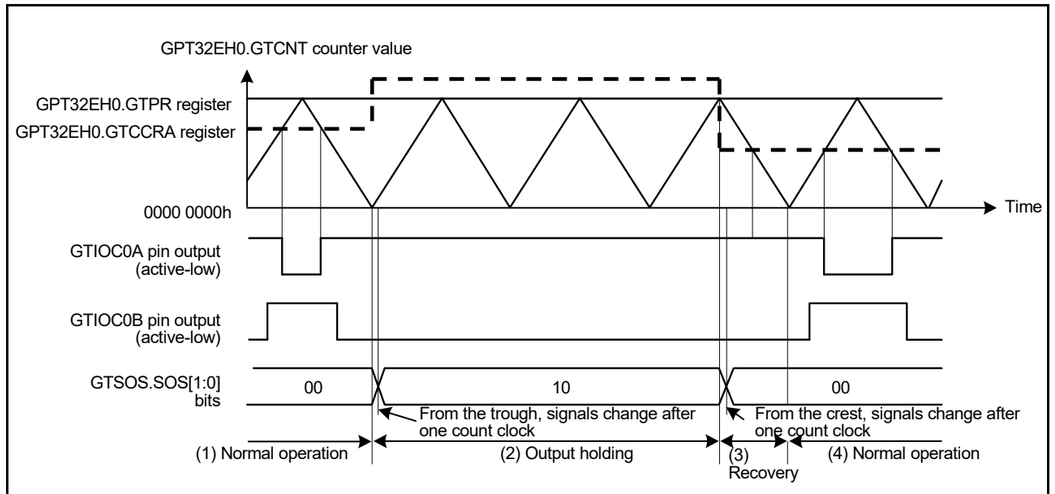
22.8.4.2 谷底缓冲转移时设定GTCCRA≥GTPR时的输出保护功能

图22.102和图22.103显示了在波谷缓冲传输期间设置GTCCRA≥GTPR时的输出保护功能操作示例。



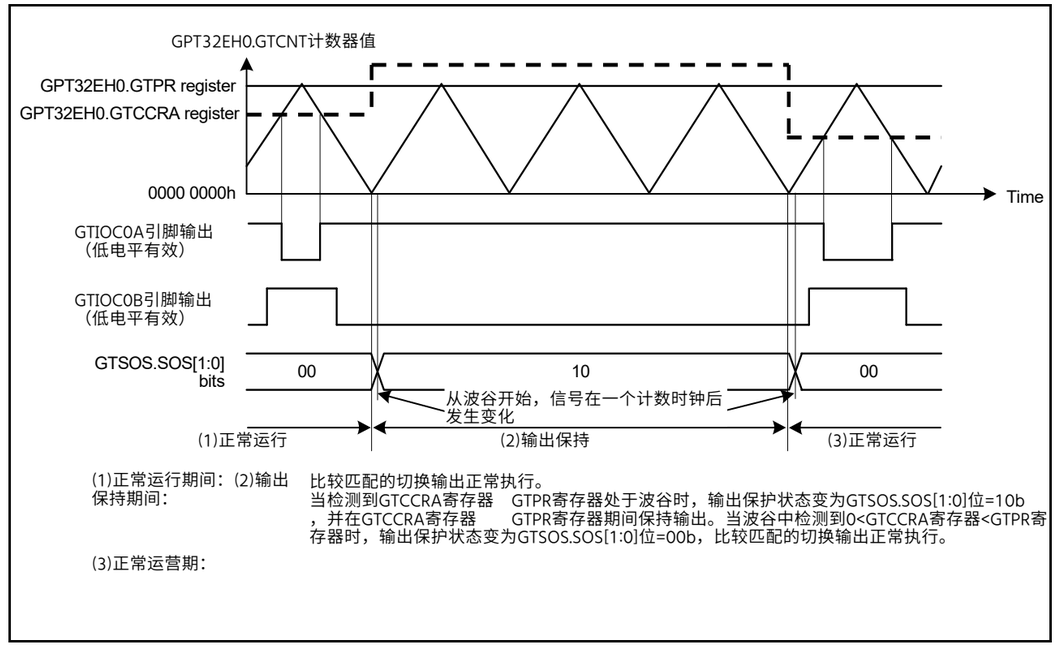
(1) Normal operation period: Toggle output from a compare match is performed normally.
(2) Output holding period: When GTCCRA register ≥ GTPR register is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 10b, and the output is held while GTCCRA register ≥ GTPR register.
(3) Normal operation period: When 0 < GTCCRA register < GTPR register is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 00b, and toggle output from a compare match is performed normally.

Figure 22.102 Example of output protection operation when GTCCRA ≥ GTPR is set during buffer transfer at troughs, with 0 < GTCCRA < GTPR restored during buffer transfer at troughs, and active-low



(1) Normal operation period: Toggle output from a compare match is performed normally.
(2) Output holding period: When GTCCRA register ≥ GTPR register is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 10b, and the output is held while GTCCRA register ≥ GTPR register.
(3) Recovery period: When 0 < GTCCRA register < GTPR register is detected in the crest, the output protection status changes to GTSOS.SOS[1:0] bits = 00b, and holding output is maintained up to the next trough.
(4) Normal operation period: Toggle output from a compare match is performed normally.

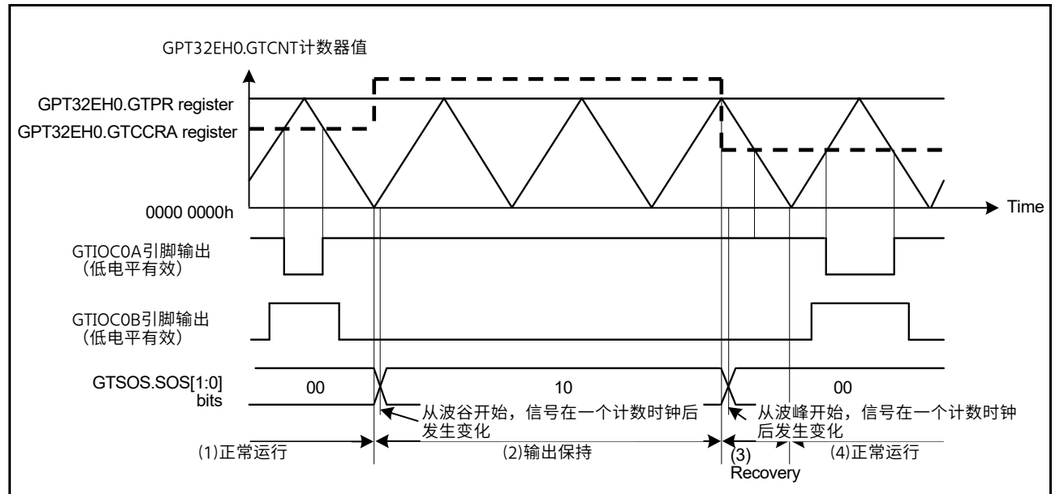
Figure 22.103 Example of output protection operation when GTCCRA ≥ GTPR is set during buffer transfer at troughs, with 0 < GTCCRA < GTPR restored during buffer transfer at crests, and active-low



(1)正常运行期间：(2)输出保持期间：比较匹配的切换输出正常执行。
当检测到GTCCRA寄存器 GTPR寄存器处于波谷时，输出保护状态变为GTSOS.SOS[1:0]位=10b，并在GTCCRA寄存器 GTPR寄存器期间保持输出。当波谷中检测到0<GTCCRA寄存器<GTPR寄存器时，输出保护状态变为GTSOS.SOS[1:0]位=00b，比较匹配的切换输出正常执行。

(3)正常运营期：

Figure 22.102 输出保护操作示例，当GTCCRA≥GTPR在谷底缓冲区传输期间设置，0<GTCCRA<GTPR在谷底缓冲区传输期间恢复，低电平有效



(1)正常运行期间：(2)输出保持期间：比较匹配的切换输出正常执行。
当检测到GTCCRA寄存器 GTPR寄存器处于波谷时，输出保护状态变为GTSOS.SOS[1:0]位=10b，并在GTCCRA寄存器 GTPR寄存器期间保持输出。当波峰检测到0<GTCCRA寄存器<GTPR寄存器时，输出保护状态变为GTSOS.SOS[1:0]位=00b，并保持输出保持到下一个波谷。比较匹配的切换输出正常执行。

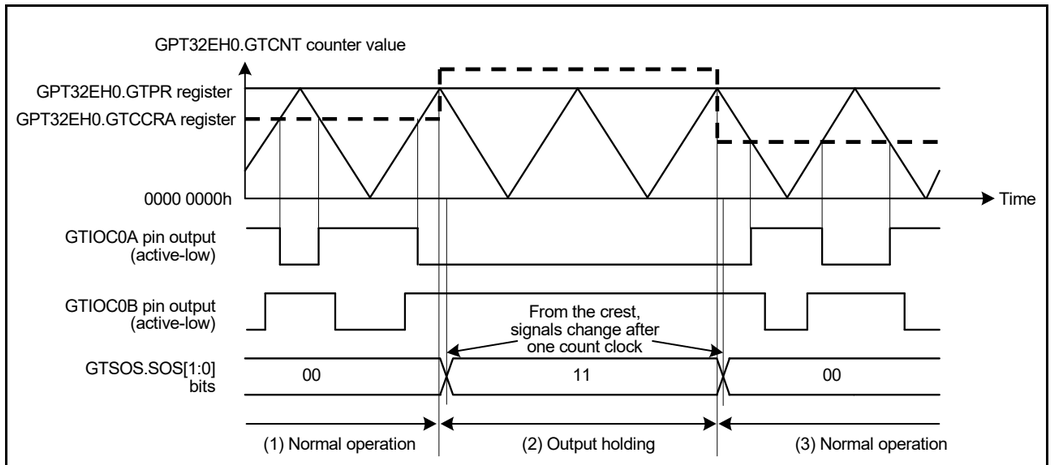
(3) Recovery period:

(4)正常运营期：

Figure 22.103 谷底缓冲传输期间设置GTCCRA≥GTPR时输出保护操作示例，峰值缓冲传输期间0<GTCCRA<GTPR恢复，低电平有效

22.8.4.3 Output protection function when GTCCRA ≥ GTPR is set during buffer transfer at crests

Figure 22.104 and Figure 22.105 show examples of output protection function operation when GTCCRA ≥ GTPR is set during buffer transfer at crests.



(1) Normal operation period: Toggle output from a compare match is performed normally.

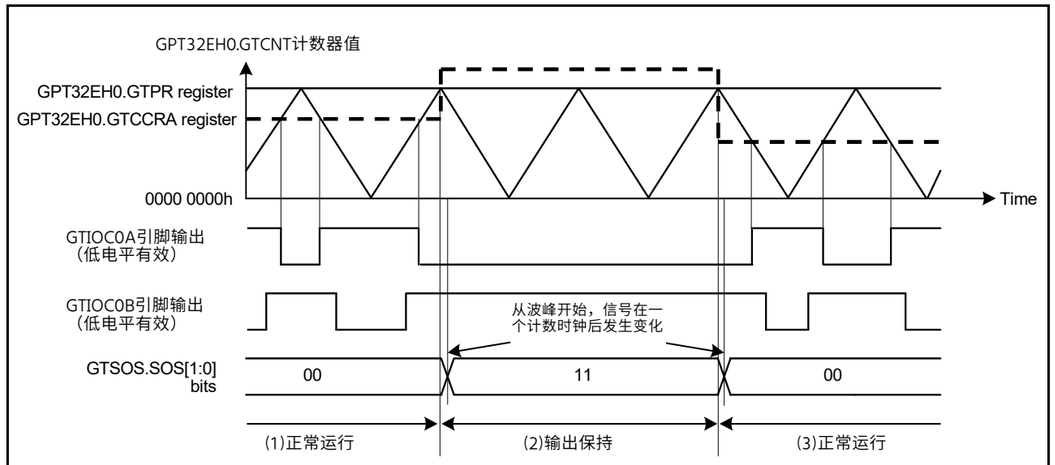
(2) Output holding period: When GTCCRA register ≥ GTPR register is detected in the crest, the output protection status changes to GTSOS.SOS[1:0] bits = 11b, and the output is held while GTCCRA register ≥ GTPR register.

(3) Normal operation period: When 0 < GTCCRA register < GTPR register is detected in the crest, the output protection status changes to GTSOS.SOS[1:0] bits = 00b, and toggle output from a compare match is performed normally.

Figure 22.104 Example of output protection operation when GTCCRA ≥ GTPR is set during buffer transfer at crests, with 0 < GTCCRA < GTPR restored during buffer transfer at crests, and active-low

22.8.4.3 GTCCRA≥GTPR时的输出保护功能在波峰缓冲传输期间设置

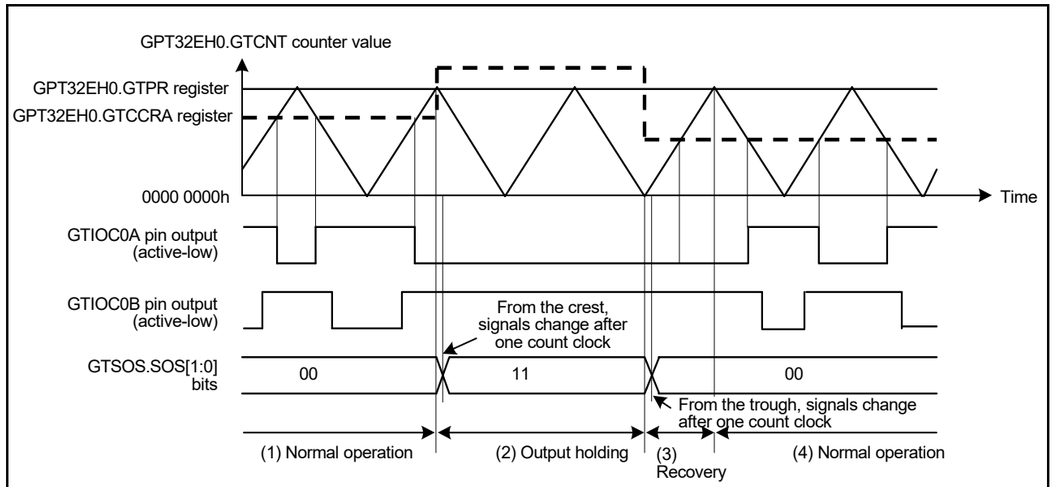
图22.104和图22.105显示了在峰值缓冲区传输期间设置GTCCRA≥GTPR时输出保护功能操作的示例。



(1)正常运行期间：(2)输出保持期间：比较匹配的切换输出正常执行。
当在波峰中检测到GTCCRA寄存器　GTPR寄存器时，输出保护状态变为GTSOS.SOS[1:0]位=11b，并在GTCCRA寄存器　GTPR寄存器期间保持输出。当在波峰中检测到0<GTCCRA寄存器<GTPR寄存器时，输出保护状态变为GTSOS.SOS[1:0]位=00b，并且正常执行比较匹配的切换输出。

(3)正常运营期：

Figure 22.104 输出保护操作示例，当GTCCRA≥GTPR在波峰缓冲传输期间设置，0<GTCCRA<GTPR在波峰缓冲传输期间恢复，低电平有效



(1) Normal operation period: Toggle output from a compare match is performed normally.
(2) Output holding period: When GTCCRA ≥ GTPR is detected in the crest, the output protection status changes to GTSOS.SOS[1:0] = 11b, and the output is held while GTCCRA ≥ GTPR.
(3) Recovery period: When 0 < GTCCRA < GTPR is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] = 00b, and holding output is maintained up to the next crest.
(4) Normal operation period: Toggle output from a compare match is performed normally.

Figure 22.105 Example of output protection function operation when GTCCRA ≥ GTPR is set during buffer transfer at crests, with 0 < GTCCRA < GTPR restored during buffer transfer at troughs, and active-low

22.8.4.4 Restricted specification of output protection function

The value of the GTCCRA register must be set within the range of (0 < GTCCRA < GTPR) at count start. If an incorrect value is set in the GTCCRA register during counting (a setting outside the range of 0 < GTCCRA < GTPR), the output protection function deactivates the level of one of the positive and negative outputs.

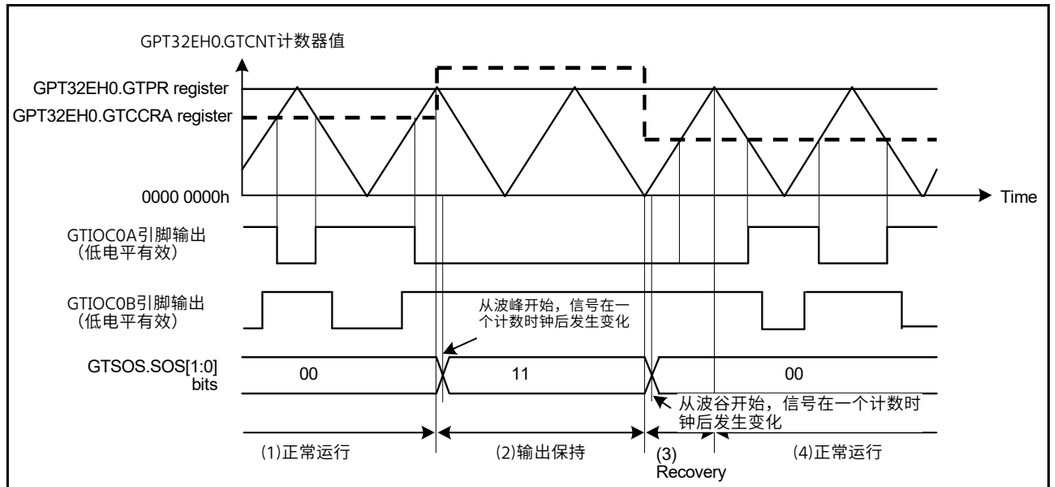
The function does not operate correctly if the following condition is not satisfied:

- 0 < GTCCRA < GTPR when counting starts.

22.8.4.5 Temporary cancellation of output protection function

When the GTSOTR.SOTR bit is set to 1 with GTSOS.SOS[1:0] bits equal to 10b (showing output protection state by GTCCRA ≥ GTPR during buffer transfer at troughs), the output protection function for GTIOCB pin is temporarily canceled. GTSOS.SOS[1:0] bits retain the value of 10b even when the output protection function is canceled. When the SOTR bit is set to 0, the output protection function for GTIOCB pin resumes.

Figure 22.106 shows examples of temporary cancellation of output protection function operation when the GTCCRA ≥ GTPR is set during buffer transfer at troughs.



(1)正常运行期间：(2)输出保持期间： 比较匹配的切换输出正常执行。当波峰检测到GTCCRA GTPR时，输出保护状态变为GTSOS.SOS[1:0]=11b，并且在GTCCRA GTPR时保持输出。
(3) Recovery period: 当波谷检测到0<GTCCRA<GTPR时，输出保护状态变为GTSOS.SOS[1:0]=00b，保持输出保持到下一个波峰。
(4)正常运营期： 比较匹配的切换输出正常执行。

Figure 22.105 峰值缓冲传输期间设置GTCCRA≥GTPR时输出保护功能操作示例，在谷值缓冲传输期间0<GTCCRA <GTPR恢复，低电平有效

22.8.4.4 输出保护功能限制规格

GTCCRA寄存器的值必须在计数开始时设置在(0<GTCCRA<GTPR)的范围内。如果在计数期间在GTCCRA寄存器中设置了不正确的值（设置超出了0<GTCCRA<GTPR的范围），则输出保护功能会停用正输出和负输出之一的电平。

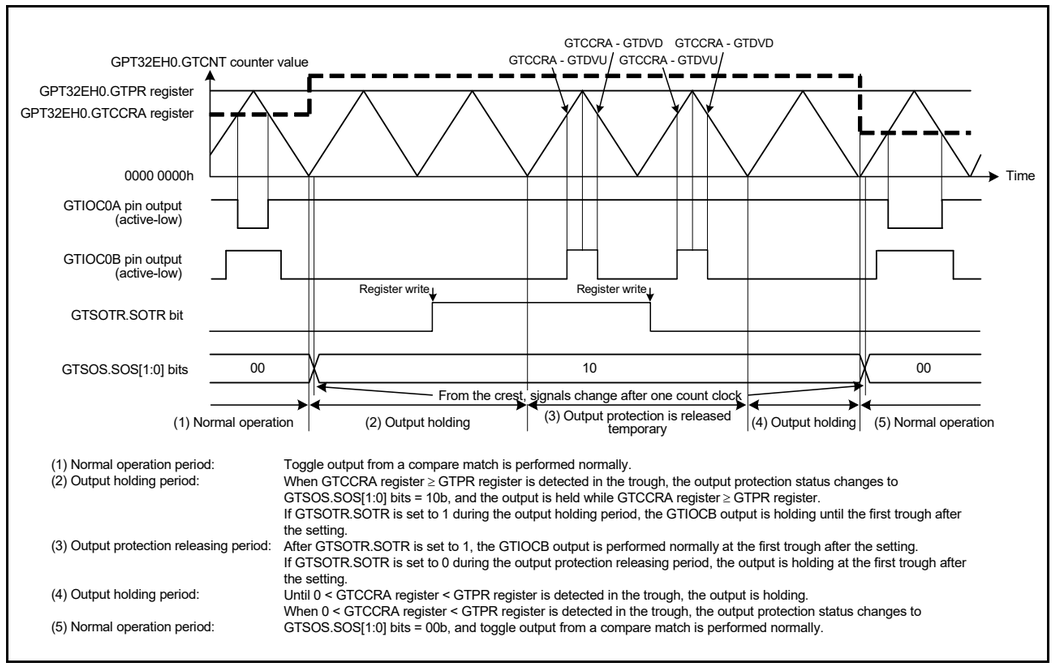
如果不满足以下条件，该功能将无法正常运行：

- 0<GTCCRA<GTPR计数开始时。

22.8.4.5 输出保护功能暂时取消

当GTSOTR.SOTR位设置为1且GTSOS.SOS[1:0]位等于10b时（显示输出保护状态
GTCCRA≥GTPR在低谷缓冲传输期间），GTIOCB引脚的输出保护功能被暂时取消。即使取消了输出保护功能，GTSOS.SOS[1:0]位也保持10b的值。当SOTR位设置为0时，GTIOCB引脚的输出保护功能恢复。

图22.106显示了当GTCCRA≥时输出保护功能操作暂时取消的示例
GTPR在波谷的缓冲区传输期间设置。



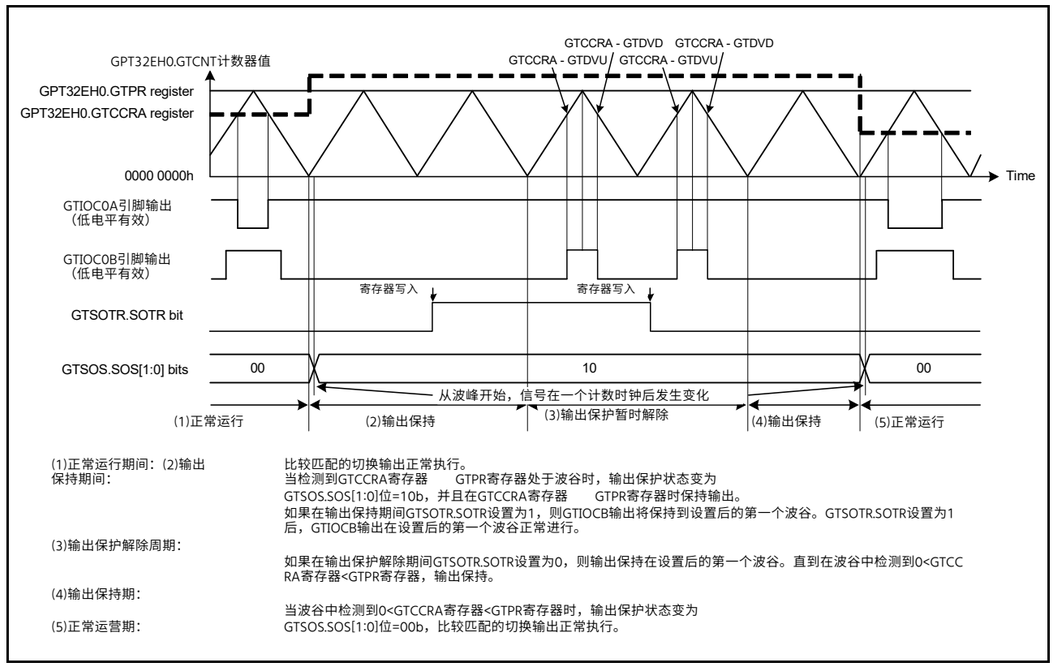
(1) Normal operation period:	Toggle output from a compare match is performed normally.
(2) Output holding period:	When GTCCRA register ≥ GTPR register is detected in the trough, the output protection status changes to GTSOS.SOS[1:0] bits = 10b, and the output is held while GTCCRA register ≥ GTPR register. If GTSOTR.SOTR is set to 1 during the output holding period, the GTIOCB output is holding until the first trough after the setting.
(3) Output protection releasing period:	After GTSOTR.SOTR is set to 1, the GTIOCB output is performed normally at the first trough after the setting. If GTSOTR.SOTR is set to 0 during the output protection releasing period, the output is holding at the first trough after the setting.
(4) Output holding period:	Until 0 < GTCCRA register < GTPR register is detected in the trough, the output is holding. When 0 < GTCCRA register < GTPR register is detected in the trough, the output protection status changes to
(5) Normal operation period:	GTSOS.SOS[1:0] bits = 00b, and toggle output from a compare match is performed normally.

Figure 22.106 Example of temporary cancellation of output protection function operation when GTCCRA ≥ GTPR is set during buffer transfer at troughs, with 0 < GTCCRA < GTPR restored during buffer transfer at troughs, and active-low

22.9 Initialization Method of Output Pins

22.9.1 Pin Settings after Reset

The GPT registers are initialized at a reset. Start counting after selecting the port pin function with the PmnPFS register, setting GTIOR.OAE and GTIOR.OBE bits, and outputting the GPT function to external pins.



(1)正常运行期间：(2)输出保持期间：	比较匹配的切换输出正常执行。 当检测到GTCCRA寄存器 GTPR寄存器处于波谷时，输出保护状态变为GTSOS.SOS[1:0]位=10b，并且在GTCCRA寄存器 GTPR寄存器时保持输出。 如果在输出保持期间GTSOTR.SOTR设置为1，则GTIOCB输出将保持到设置后的第一个波谷。GTSOTR.SOTR设置为1后，GTIOCB输出在设置后的第一个波谷正常进行。
(3)输出保护解除周期：	如果在输出保护解除期间GTSOTR.SOTR设置为0，则输出保持在设置后的第一个波谷。直到在波谷中检测到0<GTCCRA寄存器<GTPR寄存器，输出保持。
(4)输出保持期：	当波谷中检测到0<GTCCRA寄存器<GTPR寄存器时，输出保护状态变为
(5)正常运营期：	GTSOS.SOS[1:0]位=00b，比较匹配的切换输出正常执行。

Figure 22.106 GTCCRA≥时输出保护功能动作暂时取消的例子

GTPR在波谷缓冲区传输期间设置，0<GTCCRA<GTPR在波谷缓冲区传输期间恢复，低电平有效

22.9 输出管脚的初始化方法

22.9.1 复位后的引脚设置

GPT寄存器在复位时被初始化。通过PmnPFS寄存器选择端口引脚功能，设置GTIOR.OAE和GTIOR.OBE位，并将GPT功能输出到外部引脚后开始计数。

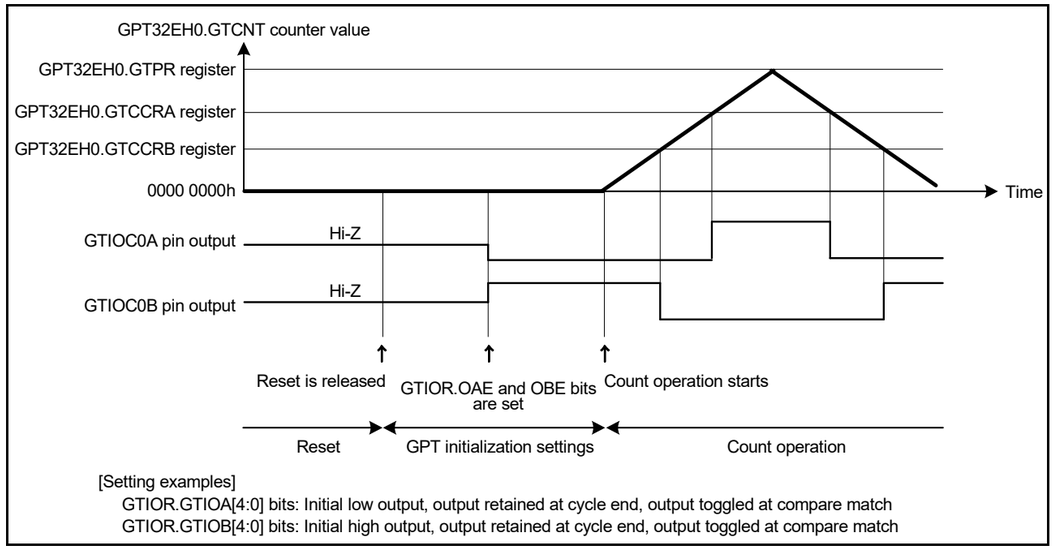


Figure 22.107 Example of pin settings after reset

22.9.2 Pin Initialization Caused by Error during Operation

If an error occurs during GPT operation, the following four types of pin processing can be performed before pin initialization:

- Set the OAHLD and OBHLD bits in GTIOR to 1 and retain the outputs at count stop
- Set the OAHLD and OBHLD bits in GTIOR to 0, specify arbitrary output values of OADFLT and OBDFLT in GTIOR, and output the arbitrary values on count stop
- Set the pin to output an arbitrary value as a general output port by setting the PDR, PODR, and PmnPFS registers of the I/O port in advance. Set the OAE and OBE bits in GTIOR to 0, and the control bit associated with the pin in PmnPFS.PMR to 0 to allow arbitrary values to be output from the pin set as a general output port when an error occurs.
- Drive the output to a high impedance state using the POEG function.

When the automatic dead time setting is made, clear the GTDTCR.TDE bit to 0 after counting stops. When counting stops, only the values of registers that are changed by a GPT external source change. If counting resumes, operation continues from where it stopped. If counting stops, registers must be initialized before counting starts.

22.10 Usage Notes

22.10.1 Module-Stop Function Setting

The Module Stop Control Register can enable or disable GPT operation. The GPT module is initially stopped after a reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

22.10.2 GTCCRn Settings during Compare Match Operation (n = A to F)

(1) When automatic dead time setting is made in triangle-wave PWM mode

The GTCCRA register must satisfy all of the following conditions:

- GTDVU < GTCCRA
- GTDVD < GTCCRA
- GTCCRA < GTPR.

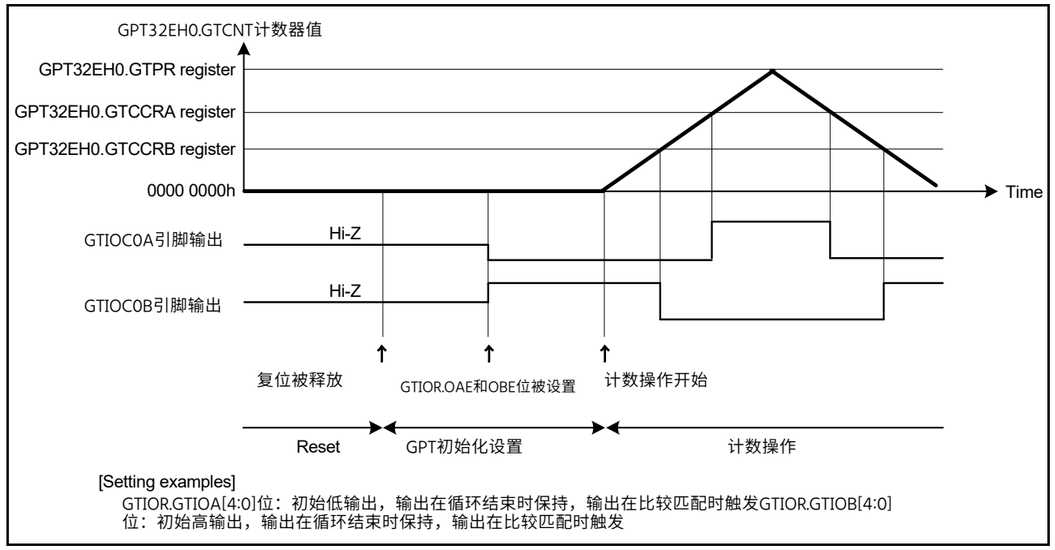


Figure 22.107 复位后的引脚设置示例

22.9.2 操作错误导致的引脚初始化

如果在GPT操作过程中发生错误，可以在引脚初始化之前进行以下四种引脚处理：

- 将GTIOR中的OAHLD和OBHLD位设置为1，并在计数停止时保留输出
- 将GTIOR中的OAHLD和OBHLD位设置为0，指定OADFLT和OBDFLT的任意输出值GTIOR，并在计数停止时输出任意值
- 通过预先设置IO端口的PDR、PODR和PmnPFS寄存器，将引脚设置为输出任意值作为通用输出端口。将GTIOR中的OAE和OBE位设置为0，并将与PmnPFS.PMR中的引脚相关的控制位设置为0，以允许在发生错误时从设置为通用输出端口的引脚输出任意值。
- 使用POEG功能将输出驱动到高阻抗状态。

进行自动死区时间设置时，计数停止后将GTDTCR.TDE位清零。当计数停止时，只有被GPT外部源改变的寄存器的值会改变。如果计数恢复，则操作从停止处继续。如果计数停止，则必须在计数开始前初始化寄存器。

22.10 使用说明

22.10.1 模块停止功能设置

模块停止控制寄存器可以启用或禁用GPT操作。GPT模块在复位后最初停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

22.10.2 比较匹配操作期间的GTCCRn设置（n=A到F）

(1) 在三角波PWM模式下进行自动死区时间设置时

GTCCRA寄存器必须满足以下所有条件：

- GTDVU < GTCCRA
- GTDVD < GTCCRA
- GTCCRA < GTPR.

When the setting of GTCCRA = 0 or GTCCRA ≥ GTPR is made during count operation, the output protection function is activated.

However, the function does not operate correctly if the following condition is not satisfied:

- 0 < GTCCRA < GTPR when counting starts.

For details, see section 22.8.4, Output Protection Function for GTIOC Pin Output.

(2) When automatic dead time setting is not made in triangle-wave PWM mode

The GTCCRA register must be set within the range of 0 < GTCCRA < GTPR. If GTCCRA = 0 or GTCCRA = GTPR is set, a compare match occurs within the cycle only when GTCCRA = 0 or GTCCRA = GTPR is satisfied. When GTCCRA > GTPR, no compare match occurs.

Similarly, GTCCRB must be set within the range of 0 < GTCCRB < GTPR. If GTCCRB = 0 or GTCCRB = GTPR is set, a compare match occurs within the cycle only when GTCCRB = 0 or GTCCRB = GTPR is satisfied. When GTCCRB > GTPR, no compare match occurs.

(3) When automatic dead time setting is made in saw-wave one-shot pulse mode

The GTCCRC and GTCCRD registers must be set to satisfy the following restrictions. If the restrictions are not satisfied, correct output waveforms with secured dead time might not be obtained:

- In up-counting: GTCCRC < GTCCRD, GTCCRC > GTDVU, GTCCRD < GTPR - GTDVD
- In down-counting: GTCCRC > GTCCRD, GTCCRC < GTPR - GTDVU, GTCCRD > GTDVD.

(4) When automatic dead time setting is not made in saw-wave one-shot pulse mode

The GTCCRC and GTCCRD registers must be set to satisfy the following restrictions. If the restrictions are not satisfied, two compare matches do not occur and pulse output cannot be performed:

- In up-counting: 0 < GTCCRC < GTCCRD < GTPR
- In down-counting: GTPR > GTCCRC > GTCCRD > 0.

Similarly, GTCCRE and GTCCRF must be set to satisfy the following restrictions. If the restrictions are not satisfied, two compare matches do not occur and pulse output cannot be performed:

- In up-counting: 0 < GTCCRE < GTCCRF < GTPR
- In down-counting: GTPR > GTCCRE > GTCCRF > 0.

(5) In saw-wave PWM mode

The GTCCRA register must be set with the range of 0 < GTCCRA < GTPR. If GTCCRA = 0 or GTCCRA = GTPR is set, a compare match occurs within the cycle only when GTCCRA = 0 or GTCCRA = GTPR is satisfied. If GTCCRA > GTPR is set, no compare match occurs.

Similarly, GTCCRB must be set with the range of 0 < GTCCRB < GTPR. If GTCCRB = 0 or GTCCRB = GTPR is set, a compare match occurs within the cycle only when GTCCRB = 0 or GTCCRB = GTPR is satisfied. If GTCCRB > GTPR is set, no compare match occurs.

22.10.3 Setting Range for the GTCNT Counter

The GTCNT counter register must be set with the range of 0 ≤ GTCNT ≤ GTPR.

22.10.4 Starting and Stopping the GTCNT Counter

The control timing of starting and stopping the GTCNT counter by the GTCR.CST bit synchronizes the count clock that is selected in GTCR.TPCS[2:0]. When GTCR.CST is updated, the GTCNT counter starts/stops after a count clock selected in GTCR.TPCS[2:0]. Therefore, an event generated before the GTCNT counter actually starts is ignored. On the other hand, there might be cases where an event is accepted or an interrupt occurs after GTCR.CST is set to 0.

当在计数操作期间设置GTCCRA=0或GTCCRA≥GTPR时，输出保护功能被激活。

但是，如果不满足以下条件，该功能将无法正常运行：

- 0<GTCCRA<GTPR计数开始时。

有关详细信息，请参见第22.8.4节，GTIOC引脚输出的输出保护功能。

(2) 在三角波PWM模式下未进行自动死区时间设置时

GTCCRA寄存器必须设置在0<GTCCRA<GTPR的范围内。如果设置了GTCCRA=0或GTCCRA=GTPR，则仅当满足GTCCRA=0或GTCCRA=GTPR时，才会在周期内发生比较匹配。当GTCCRA>GTPR时，不发生比较匹配。

同样，GTCCRB必须设置在0<GTCCRB<GTPR的范围内。如果设置了GTCCRB=0或GTCCRB=GTPR，则仅当满足GTCCRB=0或GTCCRB=GTPR时，才会在周期内发生比较匹配。当GTCCRB>GTPR时，不发生比较匹配。

(3) 在锯波单发脉冲模式下进行自动死区时间设置时

GTCCRC和GTCCRD寄存器必须设置为满足以下限制。如果不满足限制条件，则可能无法获得具有安全死区时间的正确输出波形：

- In up-counting: GTCCRC < GTCCRD, GTCCRC > GTDVU, GTCCRD < GTPR - GTDVD
- In down-counting: GTCCRC > GTCCRD, GTCCRC < GTPR - GTDVU, GTCCRD > GTDVD.

(4) 在锯波单发脉冲模式下未进行自动死区时间设置时

GTCCRC和GTCCRD寄存器必须设置为满足以下限制。如果不满足限制，则不会发生两次比较匹配，并且无法执行脉冲输出：

- In up-counting: 0 < GTCCRC < GTCCRD < GTPR
- In down-counting: GTPR > GTCCRC > GTCCRD > 0.

同样，必须设置GTCCRE和GTCCRF以满足以下限制。如果不满足限制，则不会发生两次比较匹配，并且无法执行脉冲输出：

- In up-counting: 0 < GTCCRE < GTCCRF < GTPR
- In down-counting: GTPR > GTCCRE > GTCCRF > 0.

(5) 在锯齿波PWM模式下

GTCCRA寄存器必须设置为0<GTCCRA<GTPR。如果设置了GTCCRA=0或GTCCRA=GTPR，则仅当满足GTCCRA=0或GTCCRA=GTPR时，才会在周期内发生比较匹配。如果设置了GTCCRA>GTPR，则不会发生比较匹配。

类似地，GTCCRB必须设置在0<GTCCRB<GTPR的范围内。如果设置了GTCCRB=0或GTCCRB=GTPR，则仅当满足GTCCRB=0或GTCCRB=GTPR时，才会在周期内发生比较匹配。如果设置了GTCCRB>GTPR，则不会发生比较匹配。

22.10.3 GTCNT计数器的设置范围

GTCNT计数器寄存器的设置范围必须为0≤GTCNT≤GTPR。

22.10.4 启动和停止GTCNT计数器

通过GTCR.CST位启动和停止GTCNT计数器的控制时序与在GTCR.TPCS[2:0]中选择的计数时钟同步。当GTCR.CST更新时，GTCNT计数器在GTCR.TPCS[2:0]中选择的计数时钟后开始停止。因此，在GTCNT计数器实际启动之前生成的事件将被忽略。另一方面，在GTCR.CST设置为0之后，可能会接受事件或发生中断。

22.10.5 Priority Order of Each Event

(1) GTCNT register

Table 22.24 shows a priority order of events updating GTCNT register.

Table 22.24 Priority order of sources updating GTCNT

Source updating GTCNT	Priority order
Writing by CPU (writing to GTCNT/GTCLR)	High ↑
Clear by hardware sources set in GTCSR	
Count up or down by hardware sources set in GTUPSR/GTDNSR	
Count operation	Low

If up-counting and down-counting by hardware sources occur at the same time, the GTCNT counter value does not change. When there is a conflict between updating the GTCNT register and reading by the CPU, pre-update data is read.

(2) GTCR.CST bit

When there is a conflict between starting/stopping by hardware sources set in the GTSSR/GTPSR registers and writing by the CPU (writing to GTCR/GTSTR/GTSTP registers), writing by CPU has priority over starting/stopping by hardware sources.

When there is a conflict between starting by hardware sources set in the GTSSR register and stopping by hardware sources set in GTPSR register, the GTCR.CST bit value does not change. Where there is a conflict between updating the GTCR.CST bit and reading by the CPU, pre-update data is read.

(3) GTCCRm registers (m = A to F)

When there is a conflict between input capture/buffer transfer operation and writing to GTCCRm registers, writing to GTCCRm registers has priority over input capture/buffer transfer operation. When there is a conflict between input capture and writing to the counter register by the CPU or updating the counter register by hardware sources, the pre-update counter value is captured. Where there is a conflict between updating the GTCCRm registers and reading by the CPU, pre-update data is read.

(4) GTPR registers

When there is a conflict between buffer transfer operation and writing to the GTPR register, writing to GTPR register has priority over buffer transfer operation. When there is a conflict between updating GTPR register and reading by the CPU, pre-update data is read.

(5) GTADTRm registers (m = A, B)

When there is a conflict between buffer transfer operation and writing to the GTADTRm registers, writing to the GTADTRm registers has priority over buffer transfer operation. When there is a conflict between updating GTADTRm registers and reading by the CPU, pre-update data is read.

(6) GTDVm registers (m = U, D)

When there is a conflict between buffer transfer operation and writing to GTDVm registers, writing to GTDVm registers has priority over buffer transfer operation. When there is a conflict between updating GTDVm registers and reading by the CPU, pre-update data is read.

22.10.5 每个事件的优先顺序

(1) GTCNT register

表22.24显示了更新GTCNT寄存器的事件的优先级顺序。

Table 22.24 更新GTCNT的源的优先顺序

源更新GTCNT	优先顺序
CPU写入（写入GTCNTGTCLR）	High ↑
由GTCSR中设置的硬件源清除	
通过GTUPSRGTDNSR中设置的硬件源进行向上或向下计数	
计数操作	Low

如果硬件源的递增计数和递减计数同时发生，GTCNT计数器值不会改变。当更新GTCNT寄存器和CPU读取之间存在冲突时，会读取更新前的数据。

(2) GTCR.CST bit

当GTSSRGTPSR寄存器中设置的硬件源启动停止与CPU写入（写入GTCRGTSTRGTSTP寄存器）发生冲突时，CPU写入优先于硬件源启动停止。

当GTSSR寄存器中设置的硬件源启动和GTPSR寄存器中设置的硬件源停止之间存在冲突时，GTCR.CST位的值不会改变。如果更新GTCR.CST位与CPU读取之间存在冲突，则读取更新前的数据。

(3) GTCCRm寄存器（m=A到F）

当输入捕捉缓冲区传输操作和写入GTCCRm寄存器之间存在冲突时，写入GTCCRm寄存器优先于输入捕捉缓冲区传输操作。当输入捕获与CPU写入计数器寄存器或硬件源更新计数器寄存器之间存在冲突时，会捕获更新前的计数器值。如果更新GTCCRm寄存器和CPU读取之间存在冲突，则读取更新前的数据。

(4) GTPR registers

当缓冲区传输操作与写入GTPR寄存器之间存在冲突时，写入GTPR寄存器优先于缓冲区传输操作。当更新GTPR寄存器与CPU读取发生冲突时，读取更新前的数据。

(5) GTADTRm registers (m = A, B)

当缓冲区传输操作和写入GTADTRm寄存器之间存在冲突时，写入GTADTRm寄存器优先于缓冲区传输操作。当更新GTADTRm寄存器与CPU读取之间存在冲突时，会读取更新前的数据。

(6) GTDVm registers (m = U, D)

当缓冲区传输操作和写入GTDVm寄存器之间存在冲突时，写入GTDVm寄存器优先于缓冲区传输操作。当更新GTDVm寄存器和CPU读取之间存在冲突时，会读取更新前的数据。

23. PWM Delay Generation Circuit

23.1 Overview

The MCU has four channel delay circuits that can connect to the General PWM Timer (GPT). Table 23.1 lists the PWM Delay Generation Circuit specifications, Figure 23.1 shows a block diagram, and Table 23.2 lists the I/O pins.

Table 23.1 PWM delay generation circuit specifications

Parameter	Specifications
Function	The circuit can control the timing with which signals on the two PWM output pins for channel 0/1/2/3 rise and fall to an accuracy of up to 1/32 times the period of the GPT clock (PCLKD)

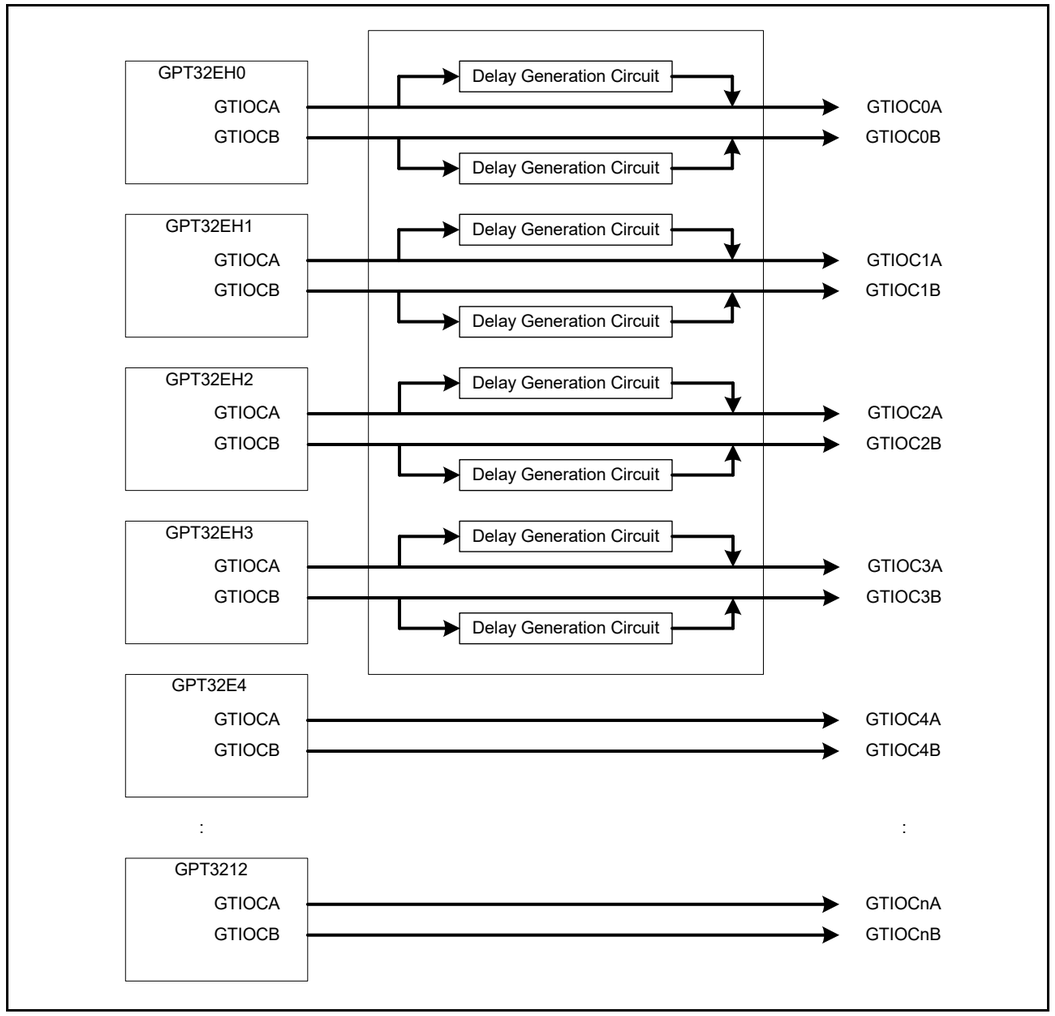


Figure 23.1 PWM delay generation circuit block diagram

23. PWM延迟产生电路

23.1 Overview

MCU有四个通道延迟电路，可以连接到通用PWM定时器(GPT)。表23.1列出了PWM延迟生成电路规范，图23.1显示了框图，表23.2列出了IO引脚。

Table 23.1 PWM延迟产生电路规格

Parameter	Specifications
Function	该电路可以控制通道0123的两个PWM输出引脚上的信号上升和下降的时序，精度高达GPT时钟(PCLKD)周期的132倍

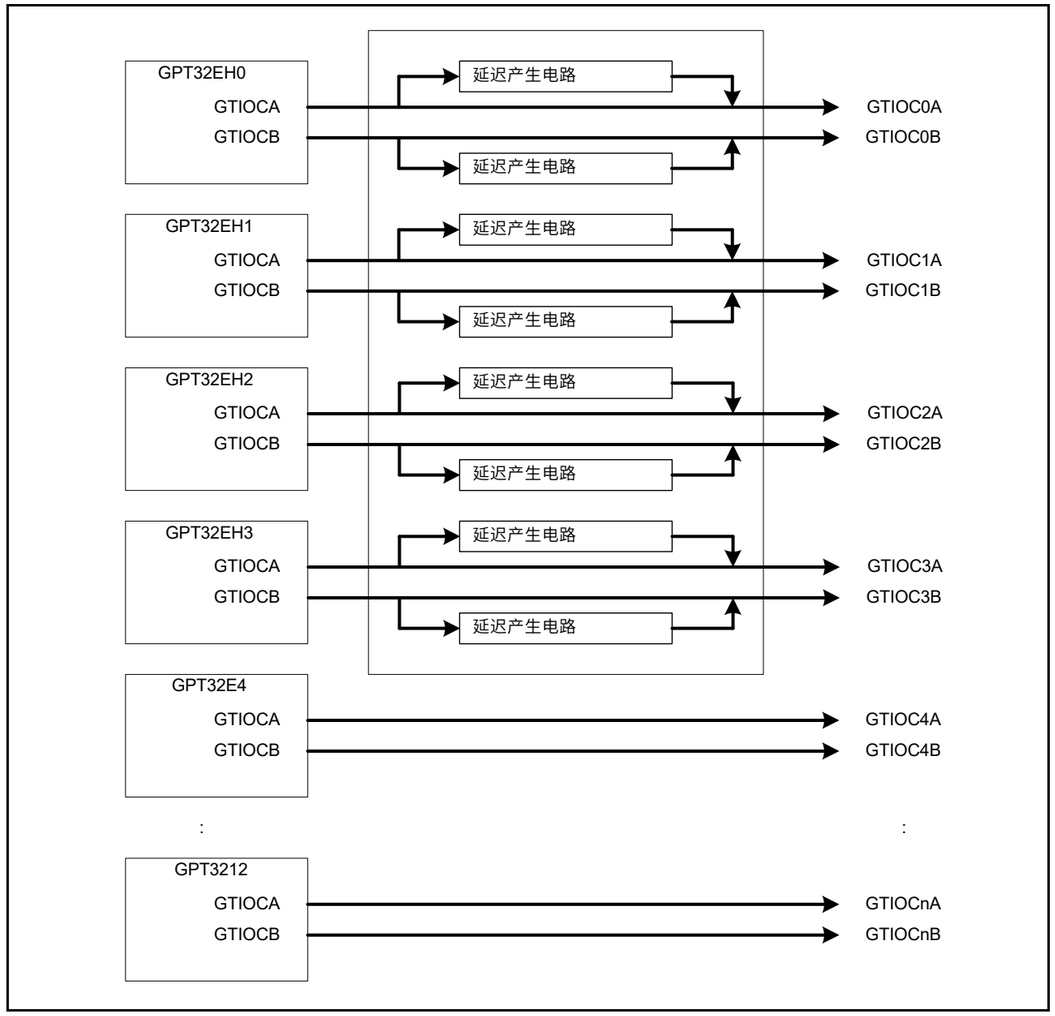


Figure 23.1 PWM延迟产生电路框图

Table 23.2 PWM delay generation circuit I/O pins

I/O pin	I/O	Function
GTIOC0A	Output	Delayed output of GTIOCA pin for GPT channel 0
GTIOC0B	Output	Delayed output of GTIOCB pin for GPT channel 0
GTIOC1A	Output	Delayed output of GTIOCA pin for GPT channel 1
GTIOC1B	Output	Delayed output of GTIOCB pin for GPT channel 1
GTIOC2A	Output	Delayed output of GTIOCA pin for GPT channel 2
GTIOC2B	Output	Delayed output of GTIOCB pin for GPT channel 2
GTIOC3A	Output	Delayed output of GTIOCA pin for GPT channel 3
GTIOC3B	Output	Delayed output of GTIOCB pin for GPT channel 3

23.2 Register Descriptions

23.2.1 PWM Output Delay Control Register (GTDLYCR)

Address(es): GPT_ODC.GTDLYCR 4007 B000h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	DLYRST	DLLEN
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DLLEN	DLL Operation Enable	0: DLL operation disabled 1: DLL operation enabled.	R/W
b1	DLYRST	PWM Delay Generation Circuit Reset	0: Normal operation 1: Reset.	R/W
b15 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTDLYCR register controls the PWM delay generation circuit, which applies delays to the PWM outputs. The GTDLYCR can be written when register write protection is disabled (GPT32EH0.GTWP.WP = 0).

DLLEN bit (DLL Operation Enable)

The DLLEN bit selects whether the on-chip DLL in the PWM delay generation circuit is activated or not.

DLYRST bit (PWM Delay Generation Circuit Reset)

The DLYRST bit resets the internal state of the PWM delay generation circuit.

23.2.2 PWM Output Delay Control Register 2 (GTDLYCR2)

Address(es): GPT_ODC.GTDLYCR2 4007 B002h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	DLYEN3	DLYEN2	DLYEN1	DLYEN0	—	—	—	—	DLYBS3	DLYBS2	DLYBS1	DLYBS0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DLYBS0	PWM Delay Generation Circuit bypass for channel 0	0: Delay generation circuit of channel 0 bypassed 1: Delay generation circuit of channel 0 not bypassed.	R/W

Table 23.2 PWM延迟产生电路IO引脚

I/O pin	I/O	Function
GTIOC0A	Output	GPT通道0的GTIOCA引脚延迟输出
GTIOC0B	Output	GPT通道0的GTIOCB引脚延迟输出
GTIOC1A	Output	GPT通道1的GTIOCA引脚延迟输出
GTIOC1B	Output	GPT通道1的GTIOCB引脚延迟输出
GTIOC2A	Output	GPT通道2的GTIOCA引脚延迟输出
GTIOC2B	Output	GPT通道2的GTIOCB引脚延迟输出
GTIOC3A	Output	GPT通道3的GTIOCA引脚延迟输出
GTIOC3B	Output	GPT通道3的GTIOCB引脚延迟输出

23.2 注册说明

23.2.1 PWM输出延迟控制寄存器(GTDLYCR)

Address(es): GPT_ODC.GTDLYCR 4007 B000h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	DLYRST	DLLEN
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DLLEN	DLL操作启用	0：禁用DLL操作1：启用DLL操作。	R/W
b1	DLYRST	PWM延迟产生电路Reset	0：正常运行1：复位。	R/W
b15 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTDLYCR寄存器控制PWM延迟生成电路，该电路将延迟应用于PWM输出。这当寄存器写保护被禁用（GPT32EH0.GTWP.WP=0）时，可以写入GTDLYCR。

DLLEN位（DLL操作使能）

DLLEN位选择是否激活PWM延迟产生电路中的片上DLL。

DLYRST位（PWM延迟产生电路复位）

DLYRST位复位PWM延迟产生电路的内部状态。

23.2.2 PWM输出延迟控制寄存器2(GTDLYCR2)

Address(es): GPT_ODC.GTDLYCR2 4007 B002h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	DLYEN3	DLYEN2	DLYEN1	DLYEN0	—	—	—	—	DLYBS3	DLYBS2	DLYBS1	DLYBS0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DLYBS0	通道0的PWM延迟生成电路旁路	0：通道0的延时产生电路被旁路1：通道0的延时产生电路不被旁路。	R/W

Bit	Symbol	Bit name	Description	R/W
b1	DLYBS1	PWM Delay Generation Circuit bypass for channel 1	0: Delay generation circuit of channel 1 bypassed 1: Delay generation circuit of channel 1 not bypassed.	R/W
b2	DLYBS2	PWM Delay Generation Circuit bypass for channel 2	0: Delay generation circuit of channel 2 bypassed 1: Delay generation circuit of channel 2 not bypassed.	R/W
b3	DLYBS3	PWM Delay Generation Circuit bypass for channel 3	0: Delay generation circuit of channel 3 bypassed 1: Delay generation circuit of channel 3 not bypassed.	R/W
b7 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b8	DLYEN0	PWM Delay Generation Circuit enable for channel 0	0: Delay generation circuit of channel 0 enabled 1: Delay generation circuit of channel 0 disabled.	R/W
b9	DLYEN1	PWM Delay Generation Circuit enable for channel 1	0: Delay generation circuit of channel 1 enabled 1: Delay generation circuit of channel 1 disabled.	R/W
b10	DLYEN2	PWM Delay Generation Circuit enable for channel 2	0: Delay generation circuit of channel 2 enabled 1: Delay generation circuit of channel 2 disabled.	R/W
b11	DLYEN3	PWM Delay Generation Circuit enable for channel 3	0: Delay generation circuit of channel 3 enabled 1: Delay generation circuit of channel 3 disabled.	R/W
b15 to b12	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTDLYCR2 register controls each channel of PWM delay generation circuit. The GTDLYCR2 can be written when register write protection is disabled (GPT32EH0.GTWP.WP = 0).

DLYBSn (n = 0 to 3) bit (PWM Delay Generation Circuit Bypass for channel n)

The DLYBSn bit selects whether delays are applied to PWM output signals from the GTIOCnA and GTIOCnB pins (n = 0 to 3) by the PWM delay generation circuit or whether the circuit is bypassed.

A signal delayed in the PWM delay generation circuit is output 3 PCLKD cycles of GPT operation clock later than if it bypasses the PWM delay generation circuit.

DLYENn (n = 0 to 3) bit (PWM Delay Generation Circuit Enable for channel n)

The DLYENn bit selects whether channel n (n = 0 to 3) of PWM delay generation circuit is power on or off. If channel n of the PWM delay generation circuit is not used, set this bit to 1.

Bit	Symbol	位名称	Description	R/W
b1	DLYBS1	通道1的PWM延迟生成电路旁路	0：通道1的延时产生电路被旁路1：通道1的延时产生电路不被旁路。	R/W
b2	DLYBS2	通道2的PWM延迟生成电路旁路	0：通道2的延迟产生电路被旁路1：通道2的延迟产生电路不被旁路。	R/W
b3	DLYBS3	通道3的PWM延迟生成电路旁路	0：通道3的延时产生电路被旁路1：通道3的延时产生电路不被旁路。	R/W
b7 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b8	DLYEN0	通道0的PWM延迟生成电路使能	0：启用通道0的延迟产生电路1：禁用通道0的延迟产生电路。	R/W
b9	DLYEN1	通道1的PWM延迟生成电路使能	0：通道1的延迟产生电路使能1：通道1的延迟产生电路禁止。	R/W
b10	DLYEN2	通道2的PWM延迟生成电路使能	0：启用通道2的延迟产生电路1：禁用通道2的延迟产生电路。	R/W
b11	DLYEN3	通道3的PWM延迟生成电路使能	0：通道3延时产生电路使能1：通道3延时产生电路禁止。	R/W
b15 to b12	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTDLYCR2寄存器控制PWM延迟产生电路的每个通道。当寄存器写保护被禁用（GPT32EH0.GTWP.WP=0）时，可以写入GTDLYCR2。

DLYBSn（n=0到3）位（通道n的PWM延迟生成电路旁路）

DLYBSn位选择是否通过PWM延迟生成电路对来自GTIOCnA和GTIOCnB引脚（n=0至3）的PWM输出信号施加延迟，或者是否绕过该电路。

在PWM延迟产生电路中延迟的信号比绕过PWM延迟产生电路的信号晚3个GPT操作时钟的PCLKD周期输出。

DLYENn（n=0到3）位（通道n的PWM延迟生成电路使能）

DLYENn位选择PWM延迟发生电路的通道n（n=0到3）是打开还是关闭。如果不使用PWM延迟产生电路的通道n，则将该位设置为1。

23.2.3 GTIOCnA Rising Output Delay Register (GTDLYRnA) (n = 0 to 3)

Address(es): GPT_ODC.GTDLYR0A 4007 B018h, GPT_ODC.GTDLYR1A 4007 B01Ch, GPT_ODC.GTDLYR2A 4007 B020h, GPT_ODC.GTDLYR3A 4007 B024h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	DLY[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	DLY[4:0]	GTIOCnA Output Rising Edge Delay Setting	b4 b0 0 0 0 0 0: Delay on rising edges is not applied 0 0 0 0 1: Delay of 1/32 times PCLKD period applied 0 0 0 1 0: Delay of 2/32 times PCLKD period applied 0 0 0 1 1: Delay of 3/ 32 times PCLKD period applied 0 0 1 0 0: Delay of 4/ 32 times PCLKD period applied 0 0 1 0 1: Delay of 5/ 32 times PCLKD period applied 0 0 1 1 0: Delay of 6/ 32 times PCLKD period applied 0 0 1 1 1: Delay of 7/ 32 times PCLKD period applied 0 1 0 0 0: Delay of 8/ 32 times PCLKD period applied 0 1 0 0 1: Delay of 9/ 32 times PCLKD period applied 0 1 0 1 0: Delay of 10/ 32 times PCLKD period applied 0 1 0 1 1: Delay of 11/ 32 times PCLKD period applied 0 1 1 0 0: Delay of 12/ 32 times PCLKD period applied 0 1 1 0 1: Delay of 13/ 32 times PCLKD period applied 0 1 1 1 0: Delay of 14/ 32 times PCLKD period applied 0 1 1 1 1: Delay of 15/ 32 times PCLKD period applied 1 0 0 0 0: Delay of 16/ 32 times PCLKD period applied 1 0 0 0 1: Delay of 17/ 32 times PCLKD period applied 1 0 0 1 0: Delay of 18/ 32 times PCLKD period applied 1 0 0 1 1: Delay of 19/ 32 times PCLKD period applied 1 0 1 0 0: Delay of 20/ 32 times PCLKD period applied 1 0 1 0 1: Delay of 21/ 32 times PCLKD period applied 1 0 1 1 0: Delay of 22/ 32 times PCLKD period applied 1 0 1 1 1: Delay of 23/ 32 times PCLKD period applied 1 1 0 0 0: Delay of 24/ 32 times PCLKD period applied 1 1 0 0 1: Delay of 25/ 32 times PCLKD period applied 1 1 0 1 0: Delay of 26/ 32 times PCLKD period applied 1 1 0 1 1: Delay of 27/ 32 times PCLKD period applied 1 1 1 0 0: Delay of 28/ 32 times PCLKD period applied 1 1 1 0 1: Delay of 29/ 32 times PCLKD period applied 1 1 1 1 0: Delay of 30/ 32 times PCLKD period applied 1 1 1 1 1: Delay of 31/ 32 times PCLKD period applied.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTDLYRnA register sets a delay to be applied to rising edges of output signals on the GTIOCnA pin. On the timing for the transfer of settings, see section 23.3.2, Timing for Transfer of GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB Register Settings.

The GTDLYRnA can be written when register write protection is disabled (GPT32EHn.GTWP.WP = 0).

23.2.3 GTIOCnA上升沿输出延迟寄存器(GTDLYRnA)(n=0to3)

Address(es): GPT_ODC.GTDLYR0A 4007 B018h, GPT_ODC.GTDLYR1A 4007 B01Ch, GPT_ODC.GTDLYR2A 4007 B020h, GPT_ODC.GTDLYR3A 4007 B024h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	DLY[4:0]				
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	DLY[4:0]	GTIOCnA输出上升边沿延迟设置	b4b000000：不应用上升沿延迟00001：应用延迟132倍PCLKD周期00010：应用延迟232倍PCLKD周期00011：延迟332倍PCLKD周期应用00100：延迟432倍PCLKD周期应用00101：延迟532倍PCLKD周期应用00110：延迟632倍PCLKD周期应用00111：延迟732倍PCLKD周期01000：延迟832倍PCLKD周期01001：延迟932倍PCLKD周期01010：延迟10应用32倍PCLKD周期01011：延迟11应用32倍PCLKD周期01100：延迟12应用32倍PCLKD周期01101：延迟13应用32倍PCLKD周期01110：延迟1432倍PCLKD周期01111：延迟1532倍PCLKD周期10000：延迟1632倍PCLKD周期10001：延迟1732倍应用PCLKD周期10010：延迟1832倍PCLKD周期应用10011：延迟1932倍PCLKD周期应用10100：延迟2032倍PCLKD周期应用10101：延迟2132倍PCLKD周期应用10110:延迟2232倍PCLKD周期10111:延迟2332倍PCLKD周期11000:延迟2432倍PCLKD周期11001:延迟2532倍PCLKD周期应用11010：应用2632倍PCLKD周期的延迟11011：应用2732倍PCLKD周期的延迟11100：应用2832倍PCLKD周期的延迟11101：延迟2932倍PCLKD周期应用11110：延迟3032倍PCLKD周期应用11111：延迟3132倍PCLKD周期应用。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTDLYRnA寄存器设置延迟应用于GTIOCnA引脚上输出信号的上升沿。关于设置传送的时序，请参见第23.3.2节，传送GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB寄存器设置的时序。

当寄存器写保护被禁用（GPT32EHn.GTWP.WP=0）时，可以写入GTDLYRnA。

23.2.4 GTIOCnA Falling Output Delay Register (GTDLYFnA) (n = 0 to 3)

Address(es): GPT_ODC.GTDLYF0A 4007 B028h, GPT_ODC.GTDLYF1A 4007 B02Ch, GPT_ODC.GTDLYF2A 4007 B030h, GPT_ODC.GTDLYF3A 4007 B034h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	DLY[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	DLY[4:0]	GTIOCnA Output Falling Edge Delay Setting	b4 b0 0 0 0 0 0: Delay on falling edges is not applied 0 0 0 0 1: Delay of 1/32 times PCLKD period applied 0 0 0 1 0: Delay of 2/32 times PCLKD period applied 0 0 0 1 1: Delay of 3/ 32 times PCLKD period applied 0 0 1 0 0: Delay of 4/ 32 times PCLKD period applied 0 0 1 0 1: Delay of 5/ 32 times PCLKD period applied 0 0 1 1 0: Delay of 6/ 32 times PCLKD period applied 0 0 1 1 1: Delay of 7/ 32 times PCLKD period applied 0 1 0 0 0: Delay of 8/ 32 times PCLKD period applied 0 1 0 0 1: Delay of 9/ 32 times PCLKD period applied 0 1 0 1 0: Delay of 10/ 32 times PCLKD period applied 0 1 0 1 1: Delay of 11/ 32 times PCLKD period applied 0 1 1 0 0: Delay of 12/ 32 times PCLKD period applied 0 1 1 0 1: Delay of 13/ 32 times PCLKD period applied 0 1 1 1 0: Delay of 14/ 32 times PCLKD period applied 0 1 1 1 1: Delay of 15/ 32 times PCLKD period applied 1 0 0 0 0: Delay of 16/ 32 times PCLKD period applied 1 0 0 0 1: Delay of 17/ 32 times PCLKD period applied 1 0 0 1 0: Delay of 18/ 32 times PCLKD period applied 1 0 0 1 1: Delay of 19/ 32 times PCLKD period applied 1 0 1 0 0: Delay of 20/ 32 times PCLKD period applied 1 0 1 0 1: Delay of 21/ 32 times PCLKD period applied 1 0 1 1 0: Delay of 22/ 32 times PCLKD period applied 1 0 1 1 1: Delay of 23/ 32 times PCLKD period applied 1 1 0 0 0: Delay of 24/ 32 times PCLKD period applied 1 1 0 0 1: Delay of 25/ 32 times PCLKD period applied 1 1 0 1 0: Delay of 26/ 32 times PCLKD period applied 1 1 0 1 1: Delay of 27/ 32 times PCLKD period applied 1 1 1 0 0: Delay of 28/ 32 times PCLKD period applied 1 1 1 0 1: Delay of 29/ 32 times PCLKD period applied 1 1 1 1 0: Delay of 30/ 32 times PCLKD period applied 1 1 1 1 1: Delay of 31/ 32 times PCLKD period applied.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTDLYFnA register sets a delay to be applied to falling edges of output signals on the GTIOCnA pin. On the timing for the transfer of settings, see section 23.3.2, Timing for Transfer of GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB Register Settings.

The GTDLYFnA can be written when register write protection is disabled (GPT32EHn.GTWP.WP = 0).

23.2.4 GTIOCnA下降输出延迟寄存器(GTDLYFnA)(n=0to3)

Address(es): GPT_ODC.GTDLYF0A 4007 B028h, GPT_ODC.GTDLYF1A 4007 B02Ch, GPT_ODC.GTDLYF2A 4007 B030h, GPT_ODC.GTDLYF3A 4007 B034h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	DLY[4:0]				
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	DLY[4:0]	GTIOCnA输出下降边沿延迟设置	b4b000000：不应用下降沿延迟00001：应用延迟132倍PCLKD周期00010：应用延迟232倍PCLKD周期00011：延迟332倍PCLKD周期应用00100：延迟432倍PCLKD周期应用00101：延迟532倍PCLKD周期应用00110：延迟632倍PCLKD周期应用00111：延迟732倍PCLKD周期01000：延迟832倍PCLKD周期01001：延迟932倍PCLKD周期01010：延迟10应用32倍PCLKD周期01011：延迟11应用32倍PCLKD周期01100：延迟12应用32倍PCLKD周期01101：延迟13应用32倍PCLKD周期01110：延迟1432倍PCLKD周期01111：延迟1532倍PCLKD周期10000：延迟1632倍PCLKD周期10001：延迟1732倍应用PCLKD周期10010：延迟1832次应用PCLKD周期10011：应用延迟1932倍PCLKD周期应用10100：应用延迟2032倍PCLKD周期10101：应用延迟2132倍PCLKD周期10110:延迟2232倍PCLKD周期10111:延迟2332倍PCLKD周期11000:延迟2432倍PCLKD周期11001:延迟2532倍PCLKD周期应用11010：应用2632倍PCLKD周期的延迟11011：应用2732倍PCLKD周期的延迟11100：应用2832倍PCLKD周期的延迟11101：延迟2932倍PCLKD周期应用11110：延迟3032倍PCLKD周期应用11111：延迟3132倍PCLKD周期应用。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTDLYFnA寄存器设置延迟应用于GTIOCnA引脚上输出信号的下降沿。关于设置传送的时序，请参见第23.3.2节，传送GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB寄存器设置的时序。

当寄存器写保护被禁用（GPT32EHn.GTWP.WP=0）时，可以写入GTDLYFnA。

23.2.5 GTIOCnB Rising Output Delay Register (GTDLYRnB) (n = 0 to 3)

Address(es): GPT_ODC.GTDLYR0B 4007 B01Ah, GPT_ODC.GTDLYR1B 4007 B01Eh, GPT_ODC.GTDLYR2B 4007 B022h, GPT_ODC.GTDLYR3B 4007 B026h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	DLY[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	DLY[4:0]	GTIOCnB Output Rising Edge Delay Setting	b4 b0 0 0 0 0 0: Delay on rising edges is not applied 0 0 0 0 1: Delay of 1/32 times PCLKD period applied 0 0 0 1 0: Delay of 2/32 times PCLKD period applied 0 0 0 1 1: Delay of 3/ 32 times PCLKD period applied 0 0 1 0 0: Delay of 4/ 32 times PCLKD period applied 0 0 1 0 1: Delay of 5/ 32 times PCLKD period applied 0 0 1 1 0: Delay of 6/ 32 times PCLKD period applied 0 0 1 1 1: Delay of 7/ 32 times PCLKD period applied 0 1 0 0 0: Delay of 8/ 32 times PCLKD period applied 0 1 0 0 1: Delay of 9/ 32 times PCLKD period applied 0 1 0 1 0: Delay of 10/ 32 times PCLKD period applied 0 1 0 1 1: Delay of 11/ 32 times PCLKD period applied 0 1 1 0 0: Delay of 12/ 32 times PCLKD period applied 0 1 1 0 1: Delay of 13/ 32 times PCLKD period applied 0 1 1 1 0: Delay of 14/ 32 times PCLKD period applied 0 1 1 1 1: Delay of 15/ 32 times PCLKD period applied 1 0 0 0 0: Delay of 16/ 32 times PCLKD period applied 1 0 0 0 1: Delay of 17/ 32 times PCLKD period applied 1 0 0 1 0: Delay of 18/ 32 times PCLKD period applied 1 0 0 1 1: Delay of 19/ 32 times PCLKD period applied 1 0 1 0 0: Delay of 20/ 32 times PCLKD period applied 1 0 1 0 1: Delay of 21/ 32 times PCLKD period applied 1 0 1 1 0: Delay of 22/ 32 times PCLKD period applied 1 0 1 1 1: Delay of 23/ 32 times PCLKD period applied 1 1 0 0 0: Delay of 24/ 32 times PCLKD period applied 1 1 0 0 1: Delay of 25/ 32 times PCLKD period applied 1 1 0 1 0: Delay of 26/ 32 times PCLKD period applied 1 1 0 1 1: Delay of 27/ 32 times PCLKD period applied 1 1 1 0 0: Delay of 28/ 32 times PCLKD period applied 1 1 1 0 1: Delay of 29/ 32 times PCLKD period applied 1 1 1 1 0: Delay of 30/ 32 times PCLKD period applied 1 1 1 1 1: Delay of 31/ 32 times PCLKD period applied.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTDLYRnB register sets a delay to be applied to rising edges of output signals on the GTIOCnB pin. On the timing for the transfer of settings, see section 23.3.2, Timing for Transfer of GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB Register Settings.

The GTDLYRnB can be written when register write protection is disabled (GPT32EHn.GTWP.WP = 0).

23.2.5 GTIOCnB上升沿输出延迟寄存器(GTDLYRnB)(n=0to3)

Address(es): GPT_ODC.GTDLYR0B 4007 B01Ah, GPT_ODC.GTDLYR1B 4007 B01Eh, GPT_ODC.GTDLYR2B 4007 B022h, GPT_ODC.GTDLYR3B 4007 B026h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	DLY[4:0]				
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	DLY[4:0]	GTIOCnB输出上升边沿延迟设置	b4b000000：不应用上升沿延迟00001：应用延迟132倍PCLKD周期00010：应用延迟232倍PCLKD周期00011：延迟332倍PCLKD周期应用00100：延迟432倍PCLKD周期应用00101：延迟532倍PCLKD周期应用00110：延迟632倍PCLKD周期应用00111：延迟732倍PCLKD周期01000：延迟832倍PCLKD周期01001：延迟932倍PCLKD周期01010：延迟10应用32倍PCLKD周期01011：延迟11应用32倍PCLKD周期01100：延迟12应用32倍PCLKD周期01101：延迟13应用32倍PCLKD周期01110：延迟1432倍PCLKD周期01111：延迟1532倍PCLKD周期10000：延迟1632倍PCLKD周期10001：延迟1732倍应用PCLKD周期10010：延迟1832倍PCLKD周期应用10011：延迟1932倍PCLKD周期应用10100：延迟2032倍PCLKD周期应用10101：延迟2132倍PCLKD周期应用10110:延迟2232倍PCLKD周期10111:延迟2332倍PCLKD周期11000:延迟2432倍PCLKD周期11001:延迟2532倍PCLKD周期应用11010：应用2632倍PCLKD周期的延迟11011：应用2732倍PCLKD周期的延迟11100：应用2832倍PCLKD周期的延迟11101：延迟2932倍PCLKD周期应用11110：延迟3032倍PCLKD周期应用11111：延迟3132倍PCLKD周期应用。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTDLYRnB寄存器设置延迟应用于GTIOCnB引脚上输出信号的上升沿。关于设置传送的时序，请参见第23.3.2节，传送GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB寄存器设置的时序。

当寄存器写保护被禁用（GPT32EHn.GTWP.WP=0）时，可以写入GTDLYRnB。

23.2.6 GTIOCnB Falling Output Delay Register (GTDLYFnB) (n = 0 to 3)

Address(es): GPT_ODC.GTDLYF0B 4007 B02Ah, GPT_ODC.GTDLYF1B 4007 B02Eh, GPT_ODC.GTDLYF2B 4007 B032h, GPT_ODC.GTDLYF3B 4007 B036h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	DLY[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	DLY[4:0]	GTIOCnB Output Falling Edge Delay Setting	b4 b0 0 0 0 0 0: Delay on falling edges is not applied 0 0 0 0 1: Delay of 1/32 times PCLKD period applied 0 0 0 1 0: Delay of 2/32 times PCLKD period applied 0 0 0 1 1: Delay of 3/ 32 times PCLKD period applied 0 0 1 0 0: Delay of 4/ 32 times PCLKD period applied 0 0 1 0 1: Delay of 5/ 32 times PCLKD period applied 0 0 1 1 0: Delay of 6/ 32 times PCLKD period applied 0 0 1 1 1: Delay of 7/ 32 times PCLKD period applied 0 1 0 0 0: Delay of 8/ 32 times PCLKD period applied 0 1 0 0 1: Delay of 9/ 32 times PCLKD period applied 0 1 0 1 0: Delay of 10/ 32 times PCLKD period applied 0 1 0 1 1: Delay of 11/ 32 times PCLKD period applied 0 1 1 0 0: Delay of 12/ 32 times PCLKD period applied 0 1 1 0 1: Delay of 13/ 32 times PCLKD period applied 0 1 1 1 0: Delay of 14/ 32 times PCLKD period applied 0 1 1 1 1: Delay of 15/ 32 times PCLKD period applied 1 0 0 0 0: Delay of 16/ 32 times PCLKD period applied 1 0 0 0 1: Delay of 17/ 32 times PCLKD period applied 1 0 0 1 0: Delay of 18/ 32 times PCLKD period applied 1 0 0 1 1: Delay of 19/ 32 times PCLKD period applied 1 0 1 0 0: Delay of 20/ 32 times PCLKD period applied 1 0 1 0 1: Delay of 21/ 32 times PCLKD period applied 1 0 1 1 0: Delay of 22/ 32 times PCLKD period applied 1 0 1 1 1: Delay of 23/ 32 times PCLKD period applied 1 1 0 0 0: Delay of 24/ 32 times PCLKD period applied 1 1 0 0 1: Delay of 25/ 32 times PCLKD period applied 1 1 0 1 0: Delay of 26/ 32 times PCLKD period applied 1 1 0 1 1: Delay of 27/ 32 times PCLKD period applied 1 1 1 0 0: Delay of 28/ 32 times PCLKD period applied 1 1 1 0 1: Delay of 29/ 32 times PCLKD period applied 1 1 1 1 0: Delay of 30/ 32 times PCLKD period applied 1 1 1 1 1: Delay of 31/ 32 times PCLKD period applied.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The GTDLYFnB register sets a delay to be applied to falling edges of output signals on the GTIOCnB pin. On the timing for the transfer of settings, see section 23.3.2, Timing for Transfer of GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB Register Settings.

The GTDLYFnB can be written when register write protection is disabled (GPT32EHn.GTWP.WP = 0).

23.3 Operation

23.3.1 Adjustments to the Timing of Rising and Falling Edges in PWM Waveforms

The timing of rising and falling edges in PWM waveforms which are output from the GTIOCnA and GTIOCnB pins, where n = channel number, can be delayed to an accuracy of 1/32 of the GPT operating clock (PCLKD) period.

If the timing of rising or falling edges in PWM waveforms output from the GTIOCnA and GTIOCnB pins must be adjusted, initialize the PWM generation circuit as shown in the procedure in Figure 23.2.

23.2.6 GTIOCnB下降输出延迟寄存器(GTDLYFnB)(n=0to3)

Address(es): GPT_ODC.GTDLYF0B 4007 B02Ah, GPT_ODC.GTDLYF1B 4007 B02Eh, GPT_ODC.GTDLYF2B 4007 B032h, GPT_ODC.GTDLYF3B 4007 B036h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	DLY[4:0]				
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	DLY[4:0]	GTIOCnB输出下降边沿延迟设置	b4b000000：不应用下降沿延迟00001：应用延迟132倍PCLKD周期00010：应用延迟232倍PCLKD周期00011：延迟332倍PCLKD周期应用00100：延迟432倍PCLKD周期应用00101：延迟532倍PCLKD周期应用00110：延迟632倍PCLKD周期应用00111：延迟732倍PCLKD周期01000：延迟832倍PCLKD周期01001：延迟932倍PCLKD周期01010：延迟10应用32倍PCLKD周期01011：延迟11应用32倍PCLKD周期01100：延迟12应用32倍PCLKD周期01101：延迟13应用32倍PCLKD周期01110：延迟1432倍PCLKD周期01111：延迟1532倍PCLKD周期10000：延迟1632倍PCLKD周期10001：延迟1732倍应用PCLKD周期10010：延迟1832次应用PCLKD周期10011：应用延迟1932倍PCLKD周期应用10100：应用延迟2032倍PCLKD周期10101：应用延迟2132倍PCLKD周期10110:延迟2232倍PCLKD周期10111:延迟2332倍PCLKD周期11000:延迟2432倍PCLKD周期11001:延迟2532倍PCLKD周期应用11010：应用2632倍PCLKD周期的延迟11011：应用2732倍PCLKD周期的延迟11100：应用2832倍PCLKD周期的延迟11101：延迟2932倍PCLKD周期应用11110：延迟3032倍PCLKD周期应用11111：延迟3132倍PCLKD周期应用。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

GTDLYFnB寄存器设置延迟应用于GTIOCnB引脚上输出信号的下降沿。关于设置传送的时序，请参见第23.3.2节，传送GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB寄存器设置的时序。

当寄存器写保护被禁用（GPT32EHn.GTWP.WP=0）时，可以写入GTDLYFnB。

23.3 Operation

23.3.1 PWM波形上升沿和下降沿时序的调整

从GTIOCnA和GTIOCnB引脚输出的PWM波形的上升沿和下降沿时序（其中n=通道数）可以延迟到GPT工作时钟(PCLKD)周期的1×32的精度。

如果必须调整GTIOCnA和GTIOCnB引脚输出的PWM波形的上升沿或下降沿时序，请按照图23.2中的步骤初始化PWM生成电路。

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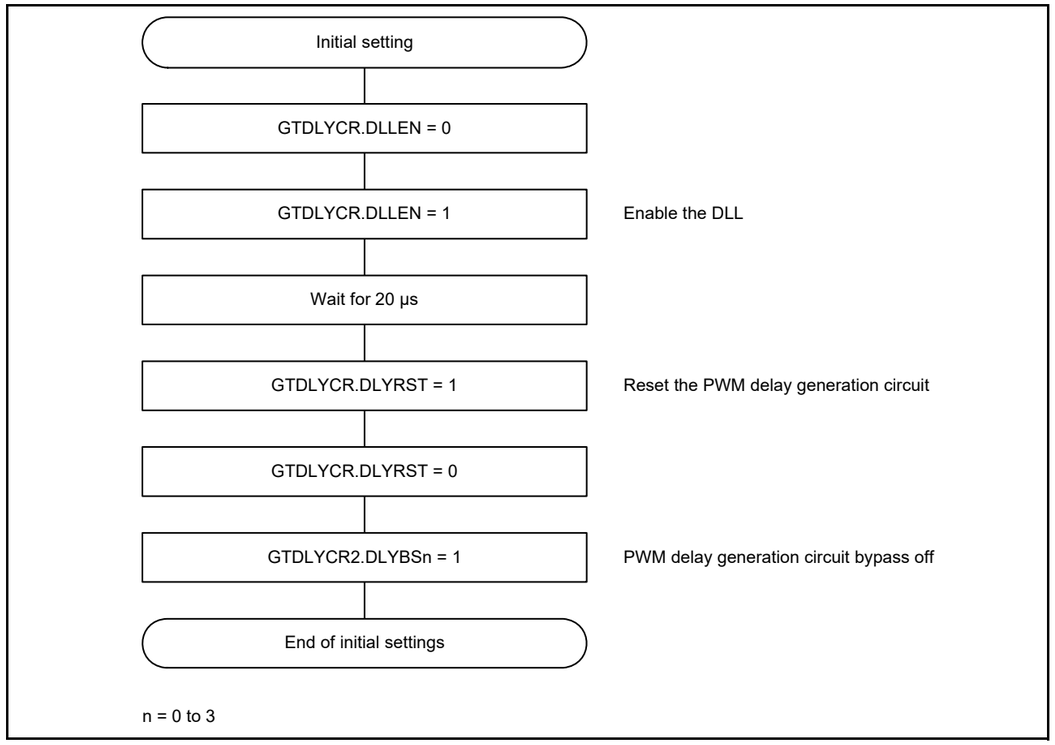

Figure 23.2 Example of initialization flow for the PWM delay generation circuit

In the PWM delay generation circuit, delay can be applied to rising and falling edges of the PWM output to an accuracy of 1/32 of the period of the GPT operation clock (PCLKD). This is described in section 22.3.3, PWM Output Operating Mode. Delays associated with the settings are reflected in the PWM output with the timing described in section 23.3.2, Timing for Transfer of GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB Register Settings.

Table 23.3 shows the association between the GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB registers and the PWM outputs.

Table 23.3 Association between PWM output pins and delay setting registers

PWM output pin	Rising-edge delay setting register	Falling-edge delay setting register
GTIOC0A	GTDLYR0A	GTDLYF0A
GTIOC0B	GTDLYR0B	GTDLYF0B
GTIOC1A	GTDLYR1A	GTDLYF1A
GTIOC1B	GTDLYR1B	GTDLYF1B
GTIOC2A	GTDLYR2A	GTDLYF2A
GTIOC2B	GTDLYR2B	GTDLYF2B
GTIOC3A	GTDLYR3A	GTDLYF3A
GTIOC3B	GTDLYR3B	GTDLYF3B

When the PWM delay generation circuit is in use, the timing with which a PWM output signal rises and falls can be controlled to an accuracy of 1/32 of the period of the GPT operation clock (PCLKD). When this option is not in use, the period of the PWM output waveform is controlled to an accuracy of one period of the input clock for the timer counter, which is PCLKD. With the PWM delay generation circuit, the output can be controlled to an accuracy 32 times better. Additionally, the delay settings also control the periods at high and low level for the PWM waveform to the given accuracy. PWM delay generation circuit channels can be individually enabled or disabled.

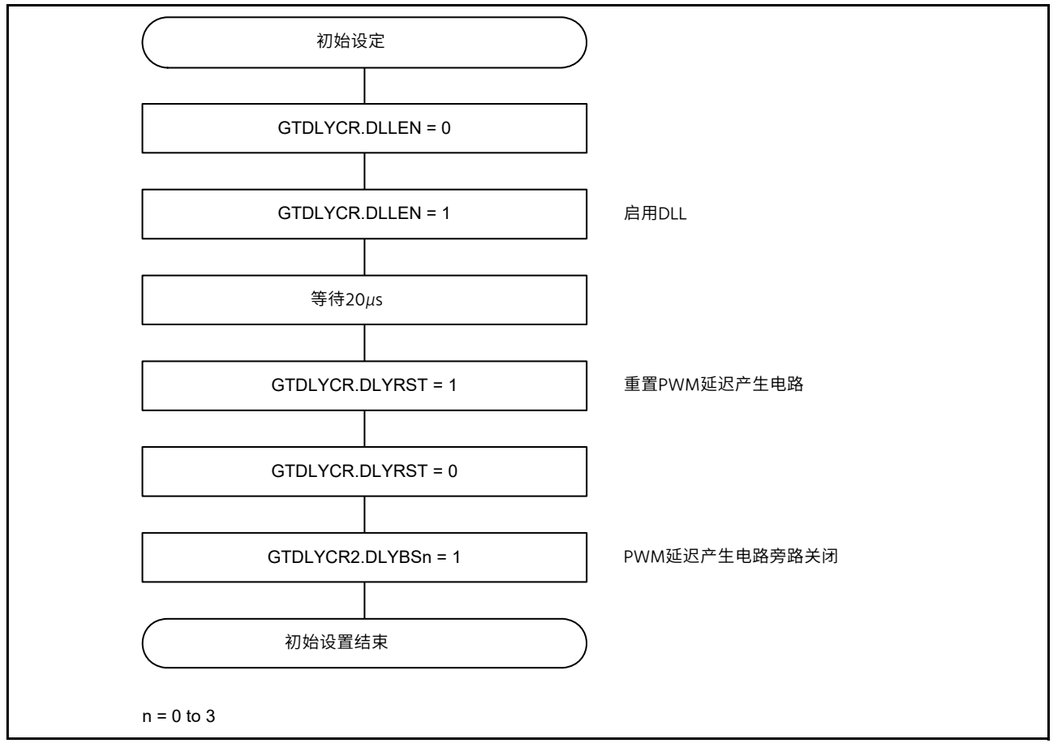

Figure 23.2 PWM延迟产生电路的初始化流程示例

在PWM延迟生成电路中，可以将延迟应用于PWM输出的上升沿和下降沿，精确到GPT操作时钟(PCLKD)周期的132。这在第22.3.3节"PWM输出操作模式"中进行了描述。与设置相关的延迟反映在PWM输出中，其时序在第23.3.2节中描述，

GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB寄存器设置的传输时序。

表23.3显示了GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB寄存器与PWM输出之间的关联。

Table 23.3 PWM输出引脚和延迟设置寄存器之间的关联

PWM输出引脚	上升沿延迟设置寄存器	下降沿延迟设置寄存器
GTIOC0A	GTDLYR0A	GTDLYF0A
GTIOC0B	GTDLYR0B	GTDLYF0B
GTIOC1A	GTDLYR1A	GTDLYF1A
GTIOC1B	GTDLYR1B	GTDLYF1B
GTIOC2A	GTDLYR2A	GTDLYF2A
GTIOC2B	GTDLYR2B	GTDLYF2B
GTIOC3A	GTDLYR3A	GTDLYF3A
GTIOC3B	GTDLYR3B	GTDLYF3B

当使用PWM延迟产生电路时，PWM输出信号的上升和下降的时序可以控制在GPT操作时钟(PCLKD)周期的1×32的精度。不使用此选项时，PWM输出波形的周期被控制为定时器计数器输入时钟（即PCLKD）的一个周期的精度。使用PWM延迟产生电路，可以将输出控制精度提高32倍。此外，延迟设置还控制PWM波形的高电平和低电平周期，以达到给定的精度。PWM延迟生成电路通道可以单独启用或禁用。

23.3.2 Timing for Transfer of GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB Register Settings

Settings for the GTDLYRnA, GTLDYRnB, GTDLYFnA, and GTDLYFnB registers are initially transferred to temporary registers, and then reflected in the delay on the GTIOCnA and GTIOCnB (n = 0 to 3) outputs. Transfer of the settings takes place on overflows (in up-counting) or underflows (in down-counting) for saw waves, and in the troughs of triangle waves.

Figure 23.3 and Figure 23.4 show examples of the operation of the GTDLYR0A and GTDLYF0A registers.

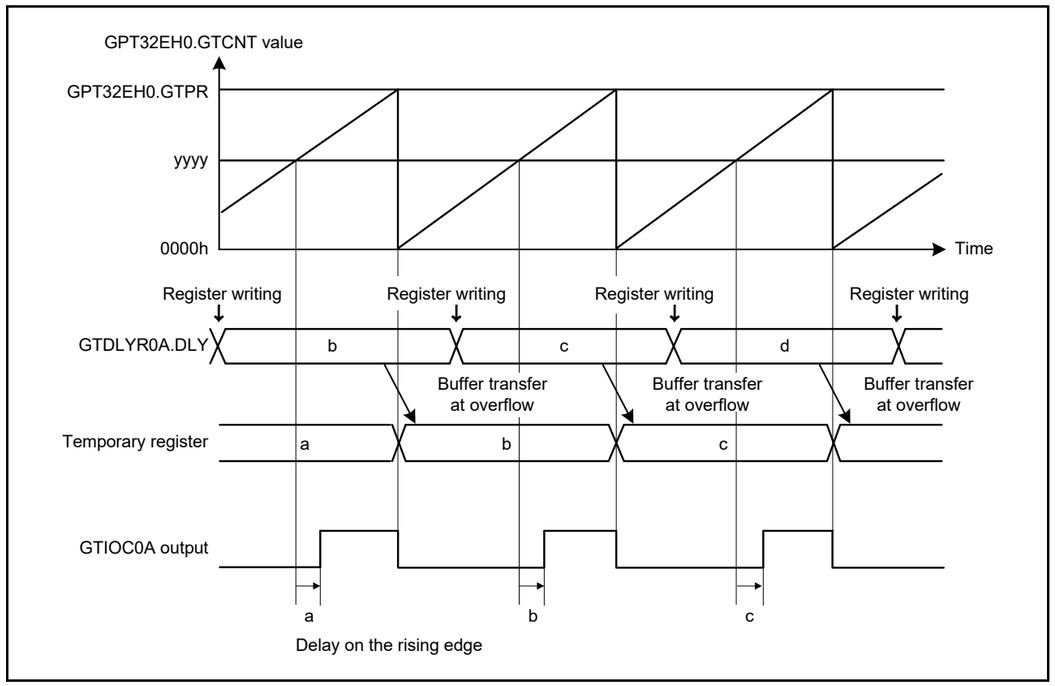

Figure 23.3 Example of GTLDYR0A register operation with PWM saw-wave generation

23.3.2 GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB的传输时间注册设置

GTDLYRnA、GTLDYRnB、GTDLYFnA和GTDLYFnB寄存器的设置最初传送到临时寄存器，然后反映在GTIOCnA和GTIOCnB（n=0到3）输出的延迟中。设置的传输发生在锯齿波的上溢（向上计数）或下溢（向下计数）以及三角波的波谷中。

图23.3和图23.4显示了GTDLYR0A和GTDLYF0A寄存器的操作示例。

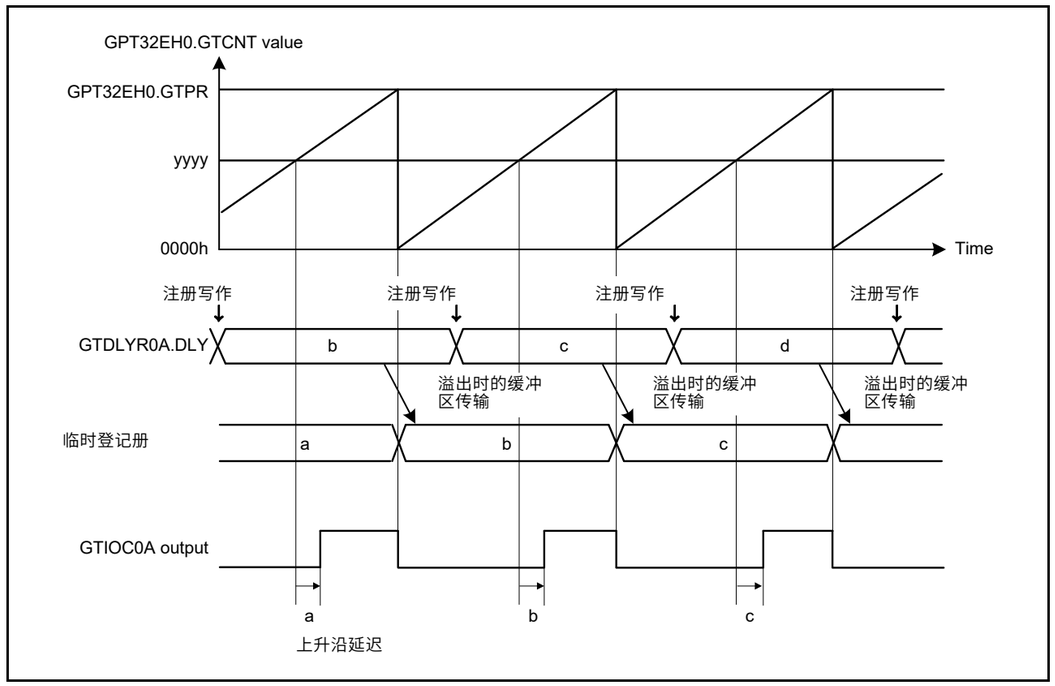

Figure 23.3 带有PWM锯齿波生成的GTLDYR0A寄存器操作示例

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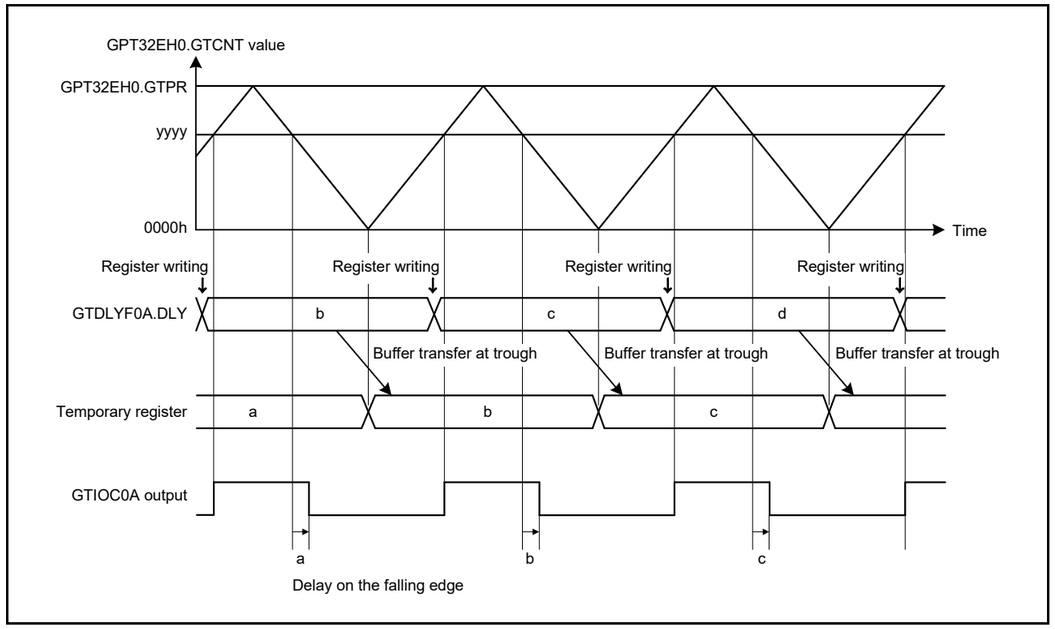

Figure 23.4 Example of GTLDYF0A register operation with PWM triangle-wave generation

23.4 Usage Notes

23.4.1 Module-Stop Function Settings

The Module Stop Control Register D (MSTPCRD) can enable or disable operation of the PWM delay generation circuit. The PWM delay generation circuit is initially stopped after a reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

23.4.2 Notes on Delay Settings for PWM Delay Generation Circuit

When the PWM delay generation circuit generates delays for a PWM output waveform and the waveform is toggled in response to compare-matches, do not change the settings for delay while the compare-match value is within the ranges listed in Table 23.4. This constraint applies to the GTDLYFnA, GTDLYRnA, GTDLFnB, and GTDLYRnB registers.

Table 23.4 Constraints on delay settings

Mode	Direction of counting	Compare-match value
Saw-wave mode	Up	GTPR - 2 or above
	Down	2 or below
Triangle-wave mode	Down	2 or below

Figure 23.5 shows an example of how the constraints apply to the timing of setting GTDLYFnA in saw-wave waveform one-shot pulse mode (counting up). Do not change the value set in GTDLYFnA while GTCCRD ≥ GTPR - 2.

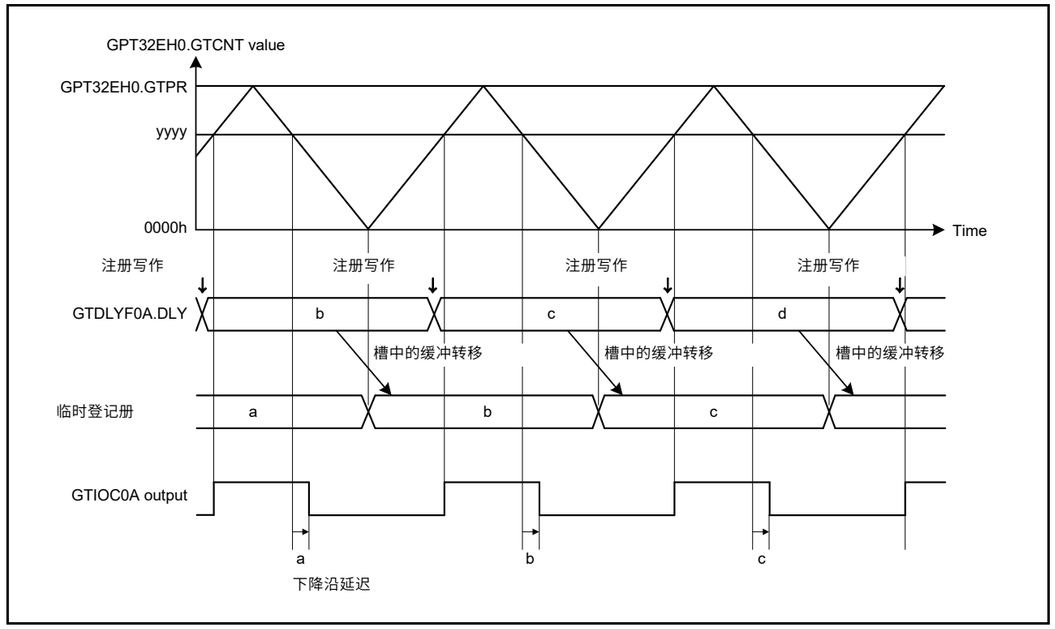

Figure 23.4 带有PWM三角波生成的GTLDYF0A寄存器操作示例

23.4 使用说明

23.4.1 模块停止功能设置

模块停止控制寄存器D(MSTPCRD)可以启用或禁用PWM延迟生成电路的操作。PWM延迟生成电路在复位后最初停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

23.4.2 PWM延迟产生电路的延迟设置注意事项

当PWM延迟生成电路为PWM输出波形产生延迟并且波形响应比较匹配而切换时，当比较匹配值在表23.4中列出的范围内时，请勿更改延迟设置。此约束适用于GTDLYFnA、GTDLYRnA、GTDLFnB和GTDLYRnB寄存器。

Table 23.4 延迟设置的限制

Mode	计数方向	Compare-match value
Saw-wave mode	Up	GTPR2或以上
	Down	2或以下
Triangle-wave mode	Down	2或以下

图23.5显示了约束如何应用于在锯波波形单次脉冲模式（向上计数）中设置GTDLYFnA的时序的示例。当GTCCRD≥GTPR2时，请勿更改GTDLYFnA中设置的值。

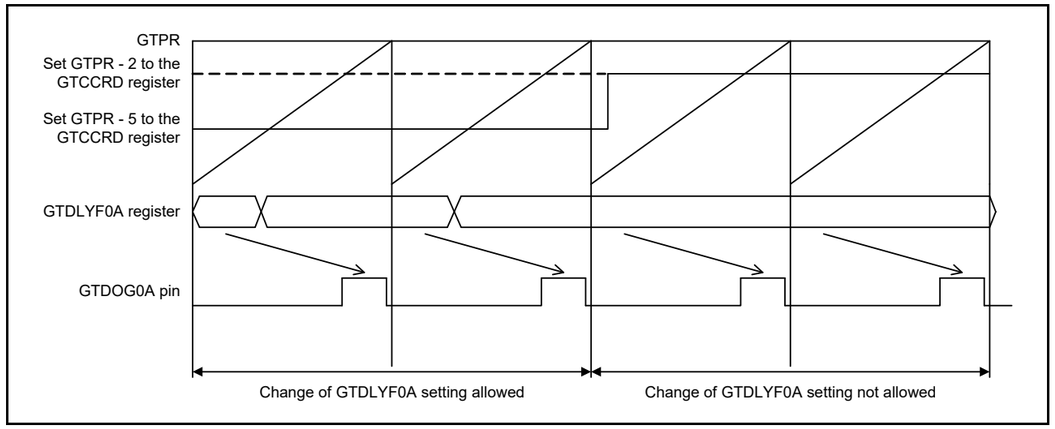

Figure 23.5 Constraints on the timing of GTDLYF0A register settings

Changing the values in the GTDLYFnA, GTDLYRnA, GTDLYFnB, and GTDLYRnB registers during periods where changes to settings are not allowed, might lead to faulty output waveforms such as shifts in the timing of output waveform transitions from the expected values.

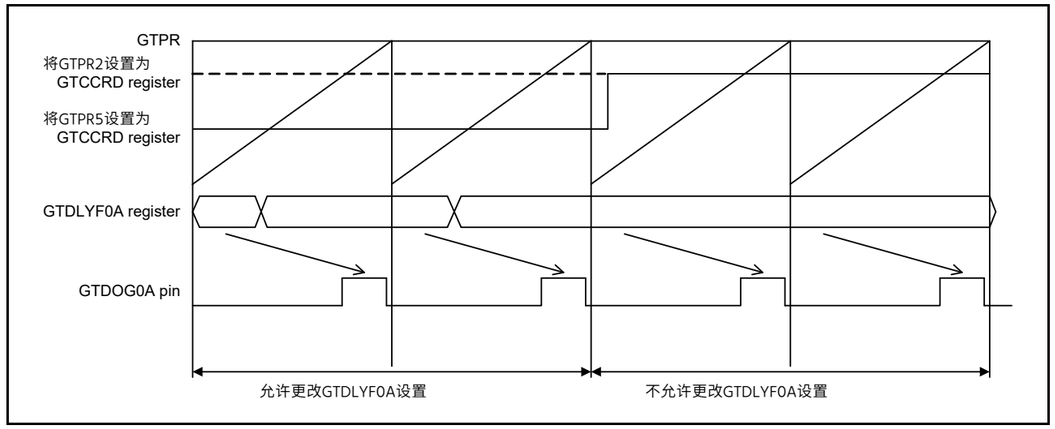

Figure 23.5 GTDLYF0A寄存器设置的时序约束

在不允许更改设置的期间更改GTDLYFnA、GTDLYRnA、GTDLYFnB和GTDLYRnB寄存器中的值可能会导致错误的输出波形，例如输出波形转换的时序偏离预期值。

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24. Low Power Asynchronous General-Purpose Timer (AGT)

24.1 Overview

The Low Power Asynchronous General-Purpose Timer (AGT) is a 16-bit timer that can be used for pulse output, external pulse width or period measurement, and counting external events.

This 16-bit timer consists of a reload register and a down counter. The reload register and the down counter are allocated in the same address, and can be accessed with the AGT register.

Table 24.1 lists the AGT specifications, Figure 24.1 shows a block diagram, and Table 24.2 lists the I/O pins.

Table 24.1 AGT specifications

Parameter		Specifications
Operating modes	Timer mode	The count source is counted
	Pulse output mode	The count source is counted and the output is inverted at each timer underflow
	Event counter mode	An external event is counted
	Pulse width measurement mode	An external pulse width is measured
	Pulse period measurement mode	An external pulse period is measured
Count source (operating clock)*2		PCLKB, PCLKB/2, PCLKB/8, AGTLCLK, AGTLCLK/2, AGTLCLK/4, AGTLCLK/8, AGTLCLK/16, AGTLCLK/32, AGTLCLK/64, AGTLCLK/128, AGTSCLK, AGTSCLK/2, AGTSCLK/4, AGTSCLK/8, AGTSCLK/16, AGTSCLK/32, AGTSCLK/64, AGTSCLK/128, or underflow signal of AGT0*1 selectable.
Interrupt/event link function (output)		• Underflow event signal or measurement complete event signal – When the counter underflows – When the measurement of the active width of the external input (AGTIO) is complete in pulse width measurement mode – When the set edge of the external input (AGTIO) is input in pulse period measurement mode. • Compare match A event signal – When the values of AGT and AGTCMA matched (compare match A function enabled) • Compare match B event signal – When the values of AGT and AGTCMB matched (compare match B function enabled).
Selectable functions		• Compare match function One or two of the compare match A and B registers is selectable.

Note 1. AGT0 cannot use the AGT0 underflow signal. AGT1 connects directly with the underflow event signal from the AGT0 timer.
Note 2. Satisfy the frequency of the peripheral module clock (PCLKB) ≥ the frequency of the count source clock.

24. 低功耗异步通用定时器(AGT)

24.1 Overview

低功耗异步通用定时器(AGT)是一个16位定时器，可用于脉冲输出、外部脉冲宽度或周期测量以及外部事件计数。

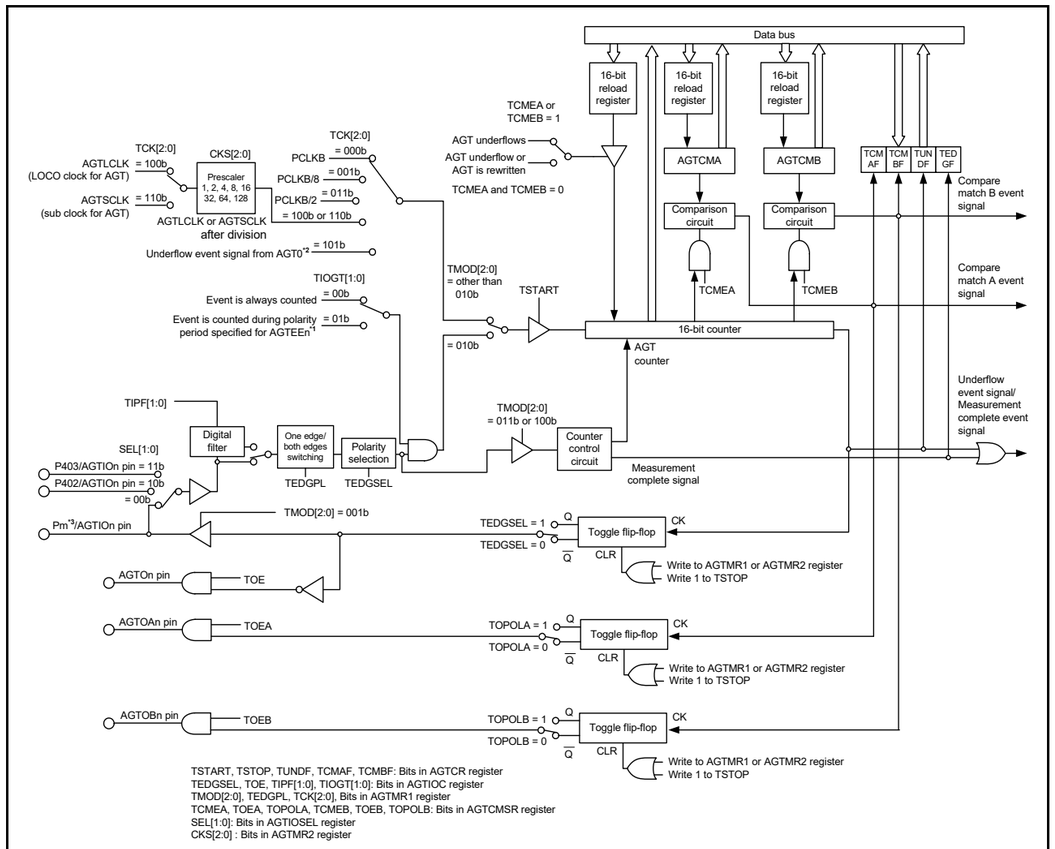
这个16位定时器由一个重载寄存器和一个递减计数器组成。重载寄存器和递减计数器分配在同一个地址，可以通过AGT寄存器访问。

表24.1列出了AGT规格，图24.1显示了框图，表24.2列出了IO引脚。

Table 24.1 AGT specifications

Parameter		Specifications
操作模式	定时器模式	计数源被计数
	脉冲输出方式	计数源被计数并在每次定时器下溢时反转输出
	事件计数器模式	计算外部事件
	脉宽测量模式	测量外部脉冲宽度
	脉冲周期测量模式	测量外部脉冲周　　期
计数源（工作时钟）*2		PCLKB, PCLKB/2, PCLKB/8, AGTLCLK, AGTLCLK/2, AGTLCLK/4, AGTLCLK/8, AGTLCLK/16, AGTLCLK/32, AGTLCLK/64, AGTLCLK/128, AGTSCLK, AGTSCLK/2, AGTSCLK/4, AGTSCLK/8, AGTSCLK/16, AGTSCLK32、AGTSCLK64、AGTSCLK128或AGT0*1的下溢信号可选。
中断事件链接功能（输出）		下溢事件信号或测量完成事件信号　当计数器下溢时　当外部输入(AGTIO)的有效宽度测量在脉冲宽度测量模式下完成时　当输入外部输入(AGTIO)的设置边沿时在脉冲周期测量模式。　比较匹配A事件信号 当AGT和AGTCMA的值匹配时（启用比较匹配A功能）　比较匹配B事件信号 当AGT和AGTCMB的值匹配时（比较匹配B功能启用）。
可选择的功能		比较匹配功能 一个或两个比较匹配A和B寄存器是可选择的。

Note 1. AGT0不能使用AGT0下溢信号。AGT1直接与来自AGT0定时器的下溢事件信号相连。
Note 2. 满足外设模块时钟（PCLKB）的频率≥计数源时钟的频率。



Note 1. The polarity can be selected by the EEPS bit in the AGTISR register.
Note 2. AGT0 cannot use AGT underflow event. AGT1 uses the underflow of AGT0.
Note 3. m = 100, 301, and 407 (AGT0), m = 400 (AGT1).

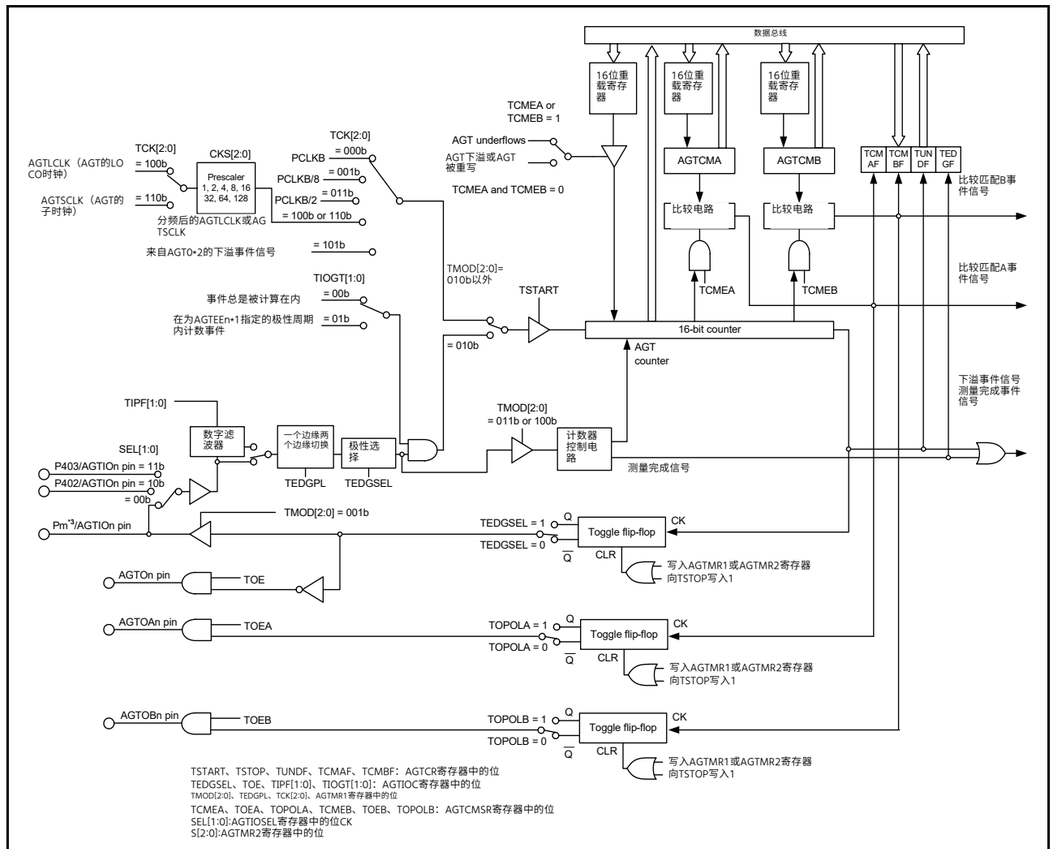
Figure 24.1 AGT block diagram

Table 24.2 AGT I/O pins

Pin name	I/O	Function
AGTEEn	Input	External event input for AGT
AGTIOn*1	Input*1/output	External event input and pulse output for AGT
AGTOn	Output	Pulse output for AGT
AGTOAn	Output	Output compare match A output for AGT
AGTOBn	Output	Output compare match B output for AGT

Note: Channel number (n = 0, 1).
Note 1. AGTIO can also be used in Deep Software Standby mode.

AGTIO can be controlled by the VBTICTLR register. For details, see section 19.2.7, AGT Input Control Register (VBTICTLR) and section 19.5.5, I/O Buffer Specification.



注1.可以通过AGTISR寄存器中的EEPS位选择极性。
注2.AGT0不能使用AGT下溢事件。AGT1使用AGT0的下溢。
注3.m=100、301和407(AGT0)，m=400(AGT1)。

Figure 24.1 AGT框图

Table 24.2 AGT I/O pins

引脚名称	I/O	Function
AGTEEn	Input	AGT的外部事件输入
AGTIOn*1	Input*1/output	AGT的外部事件输入和脉冲输出
AGTOn	Output	AGT的脉冲输出
AGTOAn	Output	输出比较匹配AGT的输出
AGTOBn	Output	AGT的输出比较匹配B输出

Note: 通道号(n=0 1)。
Note 1. AGTIO也可用于深度软件待机模式。

AGTIO可由VBTICTLR寄存器控制。有关详细信息，请参阅第19.2.7节，AGT输入控制寄存器(VBTICTLR)和第19.5.5节，IO缓冲区规范。

RA生态工作室

24.2 Register Descriptions

24.2.1 AGT Counter Register (AGT)

Address(es): AGT0.AGT 4008 4000h, AGT1.AGT 4008 4100h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Description	Setting range	R/W
b15 to b0	16-bit counter and reload register *1, *2	0000h to FFFFh	R/W

Note 1. When 1 is written to the TSTOP bit in the AGTCR register, the 16-bit counter is forcibly stopped and set to FFFFh.
Note 2. When the TCK[2:0] bit setting in the AGTMR1 register is a value other than 001b (PCLKB/8) or 011b (PCLKB/2), if the AGT register is set to 0000h, a request signal to the ICU, the DTC, and the ELC is generated once immediately after the count starts. The AGTOn and AGTIOn outputs are toggled.
When the AGT register is set to 0000h in event counter mode, regardless of the value of TCK[2:0] bits, a request signal to the ICU, the DTC, and the ELC is generated once immediately after the count starts.
In addition, the AGTOn output toggles even during a period other than the specified count period. When the AGT register is set to 0001h or more, a request signal is generated each time AGT underflows.

AGT is a 16-bit register. The write value is written to the reload register and the read value is read from the counter.

The states of the reload register and the counter change according to the TSTART bit in the AGTCR register and TCMEA/TCMEB bit in the AGTCMSR register. For details, see section 24.3.1, Reload Register and Counter Rewrite Operation. The AGT register can be set with a 16-bit memory manipulation instruction.

24.2.2 AGT Compare Match A Register (AGTCMA)

Address(es): AGT0.AGTCMA 4008 4002h, AGT1.AGTCMA 4008 4102h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Description	Setting range	R/W
b15 to b0	16-bit compare match A data is stored.*1	0000h to FFFFh	R/W

Note 1. Set the AGTCMA register to FFFFh when the compare match A is not used.

The AGTCMA register is a read/write register to set a value for compare match with the AGT counter. The states of the reload register and compare register A change according to the TSTART bit in the AGTCR register. For details, see section 24.3.2, Reload Register and Compare Register A/B Rewrite Operation. The AGTCMA register can be set by a 16-bit memory manipulation instruction.

24.2 注册说明

24.2.1 AGT计数器寄存器(AGT)

Address(es): AGT0.AGT 4008 4000h, AGT1.AGT 4008 4100h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Description	设定范围	R/W
b15 to b0	16位计数器和重载寄存器*1 *2	0000h to FFFFh	R/W

Note 1. 当AGTCR寄存器的TSTOP位写入1时，16位计数器被强制停止并设置为FFFFh。
Note 2. 当AGTMR1寄存器中的TCK[2:0]位设置为001b(PCLKB8)或011b(PCLKB2)以外的值时，如果AGT寄存器设置为0000h，则向ICU、DTC、并在计数开始后立即生成一次ELC。AGTOn和AGTIOn输出被切换。

当AGT寄存器在事件计数器模式下设置为0000h时，无论TCK[2:0]位的值如何，都会在计数开始后立即生成一次对ICU、DTC和ELC的请求信号。
此外，即使在指定计数周期以外的周期内，AGTOn输出也会切换。当AGT寄存器设置为0001h或更大时，每次AGT下溢时都会产生一个请求信号。

AGT是一个16位的寄存器。写入值写入重载寄存器，读取值从计数器中读取。

重载寄存器和计数器的状态根据AGTCR寄存器中的TSTART位和
AGTCMSR寄存器中的TCMEATCMEB位。有关详细信息，请参阅第24.3.1节，重新加载寄存器和计数器重写手术。AGT寄存器可通过16位存储器操作指令进行设置。

24.2.2 AGT比较匹配A寄存器(AGTCMA)

Address(es): AGT0.AGTCMA 4008 4002h, AGT1.AGTCMA 4008 4102h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Description	设定范围	R/W
b15 to b0	16位比较匹配A数据被存储。*1	0000h to FFFFh	R/W

Note 1. 当不使用比较匹配A时，将AGTCMA寄存器设置为FFFFh。

AGTCMA寄存器是一个读写寄存器，用于设置与AGT计数器比较匹配的值。重载寄存器和比较寄存器A的状态根据AGTCR寄存器中的TSTART位而改变。有关详细信息，请参见第24.3.2节，重载寄存器和比较寄存器AB重写操作。AGTCMA寄存器可以通过16位存储器操作指令设置。

24.2.3 AGT Compare Match B Register (AGTCMB)

Address(es): AGT0.AGTCMB 4008 4004h, AGT1.AGTCMB 4008 4104h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Description	Setting range	R/W
b15 to b0	16-bit compare match B data is stored.*1	0000h to FFFFh	R/W

Note 1. Set the AGTCMB register to FFFFh when compare match B is not used.

The AGTCMB register is a read/write register to set a value for compare match with the AGT counter. The states of the reload register and compare register B change according to the TSTART bit in the AGTCR register. For details, see section 24.3.2, Reload Register and Compare Register A/B Rewrite Operation. The AGTCMB register can be set by a 16-bit memory manipulation instruction.

24.2.4 AGT Control Register (AGTCR)

Address(es): AGT0.AGTCR 4008 4008h, AGT1.AGTCR 4008 4108h

	b7	b6	b5	b4	b3	b2	b1	b0
	TCMBF	TCMAF	TUNDF	TEDGF	—	TSTOP	TCSTF	TSTART
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TSTART	AGT Count Start*2	0: Count stops 1: Count starts.	R/W
b1	TCSTF	AGT Count Status Flag*2	0: Count stops 1: Count in progress.	R
b2	TSTOP	AGT Count Forced Stop*1	0: Writing is invalid 1: The count is forcibly stopped.	W
b3	—	Reserved	The read value is 0. The write value should be 0.	R/W
b4	TEDGF	Active Edge Judgment Flag	0: No active edge received 1: Active edge received.	R/(W)*3
b5	TUNDF	Underflow Flag	0: No underflow 1: Underflow.	R/(W)*3
b6	TCMAF	Compare Match A Flag	0: No match 1: Match.	R/(W)*3
b7	TCMBF	Compare Match B Flag	0: No match 1: Match.	R/(W)*3

Note 1. When 1 (count is forcibly stopped) is written to the TSTOP bit, the TSTART and TCSTF bits are initialized at the same time. The pulse output level is also initialized. The read value is 0.
Note 2. For information on using the TSTART and TCSTF bits, see section 24.4.1, Count Operation Start and Stop Control.
Note 3. Only 0 can be written to clear the flag.

TSTART bit (AGT Count Start*2)

The count operation is started by writing 1 to the TSTART bit and stopped by writing 0. When this bit is set to 1 (count starts), the TCSTF bit is set to 1 (count in progress) in synchronization with the count source. Also, after 0 is written to the TSTART bit, the TCSTF bit is set to 0 (count stopped) in synchronization with the count source. For details, see section 24.4.1, Count Operation Start and Stop Control.

24.2.3 AGT比较匹配B寄存器(AGTCMB)

Address(es): AGT0.AGTCMB 4008 4004h, AGT1.AGTCMB 4008 4104h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Bit	Description	设定范围	R/W
b15 to b0	存储16位比较匹配B数据。*1	0000h to FFFFh	R/W

Note 1. 当不使用比较匹配B时，将AGTCMB寄存器设置为FFFFh。

AGTCMB寄存器是一个读写寄存器，用于设置与AGT计数器比较匹配的值。重载寄存器和比较寄存器B的状态根据AGTCR寄存器中的TSTART位而改变。有关详细信息，请参见第24.3.2节，重载寄存器和比较寄存器AB重写操作。AGTCMB寄存器可以通过16位存储器操作指令设置。

24.2.4 AGT控制寄存器(AGTCR)

Address(es): AGT0.AGTCR 4008 4008h, AGT1.AGTCR 4008 4108h

	b7	b6	b5	b4	b3	b2	b1	b0
	TCMBF	TCMAF	TUNDF	TEDGF	—	TSTOP	TCSTF	TSTART
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TSTART	AGT Count Start*2	0：计数停止1 ：计数开始。	R/W
b1	TCSTF	AGT计数状态标志*2	0：计数停止1：计数 中。	R
b2	TSTOP	AGT计数强制停止*1	0：写入无效1：强制停止计数 。	W
b3	—	Reserved	读取值为0。写入值应为0。	R/W
b4	TEDGF	主动边缘判断 Flag	0：未收到有效边沿1：收 到有效边沿。	R/(W)*3
b5	TUNDF	Underflow Flag	0: No underflow 1: Underflow.	R/(W)*3
b6	TCMAF	比较匹配标志	0：不匹配1 ：匹配。	R/(W)*3
b7	TCMBF	比较匹配B标志	0：不匹配1 ：匹配。	R/(W)*3

Note 1. 当1（强制停止计数）写入TSTOP位时，TSTART和TCSTF位同时初始化。
脉冲输出电平也被初始化。读取值为0。
Note 2. 有关使用TSTART和TCSTF位的信息，请参见第24.4.1节，计数操作开始和停止控制。
Note 3. 只能写入0来清除标志。

TSTART位（AGT计数开始*2）

通过向TSTART位写入1开始计数操作，通过写入0停止计数操作。当该位设置为1（计数开始）时，TCSTF位与计数源同步设置为1（正在进行计数）。此外，在TSTART位写入0后，TCSTF位与计数源同步设置为0（计数停止）。有关详细信息，请参见第24.4.1节，计数操作开始和停止控制。

TCSTF flag (AGT Count Status Flag*2)

The TCSTF flag indicates the AGT count status.

[Setting condition]

- When 1 is written to the TSTART bit (the TCSTF flag is set to 1 in synchronization with the count source).

[Clearing conditions]

- When 0 is written to the TSTART bit (the TCSTF flag is set to 0 in synchronization with the count source)
- When 1 is written to the TSTOP bit.

TSTOP bit (AGT Count Forced Stop*1)

When 1 is written to the TSTOP bit, the count is forcibly stopped. The read value is 0.

TEDGF flag (Active Edge Judgment Flag)

The TEDGF flag indicates that an active edge was detected.

[Setting condition]

- When the measurement of the active width of the external input (AGTIO) is complete in pulse width measurement mode
- When the set edge of the external input (AGTIO) is input in pulse period measurement mode.

[Clearing condition]

- When 0 is written to this flag by software.

TUNDF flag (Underflow Flag)

The TUNDF flag indicates that the counter underflowed.

[Setting condition]

- When the counter underflows.

[Clearing condition]

- When 0 is written to this flag by software.

TCMAF flag (Compare Match A Flag)

The TCMAF flag indicates that compare match A was detected.

[Setting condition]

- When the value in the AGT register matches the value in the AGTCMA register.

[Clearing condition]

- When 0 is written to this flag by software.

TCMBF flag (Compare Match B Flag)

The TCMBF flag indicates that compare match B was detected.

[Setting condition]

- When the value in the AGT register matches the value in the AGTCMB register.

[Clearing condition]

- When 0 is written to this flag by software.

TCSTF标志（AGT计数状态标志*2）

TCSTF标志指示AGT计数状态。

[Setting condition]

- 当1写入TSTART位时（TCSTF标志设置为1与计数源同步）。

[Clearing conditions]

- 当0写入TSTART位时（TCSTF标志设置为0与计数源同步）
- 当1写入TSTOP位时。

TSTOP位（AGT计数强制停止*1）

向TSTOP位写入1时，强制停止计数。读取值为0。

TEDGF标志（活动边缘判断标志）

TEDGF标志表示检测到有效边沿。

[Setting condition]

- 在脉冲宽度测量模式下，外部输入(AGTIO)的有效宽度测量完成时
- 在脉冲周期测量模式下输入外部输入(AGTIO)的设置边沿时。

[Clearing condition]

- 当软件向该标志写入0时。

TUNDF flag (Underflow Flag)

TUNDF标志指示计数器下溢。

[Setting condition]

- 当计数器下溢时。

[Clearing condition]

- 当软件向该标志写入0时。

TCMAF标志（比较匹配A标志）

TCMAF标志表示检测到比较匹配A。

[Setting condition]

- 当AGT寄存器中的值与AGTCMA寄存器中的值匹配时。

[Clearing condition]

- 当软件向该标志写入0时。

TCMBF标志（比较匹配B标志）

TCMBF标志表示检测到比较匹配B。

[Setting condition]

- 当AGT寄存器中的值与AGTCMB寄存器中的值匹配时。

[Clearing condition]

- 当软件向该标志写入0时。

24.2.5 AGT Mode Register 1 (AGTMR1)

Address(es): AGT0.AGTMR1 4008 4009h, AGT1.AGTMR1 4008 4109h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	TCK[2:0]			TEDGPL	TMOD[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	TMOD[2:0]	Operating Mode*3	b2 b0 0 0 0: Timer mode 0 0 1: Pulse output mode 0 1 0: Event counter mode 0 1 1: Pulse width measurement mode 1 0 0: Pulse period measurement mode. Other settings are prohibited.	R/W
b3	TEDGPL	Edge Polarity*4	0: Single-edge 1: Both-edge.	R/W
b6 to b4	TCK[2:0]	Count Source*1, *2, *5	b6 b4 0 0 0: PCLKB 0 0 1: PCLKB/8 0 1 1: PCLKB/2 1 0 0: Divided clock AGTLCLK specified in CKS[2:0] bits in AGTMR2 register 1 0 1: Underflow event signal from AGT0*6 1 1 0: Divided clock AGTSCLK specified in CKS[2:0] bits in AGTMR2 register. Other settings are prohibited.	R/W
b7	—	Reserved	The read value is 0. The write value should be 0.	R/W

Note: Write access to the AGTMR1 register initializes the output from the AGTOn, AGTIOn, AGTOAn and AGTOBn pins of the AGT (n = 0, 1). For details on the output level at initialization, see section 24.2.7, AGT I/O Control Register (AGTIOC).
Note 1. When event counter mode is selected, the external input (AGTIOn) is selected as the count source regardless of the setting of TCK[2:0] bits.
Note 2. Do not switch count sources during count operation. Only switch count sources when both the TSTART and TCSTF bits in the AGTCR register are set to 0 (count is stopped).
Note 3. The operating mode can only be changed when the count is stopped while both the TSTART and TCSTF bits in the AGTCR register are set to 0 (count is stopped). Do not change the operating mode during count operation.
Note 4. The TEDGPL bit is enabled only in event counter mode.
Note 5. When running AGT in Software Standby and Deep Software Standby modes, set AGTSCLK or AGTLCLK (TCK[2:0] = 100b or 110b) as the count source.
Note 6. AGT0 cannot use AGT0 underflow (setting prohibited). AGT1 uses the AGT0 underflow.

24.2.5 AGT模式寄存器1(AGTMR1)

Address(es): AGT0.AGTMR1 4008 4009h, AGT1.AGTMR1 4008 4109h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	TCK[2:0]			TEDGPL	TMOD[2:0]		
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	TMOD[2:0]	Operating Mode*3	b2b0000：定时器模式001：脉冲输出模式010：事件计数器模式011：脉冲宽度测量模式100：脉冲周期测量模式。禁止其他设置。	R/W
b3	TEDGPL	Edge Polarity*4	0: Single-edge 1: Both-edge.	R/W
b6 to b4	TCK[2:0]	Count Source*1, *2, *5	b6b4000：PCLKB001：PCLKB8011：PCLKB2100：分频时钟AGTLCLK在AGTMR2寄存器的CKS[2:0]位中指定101：来自AGT0*的下溢事件信号6110：在AGTMR2寄存器的CKS[2:0]位中指定的分频时钟AGTSCLK。禁止其他设置。	R/W
b7	—	Reserved	读取值为0。写入值应为0。	R/W

Note: 对AGTMR1寄存器的写访问初始化AGT(n=0 1)的AGTOn、AGTIOn、AGTOAn和AGTOBn引脚的输出。有关初始化时输出电平的详细信息，请参见第24.2.7节，AGTIO控制寄存器(AGTIOC)。
Note 1. 选择事件计数器模式时，无论设置如何
TCK[2:0] bits.
Note 2. 请勿在计数操作期间切换计数源。只有在TSTART和TCSTF位都在
AGTCR寄存器设置为0（停止计数）。
Note 3. 只有在AGTCR寄存器中的TSTART和TCSTF位都设置为0（计数停止）时停止计数，才能更改操作模式。请勿在计数操作期间更改操作模式。
Note 4. TEDGPL位仅在事件计数器模式下启用。
Note 5. 在软件待机和深度软件待机模式下运行AGT时，将AGTSCLK或AGTLCLK(TCK[2:0]=100b或110b)设置为计数源。
Note 6. AGT0不能使用AGT0下溢（禁止设置）。AGT1使用AGT0下溢。

24.2.6 AGT Mode Register 2 (AGTMR2)

Address(es): AGT0.AGTMR2 4008 400Ah, AGT1.AGTMR2 4008 410Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	LPM	—	—	—	—	CKS[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	CKS[2:0]	AGTSCLK/AGTLCLK Count Source Clock Frequency Division Ratio *1, *2, *3	b2 b0 0 0 0: 1/1 0 0 1: 1/2 0 1 0: 1/4 0 1 1: 1/8 1 0 0: 1/16 1 0 1: 1/32 1 1 0: 1/64 1 1 1: 1/128.	R/W
b6 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	LPM	Low Power Mode	0: Normal mode 1: Low power mode.	R/W

Note 1. Do not rewrite CKS[2:0] during count operation. Only rewrite the CKS[2:0] bits when both the TSTART and TCSTF bits in the AGTCR register are set to 0 (count is stopped).
Note 2. When count source is AGTSCLK/AGTLCLK, the switch of CKS[2:0] is valid.
Note 3. Do not switch the TCK[2:0] bits in the AGTMR1 register when CKS[2:0] are not 000b. Switch the TCK[2:0] bits in the AGTMR1 register after CKS[2:0] are set to 000b, and wait for 1 cycle of the count source.

LPM bit (Low Power Mode)

The LPM bit sets the low power operation, which impacts access to certain AGT registers. Set this bit to 1 to operate in low power. When this bit is 1, access to the following registers is prohibited:

- AGT/AGTCMA/AGTCMB/AGTCR.

After this bit is switched from 1 to 0, the first access to the register is constrained as follows:

- AGT — Read AGT register twice. Only the second reading of data is valid.
- AGT, AGTCMA, AGTCMB, and AGTCR — Allow at least 2 cycles of the count source clock when writing to the register.

24.2.7 AGT I/O Control Register (AGTIOC)

Address(es): AGT0.AGTIOC 4008 400Ch, AGT1.AGTIOC 4008 410Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	TIOGT[1:0]		TIPF[1:0]		—	TOE	—	TEDGSEL
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TEDGSEL	I/O Polarity Switch	Function varies depending on the operating mode. See Table 24.3 and Table 24.4. The TEDGSEL bit switches the AGTO output polarity and the AGTIO input/output edge and polarity. In pulse output mode, it only controls the polarity of AGTOn and AGTIOn output. The AGTOn and AGTIOn output are initialized when the AGTMR1 register is written and the TSTOP bit in the AGTCR register is written with 1.	R/W

24.2.6 AGT模式寄存器2(AGTMR2)

Address(es): AGT0.AGTMR2 4008 400Ah, AGT1.AGTMR2 4008 410Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	LPM	—	—	—	—	CKS[2:0]		
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	CKS[2:0]	AGTSCLKAGTLCLK计数源时钟分频 Ratio *1, *2, *3	b2 b0 0 0 0: 1/1 0 0 1: 1/2 0 1 0: 1/4 0 1 1: 1/8 1 0 0: 1/16 1 0 1: 1/32 1 1 0: 1/64 1 1 1: 1/128.	R/W
b6 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	LPM	低功耗模式	0：正常模式1：低功耗模式。	R/W

Note 1. 在计数操作期间不要重写CKS[2:0]。只有当TSTART和TCSTF位都在AGTCR寄存器设置为0（停止计数）。
Note 2. 当计数源为AGTSCLKAGTLCLK时，CKS[2:0]的开关有效。
Note 3. 当CKS[2:0]不是000b时，不要切换AGTMR1寄存器中的TCK[2:0]位。在CKS[2:0]设置为000b后，切换AGTMR1寄存器中的TCK[2:0]位，并等待计数源的1个周期。

LPM位（低功耗模式）

LPM位设置低功耗操作，这会影响对某些AGT寄存器的访问。将此位设置为1以在低功耗下运行。该位为1时，禁止访问以下寄存器：

- AGT/AGTCMA/AGTCMB/AGTCR.

该位由1变为0后，对寄存器的第一次访问受到如下约束：

- AGT—读取AGT寄存器两次。只有第二次读取数据是有效的。
- AGT、AGTCMA、AGTCMB和AGTCR—写入寄存器时允许至少2个计数源时钟周期。

24.2.7 AGTIO控制寄存器(AGTIOC)

Address(es): AGT0.AGTIOC 4008 400Ch, AGT1.AGTIOC 4008 410Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	TIOGT[1:0]		TIPF[1:0]		—	TOE	—	TEDGSEL
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TEDGSEL	IO极性开关	功能因操作模式而异。见表24.3和 Table 24.4. TEDGSEL位切换AGTO输出极性和AGTIO输入输出边沿和极性。在脉冲输出模式下，它只控制AGTOn和AGTIon输出的极性。当AGTMR1寄存器被写入并且AGTCR寄存器中的TSTOP位被写入1时，AGTOn和AGTIOn输出被初始化。	R/W

Bit	Symbol	Bit name	Description	R/W
b1	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b2	TOE	AGTOn Output Enable	0: AGTOn output disabled 1: AGTOn output enabled.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b5, b4	TIPF[1:0]	Input Filter*3	b5 b4 0 0: No filter 0 1: Filter sampled at PCLKB 1 0: Filter sampled at PCLKB/8 1 1: Filter sampled at PCLKB/32. These bits specify the sampling frequency of the filter for the AGTIOn input. If the input to the AGTIOn pin is sampled and the value matches three successive times, that value is taken as the input value.	R/W
b7, b6	TIOGT[1:0]	Count Control*1,*2,*4	b7 b6 0 0: Event is always counted 0 1: Event is counted during polarity period specified for AGTEEn. Other settings are prohibited.	R/W

Note 1. When AGTEEn pin is used, the polarity to count an event can be selected with the EEPS bit in the AGTISR register.
Note 2. TIOGT[1:0] bits are enabled only in event counter mode.
Note 3. When event counter mode operation is performed during Software Standby and Deep Software Standby modes, the digital filter function cannot be used.
Note 4. When using in Deep Software Standby mode, set TIOGT[1:0] = 00b (event is always counted).

Table 24.3 AGTIOn I/O edge and polarity switching

Operating mode	Function
Timer mode	Not used
Pulse output mode	0: Output is started at high (initialization level: high) 1: Output is started at low (initialization level: low).
Event counter mode	0: Count on rising edge 1: Count on falling edge.
Pulse width measurement mode	0: Low-level width is measured 1: High-level width is measured
Pulse period measurement mode	0: Measure from one rising edge to the next rising edge 1: Measure from one falling edge to the next falling edge.

Table 24.4 AGTOn output polarity switching

Operating mode	Function
All modes	0: Output is started at low (initialization level: low) 1: Output is started at high (initialization level: high).

24.2.8 AGT Event Pin Select Register (AGTISR)

Address(es): AGT0.AGTISR 4008 400Dh, AGT1.AGTISR 4008 410Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	EEPS	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b2	EEPS	AGTEEn Polarity Selection	0: An event is counted during the low-level period 1: An event is counted during the high-level period.	R/W

Bit	Symbol	位名称	Description	R/W
b1	—	Reserved	该位读取为0。写入值应为0。	R/W
b2	TOE	AGTOn输出使能	0：禁用AGTOn输出1：启用AGTOn输出。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b5, b4	TIPF[1:0]	Input Filter*3	b5b400：无滤波器01：滤波器在PCLKB1处采样0：滤波器在PCLKB8处采样11：滤波器在PCLKB32处采样。这些位指定AGTIOn输入的滤波器采样频率。如果对AGTIOn引脚的输入进行采样并且值连续匹配3次，则将该值作为输入值。	R/W
b7, b6	TIOGT[1:0]	Count Control*1,*2,*4	b7b600：始终计数事件01：在为AGTEEn指定的极性周期内计数事件。禁止其他设置。	R/W

Note 1. 当使用AGTEEn引脚时，可以通过AGTISR寄存器中的EEPS位选择计数事件的极性。
Note 2. TIOGT[1:0]位仅在事件计数器模式下启用。
Note 3. 在软件待机和深度软件待机模式期间执行事件计数器模式操作时，不能使用数字滤波器功能。
Note 4. 在深度软件待机模式下使用时，设置TIOGT[1:0]=00b（始终计数事件）。

Table 24.3 AGTIOnIO边沿和极性切换

操作模式	Function
定时器模式	不曾用过
脉冲输出方式	0：高电平开始输出（初始化电平：高电平）1：低电平开始输出（初始化电平：低电平）。
事件计数器模式	0：上升沿计数1：下降沿计数。
脉宽测量模式	0：测量低电平宽度1：测量高电平宽度
脉冲周期测量模式	0：从一个上升沿测量到下一个上升沿1：从一个下降沿测量到下一个下降沿。

Table 24.4 AGTOn输出极性切换

操作模式	Function
所有模式	0：低电平开始输出（初始化电平：低电平）1：高电平开始输出（初始化电平：高电平）。

24.2.8 AGT事件引脚选择寄存器(AGTISR)

Address(es): AGT0.AGTISR 4008 400Dh, AGT1.AGTISR 4008 410Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	EEPS	—	—
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b2	EEPS	AGTEEn Polarity Selection	0：在低电平期间计数一个事件1：在高电平期间计数一个事件。	R/W

Bit	Symbol	Bit name	Description	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

24.2.9 AGT Compare Match Function Select Register (AGTCMSR)

Address(es): AGT0.AGTCMSR 4008 400Eh, AGT1.AGTCMSR 4008 410Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	TOPOLB	TOEB	TCMEB	—	TOPOLA	TOEA	TCMEA
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TCMEA	Compare Match A Register Enable*1, *2	0: Compare match A register disabled 1: Compare match A register enabled.	R/W
b1	TOEA	AGTOAn Output Enable*1, *2	0: AGTOAn output disabled 1: AGTOAn output enabled.	R/W
b2	TOPOLA	AGTOAn Polarity Select*1, *2	0: AGTOAn output is started on low 1: AGTOAn output is started on high.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	TCMEB	Compare Match B Register Enable*1, *2	0: Compare match B register disabled 1: Compare match B register enabled.	R/W
b5	TOEB	AGTOBn Output Enable*1, *2	0: AGTOBn output disabled 1: AGTOBn output enabled.	R/W
b6	TOPOLB	AGTOBn Polarity Select*1, *2	0: AGTOBn output is started on low 1: AGTOBn output is started on high.	R/W
b7	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

Note 1. Do not rewrite the AGTCMSR register during a count operation. Only rewrite the AGTCMSR register when both the TSTART and TCSTF bits in the AGTCR register are set to 0 (count is stopped).
Note 2. Do not set to 1 when in pulse width measurement mode or pulse period measurement mode.

24.2.10 AGT Pin Select Register (AGTIOSEL)

Address(es): AGT0.AGTIOSEL 4008 400Fh, AGT1.AGTIOSEL 4008 410Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	TIES	—	—	SEL[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	SEL[1:0]	AGTIO Pin Select*1, *3	b1 b0 0 0: Select Pm*2/AGTIO as AGTIO Pm/AGTIO cannot be used as AGTIO input pin in Deep Software Standby mode. 0 1: Setting prohibited 1 0: Select P402/AGTIO as AGTIO P402/AGTIO can be used as AGTIO input pin in Deep Software Standby mode. P402/AGTIOn is input only. It cannot be used for output. 1 1: Select P403/AGTIO as AGTIO. P403/AGTIO can be used as AGTIO input pin in Deep Software Standby mode. P403/AGTIOn is input only. It cannot be used for output.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Bit	Symbol	位名称	Description	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

24.2.9 AGT比较匹配功能选择寄存器(AGTCSR)

Address(es): AGT0.AGTCMSR 4008 400Eh, AGT1.AGTCMSR 4008 410Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	TOPOLB	TOEB	TCMEB	—	TOPOLA	TOEA	TCMEA
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TCMEA	比较匹配A寄存器使能*1 *2	0：比较匹配A寄存器禁用1：比较匹配A寄存器启用。	R/W
b1	TOEA	AGTOAn Output Enable*1, *2	0：禁用AGTOAn输出1：启用AGTOAn输出。	R/W
b2	TOPOLA	AGTOAn Polarity Select*1, *2	0：AGTOAn输出从低电平开始1：AGTOAn输出从高电平开始。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	TCMEB	比较匹配B寄存器使能*1 *2	0：比较匹配B寄存器禁用1：比较匹配B寄存器启用。	R/W
b5	TOEB	AGTOBn Output Enable*1, *2	0：AGTOBn输出禁用1：AGTOBn输出使能。	R/W
b6	TOPOLB	AGTOBn Polarity Select*1, *2	0：AGTOBn输出从低电平开始1：AGTOBn输出从高电平开始。	R/W
b7	—	Reserved	该位读取为0。写入值应为0。	R/W

Note 1. 在计数操作期间不要重写AGCTMSR寄存器。仅当AGTCR寄存器中的TSTART和TCSTF位都设置为0（计数停止）时才重写AGTCMSR寄存器。
Note 2. 在脉冲宽度测量模式或脉冲周期测量模式下不要设置为1。

24.2.10 AGT引脚选择寄存器(AGTISEL)

Address(es): AGT0.AGTIOSEL 4008 400Fh, AGT1.AGTIOSEL 4008 410Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	TIES	—	—	SEL[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	SEL[1:0]	AGTIO Pin Select*1, *3	b1b000：选择Pm*2AGTIO作为AGTIO PmAGTIO不能用作AGTIO输入引脚深度软件待机模式。01：禁止设置1 0：选择P402AGTIO作为AGTIO P402AGTIO可用作深度软件待机模式下的AGTIO输入引脚。P402AGTIOn仅为输入。它不能用于输出。11：选择P403AGTIO作为AGTIO。 P403AGTIO可用作深度软件待机模式下的AGTIO输入引脚。P403AGTION仅为输入。它不能用于输出。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b4	TIES	AGTIO Input Enable	0: External event input is disabled during Software Standby mode 1: External event input is enabled during Software Standby mode.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. P402/AGTIO and P403/AGTIO can be used as external event input pins for the AGT in Deep Software Standby mode. Pm*2/AGTIO cannot be used as external event input pins for the AGT in Deep Software Standby mode. P402/AGTIO and P403/AGTIO are input only.
When Pm/AGTIO is selected, you must set the Port mn Pin Function Select (PmnPFS) register. See section 19, I/O Ports.
Note 2. m = 100, 301, and 407 (AGT0), m = 400 (AGT1).
Note 3. When P402/AGTIO and P403/AGTIO are selected, you must set the VBTICTLR register. See section 19.2.7, AGT Input Control Register (VBTICTLR).

The AGTIOSEL register sets the AGTIO pin when using the AGTIO in Deep Software Standby mode and Software Standby mode. The AGTIOSEL register can be set with an 8-bit memory manipulation instruction.

SEL[1:0] bits (AGTIO Pin Select*1, *3)

The SEL[1:0] bits select the AGTIO pin function.

TIES bit (AGTIO Input Enable)

The TIES bit enables or disables an external event input.

24.3 Operation

24.3.1 Reload Register and Counter Rewrite Operation

Regardless of the operating mode, the timing of the rewrite operation to the reload register and the counter differs depending on the value of the TSTART bit in the AGTCR register and of the TCMEA and TCMEB bit in the AGTCMSR register. When the TSTART bit is 0 (count stops), the count value is directly written to the reload register and the counter. When the TSTART bit is 1 (count starts) and the TCMEA and TCMEB bits are 0 (compare match A/B registers are invalid), the value is written to the reload register in synchronization with the count source, and then to the counter in synchronization with the next count source. When the TSTART bit is 1 (count starts) and the TCMEA or TCMEB bit is 1 (compare match A register or compare match B register is valid), the value is written to the reload register in synchronization with the count source, and then to the counter in synchronization with the underflow of the counter.

Figure 24.2 and Figure 24.3 show the timing of rewrite operation with TSTART bit value and TCMEA/TCMEB bit value.

Bit	Symbol	位名称	Description	R/W
b4	TIES	AGTIO输入使能	0：在软件待机模式下禁用外部事件输入1：在软件待机模式下启用外部事件输入。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. P402AGTIO和P403AGTIO可用作深度软件待机模式下AGT的外部事件输入引脚。
Pm*2AGTIO不能用作深度软件待机模式下AGT的外部事件输入引脚。P402AGTIO和P403AGTIO仅为输入。

选择PMAGTIO后，必须设置端口MNPIN函数选择（PMNPFS）寄存器。请参阅第19节，IO端口。
Note 2. m = 100, 301, and 407 (AGT0), m = 400 (AGT1).
Note 3. WhenP402AGTIOandP403AGTIOareselected youmustsettheVBTICTLRregister.请参阅第19.2.7节，AGT输入控制寄存器（VBTICTLR）。

在深度软件待机模式和软件中使用AGTIO时，AGTIOSEL寄存器设置AGTIO引脚待机模式。AGTIOSEL寄存器可以使用8位存储器操作指令进行设置。

SEL[1:0]位(AGTIO引脚选择*1 *3)

SEL[1:0]位选择AGTIO引脚功能。

TIES位（AGTIO输入使能）

TIES位启用或禁用外部事件输入。

24.3 Operation

24.3.1 重载寄存器和计数器重写操作

无论工作模式如何，对重载寄存器和计数器的重写操作的时序根据AGTCR寄存器中的TSTART位以及AGTCMSR寄存器中的TCMEA和TCMEB位的值而有所不同。当TSTART位为0（计数停止）时，计数值直接写入重载寄存器和计数器。当TSTART位为1（计数开始）且TCMEA和TCMEB位为0（比较匹配AB寄存器无效）时，将值与计数源同步写入重载寄存器，然后与计数源同步写入计数器下一个计数源。当TSTART位为1（计数开始）且TCMEA或TCMEB位为1（比较匹配A寄存器或比较匹配B寄存器有效）时，该值与计数源同步写入重载寄存器，然后计数器与计数器的下溢同步。

图24.2和图24.3显示了使用TSTART位值和TCMEATCMEB位值进行重写操作的时序。

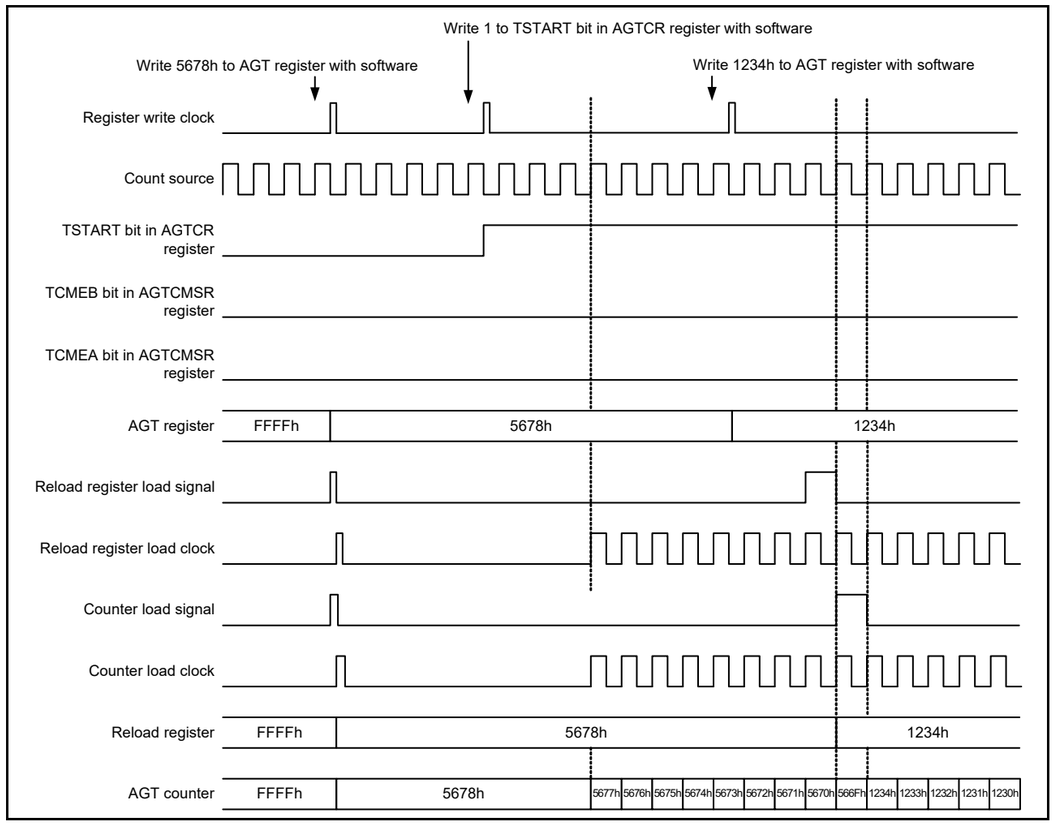


Figure 24.2 Timing of rewrite operation with TSTART bit value and TCMEA or TCMEB bit value when compare match register A or compare match B register is invalid

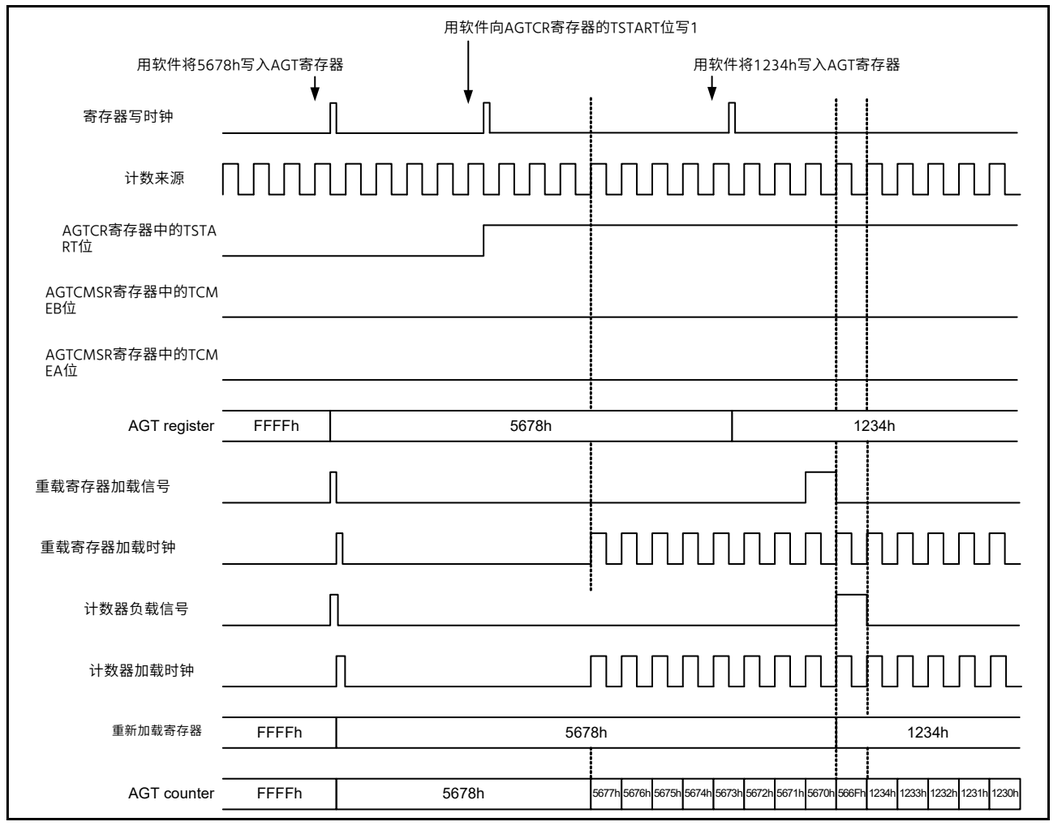


Figure 24.2 当比较匹配寄存器A或比较匹配B寄存器无效时，用TSTART位值和TCMEA或TCMEB位值重写操作的时序

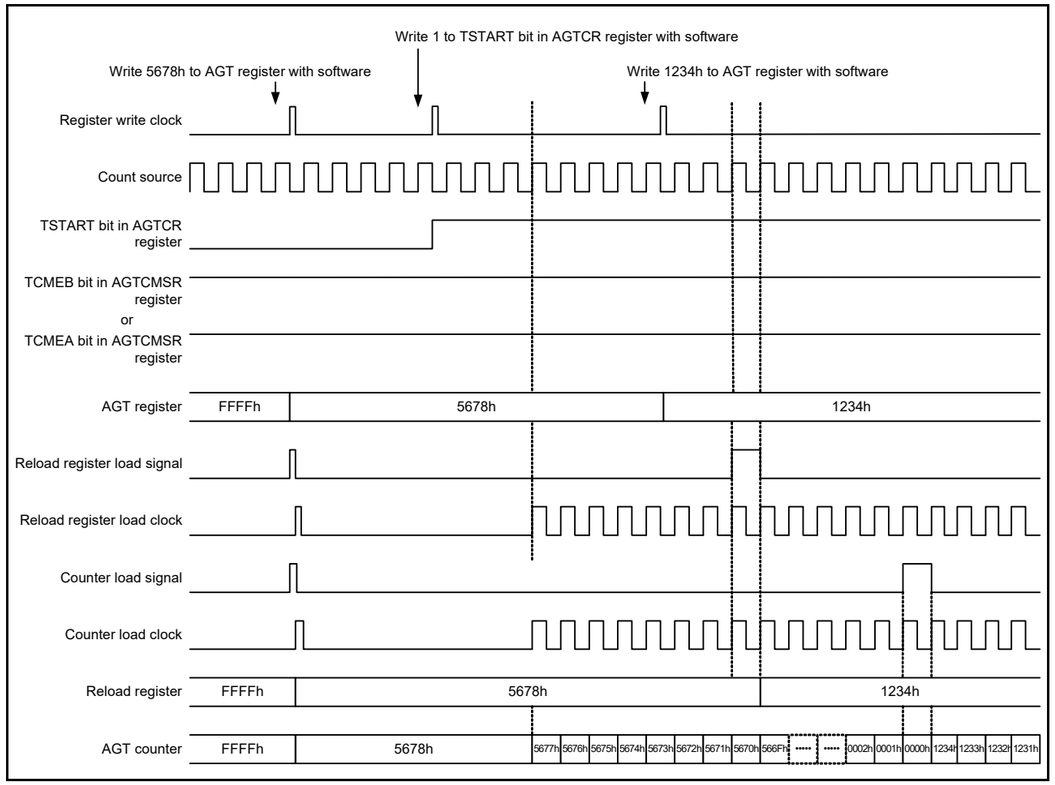


Figure 24.3 Timing of rewrite operation with TSTART bit value and TCMEA or TCMEB bit value when compare match register A or compare match B register is valid

24.3.2 Reload Register and Compare Register A/B Rewrite Operation

Regardless of the operating mode, the timing of the rewrite operation to compare register A/B depends on the value of the TSTART bit in the AGTCR register. When the TSTART bit is 0 (count stops), the count value is directly written to the reload register and compare register A/B. When the TSTART bit is 1 (count starts), the value is written to the reload register in synchronization with the count source, and then to the compare register in synchronization with the underflow of the counter.

Figure 24.4 shows the timing of rewrite operation with TSTART bit value for compare register A. Compare register B has the same timing as compare register A.

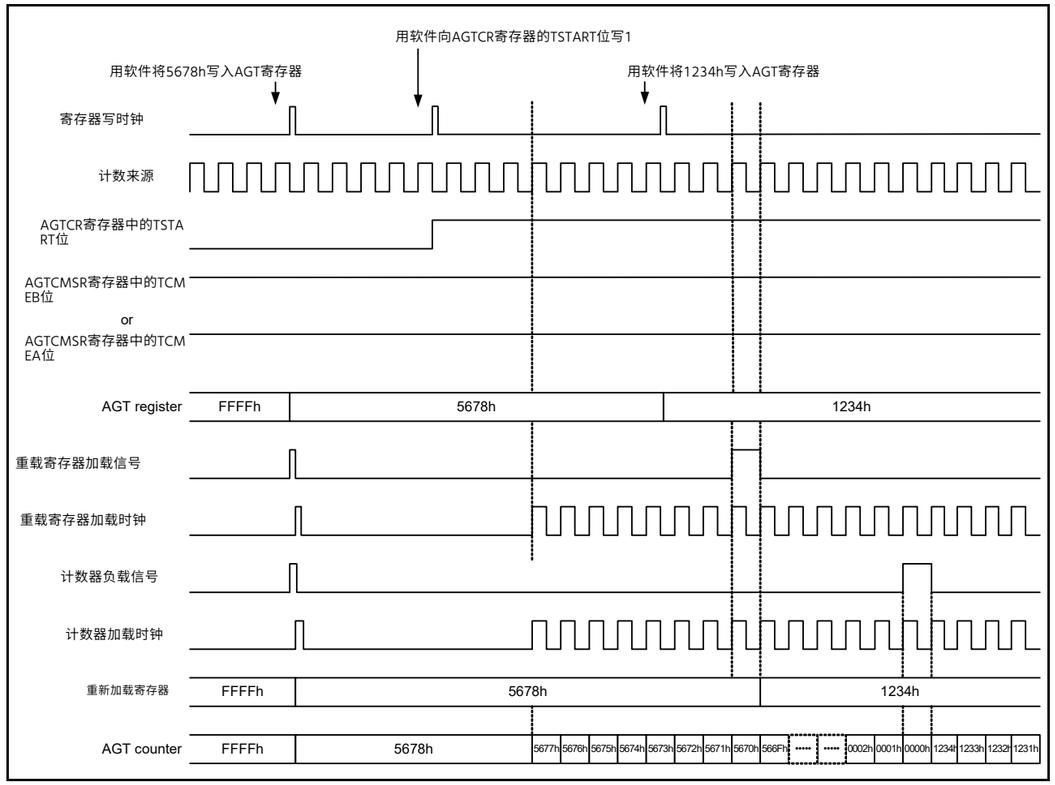


Figure 24.3 当比较匹配寄存器A或比较匹配B寄存器有效时，使用TSTART位值和TCMEA或TCMEB位值进行重写操作的时序

24.3.2 重载寄存器和比较寄存器AB重写操作

不管操作模式如何，对比较寄存器AB的重写操作的时序取决于AGTCR寄存器中TSTART位的值。当TSTART位为0（计数停止）时，将计数值直接写入重载寄存器和比较寄存器AB。当TSTART位为1（开始计数）时，将值同步写入重载寄存器计数源，然后与计数器的下溢同步到比较寄存器。

图24.4显示了比较寄存器A的TSTART位值重写操作的时序。比较寄存器B的时序与比较寄存器A的时序相同。

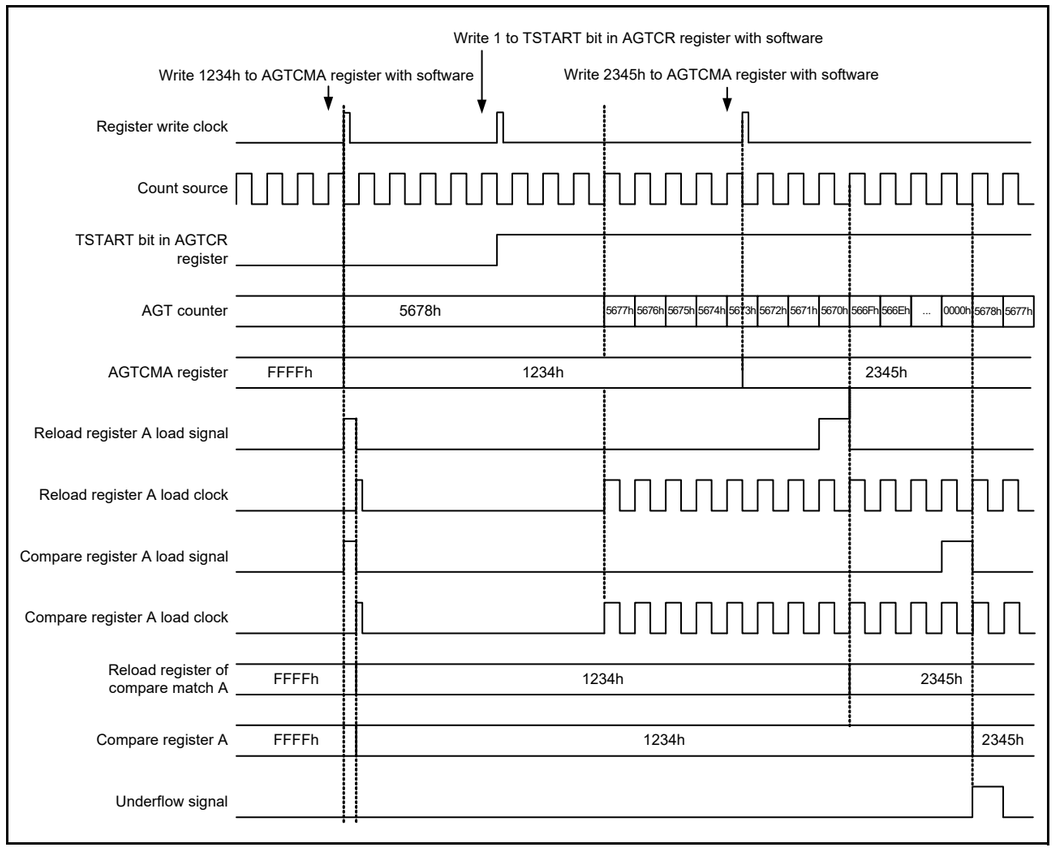


Figure 24.4 Timing of rewrite operation with the TSTART bit value for compare register A

24.3.3 Timer Mode

In timer mode, the AGT counter is decremented by the count source selected with the TCK[2:0] bits in the AGTMR1 register. In timer mode, the count value is decremented by 1 on each rising edge of the count source. When the count value reaches 0000h and the next count source is input, an underflow occurs and an interrupt request is generated.

Figure 24.5 shows the operation example in timer mode.

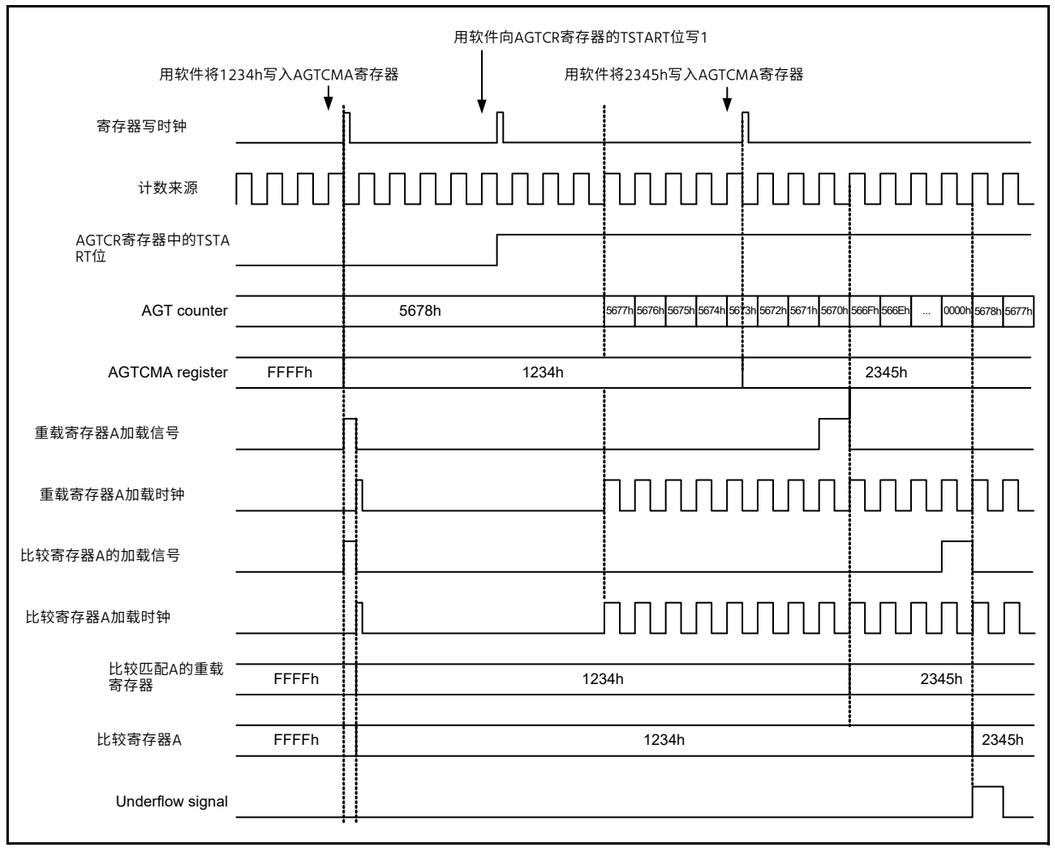


Figure 24.4 比较寄存器A的TSTART位值的重写操作时序

24.3.3 定时器模式

在定时器模式下，AGT计数器由AGTMR1寄存器中的TCK[2:0]位选择的计数源递减。在定时器模式下，计数值在计数源的每个上升沿减1。当计数值达到0000h并输入下一个计数源时，发生下溢并产生中断请求。

图24.5显示了定时器模式下的操作示例。

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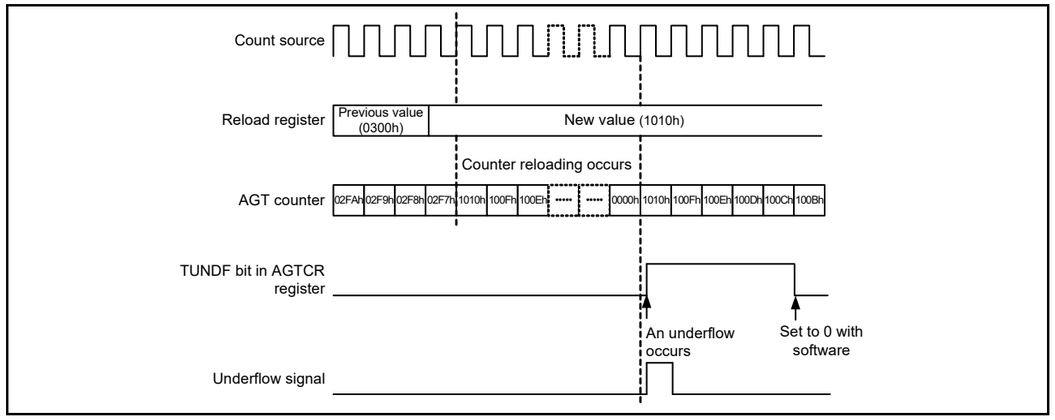


Figure 24.5 Operation example in timer mode

24.3.4 Pulse Output Mode

In pulse output mode, the counter is decremented by the count source selected with the TCK[2:0] bits in the AGTMR1 register, and the output level of the AGTIOn and AGTOn pins is inverted each time an underflow occurs.

In pulse output mode, the count value is decremented by 1 on each rising edge of the count source. When the count value reaches 0000h and the next count source is input, an underflow occurs and an interrupt request is generated. In addition, a pulse can be output from the AGTIOn and AGTOn pins. The output level is inverted each time an underflow occurs. The pulse output from the AGTOn pin can be stopped with the TOE bit in the AGTIOC register. The output level can be selected with the TEDGSEL bit in the AGTIOC register.

Figure 24.6 shows the operation example in pulse output mode.

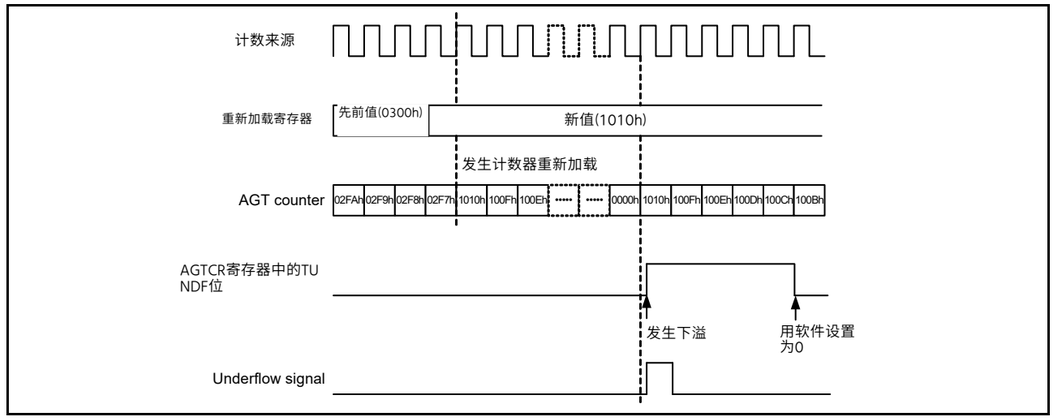


Figure 24.5 定时器模式下的操作示例

24.3.4 脉冲输出方式

在脉冲输出模式下，计数器由AGTMR1寄存器中的TCK[2:0]位选择的计数源递减，每次发生下溢时，AGTIOn和AGTOn引脚的输出电平反转。

在脉冲输出模式下，计数值在计数源的每个上升沿减1。当计数值达到0000h并输入下一个计数源时，发生下溢并产生中断请求。此外，可以从AGTIOn和AGTOn引脚输出脉冲。每次发生下溢时，输出电平都会反转。AGTOn引脚的脉冲输出可通过AGTIOC寄存器中的TOE位停止。可以通过AGTIOC寄存器中的TEDGSEL位选择输出电平。

图24.6显示了脉冲输出模式下的操作示例。

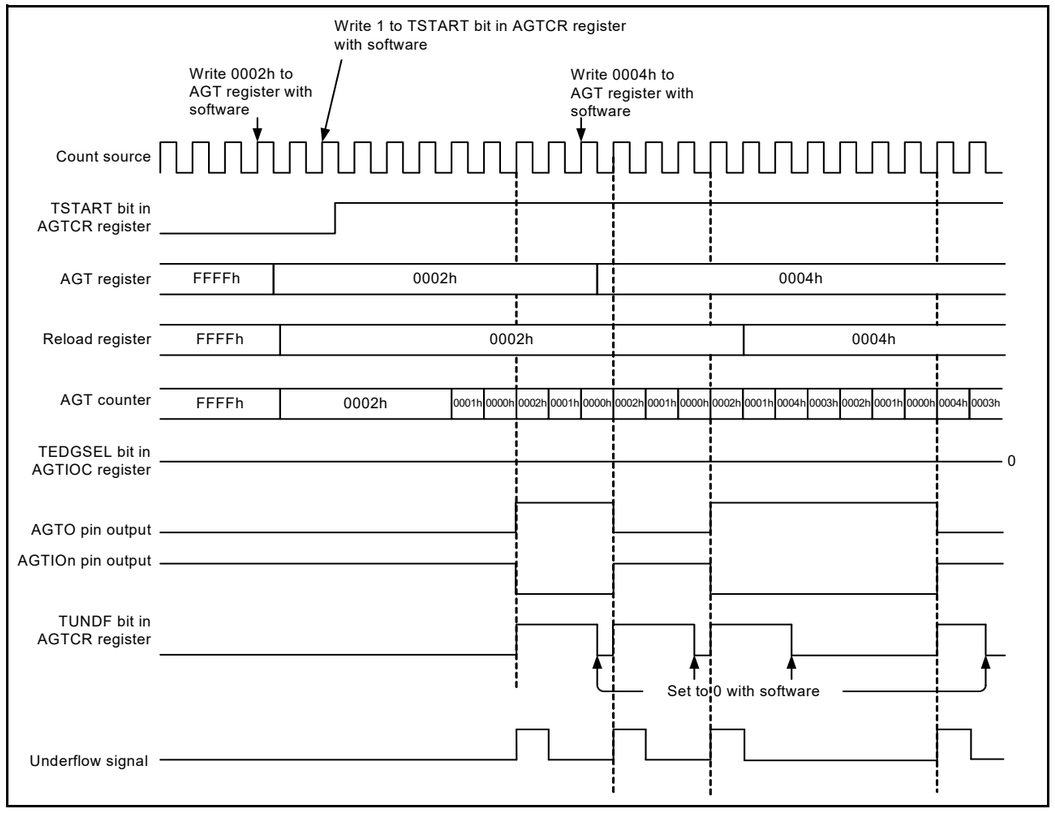


Figure 24.6 Operation example in pulse output mode

24.3.5 Event Counter Mode

In event counter mode, the counter is decremented by an external event signal (count source) input to the AGTIOn pin. Various periods for counting events can be set with the TIOGT[1:0] bits in the AGTIOC and AGTISR registers. In addition, the filter function for the AGTIOn input can be specified with the TIPF[1:0] bits in the AGTIOC register. The output from the AGTOn pin can be toggled even in event counter mode.

Figure 24.7 shows the operation example in event counter mode.

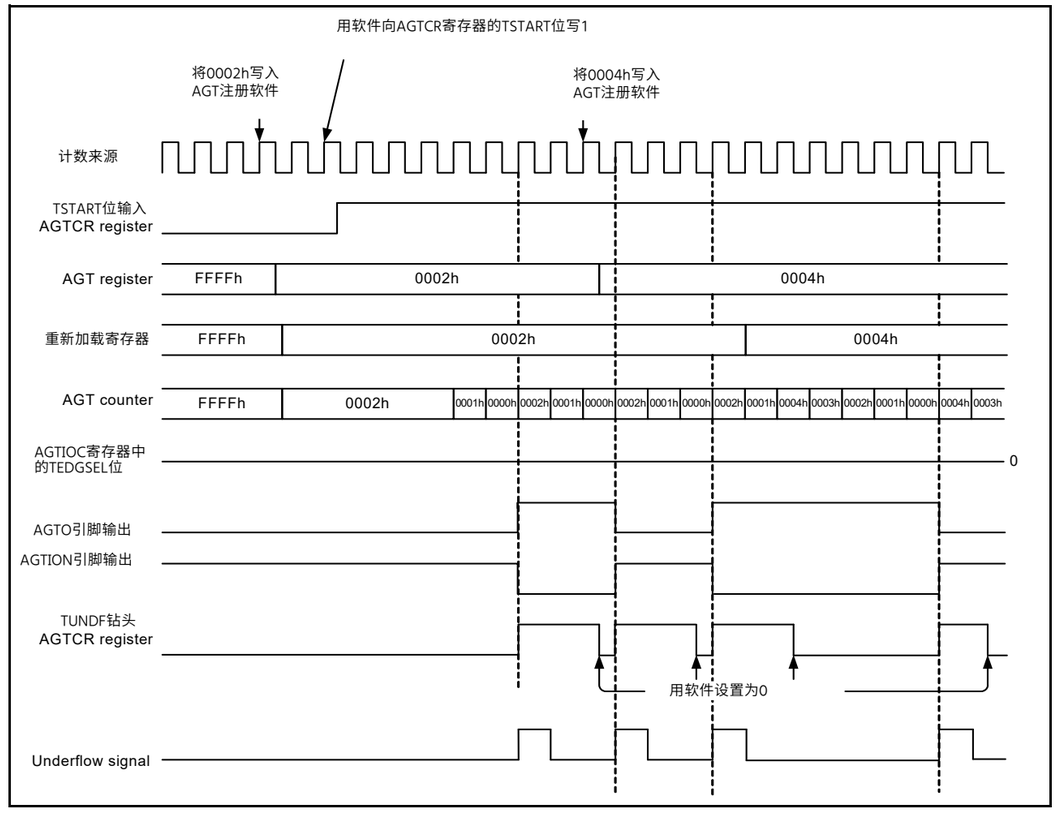


Figure 24.6 脉冲输出模式的动作示例

24.3.5 事件计数器模式

在事件计数器模式下，计数器由输入到AGTIOn引脚的外部事件信号（计数源）递减。可以使用AGTIOC和AGTISR寄存器中的TIOGT[1:0]位设置计数事件的各种周期。此外，可以使用AGTIOC寄存器中的TIPF[1:0]位指定AGTIOn输入的过滤器功能。即使在事件计数器模式下，也可以切换AGTOn引脚的输出。

图24.7显示了事件计数器模式下的操作示例。

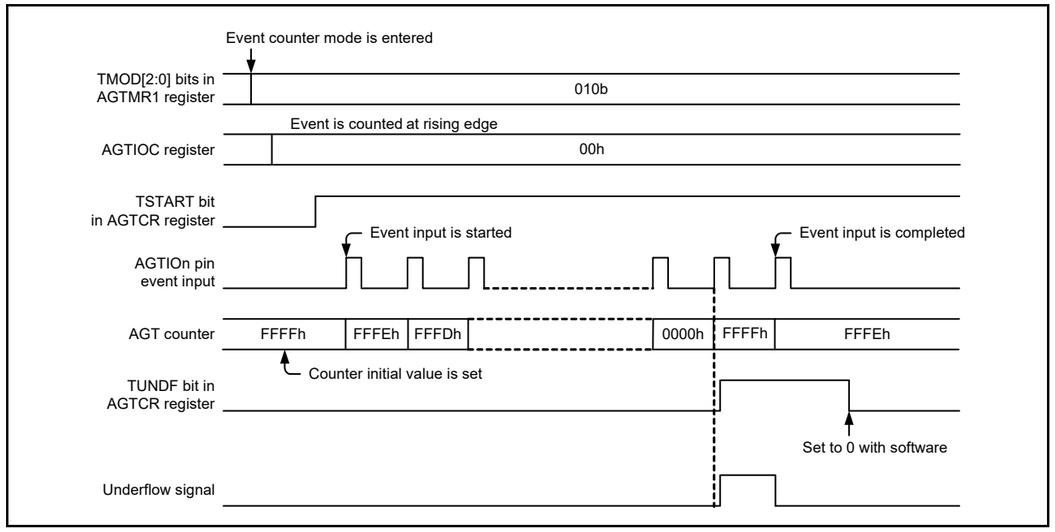
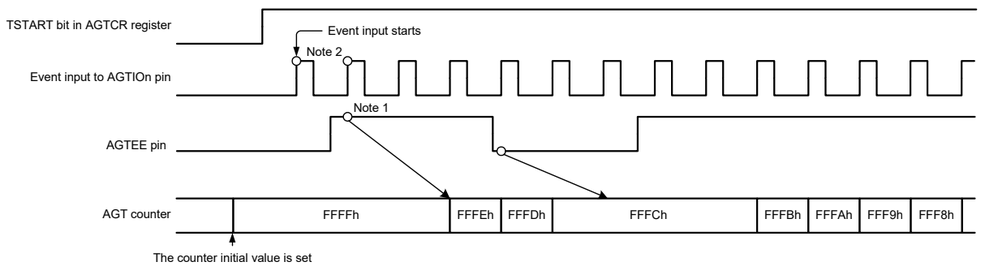


Figure 24.7 Operation example 1 in event counter mode

Figure 24.8 shows an operation example for counting during the specified period in event counter mode (TIOGT[1:0] bits in the AGTIOC register are set to 01b).

Timing example when the setting of operating mode is as follows :
AGTMR1 register: TMOD[2:0] = 010b (event counter mode)
AGTIOC register: TIOGT[1:0] = 01b (event is counted during specified period for external interrupt pin)
TIPF[1:0] = 00b (no filter)
TEDGSEL = 1 (count at rising edge)
AGTISR register: EEPS = 1 (high-level period is counted)



Note 1. To control synchronization, there is a delay of 2 cycles of the count source until count operation is affected. It is also possible that the count start timing is shifted by 1 cycle because of the phase difference between the AGTEEn and the sampling clock.

Note 2. Count operation can be performed for 2 cycles of the count source immediately after the count starts, depending on the previous state before the count stops.
To disable the count for 2 cycles immediately after the count starts, write 1 to the TSTOP bit in the AGTCR register to initialize the internal circuit, and then complete the operation settings before starting the count operation.

Figure 24.8 Operation example 2 in event counter mode

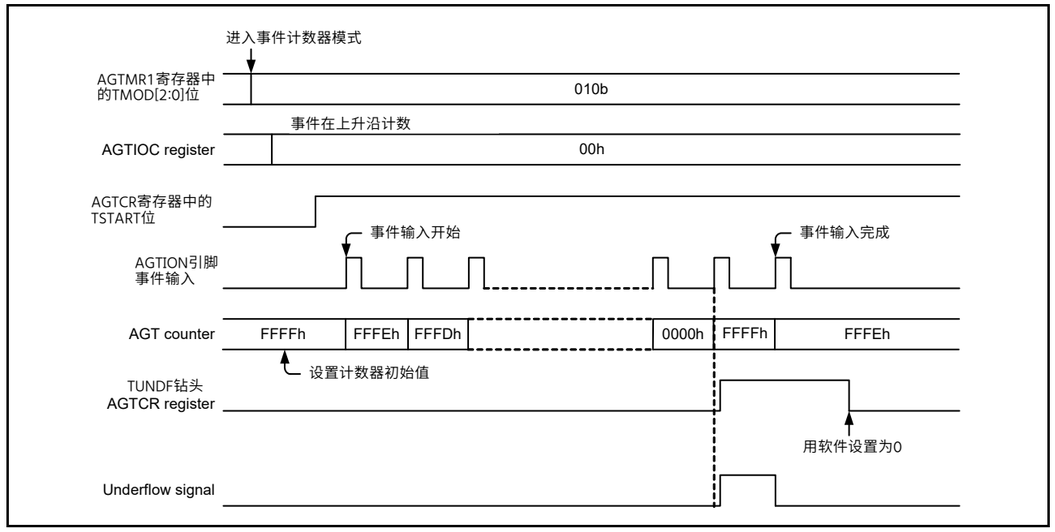
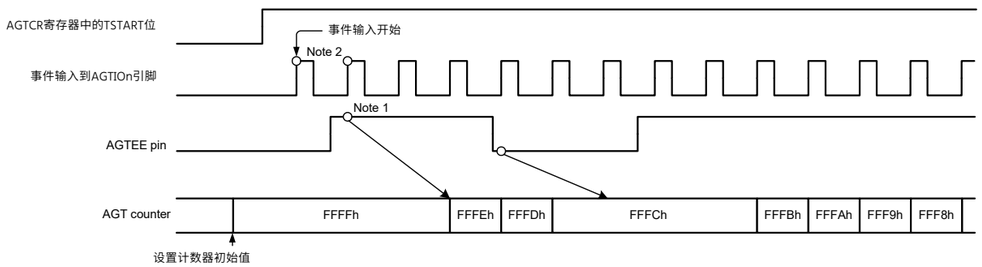


Figure 24.7 事件计数器模式下的操作示例1

图24.8显示了在事件计数器模式下在指定周期内进行计数的操作示例（AGTIOC寄存器中的TIOGT[1:0]位设置为01b）。

设置工作模式时的时序示例如下：
AGTMR1 register: TMOD[2:0] = 010b (event counter mode)
AGTIOC寄存器：TIOGT[1:0]=01b（事件在外部中断引脚的指定周期内计数）
TIPF[1:0] = 00b (no filter)
TEDGSEL=1（上升沿计数）
AGTISR寄存器：EEPS=1（高电平周期计入）



Note 1. 为了控制同步，计数源有2个周期的延迟，直到计数操作受到影响。由于AGTEEn和采样时钟之间的相位差，计数开始时间也可能偏移1个周期。

Note 2. 计数开始后，计数源的2个周期可以立即执行计数操作，具体取决于计数停止前的先前状态。要在计数开始后立即禁止计数2个周期，将1写入AGTCR寄存器的TSTOP位以初始化内部电路，然后在开始计数操作之前完成操作设置。

Figure 24.8 事件计数器模式下的操作示例2

24.3.6 Pulse Width Measurement Mode

In pulse width measurement mode, the pulse width of an external signal input to the AGTIOn pin is measured. When the level specified in the TEDGSEL bit in the AGTIOC register is input to the AGTIOn pin, the counter is decremented by the count source selected with the TCK[2:0] bits in the AGTMR1 register. When the specified level on the AGTIOn pin ends, the counter is stopped, the TEDGF bit in the AGTCR register is set to 1 (active edge received), and an interrupt request is generated. The measurement of pulse width data is performed by reading the count value while the counter is stopped. Also, when the counter underflows during measurement, the TUNDF bit in the AGTCR register is set to 1 and an interrupt request is generated.

Figure 24.9 shows the operation example in pulse width measurement mode.

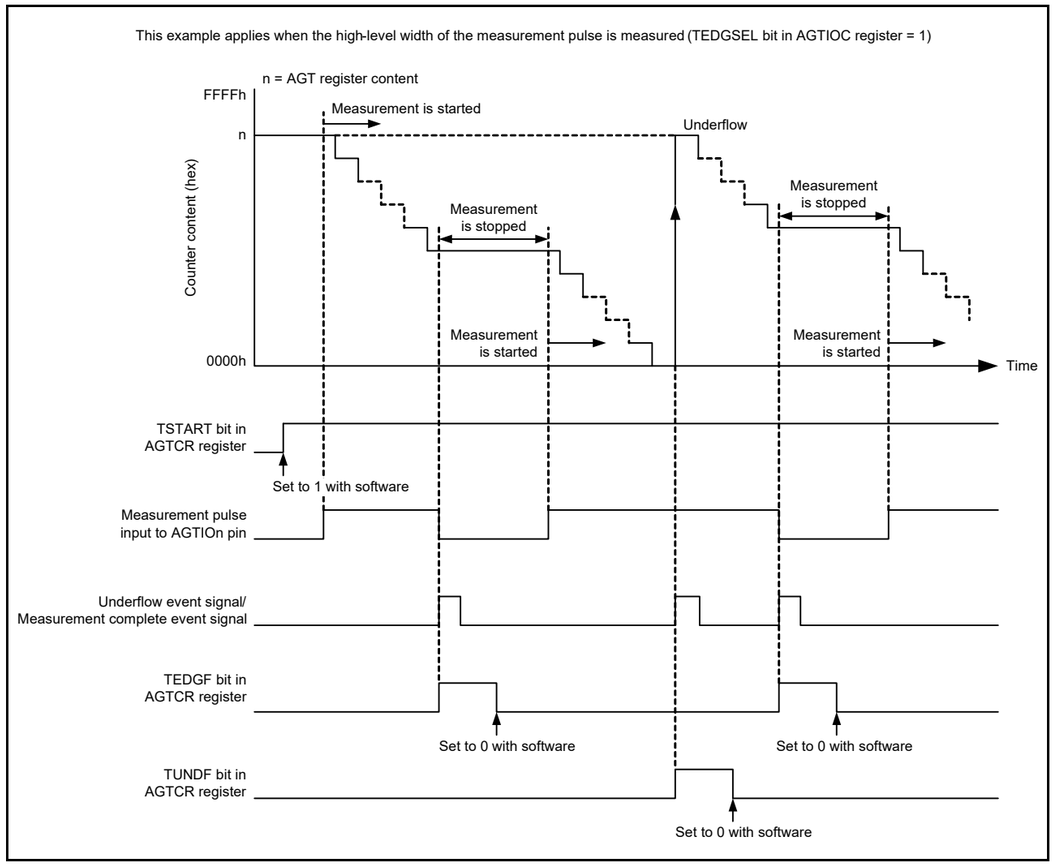


Figure 24.9 Operation example in pulse width measurement mode

24.3.7 Pulse Period Measurement Mode

In pulse period measurement mode, the pulse period of an external signal input to the AGTIOn pin is measured. The counter is decremented by the count source selected with the TCK[2:0] bits in the AGTMR1 register. When a pulse with the level specified by the TEDGSEL bit in the AGTIOC register is input to the AGTIOn pin, the count value is transferred to the read-out buffer on the rising edge of the count source. The value in the reload register is loaded to the counter at the next rising edge. Simultaneously, the TEDGF bit in the AGTCR register is set to 1 (active edge received) and an interrupt request is generated. The read-out buffer (AGT register) is read at this time and the difference from the reload value (see section 24.4.5, How to Calculate Event Number, Pulse Width, and Pulse Period) is the period data of the input pulse. The period data is retained until the read-out buffer is read. When the counter underflows, the TUNDF bit in the AGTCR register is set to 1 (underflow) and an interrupt request is generated.

24.3.6 脉冲宽度测量模式

在脉冲宽度测量模式下，测量输入到AGTIOn引脚的外部信号的脉冲宽度。当AGTIOC寄存器的TEDGSEL位指定的电平输入到AGTIOn引脚时，计数器会根据AGTMR1寄存器中的TCK[2:0]位选择的计数源递减。当AGTIOn引脚上的指定电平结束时，计数器停止，AGTCR寄存器中的TEDGF位设置为1（接收到有效沿），并产生中断请求。通过在计数器停止时读取计数值来执行脉冲宽度数据的测量。此外，当测量期间计数器下溢时，AGTCR寄存器中的TUNDF位设置为1，并产生中断请求。

图24.9显示了脉宽测量模式下的操作示例。

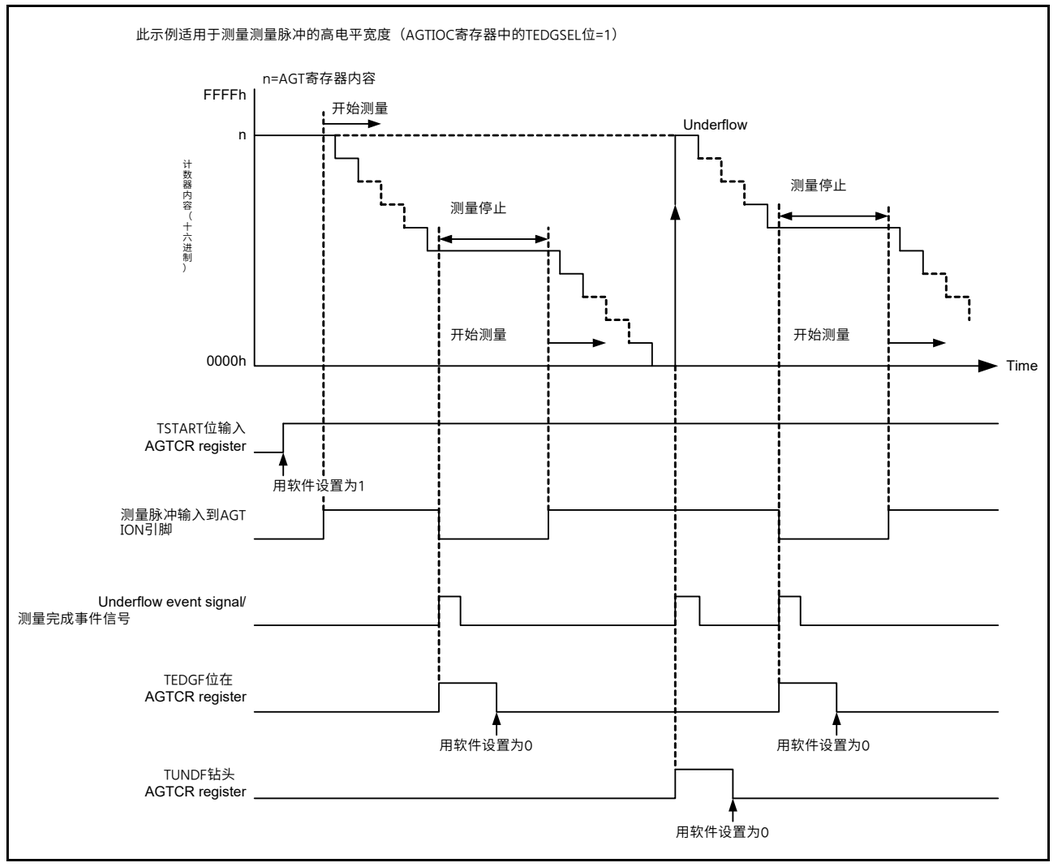


Figure 24.9 脉宽测量模式下的操作示例

24.3.7 脉冲周期测量模式

在脉冲周期测量模式下，测量输入到AGTIOn引脚的外部信号的脉冲周期。计数器按AGTMR1寄存器中的TCK[2:0]位选择的计数源递减。当AGTIOC寄存器中的TEDGSEL位指定电平的脉冲输入到AGTIOn引脚时，计数值在计数源的上升沿传送到读出缓冲器。重载寄存器中的值在下一个上升沿加载到计数器。同时，AGTCR寄存器中的TEDGF位设置为1（接收到有效边沿）并产生中断请求。此时读取读出缓冲区（AGT寄存器），与重载值的差值（参见第24.4.5节，如何计算事件编号、脉冲宽度和脉冲周期）是输入脉冲的周期数据。周期数据被保留，直到读出缓冲器被读取。当计数器下溢时，AGTCR寄存器中的TUNDF位设置为1（下溢）并产生中断请求。

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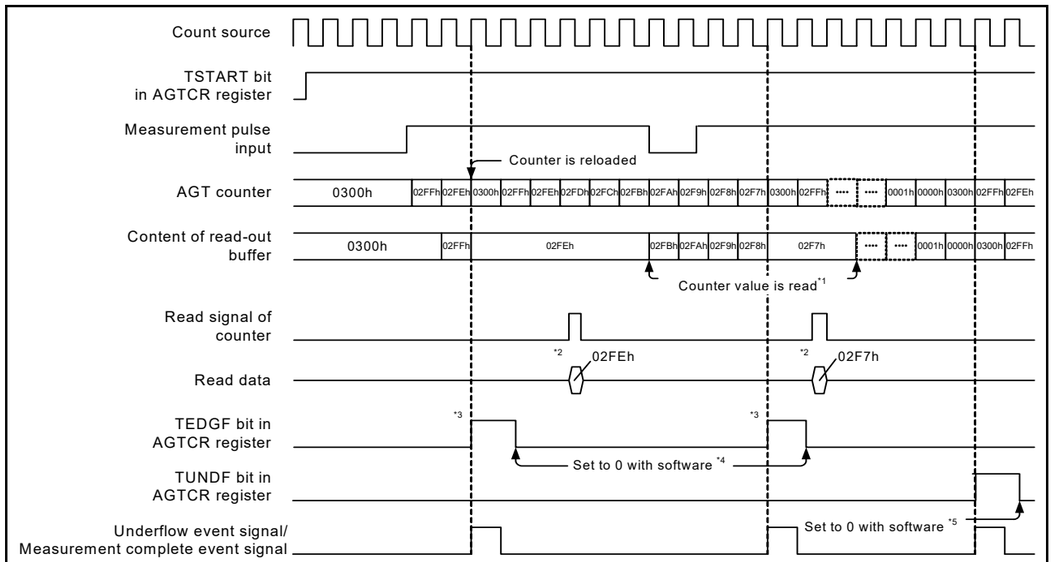
Figure 24.10 shows the operation example in pulse period measurement mode.

Only input pulses with a period longer than twice the period of the count source are measured. Also, the low-level and high-level widths must both be longer than the period of the count source. If a pulse period shorter than these conditions is input, the input might be ignored.



This example applies when the initial value of the AGT register is set to 0300h, the TEDGSEL bit in the AGTIOC register is set to 0, and the period from one rising edge to the next edge of the measurement pulse is measured.

Note 1. Reading from the AGT register must be performed during the period from when the TEDGF bit is set to 1 (active edge received) until the next active edge is input. The content of the read-out buffer is retained until the AGT register is read. If it is not read before the active edge is input, the measurement result of the previous period is retained.
Note 2. When the AGT register is read in pulse period measurement mode, the content of the read-out buffer is read.
Note 3. When the active edge of the measurement pulse is input and then the set edge of an external pulse is input, the TEDGF bit in the AGTCR register is set to 1 (active edge received).
Note 4. To set to 0 with software, write 0 to the TEDGF bit in the AGTCR register using an 8-bit memory manipulation instruction.
Note 5. To set to 0 with software, write 0 to the TUNDF bit in the AGTCR register using an 8-bit memory manipulation instruction.

Figure 24.10 Operation example in pulse period measurement mode

24.3.8 Compare Match Function

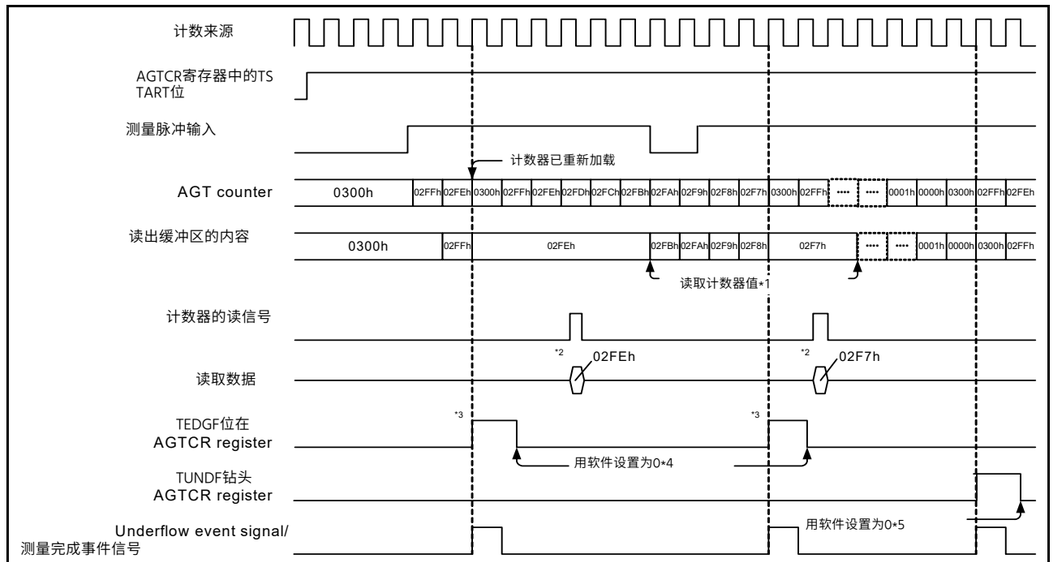
The compare match function detects matches (compare match) between the content of the AGTCMA or AGTCMB register and the content of the AGT register. This function is enabled when the TCMEA or TCMEB bit in the AGTCMSR register is 1 (compare match A register or compare match B register is valid). The counter is decremented by the count source selected with the TCK[2:0] bits in the AGTMR1 register, and when the values of AGT and AGTCMA or AGTCMB match, the TCMAF/TCMBF bit in the AGTCR register is set to 1 (match), and an interrupt request is generated.

When compare match function is enabled, the timing of the rewrite operation to the reload register and the counter differs. See section 24.3.1, Reload Register and Counter Rewrite Operation for details. In addition, the output level of the AGTOAn and AGTOBn pins is inverted by the match and by the underflow. The output level can be selected with the TOPOLA or TOPOLB bit in the AGTCMSR register.

Figure 24.11 shows the operation example in compare match mode.

图24.10显示了脉冲周期测量模式下的操作示例。

仅测量周期长于计数源周期两倍的输入脉冲。此外，低电平和高电平宽度都必须长于计数源的周期。如果输入比这些条件短的脉冲周期，输入可能会被忽略。



此示例适用于将AGT寄存器的初始值设置为0300h，将AGTIOC寄存器中的TEDGSEL位设置为0，并测量从一个上升沿到下一个测量脉冲沿的周期的情况。

Note 1. 从TEDGF位设置为1（接收到有效边沿）到输入下一个有效边沿期间，必须从AGT寄存器读取。读出缓冲器的内容一直保留到AGT寄存器被读取。如果在输入有效边沿之前未读取，则保留前一周期的测量结果。
Note 2. 在脉冲周期测量模式下读取AGT寄存器时，会读取读出缓冲区的内容。
Note 3. 当输入测量脉冲的有效边沿，然后输入外部脉冲的设置边沿时，AGTCR寄存器中的TEDGF位设置为1（接收到有效边沿）。
Note 4. 要使用软件设置为0，请使用8位存储器操作指令将0写入AGTCR寄存器中的TEDGF位。
Note 5. 要通过软件设置为0，请使用8位存储器操作指令将0写入AGTCR寄存器中的TUNDF位。

Figure 24.10 脉冲周期测量模式下的操作示例

24.3.8 比较匹配函数

比较匹配功能检测AGTCMA或AGTCMB寄存器的内容与AGT寄存器的内容之间的匹配（比较匹配）。该功能在AGTCMSR寄存器中的TCMEA或TCMEB位为1时使能（比较匹配A寄存器或比较匹配B寄存器有效）。计数器按AGTMR1寄存器中TCK[2:0]位选择的计数源递减，当AGT和AGTCMA或AGTCMB的值匹配时，AGTCR寄存器中的TCMAFTCMBF位设置为1（匹配），并产生中断请求。

当比较匹配功能启用时，对重载寄存器和计数器的重写操作的时序不同。有关详细信息，请参见第24.3.1节，重载寄存器和计数器重写操作。此外，AGTOAn和AGTOBn引脚的输出电平通过匹配和下溢反转。输出电平可以选择与

AGTCMSR寄存器中的TOPOLA或TOPOLB位。

图24.11显示了比较匹配模式下的操作示例。

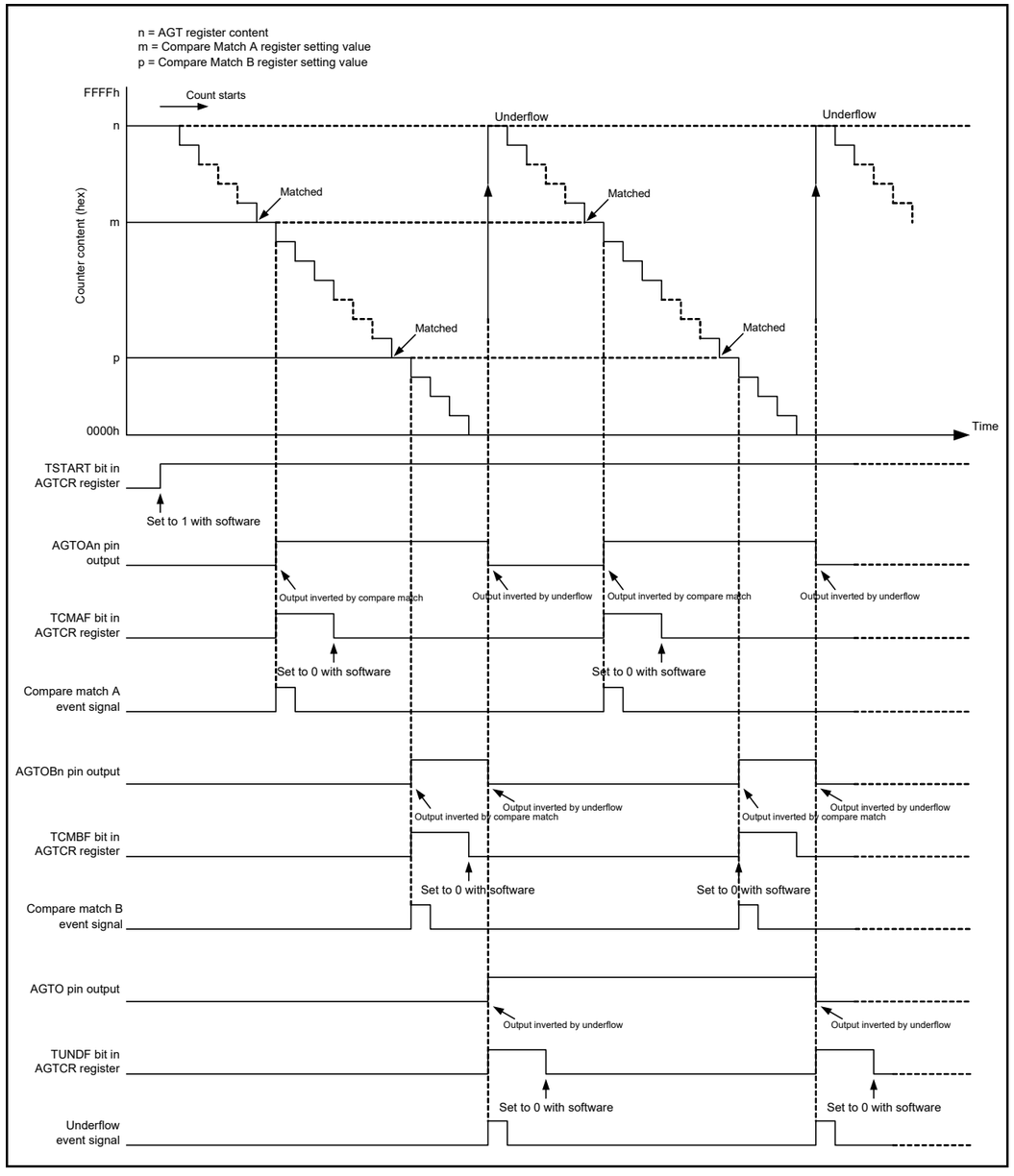


Figure 24.11 Operation example in compare match mode (TOPOLA = 0, TOPOLB = 0)

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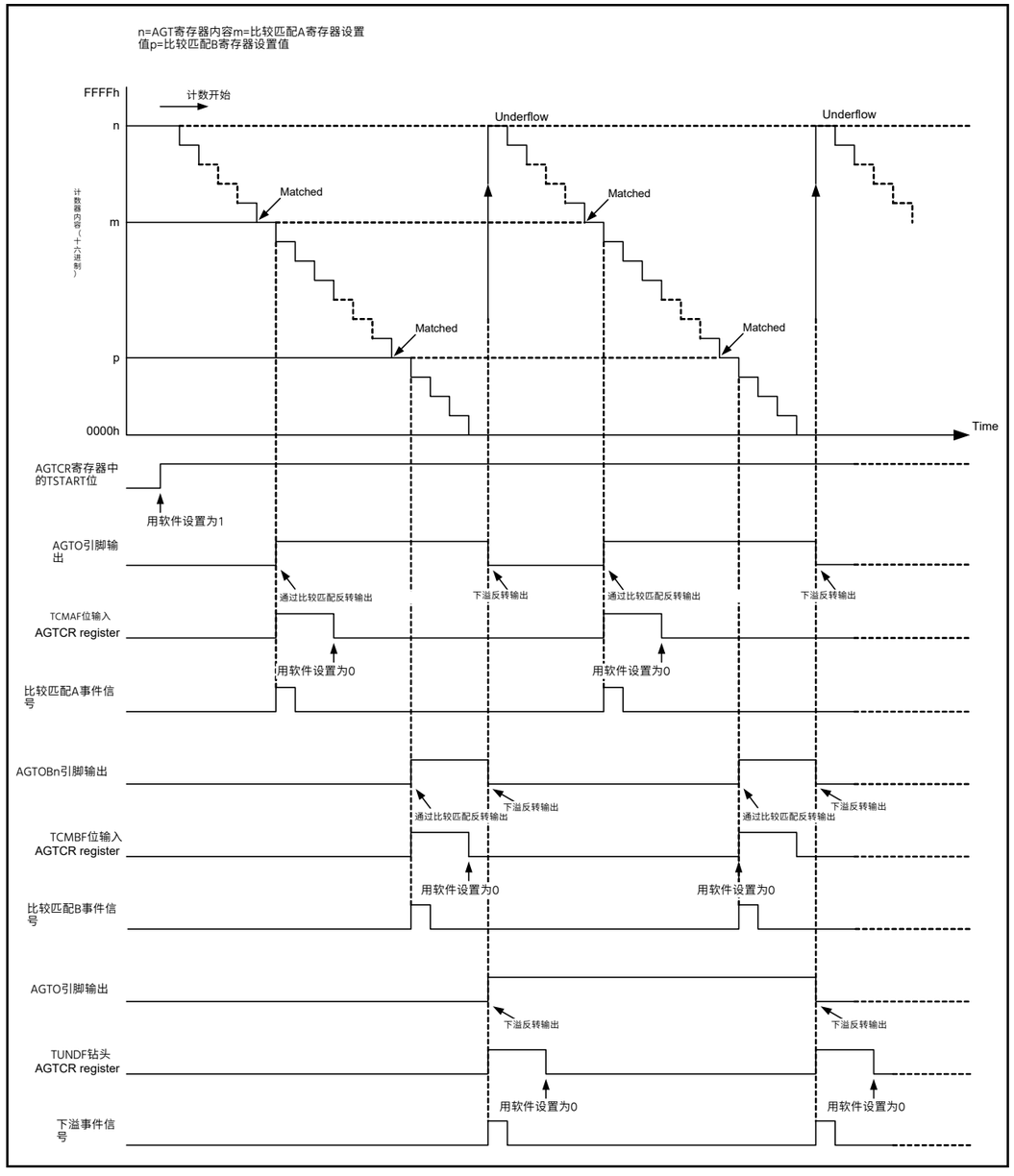


Figure 24.11 比较匹配模式下的操作示例(TOPOLA=0 TOPOLB=0)

24.3.9 Output Settings for Each Mode

Table 24.5 to Table 24.8 list the states of pins AGTOn, AGTIOn, AGTOAn, and AGTOBn in each mode.

Table 24.5 AGTOn pin setting

	AGTIOC register		
Operating mode	**TOE bit**	**TEDGSEL bit**	**AGTOn pin output**
All modes	1	1	Inverted output
		0	Normal output
	0	0 or 1	Output disabled

Table 24.6 AGTIOn pin setting

	AGTIOC register	
Operating mode	**TEDGSEL bit**	**AGTIOn pin I/O**
Timer mode	0 or 1	Input (not used)
Pulse output mode	1	Normal output
	0	Inverted output
Event counter mode	0 or 1	Input
Pulse width measurement mode		
Pulse period measurement mode		

Table 24.7 AGTOAn pin setting

	AGTCMSR register		
Operating mode	**TOEA bit**	**TOPOLA bit**	**AGTOAn pin output**
Timer mode	1	1	Inverted output
		0	Normal output
	0	0 or 1	Output disabled (not used)
Pulse output mode	1	1	Inverted output
		0	Normal output
	0	0 or 1	Output disabled (not used)
Event counter mode	1	1	Inverted output
		0	Normal output
	0	0 or 1	Output disabled (not used)
Pulse width measurement mode	0	0	Prohibited
Pulse period measurement mode			

Table 24.8 AGTOBn pin setting (1 of 2)

	AGTCMSR register		
Operating mode	**TOEB bit**	**TOPOLB bit**	**AGTOBn pin output**
Timer mode	1	1	Inverted output
		0	Normal output
	0	0 or 1	Output disabled (not used)
Pulse output mode	1	1	Inverted output
		0	Normal output
	0	0 or 1	Output disabled (not used)

24.3.9 每种模式的输出设置

表24.5至表24.8列出了每种模式下引脚AGTOn、AGTIOn、AGTOAn和AGTOBn的状态。

Table 24.5 AGTOn引脚设置

	AGTIOC register		
操作模式	**脚趾位**	**TEDGSEL bit**	**AGTOn引脚输出**
所有模式	1	1	反相输出
		0	正常输出
	0	0 or 1	输出禁用

Table 24.6 AGTIOn引脚设置

	AGTIOC register	
操作模式	**TEDGSEL bit**	**AGTIOn pin I/O**
定时器模式	0 or 1	Input (not used)
脉冲输出方式	1	正常输出
	0	反相输出
事件计数器模式	0 or 1	Input
脉宽测量模式		
脉冲周期测量模式		

Table 24.7 AGTO引脚设置

	AGTCMSR register		
操作模式	**TOEA bit**	**TOPOLA bit**	**AGTO引脚输出**
定时器模式	1	1	反相输出
		0	正常输出
	0	0 or 1	输出禁用（未使用）
脉冲输出方式	1	1	反相输出
		0	正常输出
	0	0 or 1	输出禁用（未使用）
事件计数器模式	1	1	反相输出
		0	正常输出
	0	0 or 1	输出禁用（未使用）
脉宽测量模式	0	0	Prohibited
脉冲周期测量模式			

Table 24.8 AGTOBn引脚设置(1of2)

	AGTCMSR register		
操作模式	**TOEB bit**	**TOPOLB bit**	**AGTOBn引脚输出**
定时器模式	1	1	反相输出
		0	正常输出
	0	0 or 1	输出禁用（未使用）
脉冲输出方式	1	1	反相输出
		0	正常输出
	0	0 or 1	输出禁用（未使用）

Table 24.8 AGTOBn pin setting (2 of 2)

Operating mode	AGTCMSR register TOEB bit	TOPOLB bit	AGTOBn pin output
Event counter mode	1	1	Inverted output
		0	Normal output
	0	0 or 1	Output disabled (not used)
Pulse width measurement mode	0	0	Prohibited
Pulse period measurement mode			

24.3.10 Standby Mode

The AGT can operate in Software Standby and Deep Software Standby modes. Set it to Software Standby mode or Deep Software Standby mode with count operation start (TSTART = 1, TCSTF = 1).

Table 24.9 and Table 24.10 show the settings that can be used in Software Standby and Deep Software Standby modes.

Table 24.9 Usable settings in Software Standby and Deep Software Standby modes (AGT0)

Operating mode	TCK[2:0] bits of AGTMR1 register	Operating clock	Resurgence factor of CPU
Timer mode	100b or 110b	AGTLCLK or AGTSCLK	—
Pulse output mode	100b or 110b	AGTLCLK or AGTSCLK	—
Event counter mode	- (Invalid)	AGTIOn	—
Pulse width measurement mode	100b or 110b	AGTLCLK or AGTSCLK	—
Pulse period measurement mode	100b or 110b	AGTLCLK or AGTSCLK	—

Table 24.10 Usable settings in Software Standby and Deep Software Standby modes (AGT1)

Operating mode	AGTMR1.TCK[2:0]	Operating clock	Resurgence factor of CPU
Timer mode	100b or 110b or 101b *1	AGTLCLK or AGTSCLK or AGT0 underflow	• Underflow • Compare match A/B
Pulse output mode	100b or 110b or 101b *1	AGTLCLK or AGTSCLK or AGT0 underflow	• Underflow • Compare match A/B
Event counter mode	— (invalid)	AGTIOn	• Underflow • Compare match A/B
Pulse width measurement mode	100b or 110b or 101b *1	AGTLCLK or AGTSCLK or AGT0 underflow	• Underflow • Active edge
Pulse period measurement mode	100b or 110b or 101b *1	AGTLCLK or AGTSCLK or AGT0 underflow	• Underflow • Active edge

Note: Release of Software Standby mode or Deep Software Standby mode is only AGT1.
Note 1. Only when AGT0 operates in Table 24.9.

Table 24.8 AGTOBn引脚设置（2个中的2个）

操作模式	AGTCMSR register TOEB bit	TOPOLB bit	AGTOBn引脚输出
事件计数器模式	1	1	反相输出
		0	正常输出
	0	0 or 1	输出禁用（未使用）
脉宽测量模式	0	0	Prohibited
脉冲周期测量模式			

24.3.10 待机模式

AGT可以在软件待机和深度软件待机模式下运行。将其设置为软件待机模式或深度计数操作开始的软件待机模式（TSTART=1，TCSTF=1）。

表24.9和表24.10显示了可在软件待机和深度软件待机模式下使用的设置。

Table 24.9 软件待机和深度软件待机模式(AGT0)中的可用设置

操作模式	AGTMR1寄存器的TCK[2:0]位	工作时钟	CPU的中兴系数
定时器模式	100b or 110b	AGTLCLK or AGTSCLK	—
脉冲输出方式	100b or 110b	AGTLCLK or AGTSCLK	—
事件计数器模式	- (Invalid)	AGTIOn	—
脉宽测量模式	100b or 110b	AGTLCLK or AGTSCLK	—
脉冲周期测量模式	100b or 110b	AGTLCLK or AGTSCLK	—

Table 24.10 软件待机和深度软件待机模式(AGT1)中的可用设置

操作模式	AGTMR1.TCK[2:0]	工作时钟	CPU的中兴系数
定时器模式	100b or 110b or 101b *1	AGTLCLK or AGTSCLK or AGT0 underflow	下溢 比较匹配AB
脉冲输出方式	100b or 110b or 101b *1	AGTLCLK or AGTSCLK or AGT0 underflow	下溢 比较匹配AB
事件计数器模式	— (invalid)	AGTIOn	下溢 比较匹配AB
脉宽测量模式	100b or 110b or 101b *1	AGTLCLK or AGTSCLK or AGT0 underflow	下溢 活动边沿
脉冲周期测量模式	100b or 110b or 101b *1	AGTLCLK or AGTSCLK or AGT0 underflow	下溢 活动边沿

Note: 软件待机模式或深度软件待机模式的释放只有AGT1。
注1.仅当AGT0在表24.9中运行时。

24.3.11 Interrupt Sources

The AGT has three interrupt sources described in Table 24.11.

Table 24.11 AGT interrupt sources

Name	Interrupt source	DMAC/DTC activation
AGTn_AGTI	• When the counter underflows • When measurement of the active width of the external input (AGTIO) is complete in pulse width measurement mode • When the set edge of the external input (AGTIO) is input in pulse period measurement mode.	Possible
AGTn_AGTCMAI	When the values of AGT and AGTCMA match	Possible
AGTn_AGTCMBI	When the values of AGT and AGTCMB match	Possible

Note: Channel number (n = 0 or 1).

24.3.12 Event Signal Output to ELC

The AGT uses the Event Link Controller (ELC) to perform a link operation to a specified module using the interrupt request signal as the event signal. The AGT outputs compare match A, compare match B, and underflow/measurement complete signals as event signals. For details, see section 18, Event Link Controller (ELC).

24.4 Usage Notes

24.4.1 Count Operation Start and Stop Control

- When the operating mode (see Table 24.1) is set to other than the event counter mode, or the count source is set to other than AGT0 underflow (TCK[2:0] = 101b):
  - After 1 (count starts) is written to the TSTART bit in the AGTCR register while the count is stopped, the TCSTF bit in the AGTCR register remains 0 (count stops) for 3 cycles of the count source. Do not access the registers associated with AGT*1 other than the TCSTF bit until this bit is set to 1 (count in progress).
  - After 0 (count stops) is written to the TSTART bit during a count operation, the TCSTF bit remains 1 for 3 cycles of the count source. When the TCSTF bit is set to 0, the count stops. Do not access the registers associated with AGT*1 other than the TCSTF bit until this bit is set to 0.
  - Clear the interrupt register before changing the TSTART bit from 0 to 1. See section 13, Interrupt Controller Unit (ICU) for details.

Note 1. Registers associated with AGT: AGT, AGTCMA, AGTCMB, AGTCR, AGTMR1, AGTMR2, AGTIOC, AGTISR, and AGTCMSR.

- When the operating mode (see Table 24.1) is set to event counter mode, or the count source is set to AGT0 underflow (TCK[2:0] = 101b):
  - After 1 (count starts) is written to the TSTART bit in the AGTCR register while the count is stopped, the TCSTF bit in the AGTCR register remains 0 (count stops) for 2 PCLKB cycles. Do not access the registers associated with AGT*1 other than the TCSTF bit until this bit is set to 1 (count in progress).
  - After 0 (count stops) is written to the TSTART bit during a count operation, the TCSTF bit remains 1 for 2 cycles of the PCLKB. When the TCSTF bit is set to 0, the count is stopped. Do not access the registers associated with AGT*1 other than the TCSTF bit until this bit is set to 0.
  - Clear the interrupt register before changing the TSTART bit from 0 to 1. See section 13, Interrupt Controller Unit (ICU) for details.

Note 1. Registers associated with AGT: AGT, AGTCMA, AGTCMB, AGTCR, AGTMR1, AGTMR2, AGTIOC, AGTISR, and AGTCMSR.

24.3.11 中断源

AGT具有表24.11中描述的三个中断源。

Table 24.11 AGT中断源

Name	中断源	DMAC/DTC activation
AGTn_AGTI	当计数器下溢时 当在脉冲宽度测量模式下完成外部输入(AGTIO)的有效宽度测量时 当在脉冲周期测量模式下输入外部输入(AGTIO)的设置边沿时。	Possible
AGTn_AGTCMAI	当AGT和AGTCMA的值匹配时	Possible
AGTn_AGTCMBI	当AGT和AGTCMB的值匹配时	Possible

Note: 通道号（n=0或1）。

24.3.12 事件信号输出到ELC

AGT使用事件链接控制器(ELC)使用中断请求信号作为事件信号执行到指定模块的链接操作。AGT输出比较匹配A、比较匹配B和下溢测量完成信号作为事件信号。有关详细信息，请参阅第18节，事件链接控制器(ELC)。

24.4 使用说明

24.4.1 计数操作启动和停止控制

- 当操作模式（见表24.1）设置为非事件计数器模式，或计数源设置为非AGT0下溢（TCK[2:0]=101b）时：
  - 在计数停止期间将1（计数开始）写入AGTCR寄存器中的TSTART位后，AGTCR寄存器中的TCSTF位在计数源的3个周期内保持为0（计数停止）。不要访问除TCSTF位之外的与AGT*1关联的寄存器，直到该位设置为1（正在进行计数）。
  - 在计数操作期间将0（计数停止）写入TSTART位后，TCSTF位在计数源的3个周期内保持为1。当TCSTF位设置为0时，计数停止。在此位设置为0之前，请勿访问与AGT*1相关的寄存器，而不是TCSTF位。
  - 在将TSTART位从0更改为1之前清除中断寄存器。参见第13节，中断控制器单位(ICU)了解详情。

注1.与AGT相关的寄存器：AGT、AGTCMA、AGTCMB、AGTCR、AGTMR1、AGTMR2、AGTIOC、AGTISR和AGTCMSR。

- 当操作模式（见表24.1）设置为事件计数器模式，或计数源设置为AGT0下溢（TCK[2:0]=101b）时：
  - 在停止计数的同时将1（计数开始）写入AGTCR寄存器中的TSTART位后，AGTCR寄存器中的TCSTF位保持0（计数停止）2个PCLKB周期。不要访问除TCSTF位之外的与AGT*1关联的寄存器，直到该位设置为1（正在进行计数）。
  - 在计数操作期间将0（计数停止）写入TSTART位后，TCSTF位在PCLKB的2个周期内保持为1。当TCSTF位设置为0时，停止计数。在此位设置为0之前，请勿访问与AGT*1相关的寄存器，而不是TCSTF位。
  - 在将TSTART位从0更改为1之前清除中断寄存器。参见第13节，中断控制器单位(ICU)了解详情。

注1.与AGT相关的寄存器：AGT、AGTCMA、AGTCMB、AGTCR、AGTMR1、AGTMR2、AGTIOC、AGTISR和AGTCMSR。

24.4.2 Access to Counter Register

When the TSTART and TCSTF bits in the AGTCR register are both 1 (count starts), allow at least 3 cycles of the count source clock between writes when writing to the AGT register successively.

24.4.3 When Changing Mode

The registers associated with AGT operating mode (AGTMR1, AGTMR2, AGTIOC, AGTISR, AGTCMSR and AGTIOC) can be changed only when the count is stopped with both the TSTART and TCSTF bits set to 0 (count stops). Do not change these registers during count operation.

When the registers associated with AGT operating mode are changed, the values of bits TEDGF, TUNDF, TCMAF and TCMBF are undefined. Before starting the count, write 0 to the following bits:

- TEDGF (no active edge received)
- TUNDF (no underflow)
- TCMAF (no match)
- TCMBF (no match).

24.4.4 Digital Filter

When using the digital filter, do not start the timer operation for 5 cycles of the digital filter clock after setting TIPF[1:0] bits and when the TEDGSEL bit in the AGTIOC register changes.

24.4.5 How to Calculate Event Number, Pulse Width, and Pulse Period

- In event counter mode, event number is expressed mathematically as follows:
  Event number = initial value of counter [AGT register] - counter value of active event end
- In pulse width measurement mode, pulse width is expressed mathematically as follows:
  Pulse width = counter value of stopping measurement - counter value of next stopping measurement
- In pulse period measurement mode, input pulse period is expressed mathematically as follows:
  Period of input pulse = (initial value of counter [AGT register] - reading value of the read-out buffer) + 1

24.4.6 When Count Is Forcibly Stopped by TSTOP Bit

After the counter is forcibly stopped by the TSTOP bit in the AGTCR register, do not access the following I/O registers for 1 cycle of the count source:

- AGT
- AGTCMA
- AGTCMB
- AGTCR
- AGTMR1
- AGTMR2.

24.4.7 When Selecting AGT0 Underflow as the Count Source

Operate the AGT according to the procedures described in this section when selecting the underflow signal of AGT as the count source.

(1) Procedure for starting operation

1. Set AGT0 and AGT1.
2. Start the count operation of AGT1.
3. Start the count operation of AGT0.

24.4.2 访问计数器寄存器

当AGTCR寄存器中的TSTART和TCSTF位都为1（计数开始）时，连续写入AGT寄存器时，在两次写入之间至少允许计数源时钟的3个周期。

24.4.3 更改模式时

与AGT操作模式相关的寄存器（AGTMR1、AGTMR2、AGTIOC、AGTISR、AGTCMSR和
只有在TSTART和TCSTF位都设置为0（计数停止）的情况下停止计数时才能更改AGTIOC）。
在计数操作期间不要更改这些寄存器。

当与AGT工作模式相关的寄存器发生变化时，TEDGF、TUNDF、TCMAF和
TCMBF未定义。在开始计数之前，将0写入以下位：

- TEDGF（未收到有效边沿）
- TUNDF (no underflow)
- TCMAF (no match)
- TCMBF (no match).

24.4.4 数字滤波器

使用数字滤波器时，在设置TIPF[1:0]位后以及AGTIOC寄存器中的TEDGSEL位发生变化时，在数字滤波器时钟的5个周期内不要启动定时器操作。

24.4.5 如何计算事件编号、脉冲宽度和脉冲周期

- 在事件计数器模式下，事件编号以数学方式表示如下：
  事件编号=计数器的初始值[AGT寄存器]活动事件结束的计数器值
- 在脉冲宽度测量模式下，脉冲宽度在数学上表示如下：
  脉冲宽度=停止测量的计数器值下一个停止测量的计数器值
- 在脉冲周期测量模式下，输入脉冲周期在数学上表示如下：
  输入脉冲周期=（计数器初始值[AGT寄存器]读出缓冲器的读取值）+1

24.4.6 当计数被TSTOP位强制停止时

计数器被AGTCR寄存器中的TSTOP位强制停止后，在计数源的1个周期内不要访问以下IO寄存器：

- AGT
- AGTCMA
- AGTCMB
- AGTCR
- AGTMR1
- AGTMR2.

24.4.7 选择AGT0下溢作为计数源时

选择AGT的下溢信号作为计数源时，请按照本节所述的步骤操作AGT。

(1) 开始运行的步骤

1. 设置AGT0和AGT1。
2. 启动AGT1的计数操作。
3. 启动AGT0的计数操作。

(2) Procedure for stopping operation

1. Stop the count operation of AGT0.
2. Stop the count operation of AGT1.
3. Stop the count source clock of AGT1 (write 000b in the AGT1.AGTMR1.TCK[2:0] bits).

24.4.8 Reset of I/O Register

The I/O register of the AGT is not initialized by different types of resets. For details, see section 6, Resets.

24.4.9 When Selecting PCLKB, PCLKB/8, or PCLKB/2 as the Count Source

When a reset is generated, the operation of AGT cannot be guaranteed. Set the registers associated with AGT again.

24.4.10 When Selecting AGTSCLK or AGTLCLK as the Count Source

The MSTPD2 bit in the MSTPCRD register must be set to 1 except when accessing the AGT1 registers. The MSTPD3 bit in the MSTPCRD register must be set to 1 except when accessing the AGT0 registers. When a reset occurs while MSTPD2 or MSTPD3 bit is 0, the operation of AGT1 or AGT0 cannot be guaranteed. Set the registers associated with AGT again.

24.4.11 When Switching Source Clock

When switching a clock source by changing SCKSCR.CKSEL[2:0], the clock output from the selector stops for 4 cycles of the switched clock. Therefore, when using the AGTIO, AGTEE, or both input as external event input, the clock source should not be switched. If switching the clock source while using the external event input, extend the input pulse width by 4 clock cycles of the switched source clock cycles.

(2) 停止运行的步骤

1. 停止AGT0的计数操作。
2. 停止AGT1的计数操作。
3. 停止AGT1的计数源时钟（在AGT1.AGTMR1.TCK[2:0]位中写入000b）。

24.4.8 IO寄存器的复位

AGT的IO寄存器不会被不同类型的复位初始化。有关详细信息，请参阅第6节，重置。

24.4.9 选择PCLKB、PCLKB8或PCLKB2作为计数源时

当产生复位时，不能保证AGT的操作。再次设置与AGT关联的寄存器。

24.4.10 选择AGTSCLK或AGTLCLK作为计数源时

除了访问AGT1寄存器时，MSTPCRD寄存器中的MSTPD2位必须设置为1。除了访问AGT0寄存器时，MSTPCRD寄存器中的MSTPD3位必须设置为1。当MSTPD2或MSTPD3位为0时发生复位时，不能保证AGT1或AGT0的操作。设置相关的寄存器

AGT again.

24.4.11 切换源时钟时

当通过改变SCKSCR.CKSEL[2:0]来切换时钟源时，选择器的时钟输出在切换时钟的4个周期内停止。因此，当使用AGTIO、AGTEE或两者输入作为外部事件输入时，不应切换时钟源。如果在使用外部事件输入时切换时钟源，请将输入脉冲宽度延长4个切换源时钟周期的时钟周期。

RA生态工作室

25. Watchdog Timer (WDT)

25.1 Overview

The Watchdog Timer (WDT) is a 14-bit down-counter and can be used to reset the MCU when the counter underflows because the system has run out of control and is unable to refresh the WDT. In addition, the WDT can be used to generate a non-maskable interrupt or an underflow interrupt. The refresh-permitted period can be set to refresh the counter and to detect when the system runs out of control.

Table 25.1 lists the WDT specifications and Figure 25.1 shows a block diagram.

Table 25.1 WDT specifications

Parameter	Specifications
Count source	Peripheral clock (PCLKB)
Clock division ratio	Division by 4, 64, 128, 512, 2,048, or 8,192
Counter operation	Counting down using a 14-bit down-counter
Conditions for starting the counter	• Auto start mode: Counting automatically starts after a reset, or after an underflow or refresh error occurs • Register start mode: Counting is started with a refresh by writing to the WDTRR register.
Conditions for stopping the counter	• Reset (the down-counter and other registers return to their initial values) • A counter underflows or a refresh error is generated.
Window function	Window start and end positions can be specified (refresh-permitted and refresh-prohibited periods)
WDT reset sources	• Down-counter underflows • Refreshing outside the refresh-permitted period (refresh error).
Non-maskable interrupt/interrupt sources	• Down-counter underflows • Refreshing outside the refresh-permitted period (refresh error).
Reading of the counter value	The down-counter value can be read by the WDTSR register
Event link function (output)	• Down-counter underflow event output • Refresh error event output.
Output signal (internal signal)	• Reset output • Interrupt request output • Sleep mode count stop control output.

25. 看门狗定时器(WDT)

25.1 Overview

看门狗定时器(WDT)是一个14位递减计数器，可用于在计数器下溢时复位MCU，因为系统已失控且无法刷新WDT。此外，WDT可用于产生不可屏蔽中断或下溢中断。可以设置刷新允许周期来刷新计数器并检测系统何时失控。

表25.1列出了WDT规范，图25.1显示了框图。

Table 25.1 WDT specifications

Parameter	Specifications
计数来源	外设时钟(PCLKB)
时钟分频比	除以4、64、128、512、2 048或8 192
计数器操作	使用14位递减计数器进行递减计数
启动计数器的条件	自动启动模式：在复位后或发生下溢或刷新错误后自动开始计数 寄存器启动模式：通过写入WDTRR寄存器以刷新开始计数。
停止计数器的条件	复位（递减计数器和其他寄存器返回其初始值） 计数器下溢或产生刷新错误。
窗口功能	可以指定窗口开始和结束位置（允许刷新和禁止刷新期间）
WDT复位源	递减计数器下溢 在允许刷新的时间之外刷新（刷新错误）。
Non-maskable interrupt/interrupt sources	递减计数器下溢 在允许刷新的时间之外刷新（刷新错误）。
读取计数器值	递减计数器的值可以通过WDTSR寄存器读取
事件链接功能（输出）	递减计数器下溢事件输出 刷新错误事件输出。
输出信号（内部信号）	复位输出 中断请求输出 睡眠模式计数停止控制输出。

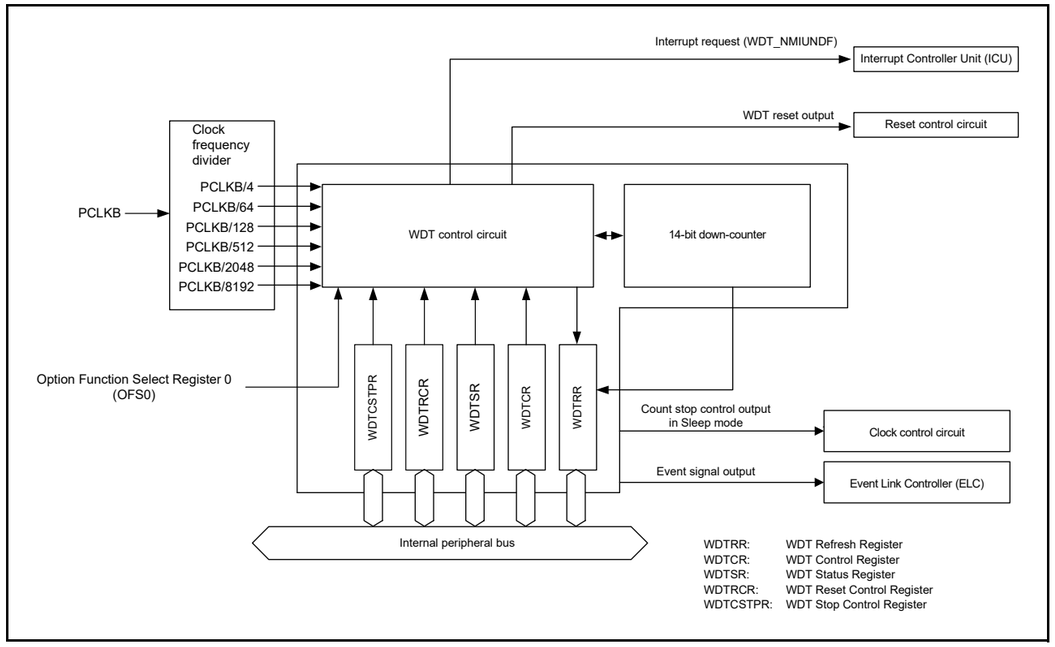


Figure 25.1 WDT block diagram

25.2 Register Descriptions

25.2.1 WDT Refresh Register (WDTRR)

Address(es): WDT.WDTRR 4004 4200h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1

Bit	Description	R/W
b7 to b0	The down-counter is refreshed by writing 00h and then writing FFh to this register	R/W

The WDTRR register refreshes the down-counter of the WDT.

The down-counter of the WDT is refreshed by writing 00h and then writing FFh to WDTRR (refresh operation) within the refresh-permitted period.

After the down-counter is refreshed, it starts counting down from the value selected in the WDT Timeout Period Select bits (OFS0.WDTTOPS[1:0]) in the Option Function Select Register 0 in auto start mode. In register start mode, counting down starts from the value selected in the Timeout Period Select bits (WDTCR.TOPS[1:0]) in the WDT Control Register.

When 00h is written, the read value is 00h. When a value other than 00h is written, the read value is FFh. For details on the refresh operation, see section 25.3.3, Refresh Operation.

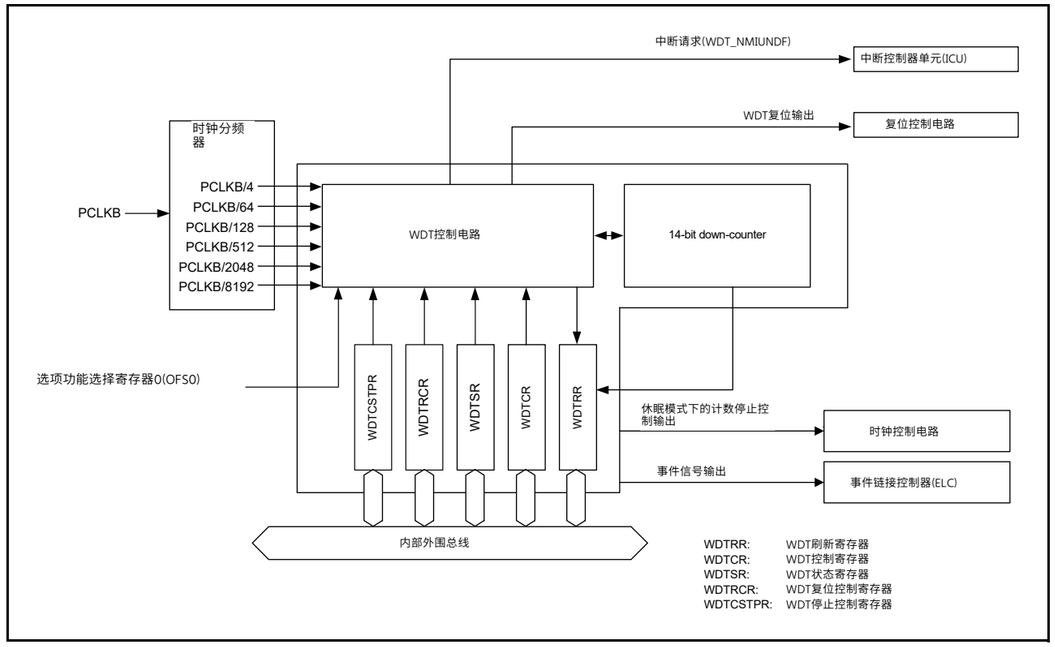


Figure 25.1 看门狗框图

25.2 注册说明

25.2.1 WDT刷新寄存器(WDTRR)

Address(es): WDT.WDTRR 4004 4200h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	1	1	1	1	1	1	1	1

Bit	Description	R/W
b7 to b0	通过写入00h然后将FFh写入该寄存器来刷新递减计数器	R/W

WDTRR寄存器刷新WDT的递减计数器。

WDT的递减计数器通过写入00h进行刷新，然后在允许刷新期间将FFh写入WDTRR（刷新操作）。

递减计数器刷新后，在自动启动模式下，它从选项功能选择寄存器0中的WDT超时周期选择位(OFS0.WDTTOPS[1:0])中选择的值开始递减计数。在寄存器启动模式下，倒计时从WDT控制寄存器的超时周期选择位(WDTCR.TOPS[1:0])中选择的值开始。

写入00h时，读取值为00h。写入00h以外的值时，读取值为FFh。有关刷新操作的详细信息，请参阅第25.3.3节，刷新操作。

25.2.2 WDT Control Register (WDTCR)

Address(es): WDT.WDTCR 4004 4202h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	RPSS[1:0]		—	—	RPES[1:0]		CKS[3:0]				—	—	TOPS[1:0]	
Value after reset:	0	0	1	1	0	0	1	1	1	1	1	1	0	0	1	1

Bit	Symbol	Bit name	Description	R/W
b1, b0	TOPS[1:0]	Timeout Period Select	b1 b0 0 0: 1024 cycles (03FFh) 0 1: 4096 cycles (0FFFh) 1 0: 8192 cycles (1FFFh) 1 1: 16384 cycles (3FFFh).	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7 to b4	CKS[3:0]	Clock Division Ratio Select	b7 b4 0 0 0 1: PCLKB/4 0 1 0 0: PCLKB/64 1 1 1 1: PCLKB/128 0 1 1 0: PCLKB/512 0 1 1 1: PCLKB/2048 1 0 0 0: PCLKB/8192. Other settings are prohibited.	R/W
b9, b8	RPES[1:0]	Window End Position Select	b9 b8 0 0: 75% 0 1: 50% 1 0: 25% 1 1: 0% (do not specify window end position).	R/W
b11, b10	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b13, b12	RPSS[1:0]	Window Start Position Select	b13 b12 0 0: 25% 0 1: 50% 1 0: 75% 1 1: 100% (do not specify window start position).	R/W
b15, b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Some constraints apply to writes to the WDTCR register. For details, see section 25.3.2, Controlling Writes to the WDTCR, WDTRCR, and WDTCSTPR Registers.

In auto start mode, the settings in the WDTCR register are disabled, and the settings in the Option Function Select Register 0 (OFS0) are enabled. The settings for the WDTCR register can also be made for the OFS0 register. For details, see section 25.3.7, Association between Option Function Select Register 0 (OFS0) and WDT Registers.

TOPS[1:0] bits (Timeout Period Select)

The TOPS[1:0] bits select the timeout period, the period until the down-counter underflows, from 1024, 4096, 8192, and 16384 cycles, taking the divided clock specified in the CKS[3:0] bits as 1 cycle. After the down-counter is refreshed, the combination of the CKS[3:0] and TOPS[1:0] bits determines the number of PCLKB cycles until the counter underflows.

Table 25.2 lists the relationship between the CKS[3:0] and TOPS[1:0] bit settings, the timeout period, and the number of PCLKB cycles.

25.2.2 WDT控制寄存器(WDTCR)

Address(es): WDT.WDTCR 4004 4202h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	RPSS[1:0]		—	—	RPES[1:0]		CKS[3:0]				—	—	TOPS[1:0]	
重置后的值:	0	0	1	1	0	0	1	1	1	1	1	1	0	0	1	1

Bit	Symbol	位名称	Description	R/W
b1, b0	TOPS[1:0]	超时时间选择	b1 b0 0 0: 1024 cycles (03FFh) 0 1: 4096 cycles (0FFFh) 1 0: 8192 cycles (1FFFh) 1 1: 16384 cycles (3FFFh).	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7 to b4	CKS[3:0]	时钟分频比选择	b7b40001:PCLKB40100:PCLKB641111:PCLKB1280110:PCLKB5120111:PCLKB20481000:PCLKB8192。禁止其他设置。	R/W
b9, b8	RPES[1:0]	窗口结束位置选择	b9b800：75%01：50%10：25%11：0%（不指定窗口结束位置）。	R/W
b11, b10	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b13, b12	RPSS[1:0]	窗口起始位置选择	b13b1200:25%01:50%10:75%11:100%（不指定窗口起始位置）。	R/W
b15, b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W

一些限制适用于写入WDTCR寄存器。有关详细信息，请参阅第25.3.2节，控制对WDTCR、WDTRCR和WDTCSTPR寄存器。

在自动启动模式下，WDTCR寄存器中的设置被禁用，OptionFunctionSelect中的设置使能寄存器0(OFS0)。WDTCR寄存器的设置也可以对OFS0寄存器进行。有关详细信息，请参阅第25.3.7节，选项功能选择寄存器0(OFS0)和WDT寄存器之间的关联。

TOPS[1:0]位（超时周期选择）

TOPS[1:0]位从1024、4096、8192和16384个周期中选择超时周期，即递减计数器下溢之前的周期，将CKS[3:0]位中指定的分频时钟作为1个周期.向下计数器刷新后，CKS[3:0]和TOPS[1:0]位的组合决定了PCLKB周期数，直到计数器下溢。

表25.2列出了CKS[3:0]和TOPS[1:0]位设置、超时时间和
PCLKB cycles.

Table 25.2 Timeout period settings

CKS[3:0] bits				TOPS[1:0] bits		Clock division ratio	Timeout period (number of cycles)	PCLKB clock cycles
b7	b6	b5	b4	b1	b0			
0	0	0	1	0	0	PCLKB/4	1024	4096
				0	1		4096	16384
				1	0		8192	32768
				1	1		16384	65536
0	1	0	0	0	0	PCLKB/64	1024	65536
				0	1		4096	262144
				1	0		8192	524288
				1	1		16384	1048576
1	1	1	1	0	0	PCLKB/128	1024	131072
				0	1		4096	524288
				1	0		8192	1048576
				1	1		16384	2097152
0	1	1	0	0	0	PCLKB/512	1024	524288
				0	1		4096	2097152
				1	0		8192	4194304
				1	1		16384	8388608
0	1	1	1	0	0	PCLKB/2048	1024	2097152
				0	1		4096	8388608
				1	0		8192	16777216
				1	1		16384	33554432
1	0	0	0	0	0	PCLKB/8192	1024	8388608
				0	1		4096	33554432
				1	0		8192	67108864
				1	1		16384	134217728

CKS[3:0] bits (Clock Division Ratio Select)

The CKS[3:0] bits specify the division ratio of the clock used for the down-counter. The division ratio can be selected from the peripheral clock (PCLKB) divided by 4, 64, 128, 512, 2048, and 8192. Combined with the TOPS[1:0] bit setting, a count period between 4096 and 134217728 PCLKB clock cycles can be selected for the WDT.

RPES[1:0] bits (Window End Position Select)

The RPES[1:0] bits specify the window end position that indicates the refresh-permitted period. 75%, 50%, 25%, or 0% of the timeout period can be selected for the window end position. The selected window end position should be a value less than the value for the window start position (window start position > window end position). If the window end position is greater than the window start position, only the window start position setting is enabled.

RPSS[1:0] bits (Window Start Position Select)

The RPSS[1:0] bits specify the window start position that indicates the refresh-permitted period. 100%, 75%, 50%, or 25% of the timeout period can be selected for the window start position. The selected window start position should be a value greater than the value for the window end position. If the window start position is set to a value less than or equal to the window end position, the window end position is set to 0%.

Table 25.3 lists the counter values for the window start and end positions, and Figure 25.2 shows the refresh-permitted period set in the RPSS[1:0], RPES[1:0], and TOPS[1:0] bits.

Table 25.2 超时时间设置

CKS[3:0] bits				TOPS[1:0] bits		时钟分频比	超时时间（周期数）	PCLKB时钟周期
b7	b6	b5	b4	b1	b0			
0	0	0	1	0	0	PCLKB/4	1024	4096
				0	1		4096	16384
				1	0		8192	32768
				1	1		16384	65536
0	1	0	0	0	0	PCLKB/64	1024	65536
				0	1		4096	262144
				1	0		8192	524288
				1	1		16384	1048576
1	1	1	1	0	0	PCLKB/128	1024	131072
				0	1		4096	524288
				1	0		8192	1048576
				1	1		16384	2097152
0	1	1	0	0	0	PCLKB/512	1024	524288
				0	1		4096	2097152
				1	0		8192	4194304
				1	1		16384	8388608
0	1	1	1	0	0	PCLKB/2048	1024	2097152
				0	1		4096	8388608
				1	0		8192	16777216
				1	1		16384	33554432
1	0	0	0	0	0	PCLKB/8192	1024	8388608
				0	1		4096	33554432
				1	0		8192	67108864
				1	1		16384	134217728

CKS[3:0]位（时钟分频比选择）

CKS[3:0]位指定用于递减计数器的时钟的分频比。分频比可以从外设时钟（PCLKB）除以4、64、128、512、2048和8192中选择。结合TOPS[1:0]位设置，计数周期在4096到134217728个PCLKB时钟周期之间可以为WDT选择。

RPES[1:0]位（窗口结束位置选择）

RPES[1:0]位指定指示刷新允许周期的窗口结束位置。可以为窗口结束位置选择75%、50%、25%或0%的超时时间。所选窗口结束位置的值应小于窗口开始位置的值（窗口开始位置>窗口结束位置）。如果窗口结束位置大于窗口起始位置，则仅启用窗口起始位置设置。

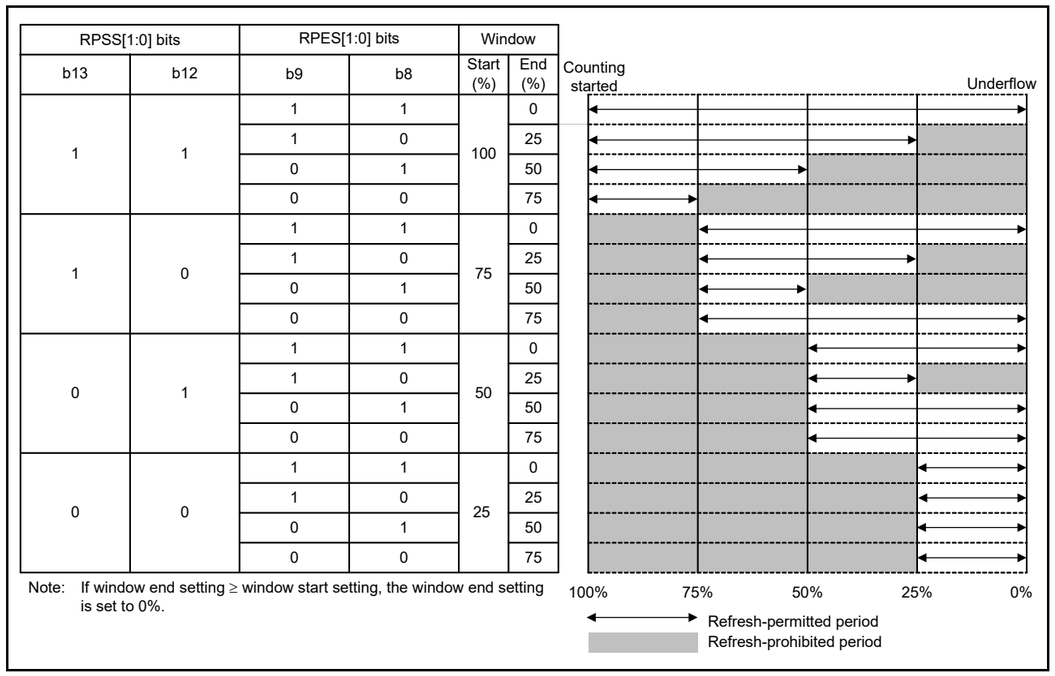
RPSS[1:0]位（窗口起始位置选择）

RPSS[1:0]位指定指示允许刷新周期的窗口起始位置。窗口起始位置可选择100%、75%、50%或25%的超时时间。所选窗口开始位置的值应大于窗口结束位置的值。如果窗口开始位置设置为小于或等于窗口结束位置的值，则窗口结束位置设置为0%。

表25.3列出了窗口开始和结束位置的计数器值，图25.2显示了在RPSS[1:0]、RPES[1:0]和TOPS[1:0]位中设置的允许刷新周期。

Table 25.3 Relationship between the timeout period and window start and end counter values

TOPS[1:0] bits		Timeout period		Window start and end counter value			
		Cycles	Counter value	100%	75%	50%	25%
0	0	1024	03FFh	03FFh	02FFh	01FFh	00FFh
0	1	4096	0FFFh	0FFFh	0BFFh	07FFh	03FFh
1	0	8192	1FFFh	1FFFh	17FFh	0FFFh	07FFh
1	1	16384	3FFFh	3FFFh	2FFFh	1FFFh	0FFFh

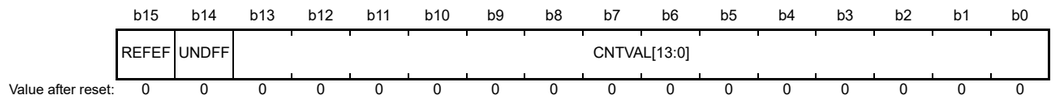


Note: If window end setting ≥ window start setting, the window end setting is set to 0%.

Figure 25.2 RPSS[1:0] and RPES[1:0] bit settings and refresh-permitted period

25.2.3 WDT Status Register (WDTSR)

Address(es): WDT.WDTSR 4004 4204h

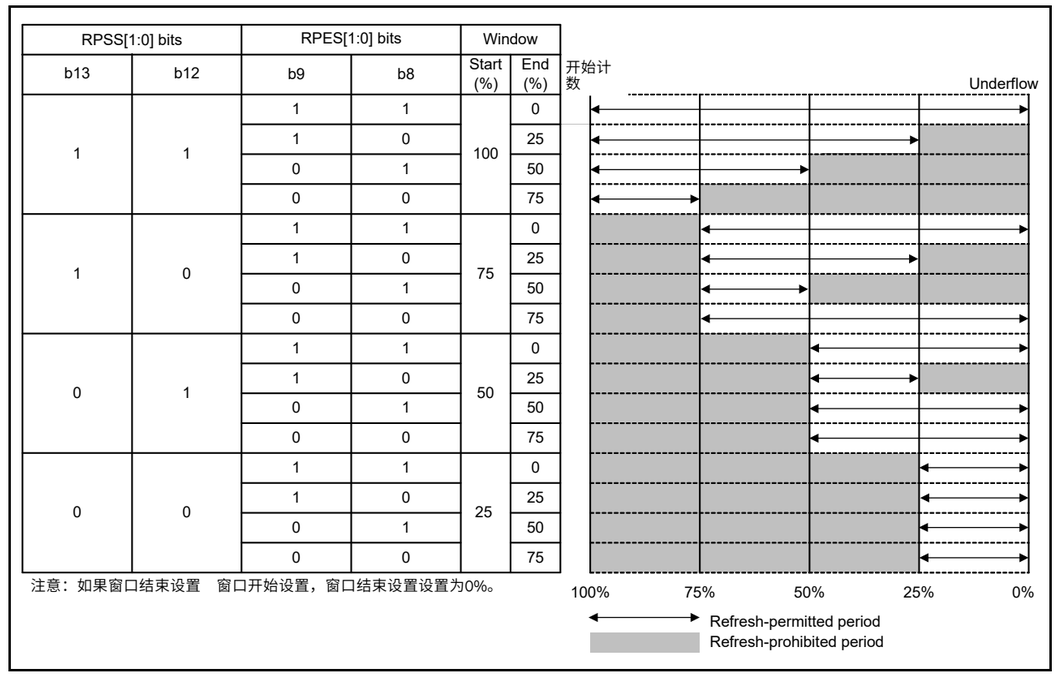


Bit	Symbol	Bit name	Description	R/W
b13 to b0	CNTVAL[13:0]	Down-Counter Value	Value counted by the down-counter	R
b14	UNDFF	Underflow Flag	0: No underflow occurred 1: Underflow occurred.	R(/W) *1
b15	REFEF	Refresh Error Flag	0: No refresh error occurred 1: Refresh error occurred.	R(/W) *1

Note 1. Only 0 can be written to clear the flag.

Table 25.3 超时时间与窗口开始和结束计数器值之间的关系

TOPS[1:0] bits		超时时间		窗口开始和结束计数器值			
		Cycles	计数器值	100%	75%	50%	25%
0	0	1024	03FFh	03FFh	02FFh	01FFh	00FFh
0	1	4096	0FFFh	0FFFh	0BFFh	07FFh	03FFh
1	0	8192	1FFFh	1FFFh	17FFh	0FFFh	07FFh
1	1	16384	3FFFh	3FFFh	2FFFh	1FFFh	0FFFh

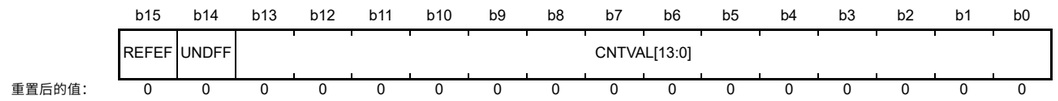


注意：如果窗口结束设置 窗口开始设置，窗口结束设置设置为0%。

Figure 25.2 RPSS[1:0]和RPES[1:0]位设置和允许刷新周期

25.2.3 WDT状态寄存器(WDTSR)

Address(es): WDT.WDTSR 4004 4204h



Bit	Symbol	位名称	Description	R/W
b13 to b0	CNTVAL[13:0]	Down-Counter Value	递减计数器计数的值	R
b14	UNDFF	Underflow Flag	0：未发生下溢1：发生下溢。	R(/W) *1
b15	REFEF	刷新错误标志	0：未发生刷新错误1：发生刷新错误。	R(/W) *1

Note 1. 只能写入0来清除标志。

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CNTVAL[13:0] bits (Down-Counter Value)

Read the CNTVAL[13:0] bits to confirm the value of the down-counter. The read value might differ from the actual count by 1.

UNDFF flag (Underflow Flag)

Read the UNDFF flag to confirm whether an underflow occurred in the down-counter. A value of 1 indicates that the down-counter underflowed. Write 0 to the UNDFF flag to set the value to 0. Writing 1 has no effect.

Clearing of the UNDFF flag takes (N + 1) PCLKB cycles. In addition, clearing of the flag is ignored for (N + 1) PCLKB cycles after an underflow. N is specified in the WDTCR.CKS[3:0] bits as follows:

- When WDTCR.CKS[3:0] = 0001b, N = 4
- When WDTCR.CKS[3:0] = 0100b, N = 64
- When WDTCR.CKS[3:0] = 1111b, N = 128
- When WDTCR.CKS[3:0] = 0110b, N = 512
- When WDTCR.CKS[3:0] = 0111b, N = 2048
- When WDTCR.CKS[3:0] = 1000b, N = 8192.

REFEF flag (Refresh Error Flag)

Read the REFEF flag to confirm whether a refresh error occurred. A value of 1 indicates that a refresh error occurred. Write 0 to the REFEF flag to set the value to 0. Writing 1 has no effect.

Clearing of the REFEF flag takes (N + 1) PCLKB cycles. In addition, clearing of the flag is ignored for (N + 1) PCLKB cycles following a refresh error. N is specified in the WDTCR.CKS[3:0] bits as follows:

- When WDTCR.CKS[3:0] = 0001b, N = 4
- When WDTCR.CKS[3:0] = 0100b, N = 64
- When WDTCR.CKS[3:0] = 1111b, N = 128
- When WDTCR.CKS[3:0] = 0110b, N = 512
- When WDTCR.CKS[3:0] = 0111b, N = 2048
- When WDTCR.CKS[3:0] = 1000b, N = 8192.

25.2.4 WDT Reset Control Register (WDTRCR)

Address(es): WDT.WDTRCR 4004 4206h

	b7	b6	b5	b4	b3	b2	b1	b0
	RSTIRQS	—	—	—	—	—	—	—
Value after reset:	1	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b6 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	RSTIRQS	Reset Interrupt Request Select	0: Non-maskable interrupt request or interrupt request output is enabled 1: Reset output is enabled.	R/W

Some constraints apply to writes to the WDTRCR register. For details, see section 25.3.2, Controlling Writes to the WDTCR, WDTRCR, and WDTCSTPR Registers.

In auto start mode, the WDTRCR register settings are disabled, and the settings in the Option Function Select Register 0 (OFS0) are enabled. The settings for the WDTCR register can also be made for the OFS0 register. For details, see section 25.3.7, Association between Option Function Select Register 0 (OFS0) and WDT Registers.

CNTVAL[13:0]位（递减计数器值）

读取CNTVAL[13:0]位以确认递减计数器的值。读取的值可能与实际计数相差1。

UNDFF flag (Underflow Flag)

读取UNDFF标志以确认递减计数器中是否发生下溢。值1表示递减计数器下溢。将0写入UNDFF标志以将值设置为0。写入1无效。

清除UNDFF标志需要(N+1)个PCLKB周期。此外，在下溢后(N+1)个PCLKB周期内忽略标志的清除。N在WDTCR.CKS[3:0]位中指定如下：

- When WDTCR.CKS[3:0] = 0001b, N = 4
- When WDTCR.CKS[3:0] = 0100b, N = 64
- When WDTCR.CKS[3:0] = 1111b, N = 128
- When WDTCR.CKS[3:0] = 0110b, N = 512
- When WDTCR.CKS[3:0] = 0111b, N = 2048
- When WDTCR.CKS[3:0] = 1000b, N = 8192.

REFEF标志（刷新错误标志）

读取REFEF标志以确认是否发生刷新错误。值1表示发生了刷新错误。
将0写入REFEF标志以将值设置为0。写入1无效。

清除REFEF标志需要(N+1)个PCLKB周期。此外，在刷新错误后的(N+1)个PCLKB周期内，标志的清除将被忽略。N在WDTCR.CKS[3:0]位中指定如下：

- When WDTCR.CKS[3:0] = 0001b, N = 4
- When WDTCR.CKS[3:0] = 0100b, N = 64
- When WDTCR.CKS[3:0] = 1111b, N = 128
- When WDTCR.CKS[3:0] = 0110b, N = 512
- When WDTCR.CKS[3:0] = 0111b, N = 2048
- When WDTCR.CKS[3:0] = 1000b, N = 8192.

25.2.4 WDT复位控制寄存器(WDTRCR)

Address(es): WDT.WDTRCR 4004 4206h

	b7	b6	b5	b4	b3	b2	b1	b0
	RSTIRQS	—	—	—	—	—	—	—
重置后的值：	1	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b6 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	RSTIRQS	复位中断请求选择	0：使能不可屏蔽中断请求或中断请求输出1：使能复位输出。	R/W

一些限制适用于写入WDTRCR寄存器。有关详细信息，请参阅第25.3.2节，控制对WDTCR、WDTRCR和WDTCSTPR寄存器。

在自动启动模式下，WDTRCR寄存器设置被禁用，而选项功能选择寄存器0(OFS0)中的设置被启用。WDTCR寄存器的设置也可以对OFS0寄存器进行。有关详细信息，请参阅第25.3.7节，选项功能选择寄存器0(OFS0)和WDT寄存器之间的关联。

25.2.5 WDT Count Stop Control Register (WDTCSTPR)

Address(es): WDT.WDTCSTPR 4004 4208h

	b7	b6	b5	b4	b3	b2	b1	b0
	SLCSTP	—	—	—	—	—	—	—
Value after reset:	1	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b6 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	SLCSTP	Sleep-Mode Count Stop Control	0: Count stop is disabled 1: Count is stopped when transition to Sleep mode.	R/W

The WDTCSTPR register controls whether to stop the WDT counter in a low power mode. Some restrictions apply to writes to the WDTCSTPR register. For details, see section 25.3.2, Controlling Writes to the WDTCR, WDTRCR, and WDTCSTPR Registers.

In auto start mode, the WDTCSTPR register settings are disabled, and the settings in the Option Function Select register 0 (OFS0) are enabled. The settings for the WDTCSTPR register can also be made for the OFS0 register. For details, see section 25.3.7, Association between Option Function Select Register 0 (OFS0) and WDT Registers.

SLCSTP bit (Sleep-Mode Count Stop Control)

The SLCSTP bit selects whether to stop counting when transition to Sleep mode.

25.2.6 Option Function Select Register 0 (OFS0)

For information on the OFS0 register, see section 25.3.7, Association between Option Function Select Register 0 (OFS0) and WDT Registers.

25.3 Operation

25.3.1 Count Operation in each Start Mode

The WDT has two start modes:

- Auto start mode, in which counting automatically starts after a release from the reset state
- Register start mode, in which counting is started with a refresh by writing to the register.

In auto start mode, counting automatically starts after a release from the reset state based on the settings in the Option Function Select Register 0 (OFS0) in the flash.

In register start mode, counting starts with a refresh by writing to the register after the respective registers are set after a release from the reset state.

Select auto start mode or register start mode by setting the WDT Start Mode Select bit (OFS0.WDTSTRT) in the OFS0 register. When the auto start mode is selected, the settings in the WDT Control Register (WDTCR), WDT Reset Control Register (WDTRCR), and WDT Count Stop Control Register (WDTCSTPR) are disabled, while the settings in the OFS0 register are enabled.

When the register start mode is selected, the OFS0 register setting is disabled while the settings in the WDT Control Register (WDTCR), WDT Reset Control Register (WDTRCR), and WDT Count Stop Control Register (WDTCSTPR) are enabled.

25.3.1.1 Register start mode

When the WDT Start Mode Select bit (OFS0.WDTSTRT) is 1, register start mode is selected and the WDT Control Register (WDTCR), WDT Reset Control Register (WDTRCR), and WDT Count Stop Control Register (WDTCSTPR) are enabled.

After the reset state is released, set the following to Sleep mode in the WDTCSTPR register:

25.2.5 WDT计数停止控制寄存器(WDTCSTPR)

Address(es): WDT.WDTCSTPR 4004 4208h

	b7	b6	b5	b4	b3	b2	b1	b0
	SLCSTP	—	—	—	—	—	—	—
重置后的值：	1	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b6 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	SLCSTP	睡眠模式计数停止控制	0：禁止计数停止1：转换到睡眠模式时停止计数。	R/W

WDTCSTPR寄存器控制是否在低功耗模式下停止WDT计数器。一些限制适用于写入WDTCSTPR寄存器。有关详细信息，请参见第25.3.2节，控制对WDTCR、WDTRCR和WDTCSTPR寄存器的写入。

在自动启动模式下，WDTCSTPR寄存器设置被禁用，而选项功能选择寄存器0(OFS0)中的设置被启用。也可以对OFS0寄存器进行WDTCSTPR寄存器的设置。有关详细信息，请参阅第25.3.7节，选项功能选择寄存器0(OFS0)和WDT寄存器之间的关联。

SLCSTP位（休眠模式计数停止控制）

SLCSTP位选择在转换到休眠模式时是否停止计数。

25.2.6 选项功能选择寄存器0(OFS0)

有关OFS0寄存器的信息，请参见第25.3.7节，选项功能选择寄存器0(OFS0)和WDT寄存器之间的关联。

25.3 Operation

25.3.1 每种启动模式下的计数操作

WDT有两种启动模式：

- 自动启动模式，从复位状态释放后自动开始计数
- 寄存器启动模式，在这种模式下，通过写入寄存器来启动计数。

在自动启动模式下，根据选项中的设置从复位状态释放后自动开始计数
功能选择闪存中的寄存器0(OFS0)。

在寄存器启动模式中，在从复位状态释放后，在设置各个寄存器后，通过写入寄存器来开始计数。

通过设置OFS0寄存器中的WDT启动模式选择位(OFS0.WDTSTRT)来选择自动启动模式或寄存器启动模式。选择自动启动模式后，WDT控制寄存器（WDTCR）中的设置，WDTRESET控制寄存器（WDTRCR）和WDT计数停止控制寄存器（WDTCSTPR）被禁用，而OFS0寄存器中的设置则启用。

选择寄存器启动模式时，在WDT控件中的设置时，禁用OFS0寄存器设置
使能寄存器(WDTCR)、WDT复位控制寄存器(WDTRCR)和WDT计数停止控制寄存器(WDTCSTPR)。

25.3.1.1 注册启动模式

当WDT启动模式选择位(OFS0.WDTSTRT)为1时，选择寄存器启动模式并且WDT控制
使能寄存器(WDTCR)、WDT复位控制寄存器(WDTRCR)和WDT计数停止控制寄存器(WDTCSTPR)。

释放复位状态后，在WDTCSTPR寄存器中将以下内容设置为休眠模式：

- Clock division ratio
- Window start and end positions
- Timeout period in the WDTCR register
- Reset output or interrupt request output in the WDTRCR register
- Counter stop control during transitions to Sleep mode in the WDTCSTPR register.

Refresh the down-counter to start counting down from the value set in the Timeout Period Select bits (WDTCR.TOPS[1:0]).

Thereafter, as long as the counter is refreshed in the refresh-permitted period, the value in the counter is reset each time the counter is refreshed and down-counting continues. The WDT does not output the reset signal as long as counting continues. However, if the down-counter underflows because the down-counter cannot be refreshed because of a program runaway, or if a refresh error occurs because the counter was refreshed outside the refresh-permitted period, the WDT outputs a reset signal or a non-maskable interrupt request/interrupt request (WDT_NMIUNDF). Reset output or interrupt request output can be selected in the WDT Reset Interrupt Request Select bit (WDTRCR.RSTIRQS). Non-maskable interrupt request or interrupt request can be selected in the WDT Underflow/Refresh Error Interrupt Enable bit (NMIER.WDTEN).

Figure 25.3 shows an example of operation under the following conditions:

- Register start mode (OFS0.WDTSTRT = 1)
- Reset output is enabled (WDTRCR.RSTIRQS = 1)
- The window start position is 75% (WDTCR.RPSS[1:0] = 10b)
- The window end position is 25% (WDTCR.RPES[1:0] = 10b).

- 时钟分频比
- 窗口开始和结束位置
- WDTCR寄存器中的超时时间
- WDTRCR寄存器中的复位输出或中断请求输出
- 在WDTCSTPR寄存器中转换到休眠模式期间的计数器停止控制。

刷新递减计数器以从超时周期选择位(WDTCR.TOPS[1:0])中设置的值开始递减计数。

此后，只要在可刷新期间刷新计数器，每次刷新计数器时计数器中的值都会被重置，并继续递减计数。只要继续计数，WDT就不会输出复位信号。但是，如果由于程序失控而导致递减计数器无法刷新而导致递减计数器下溢，或者由于计数器在刷新允许时间之外刷新而发生刷新错误，则WDT会输出复位信号或非可屏蔽中断请求中断请求(WDT_NMIUNDF)。可以在WDT复位中断请求选择位(WDTRCR.RSTIRQS)中选择复位输出或中断请求输出。可以在WDT下溢刷新错误中断 允许位(NMIER.WDTEN)中选择不可屏蔽的中断请求或中断请求。

图25.3显示了以下条件下的操作示例：

- 寄存器启动模式（OFS0.WDTSTRT=1）
- 使能复位输出(WDTRCR.RSTIRQS=1）
- 窗口起始位置为75%(WDTCR.RPSS[1:0]=10b)
- 窗口结束位置为25%(WDTCR.RPES[1:0]=10b)。

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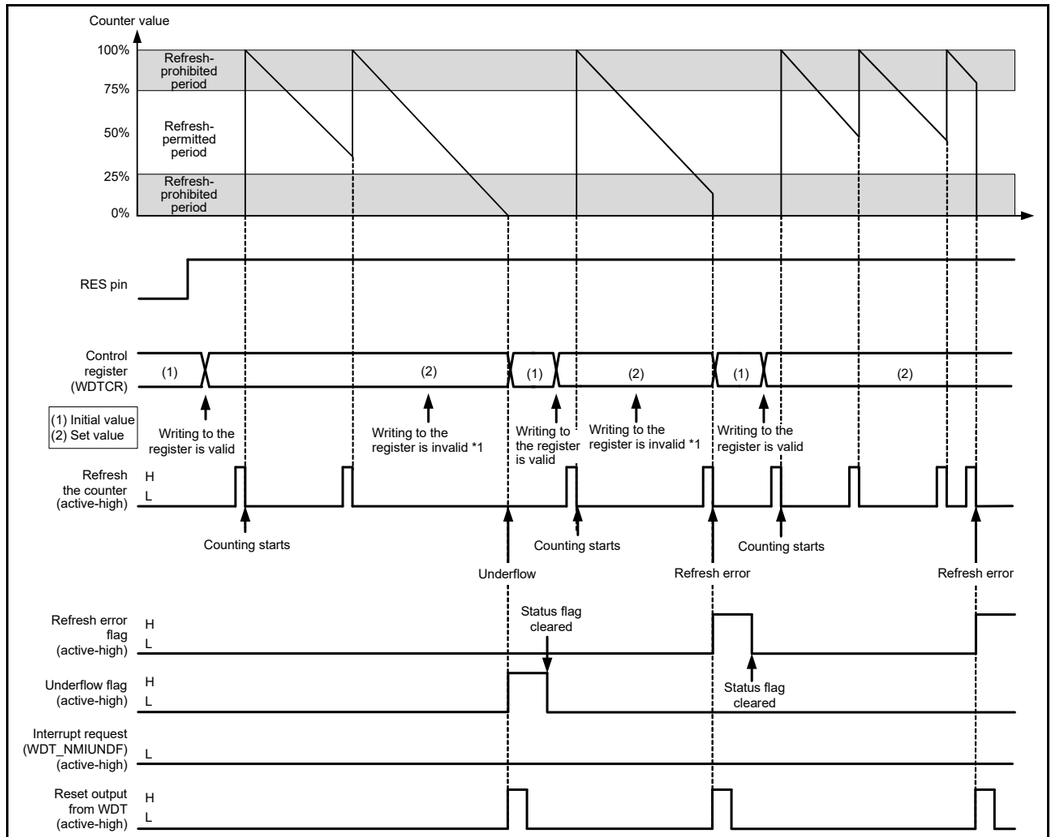


Note 1. See section 25.3.2, Controlling Writes to the WDTCR, WDTRCR, and WDTCSTPR Registers.

Figure 25.3 Operation example in register start mode

25.3.1.2 Auto start mode

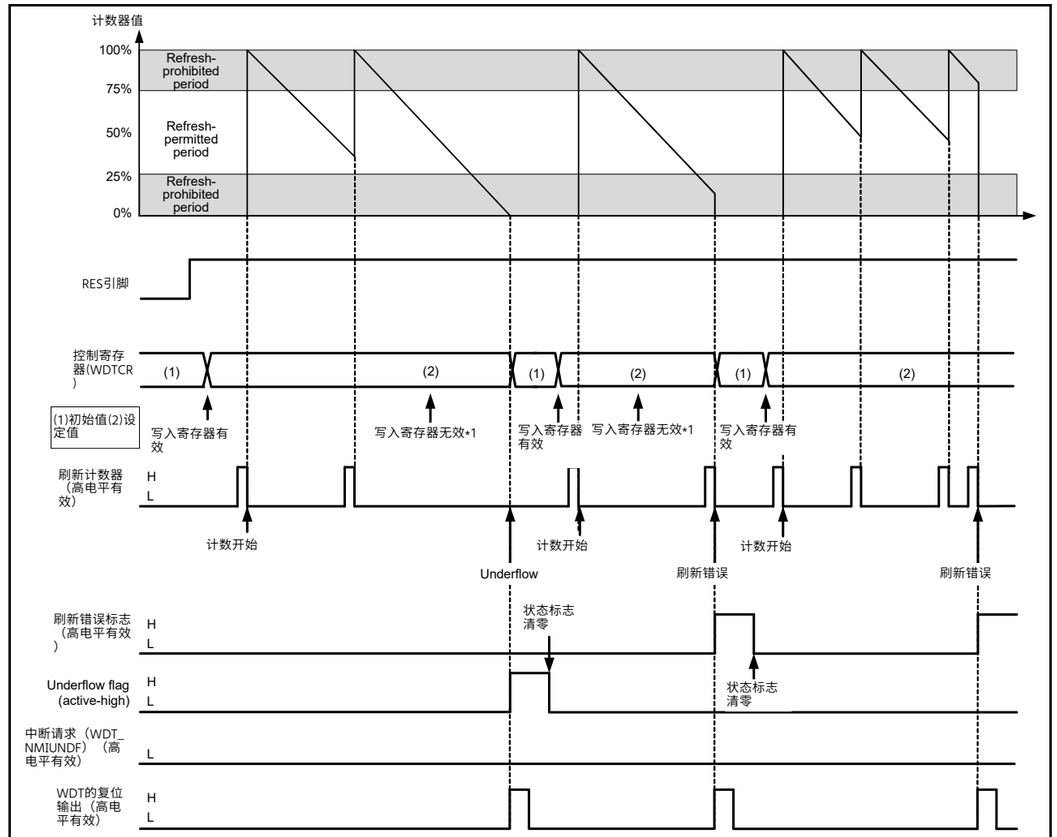
When the WDT Start Mode Select bit (OFS0.WDTSTRT) in the Option Function Select Register 0 (OFS0) is 0, auto start mode is selected. The WDT Control Register (WDTCR), WDT Reset Control Register (WDTRCR), and WDT Count Stop Control Register (WDTCSTPR) are disabled while the settings in the OFS0 register are enabled.

Within the reset state, the following values in the Option Function Select Register 0 (OFS0) are set in the WDT registers:

- Clock division ratio
- Window start and end positions
- Timeout period
- Reset output or interrupt request
- Counter stop control on transition to Sleep mode.

When the reset state is released, the down-counter automatically starts counting down from the value set in the WDT Timeout Period Select bits (OFS0.WDTTOPS[1:0]).

Thereafter, as long as the counter is refreshed in the refresh-permitted period, the value in the counter is reset each time the counter is refreshed and down-counting continues. The WDT does not output the reset signal as long as the counting continues. However, if the down-counter underflows because refreshing of the down-counter is not possible due to a runaway program or if a refresh error occurs due to refreshing outside the refresh-permitted period, the WDT outputs the



注1.请参见第25.3.2节，控制对WDTCR、WDTRCR和WDTCSTPR寄存器的写入。

Figure 25.3 寄存器启动模式下的操作示例

25.3.1.2 自动启动模式

当WDT启动模式选择位置（OFS0.WDTSTRT）中的选项功能选择寄存器0（OFS0）为0时，选择了自动启动模式。WDT控制寄存器(WDTCR)、WDT复位控制寄存器(WDTRCR)和WDT计数停止控制寄存器(WDTCSTPR)被禁用，而OFS0寄存器中的设置被启用。

在复位状态下，选项功能选择寄存器0(OFS0)中的以下值在WDT寄存器中设置：

- 时钟分频比
- 窗口开始和结束位置
- 超时时间
- 复位输出或中断请求
- 转换到睡眠模式时的计数器停止控制。

当复位状态解除时，递减计数器自动从WDT中设置的值开始递减计数
超时周期选择位(OFS0.WDTTOPS[1:0])。

此后，只要在可刷新期间刷新计数器，每次刷新计数器时计数器中的值都会被重置，并继续递减计数。只要继续计数，WDT就不会输出复位信号。但是，如果由于程序失控而无法刷新递减计数器导致递减计数器下溢，或者如果由于刷新允许刷新时间之外的刷新而发生刷新错误，则WDT输出

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reset signal or non-maskable interrupt request/interrupt request (WDT_NMIUNDF).

After the reset signal or non-maskable interrupt request/interrupt request is generated, the counter reloads the timeout period after counting for 1 cycle. The value of the timeout period is set in the down-counter and counting restarts.

Reset output or interrupt request output can be selected in the WDT Reset Interrupt Request Select bit (OFS0.WDTRSTIRQS). Non-maskable interrupt request or interrupt request can be selected in the WDT Underflow/Refresh Error Interrupt Enable bit (NMIER.WDTEN).

Figure 25.4 shows an example of operation (non-maskable interrupt) under the following conditions:

- Auto start mode (OFS0.WDTSTRT = 0)
- Non-maskable interrupt request output is enabled (OFS0.WDTRSTIRQS = 0)
- The window start position is 75% (WDTCR.RPSS[1:0] = 10b)
- The window end position is 25% (WDTCR.RPES[1:0] = 10b).

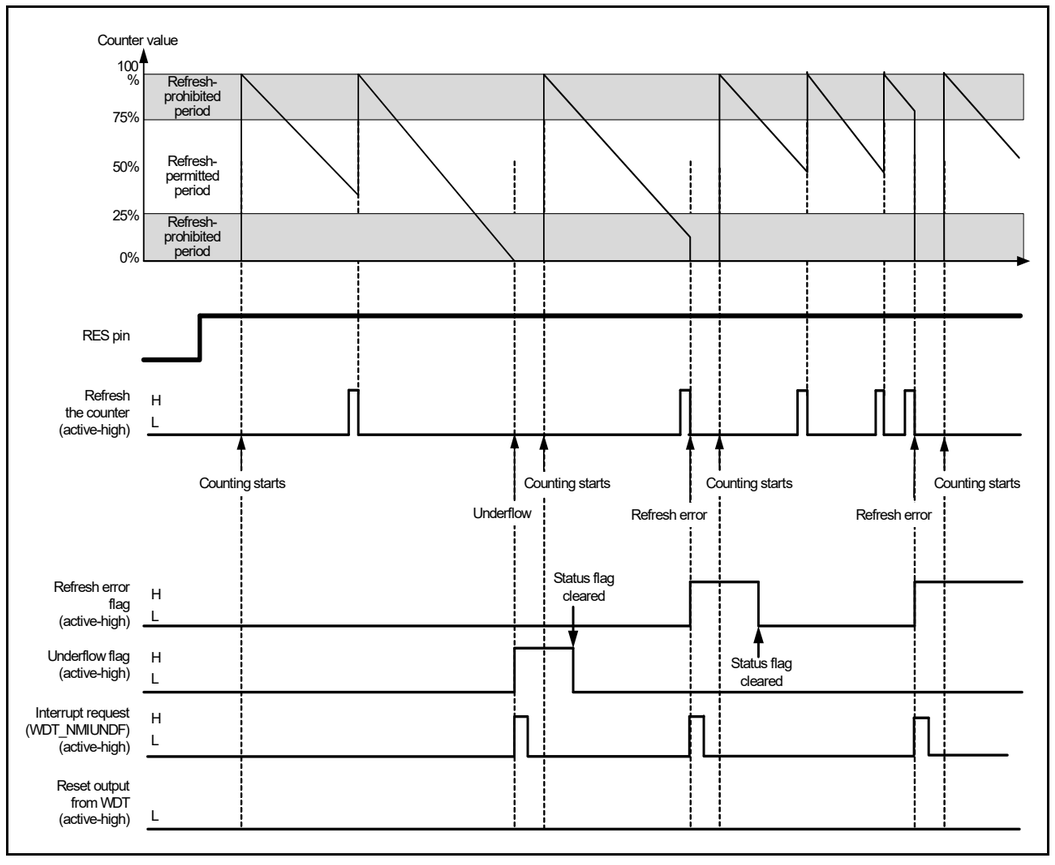

Figure 25.4 Operation example in auto start mode

25.3.2 Controlling Writes to the WDTCR, WDTRCR, and WDTCSTPR Registers

Writing to the WDT Control Register (WDTCR), WDT Reset Control Register (WDTRCR), or WDT Count Stop Control Register (WDTCSTPR) is possible once between the release from the reset state and the first refresh operation.

After a refresh (counting starts) or a write to WDTCR, WDTRCR or WDTCSTPR, the protection signal in the WDT becomes 1 to protect WDTCR, WDTRCR and WDTCSTPR against subsequent write attempts. This protection is released by a reset source of the WDT. With other reset sources, the protection is not released.

复位信号或不可屏蔽中断请求中断请求(WDT_NMIUNDF)。

复位信号或不可屏蔽中断请求中断请求产生后，计数器在计数1个周期后重新加载超时周期。超时时间的值在递减计数器中设置并重新开始计数。

可以在WDT复位中断请求选择位(OFS0.WDTRSTIRQS)中选择复位输出或中断请求输出。可以在WDT下溢刷新错误中断　　允许位(NMIER.WDTEN)中选择不可屏蔽的中断请求或中断请求。

图25.4显示了以下条件下的操作示例（不可屏蔽中断）：

- 自动启动模式（OFS0.WDTSTRT=0）
- 使能不可屏蔽中断请求输出(OFS0.WDTRSTIRQS=0)
- 窗口起始位置为75%(WDTCR.RPSS[1:0]=10b)
- 窗口结束位置为25%(WDTCR.RPES[1:0]=10b)。

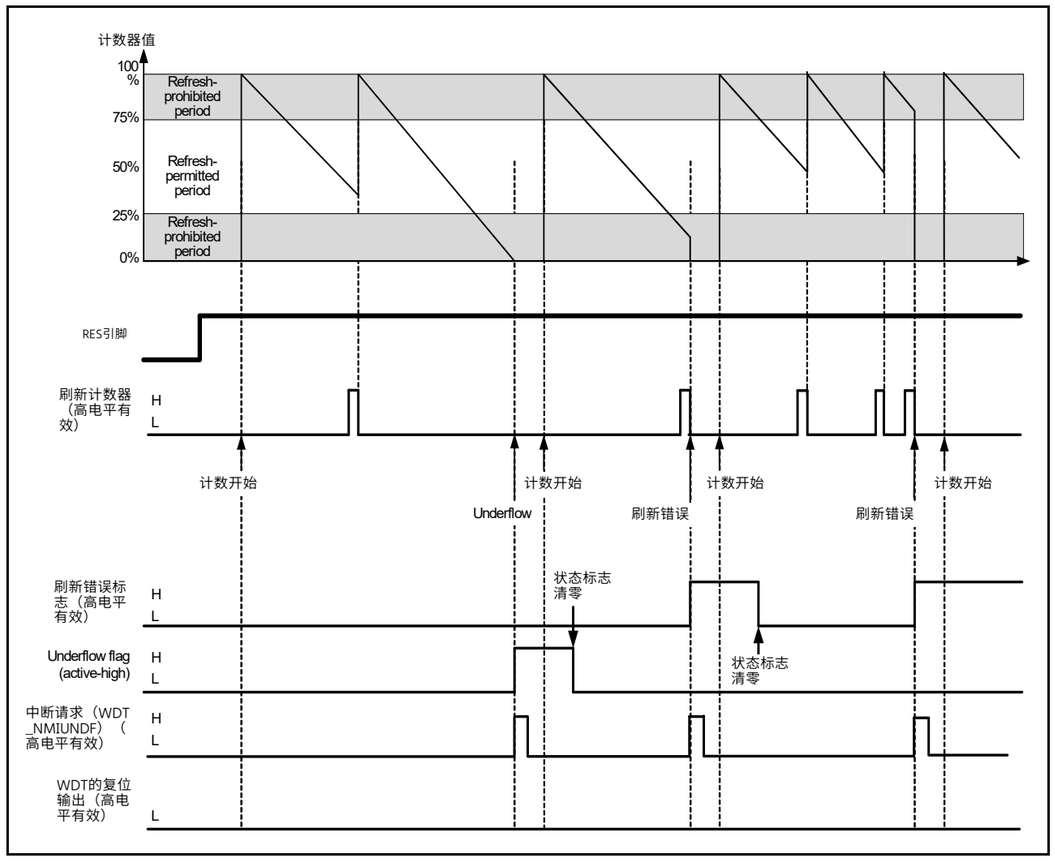

Figure 25.4 自动启动模式下的操作示例

25.3.2 控制对WDTCR、WDTRCR和WDTCSTPR寄存器的写入

写入WDT控制寄存器(WDTCR)、WDT复位控制寄存器(WDTRCR)或WDT计数停止控制寄存器(WDTCSTPR)在从复位状态释放到第一次刷新操作之间是可能的。

在刷新（计数开始）或写入WDTCR、WDTRCR或WDTCSTPR后，WDT中的保护信号变为1，以保护WDTCR、WDTRCR和WDTCSTPR免受后续写入尝试。该保护由WDT的复位源解除。使用其他复位源时，不会解除保护。

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Figure 25.5 shows control waveforms produced in response to writing to the WDTCR.

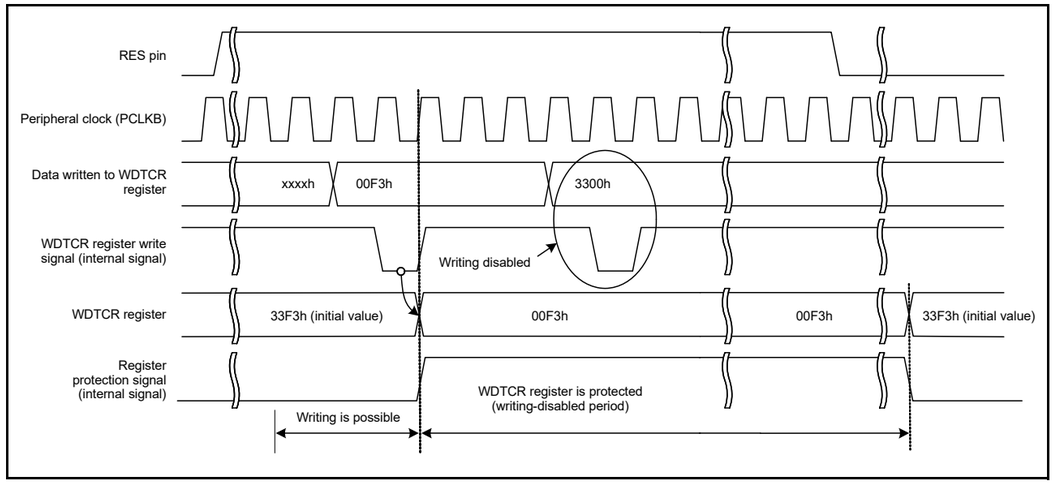


Figure 25.5 Control waveforms produced in response to writes to the WDTCR register

25.3.3 Refresh Operation

The down-counter is refreshed by writing the values 00h and FFh to the WDT Refresh Register (WDTRR). If a value other than FFh is written after 00h, the down-counter is not refreshed. If an invalid value is written, correct refreshing resumes by writing 00h and FFh to the WDTRR register.

Correct refreshing is performed when a register other than WDTRR is accessed or when WDTRR is read between writing 00h and writing FFh to WDTRR.

Writing to refresh the counter must be performed within the refresh-permitted period, and whether this is done is determined by writing FFh. For this reason, correct refreshing is performed even when 00h is written outside the refresh-permitted period.

[Example write sequences that are valid when refreshing the counter]

- 00h → FFh
- 00h ((n - 1)th time) → 00h (nth time) → FFh
- 00h → access to another register or read from WDTRR → FFh.

[Example write sequences that are invalid when refreshing the counter]

- 23h (a value other than 00h) → FFh
- 00h → 54h (a value other than FFh)
- 00h→ AAh (00h and a value other than FFh) → FFh.

After FFh is written to the WDT Refresh Register (WDTRR), refreshing the down-counter requires up to 4 cycles of the signal for counting. To meet this requirement, complete writing FFh to WDTRR 4 cycle counts before the down-counter underflows.

Figure 25.6 shows the WDT refresh-operation waveforms when the clock division ratio is PCLKB/64.

图25.5显示了响应写入WDTCR产生的控制波形。

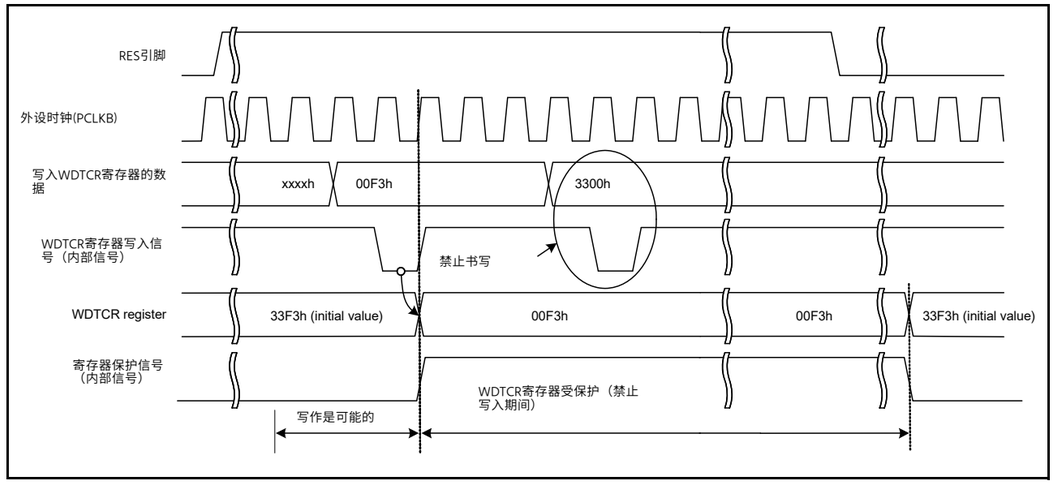


Figure 25.5 响应写入WDTCR寄存器而产生的控制波形

25.3.3 刷新操作

通过将值00h和FFh写入WDT刷新寄存器(WDTRR)来刷新递减计数器。如果在00h之后写入FFh以外的值，则不刷新递减计数器。如果写入无效值，则通过将00h和FFh写入WDTRR寄存器来恢复正确刷新。

当访问WDTRR以外的寄存器或在写入00h和将FFh写入WDTRR之间读取WDTRR时，执行正确刷新。

刷新计数器的写入必须在可刷新期间内执行，是否执行由写入FFh决定。因此，即使在允许刷新期间之外写入00h，也会执行正确的刷新。

[刷新计数器时有效的示例写入序列]

- 00h → FFh
- 00h ((n - 1)th time) → 00h (nth time) → FFh
- 00h→访问另一个寄存器或从WDTRR→FFh读取。

[刷新计数器时无效的写入序列示例]

- 23h（00h以外的值）→FFh
- 00h→54h（FFh以外的值）
- 00h→AAh（00h和FFh以外的值）→FFh。

将FFh写入WDT刷新寄存器(WDTRR)后，刷新递减计数器最多需要4个信号周期进行计数。为满足此要求，请在递减计数器下溢之前将FFh写入WDTRR4个周期计数。

图25.6显示了时钟分频比为PCLKB64时的WDT刷新操作波形。

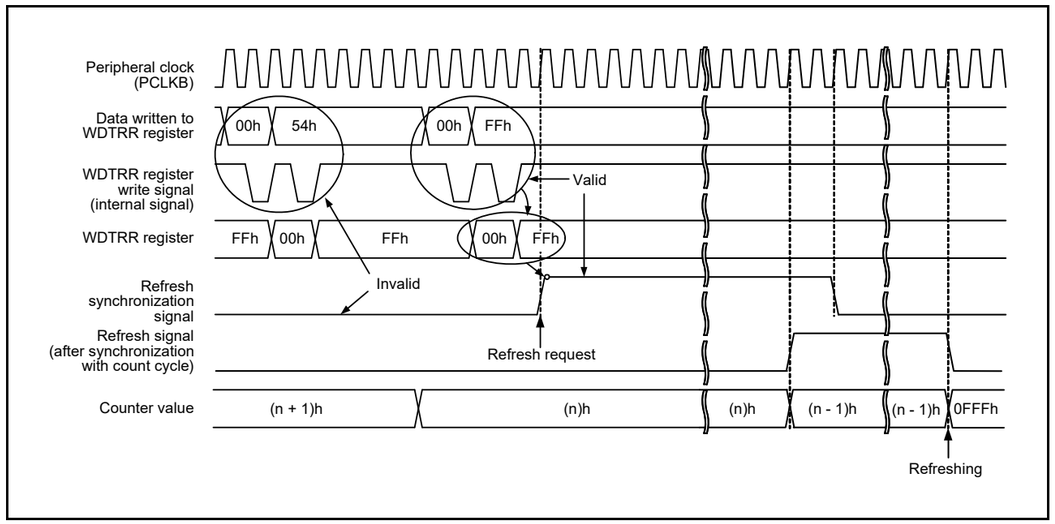


Figure 25.6 WDT refresh operation waveforms when WDTCR.CKS[3:0] = 0100b and WDTCR.TOPS[1:0] = 01b

25.3.4 Reset Output

When the Reset Interrupt Request Select bit (WDTRCR.RSTIRQS) is set to 1 in register start mode, or when the WDT Reset Interrupt Request Select bit (OFS0.WDTRSTIRQS) in the Option Function Select Register 0 (OFS0) is set to 1 in auto start mode, a reset signal is output for 1 cycle count when an underflow in the down-counter or a refresh error occurs.

In register start mode, the down-counter is initialized (all bits set to 0) and stopped in that state after output of a reset signal. After the reset state is released and the program is restarted, the counter is set up and counting down starts again with a refresh. In auto start mode, counting down starts automatically after the reset state is released.

25.3.5 Interrupt Sources

When the Reset Interrupt Request Select bit (WDTRCR.RSTIRQS) is set to 0 in register start mode or when the WDT Reset Interrupt Request Select bit (OFS0.WDTRSTIRQS) in the Option Function Select Register 0 (OFS0) is set to 0 in auto start mode, an interrupt signal (WDT_NMIUNDF) is generated when an underflow in the counter or a refresh error occurs. This interrupt can be used as a non-maskable interrupt or an interrupt. For details, see section 13, Interrupt Controller Unit (ICU).

Table 25.4 WDT interrupt sources

Name	Interrupt source	DTC activation	DMAC activation
WDT_NMIUNDF	• Down-counter underflow • Refresh error.	Not possible	Not possible

25.3.6 Reading the Down-Counter Value

The WDT stores the counter value in the down-counter value bits (WDTSR.CNTVAL[13:0]) in the WDT Status Register. Check these bits to obtain the counter value.

Figure 25.7 shows the processing for reading the WDT down-counter value when the clock division ratio is PCLKB/64.

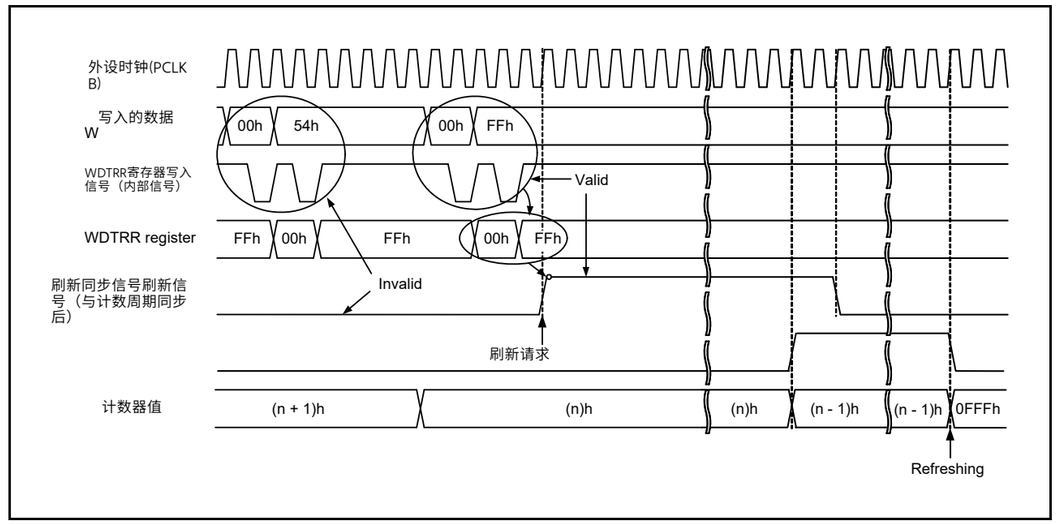


Figure 25.6 WDTCR.CKS[3:0]=0100b和WDTCR.TOPS[1:0]=01b时的WDT刷新操作波形

25.3.4 复位输出

当重置中断请求选择位（wdtrcr.rstirqs）在寄存器开始模式下设置为1，或者在wdtrepreptinterrupt请求中选择位（ofs0.wdtrstirqs）在选项函数函数选择寄存器0（OFS0）中设置为1in在自动启动模式下，当递减计数器下溢或发生刷新错误时，会在1个周期计数内输出复位信号。

在寄存器启动模式下，递减计数器被初始化（所有位设置为0）并在输出复位信号后停止在该状态。复位状态解除并重新启动程序后，计数器设置并通过刷新重新开始倒计时。在自动启动模式下，复位状态解除后自动开始倒计时。

25.3.5 中断源

当在寄存器启动模式下复位中断请求选择位(WDTRCR.RSTIRQS)设置为0或WDT
在自动启动模式下，选项功能选择寄存器0(OFS0)中的复位中断请求选择位(OFS0.WDTRSTIRQS)设置为0，当计数器下溢或发生刷新错误时会产生中断信号(WDT_NMIUNDF)。此中断可用作不可屏蔽中断或中断。有关详细信息，请参阅第13节，中断控制器单元(ICU)。

Table 25.4 WDT中断源

Name	中断源	DTC activation	DMAC activation
WDT_NMIUNDF	递减计数器下溢 刷新错误 。	不可能	不可能

25.3.6 读取递减计数器值

WDT将计数器值存储在WDT状态的递减计数器值位(WDTSR.CNTVAL[13:0])中
登记。检查这些位以获得计数器值。

图25.7显示了时钟分频比为PCLKB64时读取WDT递减计数器值的处理。

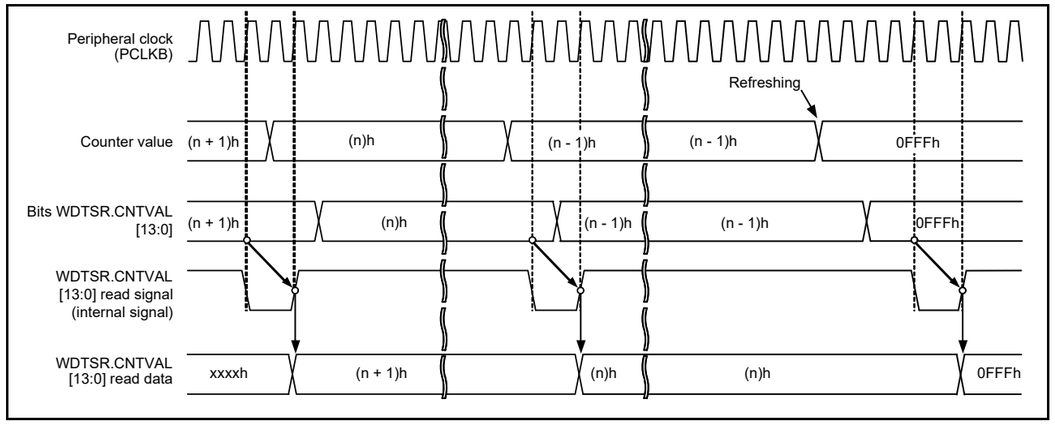


Figure 25.7 Processing for reading WDT down-counter value when WDTCR.CKS[3:0] = 0100b and WDTCR.TOPS[1:0] = 01b

25.3.7 Association between Option Function Select Register 0 (OFS0) and WDT Registers

Table 25.5 lists the association between the Option Function Select Register 0 (OFS0) used in auto start mode, and the registers used in register start mode. Do not change the OFS0 register settings during WDT operation. For details on the Option Function Select Register 0 (OFS0), see section 7, Option Function Select Register 0 (OFS0).

Table 25.5 Association between Option Function Select Register 0 (OFS0) and the WDT registers

Control target	Function	OFS0 register (enabled in auto start mode) OFS0.WDTSTRT = 0	WDT registers (enabled in register start mode) OFS0.WDTSTRT = 1
Down-counter	Timeout period select	OFS0.WDTTOPS[1:0]	WDTCR.TOPS[1:0]
	Clock division ratio select	OFS0.WDTCKS[3:0]	WDTCR.CKS[3:0]
	Window start position select	OFS0.WDTRPSS[1:0]	WDTCR.RPSS[1:0]
	Window end position select	OFS0.WDTRPES[1:0]	WDTCR.RPES[1:0]
Reset output or interrupt request output	Reset output or interrupt request output select	OFS0.WDTRSTIRQS	WDTRCR.RSTIRQS
Count stop	Sleep-mode count stop control	OFS0.WDTSTPCTL	WDTCSTPR.SLCSTP

25.4 Link Operation by ELC

The WDT is capable of a link operation for the previously specified module when interrupt request signal is used as an event signal by the ELC. The event signal is output by the counter underflow or refresh error.

An event signal is output regardless of the setting in the Reset Interrupt Request Select bit (WDTRCR.RSTIRQS) in register start mode or the WDT Reset Interrupt Request Select bit (OFS0.WDTRSTIRQS) in auto start mode. An event signal can also be output when the next interrupt source is generated while the Refresh Error flag (WDTSR.REFEF) or Underflow flag (WDTSR.UNDFF) is 1. For details, see section 18, Event Link Controller (ELC).

25.5 Usage Notes

25.5.1 ICU Event Link Setting Register n (IELSRn) Setting

Setting 47h to the ICU Event Link Setting Register n (IELSRn.IELS[8:0] bits) is prohibited when enabling the WDT reset assertion (OFS0.WDTRSTIRQS = 1 or WDTRCR.RSTIRQS = 1), or when enabling the event link operation (47h is set to ELSRm.ELS[8:0]).

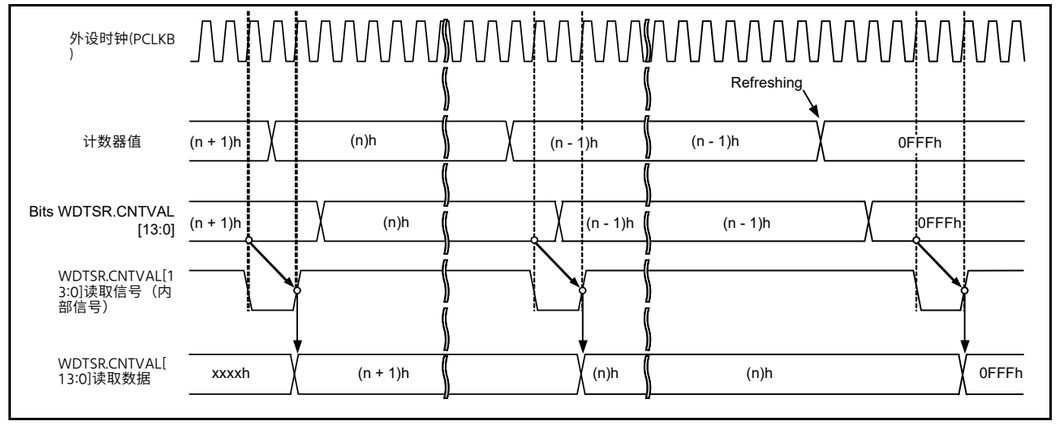


Figure 25.7 当WDTCR.CKS[3:0]=0100b和WDTCR.TOPS[1:0] = 01b

25.3.7 选项功能选择寄存器0(OFS0)和WDT之间的关联 Registers

表25.5列出了自动启动模式中使用的选项功能选择寄存器0(OFS0)和寄存器启动模式中使用的寄存器之间的关联。请勿在WDT操作期间更改OFS0寄存器设置。有关选项功能选择寄存器0(OFS0)的详细信息，请参见第7节，选项功能选择寄存器0(OFS0)。

Table 25.5 选项功能选择寄存器0(OFS0)和WDT寄存器之间的关联

控制目标	Function	OFS0寄存器（在自动启动模式下启用）OFS0.WDTSTRT=0	WDT寄存器（在寄存器启动模式下启用）OFS0.WDTSTRT=1
Down-counter	超时时间选择	OFS0.WDTTOPS[1:0]	WDTCR.TOPS[1:0]
	时钟分频比选择	OFS0.WDTCKS[3:0]	WDTCR.CKS[3:0]
	窗口起始位置选择	OFS0.WDTRPSS[1:0]	WDTCR.RPSS[1:0]
	窗口结束位置选择	OFS0.WDTRPES[1:0]	WDTCR.RPES[1:0]
复位输出或中断请求输出	复位输出或中断请求输出选择	OFS0.WDTRSTIRQS	WDTCR.RSTIRQS
计数停止	睡眠模式计数停止控制	OFS0.WDTSTPCTL	WDTCSTPR.SLCSTP

25.4 ELC的链接操作

当ELC将中断请求信号用作事件信号时，WDT能够对先前指定的模块进行链接操作。事件信号由计数器下溢或刷新错误输出。

无论寄存器启动模式下的复位中断请求选择位(WDTRCR.RSTIRQS)或自动启动模式下的WDT复位中断请求选择位(OFS0.WDTRSTIRQS)的设置如何，都会输出事件信号。当刷新错误标志(WDTSR.REFEF)或下溢标志(WDTSR.UNDFF)为1时，也可以在产生下一个中断源时输出事件信号。有关详细信息，请参阅第18节，事件链接控制器(ELC)。

25.5 使用说明

25.5.1 ICU事件链接设置寄存器n(IELSRn)设置

当启用WDT复位断言（OFS0.WDTRSTIRQS=1或WDTRCR.RSTIRQS=1）或启用事件链接操作时，禁止将47h设置为ICU事件链接设置寄存器n（IELSRn.IELS[8:0]位）（47h设置为ELSRm.ELS[8:0]）。

26. Independent Watchdog Timer (IWDT)

26.1 Overview

The Independent Watchdog Timer (IWDT) is a 14-bit down counter that must be serviced periodically to prevent counter underflow. The IWDT can be used to reset the MCU or to generate a non-maskable interrupt or an underflow interrupt. Because the timer operates using an independent, dedicated clock source, it is particularly useful in returning the MCU to a known state as a failsafe mechanism when the system runs out of control. The IWDT can be triggered automatically by a reset, underflow, refresh error, or a refresh of the count value in the registers.

The functions of the IWDT are different from those of the WDT in the following ways:

- The divided IWDT-dedicated clock (IWDTCLK) is used as the count source (not affected by PCLKB)
- IWDT does not support the register start mode
- When transitioning to a low power mode (excluding Deep Software Standby mode), the OFS0.IWDTSTPCTL bit can be used to select whether to stop the counter or not.

Table 26.1 lists the IWDT specifications and Figure 26.1 shows a block diagram.

Table 26.1 IWDT specifications

Parameter	Specifications
Count source*1	IWDT-dedicated clock (IWDTCLK)
Clock division ratio	Division by 1, 16, 32, 64, 128, or 256
Counter operation	Counting down using a 14-bit down-counter
Condition for starting the counter	Counting automatically starts after a reset
Conditions for stopping the counter	• Reset (the down-counter and other registers return to their initial values) • A counter underflows or a refresh error is generated (counting restarts automatically).
Window function	Window start and end positions can be specified (refresh-permitted and refresh-prohibited periods)
IWDT reset sources	• Down-counter underflows • Refreshing outside the refresh-permitted period (refresh error).
Non-maskable interrupt/interrupt sources	• Down-counter underflows • Refreshing outside the refresh-permitted period (refresh error).
Reading of the counter value	The down-counter value can be read by the IWDTSR register
Event link function (output)	• Down-counter underflow event output • Refresh error event output.
Output signal (internal signal)	• Reset output • Interrupt request output • Sleep-mode count stop control output.
Auto start mode	Configurable to the following triggers: • Clock frequency division ratio after a reset (OFS0.IWDTCKS[3:0] bits) • Timeout period of the IWDT (OFS0.IWDTTOPS[1:0] bits) • Window start position in the IWDT (OFS0.IWDTRPSS[1:0] bits) • Window end position in the IWDT (OFS0.IWDTRPES[1:0] bits) • Reset output or interrupt request output (OFS0.IWDTRSTIRQS bit) • Down-count stop function at transition to Sleep mode, Software Standby mode, or Snooze mode (OFS0.IWDTSTPCTL bit).

Note 1. Satisfy the frequency of the peripheral module clock (PCLKB) ≥ 4 × (the frequency of the count clock source after division).

To use the IWDT, you must supply the IWDT-dedicated clock (IWDTCLK). The bus interface and registers operate with PCLKB, and the 14-bit counter and control circuits operate with IWDTCLK.

26. 独立看门狗定时器(IWDT)

26.1 Overview

独立看门狗定时器(IWDT)是一个14位递减计数器，必须定期对其进行服务以防止计数器下溢。IWDT可用于复位MCU或产生不可屏蔽中断或下溢中断。由于定时器使用独立的专用时钟源运行，因此当系统失控时，它在将MCU作为故障保护机制返回到已知状态时特别有用。IWDT可以通过复位、下溢、刷新错误或寄存器中的计数值的刷新来自动触发。

IWDT的功能与WDT的功能有以下不同：

- 分频的IWDT专用时钟（IWDTCLK）用作计数源（不受PCLKB影响）
- IWDT不支持寄存器启动模式
- 当转换到低功耗模式（不包括深度软件待机模式）时，OFS0.IWDTSTPCL位可用于选择是否停止计数器。

表26.1列出了IWDT规范，图26.1显示了框图。

Table 26.1 IWDT specifications

Parameter	Specifications
Count source*1	IWDT-dedicated clock (IWDTCLK)
时钟分频比	除以1、16、32、64、128或256
计数器操作	使用14位递减计数器进行递减计数
启动计数器的条件	复位后自动开始计数
停止计数器的条件	复位（递减计数器和其他寄存器返回其初始值） 计数器下溢或产生刷新错误（计数自动重新开始）。
窗口功能	可以指定窗口开始和结束位置（允许刷新和禁止刷新期间）
IWDT复位源	递减计数器下溢 在允许刷新的时间之外刷新（刷新错误）。
Non-maskable interrupt/interrupt sources	递减计数器下溢 在允许刷新的时间之外刷新（刷新错误）。
读取计数器值	递减计数器的值可以通过IWDTSR寄存器读取
事件链接功能（输出）	递减计数器下溢事件输出 刷新错误事件输出。
输出信号（内部信号）	复位输出 中断请求输出 睡眠模式计数停止控制输出。
自动启动模式	可配置为以下触发器： 复位后的时钟分频比（OFS0.IWDTCKS[3:0]位） IWDT的超时周期（OFS0.IWDTTOPS[1:0]位） IWDT中的窗口开始位置（OFS0.IWDTRPSS[1:0]位） IWDT中的窗口结束位置（OFS0.IWDTRPES[1:0]位） 复位输出或中断请求输出（OFS0.IWDTRSTIRQS位） 向下计数停止功能在转换到睡眠模式、软件待机模式或贪睡模式（OFS0.IWDTSTPCL位）。

Note 1. 满足外围模块时钟（PCLKB）的频率 4×（分频后的计数时钟源的频率）。

要使用IWDT，您必须提供IWDT专用时钟(IWDTCLK)。总线接口和寄存器操作PCLKB、14位计数器和控制电路使用IWDTCLK工作。

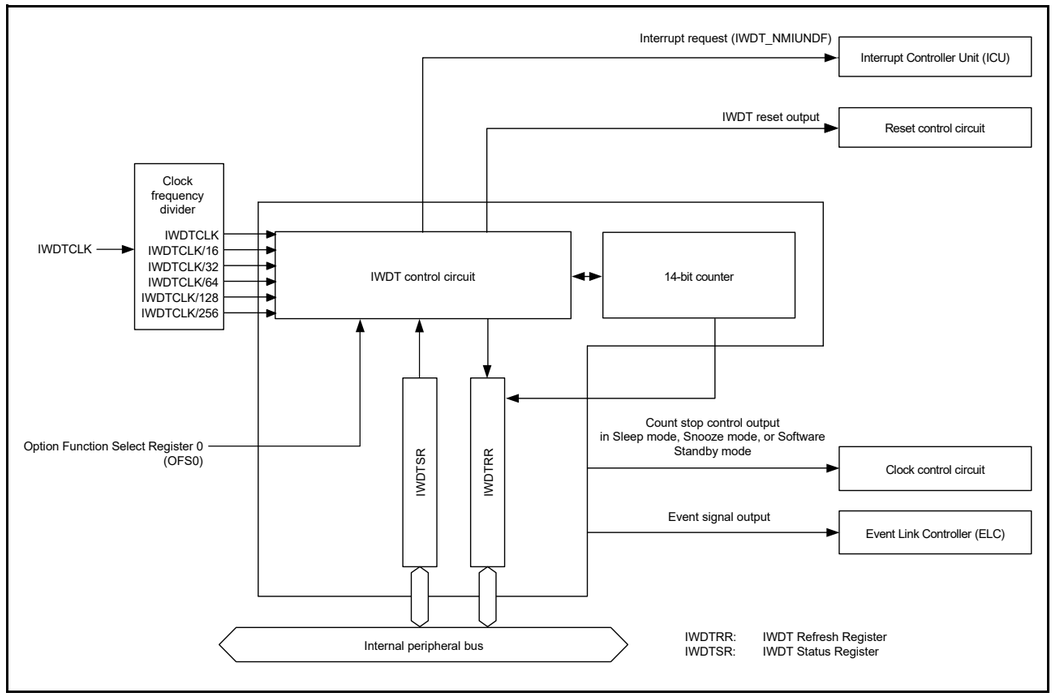


Figure 26.1 IWDT block diagram

26.2 Register Descriptions

26.2.1 IWDT Refresh Register (IWDTRR)

Address(es): IWDT.IWDTRR 4004 4400h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1

Bit	Description	R/W
b7 to b0	The down-counter is refreshed by writing 00h and then writing FFh to this register	R/W

The IWDTRR register refreshes the down-counter of the IWDT. The down-counter of the IWDT is refreshed by writing 00h and then writing FFh to IWDTRR (refresh operation) within the refresh-permitted period. After the down-counter is refreshed, it starts counting down from the value selected in the IWDT Timeout Period Select bits (OFS0.IWDTTOPS[1:0]) in Option Function Select Register 0 (OFS0).

When 00h is written, the read value is 00h. When a value other than 00h is written, the read value is FFh. For details on the refresh operation, see section 26.3.2, Refresh Operation.

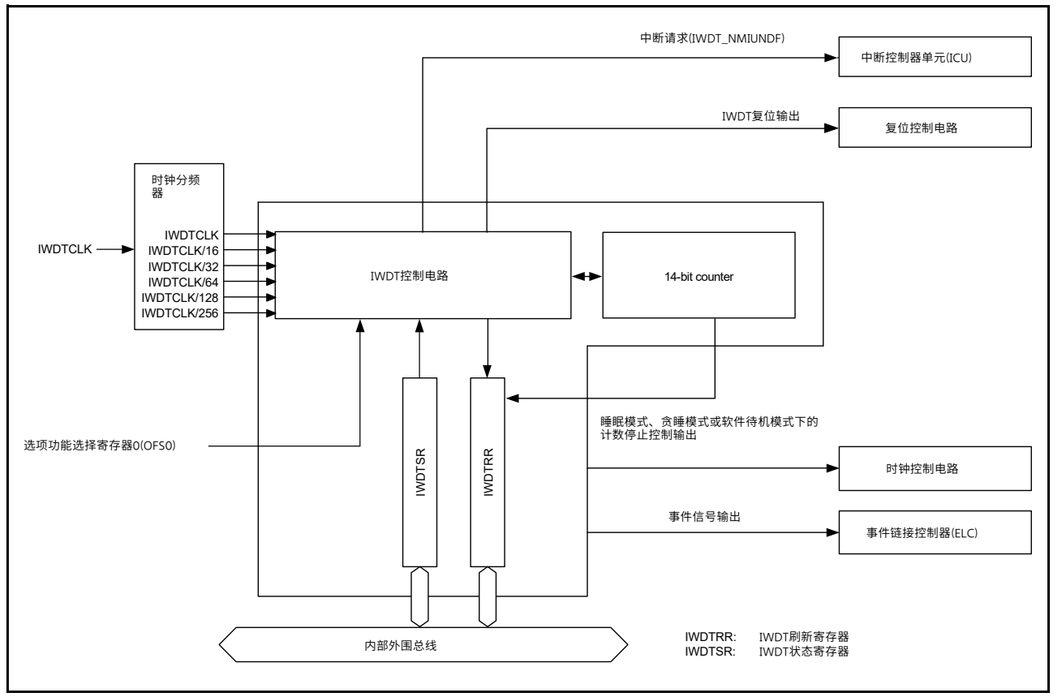


Figure 26.1 IWDT框图

26.2 注册说明

26.2.1 IWDT刷新寄存器(IWDTRR)

Address(es): IWDT.IWDTRR 4004 4400h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1

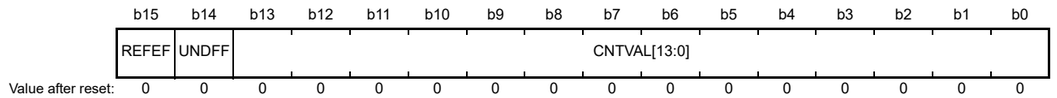
Bit	Description	R/W
b7 to b0	通过写入00h然后将FFh写入该寄存器来刷新递减计数器	R/W

IWDTRR寄存器刷新IWDT的递减计数器。IWDT的递减计数器通过写入00h进行刷新，然后在允许刷新期间将FFh写入IWDTRR（刷新操作）。递减计数器刷新后，它从选项功能选择寄存器0(OFS0)的IWDT超时周期选择位(OFS0.IWDTTOPS[1:0])中选择的值开始递减计数。

写入00h时，读取值为00h。写入00h以外的值时，读取值为FFh。有关刷新操作的详细信息，请参阅第26.3.2节，刷新操作。

26.2.2 IWDT Status Register (IWDTSR)

Address(es): IWDT.IWDTSR 4004 4404h



Bit	Symbol	Bit name	Description	R/W
b13 to b0	CNTVAL[13:0]	Counter Value	Value counted by the down-counter	R
b14	UNDFF	Underflow Flag	0: No underflow occurred 1: Underflow occurred.	R/(W)*1
b15	REFEF	Refresh Error Flag	0: No refresh error occurred 1: Refresh error occurred.	R/(W)*1

Note 1. Only 0 can be written to clear the flag.

CNTVAL[13:0] bits (Counter Value)

Read the CNTVAL[13:0] bits to confirm the value of the down-counter. The read value might differ from the actual count by 1.

UNDFF flag (Underflow Flag)

Read the UNDFF flag to confirm whether an underflow occurred in the down-counter. A value of 1 indicates that the down-counter underflowed. Write 0 to the UNDFF flag to set the value to 0. Writing 1 has no effect.

Clearing of the UNDFF flag takes (N + 2) IWDTCLK cycles and 2 PCLKB cycles. In addition, clearing of the flag is ignored for (N + 2) IWDTCLK cycles after an underflow. N is specified in the IWDTCKS[3:0] bits as follows:

- When IWDTCKS[3:0] = 0000b, N = 1
- When IWDTCKS[3:0] = 0010b, N = 16
- When IWDTCKS[3:0] = 0011b, N = 32
- When IWDTCKS[3:0] = 0100b, N = 64
- When IWDTCKS[3:0] = 1111b, N = 128
- When IWDTCKS[3:0] = 0101b, N = 256.

REFEF flag (Refresh Error Flag)

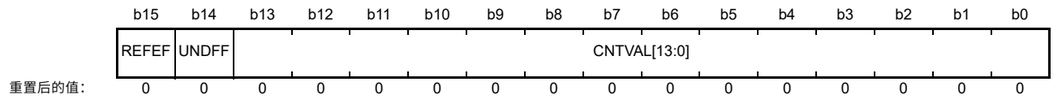
Read the REFEF flag to confirm whether a refresh error occurred. This indicates that a refresh operation was performed during a prohibited period. A value of 1 indicates that a refresh error occurred. Write 0 to the REFEF flag to set the value to 0. Writing 1 has no effect.

Clearing of the REFEF flag takes (N + 2) IWDTCLK cycles and 2 PCLKB cycles. In addition, clearing of the flag is ignored for (N + 2) IWDTCLK cycles after a refresh error. N is specified in the IWDTCKS[3:0] bits as follows:

- When IWDTCKS[3:0] = 0000b, N = 1
- When IWDTCKS[3:0] = 0010b, N = 16
- When IWDTCKS[3:0] = 0011b, N = 32
- When IWDTCKS[3:0] = 0100b, N = 64
- When IWDTCKS[3:0] = 1111b, N = 128
- When IWDTCKS[3:0] = 0101b, N = 256.

26.2.2 IWDT状态寄存器(IWDTSR)

Address(es): IWDT.IWDTSR 4004 4404h



Bit	Symbol	位名称	Description	R/W
b13 to b0	CNTVAL[13:0]	计数器值	递减计数器计数的值	R
b14	UNDFF	Underflow Flag	0：未发生下溢1：发生下溢。	R/(W)*1
b15	REFEF	刷新错误标志	0：未发生刷新错误1：发生刷新错误。	R/(W)*1

Note 1. 只能写入0来清除标志。

CNTVAL[13:0]位（计数器值）

读取CNTVAL[13:0]位以确认递减计数器的值。读取的值可能与实际计数相差1。

UNDFF flag (Underflow Flag)

读取UNDFF标志以确认递减计数器中是否发生下溢。值1表示递减计数器下溢。将0写入UNDFF标志以将值设置为0。写入1无效。

清除UNDFF标志需要(N+2)个IWDTCLK周期和2个PCLKB周期。此外，在下溢后(N+2)个IWDTCLK周期内忽略标志的清除。N在IWDTCKS[3:0]位中指定如下：

- When IWDTCKS[3:0] = 0000b, N = 1
- When IWDTCKS[3:0] = 0010b, N = 16
- When IWDTCKS[3:0] = 0011b, N = 32
- When IWDTCKS[3:0] = 0100b, N = 64
- When IWDTCKS[3:0] = 1111b, N = 128
- When IWDTCKS[3:0] = 0101b, N = 256.

REFEF标志（刷新错误标志）

读取REFEF标志以确认是否发生刷新错误。这表示在禁止期间执行了刷新操作。值1表示发生了刷新错误。将0写入REFEF标志以将值设置为0。写入1无效。

清除REFEF标志需要(N+2)个IWDTCLK周期和2个PCLKB周期。此外，在刷新错误后(N+2)个IWDTCLK周期内忽略标志的清除。N在IWDTCKS[3:0]位中指定如下：

- When IWDTCKS[3:0] = 0000b, N = 1
- When IWDTCKS[3:0] = 0010b, N = 16
- When IWDTCKS[3:0] = 0011b, N = 32
- When IWDTCKS[3:0] = 0100b, N = 64
- When IWDTCKS[3:0] = 1111b, N = 128
- When IWDTCKS[3:0] = 0101b, N = 256.

26.2.3 Option Function Select Register 0 (OFS0)

For information on the Option Function Select Register 0 (OFS0), see section 7.2.1, Option Function Select Register 0 (OFS0).

IWDTTOPS[1:0] bits (IWDT Timeout Period Select)

The IWDTTOPS[1:0] bits select the timeout period, that is, the period until the down-counter underflows, from 128, 512, 1024, or 2048 cycles, taking the divided clock specified in the IWDTCKS[3:0] bits as 1 cycle.

After the down-counter is refreshed, the combination of the IWDTCKS[3:0] and IWDTTOPS[1:0] bits determines the number of IWDTCLK cycles until the counter underflows.

Table 26.2 lists the relationship between the IWDTCKS[3:0] and IWDTTOPS[1:0] bit settings, the timeout period, and the number of IWDTCLK cycles.

Table 26.2 Timeout period settings

IWDTCKS[3:0] bits				IWDTTOPS[1:0] bits		Clock division ratio	Timeout period (number of cycles)	IWDTCLK cycles
b7	b6	b5	b4	b1	b0			
0	0	0	0	0	0	IWDTCLK	128	128
				0	1		512	512
				1	0		1024	1024
				1	1		2048	2048
0	0	1	0	0	0	IWDTCLK/16	128	2048
				0	1		512	8192
				1	0		1024	16384
				1	1		2048	32768
0	0	1	1	0	0	IWDTCLK/32	128	4096
				0	1		512	16384
				1	0		1024	32768
				1	1		2048	65536
0	1	0	0	0	0	IWDTCLK/64	128	8192
				0	1		512	32768
				1	0		1024	65536
				1	1		2048	131072
1	1	1	1	0	0	IWDTCLK/128	128	16384
				0	1		512	65536
				1	0		1024	131072
				1	1		2048	262144
0	1	0	1	0	0	IWDTCLK/256	128	32768
				0	1		512	131072
				1	0		1024	262144
				1	1		2048	524288

IWDTCKS[3:0] bits (IWDT-Dedicated Clock Frequency Division Ratio Select)

The IWDTCKS[3:0] bits specify the division ratio of the clock used for the down-counter. The division ratio can be selected from the IWDT-dedicated clock (IWDTCLK) divided by 1, 16, 32, 64, 128, and 256. Combined with the IWDTTOPS[1:0] bit setting, the IWDT can be configured to a count period between 128 and 524288 IWDTCLK cycles.

IWDTRPES[1:0] bits (IWDT Window End Position Select)

The IWDTRPES[1:0] bits specify the window end position that indicates the refresh-permitted period. 75%, 50%, 25%, or 0% of the timeout period can be selected for the window end position. Set the window end position to a value less than the window start position (window start position > window end position). If the window end position is greater than the window start position, only the window start position setting is enabled.

26.2.3 选项功能选择寄存器0(OFS0)

有关选项功能选择寄存器0(OFS0)的信息，请参阅第7.2.1节，选项功能选择寄存器0(OFS0)。

IWDTTOPS[1:0]位（IWDT超时周期选择）

IWDTTOPS[1:0]位选择超时周期，即从128、512、1024或2048个周期到递减计数器下溢的周期，采用IWDTCKS[3:0]位中指定的分频时钟作为1个周期。

向下计数器刷新后，IWDTCKS[3:0]和IWDTTOPS[1:0]位的组合决定了在计数器下溢之前的IWDTCLK周期数。

表26.2列出了IWDTCKS[3:0]和IWDTTOPS[1:0]位设置、超时周期和IWDTCLK周期数之间的关系。

Table 26.2 超时时间设置

IWDTCKS[3:0] bits				IWDTTOPS[1:0] bits		时钟分频比	超时时间（周期数）	IWDTCLK cycles
b7	b6	b5	b4	b1	b0			
0	0	0	0	0	0	IWDTCLK	128	128
				0	1		512	512
				1	0		1024	1024
				1	1		2048	2048
0	0	1	0	0	0	IWDTCLK/16	128	2048
				0	1		512	8192
				1	0		1024	16384
				1	1		2048	32768
0	0	1	1	0	0	IWDTCLK/32	128	4096
				0	1		512	16384
				1	0		1024	32768
				1	1		2048	65536
0	1	0	0	0	0	IWDTCLK/64	128	8192
				0	1		512	32768
				1	0		1024	65536
				1	1		2048	131072
1	1	1	1	0	0	IWDTCLK/128	128	16384
				0	1		512	65536
				1	0		1024	131072
				1	1		2048	262144
0	1	0	1	0	0	IWDTCLK/256	128	32768
				0	1		512	131072
				1	0		1024	262144
				1	1		2048	524288

IWDTCKS[3:0]位（IWDT专用时钟分频比选择）

IWDTCKS[3:0]位指定用于递减计数器的时钟分频比。分频比可以从IWDT专用时钟(IWDTCLK)除以1、16、32、64、128和256中选择。结合IWDTTOPS[1:0]位设置，可以将IWDT配置为计数128到524288个IWDTCLK周期之间的周期。

IWDTRPES[1:0]位（IWDT窗口结束位置选择）

IWDTRPES[1:0]位指定指示刷新允许周期的窗口结束位置。可以为窗口结束位置选择75%、50%、25%或0%的超时时间。将窗口结束位置设置为小于窗口开始位置的值（窗口开始位置>窗口结束位置）。如果窗口结束位置大于窗口起始位置，则仅启用窗口起始位置设置。

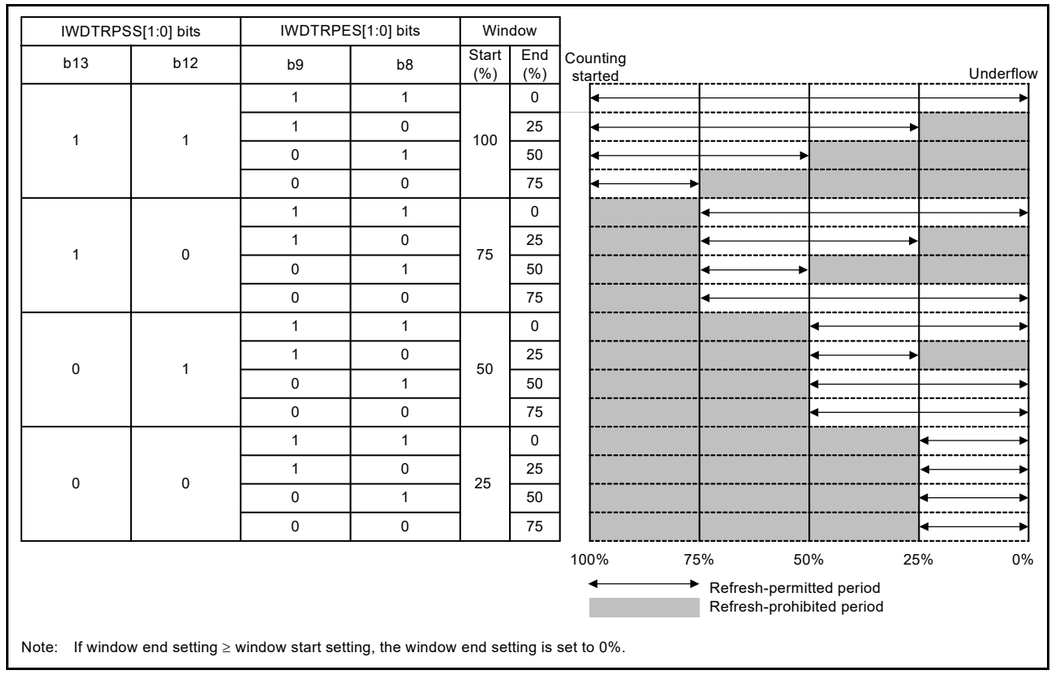
IWDTRPSS[1:0] bits (IWDT Window Start Position Select)

The IWDTRPSS[1:0] bits specify the window start position that indicates the refresh-permitted period. 100%, 75%, 50%, or 25% of the timeout period can be selected for the window start position. Set the window start position to a value greater than the window end position. If the window start position is less than or equal to the window end position, the window end position is set to 0%.

Table 26.3 lists the counter values for the window start and end positions, and Figure 26.2 shows the refresh-permitted period set in the IWDTRPSS[1:0], IWDTRPES[1:0], and IWDTTOPS[1:0] bits.

Table 26.3 Relationship between the timeout period and window start and end counter values

IWDTTOPS[1:0] bits		Timeout period		Window start and end counter value			
b1	b0	Cycles	Counter value	100%	75%	50%	25%
0	0	128	007Fh	007Fh	005Fh	003Fh	001Fh
0	1	512	01FFh	01FFh	017Fh	00FFh	007Fh
1	0	1,024	03FFh	03FFh	02FFh	01FFh	00FFh
1	1	2,048	07FFh	07FFh	05FFh	03FFh	01FFh



Note: If window end setting ≥ window start setting, the window end setting is set to 0%.

Figure 26.2 IWDTRPSS[1:0] and IWDTRPES[1:0] bit settings and refresh-permitted period

IWDTRSTIRQS bit (IWDT Reset Interrupt Request Select)

The IWDTRSTIRQS bit specifies the behavior when an underflow or a refresh error occurred. Set this bit to 1 to select reset output. Set this bit to 0 for non-maskable interrupt or interrupt.

IWDTSTPCTL bit (IWDT Stop Control)

The IWDTSTPCTL bit selects whether to stop counting on transition to Sleep, Snooze, or Software Standby mode.

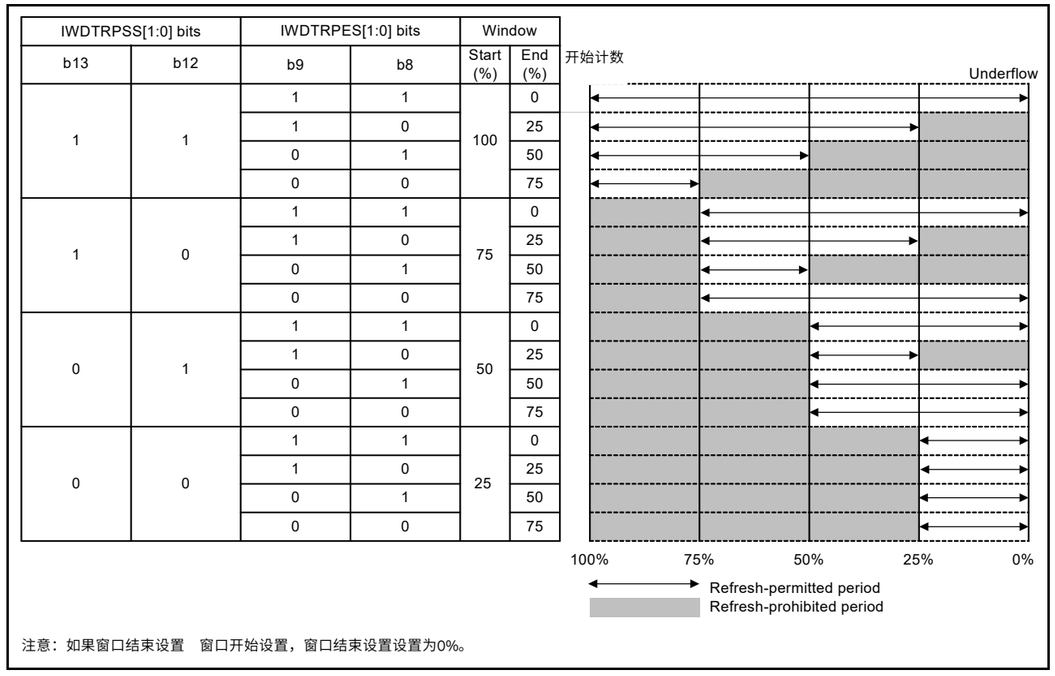
IWDTRPSS[1:0]位（IWDT窗口起始位置选择）

IWDTRPSS[1:0]位指定指示刷新允许周期的窗口起始位置。窗口起始位置可选择100%、75%、50%或25%的超时时间。将窗口开始位置设置为大于窗口结束位置的值。如果窗口开始位置小于或等于窗口结束位置，则窗口结束位置设置为0%。

表26.3列出了窗口开始和结束位置的计数器值，图26.2显示了在IWDTRPSS[1:0]、IWDTRPES[1:0]和IWDTTOPS[1:0]位中设置的允许刷新周期。

Table 26.3 超时时间与窗口开始和结束计数器值之间的关系

IWDTTOPS[1:0] bits		超时时间		窗口开始和结束计数器值			
b1	b0	Cycles	计数器值	100%	75%	50%	25%
0	0	128	007Fh	007Fh	005Fh	003Fh	001Fh
0	1	512	01FFh	01FFh	017Fh	00FFh	007Fh
1	0	1,024	03FFh	03FFh	02FFh	01FFh	00FFh
1	1	2,048	07FFh	07FFh	05FFh	03FFh	01FFh



注意：如果窗口结束设置　窗口开始设置，窗口结束设置设置为0%。

Figure 26.2 IWDTRPSS[1:0]和IWDTRPES[1:0]位设置和允许刷新周期

IWDTRSTIRQS位（IWDT复位中断请求选择）

IWDTRSTIRQS位指定发生下溢或刷新错误时的行为。将此位设置为1以选择复位输出。将该位设置为0表示不可屏蔽中断或中断。

IWDTSTPCTL位（IWDT停止控制）

IWDTSTPCTL位选择在转换到休眠、贪睡或软件待机模式时是否停止计数。

26.3 Operation

26.3.1 Auto Start Mode

When the IWDT Start Mode Select bit (OFS0.IWDTSTRT) in the Option Function Select Register 0 is 0, auto start mode is selected, otherwise the IWDT is disabled.

Within the reset state, the following values in Option Function Select Register 0 (OFS0) are set in the IWDT registers:

- Clock division ratio
- Window start and end positions
- Timeout period
- Reset output or interrupt request
- Counter stop control at transitions to low power mode.

When the reset state is released, the down-counter automatically starts counting down from the value set in the IWDT Timeout Period Select bits (OFS0.IWDTTOPS[1:0]).

After that, as long as the program continues normal operation and the counter is refreshed within the refresh-permitted period, the value in the counter is reset each time the counter is refreshed and down-counting continues. The IWDT does not output the reset signal as long as this procedure continues. However, if the counter underflows because the program crashed, or because a refresh error occurred when an attempt is made to refresh outside the refresh-permitted period, the IWDT asserts the reset signal or non-maskable interrupt request/interrupt request (IWDT_NMIUNDF).

After the reset signal or non-maskable interrupt request/interrupt request is generated, the counter reloads the timeout period after counting for 1 cycle, and restarts the count. Reset output or interrupt request output can be selected in the IWDT Reset Interrupt Request Select bit (OFS0.IWDTRSTIRQS). Non-maskable interrupt request or interrupt request can be selected in the IWDT Underflow/Refresh Error Interrupt Enable bit (NMIER.IWDTEN).

Figure 26.3 shows an example of operation under the following conditions:

- Auto start mode (OFS0.IWDTSTRT = 0)
- Non-maskable interrupt request output is enabled (OFS0.IWDTRSTIRQS = 0)
- The window start position is 75% (OFS0.IWDTRPSS[1:0] = 10b)
- The window end position is 25% (OFS0.IWDTRPES[1:0] = 10b).

26.3 Operation

26.3.1 自动启动模式

当IWDT启动模式选择位置（OFS0.IWDTSTRT）中的选项函数选择寄存器0为0时，选择了自动启动模式，否则IWDT将被禁用。

在复位状态下，选项功能选择寄存器0(OFS0)中的以下值在IWDT寄存器中设置：

- 时钟分频比
- 窗口开始和结束位置
- 超时时间
- 复位输出或中断请求
- 转换到低功耗模式时的计数器停止控制。

复位状态解除后，递减计数器自动从IWDT中设置的值开始递减计数
超时周期选择位(OFS0.IWDTOPS[1:0])。

之后，只要程序继续正常运行，并且在允许刷新的时间内刷新计数器，每次刷新计数器并继续递减计数时，计数器中的值都会被复位。只要此过程继续，IWDT就不会输出复位信号。但是，如果由于程序崩溃或在刷新允许周期之外尝试刷新时发生刷新错误导致计数器下溢，则IWDT将置位复位信号或不可屏蔽中断请求中断请求(IWDT_NMIUNDF)。

复位信号或不可屏蔽中断请求中断请求产生后，计数器在计数1个周期后重新加载超时周期，重新开始计数。可以在IWDT复位中断请求选择位(OFS0.IWDTRSTIRQS)中选择复位输出或中断请求输出。可以在IWDT下溢刷新错误中断　　允许位(NMIER.IWDTEN)中选择不可屏蔽的中断请求或中断请求。

图26.3显示了以下条件下的操作示例：

- 自动启动模式（OFS0.IWDTSTRT=0）
- 使能不可屏蔽中断请求输出(OFS0.IWDTRSTIRQS=0)
- 窗口起始位置为75%(OFS0.IWDTRPSS[1:0]=10b)
- 窗口结束位置为25%(OFS0.IWDTRPES[1:0]=10b)。

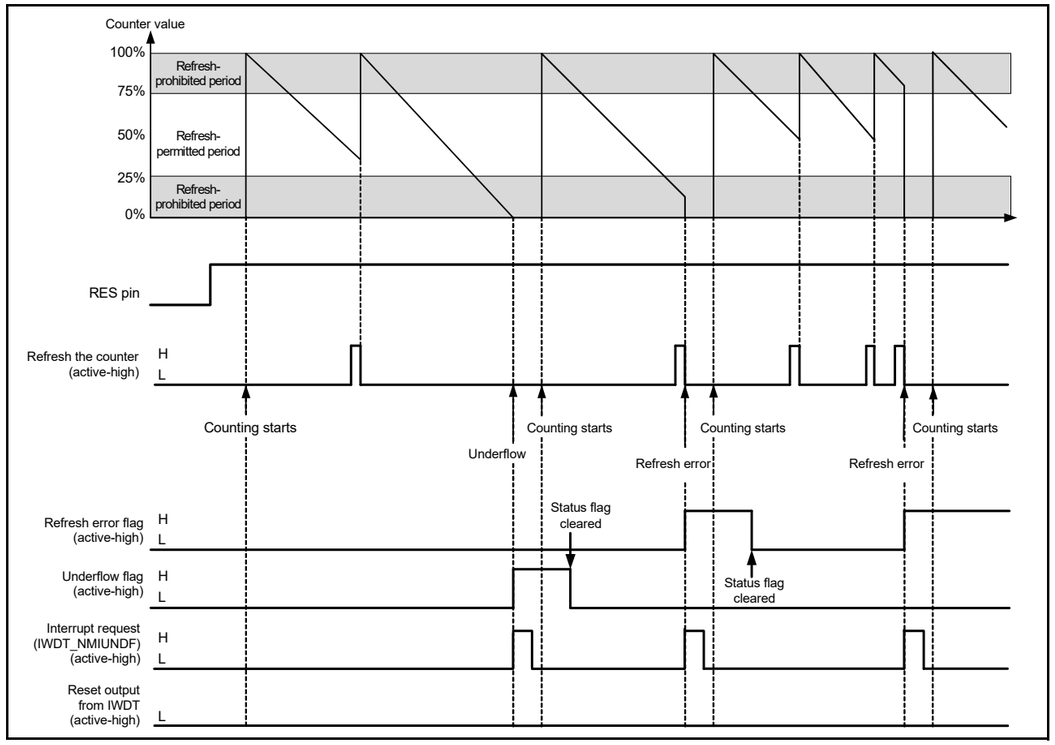


Figure 26.3 Operation example in auto start mode

26.3.2 Refresh Operation

The down-counter is refreshed by writing the values 00h and FFh to the IWDT Refresh Register (IWDTRR). If a value other than FFh is written after 00h, the down-counter is not refreshed. If an invalid value is written, correct refreshing resumes on writing 00h and FFh to the IWDTRR.

When writing is done in the order of 00h (first time) → 00h (second time), and if FFh is written after that, the writing order 00h → FFh is satisfied. Writing 00h ((n - 1)th time) → 00h (nth time) → FFh is valid, and the refresh is performed correctly. Even when the first value written before 00h is not 00h, correct refreshing is performed as long as the operation contains the write sequence 00h → FFh.

Correct refreshing is also performed regardless of whether a register other than IWDTRR is accessed or IWDTRR is read between writing 00h and writing FFh to IWDTRR. Writes to refresh the counter must be made within the refresh-permitted period, and this is determined by writing FFh. For this reason, correct refreshing is performed even when 00h is written outside the refresh-permitted period.

[Example write sequences that are valid to refresh the counter]

- 00h → FFh
- 00h ((n - 1)th time) → 00h (nth time) → FFh
- 00h → access to another register or read from IWDTRR → FFh.

[Example write sequences that are invalid to refresh the counter]

- 23h (a value other than 00h) → FFh
- 00h → 54h (a value other than FFh)
- 00h → AAh (00h and a value other than FFh) → FFh.

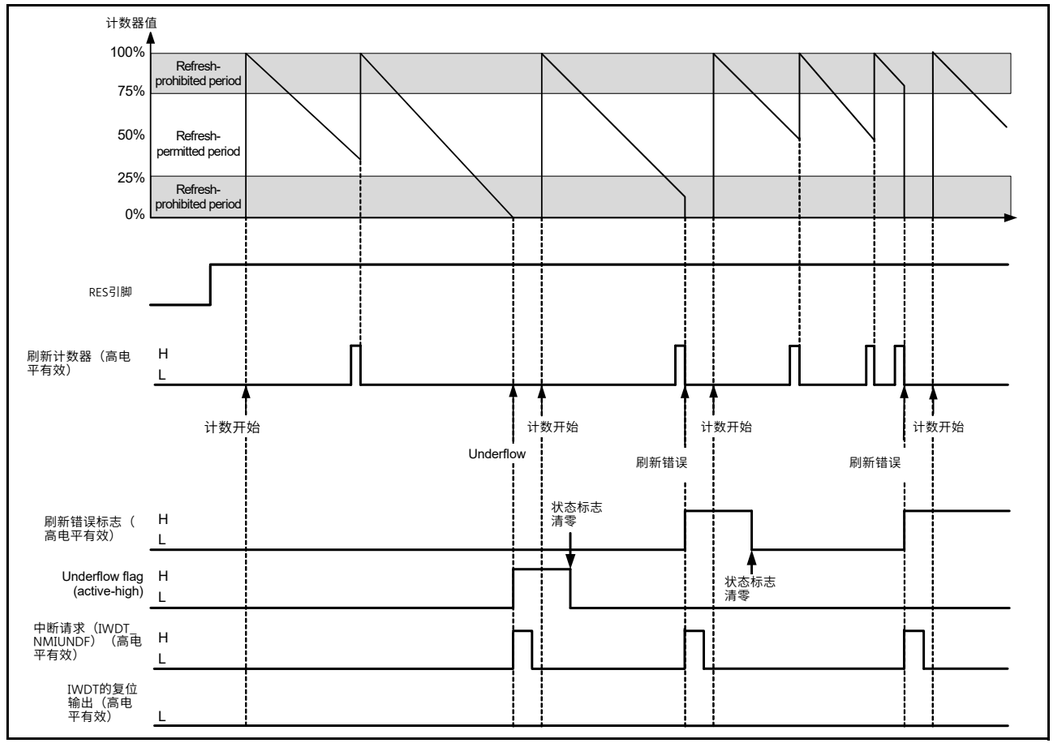


Figure 26.3 自动启动模式下的操作示例

26.3.2 刷新操作

通过将值00h和FFh写入IWDT刷新寄存器(IWDTRR)来刷新递减计数器。如果在00h之后写入FFh以外的值，则不刷新递减计数器。如果写入无效值，则在将00h和FFh写入IWDTRR时会恢复正确刷新。

当以00h（第一次）→00h（第二次）的顺序进行写入时，如果在此之后写入FFh，则满足写入顺序00h→FFh。写入00h（第（n1）次）→00h（第n次）→FFh有效，刷新正确。即使在00h之前写入的第一个值不是00h，只要操作包含写入序列00h→FFh，就会执行正确的刷新。

无论在写入00h和将FFh写入IWDTRR之间是否访问IWDTRR以外的寄存器或读取IWDTRR，也会执行正确刷新。刷新计数器的写操作必须在允许刷新的周期内进行，这由写FFh决定。因此，即使在刷新允许期间之外写入00h，也会执行正确的刷新。

[对刷新计数器有效的示例写入序列]

- 00h → FFh
- 00h ((n - 1)th time) → 00h (nth time) → FFh
- 00h→访问另一个寄存器或从IWDTRR→FFh读取。

[对刷新计数器无效的示例写入序列]

- 23h（00h以外的值）→FFh
- 00h→54h（FFh以外的值）
- 00h→AAh(00h和FFh以外的值)→FFh。

After FFh is written to the IWDTRR, refreshing the down-counter requires up to 4 cycles of the signal for counting (the IWDT-Dedicated Clock Frequency Division Ratio Select bits (OFS0.IWDTCKS[3:0]) to determine how many cycles of the IWDT-dedicated clock (IWDTCLK) make up 1 counting cycle. To meet this requirement, writing FFh to IWDTRR must be completed 4 count cycles before the end of the refresh-permitted period or a counter underflow. The value of the counter can be checked in the counter bits (IWDTSR.CNTVAL[13:0]).

[Example refreshing timings]

- When the window start position is set to 1FFFh, even if 00h is written to IWDTRR before 1FFFh is reached (at 2002h, for example), refreshing occurs if FFh is written to IWDTRR after the value of the IWDTSR.CNTVAL[13:0] bits reaches 1FFFh
- When the window end position is set to 1FFFh, refreshing occurs if 2003h (4 count cycles before 1FFFh) or a greater value is read from the IWDTSR.CNTVAL[13:0] bits immediately after writing 00h → FFh to IWDTRR
- When the refresh-permitted period continues until count 0000h, refreshing can be performed immediately before an underflow. In this case, if 0003h (4 count cycles before an underflow) or a greater value is read from the IWDTSR.CNTVAL[13:0] bits immediately after writing 00h → FFh to IWDTRR, no underflow occurs and refreshing is performed.

Figure 26.4 shows the IWDT refresh-operation waveforms when PCLKB > IWDTCLK and the clock division ratio is IWDTCLK.

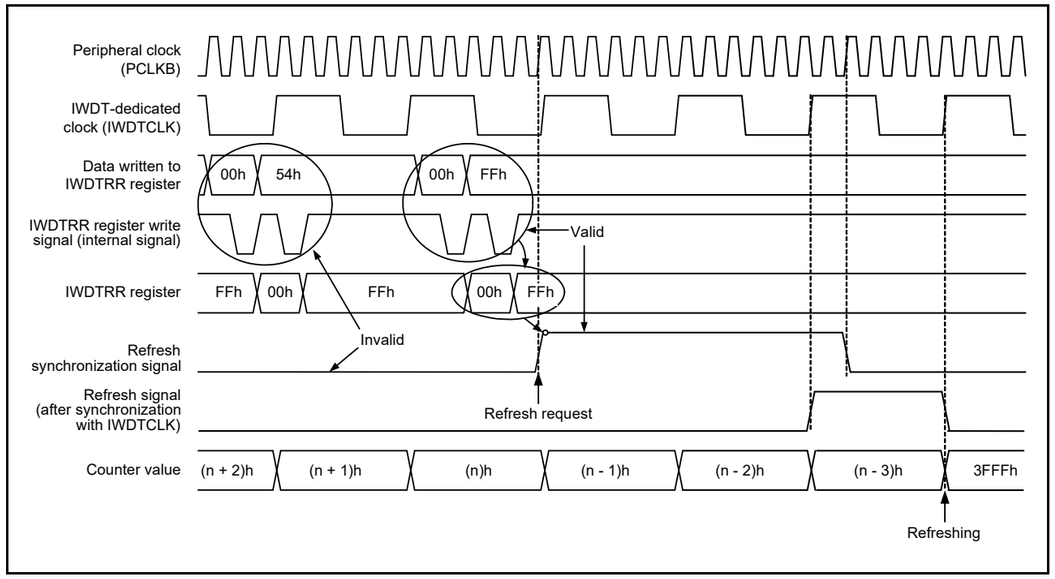


Figure 26.4 IWDT refresh operation waveforms when OFS0.IWDTCKS[3:0] = 0000b, OFS0.IWDTTOPS[1:0] = 11b

26.3.3 Status Flags

The refresh error (IWDTSR.REFEF) and underflow (IWDTSR.UNDFF) flags retain the source of the reset signal output or the source of the interrupt request from the IWDT. After a release from the reset state or interrupt request generation, read the IWDTSR.REFEF and UNDFF flags to check for the reset or interrupt source. For each flag, writing 0 clears the bit and writing 1 has no effect.

Leaving the status flags unchanged does not affect operation. If the flags are not cleared on the next reset or interrupt request from the IWDT, the earlier reset or interrupt source is cleared and the new reset or interrupt source is written. After 0 is written to each flag, up to 3 IWDTCLK cycles and 2 PCLKB cycles are required before the value is reflected.

将FFh写入IWDTRR后，刷新递减计数器需要多达4个信号周期用于计数（IWDT专用时钟分频比选择位（OFS0.IWDTCKS[3:0]）来确定有多少个周期IWDT专用时钟(IWDTCLK)构成1个计数周期。为满足此要求，必须在刷新允许周期结束或计数器下溢之前4个计数周期完成将FFh写入IWDTRR。计数器的值可以是检查计数器位(IWDTSR.CNTVAL[13:0])。

[Example refreshing timings]

- 当窗口起始位置设置为1FFFh时，即使在到达1FFFh之前（例如在2002h）将00h写入IWDTRR，如果在IWDTSR.CNTVAL[13:0]的值之后将FFh写入IWDTRR，也会发生刷新位达到1FFFh
- 当窗口结束位置设置为1FFFh时，如果在将00h→FFh写入IWDTRR后立即从IWDTSR.CNTVAL[13:0]位读取2003h（1FFFh之前的4个计数周期）或更大的值，则会发生刷新
- 当刷新允许周期持续到计数0000h时，可以在下溢之前立即执行刷新。在这种情况下，如果在将00h→FFh写入IWDTRR后立即从IWDTSR.CNTVAL[13:0]位读取0003h（下溢前4个计数周期）或更大的值，则不会发生下溢并执行刷新。

图26.4显示了当PCLKB>IWDTCLK且时钟分频比为时的IWDT刷新操作波形
IWDTCLK.

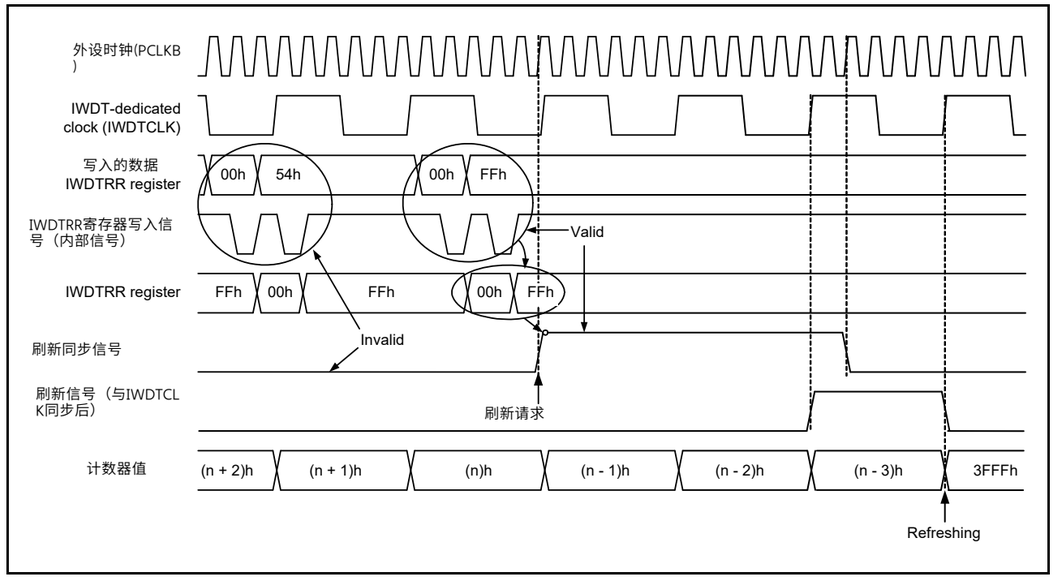


Figure 26.4 OFS0.IWDTCKS[3:0]=0000b OFS0.IWDTCKS[1:0]=11b时的IWDT刷新操作波形

26.3.3 状态标志

刷新错误(IWDTSR.REFEF)和下溢(IWDTSR.UNDFF)标志保留复位信号输出源或来自IWDT的中断请求源。从复位状态释放或产生中断请求后，读取IWDTSR.REFEF和UNDFF标志以检查复位或中断源。对于每个标志，写入0清除该位，写入1无效。

保持状态标志不变不会影响操作。如果在IWDT发出的下一次复位或中断请求时未清除标志，则清除较早的复位或中断源并写入新的复位或中断源。将0写入每个标志后，最多需要3个IWDTCLK周期和2个PCLKB周期才能反映该值。

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26.3.4 Reset Output

When the IWDT Reset Interrupt Request Select bit (OFS0.IWDTRSTIRQS) in the Option Function Select Register 0 (OFS0) is set to 1, a reset signal is output when an underflow in the down-counter or a refresh error occurs. Counting down automatically starts after the reset output.

26.3.5 Interrupt Sources

When the IWDT Reset Interrupt Request Select bit (OFS0.IWDTRSTIRQS) in the Option Function Select Register 0 (OFS0) is set to 0, an interrupt signal (IWDT_NMIUNDF) is generated when an underflow in the counter or a refresh error occurs. This interrupt can be used as a non-maskable interrupt or an interrupt. For details, see section 13, Interrupt Controller Unit (ICU).

Table 26.4 IWDT interrupt source

Name	Interrupt source	DTC activation	DMAC activation
IWDT_NMIUNDF	• Down-counter underflow • Refresh error.	Not possible	Not possible

26.3.6 Reading the Down-Counter Value

Because the counter is a IWDT-dedicated clock (IWDTCLK), the counter value cannot be read directly. The IWDT synchronizes the counter value with the peripheral clock (PCLKB) and stores it in the down-counter value bits (IWDTSR.CNTVAL[13:0]) in the IWDT Status register. Check these bits to obtain the counter value indirectly.

Reading the counter value requires multiple PCLKB clock cycles (up to 4 clock cycles), and the read counter value might differ from the actual counter value by a value of one count.

Figure 26.5 shows the processing for reading the IWDT counter value when PCLKB > IWDTCLK and the clock division ratio is IWDTCLK.

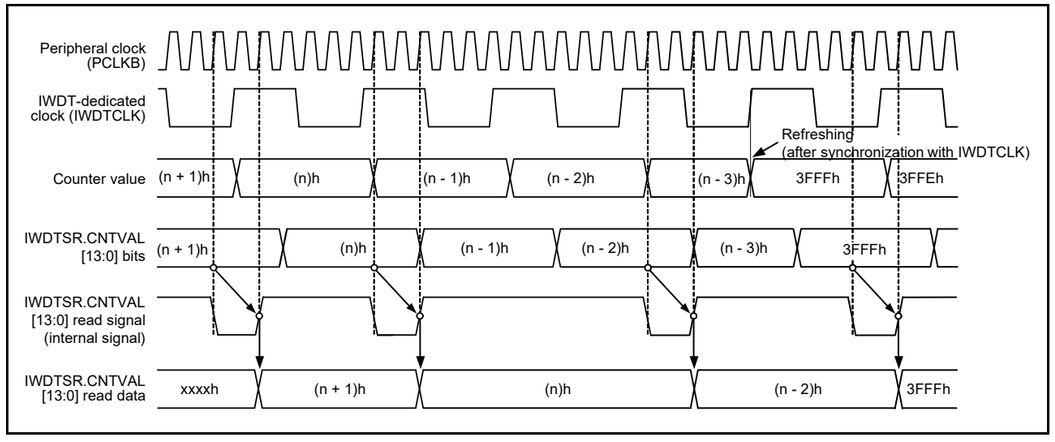


Figure 26.5 Processing for reading IWDT counter value when OFS0.IWDTCKS[3:0] = 0000b and OFS0.IWDTTOPS[1:0] = 11b

26.3.4 复位输出

当IWDT重置中断请求选择位置（OFS0.IWDTRSTIRQS）中的选项函数选择寄存器0（OFS0）中的位置为1时，当下部访问或刷新错误发生时，将输出重置信号。复位输出后自动开始倒计时。

26.3.5 中断源

当IWDT重置中断请求选择位置（OFS0.IWDTRSTIRQS）中的选项函数选择寄存器0（OFS0）的位置为0时，当计数器中的下流或刷新错误发生时，会生成中断信号（IWDT_NMIUNDF）。此中断可用作不可屏蔽中断或中断。有关详细信息，请参阅第13节，中断控制器单元(ICU)。

Table 26.4 IWDT中断源

Name	中断源	DTC activation	DMAC activation
IWDT_NMIUNDF	递减计数器下溢 刷新错误 。	不可能	不可能

26.3.6 读取递减计数器值

因为计数器是IWDT专用时钟(IWDTCLK)，所以无法直接读取计数器值。IWDT将计数器值与外设时钟(PCLKB)同步，并将其存储在IWDT状态寄存器的递减计数器值位(IWDTSR.CNTVAL[13:0])中。检查这些位以间接获得计数器值。

读取计数器值需要多个PCLKB时钟周期（最多4个时钟周期），读取的计数器值可能与实际计数器值相差一个计数值。

图26.5显示了当PCLKB>IWDTCLK且时钟分频比为IWDTCLK时读取IWDT计数器值的处理。

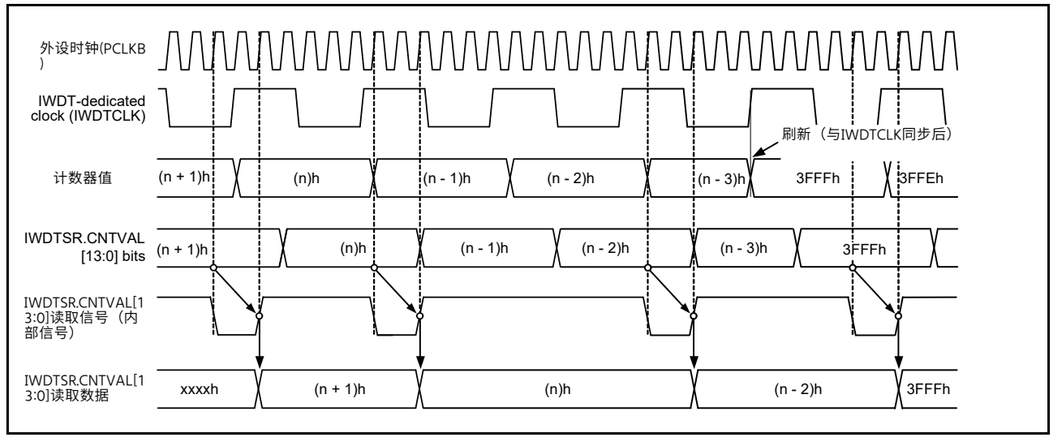


Figure 26.5 当OFS0.IWDTCKS[3:0]=0000b和时读取IWDT计数器值的处理 OFS0.IWDTTOPS[1:0] = 11b

26.4 Link Operation by the ELC

The IWDT is capable of link operation for a specified module when the interrupt request signal is used as an event signal by the ELC. The event signal is output by the counter underflow or refresh error.

An event signal is output regardless of the setting in the OFS0.WDTRSTIRQS bit. An event signal can also be output when the next interrupt source is generated while the Refresh Error flag (IWDTSR.REFEF) or Underflow flag (IWDTSR.UNDFF) is 1. For details, see section 18, Event Link Controller (ELC).

26.5 Usage Notes

26.5.1 Refresh Operations

While configuring the refresh time, consider variations in the range of errors given the accuracy of PCLKB and IWDTCLK. Set values that ensure refreshing is possible.

26.5.2 Restrictions on the Clock Division Ratio Setting

Satisfy the following required frequency of the peripheral module clock (PCLKB):

PCLKB ≥ 4 × (the frequency of the count clock source after division).

26.4 ELC的链接操作

当中断请求信号被ELC用作事件信号时，IWDT能够对指定模块进行链接操作。事件信号由计数器下溢或刷新错误输出。

无论OFS0.WDTRSTIRQS位的设置如何，都会输出事件信号。当刷新错误标志(IWDTSR.REFEF)或下溢标志(IWDTSR.UNDFF)为1时，也可以在产生下一个中断源时输出事件信号。有关详细信息，请参阅第18节，事件链接控制器(ELC)。

26.5 使用说明

26.5.1 刷新操作

在配置刷新时间时，考虑到给定PCLKB精度和误差范围的变化IWDTCLK。设置确保可以刷新的值。

26.5.2 时钟分频比设置的限制

满足以下所需的外围模块时钟（PCLKB）频率：

PCLKB 4 （分频后计数时钟源的频率）。

RA生态工作室

27. Serial Communications Interface (SCI)

27.1 Overview

The Serial Communications Interface (SCI) is configurable to five asynchronous and synchronous serial interfaces:

- Asynchronous interfaces (UART and Asynchronous Communications Interface Adapter (ACIA))
- 8-bit clock synchronous interface
- Simple IIC (master-only)
- Simple SPI
- Smart card interface.

The smart card interface complies with the ISO/IEC 7816-3 standard for electronic signals and transmission protocol. Each SCI channel has FIFO buffers to enable continuous and full-duplex communication, and the data transfer speed can be configured independently using an on-chip baud rate generator.

Table 27.1 lists the SCI specifications, Figure 27.1 shows a block diagram of SCI channel n, and Table 27.2 lists the I/O pins by mode.

Table 27.1 SCI specifications (1 of 2)

Parameter	Specifications
Serial communication modes	• Asynchronous • Clock synchronous • Smart card interface • Simple IIC • Simple SPI.
Transfer speed	Bit rate specifiable with the on-chip baud rate generator
Full-duplex communications	• Transmitter: Continuous transmission possible using double-buffering • Receiver: Continuous reception possible using double-buffering.
I/O pins	See Table 27.2
Data transfer	Selectable as LSB-first or MSB-first transfer
Interrupt sources	• Transmit end, transmit data empty, receive data full, receive error, receive data ready, and address match • Completion of generation of a start condition, restart condition, or stop condition (for simple IIC mode).
Module-stop function	Module-stop state can be set for each channel
Snooze end request	SCI0 address mismatch (SCI0_DCUF)

27. 串行通信接口(SCI)

27.1 Overview

串行通信接口(SCI)可配置为五个异步和同步串行接口：

- 异步接口（UART和异步通信接口适配器(ACIA)）
- 8位时钟同步接口
- Simple IIC (master-only)
- 简单的SPI
- 智能卡接口。

智能卡接口符合ISOIEC7816-3电子信号和传输协议标准。
每个SCI通道都有FIFO缓冲区以实现连续和全双工通信，并且可以使用片上波特率发生器独立配置数据传输速度。

表27.1列出了SCI规格，图27.1显示了SCI通道n的框图，表27.2列出了按模式划分的IO引脚。

Table 27.1 SCI规范(1of2)

Parameter	Specifications
串行通信模式	异步 时钟同步 智能卡接口 简单IIC 简单SPI。
传输速度	可通过片上波特率发生器指定比特率
Full-duplex communications	发送器：可以使用双缓冲进行连续传输 接收器：可以使用双缓冲进行连续接收。
I/O pins	见表27.2
数据传输	可选择LSB优先或MSB优先传输
中断源	发送结束、发送数据空、接收数据满、接收错误、接收数据就绪和地址匹配开始条件、重新启动条件或停止条件的生成完成（对于简单IIC模式）。
Module-stop function	每个通道可设置模块停止状态
暂停结束请求	SCI0地址不匹配(SCI0_DCUF)

Table 27.1 SCI specifications (2 of 2)

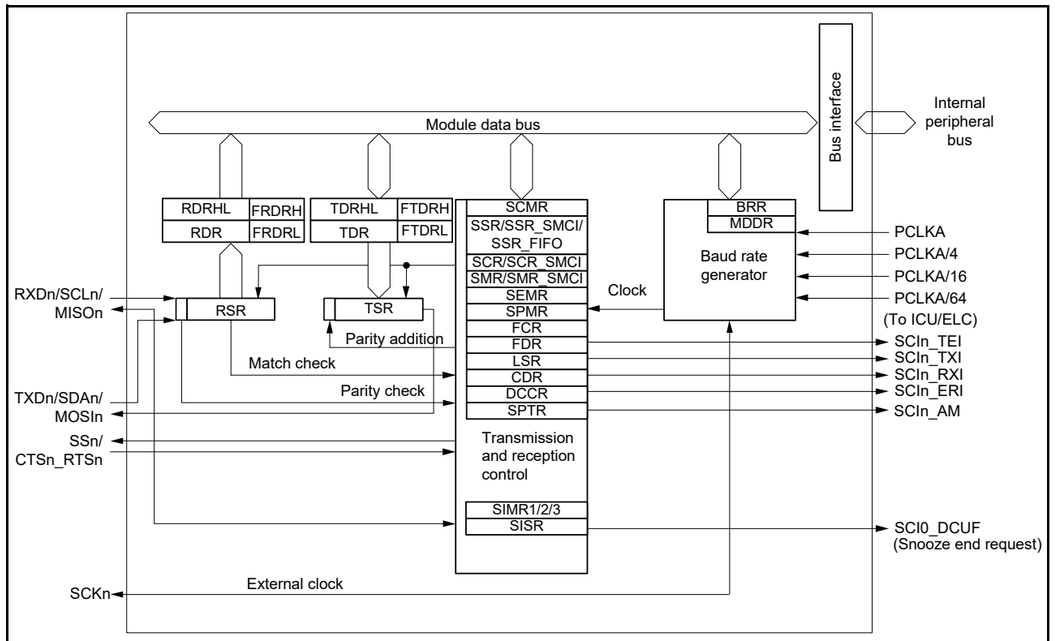
Parameter		Specifications
Asynchronous mode	Data length	7, 8, or 9 bits
	Transmission stop bit	1 or 2 bits
	Parity	Even parity, odd parity, or no parity
	Receive error detection	Parity, overrun, and framing errors
	Hardware flow control	Transmission and reception controllable with CTSn_RTSn pins
	Transmission/reception	Selectable to 1-stage register or 16-stage FIFO
	Address match	Interrupt request/event output can be issued on detecting a match between the received data and the value in the compare match register
	Address mismatch (SCI0 only) receive data	Snooze end request can be issued on detecting a mismatch between the received data and the value in the compare match register
	Start-bit detection	Selectable to low level or falling edge detection
	Break detection	Breaks from framing errors detectable by reading from the SPTR register
	Clock source	Selectable to internal or external clock
	Double-speed mode	Baud rate generator double-speed mode is selectable
	Multi-processor communications function	Serial communication enabled between multiple processors
	Noise cancellation	Digital noise filters included on signal paths from RXDn pin inputs
Clock synchronous mode	Data length	8 bits
	Receive error detection	Overrun error
	Clock source	Selectable to internal clock (master mode) or external clock (slave mode)
	Hardware flow control	Transmission and reception controllable with CTSn_RTSn pins
	Transmission/reception	Selectable to 1-stage register or 16-stage FIFO
Smart card interface mode	Error processing	Error signal can be automatically transmitted on detecting a parity error during reception
		Data can be automatically retransmitted on receiving an error signal during transmission
	Data type	Both direct and inverse convention supported
Simple IIC mode	Transfer format	I^2C bus format (MSB-first only)
	Operating mode	Master (single-master operation only)
	Transfer rate	Up to 400 kbps
	Noise cancellation	The signal paths from input on the SCLn and SDAn pins incorporate digital noise filters and provide an adjustable interval for noise cancellation
Simple SPI mode	Data length	8 bits
	Error detection	Overrun error
	Clock source	Selectable to internal clock (master mode) or external clock (slave mode)
	SS input pin function	High impedance state can be invoked on the output pins by driving the SSn pin high
	Clock settings	Configurable between four clock phase and clock polarity settings
Bit rate modulation function		Error reduction through correction of outputs from the on-chip baud rate generator
Event link function		Error event output (SCIn_ERI)*1 for receive error or error signal detection
		Receive data full event output (SCIn_RXI)*1,*2
		Transmit data empty event output (SCIn_TXI)*1,*2
		Transmit end event output (SCIn_TEI)*1,*2
		Address match event output (SCIn_AM)*1

Note 1. Channel number (n = 0 to 4, 8, 9).
Note 2. Using this event link function is prohibited when FIFO operation is selected in asynchronous mode.

Table 27.1 SCI规范（2个中的2个）

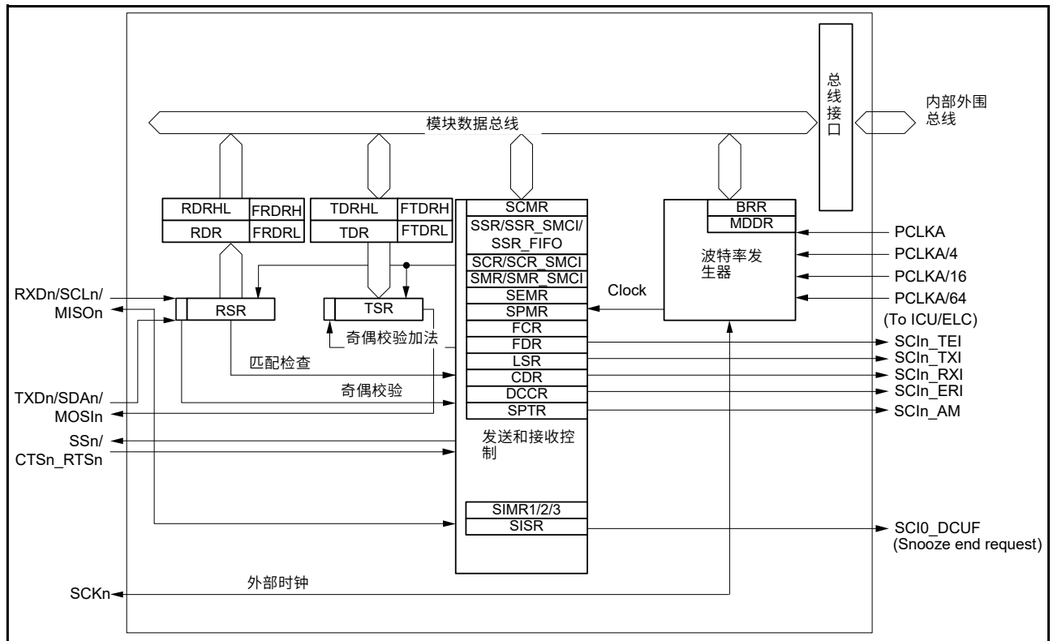
Parameter		Specifications
异步模式	数据长度	7、8或9位
	传输停止位	1或2位
	Parity	偶校验、奇校验或无校验
	接收错误检测	奇偶校验、溢出和成帧错误
	硬件流控制	可通过CTSn_RTSn引脚控制发送和接收
	Transmission/reception	可选择1级寄存器或16级FIFO
	地址匹配	检测到接收数据与比较匹配寄存器中的值匹配时，可发出中断请求事件输出
	地址不匹配（仅SCI0）接收数据	检测到接收到的数据与比较匹配寄存器中的值不匹配时，可以发出贪睡结束请求
	Start-bit detection	可选择低电平或下降沿检测
	断线检测	通过从SPTR寄存器读取可检测到的帧错误中断
	时钟源	可选择内部或外部时钟
	Double-speed mode	波特率发生器双速模式可选
	多处理器通讯功能	在多个处理器之间启用串行通信
	噪音消除	RXDn引脚输入的信号路径上包含数字噪声滤波器
时钟同步模式	数据长度	8 bits
	接收错误检测	溢出错误
	时钟源	可选择内部时钟（主模式）或外部时钟（从模式）
	硬件流控制	可通过CTSn_RTSn引脚控制发送和接收
	Transmission/reception	可选择1级寄存器或16级FIFO
智能卡接口方式	错误处理	在接收过程中检测到奇偶校验错误时可以自动发送错误信号
		传输过程中接收到错误信号可自动重传数据
	数据类型	支持直接和反向约定
简单IIC模式	传输格式	I2C总线格式（仅MSB优先）
	操作模式	主机（仅限单主机操作）
	传输率	高达400kbps
	噪音消除	来自SCLn和SDAn引脚输入的信号路径包含数字噪声滤波器，并提供可调节的噪声消除间隔
简单SPI模式	数据长度	8 bits
	错误检测	溢出错误
	时钟源	可选择内部时钟（主模式）或外部时钟（从模式）
	SS输入引脚功能	通过将SSn引脚驱动为高电平，可以在输出引脚上调用高阻抗状态
	时钟设置	可在四个时钟相位和时钟极性设置之间进行配置
比特率调制功能		通过校正片上波特率发生器的输出来减少错误
事件链接功能		错误事件输出(SCIn_ERI)*1用于接收错误或错误信号检测
		接收数据满事件输出(SCIn_RXI)*1 *2
		发送数据空事件输出(SCIn_TXI)*1 *2
		传输结束事件输出(SCIn_TEI)*1 *2
		地址匹配事件输出(SCIn_AM)*1

注1.通道编号（n=0至4、8、9）。
注2.在异步模式下选择FIFO操作时，禁止使用此事件链接功能。



RSR:	Receive Shift Register	RDRHL:	Receive 9-bit Data Register
RDR:	Receive Data Register	FRDRH/L:	Receive FIFO Data Register
TSR:	Transmit Shift Register	TDRHL:	Transmit 9-bit Data Register
TDR:	Transmit Data Register	FTDRH/L:	Transmit FIFO Data Register
SMR/SMR_SMCI:	Serial Mode Register	FCR:	FIFO Control Register
SCR/SCR_SMCI:	Serial Control Register	FDR:	FIFO Data Count Register
SSR/SSR_SMCI/SSR_FIFO:	Serial Status Register	LSR:	Line Status Register
SCMR:	Smart Card Mode Register	CDR:	Compare Match Data Register
BRR:	Bit Rate Register	DCCR:	Data Compare Match Control Register
MDDR:	Modulation Duty Register	SPTR:	Serial Port Register
SEMR:	Serial Extended Mode Register		
SPMR:	SPI Mode Register		
SNFR:	Noise Filter Setting Register		
SIMR1/2/3:	I^2C Mode Register 1/2/3		
SISR:	I^2C Status Register		

Figure 27.1 SCI channel n block diagram



RSR:	接收移位寄存器	RDRHL:	接收9位数据寄存器
RDR:	接收数据寄存器	FRDRH/L:	接收FIFO数据寄存器
TSR:	发送移位寄存器	TDRHL:	发送9位数据寄存器
TDR:	发送数据寄存器	FTDRH/L:	发送FIFO数据寄存器
SMR/SMR_SMCI:	串行模式寄存器	FCR:	FIFO控制寄存器
SCR/SCR_SMCI:	串行控制寄存器	FDR:	FIFO数据计数寄存器
SSR/SSR_SMCI/SSR_FIFO:	串行状态寄存器	LSR:	线路状态寄存器
SCMR:	智能卡模式寄存器	CDR:	比较匹配数据寄存器
BRR:	比特率寄存器	DCCR:	数据比较匹配控制寄存器
MDDR:	调制占空比寄存器	SPTR:	串口寄存器
SEMR:	串行扩展模式寄存器		
SPMR:	SPI模式寄存器		
SNFR:	噪声滤波器设置寄存器		
SIMR1/2/3:	I2C模式寄存器123		
SISR:	我2C状态寄存器		

Figure 27.1 SCI通道n框图

Table 27.2 SCI I/O pins (1 of 2)

Channel	Pin name	Input/Output	Function
SCI0	SCK0	Input/Output	SCI0 clock input/output
	RXD0/SCL0/MISO0	Input/Output	SCI0 receive data input SCI0 I²C clock input/output SCI0 slave transmit data input/output
	TXD0/SDA0/MOSI0	Input/Output	SCI0 transmit data output SCI0 I²C data input/output SCI0 master transmit data input/output
	SS0/CTS0_RTS0	Input/Output	SCI0 chip select input, active-low SCI0 transfer start control input/output, active-low
SCI1	SCK1	Input/Output	SCI1 clock input/output
	RXD1/SCL1/MISO1	Input/Output	SCI1 receive data input SCI1 I²C clock input/output SCI1 slave transmit data input/output
	TXD1/SDA1/MOSI1	Input/Output	SCI1 transmit data output SCI1 I²C data input/output SCI1 master transmit data input/output
	SS1/CTS1_RTS1	Input/Output	SCI1 chip select input, active-low SCI1 transfer start control input/output, active-low
SCI2	SCK2	Input/Output	SCI2 clock input/output
	RXD2/SCL2/MISO2	Input/Output	SCI2 receive data input SCI2 I²C clock input/output SCI2 slave transmit data input/output
	TXD2/SDA2/MOSI2	Input/Output	SCI2 transmit data output SCI2 I²C data innput/output SCI2 master trasmit data input/output
	SS2/CTS2_RTS2	Input/Output	SCI2 chip select input, active-low SCI2 transfer start control input/output, active-low
SCI3	SCK3	Input/Output	SCI3 clock input/output
	RXD3/SCL3/MISO3	Input/Output	SCI3 receive data input SCI3 I²C clock input/output SCI3 slave transmit data input/output
	TXD3/SDA3/MOSI3	Input/Output	SCI3 transmit data output SCI3 I²C data input/output SCI3 master transmit data input/output
	SS3/CTS3_RTS3	Input/Output	SCI3 chip select input, active-low SCI3 transfer start control input/output, active-low
SCI4	SCK4	Input/Output	SCI4 clock input/output
	RXD4/SCL4/MISO4	Input/Output	SCI4 receive data input SCI4 I²C clock input/output SCI4 slave transmit data input/output
	TXD4/SDA4/MOSI4	Input/Output	SCI4 transmit data output SCI4 I²C data input/output SCI4 master transmit data input/output
	SS4/CTS4_RTS4	Input/Output	SCI4 chip select input, active-low SCI4 transfer start control input/output, active-low
SCI8	SCK8	Input/Output	SCI8 clock input/output
	RXD8/SCL8/MISO8	Input/Output	SCI8 receive data input SCI8 I²C clock input/output SCI8 slave transmit data input/output
	TXD8/SDA8/MOSI8	Input/Output	SCI8 transmit data output SCI8 I²C data input/output SCI8 master transmit data input/output
	SS8/CTS8_RTS8	Input/Output	SCI8 chip select input, active-low SCI8 transfer start control input/output, active-low

Table 27.2 SCIIO引脚（2个中的1个）

Channel	引脚名称	Input/Output	Function
SCI0	SCK0	Input/Output	SCI0 clock input/output
	RXD0/SCL0/MISO0	Input/Output	SCI0接收数据输入 SCI0 I²C clock input/output SCI0从机发送数据输入输出
	TXD0/SDA0/MOSI0	Input/Output	SCI0发送数据输出SCI0I2C 数据输入输出 SCI0主机发送数据输入输出
	SS0/CTS0_RTS0	Input/Output	SCI0片选输入，低电平有效 SCI0传输开始控制输入输出，低电平有效
SCI1	SCK1	Input/Output	SCI1 clock input/output
	RXD1/SCL1/MISO1	Input/Output	SCI1接收数据输入 SCI1 I²C clock input/output SCI1从机发送数据输入输出
	TXD1/SDA1/MOSI1	Input/Output	SCI1发送数据输出SCI1I2C 数据输入输出 SCI1主机发送数据输入输出
	SS1/CTS1_RTS1	Input/Output	SCI1片选输入，低电平有效 SCI1传输开始控制输入输出，低电平有效
SCI2	SCK2	Input/Output	SCI2 clock input/output
	RXD2/SCL2/MISO2	Input/Output	SCI2接收数据输入 SCI2 I²C clock input/output SCI2从机发送数据输入输出
	TXD2/SDA2/MOSI2	Input/Output	SCI2发送数据输出 SCI2 I²C data innput/output SCI2主机传输数据输入输出
	SS2/CTS2_RTS2	Input/Output	SCI2片选输入，低电平有效 SCI2传输启动控制输入输出，低电平有效
SCI3	SCK3	Input/Output	SCI3 clock input/output
	RXD3/SCL3/MISO3	Input/Output	SCI3接收数据输入 SCI3 I²C clock input/output SCI3从机发送数据输入输出
	TXD3/SDA3/MOSI3	Input/Output	SCI3发送数据输出SCI3I2C 数据输入输出 SCI3主机发送数据输入输出
	SS3/CTS3_RTS3	Input/Output	SCI3片选输入，低电平有效 SCI3传输启动控制输入输出，低电平有效
SCI4	SCK4	Input/Output	SCI4 clock input/output
	RXD4/SCL4/MISO4	Input/Output	SCI4接收数据输入 SCI4 I²C clock input/output SCI4从机发送数据输入输出
	TXD4/SDA4/MOSI4	Input/Output	SCI4发送数据输出SCI4I2C 数据输入输出 SCI4主机发送数据输入输出
	SS4/CTS4_RTS4	Input/Output	SCI4片选输入，低电平有效 SCI4传输开始控制输入输出，低电平有效
SCI8	SCK8	Input/Output	SCI8 clock input/output
	RXD8/SCL8/MISO8	Input/Output	SCI8接收数据输入 SCI8 I²C clock input/output SCI8从机发送数据输入输出
	TXD8/SDA8/MOSI8	Input/Output	SCI8发送数据输出SCI8I2C 数据输入输出 SCI8主机发送数据输入输出
	SS8/CTS8_RTS8	Input/Output	SCI8片选输入，低电平有效 SCI8传输启动控制输入输出，低电平有效

Table 27.2 SCI I/O pins (2 of 2)

Channel	Pin name	Input/Output	Function
SCI9	SCK9	Input/Output	SCI9 clock input/output
	RXD9/SCL9/MISO9	Input/Output	SCI9 receive data input SCI9 I²C clock input/output SCI9 slave transmit data input/output
	TXD9/SDA9/MOSI9	Input/Output	SCI9 transmit data output SCI9 I²C data input/output SCI9 master transmit data input/output
	SS9/CTS9_RTS9	Input/Output	SCI9 chip select input, active-low SCI9 transfer start control input/output, active-low

27.2 Register Descriptions

27.2.1 Receive Shift Register (RSR)

RSR is a shift register that receives serial data input from the RXDn pin and converts it into parallel data. When one frame of data is received, the data is automatically transferred to the RDR, RDRHL, or the receive FIFO register. The RSR register cannot be directly accessed by the CPU.

27.2.2 Receive Data Register (RDR)

Address(es): SCI0.RDR 4007 0005h, SCI1.RDR 4007 0025h, SCI2.RDR 4007 0045h, SCI3.RDR 4007 0065h, SCI4.RDR 4007 0085h, SCI8.RDR 4007 0105h, SCI9.RDR 4007 0125h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0

RDR is an 8-bit register that stores receive data. When one frame of serial data is received, it is transferred from RSR to RDR, and the RSR register can receive more data. Because RSR and RDR function as a double buffer, continuous received operations can be performed.

Read the RDR register only once after a receive data full interrupt (SCIn_RXI) occurs.

Note: If the next frame of data is received before reading the received data from RDR, an overrun error occurs. The CPU cannot write to the RDR.

27.2.3 Receive 9-Bit Data Register (RDRHL)

Address(es): SCI0.RDRHL 4007 0010h, SCI1.RDRHL 4007 0030h, SCI2.RDRHL 4007 0050h, SCI3.RDRHL 4007 0070h, SCI4.RDRHL 4007 0090h, SCI8.RDRHL 4007 0110h, SCI9.RDRHL 4007 0130h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RDRHL is a 16-bit register that stores receive data. Use this register when asynchronous mode and 9-bit data length are selected.

The lower 8 bits of RDRHL are the shadow register of RDR, so access to RDRHL affects the RDR register. Access to the RDRHL register is prohibited if 7-bit or 8-bit data length is selected.

After one frame of data is received, the received data is transferred from the RSR to the RDR or RDRHL register, allowing the RSR register to receive more data.

The RSR and RDRHL registers have a double-buffered structure to enable continuous reception. RDRHL should be read only when a receive data full interrupt (SCIn_RXI) request is issued. An overrun error occurs when the next frame of data is received before the received data is read from RDRHL. The CPU cannot write to the RDRHL register. Bits [15:9] of the RDRHL register are fixed to 0. These bits are read as 0. The write value should be 0.

Table 27.2 SCIIO引脚（2个中的2个）

Channel	引脚名称	Input/Output	Function
SCI9	SCK9	Input/Output	SCI9 clock input/output
	RXD9/SCL9/MISO9	Input/Output	SCI9接收数据输入 SCI9 I²C clock input/output SCI9从机发送数据输入输出
	TXD9/SDA9/MOSI9	Input/Output	SCI9发送数据输出SCI9I2C 数据输入输出 SCI9主机发送数据输入输出
	SS9/CTS9_RTS9	Input/Output	SCI9片选输入，低电平有效 SCI9传输启动控制输入输出，低电平有效

27.2 注册说明

27.2.1 接收移位寄存器(RSR)

RSR是一个移位寄存器，它接收从RXDn引脚输入的串行数据并将其转换为并行数据。当接收到一帧数据时，数据会自动传输到RDR、RDRHL或接收FIFO寄存器。CPU不能直接访问RSR寄存器。

27.2.2 接收数据寄存器(RDR)

Address(es): SCI0.RDR 4007 0005h, SCI1.RDR 4007 0025h, SCI2.RDR 4007 0045h, SCI3.RDR 4007 0065h, SCI4.RDR 4007 0085h, SCI8.RDR 4007 0105h, SCI9.RDR 4007 0125h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0

RDR是一个8位寄存器，用于存储接收数据。当接收到一帧串行数据时，将其从RSR传输到RDR，而RSR寄存器可以接收更多的数据。由于RSR和RDR用作双缓冲器，因此可以执行连续接收操作。

在接收数据完全中断(SCIn_RXI)发生后，仅读取一次RDR寄存器。

Note: 如果在从RDR读取接收到的数据之前接收到下一帧数据，则会发生溢出错误。这CPU无法写入RDR。

27.2.3 接收9位数据寄存器(RDRHL)

Address(es): SCI0.RDRHL 4007 0010h, SCI1.RDRHL 4007 0030h, SCI2.RDRHL 4007 0050h, SCI3.RDRHL 4007 0070h, SCI4.RDRHL 4007 0090h, SCI8.RDRHL 4007 0110h, SCI9.RDRHL 4007 0130h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RDRHL是一个16位寄存器，用于存储接收数据。选择异步模式和9位数据长度时，请使用此寄存器。

RDRHL的低8位是RDR的影子寄存器，因此访问RDRHL会影响RDR寄存器。访问
如果选择7位或8位数据长度，则禁止RDRHL寄存器。

接收到一帧数据后，将接收到的数据从RSR传送到RDR或RDRHL寄存器，让RSR寄存器接收更多数据。

RSR和RDRHL寄存器具有双缓冲结构以实现连续接收。只有在发出接收数据完全中断(SCIn_RXI)请求时才应读取RDRHL。在从RDRHL读取接收到的数据之前接收到下一帧数据时，会发生溢出错误。CPU无法写入RDRHL寄存器。RDRHL寄存器的位[15:9]固定为0。这些位被读取为0。写入值应为0。

27.2.4 Receive FIFO Data Register H, L, HL (FRDRH, FRDRL, FRDRHL)

Receive FIFO Data Register H (FRDRH)

Address(es): SCI0.FRDRH 4007 0010h, SCI1.FRDRH 4007 0030h, SCI2.FRDRH 4007 0050h, SCI3.FRDRH 4007 0070h, SCI4.FRDRH 4007 0090h, SCI8.FRDRH 4007 0110h, SCI9.FRDRH 4007 0130h

Receive FIFO Data Register L (FRDRL)

Address(es): SCI0.FRDRL 4007 0011h, SCI1.FRDRL 4007 0031h, SCI2.FRDRL 4007 0051h, SCI3.FRDRL 4007 0071h, SCI4.FRDRL 4007 0091h, SCI8.FRDRL 4007 0111h, SCI9.FRDRL 4007 0131h

Receive FIFO Data Register HL (FRDRHL)

Address(es): SCI0.FRDRHL 4007 0010h, SCI1.FRDRHL 4007 0030h, SCI2.FRDRHL 4007 0050h, SCI3.FRDRHL 4007 0070h, SCI4.FRDRHL 4007 0090h, SCI8.FRDRHL 4007 0110h, SCI9.FRDRHL 4007 0130h

SCIn.FRDRHL

SCIn.FRDRH SCIn.FRDRL

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	RDF	ORER	FER	PER	DR	MPB	RDAT[8:0]								
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b8 to b0	RDAT[8:0]	Serial Receive Data	Received serial data, valid only in asynchronous mode, including multi-processor mode or clock synchronous mode, with FIFO selected	R
b9	MPB	Multi-Processor Bit Flag	Multi-processor bit associated with serial receive data (RDAT[8:0]): 0: Data transmission cycle 1: ID transmission cycle. MPB is valid only in asynchronous mode with SMR.MP = 1, and with FIFO selected.	R
b10	DR	Receive Data Ready Flag	This flag is the same as SSR_FIFO.DR: 0: Receiving is in progress, or no received data remains in FRDRH and FRDRL after successfully completed reception 1: Next receive data is not received for a period after successfully completed reception.	R*1
b11	PER	Parity Error Flag	0: No parity error occurred in the first data of FRDRH and FRDRL 1: Parity error occurred in the first data of FRDRH and FRDRL.	R
b12	FER	Framing Error Flag	0: No framing error occurred in the first data of FRDRH and FRDRL 1: Framing error occurred in the first data of FRDRH and FRDRL.	R
b13	ORER	Overrun Error Flag	This flag is the same as SSR_FIFO.ORER: 0: No overrun error occurred 1: Overrun error occurred.	R*1
b14	RDF	Receive FIFO Data Full Flag	This flag is the same as SSR_FIFO.RDF: 0: The amount of receive data written in FRDRH and FRDRL is less than the specified receive triggering number 1: The amount of receive data written in FRDRH and FRDRL is equal to or greater than the specified receive triggering number.	R*1
b15	—	Reserved	This bit is read as 0	R

Note 1. If this flag is read, it indicates the same value as that read from the SSR_FIFO register. Write 0 to the SSR_FIFO register to clear the flag.

27.2.4 接收FIFO数据寄存器H L HL(FRDRH FRDRL FRDRHL)

接收FIFO数据寄存器H(FRDRH)

Address(es): SCI0.FRDRH 4007 0010h, SCI1.FRDRH 4007 0030h, SCI2.FRDRH 4007 0050h, SCI3.FRDRH 4007 0070h, SCI4.FRDRH 4007 0090h, SCI8.FRDRH 4007 0110h, SCI9.FRDRH 4007 0130h

接收FIFO数据寄存器L(FRRDL)

Address(es): SCI0.FRDRL 4007 0011h, SCI1.FRDRL 4007 0031h, SCI2.FRDRL 4007 0051h, SCI3.FRDRL 4007 0071h, SCI4.FRDRL 4007 0091h, SCI8.FRDRL 4007 0111h, SCI9.FRDRL 4007 0131h

接收FIFO数据寄存器HL(FRDRHL)

Address(es): SCI0.FRDRHL 4007 0010h, SCI1.FRDRHL 4007 0030h, SCI2.FRDRHL 4007 0050h, SCI3.FRDRHL 4007 0070h, SCI4.FRDRHL 4007 0090h, SCI8.FRDRHL 4007 0110h, SCI9.FRDRHL 4007 0130h

SCIn.FRDRHL

SCIn.FRDRH SCIn.FRDRL

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	RDF	ORER	FER	PER	DR	MPB	RDAT[8:0]								
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b8 to b0	RDAT[8:0]	串行接收数据	接收到的串行数据，仅在异步模式下有效，包括多处理器模式或时钟同步模式，选择FIFO	R
b9	MPB	多处理器位标志	与串行接收数据相关的多处理器位（RDAT[8:0]）：0：数据传输周期1：ID传输周期。MPB仅在SMR.MP=1且选择了FIFO的异步模式下有效。	R
b10	DR	接收数据就绪标志	该标志与SSR_FIFO.DR相同：0：正在接收，或者没有接收到的数据留在 接收成功后的FRDRH和FRDRL1：接收成功后一段时间内没有接收到下一个接收数据。	R*1
b11	PER	奇偶校验错误标志	0：FRRDH和FRDRL的第一个数据没有发生奇偶校验错误1：FRRDH和FRDRL的第一个数据发生奇偶校验错误。	R
b12	FER	成帧错误标志	0：FRRDH和FRDRL的第一个数据没有发生帧错误1：FRRDH和FRDRL的第一个数据发生了帧错误。	R
b13	ORER	溢出错误标志	该标志与SSR_FIFO.ORER相同：0：未发生溢出错误1：发生溢出错误。	R*1
b14	RDF	接收FIFO数据满标志	该标志与SSR_FIFO.RDF相同：0：写入FRDRH和FRDRL的接收数据量小于指定的接收触发数1：写入FRDRH和FRDRL的接收数据量等于或大于指定的接收数据量接收触发号码。	R*1
b15	—	Reserved	该位读为0	R

Note 1. 如果读取该标志，则表示与从SSR_FIFO寄存器读取的值相同。将0写入SSR_FIFO寄存器以清除标志。

FRDRHL is a 16-bit register that consists of the 8-bit FRDRH and FRDRL registers.

FRDRH and FRDRL constitute a 16-stage FIFO register that stores serial receive data and related status information readable by software. This register is only valid in asynchronous mode, including multi-processor mode, or clock synchronous mode.

The SCI completes reception of one frame of serial data by transferring the received data from the RSR register into FRDRH and FRDRL for storage. Continuous reception is executed until 16 stages are stored. If data is read when there is no received data in FRDRH and FRDRL, the value is undefined. When FRDRH and FRDRL are full of receive data, subsequent serial receive data is lost. The CPU can read from FRDRH and FRDRL but cannot write to them.

Reading 1 from the RDF, ORER, or DR flag of the FRDRH register is the same as reading from those bits in the SSR_FIFO register. When writing 0 to clear a flag in the SSR_FIFO register after reading the FRDRH register, write 0 only to the flag that is to be cleared and write 1 to the other flags.

When reading both the FRDRH and FRDRL registers, read in the order from FRDRH to FRDRL. The FDRHL register can be accessed in 16-bit units.

27.2.5 Transmit Data Register (TDR)

Address(es): SCI0.TDR 4007 0003h, SCI1.TDR 4007 0023h, SCI2.TDR 4007 0043h, SCI3.TDR 4007 0063h, SCI4.TDR 4007 0083h, SCI8.TDR 4007 0103h, SCI9.TDR 4007 0123h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1

TDR is an 8-bit register that stores transmit data.

When the SCI detects that TSR is empty, it transfers the transmit data written in TDR to TSR and starts transmission.

The double-buffered structure of TDR and TSR enables continuous serial transmission. If the next transmit data is already written to TDR when one frame of data is transmitted, the SCI transfers the written data to TSR to continue transmission.

The CPU can read from or write to TDR at any time. Only write transmit data to TDR once after each instance of the transmit data empty interrupt (SCIn_TXI).

27.2.6 Transmit 9-Bit Data Register (TDRHL)

Address(es): SCI0.TDRHL 4007 000Eh, SCI1.TDRHL 4007 002Eh, SCI2.TDRHL 4007 004Eh, SCI3.TDRHL 4007 006Eh, SCI4.TDRHL 4007 008Eh, SCI8.TDRHL 4007 010Eh, SCI9.TDRHL 4007 012Eh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TDRHL is a 16-bit register that stores transmit data. Use this register when asynchronous mode and 9-bit data length are selected.

The lower 8 bits of TDRHL are the shadow register of TDR, so access to TDRHL affects the TDR register. Access to the TDRHL register is prohibited if 7-bit or 8-bit data length is selected. When empty space is detected in the TSR register, the transmit data stored in the TDRHL register is transferred to TSR and transmission starts.

The TSR and TDRHL registers have a double-buffered structure to support continuous transmission. When the next data to be transmitted is stored in TDRHL after one frame of data is transmitted, the transmitting operation continues by transferring the data from the TDRHL register to the TSR register.

The CPU can read from and write to the TDRHL register. Bits [15:9] in TDRHL are fixed to 1. These bits are read as 1. The write value should be 1. Write transmit data to the TDRHL register only when a transmit data empty interrupt (SCIn_TXI) request is issued.

FRDRHL是一个16位寄存器，由8位FRDRH和FRDRL寄存器组成。

FRDRH和FRDRL构成一个16级FIFO寄存器，用于存储串行接收数据和软件可读的相关状态信息。该寄存器仅在异步模式下有效，包括多处理器模式或时钟同步模式。

SCI将接收到的数据从RSR寄存器传送到FRDRH和FRDRL中存储，完成一帧串行数据的接收。执行连续接收，直到存储16个阶段。如果在FRDRH和FRDRL中没有接收到数据时读取数据，则该值未定义。当FRDRH和FRDRL充满接收数据时，后续串行接收数据丢失。CPU可以从FRDRH和FRDRL读取，但不能写入它们。

从FRDRH寄存器的RDF、ORER或DR标志读取1与从寄存器中的这些位读取相同SSR_FIFO寄存器。在读取FRDRH寄存器后写入0以清除SSR_FIFO寄存器中的标志时，仅将0写入要清除的标志，将1写入其他标志。

读取FRDRH和FRDRL寄存器时，按照从FRDRH到FRDRL的顺序读取。FDRHL寄存器可以以16位为单位进行访问。

27.2.5 发送数据寄存器(TDR)

Address(es): SCI0.TDR 4007 0003h, SCI1.TDR 4007 0023h, SCI2.TDR 4007 0043h, SCI3.TDR 4007 0063h, SCI4.TDR 4007 0083h, SCI8.TDR 4007 0103h, SCI9.TDR 4007 0123h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1

TDR是一个8位寄存器，用于存储发送数据。

当SCI检测到TSR为空时，它将写入TDR的发送数据传送到TSR并开始发送。

TDR和TSR的双缓冲结构可实现连续串行传输。如果在传输一帧数据时，下一个传输数据已经写入TDR，则SCI将写入的数据传输到TSR继续传输。

CPU可以随时读取或写入TDR。每次发送数据空中断(SCIn_TXI)后，仅将发送数据写入TDR一次。

27.2.6 发送9位数据寄存器(TDRHL)

Address(es): SCI0.TDRHL 4007 000Eh, SCI1.TDRHL 4007 002Eh, SCI2.TDRHL 4007 004Eh, SCI3.TDRHL 4007 006Eh, SCI4.TDRHL 4007 008Eh, SCI8.TDRHL 4007 010Eh, SCI9.TDRHL 4007 012Eh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TDRHL是一个16位寄存器，用于存储发送数据。选择异步模式和9位数据长度时，请使用此寄存器。

TDRHL的低8位是TDR的影子寄存器，因此访问TDRHL会影响TDR寄存器。如果选择7位或8位数据长度，则禁止访问TDRHL寄存器。当在TSR寄存器中检测到空空间时，存储在TDRHL寄存器中的发送数据被传送到TSR并开始发送。

TSR和TDRHL寄存器具有双缓冲结构以支持连续传输。当下一个要发送的数据在发送一帧数据后存储在TDRHL中时，通过将数据从TDRHL寄存器传输到TSR寄存器来继续发送操作。

CPU可以读取和写入TDRHL寄存器。TDRHL中的位[15:9]固定为1。这些位读为1。
写入值应为1。仅当发出发送数据空中断(SCIn_TXI)请求时，才将发送数据写入TDRHL寄存器。

27.2.7 Transmit FIFO Data Register H, L, HL (FTDRH, FTDRL, FTDRHL)

Transmit FIFO Data Register H (FTDRH)

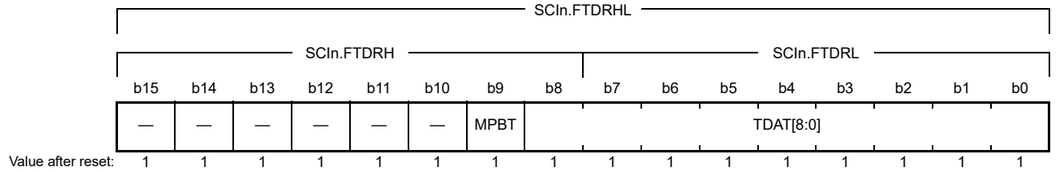
Address(es): SCI0.FTDRH 4007 000Eh, SCI1.FTDRH 4007 002Eh, SCI2.FTDRH 4007 004Eh, SCI3.FTDRH 4007 006Eh, SCI4.FTDRH 4007 008Eh, SCI8.FTDRH 4007 010Eh, SCI9.FTDRH 4007 012Eh

Transmit FIFO Data Register L (FTDRL)

Address(es): SCI0.FTDRL 4007 000Fh, SCI1.FTDRL 4007 002Fh, SCI2.FTDRL 4007 004Fh, SCI3.FTDRL 4007 006Fh, SCI4.FTDRL 4007 008Fh, SCI8.FTDRL 4007 010Fh, SCI9.FTDRL 4007 012Fh

Transmit FIFO Data Register HL (FTDRHL)

Address(es): SCI0.FTDRHL 4007 000Eh, SCI1.FTDRHL 4007 002Eh, SCI2.FTDRHL 4007 004Eh, SCI3.FTDRHL 4007 006Eh, SCI4.FTDRHL 4007 008Eh, SCI8.FTDRHL 4007 010Eh, SCI9.FTDRHL 4007 012Eh



Bit	Symbol	Bit name	Description	R/W
b8 to b0	TDAT[8:0]	Serial Transmit Data	Serial transmit data, valid only in asynchronous mode, including multi-processor mode, or clock synchronous mode, with FIFO selected	W
b9	MPBT	Multi-Processor Transfer Bit Flag	Specifies the multi-processor bit in the transmission frame: 0: Data transmission cycle 1: ID transmission cycle. Valid only in asynchronous mode with SMR.MP = 1 and FIFO selected.	W
b15 to b10	—	Reserved	The write value should be 1	W

FTDRHL is a 16-bit register that consists of 8-bit FTDRH and FTDRL registers.

FTDRH and FTDRL constitute a 16-stage FIFO register that stores data for serial transmission and a multi-processor transfer bit. This register is valid only in asynchronous mode, including multi-processor mode, or clock synchronous mode.

When the SCI detects that the Transmit Shift Register (TSR) is empty, it transfers data written in the FTDRH and FTDRL registers to the TSR register and starts serial transmission. Continuous serial transmission is executed until no transmit data is left in FTDRH and FTDRL. When FTDRHL is full of transmit data, no more data can be written. If writing new data is attempted, the data is ignored. The CPU can write to the FTDRH and FTDRL registers but cannot read them.

When writing to both the FTDRH and FTDRL registers, write in the order from FTDRH to FTDRL.

MPBT flag (Multi-Processor Transfer Bit Flag)

The MPBT flag specifies the value of the multi-processor bit of the transmit frame. When FCR.FM = 1, SSR.MPBT is not valid.

27.2.7 发送FIFO数据寄存器H L HL(FTDRH FTDRL FTDRHL)

发送FIFO数据寄存器H(FTDRH)

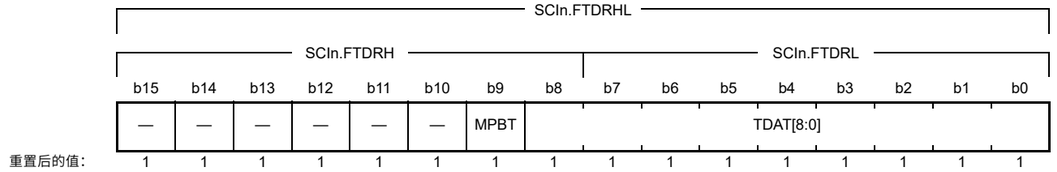
Address(es): SCI0.FTDRH 4007 000Eh, SCI1.FTDRH 4007 002Eh, SCI2.FTDRH 4007 004Eh, SCI3.FTDRH 4007 006Eh, SCI4.FTDRH 4007 008Eh, SCI8.FTDRH 4007 010Eh, SCI9.FTDRH 4007 012Eh

发送FIFO数据寄存器L(FTDRL)

Address(es): SCI0.FTDRL 4007 000Fh, SCI1.FTDRL 4007 002Fh, SCI2.FTDRL 4007 004Fh, SCI3.FTDRL 4007 006Fh, SCI4.FTDRL 4007 008Fh, SCI8.FTDRL 4007 010Fh, SCI9.FTDRL 4007 012Fh

发送FIFO数据寄存器HL(FTDRHL)

Address(es): SCI0.FTDRHL 4007 000Eh, SCI1.FTDRHL 4007 002Eh, SCI2.FTDRHL 4007 004Eh, SCI3.FTDRHL 4007 006Eh, SCI4.FTDRHL 4007 008Eh, SCI8.FTDRHL 4007 010Eh, SCI9.FTDRHL 4007 012Eh



Bit	Symbol	位名称	Description	R/W
b8 to b0	TDAT[8:0]	串行传输数据	串行发送数据，仅在异步模式下有效，包括多处理器模式，或时钟同步模式，选择FIFO	W
b9	MPBT	多处理器传输位标志	指定传输帧中的多处理器位：0：数据传输周期1：ID传输周期。仅在SMR.MP=1且选择了FIFO的异步模式下有效。	W
b15 to b10	—	Reserved	写入值应为1	W

FTDRHL是一个16位寄存器，由8位FTDRH和FTDRL寄存器组成。

FTDRH和FTDRL构成一个16级FIFO寄存器，用于存储串行传输的数据和一个多处理器传输位。该寄存器仅在异步模式下有效，包括多处理器模式或时钟同步模式。

当SCI检测到发送移位寄存器(TSR)为空时，它会传输写入FTDRH中的数据并FTDRL注册到TSR寄存器并开始串行传输。执行连续串行传输，直到在FTDRH和FTDRL中没有剩余传输数据。当FTDRHL充满传输数据时，不能再写入数据。如果尝试写入新数据，则忽略该数据。CPU可以写入FTDRH和FTDRL寄存器，但不能读取它们。

写入FTDRH和FTDRL寄存器时，按照从FTDRH到FTDRL的顺序写入。

MPBT标志（多处理器传输位标志）

MPBT标志指定发送帧的多处理器位的值。当FCR.FM=1时，SSR.MPBT无效。

27.2.8 Transmit Shift Register (TSR)

TSR is a shift register that transmits serial data. To perform serial data transmission, the SCI first automatically transfers transmit data from TDR, TDRHL, or transmit FIFO to TSR, then sends the data to the TXDn pin. The CPU cannot directly access the TSR.

27.2.9 Serial Mode Register (SMR) for Non-Smart Card Interface Mode (SCMR.SMIF = 0)

Address(es): SCI0.SMR 4007 0000h, SCI1.SMR 4007 0020h, SCI2.SMR 4007 0040h, SCI3.SMR 4007 0060h, SCI4.SMR 4007 0080h, SCI8.SMR 4007 0100h, SCI9.SMR 4007 0120h

	b7	b6	b5	b4	b3	b2	b1	b0
	CM	CHR	PE	PM	STOP	MP	CKS[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	CKS[1:0]	Clock Select	b1 b0 0 0: PCLKA clock (n = 0)*1 0 1: PCLKA/4 clock (n = 1)*1 1 0: PCLKA/16 clock (n = 2)*1 1 1: PCLKA/64 clock (n = 3)*1.	R/W*4
b2	MP	Multi-Processor Mode	Valid only in asynchronous mode: 0: Multi-processor communications function is disabled 1: Multi-processor communications function is enabled.	R/W*4
b3	STOP	Stop Bit Length	Valid only in asynchronous mode: 0: 1 stop bit 1: 2 stop bits.	R/W*4
b4	PM	Parity Mode	Valid only when the PE bit is 1: 0: Even parity is selected 1: Odd parity is selected.	R/W*4
b5	PE	Parity Enable	Valid only in asynchronous mode: • When transmitting: 0: Parity bit is not added 1: Parity bit is added. • When receiving: 0: Parity bit is not checked 1: Parity bit is checked.	R/W*4
b6	CHR	Character Length	Valid only in asynchronous mode*2. Selects the transmit/receive character length in combination with the SCMR.CHR1 bit: CHR1 CHR 0 0: Transmit/receive in 9-bit data length 0 1: Transmit/receive in 9-bit data length 1 0: Transmit/receive in 8-bit data length (initial value) 1 1: Transmit/receive in 7-bit data length*3.	R/W*4
b7	CM	Communication Mode	0: Asynchronous mode or simple IIC mode 1: Clock synchronous mode or simple SPI mode.	R/W*4

Note 1. n is the decimal notation of the value of n in BRR, see section 27.2.17, Bit Rate Register (BRR).
Note 2. In any mode other than asynchronous mode, this bit setting is invalid and a fixed data length of 8 bits is used.
Note 3. LSB-first is fixed and the MSB bit [7] in TDR is not transmitted.
Note 4. Writable only when SCR.TE = 0 and SCR.RE = 0 (both serial transmission and reception are disabled).

The SMR register sets the communication format and the clock source for the on-chip baud rate generator.

27.2.8 发送移位寄存器(TSR)

TSR是传送串行数据的移位寄存器。为了进行串行数据传输，SCI首先自动将发送数据从TDR、TDRHL或发送FIFO传输到TSR，然后将数据发送到TXDn引脚。CPU不能直接访问TSR。

27.2.9 非智能卡接口模式的串行模式寄存器(SMR)(SCMR.SMIF=0)

Address(es): SCI0.SMR 4007 0000h, SCI1.SMR 4007 0020h, SCI2.SMR 4007 0040h, SCI3.SMR 4007 0060h, SCI4.SMR 4007 0080h, SCI8.SMR 4007 0100h, SCI9.SMR 4007 0120h

	b7	b6	b5	b4	b3	b2	b1	b0
	CM	CHR	PE	PM	STOP	MP	CKS[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	CKS[1:0]	时钟选择	b1 b0 0 0: PCLKA clock (n = 0)*1 0 1: PCLKA/4 clock (n = 1)*1 1 0: PCLKA/16 clock (n = 2)*1 1 1: PCLKA/64 clock (n = 3)*1.	R/W*4
b2	MP	Multi-Processor Mode	仅在异步模式下有效：0：禁用多处理器通信功能1：启用多处理器通信功能。	R/W*4
b3	STOP	停止位长度	仅在异步模式下有效：0：1个停止位1：2个停止位。	R/W*4
b4	PM	奇偶校验模式	仅当PE位为1时有效：0：选择偶校验1：选择奇校验。	R/W*4
b5	PE	奇偶校验使能	仅在异步模式下有效：　发送时：0：不添加奇偶校验位1：添加奇偶校验位。　接收时：0：不检查奇偶校验位1：检查奇偶校验位。	R/W*4
b6	CHR	字符长度	仅在异步模式下有效*2。 结合SCMR.CHR1位选择发送接收字符长度：CHR1CHR00：发送接收9位数据长度01：发送接收9位数据长度10：发送接收8位数据长度（初始值）11：以7位数据长度发送接收*3。	R/W*4
b7	CM	通讯方式	0：异步模式或简单IIC模式1：时钟同步模式或简单SPI模式。	R/W*4

Note 1. n是BRR中n值的十进制表示法，请参见第27.2.17节，比特率寄存器(BRR)。
Note 2. 在异步模式以外的任何模式下，该位设置无效，使用固定的8位数据长度。
Note 3. LSB-first是固定的，并且不传输TDR中的MSB位[7]。
Note 4. 仅当SCR.TE=0和SCR.RE=0时可写（串行发送和接收均禁用）。

SMR寄存器设置片内波特率发生器的通信格式和时钟源。

CKS[1:0] bits (Clock Select)

The CKS[1:0] bits select the clock source for the on-chip baud rate generator.

For the relationship between the settings of these bits and the baud rate, see section 27.2.17, Bit Rate Register (BRR).

MP bit (Multi-Processor Mode)

The MP bit disables or enables the multi-processor communications function. The settings of the PE and PM bits are invalid in multi-processor mode.

STOP bit (Stop Bit Length)

The STOP bit selects the stop bit length in transmission.

In reception, only the first stop bit is checked regardless of this bit setting. If the second stop bit is 0, it is treated as the start bit of the next transmit frame.

PM bit (Parity Mode)

The PM bit selects the parity mode (even or odd) for transmission and reception.

The PM bit setting is invalid in multi-processor mode.

PE bit (Parity Enable)

When the PE bit is set to 1, the parity bit is added to transmit data, and the parity bit is checked at reception.

Regardless of the PE bit setting, the parity bit is not added or checked in multi-processor format.

CHR bit (Character Length)

The CHR bit selects the data length for transmission and reception in combination with the SCMR.CHR1 bit.

In modes other than asynchronous, a fixed data length of 8 bits is used.

CM bit (Communication Mode)

The CM bit selects the communication mode:

- Asynchronous mode or simple IIC mode
- Clock synchronous mode or simple SPI mode.

27.2.10 Serial Mode Register for Smart Card Interface Mode (SMR_SMCI) (SCMR.SMIF = 1)

Address(es): SCI0.SMR_SMCI 4007 0000h, SCI1.SMR_SMCI 4007 0020h, SCI2.SMR_SMCI 4007 0040h, SCI3.SMR_SMCI 4007 0060h, SCI4.SMR_SMCI 4007 0080h, SCI8.SMR_SMCI 4007 0100h, SCI9.SMR_SMCI 4007 0120h

	b7	b6	b5	b4	b3	b2	b1	b0
	GM	BLK	PE	PM	BCP[1:0]		CKS[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	CKS[1:0]	Clock Select	b1 b0 0 0: PCLKA clock (n = 0)*1 0 1: PCLKA/4 clock (n = 1)*1 1 0: PCLKA/16 clock (n = 2)*1 1 1: PCLKA/64 clock (n = 3)*1.	R/W*2
b3, b2	BCP[1:0]	Base Clock Pulse	Selects the number of base clock cycles in combination with the SCMR.BCP2 bit. Table 27.3 lists the combinations of the SCMR.BCP2 and SMR.BCP[1:0] bits.	R/W*2

CKS[1:0]位（时钟选择）

CKS[1:0]位选择片内波特率发生器的时钟源。

有关这些位的设置与波特率之间的关系，请参见第27.2.17节，比特率寄存器(BRR)。

MP位（多处理器模式）

MP位禁用或启用多处理器通信功能。PE和PM位的设置在多处理器模式下无效。

停止位（停止位长度）

STOP位选择传输中的停止位长度。

在接收中，无论该位设置如何，都只检查第一个停止位。如果第二个停止位为0，则将其视为下一个发送帧的起始位。

PM位（奇偶校验模式）

PM位选择发送和接收的奇偶校验模式（偶数或奇数）。

PM位设置在多处理器模式下无效。

PE位（奇偶校验使能）

当PE位设置为1时，发送数据时添加奇偶校验位，接收时检查奇偶校验位。

无论PE位设置如何，在多处理器格式中都不会添加或检查奇偶校验位。

CHR位（字符长度）

CHR位与SCMR.CHR1位一起选择发送和接收的数据长度。

在非异步模式下，使用8位的固定数据长度。

CM位（通信模式）

CM位选择通信模式：

- 异步模式或简单IIC模式
- 时钟同步模式或简单的SPI模式。

27.2.10 智能卡接口模式的串行模式寄存器(SMR_SMCI)(SCMR.SMIF=1)

Address(es): SCI0.SMR_SMCI 4007 0000h, SCI1.SMR_SMCI 4007 0020h, SCI2.SMR_SMCI 4007 0040h, SCI3.SMR_SMCI 4007 0060h, SCI4.SMR_SMCI 4007 0080h, SCI8.SMR_SMCI 4007 0100h, SCI9.SMR_SMCI 4007 0120h

	b7	b6	b5	b4	b3	b2	b1	b0
	GM	BLK	PE	PM	BCP[1:0]		CKS[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	CKS[1:0]	时钟选择	b1 b0 0 0: PCLKA clock (n = 0)*1 0 1: PCLKA/4 clock (n = 1)*1 1 0: PCLKA/16 clock (n = 2)*1 1 1: PCLKA/64 clock (n = 3)*1.	R/W*2
b3, b2	BCP[1:0]	基本时钟脉冲	结合SCMR.BCP2位选择基本时钟周期数。表27.3列出了SCMR.BCP2和 SMR.BCP[1:0] bits.	R/W*2

Bit	Symbol	Bit name	Description	R/W
b4	PM	Parity Mode	Valid only when the PE bit is 1: 0: Even parity is selected 1: Odd parity is selected.	R/W*2
b5	PE	Parity Enable	When this bit is set to 1, a parity bit is added to transmit data, and the parity of received data is checked. Set this bit to 1 in smart card interface mode.	R/W*2
b6	BLK	Block Transfer Mode	0: Non-block transfer mode operation 1: Block transfer mode operation.	R/W*2
b7	GM	GSM Mode	0: Non-GSM mode operation 1: GSM mode operation.	R/W*2

Note 1. n is the decimal notation of the value of n in BRR, see section 27.2.17, Bit Rate Register (BRR).
Note 2. Writable only when SCR_SMCI.TE = 0 and SCR_SMCI.RE = 0 (both serial transmission and reception are disabled).

The SMR_SMCI register sets the communication format and clock source for the on-chip baud rate generator.

CKS[1:0] bit (Clock Select)

The CKS[1:0] bits select the clock source for the on-chip baud rate generator.

For the relationship between the settings of these bits and the baud rate, see section 27.2.17, Bit Rate Register (BRR).

BCP[1:0] bits (Base Clock Pulse)

The BCP[1:0] bits select the number of base clock cycles in a 1-bit data transfer time in smart card interface mode.

Set these bits in combination with the SCMR.BCP2 bit.

For details, see section 27.6.4, Receive Data Sampling Timing and Reception Margin.

Table 27.3 Combinations of SCMR.BCP2 and SMR_SMCI.BCP[1:0] bits

SCMR.BCP2 bit	SMR_SMCI.BCP[1:0] bits	Number of base clock cycles for 1-bit transfer period
0	00	93 clock cycles (S = 93)*1
0	01	128 clock cycles (S = 128)*1
0	10	186 clock cycles (S = 186)*1
0	11	512 clock cycles (S = 512)*1
1	00	32 clock cycles (S = 32)*1 (initial value)
1	01	64 clock cycles (S = 64)*1
1	10	372 clock cycles (S = 372)*1
1	11	256 clock cycles (S = 256)*1

Note 1. S is the value of S in BRR, see section 27.2.17, Bit Rate Register (BRR).

PM bit (Parity Mode)

The PM bit selects the parity mode for transmission and reception (even or odd). For details on the usage of this bit in smart card interface mode, see section 27.6.2, Data Format (Except in Block Transfer Mode).

PE bit (Parity Enable)

Set the PE bit to 1. The parity bit is added to the transmit data before transmission, and the parity bit is checked at reception.

BLK bit (Block Transfer Mode)

Set the BLK bit to 1 to enable the block transfer mode operation. For details, see section 27.6.3, Block Transfer Mode.

GM bit (GSM Mode)

Set the GM bit to 1 to enable GSM mode operation. In GSM mode, the SSR_SMCI.TEND flag set timing is moved forward to 11.0 ETUs (elementary time unit = 1-bit transfer time) from the start bit, and the clock output control function is enabled. For details, see section 27.6.6, Serial Data Transmission (Except in Block Transfer Mode) and section 27.6.8, Clock Output Control.

Bit	Symbol	位名称	Description	R/W
b4	PM	奇偶校验模式	仅当PE位为1时有效：0：选择 偶校验1：选择奇校验。	R/W*2
b5	PE	奇偶校验使能	当该位设置为1时，发送数据时添加一个奇偶校验位，并检查接收数据的奇偶校验。在智能卡接口模式下将此位设置为1。	R/W*2
b6	BLK	块传输模式	0：非块传输模式操作1：块传输模式 操作。	R/W*2
b7	GM	GSM Mode	0：非GSM模式操作1：GSM 模式操作。	R/W*2

Note 1. n是BRR中n值的十进制表示法，请参见第27.2.17节，比特率寄存器(BRR)。
Note 2. 仅当SCR_SMCI.TE=0且SCR_SMCI.RE=0时可写（串行传输和接收均禁用）。

SMR_SMCI寄存器设置片内波特率发生器的通信格式和时钟源。

CKS[1:0]位（时钟选择）

CKS[1:0]位选择片内波特率发生器的时钟源。

有关这些位的设置与波特率之间的关系，请参见第27.2.17节，比特率寄存器(BRR)。

BCP[1:0]位（基本时钟脉冲）

BCP[1:0]位选择智能卡接口模式下1位数据传输时间内的基本时钟周期数。

将这些位与SCMR.BCP2位一起设置。

有关详细信息，请参阅第27.6.4节，接收数据采样时序和接收余量。

Table 27.3 SCMR.BCP2和SMR_SMCI.BCP[1:0]位的组合

SCMR.BCP2 bit	SMR_SMCI.BCP[1:0] bits	1位传输周期的基本时钟周期数
0	00	93个时钟周期(S=93)*1
0	01	128个时钟周期(S=128)*1
0	10	186个时钟周期(S=186)*1
0	11	512个时钟周期(S=512)*1
1	00	32个时钟周期(S=32)*1（初始值）
1	01	64个时钟周期(S=64)*1
1	10	372个时钟周期(S=372)*1
1	11	256个时钟周期(S=256)*1

Note 1. S是BRR中S的值，请参见第27.2.17节，比特率寄存器(BRR)。

PM位（奇偶校验模式）

PM位选择发送和接收的奇偶校验模式（偶数或奇数）。有关该位在智能卡接口模式下的使用详情，请参见第27.6.2节，数据格式（块传输模式除外）。

PE位（奇偶校验使能）

将PE位设置为1。奇偶校验位在发送前添加到发送数据中，并在接收时检查奇偶校验位。

BLK位（块传输模式）

将BLK位设置为1以启用块传输模式操作。有关详细信息，请参阅第27.6.3节，块传输模式。

GM位（GSM模式）

将GM位设置为1以启用GSM模式操作。在GSM模式下，SSR_SMCI.TEND标志设置时序从起始位前移到11.0ETU（基本时间单位=1位传输时间），并启用时钟输出控制功能。有关详细信息，请参见第27.6.6节，串行数据传输（块传输模式除外）和第27.6.8节，时钟输出控制。

27.2.11 Serial Control Register (SCR) for Non-Smart Card Interface Mode (SCMR.SMIF = 0)

Address(es): SCI0.SCR 4007 0002h, SCI1.SCR 4007 0022h, SCI2.SCR 4007 0042h, SCI3.SCR 4007 0062h, SCI4.SCR 4007 0082h, SCI8.SCR 4007 0102h, SCI9.SCR 4007 0122h

	b7	b6	b5	b4	b3	b2	b1	b0
	TIE	RIE	TE	RE	MPIE	TEIE	CKE[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	CKE[1:0]	Clock Enable	• Asynchronous mode: b1 b0 0 0: On-chip baud rate generator. The SCKn pin is available for use as an I/O port based on the I/O port settings. 0 1: On-chip baud rate generator. A clock with the same frequency as the bit rate is output from the SCKn pin. 1 x: External clock. A clock with a frequency 16 times the bit rate should be input from the SCKn pin when the SEMR.ABCS bit is 0. Input a clock signal with a frequency eight times the bit rate when the SEMR.ABCS bit is 1. • Clock synchronous mode: b1 b0 0 x: Internal clock. The SCKn pin functions as the clock output pin. 1 x: External clock. The SCKn pin functions as the clock input pin.	R/W*1
b2	TEIE	Transmit End Interrupt Enable	0: An SCIn_TEI interrupt request is disabled 1: An SCIn_TEI interrupt request is enabled.	R/W
b3	MPIE	Multi-Processor Interrupt Enable	Valid in asynchronous mode when SMR.MP = 1: 0: Non-multi-processor reception 1: When data with the multi-processor bit set to 0 is received, the data is not read, and setting the status flags RDRF, ORER, and FER in SSR to 1 is disabled. When data with the multi-processor bit set to 1 is received, the MPIE bit is automatically set to 0, and non-multi-processor reception is resumed.	R/W*3
b4	RE	Receive Enable	0: Serial reception is disabled 1: Serial reception is enabled.	R/W*2
b5	TE	Transmit Enable	0: Serial transmission is disabled 1: Serial transmission is enabled.	R/W*2
b6	RIE	Receive Interrupt Enable	0: SCIn_RXI and SCIn_ERI interrupt requests are disabled 1: SCIn_RXI and SCIn_ERI interrupt requests are enabled.	R/W
b7	TIE	Transmit Interrupt Enable	0: An SCIn_TXI interrupt request is disabled 1: An SCIn_TXI interrupt request is enabled.	R/W

x: Don't care

Note 1. Writable only when TE = 0 and RE = 0.

Note 2. 1 can be written only when TE = 0 and RE = 0, when the SMR.CM bit is 1. After setting TE or RE to 1, only 0 can be written to TE and RE. When the SMR.CM bit is 0 and the SIMR1.IICM bit is 0, writing is enabled under any condition.

Note 3. When writing a new value to a bit other than the MPIE bit of this register in multi-processor mode (SMR.MP bit = 1), write 0 to the MPIE bit using the store instruction to avoid accidentally setting the MPIE bit to 1 by a read-modify-write operation when using a bit manipulation instruction.

The SCR controls operation and clock source selection for transmission and reception.

CKE[1:0] bits (Clock Enable)

The CKE[1:0] bits select the clock source and the SCKn pin function.

27.2.11 非智能卡接口模式的串行控制寄存器(SCR)(SCMR.SMIF=0)

Address(es): SCI0.SCR 4007 0002h, SCI1.SCR 4007 0022h, SCI2.SCR 4007 0042h, SCI3.SCR 4007 0062h, SCI4.SCR 4007 0082h, SCI8.SCR 4007 0102h, SCI9.SCR 4007 0122h

	b7	b6	b5	b4	b3	b2	b1	b0
	TIE	RIE	TE	RE	MPIE	TEIE	CKE[1:0]	
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	CKE[1:0]	时钟使能	异步模式：b1b000：片上波特率发生器。 SCKn引脚可根据IO端口设置用作IO端口。01：片内波特率发生器。 从SCKn引脚输出与比特率相同频率的时钟。1x：外部时钟。 当SEMR.ABCS位为0时，应从SCKn引脚输入频率为16倍比特率的时钟。当SEMR.ABCS位为1时，输入频率为8倍比特率的时钟信号。 时钟同步模式：b1b00x：内部时钟。 SCKn引脚用作时钟输出引脚。1x：外部时钟。 SCKn引脚用作时钟输入引脚。	R/W*1
b2	TEIE	发送结束中断使能	0：禁止SCIn_TEI中断请求1：使能SCIn_TEI中断请求。	R/W
b3	MPIE	多处理器中断使能	SMR.MP=1时在异步模式下有效：0：非多处理器接收1：当多处理器位设置为0的数据是 接收时，不读取数据，并且将SSR中的状态标志RDRF、ORER和FER设置为1被禁用。当接收到多处理器位设置为1的数据时，MPIE位自动设置为0，并恢复非多处理器接收。	R/W*3
b4	RE	接收启用	0：禁用串行接收1：启用串行接收。	R/W*2
b5	TE	发送启用	0：禁用串行传输1：启用串行传输。	R/W*2
b6	RIE	接收中断使能	0：禁用SCIn_RXI和SCIn_ERI中断请求1：启用SCIn_RXI和SCIn_ERI中断请求。	R/W
b7	TIE	发送中断使能	0：禁止SCIn_TXI中断请求1：使能SCIn_TXI中断请求。	R/W

x：不关心注

1。 仅当TE=0且RE=0时可写。

Note 2. 只有当TE=0且RE=0时，SMR.CM位为1时才能写入1。将TE或RE设置为1后，TE和RE只能写入0。当SMR.CM位为0且SIMR1.IICM位为0时，在任何情况下都可以写入。

Note 3. 在多处理器模式下（SMR.MP位=1）向该寄存器的MPIE位以外的位写入新值时，使用存储指令将0写入MPIE位，以避免意外将MPIE位设置为1使用位操作指令时的读-修改-写操作。

SCR控制发送和接收的操作和时钟源选择。

CKE[1:0]位（时钟使能）

CKE[1:0]位选择时钟源和SCKn引脚功能。

TEIE bit (Transmit End Interrupt Enable)

The TEIE bit enables or disables an SCIn_TEI interrupt request. Set the TEIE bit to 0 to disable the SCIn_TEI interrupt request.

In simple IIC mode, SCIn_TEI is allocated to the interrupt on completion of issuing a start, restart, or stop condition (STIn). In this case, the TEIE bit can be used to enable or disable the STI.

MPIE bit (Multi-Processor Interrupt Enable)

When the MPIE bit is set to 1 and data with the multi-processor bit set to 0 is received, the data is not read, and setting the status flags RDRF, RDF, ORER, and FER in SSR/SSR_FIFO to 1 is disabled. When data with the multi-processor bit set to 1 is received, the MPIE bit is automatically set to 0, and non-multi-processor reception resumes. For details, see section 27.4, Multi-Processor Communication Function.

When the MPB bit in the SSR is 0, the receive data is not transferred from the RSR to the RDR, a receive error is not detected, and setting the flags ORER and FER to 1 is disabled.

When the MPB bit is 1, the MPIE bit is automatically set to 0, SCIn_RXI and SCIn_ERI interrupt requests are enabled (if the RIE bit in SCR is set to 1), and setting of the ORER and FER flags to 1 is enabled.

Set MPIE to 0 if the multi-processor communications function is not used.

RE bit (Receive Enable)

The RE bit enables or disables serial reception.

When this bit is set to 1, serial reception starts by detecting the start bit in asynchronous mode or the synchronous clock input in clock synchronous mode. Set the reception format in the SMR register before setting the RE bit to 1.

When non-FIFO operation is selected and reception is halted by setting the RE bit to 0, the RDRF, ORER, FER, and PER flags in the SSR register are not affected, and the previous values are saved.

When FIFO operation is selected and reception is halted by setting the RE bit to 0, the RDF, ORER, FER, PER, and DR flags in SSR_FIFO are not affected and the previous values are saved.

TE bit (Transmit Enable)

The TE bit enables or disables serial transmission.

When the TE bit is set to 1, serial transmission starts by writing transmit data to TDR. Set the transmission format in the SMR register before setting the TE bit to 1.

RIE bit (Receive Interrupt Enable)

The RIE bit enables or disables SCIn_RXI and SCIn_ERI interrupt requests.

Setting the RIE bit to 0 disables SCIn_RXI and SCIn_ERI interrupt requests.

To cancel an SCIn_ERI interrupt request, read 1 from the ORER, FER, or PER flag in SSR/SSR_FIFO, then set the flag to 0, or set the RIE bit to 0.

TIE bit (Transmit Interrupt Enable)

The TIE bit enables or disables SCIn_TXI interrupt requests.

Setting the TIE bit to 0 disables an SCIn_TXI interrupt request. For the SCIn_TXI interrupt to occur, set the TE and TIE bits to 1 simultaneously, before transfer starts.

TEIE位（发送结束中断使能）

TEIE位启用或禁用SCIn_TEI中断请求。将TEIE位设置为0以禁用SCIn_TEI中断请求。

在简单IIC模式下，SCIn_TEI在完成发出启动、重新启动或停止条件(STIn)时分配给中断。在这种情况下，TEIE位可用于启用或禁用STI。

MPIE位（多处理器中断使能）

当MPIE位设置为1并且接收到多处理器位设置为0的数据时，不读取数据，并且将SSRSSR_FIFO中的状态标志RDRF、RDF、ORER和FER设置为1被禁用。当接收到多处理器位设置为1的数据时，MPIE位自动设置为0，并恢复非多处理器接收。有关详细信息，请参阅第27.4节，多处理器通信功能。

当SSR中的MPB位为0时，接收数据不会从RSR传送到RDR，不会检测到接收错误，并且将标志ORER和FER设置为1被禁止。

当MPB位为1时，MPIE位自动设置为0，允许SCIn_RXI和SCIn_ERI中断请求（如果SCR中的RIE位设置为1），并且允许设置ORER和FER标志为1。

如果不使用多处理器通信功能，则将MPIE设置为0。

RE位（接收使能）

RE位启用或禁用串行接收。

当该位设置为1时，串行接收通过检测异步模式下的起始位或时钟同步模式下的同步时钟输入来启动。在将RE位设置为1之前，在SMR寄存器中设置接收格式。

Whennon-FIFOoperationisselectedandreceptionishaltedbysettingtheREbitto0 theRDRF ORER FER andPERflagsintheSSRregisterarenotaffected andthepreviousvaluesaresaved.

WhenFIFOoperationisselectedandreceptionishaltedbysettingtheREbitto0 theRDF ORER FER PER andDRflagsinSSR_FIFOarenotaffectedandthepreviousvaluesaresaved.

TE位（发送使能）

TE位启用或禁用串行传输。

当TE位设置为1时，串行发送通过将发送数据写入TDR开始。设置传输格式
将TE位设置为1之前的SMR寄存器。

RIE位（接收中断使能）

RIE位启用或禁用SCIn_RXI和SCIn_ERI中断请求。

将RIE位设置为0会禁用SCIn_RXI和SCIn_ERI中断请求。

要取消SCIn_ERI中断请求，请从SSRSSR_FIFO中的ORER、FER或PER标志读取1，然后将该标志设置为0，或将RIE位设置为0。

TIE位（发送中断使能）

TIE位启用或禁用SCIn_TXI中断请求。

将TIE位设置为0将禁用SCIn_TXI中断请求。为了使SCIn_TXI中断发生，在传输开始之前将TE和TIE位同时设置为1。

RA生态工作室

27.2.12 Serial Control Register for Smart Card Interface Mode (SCR_SMCI) (SCMR.SMIF = 1)

Address(es): SCI0.SCR_SMCI 4007 0002h, SCI1.SCR_SMCI 4007 0022h, SCI2.SCR_SMCI 4007 0042h, SCI3.SCR_SMCI 4007 0062h, SCI4.SCR_SMCI 4007 0082h, SCI8.SCR_SMCI 4007 0102h, SCI9.SCR_SMCI 4007 0122h

	b7	b6	b5	b4	b3	b2	b1	b0
	TIE	RIE	TE	RE	MPIE	TEIE	CKE[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	CKE[1:0]	Clock Enable	• When GM in SMR_SMCI = 0: b1 b0 0 0: Output disabled. The SCKn pin is available for use as an I/O port based on the I/O port settings 0 1: Output clock 1 x: Setting prohibited. • When GM in SMR_SMCI = 1: b1 b0 0 0: Output fixed low x 1: Output clock 1 0: Output fixed high.	R/W*1
b2	TEIE	Transmit End Interrupt Enable	This bit should be 0 in smart card interface mode	R/W
b3	MPIE	Multi-Processor Interrupt Enable	This bit should be 0 in smart card interface mode	R/W
b4	RE	Receive Enable	0: Serial reception is disabled 1: Serial reception is enabled.	R/W*2
b5	TE	Transmit Enable	0: Serial transmission is disabled 1: Serial transmission is enabled.	R/W*2
b6	RIE	Receive Interrupt Enable	0: SCIn_RXI and SCIn_ERI interrupt requests are disabled 1: SCIn_RXI and SCIn_ERI interrupt requests are enabled.	R/W
b7	TIE	Transmit Interrupt Enable	0: SCIn_TXI interrupt request is disabled 1: SCIn_TXI interrupt request is enabled.	R/W

x: Don't care
Note 1. Writable only when TE = 0 and RE = 0.
Note 2. 1 can be written only when TE = 0 and RE = 0. After setting TE or RE to 1, only 0 can be written to TE and RE.

The SCR_SMCI sets transmission and reception control, interrupt control, and clock source selection for transmission and reception.

For details on interrupt requests, see section 27.10, Interrupt Sources.

CKE[1:0] bits (Clock Enable)

The CKE[1:0] bits control the clock output from the SCKn pin.

In GSM mode, clock output can be dynamically switched. For details, see section 27.6.8, Clock Output Control.

TEIE bit (Transmit End Interrupt Enable)

Set the TEIE bit to 0 in smart card interface mode.

MPIE bit (Multi-Processor Interrupt Enable)

Set the MPIE bit to 0 in smart card interface mode.

27.2.12 智能卡接口模式的串行控制寄存器(SCR_SMCI)(SCMR.SMIF=1)

Address(es): SCI0.SCR_SMCI 4007 0002h, SCI1.SCR_SMCI 4007 0022h, SCI2.SCR_SMCI 4007 0042h, SCI3.SCR_SMCI 4007 0062h, SCI4.SCR_SMCI 4007 0082h, SCI8.SCR_SMCI 4007 0102h, SCI9.SCR_SMCI 4007 0122h

	b7	b6	b5	b4	b3	b2	b1	b0
	TIE	RIE	TE	RE	MPIE	TEIE	CKE[1:0]	
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	CKE[1:0]	时钟使能	当SMR_SMCI中的GM=0时：b1 b000：禁用输出。 根据IO端口设置，SCKn引脚可用作IO端口01：输出时钟1x：禁止设置。 当SMR_SMCI中的GM=1时：b1 b000：输出固定低x1：输出时钟10：输出固定高。	R/W*1
b2	TEIE	发送结束中断使能	该位在智能卡接口模式下应为0	R/W
b3	MPIE	多处理器中断使能	该位在智能卡接口模式下应为0	R/W
b4	RE	接收启用	0：禁用串行接收1：启用串行接收。	R/W*2
b5	TE	发送启用	0：禁用串行传输1：启用串行传输。	R/W*2
b6	RIE	接收中断使能	0：禁用SCIn_RXI和SCIn_ERI中断请求1：启用SCIn_RXI和SCIn_ERI中断请求。	R/W
b7	TIE	发送中断使能	0：禁止SCIn_TXI中断请求1：使能SCIn_TXI中断请求。	R/W

x：不关心注
1。 仅当TE=0且RE=0时可写。
Note 2. 只有在TE=0和RE=0时才能写入1。将TE或RE设置为1后，TE和RE只能写入0。

SCR_SMCI设置发送和接收的发送和接收控制、中断控制和时钟源选择。

有关中断请求的详细信息，请参见第27.10节，中断源。

CKE[1:0]位（时钟使能）

CKE[1:0]位控制SCKn引脚的时钟输出。

在GSM模式下，时钟输出可以动态切换。有关详细信息，请参见第27.6.8节，时钟输出控制。

TEIE位（发送结束中断使能）

在智能卡接口模式下将TEIE位设置为0。

MPIE位（多处理器中断使能）

在智能卡接口模式下将MPIE位设置为0。

RE bit (Receive Enable)

The RE bit enables or disables serial reception.

When this bit is set to 1, serial reception starts by detecting the start bit. Set the reception format in the SMR_SMCI register before setting the RE bit to 1.

If reception is halted by setting the RE bit to 0, the ORER, FER, and PER flags in SSR_SMCI are not affected and the previous values are saved.

TE bit (Transmit Enable)

The TE bit enables or disables serial transmission. When this bit is set to 1, serial transmission starts by writing transmit data to TDR. Set the transmission format in the SMR_SMCI register before setting the TE bit to 1.

RIE bit (Receive Interrupt Enable)

The RIE bit enables or disables SCIn_RXI and SCIn_ERI interrupt requests.

Setting the RIE bit to 0 disables SCIn_RXI and SCIn_ERI interrupt requests.

To cancel an SCIn_ERI interrupt request, read 1 from the ORER, FER, or PER flag in the SSR_SMCI register, then set the flag to 0, or set the RIE bit to 0.

TIE bit (Transmit Interrupt Enable)

The TIE bit enables or disables an SCIn_TXI interrupt request.

Setting the TIE bit to 0 disables an SCIn_TXI interrupt request. Set the TIE bit to 1 while the TE bit is 1. For the SCIn_TXI interrupt to occur, set the TE and TIE bits to 1 simultaneously before transfer starts.

27.2.13 Serial Status Register (SSR) for Non-Smart Card Interface and Non-FIFO Mode (SCMR.SMIF = 0 and FCR.FM = 0)

Address(es): SCI0.SSR 4007 0004h, SCI1.SSR 4007 0024h, SCI2.SSR 4007 0044h, SCI3.SSR 4007 0064h, SCI4.SSR 4007 0084h, SCI8.SSR 4007 0104h, SCI9.SSR 4007 0124h

	b7	b6	b5	b4	b3	b2	b1	b0
	TDRE	RDRF	ORER	FER	PER	TEND	MPB	MPBT
Value after reset:	1	0	0	0	0	1	0	0

Bit	Symbol	Bit name	Description	R/W
b0	MPBT	Multi-Processor Bit Transfer	Value of the multi-processor bit in the transmission frame: 0: Data transmission cycle 1: ID transmission cycle.	R/W
b1	MPB	Multi-Processor	Value of the multi-processor bit in the reception frame: 0: Data transmission cycle 1: ID transmission cycle.	R
b2	TEND	Transmit End Flag	0: A character is being transmitted 1: Character transfer is complete.	R
b3	PER	Parity Error Flag	0: No parity error occurred 1: Parity error occurred.	R/(W)*1
b4	FER	Framing Error Flag	0: No framing error occurred 1: Framing error occurred.	R/(W)*1
b5	ORER	Overrun Error Flag	0: No overrun error occurred 1: Overrun error occurred.	R/(W)*1
b6	RDRF	Receive Data Full Flag	0: No received data in RDR register 1: Received data in RDR register.	R/(W)*1
b7	TDRE	Transmit Data Empty Flag	0: Transmit data in TDR register 1: No transmit data in TDR register.	R/(W)*1

RE位（接收使能）

RE位启用或禁用串行接收。

当该位设置为1时，串行接收通过检测起始位开始。在将RE位设置为1之前，在SMR_SMCI寄存器中设置接收格式。

如果通过将RE位设置为0来停止接收，则SSR_SMCI中的ORER、FER和PER标志不受影响，并且之前的值被保存。

TE位（发送使能）

TE位启用或禁用串行传输。当该位设置为1时，串行传输通过将发送数据写入TDR开始。在将TE位设置为1之前，在SMR_SMCI寄存器中设置传输格式。

RIE位（接收中断使能）

RIE位启用或禁用SCIn_RXI和SCIn_ERI中断请求。

将RIE位设置为0会禁用SCIn_RXI和SCIn_ERI中断请求。

要取消SCIn_ERI中断请求，请从SSR_SMCI寄存器中的ORER、FER或PER标志读取1，然后将该标志设置为0，或将RIE位设置为0。

TIE位（发送中断使能）

TIE位启用或禁用SCIn_TXI中断请求。

将TIE位设置为0将禁用SCIn_TXI中断请求。当TE位为1时，将TIE位设置为1。对于SCIn_TXI中断发生，在传输开始前将TE和TIE位同时设置为1。

27.2.13 用于非智能卡接口和非FIFO模式的串行状态寄存器(SSR)（SCMR.SMIF=0和FCR.FM=0）

Address(es): SCI0.SSR 4007 0004h, SCI1.SSR 4007 0024h, SCI2.SSR 4007 0044h, SCI3.SSR 4007 0064h, SCI4.SSR 4007 0084h, SCI8.SSR 4007 0104h, SCI9.SSR 4007 0124h

	b7	b6	b5	b4	b3	b2	b1	b0
	TDRE	RDRF	ORER	FER	PER	TEND	MPB	MPBT
重置后的值：	1	0	0	0	0	1	0	0

Bit	Symbol	位名称	Description	R/W
b0	MPBT	多处理器位传输	传输帧中多处理器位的值：0：数据传输周期1：ID传输周期。	R/W
b1	MPB	Multi-Processor	接收帧中多处理器位的值：0：数据发送周期1：ID发送周期。	R
b2	TEND	发送结束标志	0：正在传输字符1：字符传输完成。	R
b3	PER	奇偶校验错误标志	0：未发生奇偶校验错误1：发生奇偶校验错误。	R/(W)*1
b4	FER	成帧错误标志	0：未发生帧错误1：发生帧错误。	R/(W)*1
b5	ORER	溢出错误标志	0：未发生溢出错误1：发生溢出错误。	R/(W)*1
b6	RDRF	接收数据满标志	0：RDR寄存器中没有接收到数据1：RDR寄存器中接收到数据。	R/(W)*1
b7	TDRE	传输数据空标志	0：在TDR寄存器中发送数据1：在TDR寄存器中不发送数据。	R/(W)*1

Note 1. Only 0 can be written to clear the flag after reading 1.

The SSR register provides the SCI status flags and transmission/reception multi-processor bits.

MPBT bit (Multi-Processor Bit Transfer)

The MPBT bit selects the multi-processor bit in the transmit frame.

MPB bit (Multi-Processor)

The MPB bit holds the value of the multi-processor bit in the reception frame. This bit does not change when the SCR.RE bit is 0.

TEND flag (Transmit End Flag)

The TEND flag indicates completion of transmission.

[Setting conditions]

- When the SCR.TE bit is set to 0 to disable serial transmission and the FCR.FM bit is set to 0 (non-FIFO selected)
- When the SCR.TE bit is set to 1, the TEND flag is not affected and keeps the value 1
- When the TDR register is not updated on transmission of the tail-end bit of a character.

[Clearing conditions]

- When transmit data is written to the TDR register when the SCR.TE bit is 1
- When 0 is written to TDRE after reading TDRE = 1 when the SCR.TE bit is 1.

PER flag (Parity Error Flag)

The PER flag indicates that a parity error occurred during reception in asynchronous mode and the reception ended abnormally.

[Setting condition]

- When a parity error is detected during reception in asynchronous mode and the address match function is disabled (DCCR.DCME = 0).

  Although receive data is transferred to the RDR register when the parity error occurs, no SCIn_RXI interrupt request occurs. When the PER flag is set to 1, the subsequent receive data is not transferred to RDR.

[Clearing condition]

- When 0 is written to the PER flag after reading PER = 1. After writing 0 to this flag, read it to verify that its value is 0.

When the SCR.RE bit is set to 0 to disable serial reception, the PER flag is not affected and keeps its previous value.

FER flag (Framing Error Flag)

The FER flag indicates that a framing error occurred during reception in asynchronous mode and the reception ended abnormally.

[Setting condition]

- When 0 is sampled as the stop bit during reception in asynchronous mode and the address match function is disabled (DCCR.DCME = 0).

  In 2-stop-bit mode, only the first stop bit is checked, but the second stop bit is not checked. Although receive data is transferred to the RDR register when the framing error occurs, no SCIn_RXI interrupt request occurs. Also, when the FER flag is set to 1, the subsequent receive data is not transferred to RDR.

[Clearing condition]

- When 0 is written to the FER flag after reading FER = 1. After writing 0 to this flag, read it to verify that its value is 0.

When the SCR.RE bit is set to 0 (serial reception is disabled), the FER flag is not affected and keeps its previous value.

Note 1. 读1后只能写0清除标志。

SSR寄存器提供SCI状态标志和发送接收多处理器位。

MPBT位（多处理器位传输）

MPBT位选择发送帧中的多处理器位。

MPB bit (Multi-Processor)

MPB位保存接收帧中多处理器位的值。该位不改变时
SCR.RE位为0。

TEND标志（发送结束标志）

TEND标志表示传输完成。

[Setting conditions]

- 当SCR.TE位设置为0以禁用串行传输且FCR.FM位设置为0（选择非FIFO）时
- 当SCR.TE位设置为1时，TEND标志不受影响并保持值1
- 当TDR寄存器未在字符尾端位传输时更新时。

[Clearing conditions]

- 当SCR.TE位为1时将发送数据写入TDR寄存器
- 当SCR.TE位为1时，读取TDRE=1后将0写入TDRE。

PER标志（奇偶校验错误标志）

PER标志表示在异步模式接收过程中发生奇偶校验错误，接收异常结束。

[Setting condition]

- 当在异步模式下接收期间检测到奇偶校验错误并且地址匹配功能被禁用（DCCR.DCME=0）。

尽管发生奇偶校验错误时接收数据被传送到RDR寄存器，但不会发生SCIn_RXI中断请求。当PER标志设置为1时，后续接收数据不传输到RDR。【结算条件】

- 当读取PER=1后将0写入PER标志。在向该标志写入0后，读取它以验证其值为0。

当SCR.RE位设置为0以禁用串行接收时，PER标志不受影响并保持其先前的值。

FER标志（帧错误标志）

FER标志表示在异步模式下接收过程中发生了帧错误，并且接收异常结束。

[Setting condition]

- 在异步模式下接收期间采样0作为停止位并且禁用地址匹配功能(DCCR.DCME=0)。

在2-stop-bit模式下，只检查第一个停止位，但不检查第二个停止位。虽然发生帧错误时接收数据被传输到RDR寄存器，但不会发生SCIn_RXI中断请求。此外，当FER标志设置为1时，后续接收数据不会传输到RDR。【结算条件】

- 当读取FER=1后将0写入FER标志时。将0写入此标志后，读取它以验证其值为0。

当SCR.RE位设置为0（禁用串行接收）时，FER标志不受影响并保持其先前的值。

ORER flag (Overrun Error Flag)

The ORER flag indicates that an overrun error occurred during reception and the reception ended abnormally.

[Setting condition]

- When the next data is received before receive data that does not have a parity error and a framing error is read from RDR.

  In RDR, data received prior to an overrun error occurrence is saved, but data received after the overrun error is lost. When the ORER flag is set to 1, data received is not forwarded to the RDR register. In clock synchronous mode, serial transmission and reception are stopped.

[Clearing condition]

- When 0 is written to the ORER flag after 1 is read. After writing 0 to this flag, read it to verify that its value is 0.

When the SCR.RE bit is set to 0 to disable serial reception, the ORER flag is not affected and keeps its previous value.

RDRF flag (Receive Data Full Flag)

The RDRF flag indicates the presence of receive data in the RDR register.

[Setting condition]

- When the reception ends normally, and receive data is forwarded from the RSR register to the RDR register.

[Clearing conditions]

- When 0 is written to RDRF flag after 1 is read
- When data is read from the RDR register.

Note: Do not clear RDRF flag by accessing RDRF bit in SSR register unless communication is aborted.

TDRE flag (Transmit Data Empty Flag)

The TDRE flag indicates the presence of transmit data in the TDR register.

[Setting conditions]

- When the SCR.TE bit is 0
- When data is transmitted from the TDR register to the TSR register.

[Clearing conditions]

- When 0 is written to TDRE flag after 1 is read
- When the SCR.TE bit is 1 and data is written to the TDR register.

Note: Do not clear TDRE flag by accessing TDRE in the SSR register unless communication is aborted.

ORER标志（溢出错误标志）

ORER标志表示接收期间发生溢出错误，接收异常结束。

[Setting condition]

- 在接收没有奇偶校验错误和帧错误的数据之前接收下一个数据时，从
  RDR.

  在RDR中，会保存发生溢出错误之前接收的数据，但会丢失发生溢出错误之后接收的数据。

当ORER标志设置为1时，接收到的数据不转发到RDR寄存器。在时钟同步模式下，串行发送和接收停止。【结算条件】

- 在读取1后将0写入ORER标志时。将0写入此标志后，读取它以验证其值为0。

当SCR.RE位设置为0以禁用串行接收时，ORER标志不受影响并保持其先前的值。

RDRF标志（接收数据满标志）

RDRF标志指示RDR寄存器中存在接收数据。

[Setting condition]

- 当接收正常结束时，接收数据从RSR寄存器转发到RDR寄存器。

[Clearing conditions]

- 读取1后将0写入RDRF标志时
- 从RDR寄存器读取数据时。

Note: 除非通信中止，否则不要通过访问SSR寄存器中的RDRF位来清除RDRF标志。

TDRE标志（传输数据空标志）

TDRE标志表示TDR寄存器中存在发送数据。

[Setting conditions]

- 当SCR.TE位为0时
- 当数据从TDR寄存器传输到TSR寄存器时。

[Clearing conditions]

- 读取1后将0写入TDRE标志时
- 当SCR.TE位为1且数据写入TDR寄存器时。

Note: 除非通信中止，否则不要通过访问SSR寄存器中的TDRE来清除TDRE标志。

27.2.14 Serial Status Register for Non-Smart Card Interface and FIFO Mode (SSR_FIFO) (SCMR.SMIF = 0 and FCR.FM = 1)

Address(es): SCI0.SSR_FIFO 4007 0004h, SCI1.SSR_FIFO 4007 0024h, SCI2.SSR_FIFO 4007 0044h, SCI3.SSR_FIFO 4007 0064h, SCI4.SSR_FIFO 4007 0084h, SCI8.SSR_FIFO 4007 0104h, SCI9.SSR_FIFO 4007 0124h

	b7	b6	b5	b4	b3	b2	b1	b0
	TDFE	RDF	ORER	FER	PER	TEND	—	DR
Value after reset:	1	0	0	0	0	0	x	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	DR	Receive Data Ready Flag	0: Reception is in progress, or no received data remains in FRDRHL after successfully completed reception (receive FIFO is empty) 1: Next receive data is not received for a period after successfully completed reception, and when the amount of data stored in the FIFO is equal to or less than the receive triggering number.	R/(W)*1
b1	—	Reserved	The read value is undefined. The write value should be 1.	R/W
b2	TEND	Transmit End Flag	0: A character is being transmitted 1: Character transfer is complete.	R/(W)*1
b3	PER	Parity Error Flag	0: No parity error occurred 1: Parity error occurred.	R/(W)*1
b4	FER	Framing Error Flag	0: No framing error occurred 1: Framing error occurred.	R/(W)*1
b5	ORER	Overrun Error Flag	0: No overrun error occurred 1: Overrun error occurred.	R/(W)*1
b6	RDF	Receive FIFO Data Full Flag	0: The amount of receive data written in FRDRHL is less than the specified receive triggering number 1: The amount of receive data written in FRDRHL is equal to or greater than the specified receive triggering number.	R/(W)*1
b7	TDFE	Transmit FIFO Data Empty Flag	0: The amount of transmit data written in FTDRHL exceeds the specified transmit triggering number 1: The amount of transmit data written in FTDRHL is equal to or less than the specified transmit triggering number.	R/(W)*1

Note 1. Only 0 can be written to clear the flag after reading 1.

The SSR_FIFO register provides the SCI with FIFO mode status flags.

DR flag (Receive Data Ready Flag)

The DR flag indicates that the amount of data stored in the Receive FIFO Data Register (FRDRHL) falls below the specified receive triggering number, and that no next data is received after 15 ETUs (elementary time units) from the last stop bit in asynchronous mode. This flag is valid only in asynchronous mode, including multi-processor mode, and when FIFO operation is selected. In clock synchronous mode, this flag is not set to 1.

[Setting condition]

- When FRDRHL contains less data than the specified receive triggering number, and no next data is received after 15 ETUs*1 from the last stop bit, and the SSR_FIFO.FER and SSR_FIFO.PER flags are 0.

[Clearing conditions]

- When 1 is read from DR, after all received data is read
- When the FCR.FM bit is changed from 0 to 1.

27.2.14 非智能卡接口和FIFO模式的串行状态寄存器(SSR_FIFO)（SCMR.SMIF=0和FCR.FM=1）

Address(es): SCI0.SSR_FIFO 4007 0004h, SCI1.SSR_FIFO 4007 0024h, SCI2.SSR_FIFO 4007 0044h, SCI3.SSR_FIFO 4007 0064h, SCI4.SSR_FIFO 4007 0084h, SCI8.SSR_FIFO 4007 0104h, SCI9.SSR_FIFO 4007 0124h

	b7	b6	b5	b4	b3	b2	b1	b0
	TDFE	RDF	ORER	FER	PER	TEND	—	DR
重置后的值：	1	0	0	0	0	0	x	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	DR	接收数据就绪标志	0：接收中，或者接收成功后FRDRHL中没有接收到的数据（接收FIFO为空）1：接收成功后一段时间内没有接收到下一个接收数据，当FIFO中存储的数据量达到等于或小于接收触发数。	R/(W)*1
b1	—	Reserved	读取值未定义。写入值应为1。	R/W
b2	TEND	发送结束标志	0：正在传输字符1：字符传输完成。	R/(W)*1
b3	PER	奇偶校验错误标志	0：未发生奇偶校验错误1：发生奇偶校验错误。	R/(W)*1
b4	FER	成帧错误标志	0：未发生帧错误1：发生帧错误。	R/(W)*1
b5	ORER	溢出错误标志	0：未发生溢出错误1：发生溢出错误。	R/(W)*1
b6	RDF	接收FIFO数据满标志	0：写入FRDRHL的接收数据量小于指定的接收触发数1：写入FRDRHL的接收数据量为 等于或大于指定的接收触发数。	R/(W)*1
b7	TDFE	发送FIFO数据空标志	0：写入FTDRHL的发送数据量超过指定的发送触发数1：写入FTDRHL的发送数据量等于或小于指定的发送触发数。	R/(W)*1

Note 1. 读1后只能写0清除标志。

SSR_FIFO寄存器为SCI提供FIFO模式状态标志。

DR标志（接收数据就绪标志）

DR标志表示存储在接收FIFO数据寄存器(FRDRHL)中的数据量低于指定的接收触发数，并且在异步模式下从最后一个停止位开始15个ETU（基本时间单位）后没有接收到下一个数据.该标志仅在异步模式（包括多处理器模式）以及选择FIFO操作时有效。在时钟同步模式下，该标志不设置为1。

[Setting condition]

- 当FRDRHL包含的数据少于指定的接收触发数，并且从最后一个停止位开始15个ETU*1后没有接收到下一个数据，并且SSR_FIFO.FER和SSR_FIFO.PER标志为0。

[Clearing conditions]

- 从DR读取1时，在读取所有接收到的数据之后
- 当FCR.FM位从0变为1时。

Note 1. This is equivalent to 1.5 frames in the 8-bit format with one stop bit.
The DR flag is only set to 1 when FIFO is selected in asynchronous mode, including multi-processor mode. It is not set to 1 in other operation modes.

TEND flag (Transmit End Flag)

The TEND flag indicates that FTDRHL does not contain valid data when transmitting the last bit of a serial character, so the transmission is halted.

[Setting condition]

- TEND is set to 1 when FTDRHL does not contain transmit data when the last bit of a 1-byte serial character is transmitted.

[Clearing conditions]

- When transmit data is written to FTDRHL when the SCR.TE bit is 1
- When 0 is written to TEND after 1 is read, when the SCR.TE bit is 1
- When the FCR.FM bit is changed from 0 to 1.

PER flag (Parity Error Flag)

The PER flag indicates whether there is a parity error in the data read from the FRDRHL register in asynchronous mode when the address match function is disabled (DCCR.DCME = 0).

[Setting condition]

- When data is received and a parity error is detected, and the address match function is disabled (DCCR.DCME = 0).

[Clearing condition]

- When 0 is written to PER after 1 is read.

The receive operation is continuous when receive data is stored in the FRDRHL register even when a parity error occurs during reception.

When the SCR.RE bit is set to 0 (serial reception is disabled), the PER flag is not affected and keeps its previous value.

FER flag (Framing Error Flag)

The FER flag indicates whether there is a framing error in the data read from the FRDRHL register in asynchronous mode when the address match function is disabled (DCCR.DCME = 0).

[Setting condition]

- When 0 is sampled as the stop bit during reception and the address match function is disabled (DCCR.DCME = 0).

[Clearing condition]

- When 0 is written to FER after 1 is read.

The receive operation is continuous, and receive data is stored to the FRDRHL register even when a framing error occurs during reception.

When the SCR.RE bit is set to 0 (serial reception is disabled), the FER flag is not affected and keeps its previous value.

ORER flag (Overrun Error Flag)

The ORER flag indicates that the receive operation stopped abnormally because an overrun error occurred.

[Setting condition]

- When the next serial reception completes while the receive FIFO is full with 16-byte receive data.

[Clearing condition]

- When 0 is written to ORER after 1 is read.

When the SCR.RE bit is set to 0 (serial reception is disabled), the ORER flag is not affected and keeps its previous value.

注1.这相当于8位格式的1.5帧，带有一位停止位。
只有在异步模式（包括多处理器模式）下选择FIFO时，DR标志才设置为1。在其他操作模式下不设置为1。

TEND标志（发送结束标志）

TEND标志表明FTDRHL在发送串行字符的最后一位时不包含有效数据，因此暂停发送。

[Setting condition]

- 当发送1字节串行字符的最后一位时，如果FTDRHL不包含发送数据，则TEND设置为1。

[Clearing conditions]

- 当SCR.TE位为1时将发送数据写入FTDRHL
- 读取1后向TEND写入0时，SCR.TE位为1时
- 当FCR.FM位从0变为1时。

PER标志（奇偶校验错误标志）

PER标志指示在禁用地址匹配功能（DCCR.DCME=0）时，异步模式下从FRDRHL寄存器读取的数据是否存在奇偶校验错误。

[Setting condition]

- 当接收到数据并检测到奇偶校验错误时，地址匹配功能被禁用（DCCR.DCME=0）。

[Clearing condition]

- 在读取1后将0写入PER时。

当接收数据存储在FRDRHL寄存器中时，即使在接收过程中发生奇偶校验错误，接收操作也会继续进行。

当SCR.RE位设置为0（禁用串行接收）时，PER标志不受影响并保持其先前的值。

FER标志（帧错误标志）

FER标志指示在禁用地址匹配功能（DCCR.DCME=0）时，异步模式下从FRDRHL寄存器读取的数据是否存在帧错误。

[Setting condition]

- 当在接收期间采样0作为停止位并且地址匹配功能被禁用(DCCR.DCME=0)。

[Clearing condition]

- 在读取1后将0写入FER时。

接收操作是连续的，即使在接收过程中发生帧错误，接收数据也会存储到FRDRHL寄存器中。

当SCR.RE位设置为0（禁用串行接收）时，FER标志不受影响并保持其先前的值。

ORER标志（溢出错误标志）

ORER标志指示接收操作由于发生溢出错误而异常停止。

[Setting condition]

- 当接收FIFO充满16字节接收数据时，下一次串行接收完成。

[Clearing condition]

- 在读取1后将0写入ORER时。

当SCR.RE位设置为0（禁用串行接收）时，ORER标志不受影响并保持其先前的值。

RDF flag (Receive FIFO Data Full Flag)

The RDF flag indicates that receive data is transferred to the FRDRHL register, and the amount of data in FRDRHL is equal to or exceeds the specified receive triggering number. When RTRG is set to 0, the RDF flag is not set even when the amount of data in the receive FIFO is equal to 0.

[Setting condition]

- When the amount of receive data equal to or greater than the specified receive triggering number is stored in FRDRHL,*1 and the FIFO is not empty.

[Clearing conditions]

- When 0 is written to RDF after 1 is read
- When FRDRHL is read by the DMAC or DTC, but only when the block transfer is the last transmission
- When the setting and clearing conditions occur at the same time, the RDF flag is 0. After that, when the amount of data stored in the FRDRHL register is equal to or greater than the RTRG value, RDF is set to 1 after 1 PCLKA.

Note: Do not clear the RDF flag by accessing RDF in the SSR register before reading receive data unless communication is aborted.

Note 1. Because FRDRHL is a 16-stage FIFO register, the maximum amount of data that can be read when RDF is 1 is equivalent to the specified receive triggering number. If an attempt is made to read after all the data in FRDRHL is read, the data is undefined.

TDFE flag (Transmit FIFO Data Empty Flag)

The TDFE flag indicates that when data is transferred from the FTDRHL register into the TSR register, the amount of data in FTDRHL is less than the specified transmit triggering number, and writing of transmit data to FTDRHL is enabled.

[Setting conditions]

- When the TE bit in SCR is 0
- When the amount of transmit data written in FTDRHL is equal to or less than the specified transmit triggering number.*1

[Clearing conditions]

- When writing to FTDRHL is executed on the last transmission while the DMAC or DTC is activated
- When 0 is written to the TDFE flag after 1 is read.
  The setting conditions are given priority when TE = 0. When the setting and clearing conditions occur at the same time, the TDFE flag is 0. After that, when the amount of data stored in the FTDRHL register is equal to or less than the TTRG value, TDFE is set to 1 after 1 PCLKA.

Note: Do not clear the TDFE flag by accessing TDFE in the SSR register before writing transmit data unless communication is aborted.

Note 1. Because the FTDRHL register is a 16-stage FIFO register, the maximum amount of data that can be written when the TDFE flag is set to 1 is 16 minus FDR.T[4:0]. If more data is written, data is discarded.

RDF标志（接收FIFO数据满标志）

RDF标志表示接收数据被传送到FRDRHL寄存器，并且FRDRHL中的数据量等于或超过指定的接收触发数。当RTRG设置为0时，即使接收FIFO中的数据量等于0，RDF标志也不会设置。

[Setting condition]

- 当接收数据量等于或大于指定的接收触发数时存储在FRDRHL *1且FIFO不为空。

[Clearing conditions]

- 读取1后将0写入RDF时
- 当DMAC或DTC读取FRDRHL时，但仅当块传输是最后一次传输时
- 当置位和清零条件同时发生时，RDF标志为0。此后，当FRDRHL寄存器中存储的数据量等于或大于RTRG值时，1个PCLKA后RDF置1。

注意：除非通信中止，否则在读取接收数据之前不要通过访问SSR寄存器中的RDF来清除RDF标志。注1.因为FRDRHL是16级FIFO寄存器，所以当RDF为1时可以读取的最大数据量等于指定的接收触发数。如果在读取FRDRHL中的所有数据后尝试读取，则数据未定义。

TDFE标志（发送FIFO数据空标志）

TDFE标志表示当数据从FTDRHL寄存器传输到TSR寄存器时，FTDRHL中的数据量小于指定的发送触发数，并且允许将发送数据写入FTDRHL。

[Setting conditions]

- 当SCR的TE位为0时
- 当写入FTDRHL的传输数据量等于或小于指定的传输触发数时。*1

[Clearing conditions]

- 当DMAC或DTC被激活时，在最后一次传输上执行写入FTDRHL
- 读取1后向TDFE标志写入0时。
  当TE=0时，设置条件优先。当设置和清除条件同时发生时，TDFE标志为0。之后，当FTDRHL寄存器中存储的数据量等于或小于TTRG时值，TDFE在1个PCLKA之后设置为1。

注意：除非通信中止，否则在写入发送数据之前不要通过访问SSR寄存器中的TDFE来清除TDFE标志。注1.因为FTDRHL寄存器是16级FIFO寄存器，所以TDFE标志设置为1时可写入的最大数据量为16减去FDR.T[4:0]。如果写入更多数据，则丢弃数据。

27.2.15 Serial Status Register for Smart Card Interface Mode (SSR_SMCI) (SCMR.SMIF = 1)

Address(es): SCI0.SSR_SMCI 4007 0004h, SCI1.SSR_SMCI 4007 0024h, SCI2.SSR_SMCI 4007 0044h, SCI3.SSR_SMCI 4007 0064h, SCI4.SSR_SMCI 4007 0084h, SCI8.SSR_SMCI 4007 0104h, SCI9.SSR_SMCI 4007 0124h

	b7	b6	b5	b4	b3	b2	b1	b0
	TDRE	RDRF	ORER	ERS	PER	TEND	MPB	MPBT
Value after reset:	1	0	0	0	0	1	0	0

Bit	Symbol	Bit name	Description	R/W
b0	MPBT	Multi-Processor Bit Transfer	Set this bit to 0 in smart card interface mode	R/W
b1	MPB	Multi-Processor	Set this bit to 0 in smart card interface mode	R
b2	TEND	Transmit End Flag	0: A character is being transmitted 1: Character transfer is complete.	R
b3	PER	Parity Error Flag	0: No parity error occurred 1: Parity error occurred.	R/(W)*1
b4	ERS	Error Signal Status Flag	0: Low error signal is not sampled 1: Low error signal is sampled.	R/(W)*1
b5	ORER	Overrun Error Flag	0: No overrun error occurred 1: Overrun error occurred.	R/(W)*1
b6	RDRF	Receive Data Full Flag	0: No received data in RDR register 1: Received data in RDR register.	R/(W)*1
b7	TDRE	Transmit Data Empty Flag	0: Transmit data in TDR register 1: No transmit data in TDR register.	R/(W)*1

Note 1. Only 0 can be written to clear the flag after 1 is read.

The SSR_SMCI register provides SCI with smart card interface mode status flags.

TEND flag (Transmit End Flag)

When there is no error signal from the receiving side, the TEND flag is set to 1 when more data is ready to be transferred to the TDR register.

[Setting conditions]

- When the SCR_SMCI.TE bit = 0 (serial transmission is disabled). When the SCR_SMCI.TE bit changes from 0 to 1, the TEND flag is not affected and keeps the value 1.
- When a specified period elapses after the latest transmission of 1 byte, the ERS flag is 0, and the TDR register is not updated.

  The set timing is determined by the following register settings:
  - When SMR_SMCI.GM = 0 and SMR_SMCI.BLK = 0, 12.5 ETUs after the start of transmission
  - When SMR_SMCI.GM = 0 and SMR_SMCI.BLK = 1, 11.5 ETUs after the start of transmission
  - When SMR_SMCI.GM = 1 and SMR_SMCI.BLK = 0, 11.0 ETUs after the start of transmission
  - When SMR_SMCI.GM = 1 and SMR_SMCI.BLK = 1, 11.0 ETUs after the start of transmission.

[Clearing conditions]

- When transmit data is written to the TDR register while the SCR_SMCI.TE bit is 1
- When 0 is written to TDRE after 1 is read while the SCR_SMCI.TE bit is 1.

PER flag (Parity Error Flag)

The PER flag indicates that a parity error occurred during reception in asynchronous mode and the reception ended abnormally.

27.2.15 智能卡接口模式的串行状态寄存器(SSR_SMCI)(SCMR.SMIF=1)

Address(es): SCI0.SSR_SMCI 4007 0004h, SCI1.SSR_SMCI 4007 0024h, SCI2.SSR_SMCI 4007 0044h, SCI3.SSR_SMCI 4007 0064h, SCI4.SSR_SMCI 4007 0084h, SCI8.SSR_SMCI 4007 0104h, SCI9.SSR_SMCI 4007 0124h

	b7	b6	b5	b4	b3	b2	b1	b0
	TDRE	RDRF	ORER	ERS	PER	TEND	MPB	MPBT
重置后的值:	1	0	0	0	0	1	0	0

Bit	Symbol	位名称	Description	R/W
b0	MPBT	多处理器位传输	在智能卡接口模式下将此位设置为0	R/W
b1	MPB	Multi-Processor	在智能卡接口模式下将此位设置为0	R
b2	TEND	发送结束标志	0：正在传输字符1：字符传输完成。	R
b3	PER	奇偶校验错误标志	0：未发生奇偶校验错误1：发生奇偶校验错误。	R/(W)*1
b4	ERS	错误信号状态标志	0：不采样低误差信号1：采样低误差信号。	R/(W)*1
b5	ORER	溢出错误标志	0：未发生溢出错误1：发生溢出错误。	R/(W)*1
b6	RDRF	接收数据满标志	0：RDR寄存器中没有接收到数据1：RDR寄存器中接收到数据。	R/(W)*1
b7	TDRE	传输数据空标志	0：在TDR寄存器中发送数据1：在TDR寄存器中不发送数据。	R/(W)*1

Note 1. 读取1后，只能写入0以清除标志。

SSR_SMCI寄存器为SCI提供智能卡接口模式状态标志。

TEND标志（发送结束标志）

当接收端没有错误信号时，当更多数据准备好传输到TDR寄存器时，TEND标志设置为1。

[Setting conditions]

- 当SCR_SMCI.TE位=0时（禁用串行传输）。当SCR_SMCI.TE位由0变为1时，TEND标志不受影响，保持值为1。
- 在最后一次发送1个字节后经过指定时间后，ERS标志为0，并且不更新TDR寄存器。

  设置时序由以下寄存器设置确定：
  - 当SMR_SMCI.GM=0且SMR_SMCI.BLK=0时，传输开始后12.5ETU
  - 当SMR_SMCI.GM=0且SMR_SMCI.BLK=1时，传输开始后11.5ETU
  - 当SMR_SMCI.GM=1且SMR_SMCI.BLK=0时，传输开始后11.0ETU
  - 当SMR_SMCI.GM=1和SMR_SMCI.BLK=1时，传输开始后11.0ETU。

[Clearing conditions]

- 当SCR_SMCI.TE位为1时将发送数据写入TDR寄存器
- 当SCR_SMCI.TE位为1时读取1后将0写入TDRE。

PER标志（奇偶校验错误标志）

PER标志表示在异步模式接收过程中发生奇偶校验错误，接收异常结束。

[Setting condition]

- When a parity error is detected during reception. Although receive data is transferred to RDR when a parity error occurs, no SCIn_RXI interrupt request occurs. After the PER flag is set to 1, the next receive data is not transferred to RDR.

[Clearing condition]

- When 0 is written to PER after 1 is read. After writing 0 to the PER flag, read it to verify that its value is 0.

When the RE bit in SCR_SMCI is set to 0 (serial reception is disabled), the PER flag is not affected and keeps its previous value.

ERS flag (Error Signal Status Flag)

[Setting condition]

- When a low error signal is sampled.

[Clearing condition]

- When 0 is written to the ERS flag after 1 is read.

ORER flag (Overrun Error Flag)

The ORER flag indicates that an overrun error occurred during reception and the reception ended abnormally.

[Setting condition]

- When the next data is received before receive data that does not have a parity error is read from the RDR register. The data received before an overrun error occurred is saved in the RDR, but data received after the overrun error is lost. When the ORER flag is set to 1, receive data is not forwarded to the RDR register.

[Clearing condition]

- When 0 is written to the ORER flag after 1 is read. After writing 0 to the ORER flag, read it to verify that its value is 0.

When the RE bit in SCR_SMCI is set to 0, the ORER flag is not affected and keeps its previous value.

RDRF flag (Receive Data Full Flag)

The RDRF flag indicates the presence of receive data in the RDR register.

[Setting condition]

- When the reception ends normally, and receive data is forwarded from the RSR register to the RDR register.

[Clearing conditions]

- When 0 is written to the RDRF flag after 1 is read
- When data is read from the RDR register.

Note: Do not clear the RDRF flag by accessing RDRF in the SSR register unless communication is aborted.

TDRE flag (Transmit Data Empty Flag)

The TDRE flag indicates the presence of transmit data in the TDR register.

[Setting conditions]

- When the SCR_SMCI.TE bit is 0
- When data is transmitted from the TDR register to the TSR register.

[Clearing conditions]

- When 0 is written to the TDRE flag after 1 is read
- When the SCR_SMCI.TE bit is 1 and data is written to the TDR register.

Note: Do not clear TDRE flag by accessing TDRE in the SSR register unless communication is aborted.

[Setting condition]

- 在接收过程中检测到奇偶校验错误时。尽管发生奇偶校验错误时将接收数据传输到RDR，但不会发生SCIn_RXI中断请求。PER标志设置为1后，下一个接收数据不会传输到RDR。

[Clearing condition]

- 在读取1后将0写入PER时。将0写入PER标志后，读取它以验证其值为0。

当SCR_SMCI中的RE位设置为0（禁用串行接收）时，PER标志不受影响并保持其先前的值。

ERS标志（错误信号状态标志）

[Setting condition]

- 当对低误差信号进行采样时。

[Clearing condition]

- 读取1后将0写入ERS 标志时。

ORER标志（溢出错误标志）

ORER标志表示接收期间发生溢出错误，接收异常结束。

[Setting condition]

- 在从RDR寄存器读取没有奇偶校验错误的接收数据之前接收到下一个数据时。溢出错误发生前接收的数据保存在RDR中，但溢出错误后接收的数据丢失。当ORER标志设置为1时，接收数据不转发到RDR寄存器。

[Clearing condition]

- 在读取1后将0写入ORER标志时。将0写入ORER标志后，读取它以验证其值为0。

当SCR_SMCI中的RE位设置为0时，ORER标志不受影响并保持其先前的值。

RDRF标志（接收数据满标志）

RDRF标志指示RDR寄存器中存在接收数据。

[Setting condition]

- 当接收正常结束时，接收数据从RSR寄存器转发到RDR寄存器。

[Clearing conditions]

- 读取1后向RDRF标志写入0时
- 从RDR寄存器读取数据时。

Note: 除非通信被中止，否则不要通过访问SSR寄存器中的RDRF来清除RDRF标志。

TDRE标志（传输数据空标志）

TDRE标志表示TDR寄存器中存在发送数据。

[Setting conditions]

- 当SCR_SMCI.TE位为0时
- 当数据从TDR寄存器传输到TSR寄存器时。

[Clearing conditions]

- 读取1后向TDRE标志写入0时
- 当SCR_SMCI.TE位为1且数据写入TDR寄存器时。

Note: 除非通信中止，否则不要通过访问SSR寄存器中的TDRE来清除TDRE标志。

27.2.16 Smart Card Mode Register (SCMR)

Address(es): SCI0.SCMR 4007 0006h, SCI1.SCMR 4007 0026h, SCI2.SCMR 4007 0046h, SCI3.SCMR 4007 0066h, SCI4.SCMR 4007 0086h, SCI8.SCMR 4007 0106h, SCI9.SCMR 4007 0126h

	b7	b6	b5	b4	b3	b2	b1	b0
	BCP2	—	—	CHR1	SDIR	SINV	—	SMIF
Value after reset:	1	1	1	1	0	0	1	0

Bit	Symbol	Bit name	Description	R/W
b0	SMIF	Smart Card Interface Mode Select	0: Non-smart card interface mode (asynchronous mode, clock synchronous mode, simple SPI mode, or simple IIC mode) 1: Smart card interface mode.	R/W*1
b1	—	Reserved	This bit is read as 1. The write value should be 1.	R/W
b2	SINV	Transmitted/Received Data Invert	0: TDR register contents are transmitted as is. Receive data is stored as received in the RDR. 1: TDR register contents are inverted before transmitted. Receive data is stored in inverted form in the RDR. This bit can be used in the following modes: • Smart card interface mode • Asynchronous mode including multi-processor mode • Clock synchronous mode • Simple SPI mode. Set this bit to 0 for operation in simple IIC mode.	R/W*1
b3	SDIR	Transmitted/Received Data Transfer Direction	0: Transfer with LSB-first 1: Transfer with MSB-first. This bit can be used in the following modes: • Smart card interface mode • Asynchronous mode including multi-processor mode • Clock synchronous mode • Simple SPI mode. Set this bit to 1 for operation in simple IIC mode.	R/W*1
b4	CHR1	Character Length 1	Valid only in asynchronous mode.*2 Selects the transmit/receive character length in combination with the SMR.CHR bit: CHR1 CHR 0 0: Transmit/receive in 9-bit data length 0 1: Transmit/receive in 9-bit data length 1 0: Transmit/receive in 8-bit data length (initial value) 1 1: Transmit/receive in 7-bit data length.*3	R/W*1
b6, b5	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b7	BCP2	Base Clock Pulse 2	Selects the number of base clock cycles in combination with the SMR_SMCI.BCP[1:0] bits. Table 27.4 lists the combinations of the SCMR.BCP2 and SMR_SMCI.BCP[1:0] bits.	R/W*1

Note 1. Writable only when the TE and RE bits in SCR/SCR_SMCI are 0 (both serial transmission and reception are disabled).
Note 2. The setting is invalid and a fixed data length of 8 bits is used in modes other than asynchronous mode.
Note 3. LSB-first should be selected and the value of the MSB bit [7] in TDR cannot be transmitted.

The SCMR register selects the smart card interface and communication format.

27.2.16 智能卡模式寄存器(SCMR)

Address(es): SCI0.SCMR 4007 0006h, SCI1.SCMR 4007 0026h, SCI2.SCMR 4007 0046h, SCI3.SCMR 4007 0066h, SCI4.SCMR 4007 0086h, SCI8.SCMR 4007 0106h, SCI9.SCMR 4007 0126h

	b7	b6	b5	b4	b3	b2	b1	b0
	BCP2	—	—	CHR1	SDIR	SINV	—	SMIF
重置后的值:	1	1	1	1	0	0	1	0

Bit	Symbol	位名称	Description	R/W
b0	SMIF	智能卡接口模式选择	0：非智能卡接口模式（异步模式，时钟同步模式、简单SPI模式或简单IIC模式）1：智能卡接口模式。	R/W*1
b1	—	Reserved	该位读取为1。写入值应为1。	R/W
b2	SINV	发送接收数据反转	0：TDR寄存器内容按原样发送。接收数据存储在RDR中。1：TDR寄存器内容在发送前反转。接收数据以反转形式存储在RDR中。 该位可用于以下模式： 智能卡接口模式 包括多处理器模式的异步模式 时钟同步模式 简单SPI模式。将此位设置为0以在简单IIC模式下运行。	R/W*1
b3	SDIR	Transmitted/Received Data 转移方向	0：以LSB-first传输1：以MSB-first传输。 该位可用于以下模式： 智能卡接口模式 包括多处理器模式的异步模式 时钟同步模式 简单SPI模式。将该位设置为1以在简单IIC模式下运行。	R/W*1
b4	CHR1	字符长度1	仅在异步模式下有效。*2 结合SMR.CHR位选择发送接收字符长度：CHR1CHR 0 0：以9位数据长度发送接收 0 1：以9位数据长度发送接收 1 0：发送接收8位数据长度（初始值） 1 1：以7位数据长度发送接收。*3	R/W*1
b6, b5	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b7	BCP2	基本时钟脉冲2	结合SMR_SMCI.BCP[1:0]位选择基本时钟周期数。表27.4列出了SCMR.BCP2和SMR_SMCI.BCP[1:0] bits.	R/W*1

Note 1. 仅当SCRSCR_SMCI中的TE和RE位为0时可写（串行发送和接收都被禁用）。
Note 2. 该设置无效，并且在非异步模式下使用了固定的8位数据长度。
Note 3. 应该选择LSB-first并且不能传输TDR中MSB位[7]的值。

SCMR寄存器选择智能卡接口和通信格式。

SMIF bit (Smart Card Interface Mode Select)

Setting the SMIF bit to 1 selects the smart card interface mode. Setting it to 0 selects all other modes as follows:

- Asynchronous mode, including multi-processor mode
- Clock synchronous mode
- Simple SPI mode
- Simple IIC mode.

SINV bit (Transmitted/Received Data Invert)

The SINV bit inverts the transmit/receive data logic level. This bit does not affect the logic level of the parity bit. To invert the parity bit, invert the PM bit in SMR or SMR_SMCI.

CHR1 bit (Character Length 1)

The CHR1 bit selects the data length of transmit/receive data in combination with the CHR bit in SMR.

A fixed data length of 8 bits is used in modes other than asynchronous mode.

BCP2 bit (Base Clock Pulse 2)

The BCP2 bit selects the number of base clock cycles in a 1-bit data transfer time in smart card interface mode. Set this bit in combination with the SMR_SMCI.BCP[1:0] bits.

Table 27.4 Combinations of SCMR.BCP2 bit and SMR_SMCI.BCP[1:0] bits

SCMR.BCP2 bit	SMR_SMCI.BCP[1:0] bits	Number of base clock cycles for 1-bit transfer period
0	00	93 clock cycles (S = 93)*1
0	01	128 clock cycles (S = 128)*1
0	10	186 clock cycles (S = 186)*1
0	11	512 clock cycles (S = 512)*1
1	00	32 clock cycles (S = 32)*1 (initial value)
1	01	64 clock cycles (S = 64)*1
1	10	372 clock cycles (S = 372)*1
1	11	256 clock cycles (S = 256)*1

Note 1. For S, see section 27.2.17, Bit Rate Register (BRR).

27.2.17 Bit Rate Register (BRR)

Address(es): SCI0.BRR 4007 0001h, SCI1.BRR 4007 0021h, SCI2.BRR 4007 0041h, SCI3.BRR 4007 0061h, SCI4.BRR 4007 0081h, SCI8.BRR 4007 0101h, SCI9.BRR 4007 0121h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1

BRR is an 8-bit register that adjusts the bit rate.

As each SCI channel has independent baud rate generator control, different bit rates can be set for each channel. Table 27.5 shows the relationship between the setting (N) and the bit rate (B) in the BRR for asynchronous mode, multi-processor transfer, clock synchronous mode, smart card interface mode, simple SPI mode, and simple IIC mode.

The initial value of the BRR register is FFh. The BRR can be read by the CPU, but can only be written to when the TE and RE bits in SCR/SCR_SMCI are 0.

SMIF位（智能卡接口模式选择）

将SMIF位设置为1选择智能卡接口模式。将其设置为0会选择所有其他模式，如下所示：

- 异步模式，包括多处理器模式
- 时钟同步模式
- 简单SPI模式
- 简单的IIC模式。

SINV位（发送接收数据反转）

SINV位反转发送接收数据逻辑电平。该位不影响奇偶校验位的逻辑电平。要反转奇偶校验位，请反转SMR或SMR_SMCI中的PM位。

CHR1位（字符长度1）

CHR1位结合SMR中的CHR位选择发送接收数据的数据长度。

在异步模式以外的模式中使用8位的固定数据长度。

BCP2位（基本时钟脉冲2）

BCP2位选择智能卡接口模式下1位数据传输时间内的基本时钟周期数。将该位与SMR_SMCI.BCP[1:0]位一起设置。

Table 27.4 SCMR.BCP2位和SMR_SMCI.BCP[1:0]位的组合

SCMR.BCP2 bit	SMR_SMCI.BCP[1:0] bits	1位传输周期的基本时钟周期数
0	00	93个时钟周期(S=93)*1
0	01	128个时钟周期(S=128)*1
0	10	186个时钟周期(S=186)*1
0	11	512个时钟周期(S=512)*1
1	00	32个时钟周期(S=32)*1（初始值）
1	01	64个时钟周期(S=64)*1
1	10	372个时钟周期(S=372)*1
1	11	256个时钟周期(S=256)*1

Note 1. 对于S，请参阅第27.2.17节，比特率寄存器(BRR)。

27.2.17 比特率寄存器(BRR)

Address(es): SCI0.BRR 4007 0001h, SCI1.BRR 4007 0021h, SCI2.BRR 4007 0041h, SCI3.BRR 4007 0061h, SCI4.BRR 4007 0081h, SCI8.BRR 4007 0101h, SCI9.BRR 4007 0121h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	1	1	1	1	1	1	1	1

BRR是一个8位寄存器，用于调整比特率。

由于每个SCI通道都有独立的波特率发生器控制，因此可以为每个通道设置不同的比特率。表27.5显示了异步模式、多处理器传输、时钟同步模式、智能卡接口模式、简单SPI模式和简单IIC模式的BRR中的设置(N)和比特率(B)之间的关系。

BRR寄存器的初始值为FFh。BRR可以被CPU读取，但只能在SCRSCR_SMCI中的TE和RE位为0时写入。

Table 27.5 Relationship between N setting in BRR and bit rate B

Mode	SEMR settings BGDM bit	ABCS bit	ABCSE bit	BRR setting	Error
Asynchro-nous, multi-processor transfer	0	0	0	$N = \frac{PCLKA \times 10^6}{64 \times 2^{2n-1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times 64 \times 2^{2n-1} \times (N+1)} - 1\} \times 100$
	1	0	0	$N = \frac{PCLKA \times 10^6}{32 \times 2^{2n-1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times 32 \times 2^{2n-1} \times (N+1)} - 1\} \times 100$
	0	1	0		
	1	1	0	$N = \frac{PCLKA \times 10^6}{16 \times 2^{2n-1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times 16 \times 2^{2n-1} \times (N+1)} - 1\} \times 100$
	Don't care	Don't care	1	$N = \frac{PCLKA \times 10^6}{12 \times 2^{2n-1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times 12 \times 2^{2n-1} \times (N+1)} - 1\} \times 100$
Clock synchronous, simple SPI				$N = \frac{PCLKA \times 10^6}{8 \times 2^{2n-1} \times B} - 1$	-
Smart card interface				$N = \frac{PCLKA \times 10^6}{S \times 2^{2n+1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times S \times 2^{2n+1} \times (N+1)} - 1\} \times 100$
Simple IIC*1				$N = \frac{PCLKA \times 10^6}{64 \times 2^{2n-1} \times B} - 1$	-

B: Bit rate (bps)
N: BRR setting for on-chip baud rate generator ($0 \le N \le 255$)
PCLKA: Operating frequency (MHz)
n and S: Determined by the SMR/SMR_SMCI and SCMR register settings as listed in Table 27.7 and Table 27.8.

Note 1. Adjust the bit rate so that the high and low-level widths of the SCLn output in simple IIC mode satisfy the I^2C bus standard.

Table 27.6 Calculating widths at high and low level for SCL

Mode	SCL	Formula (result in seconds)
Simple IIC	Width at high level (minimum value)	$(N+1) \times 4 \times 2^{2n-1} \times 7 \times \frac{1}{PCLKA \times 10^6}$
	Width at low level (minimum value)	$(N+1) \times 4 \times 2^{2n-1} \times 8 \times \frac{1}{PCLKA \times 10^6}$

Table 27.7 Clock source settings

SMR or SMR_SMCI.CKS[1:0] bit setting		
CKS[1:0] bits	Clock source	n
0 0	PCLKA clock	0
0 1	PCLKA/4 clock	1
1 0	PCLKA/16 clock	2
1 1	PCLKA/64 clock	3

Table 27.5 BRR中的N设置与比特率B的关系

Mode	SEMR settings BGDM bit	ABCS 位	ABCSE bit	BRR setting	Error
异步、多处理器传输	0	0	0	$N = \frac{PCLKA \times 10^6}{64 \times 2^{2n-1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times 64 \times 2^{2n-1} \times (N+1)} - 1\} \times 100$
	1	0	0	$N = \frac{PCLKA \times 10^6}{32 \times 2^{2n-1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times 32 \times 2^{2n-1} \times (N+1)} - 1\} \times 100$
	0	1	0		
	1	1	0	$N = \frac{PCLKA \times 10^6}{16 \times 2^{2n-1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times 16 \times 2^{2n-1} \times (N+1)} - 1\} \times 100$
	Don't care	Don't care	1	$N = \frac{PCLKA \times 10^6}{12 \times 2^{2n-1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times 12 \times 2^{2n-1} \times (N+1)} - 1\} \times 100$
时钟同步，简单的SPI				$N = \frac{PCLKA \times 10^6}{8 \times 2^{2n-1} \times B} - 1$	-
智能卡接口				$N = \frac{PCLKA \times 10^6}{S \times 2^{2n+1} \times B} - 1$	$Error\ (\%) = \{\frac{PCLKA \times 10^6}{B \times S \times 2^{2n+1} \times (N+1)} - 1\} \times 100$
Simple IIC*1				$N = \frac{PCLKA \times 10^6}{64 \times 2^{2n-1} \times B} - 1$	-

B：比特率（bps）
N：片内波特率发生器的BRR设置(0 N 255)
PCLKA：工作频率(MHz)n和S：由表27.7和表27.8中列出的SMRSMR_SMCI和SCMR寄存器设置决定。

注1.调整比特率，使简单IIC模式下SCLn输出的高低电平宽度满足I2C总线标准。

Table 27.6 计算SCL的高低电平宽度

Mode	SCL	公式（以秒为单位的结果）
Simple IIC	高电平宽度（最小值）	$(N+1) \times 4 \times 2^{2n-1} \times 7 \times \frac{1}{PCLKA \times 10^6}$
	低电平宽度（最小值）	$(N+1) \times 4 \times 2^{2n-1} \times 8 \times \frac{1}{PCLKA \times 10^6}$

Table 27.7 时钟源设置

SMR或SMR_SMCI.CKS[1:0]位设置		
CKS[1:0] bits	时钟源	n
0 0	PCLKA clock	0
0 1	PCLKA/4 clock	1
1 0	PCLKA/16 clock	2
1 1	PCLKA/64 clock	3

Table 27.8 Base clock settings in smart card interface mode

SCMR.BCP2 bit setting	SMR_SMCI.BCP[1:0] bit setting	Base clock cycles for 1-bit period	S
0	0 0	93 clock cycles	93
0	0 1	128 clock cycles	128
0	1 0	186 clock cycles	186
0	1 1	512 clock cycles	512
1	0 0	32 clock cycles	32
1	0 1	64 clock cycles	64
1	1 0	372 clock cycles	372
1	1 1	256 clock cycles	256

Table 27.9 and Table 27.10 list examples of BRR (N) settings in asynchronous mode. Table 27.11 lists the maximum bit rate selectable for each operating frequency. Table 27.15 lists examples of BRR (N) settings in smart card interface mode.

Table 27.17 lists examples of BRR (N) settings in simple IIC mode. In smart card interface mode, the number of base clock cycles S in a 1-bit data transfer time can be selected. For details, see section 27.6.4, Receive Data Sampling Timing and Reception Margin. Table 27.12 and Table 27.14 list the maximum bit rates with external clock input.

When either the Asynchronous Mode Base Clock Select bit (ABCS) or the Baud Rate Generator Double-Speed Mode Select bit (BGDM) in the Serial Extended Mode Register (SEMR) is set to 1 in asynchronous mode, the bit rate becomes twice the value listed in Table 27.16. When both of those bits are set to 1, the bit rate becomes four times the listed value.

Table 27.9 Examples of BRR settings for different bit rates in asynchronous mode (1)

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	8			9.8304			10			12			12.288		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
110	2	141	0.03	2	174	-0.26	2	177	-0.25	2	212	0.03	2	217	0.08
150	2	103	0.16	2	127	0.00	2	129	0.16	2	155	0.16	2	159	0.00
300	1	207	0.16	1	255	0.00	2	64	0.16	2	77	0.16	2	79	0.00
600	1	103	0.16	1	127	0.00	1	129	0.16	1	155	0.16	1	159	0.00
1200	0	207	0.16	0	255	0.00	1	64	0.16	1	77	0.16	1	79	0.00
2400	0	103	0.16	0	127	0.00	0	129	0.16	0	155	0.16	0	159	0.00
4800	0	51	0.16	0	63	0.00	0	64	0.16	0	77	0.16	0	79	0.00
9600	0	25	0.16	0	31	0.00	0	32	-1.36	0	38	0.16	0	39	0.00
19200	0	12	0.16	0	15	0.00	0	15	1.73	0	19	-2.34	0	19	0.00
31250	0	7	0.00	0	9	-1.70	0	9	0.00	0	11	0.00	0	11	2.40
38400	-	-	-	0	7	0.00	0	7	1.73	0	9	-2.34	0	9	0.00

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	14			16			17.2032			18			19.6608		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
110	2	248	-0.17	3	70	0.03	3	75	0.48	3	79	-0.12	3	86	0.31
150	2	181	0.16	2	207	0.16	2	223	0.00	2	233	0.16	2	255	0.00
300	2	90	0.16	2	103	0.16	2	111	0.00	2	116	0.16	2	127	0.00
600	1	181	0.16	1	207	0.16	1	223	0.00	1	233	0.16	1	255	0.00
1200	1	90	0.16	1	103	0.16	1	111	0.00	1	116	0.16	1	127	0.00
2400	0	181	0.16	0	207	0.16	0	223	0.00	0	233	0.16	0	255	0.00
4800	0	90	0.16	0	103	0.16	0	111	0.00	0	116	0.16	0	127	0.00

Table 27.8 智能卡接口模式下的基本时钟设置

SCMR.BCP2位设置	SMR_SMCI.BCP[1:0]位设置	1位周期的基本时钟周期	S
0	0 0	93个时钟周期	93
0	0 1	128个时钟周期	128
0	1 0	186个时钟周期	186
0	1 1	512个时钟周期	512
1	0 0	32个时钟周期	32
1	0 1	64个时钟周期	64
1	1 0	372个时钟周期	372
1	1 1	256个时钟周期	256

表27.9和表27.10列出了异步模式下的BRR(N)设置示例。表27.11列出了每个工作频率可选择的最大比特率。表27.15列出了智能卡接口模式下的BRR(N)设置示例。

表27.17列出了简单IIC模式下的BRR(N)设置示例。在智能卡接口模式下，可以选择1位数据传输时间内的基本时钟周期数S。有关详细信息，请参阅第27.6.4节，接收数据采样时序和接收余量。表27.12和表27.14列出了外部时钟输入的最大比特率。

当异步模式基本时钟选择位(ABCS)或波特率发生器双速模式
串行扩展模式寄存器(SEMR)中的选择位(BGDM)在异步模式下设置为1，比特率变为表27.16中列出的值的两倍。当这两个位都设置为1时，比特率变为所列值的四倍。

Table 27.9 异步模式下不同比特率的BRR设置示例（一）

比特率(bps)	工作频率PCLKA(MHz)														
	8			9.8304			10			12			12.288		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
110	2	141	0.03	2	174	-0.26	2	177	-0.25	2	212	0.03	2	217	0.08
150	2	103	0.16	2	127	0.00	2	129	0.16	2	155	0.16	2	159	0.00
300	1	207	0.16	1	255	0.00	2	64	0.16	2	77	0.16	2	79	0.00
600	1	103	0.16	1	127	0.00	1	129	0.16	1	155	0.16	1	159	0.00
1200	0	207	0.16	0	255	0.00	1	64	0.16	1	77	0.16	1	79	0.00
2400	0	103	0.16	0	127	0.00	0	129	0.16	0	155	0.16	0	159	0.00
4800	0	51	0.16	0	63	0.00	0	64	0.16	0	77	0.16	0	79	0.00
9600	0	25	0.16	0	31	0.00	0	32	-1.36	0	38	0.16	0	39	0.00
19200	0	12	0.16	0	15	0.00	0	15	1.73	0	19	-2.34	0	19	0.00
31250	0	7	0.00	0	9	-1.70	0	9	0.00	0	11	0.00	0	11	2.40
38400	-	-	-	0	7	0.00	0	7	1.73	0	9	-2.34	0	9	0.00

比特率(bps)	工作频率PCLKA(MHz)														
	14			16			17.2032			18			19.6608		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
110	2	248	-0.17	3	70	0.03	3	75	0.48	3	79	-0.12	3	86	0.31
150	2	181	0.16	2	207	0.16	2	223	0.00	2	233	0.16	2	255	0.00
300	2	90	0.16	2	103	0.16	2	111	0.00	2	116	0.16	2	127	0.00
600	1	181	0.16	1	207	0.16	1	223	0.00	1	233	0.16	1	255	0.00
1200	1	90	0.16	1	103	0.16	1	111	0.00	1	116	0.16	1	127	0.00
2400	0	181	0.16	0	207	0.16	0	223	0.00	0	233	0.16	0	255	0.00
4800	0	90	0.16	0	103	0.16	0	111	0.00	0	116	0.16	0	127	0.00

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	14			16			17.2032			18			19.6608		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	45	-0.93	0	51	0.16	0	55	0.00	0	58	-0.69	0	63	0.00
19200	0	22	-0.93	0	25	0.16	0	27	0.00	0	28	1.02	0	31	0.00
31250	0	13	0.00	0	15	0.00	0	16	1.20	0	17	0.00	0	19	-1.70
38400	-	-	-	0	12	0.16	0	13	0.00	0	14	-2.34	0	15	0.00

Note: In this example, SEMR.ABCS = 0, SEMR.ABCSE = 0, and SEMR.BGDM = 0.
When either the ABCS or BGDM bit is set to 1, the bit rate doubles.
When both ABCS and BGDM are set to 1, the bit rate quadruples.

Table 27.10 Examples of BRR settings for different bit rates in asynchronous mode (2)

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	20			25			30			33			40		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
110	3	88	-0.25	3	110	-0.02	3	132	0.13	3	145	0.33	3	177	-0.25
150	3	64	0.16	3	80	0.47	3	97	-0.35	3	106	0.39	3	129	0.16
300	2	129	0.16	2	162	-0.15	2	194	0.16	2	214	-0.07	3	64	0.16
600	2	64	0.16	2	80	0.47	2	97	-0.35	2	106	0.39	2	129	0.16
1200	1	129	0.16	1	162	-0.15	1	194	0.16	1	214	-0.07	2	64	0.16
2400	1	64	0.16	1	80	0.47	1	97	-0.35	1	106	0.39	1	129	0.16
4800	0	129	0.16	0	162	-0.15	0	194	0.16	0	214	-0.07	1	64	0.16
9600	0	64	0.16	0	80	0.47	0	97	-0.35	0	106	0.39	0	129	0.16
19200	0	32	-1.36	0	40	-0.76	0	48	-0.35	0	53	-0.54	0	64	0.16
31250	0	19	0.00	0	24	0.00	0	29	0.00	0	32	0.00	0	39	0.00
38400	0	15	1.73	0	19	1.73	0	23	1.73	0	26	-0.54	0	32	-1.36

Bit rate (bps)	Operating frequency PCLKA (MHz)								
	50			60			120		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
110	3	221	-0.02	-	-	-	-	-	-
150	3	162	-0.15	3	194	0.16	-	-	-
300	3	80	0.47	3	97	-0.35	3	194	0.16
600	2	162	-0.15	3	48	-0.35	3	97	-0.35
1200	2	80	0.47	2	97	-0.35	3	48	-0.35
2400	1	162	-0.15	2	48	-0.35	2	97	-0.35
4800	1	80	0.47	1	97	-0.35	2	48	-0.35
9600	0	162	-0.15	1	48	-0.35	1	97	-0.35
19200	0	80	0.47	0	97	-0.35	1	48	-0.35
31250	0	49	0.00	0	59	0.00	0	119	0
38400	0	40	-0.76	0	48	-0.35	0	97	-0.35

Note: In this example, SEMR.ABCS = 0, SEMR.ABCSE = 0, and SEMR.BGDM = 0.
When either the ABCS or BGDM bit is set to 1, the bit rate doubles.
When both ABCS and BGDM are set to 1, the bit rate quadruples.

比特率(bps)	工作频率PCLKA(MHz)														
	14			16			17.2032			18			19.6608		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	45	-0.93	0	51	0.16	0	55	0.00	0	58	-0.69	0	63	0.00
19200	0	22	-0.93	0	25	0.16	0	27	0.00	0	28	1.02	0	31	0.00
31250	0	13	0.00	0	15	0.00	0	16	1.20	0	17	0.00	0	19	-1.70
38400	-	-	-	0	12	0.16	0	13	0.00	0	14	-2.34	0	15	0.00

Note: 在此示例中，SEMR.ABCS=0、SEMR.ABCSE=0和SEMR.BGDM=0。
当ABCS或BGDM位设置为1时，比特率加倍。当ABCS和BGDM都设置为1时，比特率翻四倍。

Table 27.10 异步模式下不同比特率的BRR设置示例（二）

比特率(bps)	工作频率PCLKA(MHz)														
	20			25			30			33			40		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
110	3	88	-0.25	3	110	-0.02	3	132	0.13	3	145	0.33	3	177	-0.25
150	3	64	0.16	3	80	0.47	3	97	-0.35	3	106	0.39	3	129	0.16
300	2	129	0.16	2	162	-0.15	2	194	0.16	2	214	-0.07	3	64	0.16
600	2	64	0.16	2	80	0.47	2	97	-0.35	2	106	0.39	2	129	0.16
1200	1	129	0.16	1	162	-0.15	1	194	0.16	1	214	-0.07	2	64	0.16
2400	1	64	0.16	1	80	0.47	1	97	-0.35	1	106	0.39	1	129	0.16
4800	0	129	0.16	0	162	-0.15	0	194	0.16	0	214	-0.07	1	64	0.16
9600	0	64	0.16	0	80	0.47	0	97	-0.35	0	106	0.39	0	129	0.16
19200	0	32	-1.36	0	40	-0.76	0	48	-0.35	0	53	-0.54	0	64	0.16
31250	0	19	0.00	0	24	0.00	0	29	0.00	0	32	0.00	0	39	0.00
38400	0	15	1.73	0	19	1.73	0	23	1.73	0	26	-0.54	0	32	-1.36

比特率(bps)	工作频率PCLKA(MHz)								
	50			60			120		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
110	3	221	-0.02	-	-	-	-	-	-
150	3	162	-0.15	3	194	0.16	-	-	-
300	3	80	0.47	3	97	-0.35	3	194	0.16
600	2	162	-0.15	3	48	-0.35	3	97	-0.35
1200	2	80	0.47	2	97	-0.35	3	48	-0.35
2400	1	162	-0.15	2	48	-0.35	2	97	-0.35
4800	1	80	0.47	1	97	-0.35	2	48	-0.35
9600	0	162	-0.15	1	48	-0.35	1	97	-0.35
19200	0	80	0.47	0	97	-0.35	1	48	-0.35
31250	0	49	0.00	0	59	0.00	0	119	0
38400	0	40	-0.76	0	48	-0.35	0	97	-0.35

Note: 在此示例中，SEMR.ABCS=0、SEMR.ABCSE=0和SEMR.BGDM=0。
当ABCS或BGDM位设置为1时，比特率加倍。当ABCS和BGDM都设置为1时，比特率翻四倍。

Table 27.11 Maximum bit rate for each operating frequency in asynchronous mode (1 of 2)

PCLKA (MHz)	SEMR settings					Maximum bit rate (bps)	PCLKA (MHz)	SEMR settings					Maximum bit rate (bps)
	BGDM bit	ABCS bit	ABCSE bit	n	N			BGDM bit	ABCS bit	ABCSE bit	n	N	
8	0	0	0	0	0	250000	16	0	0	0	0	0	500000
		1	0	0	0	500000			1	0	0	0	1000000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1000000			1	0	0	0	2000000
	Don't care	Don't care	1	0	0	1333333		Don't care	Don't care	1	0	0	2666666
9.8304	0	0	0	0	0	307200	17.2032	0	0	0	0	0	537600
		1	0	0	0	614400			1	0	0	0	1075200
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1228800			1	0	0	0	2150400
	Don't care	Don't care	1	0	0	1638400		Don't care	Don't care	1	0	0	2867200
10	0	0	0	0	0	312500	18	0	0	0	0	0	562500
		1	0	0	0	625000			1	0	0	0	1125000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1250000			1	0	0	0	2250000
	Don't care	Don't care	1	0	0	1666666		Don't care	Don't care	1	0	0	3000000
12	0	0	0	0	0	375000	19.6608	0	0	0	0	0	614400
		1	0	0	0	750000			1	0	0	0	1228800
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1500000			1	0	0	0	2457600
	Don't care	Don't care	1	0	0	2000000		Don't care	Don't care	1	0	0	3276800
12.288	0	0	0	0	0	384000	20	0	0	0	0	0	625000
		1	0	0	0	768000			1	0	0	0	1250000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1536000			1	0	0	0	2500000
	Don't care	Don't care	1	0	0	2048000		Don't care	Don't care	1	0	0	3333333
14	0	0	0	0	0	437500	25	0	0	0	0	0	781250
		1	0	0	0	875000			1	0	0	0	1562500
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1750000			1	0	0	0	3125000
	Don't care	Don't care	1	0	0	2333333		Don't care	Don't care	1	0	0	4166666
30	0	0	0	0	0	937500	50	0	0	0	0	0	1562500
		1	0	0	0	1875000			1	0	0	0	3125000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	3750000			1	0	0	0	6250000
	Don't care	Don't care	1	0	0	5000000		Don't care	Don't care	1	0	0	8333333
33	0	0	0	0	0	1031250	60	0	0	0	0	0	1875000
		1	0	0	0	2062500			1	0	0	0	3750000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	4125000			1	0	0	0	7500000
	Don't care	Don't care	1	0	0	5500000		Don't care	Don't care	1	0	0	10000000

Table 27.11 异步模式下每个工作频率的最大比特率（1of2）

PCLKA (MHz)	SEMR settings					最大比特率(bps)	PCLKA (MHz)	SEMR settings					最大比特率(bps)
	BGDM bit	ABCS位	ABCSE bit	n	N			BGDM bit	ABCS位	ABCSE bit	n	N	
8	0	0	0	0	0	250000	16	0	0	0	0	0	500000
		1	0	0	0	500000			1	0	0	0	1000000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1000000			1	0	0	0	2000000
	Don't care	Don't care	1	0	0	1333333		Don't care	Don't care	1	0	0	2666666
9.8304	0	0	0	0	0	307200	17.2032	0	0	0	0	0	537600
		1	0	0	0	614400			1	0	0	0	1075200
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1228800			1	0	0	0	2150400
	Don't care	Don't care	1	0	0	1638400		Don't care	Don't care	1	0	0	2867200
10	0	0	0	0	0	312500	18	0	0	0	0	0	562500
		1	0	0	0	625000			1	0	0	0	1125000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1250000			1	0	0	0	2250000
	Don't care	Don't care	1	0	0	1666666		Don't care	Don't care	1	0	0	3000000
12	0	0	0	0	0	375000	19.6608	0	0	0	0	0	614400
		1	0	0	0	750000			1	0	0	0	1228800
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1500000			1	0	0	0	2457600
	Don't care	Don't care	1	0	0	2000000		Don't care	Don't care	1	0	0	3276800
12.288	0	0	0	0	0	384000	20	0	0	0	0	0	625000
		1	0	0	0	768000			1	0	0	0	1250000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1536000			1	0	0	0	2500000
	Don't care	Don't care	1	0	0	2048000		Don't care	Don't care	1	0	0	3333333
14	0	0	0	0	0	437500	25	0	0	0	0	0	781250
		1	0	0	0	875000			1	0	0	0	1562500
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	1750000			1	0	0	0	3125000
	Don't care	Don't care	1	0	0	2333333		Don't care	Don't care	1	0	0	4166666
30	0	0	0	0	0	937500	50	0	0	0	0	0	1562500
		1	0	0	0	1875000			1	0	0	0	3125000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	3750000			1	0	0	0	6250000
	Don't care	Don't care	1	0	0	5000000		Don't care	Don't care	1	0	0	8333333
33	0	0	0	0	0	1031250	60	0	0	0	0	0	1875000
		1	0	0	0	2062500			1	0	0	0	3750000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	4125000			1	0	0	0	7500000
	Don't care	Don't care	1	0	0	5500000		Don't care	Don't care	1	0	0	10000000

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Table 27.11 Maximum bit rate for each operating frequency in asynchronous mode (2 of 2)

PCLKA (MHz)	SEMR settings					Maximum bit rate (bps)	PCLKA (MHz)	SEMR settings					Maximum bit rate (bps)
	BGDM bit	ABCS bit	ABCSE bit	n	N			BGDM bit	ABCS bit	ABCSE bit	n	N	
40	0	0	0	0	0	1250000	120	0	0	0	0	0	3750000
		1	0	0	0	2500000			1	0	0	0	7500000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	5000000			1	0	0	0	15000000
	Don't care	Don't care	1	0	0	6666666		Don't care	Don't care	1	0	0	20000000

Table 27.12 Maximum bit rate with external clock input in asynchronous mode

PCLKA (MHz)	External input clock (MHz)	Maximum bit rate (bps) SEMR.ABCS bit = 0	SEMR.ABCS bit = 1
8	2.0000	125000	250000
9.8304	2.4576	153600	307200
10	2.5000	156250	312500
12	3.0000	187500	375000
12.288	3.0720	192000	384000
14	3.5000	218750	437500
16	4.0000	250000	500000
17.2032	4.3008	268800	537600
18	4.5000	281250	562500
19.6608	4.9152	307200	614400
20	5.0000	312500	625000
25	6.2500	390625	781250
30	7.5000	468750	937500
33	8.2500	515625	1031250
40	10.0000	625000	1250000
50	12.5000	781250	1562500
60	15.0000	937500	1875000
120	30.0000	1875000	3750000

Table 27.13 BRR settings for different bit rates in clock synchronous and simple SPI modes (1 of 2)

Bit rate (bps)	Operating frequency PCLKA (MHz)																					
	8		10		16		20		25		30		33		40		50		60		120	
	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N
110	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
250	3	124	—	—	3	249	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
500	2	249	—	—	3	124	—	—	x	x	3	233	x	x	x	x	x	x	x	x	x	x
1 k	2	124	—	—	2	249	—	—	3	97	3	116	3	128	3	155	3	194	3	233	x	x
2.5 k	1	199	1	249	2	99	2	124	2	155	2	187	2	205	2	249	3	77	3	93	3	186
5 k	1	99	1	124	1	199	1	249	2	77	2	93	2	102	2	124	2	155	3	46	3	93
10 k	0	199	0	249	1	99	1	124	1	155	1	187	1	205	1	249	2	77	2	93	3	46
25 k	0	79	0	99	0	159	0	199	0	249	1	74	1	82	1	99	1	124	1	149	2	74
50 k	0	39	0	49	0	79	0	99	0	124	0	149	0	164	1	49	1	61	1	74	1	149
100 k	0	19	0	24	0	39	0	49	0	62	0	74	0	82	0	99	0	124	0	149	1	74
250 k	0	7	0	9	0	15	0	19	0	24	0	29	0	32	0	39	0	49	0	59	1	29
500 k	0	3	0	4	0	7	0	9	—	—	0	14	—	—	0	19	0	24	0	29	1	14

Table 27.11 异步模式下每个工作频率的最大比特率（2之2）

PCLKA (MHz)	SEMR settings					最大比特率(bps)	PCLKA (MHz)	SEMR settings					最大比特率(bps)
	BGDM bit	ABCS位	ABCSE bit	n	N			BGDM bit	ABCS位	ABCSE bit	n	N	
40	0	0	0	0	0	1250000	120	0	0	0	0	0	3750000
		1	0	0	0	2500000			1	0	0	0	7500000
	1	0	0	0	0			1	0	0	0	0	
		1	0	0	0	5000000			1	0	0	0	15000000
	Don't care	Don't care	1	0	0	6666666		Don't care	Don't care	1	0	0	20000000

Table 27.12 异步模式下外部时钟输入的最大比特率

PCLKA (MHz)	外部输入时钟(MHz)	最大比特率(bps) SEMR.ABCS bit = 0	SEMR.ABCS bit = 1
8	2.0000	125000	250000
9.8304	2.4576	153600	307200
10	2.5000	156250	312500
12	3.0000	187500	375000
12.288	3.0720	192000	384000
14	3.5000	218750	437500
16	4.0000	250000	500000
17.2032	4.3008	268800	537600
18	4.5000	281250	562500
19.6608	4.9152	307200	614400
20	5.0000	312500	625000
25	6.2500	390625	781250
30	7.5000	468750	937500
33	8.2500	515625	1031250
40	10.0000	625000	1250000
50	12.5000	781250	1562500
60	15.0000	937500	1875000
120	30.0000	1875000	3750000

Table 27.13 时钟同步和简单SPI模式下不同比特率的BRR设置（1of2）

比特率(bps)	工作频率PCLKA(MHz)																					
	8		10		16		20		25		30		33		40		50		60		120	
	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N
110	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
250	3	124	—	—	3	249	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
500	2	249	—	—	3	124	—	—	x	x	3	233	x	x	x	x	x	x	x	x	x	x
1 k	2	124	—	—	2	249	—	—	3	97	3	116	3	128	3	155	3	194	3	233	x	x
2.5 k	1	199	1	249	2	99	2	124	2	155	2	187	2	205	2	249	3	77	3	93	3	186
5 k	1	99	1	124	1	199	1	249	2	77	2	93	2	102	2	124	2	155	3	46	3	93
10 k	0	199	0	249	1	99	1	124	1	155	1	187	1	205	1	249	2	77	2	93	3	46
25 k	0	79	0	99	0	159	0	199	0	249	1	74	1	82	1	99	1	124	1	149	2	74
50 k	0	39	0	49	0	79	0	99	0	124	0	149	0	164	1	49	1	61	1	74	1	149
100 k	0	19	0	24	0	39	0	49	0	62	0	74	0	82	0	99	0	124	0	149	1	74
250 k	0	7	0	9	0	15	0	19	0	24	0	29	0	32	0	39	0	49	0	59	1	29
500 k	0	3	0	4	0	7	0	9	—	—	0	14	—	—	0	19	0	24	0	29	1	14

Table 27.13 BRR settings for different bit rates in clock synchronous and simple SPI modes (2 of 2)

Bit rate (bps)	Operating frequency PCLKA (MHz)																					
	8		10		16		20		25		30		33		40		50		60		120	
	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N
1 M	0	1			0	3	0	4	—	—	—	—	—	—	0	9	—	—	0	14	0	29
2.5 M	x	x	0	0*1	x	x	0	1	—	—	0	2	—	—	0	3	0	4	0	5	0	11
5 M	x	x	x	x	x	x	0	0*1	—	—	—	—	—	—	0	1	—	—	0	2	0	5
7.5 M	x	x	x	x	x	x	x	x	x	x	0	0*1	x	x	x	x	x	x	0	1	0	3
10 M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	0*1	x	x	x	x	0	2

x: Setting prohibited.

—: Can be set, but an error occurs.

Note 1. Continuous transmission or reception is not possible. After transmitting or receiving one frame of data, a 1-bit period elapses before starting to transmit or receive the next frame of data. The output of the synchronization clock is stopped for a 1-bit period. Therefore, it takes 9 bits worth of time to transfer one frame (8 bits) of data, and the average transfer rate is 8/9 times the bit rate. When the FIFO is selected, this setting (BRR = 00h and SMR.CKS[1:0] = 00b) is not available.

Table 27.14 Maximum bit rate with external clock input in clock synchronous mode and simple SPI mode

PCLKA (MHz)	External input clock (MHz)	Maximum bit rate (Mbps)
8	1.3333	1.3333333
10	1.6667	1.6666667
12	2.0000	2.0000000
14	2.3333	2.3333333
16	2.6667	2.6666667
18	3.0000	3.0000000
20	3.3333	3.3333333
25	4.1667	4.1666667
30	5.0000	5.0000000
33	5.5000	5.5000000
40	6.6667	6.6666667
50	8.3333	8.3333333
60	10.0000	10.0000000
120	20.0000 (clock synchronous mode)	20.00000000
	10.0000 (simple SPI mode)	10.00000000

Table 27.15 BRR settings for different bit rates in smart card interface mode, n = 0, S = 372

	Operating frequency PCLKA (MHz)											
	7.1424			10.00			10.7136			13.00		
Bit rate (bps)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	0	0.00	0	1	-30	0	1	-25	0	1	-8.99

	Operating frequency PCLKA (MHz)											
	14.2848			16.00			18.00			20.00		
Bit rate (bps)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	1	0.00	0	1	12.01	0	2	-15.99	0	2	-6.66

	Operating frequency PCLKA (MHz)											
	25.00			30.00			33.00			40.00		
Bit rate (bps)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	3	-12.49	0	3	5.01	0	4	-7.59	0	5	–6.66

Table 27.13 时钟同步和简单SPI模式下不同比特率的BRR设置(2of2)

比特率(bps)	工作频率PCLKA(MHz)																					
	8		10		16		20		25		30		33		40		50		60		120	
	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N
1 M	0	1			0	3	0	4	—	—	—	—	—	—	0	9	—	—	0	14	0	29
2.5 M	x	x	0	0*1	x	x	0	1	—	—	0	2	—	—	0	3	0	4	0	5	0	11
5 M	x	x	x	x	x	x	0	0*1	—	—	—	—	—	—	0	1	—	—	0	2	0	5
7.5 M	x	x	x	x	x	x	x	x	x	x	0	0*1	x	x	x	x	x	x	0	1	0	3
10 M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	0*1	x	x	x	x	0	2

×：禁止设定。—：可以设置，但发
生错误。

Note 1. 无法连续发送或接收。在发送或接收一帧数据后，在开始发送或接收下一帧数据之前会经过1位周期。同步时钟的输出停止1位周期。因此，传输一帧（8位）数据需要9位的时间，平均传输速率为89倍的位速率。选择FIFO时，此设置（BRR=00h且SMR.CKS[1:0]=00b）不可用。

Table 27.14 时钟同步模式和简单SPI模式下外部时钟输入的最大比特率

PCLKA (MHz)	外部输入时钟(MHz)	最大比特率(Mbps)
8	1.3333	1.3333333
10	1.6667	1.6666667
12	2.0000	2.0000000
14	2.3333	2.3333333
16	2.6667	2.6666667
18	3.0000	3.0000000
20	3.3333	3.3333333
25	4.1667	4.1666667
30	5.0000	5.0000000
33	5.5000	5.5000000
40	6.6667	6.6666667
50	8.3333	8.3333333
60	10.0000	10.0000000
120	20.0000 (clock synchronous mode)	20.00000000
	10.0000 (simple SPI mode)	10.00000000

Table 27.15 智能卡接口模式下不同比特率的BRR设置，n=0 S=372

	工作频率PCLKA(MHz)											
	7.1424			10.00			10.7136			13.00		
比特率(bps)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	0	0.00	0	1	-30	0	1	-25	0	1	-8.99

	工作频率PCLKA(MHz)											
	14.2848			16.00			18.00			20.00		
比特率(bps)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	1	0.00	0	1	12.01	0	2	-15.99	0	2	-6.66

	工作频率PCLKA(MHz)											
	25.00			30.00			33.00			40.00		
比特率(bps)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	3	-12.49	0	3	5.01	0	4	-7.59	0	5	–6.66

Bit rate (bps)	Operating frequency PCLKA (MHz)								
	50.00			60.00			120.00		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	6	0.01	0	7	5.01	0	16	–1.17

Table 27.16 Maximum bit rate for each operating frequency in smart card interface mode (S = 32)

PCLKA (MHz)	Maximum bit rate (bps)	n	N
10.00	156250	0	0
10.7136	167400	0	0
13.00	203125	0	0
16.00	250000	0	0
18.00	281250	0	0
20.00	312500	0	0
25.00	390625	0	0
30.00	468750	0	0
33.00	515625	0	0
40.00	625000	0	0
50.00	781250	0	0
60.00	937500	0	0
120.00	1875000	0	0

Table 27.17 BRR settings for different bit rates in simple IIC mode

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	8			10			16			20			25		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
10 k	0	24	0.0	0	30	0.8	1	12	-3.8	1	15	-2.3	1	19	-2.3
25 k	0	9	0.0	0	12	-3.8	1	4	0.0	1	5	4.2	1	7	-2.3
50 k	0	4	0.0	0	5	4.2	1	2	-16.7	1	2	4.2	1	3	-2.3
100 k*1	0	2	-16.7	0	3	-21.9	0	4	0.0	0	6	-10.7	1	1	-2.3
250 k	0	0	0.0	0	0	25	0	1	0.0	0	2	-16.7	0	2	4.2
350 k										0	1	-10.7	0	1	11.6*2
400 k*1										0	1	-21.9	0	1	-2.3*2

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	30			33			40			50			60		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
10 k	1	22	1.9	1	25	-0.8	0	124	0.0	2	9	-2.3	1	46	-0.3
25 k	1	8	4.2	1	9	3.1	0	49	0.0	2	3	-2.3	0	74	0.0
50 k	1	4	-6.3	1	4	3.1	0	24	0.0	2	1	-2.3	0	37	-1.3
100 k*1	1	2	-21.9	1	2	-14.1	0	12	-3.9	1	3	-2.3	0	18	-1.3
250 k	0	3	-6.3	0	3	3.1	0	4	0.0	0	5	4.2	0	7	-6.3
350 k	0	2	-10.7	0	2	-1.8	0	3	-10.7	0	4	-10.7	0	4	7.1
400 k*1	0	1	17.2	0	2	-14.1	0	3	-21.9	0	3	-2.3*2	0	4	-6.3

比特率(bps)	工作频率PCLKA(MHz)								
	50.00			60.00			120.00		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
9600	0	6	0.01	0	7	5.01	0	16	–1.17

Table 27.16 智能卡接口模式下每个工作频率的最大比特率(S=32)

PCLKA (MHz)	最大比特率(bps)	n	N
10.00	156250	0	0
10.7136	167400	0	0
13.00	203125	0	0
16.00	250000	0	0
18.00	281250	0	0
20.00	312500	0	0
25.00	390625	0	0
30.00	468750	0	0
33.00	515625	0	0
40.00	625000	0	0
50.00	781250	0	0
60.00	937500	0	0
120.00	1875000	0	0

Table 27.17 简单IIC模式下不同比特率的BRR设置

比特率(bps)	工作频率PCLKA(MHz)														
	8			10			16			20			25		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
10 k	0	24	0.0	0	30	0.8	1	12	-3.8	1	15	-2.3	1	19	-2.3
25 k	0	9	0.0	0	12	-3.8	1	4	0.0	1	5	4.2	1	7	-2.3
50 k	0	4	0.0	0	5	4.2	1	2	-16.7	1	2	4.2	1	3	-2.3
100 k*1	0	2	-16.7	0	3	-21.9	0	4	0.0	0	6	-10.7	1	1	-2.3
250 k	0	0	0.0	0	0	25	0	1	0.0	0	2	-16.7	0	2	4.2
350 k										0	1	-10.7	0	1	11.6*2
400 k*1										0	1	-21.9	0	1	-2.3*2

比特率(bps)	工作频率PCLKA(MHz)														
	30			33			40			50			60		
	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
10 k	1	22	1.9	1	25	-0.8	0	124	0.0	2	9	-2.3	1	46	-0.3
25 k	1	8	4.2	1	9	3.1	0	49	0.0	2	3	-2.3	0	74	0.0
50 k	1	4	-6.3	1	4	3.1	0	24	0.0	2	1	-2.3	0	37	-1.3
100 k*1	1	2	-21.9	1	2	-14.1	0	12	-3.9	1	3	-2.3	0	18	-1.3
250 k	0	3	-6.3	0	3	3.1	0	4	0.0	0	5	4.2	0	7	-6.3
350 k	0	2	-10.7	0	2	-1.8	0	3	-10.7	0	4	-10.7	0	4	7.1
400 k*1	0	1	17.2	0	2	-14.1	0	3	-21.9	0	3	-2.3*2	0	4	-6.3

Bit rate (bps)	Operating frequency PCLKA (MHz)		
	120		
	n	N	Error (%)
10 k	1	93	-0.3
25 k	0	149	0.0
50 k	0	74	0.0
100 k*1	0	37	-1.3
250 k	0	14	0.0
350 k	0	10	-2.6
400 k*1	0	9	-6.3

Note 1. The bit rate of 100 kbps and 400 kbps indicates the set value at which the error is on the negative side.
Note 2. The minimum value of low width is smaller than 1.3 µs which is the standard value in the fast mode.

Table 27.18 Minimum widths at SCL high and low levels at multiple bit rates in simple IIC mode

Bit rate (bps)	Operating frequency PCLKA (MHz)											
	8			10			16			20		
	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)
10 k	0	24	43.75/50.00	0	30	43.40/49.60	1	12	45.5/52.00	1	15	44.80/51.20
25 k	0	9	17.50/20.00	0	12	18.2/20.80	1	4	17.50/20.00	1	5	16.80/19.20
50 k	0	4	8.75/10.00	0	5	8.40/9.60	1	2	10.50/12.00	1	2	8.40/9.60
100 k	0	2	5.25/6.00	0	3	5.60/6.40	0	4	4.38/5.00	0	6	4.90/5.60
250 k	0	0	1.75/2.00	0	0	1.40/1.60	0	1	1.75/2.00	0	2	2.10/2.40
350 k										0	1	1.40/1.60
400 k										0	1	1.40/1.60

Bit rate (bps)	Operating frequency PCLKA (MHz)											
	25			30			33			40		
	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)
10 k	1	19	44.80/51.20	1	22	42.93/49.60	1	25	44.12/50.42	0	124	43.75/50.00
25 k	1	7	17.92/20.48	1	8	16.80/19.20	1	9	16.97/19.39	0	49	17.50/20.00
50 k	1	3	8.96/10.24	1	4	9.33/10.66	1	4	8.48/9.70	0	24	8.75/10.00
100 k	1	1	4.48/5.12	1	2	5.60/6.40	1	2	5.09/5.82	0	12	4.55/5.20
250 k	0	2	1.68/1.92	0	3	1.86/2.13	0	3	1.70/1.94	0	4	1.75/2.00
350 k	0	1	1.12/1.28*1	0	2	1.40/1.60	0	2	1.27/1.45	0	3	1.40/1.60
400 k	0	1	1.12/1.28*1	0	2	1.40/1.60	0	2	1.27 /1.45	0	3	1.40/1.60

Bit rate (bps)	Operating frequency PCLKA (MHz)								
	50			60			120		
	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)
10 k	2	9	44.80/51.20	1	46	43.87/50.13	1	93	43.87/50.13
25 k	2	3	17.92/20.48	0	74	17.50/20.00	0	149	17.50/20.00
50 k	2	1	8.96/10.24	0	37	8.87/10.13	0	74	8.75/10.00
100 k	1	3	4.48/5.12	0	18	4.43/5.07	0	37	4.43/5.07
250 k	0	5	1.68/1.92	0	7	1.87/2.13	0	14	1.75/2.00

比特率(bps)	工作频率 PCLKA (MHz)		
	120		
	n	N	Error (%)
10 k	1	93	-0.3
25 k	0	149	0.0
50 k	0	74	0.0
100 k*1	0	37	-1.3
250 k	0	14	0.0
350 k	0	10	-2.6
400 k*1	0	9	-6.3

Note 1. 100kbps和400kbps的比特率表示错误在负侧的设定值。
Note 2. 低宽度的最小值小于1.3μs，这是快速模式下的标准值。

Table 27.18 简单IIC模式下多个比特率下SCL高电平和低电平的最小宽度

比特率(bps)	工作频率PCLKA(MHz)											
	8			10			16			20		
	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)
10 k	0	24	43.75/50.00	0	30	43.40/49.60	1	12	45.5/52.00	1	15	44.80/51.20
25 k	0	9	17.50/20.00	0	12	18.2/20.80	1	4	17.50/20.00	1	5	16.80/19.20
50 k	0	4	8.75/10.00	0	5	8.40/9.60	1	2	10.50/12.00	1	2	8.40/9.60
100 k	0	2	5.25/6.00	0	3	5.60/6.40	0	4	4.38/5.00	0	6	4.90/5.60
250 k	0	0	1.75/2.00	0	0	1.40/1.60	0	1	1.75/2.00	0	2	2.10/2.40
350 k										0	1	1.40/1.60
400 k										0	1	1.40/1.60

比特率(bps)	工作频率PCLKA(MHz)											
	25			30			33			40		
	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)
10 k	1	19	44.80/51.20	1	22	42.93/49.60	1	25	44.12/50.42	0	124	43.75/50.00
25 k	1	7	17.92/20.48	1	8	16.80/19.20	1	9	16.97/19.39	0	49	17.50/20.00
50 k	1	3	8.96/10.24	1	4	9.33/10.66	1	4	8.48/9.70	0	24	8.75/10.00
100 k	1	1	4.48/5.12	1	2	5.60/6.40	1	2	5.09/5.82	0	12	4.55/5.20
250 k	0	2	1.68/1.92	0	3	1.86/2.13	0	3	1.70/1.94	0	4	1.75/2.00
350 k	0	1	1.12/1.28*1	0	2	1.40/1.60	0	2	1.27/1.45	0	3	1.40/1.60
400 k	0	1	1.12/1.28*1	0	2	1.40/1.60	0	2	1.27 /1.45	0	3	1.40/1.60

比特率(bps)	工作频率PCLKA(MHz)								
	50			60			120		
	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)
10 k	2	9	44.80/51.20	1	46	43.87/50.13	1	93	43.87/50.13
25 k	2	3	17.92/20.48	0	74	17.50/20.00	0	149	17.50/20.00
50 k	2	1	8.96/10.24	0	37	8.87/10.13	0	74	8.75/10.00
100 k	1	3	4.48/5.12	0	18	4.43/5.07	0	37	4.43/5.07
250 k	0	5	1.68/1.92	0	7	1.87/2.13	0	14	1.75/2.00

Bit rate (bps)	Operating frequency PCLKA (MHz)								
	50			60			120		
	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)	n	N	Min. widths at SCL high/low levels (µs)
350 k	0	4	1.40/1.60	0	4	1.17/1.33	0	10	1.28/1.47
400 k	0	3	1.12/1.28	0	4	1.17/1.33	0	8	1.05/1.20

Note 1. The minimum value of low width is smaller than 1.3 µs which is the standard value of the fast mode. The setting values are the same as in Table 27.17.

27.2.18 Modulation Duty Register (MDDR)

Address(es): SCI0.MDDR 4007 0012h, SCI1.MDDR 4007 0032h, SCI2.MDDR 4007 0052h, SCI3.MDDR 4007 0072h, SCI4.MDDR 4007 0092h, SCI8.MDDR 4007 0112h, SCI9.MDDR 4007 0132h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1

The MDDR register corrects the bit rate adjusted by the BRR register.

When the SEMR.BRME bit is set to 1, the bit rate generated by the on-chip baud rate generator is evenly corrected using the settings in the MDDR register (M/256). Table 27.19 shows the relationship between the MDDR setting (M) and the bit rate (B).

The initial value of the MDDR register is FFh. Bit [7] in this register is fixed to 1. The CPU can read the MDDR register, but the MDDR register is only writable when the TE and RE bits in SCR/SCR_SMCI are 0.

Table 27.19 Relationship between MDDR setting (M) and bit rate (B) when bit rate modulation function is used

Mode	SEMR settings			BRR setting	Error
	BGDM bit	ABCS bit	ABCSE bit		
Asynchronous, multi-processor transfer	0	0	0	$N = \frac{PCLKA \times 10^6}{64 \times 2^{2n-1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times 64 \times 2^{2n-1} \times (256/M) \times (N+1)} - 1\} \times 100$
	1	0	0	$N = \frac{PCLKA \times 10^6}{32 \times 2^{2n-1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times 32 \times 2^{2n-1} \times (256/M) \times (N+1)} - 1\} \times 100$
	0	1	0		
	1	1	0	$N = \frac{PCLKA \times 10^6}{16 \times 2^{2n-1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times 16 \times 2^{2n-1} \times (256/M) \times (N+1)} - 1\} \times 100$
	Don't care	Don't care	1	$N = \frac{PCLKA \times 10^6}{12 \times 2^{2n-1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times 12 \times 2^{2n-1} \times (256/M) \times (N+1)} - 1\} \times 100$
Clock synchronous, simple SPI*1				$N = \frac{PCLKA \times 10^6}{8 \times 2^{2n-1} \times (256/M) \times B} - 1$	-
Smart card interface				$N = \frac{PCLKA \times 10^6}{S \times 2^{2n+1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times S \times 2^{2n+1} \times (256/M) \times (N+1)} - 1\} \times 100$
Simple IIC*2				$N = \frac{PCLKA \times 10^6}{64 \times 2^{2n-1} \times (256/M) \times B} - 1$	-

B: Bit rate (bps)
M: MDDR setting (128 ≤ MDDR ≤ 255)

比特率(bps)	工作频率PCLKA(MHz)								
	50			60			120		
	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)	n	N	分钟。SCL高低电平时的宽度(µs)
350 k	0	4	1.40/1.60	0	4	1.17/1.33	0	10	1.28/1.47
400 k	0	3	1.12/1.28	0	4	1.17/1.33	0	8	1.05/1.20

Note 1. 低宽度的最小值小于1.3µs，这是快速模式的标准值。
设定值与表27.17相同。

27.2.18 调制占空比寄存器(MDDR)

Address(es): SCI0.MDDR 4007 0012h, SCI1.MDDR 4007 0032h, SCI2.MDDR 4007 0052h, SCI3.MDDR 4007 0072h, SCI4.MDDR 4007 0092h, SCI8.MDDR 4007 0112h, SCI9.MDDR 4007 0132h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	1	1	1	1	1	1	1	1

MDDR寄存器校正由BRR寄存器调整的比特率。

当SEMR.BRME位设置为1时，片上波特率发生器生成的比特率使用MDDR寄存器(M256)中的设置进行均匀校正。表27.19显示了MDDR设置(M)和比特率(B)之间的关系。

MDDR寄存器的初始值为FFh。该寄存器中的Bit[7]固定为1。CPU可以读取MDDR寄存器，但MDDR寄存器只有在SCRSCR_SMCI中的TE和RE位为0时才可写。

Table 27.19 使用比特率调制功能时MDDR设置(M)和比特率(B)的关系

Mode	SEMR settings			BRR setting	Error
	BGDM bit	ABCS 位	ABCSE bit		
异步、多处理器传输	0	0	0	$N = \frac{PCLKA \times 10^6}{64 \times 2^{2n-1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times 64 \times 2^{2n-1} \times (256/M) \times (N+1)} - 1\} \times 100$
	1	0	0	$N = \frac{PCLKA \times 10^6}{32 \times 2^{2n-1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times 32 \times 2^{2n-1} \times (256/M) \times (N+1)} - 1\} \times 100$
	0	1	0		
	1	1	0	$N = \frac{PCLKA \times 10^6}{16 \times 2^{2n-1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times 16 \times 2^{2n-1} \times (256/M) \times (N+1)} - 1\} \times 100$
	Don't care	Don't care	1	$N = \frac{PCLKA \times 10^6}{12 \times 2^{2n-1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times 12 \times 2^{2n-1} \times (256/M) \times (N+1)} - 1\} \times 100$
时钟同步，简单SPI*1				$N = \frac{PCLKA \times 10^6}{8 \times 2^{2n-1} \times (256/M) \times B} - 1$	-
智能卡接口				$N = \frac{PCLKA \times 10^6}{S \times 2^{2n+1} \times (256/M) \times B} - 1$	Error (%) $= \{\frac{PCLKA \times 10^6}{B \times S \times 2^{2n+1} \times (256/M) \times (N+1)} - 1\} \times 100$
Simple IIC*2				$N = \frac{PCLKA \times 10^6}{64 \times 2^{2n-1} \times (256/M) \times B} - 1$	-

B：比特率（bps）
M: MDDR setting (128 ≤ MDDR ≤ 255)

N: BRR setting for baud rate generator (0 ≤ N ≤ 255)
PCLKA: Operating frequency (MHz)
n and S: Determined by the SMR/SMR_SMCI and SCMR register settings as listed in Table 27.7 and Table 27.8. See section 27.2.17, Bit Rate Register (BRR) for details.

Note 1. Do not use this function in clock synchronous mode or in the highest speed settings in simple SPI mode (SMR.CKS[1:0] = 00b, SCR.CKE[1] = 0, and BRR = 0).
Note 2. Adjust the bit rate so that the high and low-level widths of the SCL output in simple IIC mode satisfy the I²C standard.

Table 27.20 and Table 27.21 list examples of N settings in BRR and M settings in MDDR in asynchronous mode.

Table 27.20 Examples of BRR and MDDR settings for different bit rates in asynchronous mode (1)

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	8					9.8304					16				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	5	236	0	0.03	0	7	(256)*1	0	0.00	0	10	173	1	-0.01
57600	0	3	236	0	0.03	0	4	240	0	0.00	0	4	236	0	0.03
115200	0	1	236	0	0.03	0	1	192	0	0.00	0	4	236	1	0.03
230400	0	0	236	0	0.03	0	0	192	0	0.00	0	1	189	1	0.14
460800	0	0	236	1	0.03	0	0	192	1	0.00	0	0	189	1	0.14

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	12					12.288					14				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	8	236	0	0.03	0	9	(256)*1	0	0.00	0	16	191	1	0.00
57600	0	5	236	0	0.03	0	4	192	0	0.00	0	13	236	1	0.03
115200	0	2	236	0	0.03	0	4	192	1	0.00	0	6	236	1	0.03
230400	0	2	236	1	0.03	0	2	230	1	-0.17	0	2	202	1	-0.11
460800	0	0	157	1	-0.18	0	0	154	1	-0.26	0	0	135	1	0.14

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	16					17.2032					18				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	11	236	0	0.03	0	13	(256)*1	0	0.00	0	18	166	1	-0.01
57600	0	7	236	0	0.03	0	6	192	0	0.00	0	18	249	1	-0.01
115200	0	3	236	0	0.03	0	6	192	1	0.00	0	8	236	1	0.03
230400	0	1	236	0	0.03	0	3	219	1	-0.20	0	1	210	0	0.14
460800	0	1	236	1	0.03	0	1	219	1	-0.20	0	0	210	0	0.14

Note 1. In this example, the ABCS and ABCSE bits in the SEMR register are 0. SEMR.BRME = 0 (M = 256) disables the bit rate modulation function.

Table 27.21 Examples of BRR and MDDR settings for different bit rates in asynchronous mode (2) (1 of 2)

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	19.6608					20					25				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	15	(256)*2	0	0.00	0	10	173	0	-0.01	0	11	151	0	0.00
57600	0	9	240	0	0.00	0	9	236	0	0.03	0	7	151	0	0.00
115200	0	4	240	0	0.00	0	4	236	0	0.03	0	3	151	0	0.00
230400	0	1	192	0	0.00	0	4	236	1	0.03	0	1	151	0	0.00

N：波特率发生器的BRR设置（0≤N≤255）
PCLKA：工作频率(MHz)n和S：由表27.7和表27.8中列出的SMRSMR_SMCI和SCMR寄存器设置决定。有关详细信息，请参见第27.2.17节，比特率寄存器(BRR)。

Note 1. 请勿在时钟同步模式或简单SPI模式的最高速度设置中使用此功能（SMR.CKS[1:0]=00b，SCR.CKE[1] = 0, and BRR = 0).
Note 2. 调整码率，使简单IIC模式下SCL输出的高低电平宽度满足I2C标准。

表27.20和表27.21列出了异步模式下BRR中的N设置和MDDR中的M设置的示例。

Table 27.20 异步模式下不同比特率的BRR和MDDR设置示例(1)

比特率(bps)	工作频率PCLKA(MHz)														
	8					9.8304					16				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	5	236	0	0.03	0	7	(256)*1	0	0.00	0	10	173	1	-0.01
57600	0	3	236	0	0.03	0	4	240	0	0.00	0	4	236	0	0.03
115200	0	1	236	0	0.03	0	1	192	0	0.00	0	4	236	1	0.03
230400	0	0	236	0	0.03	0	0	192	0	0.00	0	1	189	1	0.14
460800	0	0	236	1	0.03	0	0	192	1	0.00	0	0	189	1	0.14

比特率(bps)	工作频率PCLKA(MHz)														
	12					12.288					14				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	8	236	0	0.03	0	9	(256)*1	0	0.00	0	16	191	1	0.00
57600	0	5	236	0	0.03	0	4	192	0	0.00	0	13	236	1	0.03
115200	0	2	236	0	0.03	0	4	192	1	0.00	0	6	236	1	0.03
230400	0	2	236	1	0.03	0	2	230	1	-0.17	0	2	202	1	-0.11
460800	0	0	157	1	-0.18	0	0	154	1	-0.26	0	0	135	1	0.14

比特率(bps)	工作频率PCLKA(MHz)														
	16					17.2032					18				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	11	236	0	0.03	0	13	(256)*1	0	0.00	0	18	166	1	-0.01
57600	0	7	236	0	0.03	0	6	192	0	0.00	0	18	249	1	-0.01
115200	0	3	236	0	0.03	0	6	192	1	0.00	0	8	236	1	0.03
230400	0	1	236	0	0.03	0	3	219	1	-0.20	0	1	210	0	0.14
460800	0	1	236	1	0.03	0	1	219	1	-0.20	0	0	210	0	0.14

Note 1. 在本例中，SEMR寄存器中的ABCS和ABCSE位为0。SEMR.BRME=0(M=256)禁用比特率调制功能。

Table 27.21 异步模式下不同比特率的BRR和MDDR设置示例(2)(1of2)

比特率(bps)	工作频率PCLKA(MHz)														
	19.6608					20					25				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	15	(256)*2	0	0.00	0	10	173	0	-0.01	0	11	151	0	0.00
57600	0	9	240	0	0.00	0	9	236	0	0.03	0	7	151	0	0.00
115200	0	4	240	0	0.00	0	4	236	0	0.03	0	3	151	0	0.00
230400	0	1	192	0	0.00	0	4	236	1	0.03	0	1	151	0	0.00

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Table 27.21 Examples of BRR and MDDR settings for different bit rates in asynchronous mode (2) (2 of 2)

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	19.6608					20					25				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
460800	0	0	192	0	0.00	0	0	189	0	0.14	0	0	151	0	0.00

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	30					33					40				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	36	194	1	0.01	0	14	143	0	0.01	0	21	173	0	-0.01
57600	0	10	173	0	-0.01	0	9	143	0	0.01	0	38	230	1	-0.01
115200	0	10	173	1	-0.01	0	4	143	0	0.01	0	9	236	0	0.03
230400	0	6	220	1	-0.09	0	4	143	1	0.01	0	4	236	0	0.03
460800	0	3	252	1	0.14	0	1	229	0	0.10	0	4	236	1	0.03

Bit rate (bps)	Operating frequency PCLKA (MHz)														
	50					60					120				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	23	151	0	0.00	0	36	194	0	0.01	0	73	194	0	0.01
57600	0	15	151	0	0.00	0	21	173	0	-0.01	0	58	232	0	0.00
115200	0	7	151	0	0.00	0	10	173	0	-0.01	0	21	173	0	-0.01
230400	0	3	151	0	0.00	0	10	173	1	-0.01	0	10	173	0	-0.01
460800	0	1	151	0	0.00	0	6	220	1	-0.09	0	10	173	1	-0.09

Note 2. In this example, the ABCS and ABCSE bits in the SEMR register are 0. SEMR.BRME = 0 (M = 256) disables the bit rate modulation function.

27.2.19 Serial Extended Mode Register (SEMR)

Address(es): SCI0.SEMR 4007 0007h, SCI1.SEMR 4007 0027h, SCI2.SEMR 4007 0047h, SCI3.SEMR 4007 0067h, SCI4.SEMR 4007 0087h, SCI8.SEMR 4007 0107h, SCI9.SEMR 4007 0127h

	b7	b6	b5	b4	b3	b2	b1	b0
	RXDESEL	BGDM	NFEN	ABCS	ABCSE	BRME	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0, b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b2	BRME	Bit Rate Modulation Enable	0: Bit rate modulation function is disabled 1: Bit rate modulation function is enabled.	R/W*1
b3	ABCSE	Asynchronous Mode Extended Base Clock Select 1	Valid only in asynchronous mode with SCR.CKE[1] = 0: 0: Clock cycle for 1-bit period is determined with combination of BGDM and ABCS bits in the SEMR register 1: Baud rate is 6 base clock cycles for 1-bit period.	R/W*1
b4	ABCS	Asynchronous Mode Base Clock Select	Valid only in asynchronous mode: 0: Selects 16 base clock cycles for 1-bit period 1: Selects 8 base clock cycles for 1-bit period.	R/W*1

Table 27.21 异步模式下不同比特率的BRR和MDDR设置示例(2)(2of2)

比特率(bps)	工作频率PCLKA(MHz)														
	19.6608					20					25				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
460800	0	0	192	0	0.00	0	0	189	0	0.14	0	0	151	0	0.00

比特率(bps)	工作频率PCLKA(MHz)														
	30					33					40				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	36	194	1	0.01	0	14	143	0	0.01	0	21	173	0	-0.01
57600	0	10	173	0	-0.01	0	9	143	0	0.01	0	38	230	1	-0.01
115200	0	10	173	1	-0.01	0	4	143	0	0.01	0	9	236	0	0.03
230400	0	6	220	1	-0.09	0	4	143	1	0.01	0	4	236	0	0.03
460800	0	3	252	1	0.14	0	1	229	0	0.10	0	4	236	1	0.03

比特率(bps)	工作频率PCLKA(MHz)														
	50					60					120				
	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)	n	N	M	BGDM bit	Error (%)
38400	0	23	151	0	0.00	0	36	194	0	0.01	0	73	194	0	0.01
57600	0	15	151	0	0.00	0	21	173	0	-0.01	0	58	232	0	0.00
115200	0	7	151	0	0.00	0	10	173	0	-0.01	0	21	173	0	-0.01
230400	0	3	151	0	0.00	0	10	173	1	-0.01	0	10	173	0	-0.01
460800	0	1	151	0	0.00	0	6	220	1	-0.09	0	10	173	1	-0.09

Note 2. 在本例中，SEMR寄存器中的ABCS和ABCSE位为0。SEMR.BRME=0(M=256)禁用比特率调制功能。

27.2.19 串行扩展模式寄存器(SEMR)

Address(es): SCI0.SEMR 4007 0007h, SCI1.SEMR 4007 0027h, SCI2.SEMR 4007 0047h, SCI3.SEMR 4007 0067h, SCI4.SEMR 4007 0087h, SCI8.SEMR 4007 0107h, SCI9.SEMR 4007 0127h

	b7	b6	b5	b4	b3	b2	b1	b0
	RXDESEL	BGDM	NFEN	ABCS	ABCSE	BRME	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0, b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b2	BRME	比特率调制 Enable	0：码率调制功能关闭1：码率调制功能开启。	R/W*1
b3	ABCSE	异步模式扩展基本时钟 Select 1	仅在SCR.CKE[1]=0的异步模式下有效：0：1位周期的时钟周期由SEMR寄存器中的BGDM和ABCS位组合确定1：波特率为1位的6个基本时钟周期时期。	R/W*1
b4	ABCS	异步模式 基本时钟选择	仅在异步模式下有效：0：为1位周期选择16个基本时钟周期1：为1位周期选择8个基本时钟周期。	R/W*1

Bit	Symbol	Bit name	Description	R/W
b5	NFEN	Digital Noise Filter Function Enable	In asynchronous mode: 0: Noise cancellation function for the RXDn input signal is disabled 1: Noise cancellation function for the RXDn input signal is enabled. In simple IIC mode: 0: Noise cancellation function for the SCLn and SDAn input signals is disabled 1: Noise cancellation function for the SCLn and SDAn input signals is enabled. The NFEN bit must be 0 in all other modes.	R/W*1
b6	BGDM	Baud Rate Generator Double-Speed Mode Select	Valid only in asynchronous mode with SCR.CKE[1] = 0: 0: Baud rate generator outputs the clock with single frequency 1: Baud rate generator outputs the clock with double frequency.	R/W*1
b7	RXDESEL	Asynchronous Start Bit Edge Detection Select	Valid only in asynchronous mode: 0: The low level on the RXDn pin is detected as the start bit 1: A falling edge on the RXDn pin is detected as the start bit.	R/W*1

Note 1. Writable only when the TE and RE bits in SCR/SCR_SMCI are 0 (both serial transmission and reception are disabled).

The SEMR register selects the clock source for a 1-bit period in asynchronous mode.

BRME bit (Bit Rate Modulation Enable)

The BRME bit enables or disables the bit rate modulation function. The bit rate generated by the on-chip baud rate generator is evenly corrected when this function is enabled.

ABCSE bit (Asynchronous Mode Extended Base Clock Select 1)

The ABCSE bit sets the pulse number for the base clock in a 1-bit period to 6, and the double-frequency clock is output from the baud rate generator. When the bit rate is set to 6 while dividing the bus clock frequency, use the ABCSE bit to set SMR.CKS[1:0] to 00b and BRR to 0. Set this bit to 0 except in asynchronous mode.

ABCS bit (Asynchronous Mode Base Clock Select)

The ABCS bit selects the clock cycles for a 1-bit period. Set this bit to 0 except in asynchronous mode.

NFEN bit (Digital Noise Filter Function Enable)

The NFEN bit enables or disables the digital noise filter function.

When the digital noise filter function is enabled:

- Noise cancellation is applied to the RXDn input signal in asynchronous mode
- Noise cancellation is applied to the SDAn and SCLn input signals in simple IIC mode.

In all other modes, set the NFEN bit to 0 to disable the digital noise filter function. When the function is disabled, input signals are transferred as received.

BGDM bit (Baud Rate Generator Double-Speed Mode Select)

The BGDM bit selects the cycle of output clock for the baud rate generator to be either single or double frequency.

This bit is valid when the on-chip baud rate generator is selected as the clock source (SCR.CKE[1] = 0) in asynchronous mode (SMR.CM = 0). The base clock is generated by the clock output from the baud rate generator. When the BGDM bit is set to 1, the base clock cycle is halved and the bit rate is doubled.

Set this bit to 0 in modes other than asynchronous mode.

RXDESEL bit (Asynchronous Start Bit Edge Detection Select)

The RXDSEL bit selects the detection method of the start bit for reception in asynchronous mode. When a break occurs, set this bit to 1 to stop reception, or to start reception without retaining the RXDn pin input at a high level for the period of one data frame or longer after completion of the break.

Set this bit to 0 in modes other than asynchronous mode.

Bit	Symbol	位名称	Description	R/W
b5	NFEN	数字噪声滤波器功能启用	在异步模式下：0：禁用RXDn输入信号的噪声消除功能1：启用RXDn输入信号的噪声消除功能。在简单IIC模式下：0：禁用SCLn和SDAn输入信号的噪声消除功能1：启用SCLn和SDAn输入信号的噪声消除功能。在所有其他模式下，NFEN位必须为0。	R/W*1
b6	BGDM	波特率发生器双速模式选择	仅在SCR.CKE[1]=0的异步模式下有效：0：波特率发生器输出单频时钟1：波特率发生器输出双频时钟。	R/W*1
b7	RXDESEL	异步起始位边沿检测选择	仅在异步模式下有效：0：将RXDn引脚的低电平检测为起始位1：将RXDn引脚的下降沿检测为起始位。	R/W*1

Note 1. 仅当SCRSCR_SMCI中的TE和RE位为0时可写（串行发送和接收都被禁用）。

SEMR寄存器在异步模式下选择1位周期的时钟源。

BRME位（比特率调制使能）

BRME位启用或禁用比特率调制功能。该功能使能时，片内波特率发生器产生的比特率得到均匀校正。

ABCSE位（异步模式扩展基本时钟选择1）

ABCSE位将基本时钟在1位周期内的脉冲数设置为6，并从波特率发生器输出双频时钟。当比特率设置为6并同时分频总线时钟频率时，使用ABCSE位将SMR.CKS[1:0]设置为00b并将BRR设置为0。除异步模式外，将此位设置为0。

ABCS位（异步模式基本时钟选择）

ABCS位选择1位周期的时钟周期。除异步模式外，将此位设置为0。

NFEN位（数字噪声滤波器功能使能）

NFEN位启用或禁用数字噪声滤波器功能。

启用数字噪声滤波器功能时：

- 噪声消除应用于异步模式下的RXDn输入信号
- 噪声消除应用于简单IIC模式下的SDAn和SCLn输入信号。

在所有其他模式下，将NFEN位设置为0以禁用数字噪声滤波器功能。禁用该功能时，输入信号按接收到的方式传输。

BGDM位（波特率发生器双速模式选择）

BGDM位选择波特率发生器的输出时钟周期为单频或双频。

当在异步模式（SMR.CM=0）下选择片内波特率发生器作为时钟源（SCR.CKE[1]=0）时，该位有效。基本时钟由波特率发生器的时钟输出生成。当BGDM位设置为1时，基本时钟周期减半，比特率加倍。

在异步模式以外的模式下将此位设置为0。

RXDESEL位（异步起始位边沿检测选择）

RXDSEL位选择异步模式下接收起始位的检测方法。发生中断时，将该位设置为1以停止接收，或在中断完成后不将RXDn引脚输入保持为高电平的情况下开始接收1个数据帧或更长时间。

在异步模式以外的模式下将此位设置为0。

27.2.20 Noise Filter Setting Register (SNFR)

Address(es): SCI0.SNFR 4007 0008h, SCI1.SNFR 4007 0028h, SCI2.SNFR 4007 0048h, SCI3.SNFR 4007 0068h, SCI4.SNFR 4007 0088h, SCI8.SNFR 4007 0108h, SCI9.SNFR 4007 0128h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	NFCS[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	NFCS[2:0]	Noise Filter Clock Select	In asynchronous mode, the standard setting for the base clock is as follows: b2 b0 0 0 0: The clock signal divided by 1 is used with the noise filter. In simple IIC mode, the standard settings for the clock source of the on-chip baud rate generator selected in the SMR.CKS[1:0] bits are as follows: b2 b0 0 0 1: The clock signal divided by 1 is used with noise filter 0 1 0: The clock signal divided by 2 is used with noise filter 0 1 1: The clock signal divided by 4 is used with noise filter 1 0 0: The clock signal divided by 8 is used with noise filter. Other settings are prohibited.	R/W*1
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. Writing to these bits is only possible when the RE and TE bits in SCR/SCR_SMCI are 0 (serial reception and transmission disabled).

The SNFR register sets the digital noise filter clock.

NFCS[2:0] bits (Noise Filter Clock Select)

The NFCS[2:0] bits select the sampling clock for the digital noise filter. To use the noise filter in asynchronous mode, set these bits to 000b. In simple IIC mode, set the bits to a value in the range from 001b to 100b.

27.2.21 I2C Mode Register 1 (SIMR1)

Address(es): SCI0.SIMR1 4007 0009h, SCI1.SIMR1 4007 0029h, SCI2.SIMR1 4007 0049h, SCI3.SIMR1 4007 0069h, SCI4.SIMR1 4007 0089h, SCI8.SIMR1 4007 0109h, SCI9.SIMR1 4007 0129h

	b7	b6	b5	b4	b3	b2	b1	b0
	IICDL[4:0]					—	—	IICM
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	IICM	Simple IIC Mode Select	SMIF IICM 0 0: Asynchronous mode, multi-processor mode, clock synchronous mode, or simple SPI mode 0 1: Simple IIC mode 1 0: Smart card interface mode 1 1: Setting prohibited.	R/W*1
b2, b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

27.2.20 噪声滤波器设置寄存器(SNFR)

Address(es): SCI0.SNFR 4007 0008h, SCI1.SNFR 4007 0028h, SCI2.SNFR 4007 0048h, SCI3.SNFR 4007 0068h, SCI4.SNFR 4007 0088h, SCI8.SNFR 4007 0108h, SCI9.SNFR 4007 0128h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	NFCS[2:0]		
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	NFCS[2:0]	噪声滤波器时钟选择	在异步模式下，基准时钟的标准设置如下：b2b0000：时钟信号除以1与噪声滤波器一起使用。 在简单IIC模式下，SMR.CKS[1:0]位选择的片内波特率发生器时钟源的标准设置如下：b2b0001：使用时钟信号除以1带噪声滤波器010：时钟信号除以2与噪声滤波器一起使用011：时钟信号除以4与噪声滤波器一起使用100：时钟信号除以8与噪声滤波器一起使用。禁止其他设置。	R/W*1
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 只有当SCRSCR_SMCI中的RE和TE位为0（串行接收和发送禁用）时，才能写入这些位。

SNFR寄存器设置数字噪声滤波器时钟。

NFCS[2:0]位（噪声滤波器时钟选择）

NFCS[2:0]位选择数字噪声滤波器的采样时钟。要在异步模式下使用噪声滤波器，请将这些位设置为000b。在简单IIC模式下，将位设置为001b到100b范围内的值。

27.2.21 I2C模式寄存器1(SIMR1)

Address(es): SCI0.SIMR1 4007 0009h, SCI1.SIMR1 4007 0029h, SCI2.SIMR1 4007 0049h, SCI3.SIMR1 4007 0069h, SCI4.SIMR1 4007 0089h, SCI8.SIMR1 4007 0109h, SCI9.SIMR1 4007 0129h

	b7	b6	b5	b4	b3	b2	b1	b0
	IICDL[4:0]					—	—	IICM
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	IICM	简单IIC模式选择	SMIFIICM00：异步模式、多处理器模式、时钟同步模式或简单SPI模式01：简单IIC模式10：智能卡接口模式11：禁止设置。	R/W*1
b2, b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b7 to b3	IICDL[4:0]	SDA Delay Output Select	The following cycles are of the clock signal from the on-chip baud rate generator: b7 b3 0 0 0 0 0: No output delay 0 0 0 0 1: 0 to 1 cycle 0 0 0 1 0: 1 to 2 cycles 0 0 0 1 1: 2 to 3 cycles 0 0 1 0 0: 3 to 4 cycles 0 0 1 0 1: 4 to 5 cycles : 1 1 1 1 0: 29 to 30 cycles 1 1 1 1 1: 30 to 31 cycles.	R/W*1

Note 1. Writing to these bits is only possible when the RE and TE bits in the SCR register are 0 (both serial transmission and reception are disabled).

SIMR1 selects simple IIC mode and the number of delay stages for the SDAn output.

IICM bit (Simple IIC Mode Select)

In combination with the SMIF bit in SCMR, the IICM bit selects the operating mode.

IICDL[4:0] bits (SDA Delay Output Select)

The IICDL[4:0] bits specify an output delay on the SDAn pin relative to the falling edge of the output on the SCLn pin.

The available delay settings range from no delay to 31 cycles, with the clock signal from the on-chip baud rate generator as the base. The signal obtained by frequency-dividing PCLKA by the divisor set in SMR.CKS[1:0] is supplied as the clock signal from the on-chip baud rate generator. Set these bits to 00000b unless the operation is in simple IIC mode. In simple IIC mode, set the bits to a value in the range from 00001b to 11111b.

27.2.22 I²C Mode Register 2 (SIMR2)

Address(es): SCI0.SIMR2 4007 000Ah, SCI1.SIMR2 4007 002Ah, SCI2.SIMR2 4007 004Ah, SCI3.SIMR2 4007 006Ah, SCI4.SIMR2 4007 008Ah, SCI8.SIMR2 4007 010Ah, SCI9.SIMR2 4007 012Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	IICACKT	—	—	—	IICCSC	IICINTM
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	IICINTM	IIC Interrupt Mode Select	0: Use ACK/NACK interrupts 1: Use reception and transmission interrupts.	R/W*1
b1	IICCSC	Clock Synchronization	0: No synchronization with the clock signal 1: Synchronization with the clock signal.	R/W*1
b4 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b5	IICACKT	ACK Transmission Data	0: ACK transmission 1: NACK transmission and ACK/NACK reception.	R/W
b7, b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. Writing to these bits is only possible when the RE and TE bits in the SCR register are 0 (serial reception and transmission disabled).

SIMR2 selects how reception and transmission are controlled in simple IIC mode.

IICINTM bit (IIC Interrupt Mode Select)

The IICINTM bit selects the sources of interrupt requests in simple IIC mode.

IICCSC bit (Clock Synchronization)

Set the IICCSC bit to 1 to synchronize the internally generated SCLn clock signal when the SCLn pin is driven low

Bit	Symbol	位名称	Description	R/W
b7 to b3	IICDL[4:0]	SDA延迟输出选择	以下周期是来自片内波特率发生器的时钟信号： b7b300000：无输出延迟 00001：0到1个周期00010：1到2个周期00011：2到3个周期00100：3到4个周期循环00101：4到5个循环 ：11110：29至30个周期 11111：30至31个周期。	R/W*1

Note 1. 只有当SCR寄存器中的RE和TE位为0（串行发送和接收都被禁用）时，才能写入这些位。

SIMR1选择简单IIC模式和SDAn输出的延迟级数。

IICM位（简单IIC模式选择）

IICM位结合SCMR中的SMIF位选择工作模式。

IICDL[4:0]位（SDA延迟输出选择）

IICDL[4:0]位指定SDAn引脚上相对于SCLn引脚输出下降沿的输出延迟。

可用的延迟设置范围从无延迟到31个周期，以来自片上波特率发生器的时钟信号为基准。通过在SMR.CKS[1:0]中设置的除数对PCLKA进行分频获得的信号作为来自片上波特率发生器的时钟信号提供。除非操作处于简单IIC模式，否则将这些位设置为00000b。在简单IIC模式下，将位设置为00001b到11111b范围内的值。

27.2.22 I2C模式寄存器2(SIMR2)

Address(es): SCI0.SIMR2 4007 000Ah, SCI1.SIMR2 4007 002Ah, SCI2.SIMR2 4007 004Ah, SCI3.SIMR2 4007 006Ah, SCI4.SIMR2 4007 008Ah, SCI8.SIMR2 4007 010Ah, SCI9.SIMR2 4007 012Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	IICACKT	—	—	—	IICCSC	IICINTM
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	IICINTM	IIC中断模式选择	0：使用ACKNACK中断1：使用接收和发送中断。	R/W*1
b1	IICCSC	时钟同步	0：与时钟信号不同步1：与时钟信号同步。	R/W*1
b4 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b5	IICACKT	ACK传输数据	0：ACK发送1：NACK发送和ACKNACK接收。	R/W
b7, b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 只有当SCR寄存器中的RE和TE位为0（串行接收和发送禁用）时，才能写入这些位。

SIMR2选择在简单IIC模式下如何控制接收和发送。

IICINTM位（IIC中断模式选择）

IICINTM位选择简单IIC模式下的中断请求源。

IICCSC bit (Clock Synchronization)

当SCLn引脚驱动为低电平时，将IICCSC位设置为1以同步内部生成的SCLn时钟信号

because of a wait inserted by another device, for example.

The SCL clock signal is not synchronized if the IICCSC bit is 0. The SCLn clock signal is generated according to the rate selected in the BRR register regardless of the level being input on the SCLn pin.

Set this bit to 1 except during debugging.

IICACKT bit (ACK Transmission Data)

The IICACKT bit transmits data that contains ACK bits. Set this bit to 1 when ACK and NACK bits are received.

27.2.23 I²C Mode Register 3 (SIMR3)

Address(es): SCI0.SIMR3 4007 000Bh, SCI1.SIMR3 4007 002Bh, SCI2.SIMR3 4007 004Bh, SCI3.SIMR3 4007 006Bh, SCI4.SIMR3 4007 008Bh, SCI8.SIMR3 4007 010Bh, SCI9.SIMR3 4007 012Bh

	b7	b6	b5	b4	b3	b2	b1	b0
	IICSCLS[1:0]		IICSDAS[1:0]		IICSTIF	IICSTP REQ	IICRST AREQ	IICSTA REQ
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	IICSTAREQ	Start Condition Generation	0: Do not generate start condition 1: Generate start condition.*1, *3, *5, *6	R/W
b1	IICRSTAREQ	Restart Condition Generation	0: Do not generate restart condition 1: Generate restart condition.*2, *3, *5, *6	R/W
b2	IICSTPREQ	Stop Condition Generation	0: Do not generate stop condition 1: Generate stop condition.*2, *3, *5, *6	R/W
b3	IICSTIF	Issuing of Start, Restart, or Stop Condition Completed Flag	0: No requests are being made for generating conditions, or a condition is being generated 1: Generation of start, restart, or stop condition is complete. When 0 is written to IICSTIF, it is set to 0.*4	R/W*4
b5, b4	IICSDAS[1:0]	SDA Output Select	b5 b4 0 0: Output serial data 0 1: Generate start, restart, or stop condition 1 0: Output low on SDAn pin 1 1: Drive SDAn pin to high-impedance state.	R/W
b7, b6	IICSCLS[1:0]	SCL Output Select	b7 b6 0 0: Output serial clock 0 1: Generate start, restart, or stop condition 1 0: Output low on SCLn pin 1 1: Drive SCLn pin to high-impedance state.	R/W

Note 1. Only generate a start condition after checking the bus state and confirming that the bus is free.
Note 2. Generate a restart or stop condition after checking the bus state and confirming that the bus is busy.
Note 3. Do not set more than one of the IICSTAREQ, IICRSTAREQ, and IICSTPREQ bits to 1 at a given time.
Note 4. Write only 0. When 1 is written, the value is ignored.
Note 5. Execute the generation of a condition after the value of the IICSTIF flag is 0.
Note 6. Do not write 0 to this bit while it is 1. Generation of a condition is suspended by writing 0 to this bit while it is 1.

IICSTAREQ bit (Start Condition Generation)

When a start condition is to be generated, set both IICSDAS[1:0] and IICSCLS[1:0] to 01b in addition to setting the IICSTAREQ bit to 1.

[Setting condition]

- Writing 1 to the bit.

[Clearing condition]

- When generation of a start condition is complete.

例如，由于另一个设备插入了等待。

如果IICCSC位为0，则SCL时钟信号不同步。SCLn时钟信号根据BRR寄存器中选择的速率生成，与SCLn引脚上输入的电平无关。

除调试期间外，将此位设置为1。

IICACKT位（ACK传输数据）

IICACKT位发送包含ACK位的数据。当收到ACK和NACK位时，将该位设置为1。

27.2.23 I2C模式寄存器3(SIMR3)

Address(es): SCI0.SIMR3 4007 000Bh, SCI1.SIMR3 4007 002Bh, SCI2.SIMR3 4007 004Bh, SCI3.SIMR3 4007 006Bh, SCI4.SIMR3 4007 008Bh, SCI8.SIMR3 4007 010Bh, SCI9.SIMR3 4007 012Bh

	b7	b6	b5	b4	b3	b2	b1	b0
	IICSCLS[1:0]		IICSDAS[1:0]		IICSTIF	IICSTP REQ	IICRST AREQ	IICSTA REQ
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	IICSTAREQ	开始条件生成	0：不产生启动条件1：产生启动条件 。 1，*3，*5，*6	R/W
b1	IICRSTAREQ	重启条件 Generation	0：不产生重启条件1：产生重启条件。* 2，*3，*5，*6	R/W
b2	IICSTPREQ	停止条件生成	0：不产生停止条件1：产生停止条件 。*2 *3 *5 *6	R/W
b3	IICSTIF	发出启动、重启或停止条件已完成 Flag	0：没有请求生成条件，或正在生成条件1：开始、重新启动或停止条件的生成已完成。当0写入IICSTIF时，设置为0.*4	R/W*4
b5, b4	IICSDAS[1:0]	SDA输出选择	b5b400：输出串行数据01：产生启动、重启或停止条件10：SDAn引脚1输出低电平1：驱动SDAn引脚为高阻态。	R/W
b7, b6	IICSCLS[1:0]	SCL输出选择	b7b600：输出串行时钟01：产生启动、重启或停止条件10：在SCLn引脚上输出低电平11：将SCLn引脚驱动为高阻态。	R/W

Note 1. 只有在检查总线状态并确认总线空闲后才产生启动条件。
Note 2. 在检查总线状态并确认总线繁忙后生成重新启动或停止条件。
Note 3. 在给定时间，不要将IICSTAREQ、IICRSTAREQ和IICSTPREQ位中的一个以上设置为1。
Note 4. 仅写入0。写入1时，忽略该值。
Note 5. 在IICSTIF标志的值为0后执行条件的生成。
Note 6. 请勿在该位为1时向其写入0。当该位为1时，向该位写入0可暂停条件的生成。

IICSTAREQ位（开始条件生成）

当要产生一个开始条件时，除了设置IICSDAS[1:0]和IICSCLS[1:0]为01b IICSTAREQ位为1。

[Setting condition]

- 向该位写入1。

[Clearing condition]

- 当开始条件的生成完成时。

IICRSTAREQ bit (Restart Condition Generation)

When a restart condition is to be generated, set both the IICSDAS[1:0] and IICSCLS[1:0] bits to 01b in addition to setting the IICRSTAREQ bit to 1.

[Setting condition]

- Writing 1 to the bit.

[Clearing condition]

- When generation of a restart condition is complete.

IICSTPREQ bit (Stop Condition Generation)

When a stop condition is to be generated, set both the IICSDAS[1:0] and IICSCLS[1:0] bits to 01b in addition to setting the IICSTPREQ bit to 1.

[Setting condition]

- Writing 1 to the bit.

[Clearing condition]

- When generation of a stop condition is complete.

IICSTIF flag (Issuing of Start, Restart, or Stop Condition Completed Flag)

After generating a condition, the IICSTIF flag indicates that the condition generation is complete. When using the IICSTAREQ, IICRSTAREQ, or IICSTPREQ bit to cause generation of a condition, do so after setting the IICSTIF flag to 0.

When the IICSTIF flag is 1 while an interrupt request is enabled by setting the SCR.TEIE bit, an STI request is output.

[Setting condition]

- When generation of a start, restart, or stop condition completes. If the setting condition conflicts with any of the clearing conditions for the flag, the clearing condition takes precedence.

[Clearing conditions]

- Writing 0 to the bit, then confirm that the IICSTIF flag is 0.
- Writing 0 to the SIMR1.IICM bit when operation is not in simple IIC mode
- Writing 0 to the SCR.TE bit.

IICSDAS[1:0] bits (SDA Output Select)

The IICSDAS[1:0] bits control output from the SDAn pin. Set the IICSDAS[1:0] and IICSCLS[1:0] bits to the same value.

IICSCLS[1:0] bits (SCL Output Select)

The IICSCLS[1:0] bits control output from the SCLn pin. Set the IICSCLS[1:0] and IICSDAS[1:0] bits to the same value.

IICRSTAREQ位（重启条件生成）

当要产生重启条件时，除了将IICRSTAREQ位设置为1之外，将IICSDAS[1:0]和IICSCLS[1:0]位都设置为01b。

[Setting condition]

- 向该位写入1。

[Clearing condition]

- 当重新启动条件的生成完成时。

IICSTPREQ位（停止条件生成）

当要产生停止条件时，除了将IICSTPREQ位设置为1之外，还将IICSDAS[1:0]和IICSCLS[1:0]位设置为01b。

[Setting condition]

- 向该位写入1。

[Clearing condition]

- 当停止条件的生成完成时。

IICSTIF标志（发出启动、重启或停止条件完成标志）

生成条件后，IICSTIF标志指示条件生成完成。使用时IICSTAREQ、IICRSTAREQ或IICSTPREQ位会导致条件生成，请在将IICSTIF标志设置为0后执行此操作。

当IICSTIF标志为1且通过设置SCR.TEIE位使能中断请求时，输出STI请求。

[Setting condition]

- 当启动、重新启动或停止条件的生成完成时。如果设置条件与标志的任何清除条件冲突，则清除条件优先。

[Clearing conditions]

- 将0写入该位，然后确认IICSTIF标志为0。
- 非简单IIC模式下向SIMR1.IICM位写入0
- 将0写入SCR.TE位。

IICSDAS[1:0]位（SDA输出选择）

IICSDAS[1:0]位控制SDAn引脚的输出。将IICSDAS[1:0]和IICSCLS[1:0]位设置为相同的值。

IICSCLS[1:0]位（SCL输出选择）

IICSCLS[1:0]位控制SCLn引脚的输出。将IICSCLS[1:0]和IICSDAS[1:0]位设置为相同的值。

27.2.24 I²C Status Register (SISR)

Address(es): SCI0.SISR 4007 000Ch, SCI1.SISR 4007 002Ch, SCI2.SISR 4007 004Ch, SCI3.SISR 4007 006Ch, SCI4.SISR 4007 008Ch, SCI8.SISR 4007 010Ch, SCI9.SISR 4007 012Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	IICACKR
Value after reset:	0	0	x	x	0	x	0	0

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b0	IICACKR	ACK Reception Data Flag	0: ACK received 1: NACK received.	R
b1	—	Reserved	This bit is read as 0	R
b2	—	Reserved	The read value is undefined	R
b3	—	Reserved	This bit is read as 0	R
b5, b4	—	Reserved	The read value is undefined	R
b7, b6	—	Reserved	These bits are read as 0	R

SISR monitors the state in simple IIC mode.

IICACKR flag (ACK Reception Data Flag)

Received ACK and NACK bits can be read from the IICACKR flag. This flag is updated on the rising edge of the SCLn clock for the received ACK/NACK bit.

27.2.25 SPI Mode Register (SPMR)

Address(es): SCI0.SPMR 4007 000Dh, SCI1.SPMR 4007 002Dh, SCI2.SPMR 4007 004Dh, SCI3.SCI3 4007 006Dh, SCI4.SPMR 4007 008Dh, SCI8.SPMR 4007 010Dh, SCI9.SPMR 4007 012Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	CKPH	CKPOL	—	MFF	—	MSS	CTSE	SSE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SSE	SSn Pin Function Enable	0: SSn pin function is disabled 1: SSn pin function is enabled.	R/W*1
b1	CTSE	CTS Enable	0: CTS function is disabled (RTS output function is enabled) 1: CTS function is enabled.	R/W*1
b2	MSS	Master Slave Select	0: Transmission is through the TXDn pin and reception is through the RXDn pin (master mode) 1: Reception is through the TXDn pin and transmission is through the RXDn pin (slave mode).	R/W*1
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	MFF	Mode Fault Flag	0: No mode fault error 1: Mode fault error.	R/W*2
b5	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6	CKPOL	Clock Polarity Select	0: Clock polarity is not inverted 1: Clock polarity is inverted.	R/W*1
b7	CKPH	Clock Phase Select	0: Clock is not delayed 1: Clock is delayed.	R/W*1

Note 1. Writing to these bits is only possible when the RE and TE bits in the SCR register are 0 (both serial transmission and reception

27.2.24 I2C状态寄存器(SISR)

Address(es): SCI0.SISR 4007 000Ch, SCI1.SISR 4007 002Ch, SCI2.SISR 4007 004Ch, SCI3.SISR 4007 006Ch, SCI4.SISR 4007 008Ch, SCI8.SISR 4007 010Ch, SCI9.SISR 4007 012Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	IICACKR
重置后的值:	0	0	x	x	0	x	0	0

x: Undefined

Bit	Symbol	位名称	Description	R/W
b0	IICACKR	ACK接收数据标志	0：收到ACK1：收到NACK。	R
b1	—	Reserved	该位读为0	R
b2	—	Reserved	读取值未定义	R
b3	—	Reserved	该位读为0	R
b5, b4	—	Reserved	读取值未定义	R
b7, b6	—	Reserved	这些位被读为0	R

SISR在简单IIC模式下监控状态。

IICACKR标志（ACK接收数据标志）

接收到的ACK和NACK位可以从IICACKR标志中读取。该标志在接收到的ACKNACK位的SCLn时钟的上升沿更新。

27.2.25 SPI模式寄存器(SPMR)

Address(es): SCI0.SPMR 4007 000Dh, SCI1.SPMR 4007 002Dh, SCI2.SPMR 4007 004Dh, SCI3.SCI3 4007 006Dh, SCI4.SPMR 4007 008Dh, SCI8.SPMR 4007 010Dh, SCI9.SPMR 4007 012Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	CKPH	CKPOL	—	MFF	—	MSS	CTSE	SSE
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SSE	SSn引脚功能使能	0：禁用SSn引脚功能1：启用SSn引脚功能。	R/W*1
b1	CTSE	CTS Enable	0：CTS功能无效（RTS输出功能有效）1：CTS功能有效。	R/W*1
b2	MSS	主从选择	0：通过TXDn引脚发送，通过RXDn引脚接收（主模式）1：通过TXDn引脚接收，通过RXDn引脚发送（从模式）。	R/W*1
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	MFF	模式故障标志	0：无模式故障错误1：模式故障错误。	R/W*2
b5	—	Reserved	该位读取为0。写入值应为0。	R/W
b6	CKPOL	时钟极性选择	0：时钟极性不反转1：时钟极性反转。	R/W*1
b7	CKPH	时钟相位选择	0：时钟不延迟1：时钟延迟。	R/W*1

Note 1. 仅当SCR寄存器中的RE和TE位为0时才可以写入这些位（串行发送和接收

are disabled).
Note 2. Only 0 can be written to this bit to clear the flag.

The SPMR register selects settings for simple SPI mode.

SSE bit (SSn Pin Function Enable)

Set the SSE bit to 1 to use the SSn pin to control transmission and reception in simple SPI mode. Set this bit to 0 in all other modes. When master mode is selected (SCR.CKE[1:0] = 00b and SPMR.MSS = 0) and there is a single master, the SSn pin on the master side is not required to control reception and transmission. In such a case, set the SSE bit to 0. Do not set both the SSE and CTSE bits to 1 as the operation is the same as that when these bits are set to 0.

CTSE bit (CTS Enable)

Set the CTSE bit to 1 to use the SSn pin to input the CTS control signal for controlling transmission and reception. The RTS signal is output when this bit is set to 0. Set this bit to 0 in smart card interface mode, simple SPI mode, and simple IIC mode. Do not set both the CTSE and SSE bits to 1 as the operation is the same as that when these bits are set to 0.

MSS bit (Master Slave Select)

The MSS bit selects between master or slave operation in simple SPI mode. The functions of the TXDn and RXDn pins are reversed when this bit is set to 1, so that data is received through the TXDn pin and transmitted through the RXDn pin. Set this bit to 0 in modes other than simple SPI mode.

MFF flag (Mode Fault Flag)

The MFF flag indicates mode fault errors. In a multi-master configuration, determine the mode fault error occurrence by reading this flag.

[Setting condition]

- When input on the SSn pin is low during master operation in simple SPI mode (SSE bit = 1 and MSS bit = 0).

[Clearing condition]

- Writing 0 to the bit after 1 is read.

CKPOL bit (Clock Polarity Select)

The CKPOL bit selects the polarity of the clock signal output through the SCKn pin. See Figure 27.70 for details. Set the CKPOL bit to 0 in modes other than simple SPI mode and clock synchronous mode.

CKPH bit (Clock Phase Select)

The CKPH bit selects the phase of the clock signal output through the SCKn pin. See Figure 27.70 for details. Set the CKPH bit to 0 in modes other than simple SPI mode and clock synchronous mode.

27.2.26 FIFO Control Register (FCR)

Address(es): SCI0.FCR 4007 0014h, SCI1.FCR 4007 0034h, SCI2.FCR 4007 0054h, SCI3.FCR 4007 0074h, SCI4.FCR 4007 0094h, SCI8.FCR 4007 0114h, SCI9.FCR 4007 0134h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	RSTRG[3:0]				RTRG[3:0]				TTRG[3:0]				DRES	TFRST	RFRST	FM
Value after reset:	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	FM	FIFO Mode Select	Valid only in asynchronous mode, including multi-processor or clock synchronous mode: 0: Non-FIFO mode. Selects TDR/RDR or TDRHL/RDRHL for communication. 1: FIFO mode. Selects FTDRHL/FRDRHL for communication.	R/W*1

are disabled).
Note 2. 只能向该位写入0以清除标志。

SPMR寄存器选择简单SPI模式的设置。

SSE位（SSn引脚功能使能）

将SSE位设置为1以使用SSn引脚控制简单SPI模式下的发送和接收。在所有其他模式下将此位设置为0。Whenmastermodeisselected(SCR.CKE[1:0]=00bandSPMR.MSS=0)andthereisasinglemaster theSSnpinonthemastersideisnotrequiredtocontrolreceptionandtransmission.在这种情况下，请将SSE位设置为0。不要将SSE和CTSE位都设置为1，因为操作与将这些位设置为0时的操作相同。

CTSE位（CTS使能）

将CTSE位设置为1以使用SSn引脚输入CTS控制信号以控制发送和接收。该位设置为0时输出RTS信号。在智能卡接口模式、简单SPI模式和简单模式下设置该位为0
IIC模式。不要将CTSE和SSE位都设置为1，因为操作与将这些位设置为0时的操作相同。

MSS位（主从选择）

MSS位在简单SPI模式下选择主操作或从操作。当该位设置为1时，TXDn和RXDn引脚的功能相反，因此数据通过TXDn引脚接收并通过RXDn引脚发送。在简单SPI模式以外的模式下将此位设置为0。

MFF标志（模式故障标志）

MFF标志指示模式故障错误。在多主机配置中，通过读取该标志确定模式故障错误发生。

[Setting condition]

- 在简单SPI模式（SSE位=1和MSS位=0）下主机操作期间SSn引脚上的输入为低电平时。

[Clearing condition]

- 读取1后向该位写入0。

CKPOL位（时钟极性选择）

CKPOL位选择通过SCKn引脚输出的时钟信号的极性。详见图27.70。设置在简单SPI模式和时钟同步模式以外的模式下，CKPOL位为0。

CKPH位（时钟相位选择）

CKPH位选择通过SCKn引脚输出的时钟信号的相位。详见图27.70。设置在简单SPI模式和时钟同步模式以外的模式下，CKPH位为0。

27.2.26 先进先出控制寄存器(FCR)

Address(es): SCI0.FCR 4007 0014h, SCI1.FCR 4007 0034h, SCI2.FCR 4007 0054h, SCI3.FCR 4007 0074h, SCI4.FCR 4007 0094h, SCI8.FCR 4007 0114h, SCI9.FCR 4007 0134h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	RSTRG[3:0]				RTRG[3:0]				TTRG[3:0]				DRES	TFRST	RFRST	FM
重置后的值：	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	FM	先进先出模式选择	仅在异步模式下有效，包括多处理器或时钟同步模式：0：非FIFO模式。 选择TDRRDR或TDRHLRDRHL进行通信。1：先进先出模式。 选择FTDRHLFRDRHL进行通信。	R/W*1

Bit	Symbol	Bit name	Description	R/W
b1	RFRST	Receive FIFO Data Register Reset	Valid only when FCR.FM = 1: 0: Do not reset FRDRHL 1: Reset FRDRHL.	R/W
b2	TFRST	Transmit FIFO Data Register Reset	Valid only when FCR.FM = 1: 0: Do not reset FTDRHL 1: Reset FTDRHL.	R/W
b3	DRES	Receive Data Ready Error Select Bit	Selects the interrupt request when detecting a receive data ready: 0: Receive data full interrupt (SCIn_RXI) 1: Receive error interrupt (SCIn_ERI).	R/W
b7 to b4	TTRG[3:0]	Transmit FIFO Data Trigger Number	Valid only in asynchronous mode, including multi-processor or clock synchronous mode: 0000: Trigger number 0 : 1111: Trigger number 15.	R/W
b11 to b8	RTRG[3:0]	Receive FIFO Data Trigger Number	Valid only in asynchronous mode, including multi-processor or clock synchronous mode: 0000: Trigger number 0 : 1111: Trigger number 15.	R/W
b15 to b12	RSTRG[3:0]	RTS Output Active Trigger Number Select	Valid only in asynchronous mode, including multi-processor or clock synchronous mode, while FCR.FM = 1, SPMR.CTSE = 0, and SPMR.SSE = 0: 0000: Trigger number 0 : 1111: Trigger number 15.	R/W

Note 1. Writable only when TE = 0 and RE = 0.

FCR selects the FIFO mode, resets FTDRHL/FRDRHL, selects the FIFO data trigger number for transmission/reception, and selects the RTS output active trigger number.

FM bit (FIFO Mode Select)

When the FM bit is set to 1, FTDRHL and FRDRHL are selected for communication. When the FM bit is set to 0, TDR and RDR, or TDRHL and RDRHL are selected for communication.

RFRST bit (Receive FIFO Data Register Reset)

When the RFRST bit is set to 1, the FRDRHL register is reset, and the receive data count is reset to 0. When 1 is written to the RFRST bit, it is set to 0 after 1 PCLKA.

TFRST bit (Transmit FIFO Data Register Reset)

When the TFRST bit is set to 1, the FTDRHL register is reset, and the transmit data count is reset to 0. When 1 is written to the TFRST bit, it is set to 0 after 1 PCLKA.

DRES bit (Receive Data Ready Error Select Bit)

On detecting a receive data ready error, the DRES bit selects between an SCIn_RXI interrupt request or an SCIn_ERI interrupt request. Set the DRES bit to 1 when starting the DMAC or DTC and reading from the FRDRH and FRDRL registers.

TTRG[3:0] bits (Transmit FIFO Data Trigger Number)

The TDFE flag is set to 1 when the amount of transmit data in FTDRHL is equal to or less than the transmit triggering number specified in the TTRG[3:0] bits, and software can write data to FTDRHL. If SCR.TIE = 1, an SCIn_TXI interrupt request occurs.

RTRG[3:0] bits (Receive FIFO Data Trigger Number)

The RDF flag is set to 1 when the amount of receive data in FRDRHL is equal to or greater than the specified receive triggering number specified in the RTRG[3:0] bits, and software can read data from FRDRHL. If SCR.RIE = 1, an SCIn_RXI interrupt request occurs.

When RTRG[3:0] is set to 0, the RDF flag is not set even when the amount of data in the receive FIFO is equal to 0, and an SCIn_RXI interrupt does not occur.

Bit	Symbol	位名称	Description	R/W
b1	RFRST	接收FIFO数据寄存器 Reset	仅在FCR.FM=1时有效：0：不复位FRDRHL1：复位FRDRHL。	R/W
b2	TFRST	发送FIFO数据注册重置	仅当FCR.FM=1时有效：0：不复位FTDRHL1：复位FTDRHL。	R/W
b3	DRES	接收数据就绪错误选择位	检测到接收数据就绪时选择中断请求：0：接收数据满中断（SCIn_RXI）1：接收错误中断（SCIn_ERI）。	R/W
b7 to b4	TTRG[3:0]	发送FIFO数据触发 Number	仅在异步模式下有效，包括多处理器或时钟同步模式：0000：触发编号0 :1111:触发器编号15。	R/W
b11 to b8	RTRG[3:0]	接收FIFO数据触发 Number	仅在异步模式下有效，包括多处理器或时钟同步模式：0000：触发编号0 :1111:触发器编号15。	R/W
b15 to b12	RSTRG[3:0]	RTS输出有源触发号码选择	仅在异步模式下有效，包括多处理器或时钟同步模式，同时FCR.FM=1，SPMR.CTSE=0，和SPMR.SSE=0：0000：触发编号0 :1111:触发器编号15。	R/W

Note 1. 仅当TE=0且RE=0时可写。

FCR选择FIFO模式，复位FTDRHLFRDRHL，选择发送接收的FIFO数据触发数，选择RTS输出激活触发数。

FM位（FIFO模式选择）

当FM位设置为1时，选择FTDRHL和FRDRHL进行通信。当FM位设置为0时，选择TDR和RDR，或TDRHL和RDRHL进行通信。

RFRST位（接收FIFO数据寄存器复位）

当RFRST位设置为1时，FRDRHL寄存器复位，接收数据计数复位为0。当RFRST位写入1时，1个PCLKA后设置为0。

TFRST位（发送FIFO数据寄存器复位）

当TFRST位设置为1时，FTDRHL寄存器复位，发送数据计数复位为0。当TFRST位写入1时，经过1个PCLKA后设置为0。

DRES位（接收数据就绪错误选择位）

在检测到接收数据就绪错误时，DRES位在SCIn_RXI中断请求或SCIn_ERI中断请求之间进行选择。启动DMAC或DTC并读取FRDRH和FRDRL寄存器时，将DRES位设置为1。

TTRG[3:0]位（发送FIFO数据触发数）

当FTDRHL中的发送数据量等于或小于TTRG[3:0]位中指定的发送触发数时，TDFE标志设置为1，并且软件可以将数据写入FTDRHL。如果SCR.TIE=1，则发生SCIn_TXI中断请求。

RTRG[3:0]位（接收FIFO数据触发数）

当FRDRHL中的接收数据量等于或大于RTRG[3:0]位中指定的指定接收触发数时，RDF标志设置为1，并且软件可以从FRDRHL中读取数据。如果SCR.RIE=1，则发生SCIn_RXI中断请求。

当RTRG[3:0]设置为0时，即使接收FIFO中的数据量等于0，也不会设置RDF标志，并且不会发生SCIn_RXI中断。

RSTRG[3:0] bits (RTS Output Active Trigger Number Select)

When the amount of receive data stored in FRDRHL is equal to or greater than the receive triggering number specified in the RSTRG[3:0] bits, the RTS signal goes high.

When RSTRG[3:0] is 0, the RTS signal does not go high even when the amount of data in FRDRHL is equal to 0.

27.2.27 FIFO Data Count Register (FDR)

Address(es): SCI0.FDR 4007 0016h, SCI1.FDR 4007 0036h, SCI2.FDR 4007 0056h, SCI3.FDR 4007 0076h, SCI4.FDR 4007 0096h, SCI8.FDR 4007 0116h, SCI9.FDR 4007 0136h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	T[4:0]					—	—	—	R[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	R[4:0]	Receive FIFO Data Count	Indicates the amount of receive data stored in FRDRHL (valid only in asynchronous mode, including multi-processor mode, or clock synchronous mode, when FCR.FM = 1)	R
b7 to b5	—	Reserved	These bits are read as 0.	R
b12 to b8	T[4:0]	Transmit FIFO Data Count	Indicates the amount of non-transmitted data stored in FTDRHL (valid only in asynchronous mode, including multi-processor mode, or clock synchronous mode, when FCR.FM = 1)	R
b15 to b13	—	Reserved	These bits are read as 0	R

The FDR register indicates the amount of data stored in FRDRHL/FTDRHL.

R[4:0] bits (Receive FIFO Data Count)

The R[4:0] bits indicate the amount of receive data stored in FRDRHL. A value of 00h indicates no receive data, and 10h means that the maximum received data is stored in FRDRHL.

T[4:0] bits (Transmit FIFO Data Count)

The T[4:0] bits indicate the amount of non-transmitted data stored in FTDRHL. A value of 00h indicates no transmit data, and 10h indicates that all (maximum amount) of the data to be transmitted is stored in FTDRHL.

27.2.28 Line Status Register (LSR)

Address(es): SCI0.LSR 4007 0018h, SCI1.LSR 4007 0038h, SCI2.LSR 4007 0058h, SCI3.LSR 4007 0078h, SCI4.LSR 4007 0098h, SCI8.LSR 4007 0118h, SCI9.LSR 4007 0138h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	PNUM[4:0]					—	FNUM[4:0]					—	ORER
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	ORER	Overrun Error Flag	Valid only in asynchronous mode, including multi-processor mode, or clock synchronous mode, with FIFO operation selected: 0: No overrun error occurred 1: Overrun error occurred.	R*1
b1	—	Reserved	This bit is read as 0	R
b6 to b2	FNUM[4:0]	Framing Error Count	Indicates the amount of data with a framing error in the receive data stored in the Receive FIFO Data Register (FRDRHL)	R
b7	—	Reserved	This bit is read as 0	R

RSTRG[3:0]位（RTS输出有效触发数选择）

当FRDRHL中存储的接收数据量等于或大于RSTRG[3:0]位中指定的接收触发数时，RTS信号变为高电平。

当RSTRG[3:0]为0时，即使FRDRHL中的数据量等于0，RTS信号也不会变高。

27.2.27 FIFO数据计数寄存器(FDR)

Address(es): SCI0.FDR 4007 0016h, SCI1.FDR 4007 0036h, SCI2.FDR 4007 0056h, SCI3.FDR 4007 0076h, SCI4.FDR 4007 0096h, SCI8.FDR 4007 0116h, SCI9.FDR 4007 0136h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	T[4:0]					—	—	—	R[4:0]				
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	R[4:0]	接收FIFO数据计数	表示FRDRHL中存储的接收数据量（仅在异步模式下有效，包括多处理器模式，或时钟同步模式，当FCR.FM=1时）	R
b7 to b5	—	Reserved	这些位读为0。	R
b12 to b8	T[4:0]	发送FIFO数据计数	表示FTDRHL中存储的未传输数据量（仅在异步模式下有效，包括多处理器模式，或时钟同步模式，当FCR.FM=1时）	R
b15 to b13	—	Reserved	这些位被读为0	R

FDR寄存器指示存储在FRDRHLFTDRHL中的数据量。

R[4:0]位（接收FIFO数据计数）

R[4:0]位指示存储在FRDRHL中的接收数据量。00h表示没有接收数据，10h表示最大接收数据存储在FRDRHL中。

T[4:0]位（发送FIFO数据计数）

T[4:0]位指示存储在FTDRHL中的未传输数据量。值00h表示没有发送数据，而10h表示要发送的所有（最大量）数据都存储在FTDRHL中。

27.2.28 线路状态寄存器(LSR)

Address(es): SCI0.LSR 4007 0018h, SCI1.LSR 4007 0038h, SCI2.LSR 4007 0058h, SCI3.LSR 4007 0078h, SCI4.LSR 4007 0098h, SCI8.LSR 4007 0118h, SCI9.LSR 4007 0138h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	PNUM[4:0]					—	FNUM[4:0]					—	ORER
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	ORER	溢出错误标志	仅在异步模式下有效，包括多处理器模式，或时钟同步模式，选择FIFO操作：0：未发生溢出错误1：发生溢出错误。	R*1
b1	—	Reserved	该位读为0	R
b6 to b2	FNUM[4:0]	帧错误计数	指示存储在接收FIFO数据寄存器(FRDRHL)中的接收数据中存在帧错误的数据量	R
b7	—	Reserved	该位读为0	R

Bit	Symbol	Bit name	Description	R/W
b12 to b8	PNUM[4:0]	Parity Error Count	Indicates the amount of data with a parity error in the receive data stored in the Receive FIFO Data Register (FRDRHL)	R
b15 to b13	—	Reserved	These bits are read as 0	R

Note 1. If this flag is 1, write 0 to SSR_FIFO.ORER to clear the flag.

The LSR register indicates the status of receive error.

ORER flag (Overrun Error Flag)

The ORER flag reflects the value in SSR_FIFO.ORER.

FNUM[4:0] bits (Framing Error Count)

The FNUM[4:0] bit value indicates the amount of data with a framing error stored in the FRDRHL register.

PNUM[4:0] bits (Parity Error Count)

The PNUM[4:0] bit value indicates the amount of data with a parity error stored in the FRDRHL register.

27.2.29 Compare Match Data Register (CDR)

Address(es): SCI0.CDR 4007 001Ah, SCI1.CDR 4007 003Ah, SCI2.CDR 4007 005Ah, SCI3.CDR 4007 007Ah, SCI4.CDR 4007 009Ah, SCI8.CDR 4007 011Ah, SCI9.CDR 4007 013Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CMPD[8:0]								
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b8 to b0	CMPD[8:0]	Compare Match Data	Holds compare data pattern for address match wakeup function	R/W
b15 to b9	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The CDR register sets the compare data for the address match function.

CMPD[8:0] bits (Compare Match Data)

The CMPD[8:0] bits set the data to be compared to receive data for the address match function when the address match function is enabled (DCCR.DCME = 1).

Three bit lengths are available:

- CMPD[6:0] with 7-bit length
- CMPD[7:0] with 8-bit length
- CMPD[8:0] with 9-bit length.

Bit	Symbol	位名称	Description	R/W
b12 to b8	PNUM[4:0]	奇偶错误计数	表示存储在接收FIFO数据寄存器(FRDRHL)中的接收数据中有奇偶校验错误的数据量	R
b15 to b13	—	Reserved	这些位被读为0	R

Note 1. 如果该标志为1，则向SSR_FIFO.ORER写入0以清除该标志。

LSR寄存器指示接收错误的状态。

ORER标志（溢出错误标志）

ORER标志反映了SSR_FIFO.ORER中的值。

FNUM[4:0]位（帧错误计数）

FNUM[4:0]位值表示存储在FRDRHL寄存器中的具有帧错误的数据量。

PNUM[4:0]位（奇偶错误计数）

PNUM[4:0]位值表示存储在FRDRHL寄存器中的具有奇偶校验错误的数据量。

27.2.29 比较匹配数据寄存器(CDR)

Address(es): SCI0.CDR 4007 001Ah, SCI1.CDR 4007 003Ah, SCI2.CDR 4007 005Ah, SCI3.CDR 4007 007Ah, SCI4.CDR 4007 009Ah, SCI8.CDR 4007 011Ah, SCI9.CDR 4007 013Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CMPD[8:0]								
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b8 to b0	CMPD[8:0]	比较匹配数据	保存地址匹配唤醒功能的比较数据模式	R/W
b15 to b9	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CDR寄存器设置地址匹配功能的比较数据。

CMPD[8:0]位（比较匹配数据）

当地址匹配功能使能（DCCR.DCME=1）时，CMPD[8:0]位设置要比较的数据以接收地址匹配功能的数据。

提供三种位长：

- 7位长度的CMPD[6:0]
- CMPD[7:0]8位长度
- CMPD[8:0]，长度为9位。

27.2.30 Data Compare Match Control Register (DCCR)

Address(es): SCI0.DCCR 4007 0013h, SCI1.DCCR 4007 0033h, SCI2.DCCR 4007 0053h, SCI3.DCCR 4007 0073h, SCI4.DCCR 4007 0093h, SCI8.DCCR 4007 0113h, SCI9.DCCR 4007 0133h

	b7	b6	b5	b4	b3	b2	b1	b0
	DCME	IDSEL	—	DFER	DPER	—	—	DCMF
Value after reset:	0	1	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	DCMF	Data Compare Match Flag	0: Not matched 1: Matched.	R/(W)*1
b2, b1	—	Reserved	These bits are read as 0. The write value should be 0.	R
b3	DPER	Data Compare Match Parity Error Flag	0: No parity error occurred 1: Parity error occurred.	R/(W)*1
b4	DFER	Data Compare Match Framing Error Flag	0: No framing error occurred 1: Framing error occurred.	R/(W)*1
b5	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6	IDSEL	ID Frame Select	Valid only in asynchronous mode, including multi-processor mode: 0: Always compare data regardless of the MPB bit value 1: Only compare data when MPB bit is 1 (ID frame).	R/W
b7	DCME	Data Compare Match Enable	Valid only in asynchronous mode, including multi-processor mode: 0: Address match function disabled 1: Address match function enabled.	R/W

Note 1. Only 0 can be written to clear the flag after reading 1.

The DCCR register sets control of the address match function.

DCMF flag (Data Compare Match Flag)

The DCMF flag indicates that the SCI detects a match of the comparison data (CDR.CMPD) with receive data.

[Setting condition]

- When comparison data (CDR.CMPD) matches the receive data, when DCCR.DCME = 1.

[Clearing condition]

- When 0 is written after 1 is read from DCMF.

Clearing the SCR.RE bit to 0 does not affect the DCMF flag, which keeps its previous value.

DPER flag (Data Compare Match Parity Error Flag)

The DPER flag indicates that a parity error occurred at address match detection (receive data match detection).

[Setting condition]

- When a parity error is detected in the frame in which an address match is detected.

[Clearing conditions]

- When 0 is written after 1 is read from DPER.

Clearing the SCR.RE bit to 0 (serial reception is disabled) does not affect the DPER flag, which keeps its previous value.

DFER flag (Data Compare Match Framing Error Flag)

The DFER flag indicates that a framing error occurred at address match detection (receive data match detection).

[Setting conditions]

- When a stop bit is 0 in the frame in which an address match is detected.

27.2.30 数据比较匹配控制寄存器(DCCR)

Address(es): SCI0.DCCR 4007 0013h, SCI1.DCCR 4007 0033h, SCI2.DCCR 4007 0053h, SCI3.DCCR 4007 0073h, SCI4.DCCR 4007 0093h, SCI8.DCCR 4007 0113h, SCI9.DCCR 4007 0133h

	b7	b6	b5	b4	b3	b2	b1	b0
	DCME	IDSEL	—	DFER	DPER	—	—	DCMF
重置后的值:	0	1	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	DCMF	数据比较匹配标志	0：不匹配1： 匹配。	R/(W)*1
b2, b1	—	Reserved	这些位被读取为0。写入值应为0。	R
b3	DPER	数据比较匹配奇偶校验 错误标志	0：未发生奇偶校验错误1 ：发生奇偶校验错误。	R/(W)*1
b4	DFER	数据比较匹配 成帧错误标志	0：未发生帧错误1：发生帧 错误。	R/(W)*1
b5	—	Reserved	该位读取为0。写入值应为0。	R/W
b6	IDSEL	ID帧选择	仅在异步模式下有效，包括多处理器模式：0：无论MPB位值如何 ，始终比较数据1：仅当MPB位为1（ID帧）时比较数据。	R/W
b7	DCME	数据比较匹配 Enable	仅在异步模式下有效，包括多处理器模式：0：禁用地址匹配功能 1：启用地址匹配功能。	R/W

Note 1. 读1后只能写0清除标志。

DCCR寄存器设置地址匹配功能的控制。

DCMF标志（数据比较匹配标志）

DCMF标志表示SCI检测到比较数据(CDR.CMPD)与接收数据的匹配。

[Setting condition]

- 当比较数据(CDR.CMPD)与接收数据匹配时，当DCCR.DCME=1。

[Clearing condition]

- 从DCMF读取1后写入0时。

将SCR.RE位清除为0不会影响DCMF标志，它保持其先前的值。

DPER标志（数据比较匹配奇偶校验错误标志）

DPER标志表示在地址匹配检测（接收数据匹配检测）时发生奇偶校验错误。

[Setting condition]

- 在检测到地址匹配的帧中检测到奇偶校验错误时。

[Clearing conditions]

- 当从DPER读取1后写入0。

将SCR.RE位清为0（禁用串行接收）不会影响DPER标志，它保持其先前的值。

DFER标志（数据比较匹配成帧错误标志）

DFER标志表示在地址匹配检测（接收数据匹配检测）时发生了帧错误。

[Setting conditions]

- 当检测到地址匹配的帧中停止位为0时。

- When in 2-stop-bit mode, only the first stop bit is checked for a value of 1, while the second stop bit is not checked.

[Clearing condition]

- When 0 is written after 1 is read from DFER.

When the SCR.RE bit is set to 0 (serial reception is disabled), the DFER flag is not affected and keeps its previous value.

IDSEL bit (ID Frame Select)

The IDSEL bit selects whether to compare data regardless of the MPB bit value or to compare data only when MPB = 1 (ID frame), when the address match function is enabled.

DCME bit (Data Compare Match Enable)

The DCME bit enables or disables the address match function (data compare match function).

If the SCI detects a match between comparison data (CDR.CMPD) and receive data, the DCME bit is cleared automatically and the SCI operates in receive mode without the data compare match function. See section 27.3.6, Address Match (Receive Data Match Detection) Function.

The write value should be 0 for any mode other than asynchronous mode.

27.2.31 Serial Port Register (SPTR)

Address(es): SCI0.SPTR 4007 001Ch, SCI1.SPTR 4007 003Ch, SCI2.SPTR 4007 005Ch, SCI3.SPTR 4007 007Ch, SCI4.SPTR 4007 009Ch, SCI8.SPTR 4007 011Ch, SCI9.SPTR 4007 013Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SPB2IO	SPB2DT	RXDMON
Value after reset:	0	0	0	0	0	0	1	1

Bit	Symbol	Bit name	Description	R/W
b0	RXDMON	Serial Input Data Monitor	Indicates the state of the RXDn pin: 0: RXDn pin is low 1: RXDn pin is high.	R
b1	SPB2DT	Serial Port Break Data Select	Selects the output level of the TXDn pin when SCR.TE = 0: 0: Output low on TXDn pin 1: Output high on TXDn pin.	R/W
b2	SPB2IO	Serial Port Break I/O	Selects whether the value of SPB2DT is output on the TXDn pin: 0: The value of SPB2DT bit is not output on TXDn pin 1: The value of SPB2DT bit is output on TXDn pin.	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The SPTR register provides confirmation of the serial reception pin (RXDn) status and sets the transmission pin (TXDn) status. This register can only be used in asynchronous mode.

The TXDn pin status is determined by the combination of SCR.TE, SPTR.SPB2IO, and SPTR.SPB2DT bit settings, as shown in Table 27.22.

Table 27.22 TXDn pin status

Value of SCR.TE	Value of SPTR.SPB2IO	Value of SPTR.SPB2DT	TXDn pin status
0	0	x	Hi-Z (initial value)
0	1	0	Low level output
0	1	1	High level output
1	x	x	Serial transmit data is output

x: Don't care.

Note: Use the SPTR register in asynchronous mode only. Using this register in any other mode is not guaranteed.

- 在2停止位模式下，仅检查第一个停止位的值是否为1，而不检查第二个停止位。

[Clearing condition]

- 从DFER读取1后写入0。

当SCR.RE位设置为0（禁用串行接收）时，DFER标志不受影响并保持其先前的值。

IDSEL位（ID帧选择）

IDSEL位选择无论MPB位值如何比较数据，还是仅在MPB=1（ID帧）时比较数据，当地址匹配功能启用时。

DCME位（数据比较匹配使能）

DCME位启用或禁用地址匹配功能（数据比较匹配功能）。

如果SCI检测到比较数据（CDR.CMPD）与接收数据匹配，则DCME位自动清零，SCI在接收模式下运行，没有数据比较匹配功能。请参见第27.3.6节，地址匹配（接收数据匹配检测）功能。

对于异步模式以外的任何模式，写入值都应为0。

27.2.31 串行端口寄存器(SPTR)

Address(es): SCI0.SPTR 4007 001Ch, SCI1.SPTR 4007 003Ch, SCI2.SPTR 4007 005Ch, SCI3.SPTR 4007 007Ch, SCI4.SPTR 4007 009Ch, SCI8.SPTR 4007 011Ch, SCI9.SPTR 4007 013Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SPB2IO	SPB2DT	RXDMON
重置后的值：	0	0	0	0	0	0	1	1

Bit	Symbol	位名称	Description	R/W
b0	RXDMON	串行输入数据监视器	指示RXDn引脚的状态：0：RXDn引脚为低电平1：RXDn引脚为高电平。	R
b1	SPB2DT	串口中断数据 Select	选择SCR.TE=0时TXDn引脚的输出电平：0：TXDn引脚输出低电平1：TXDn引脚输出高电平。	R/W
b2	SPB2IO	串口中断IO	选择是否在TXDn引脚上输出SPB2DT的值：0：在TXDn引脚上不输出SPB2DT位的值1：在TXDn引脚上输出SPB2DT位的值。	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SPTR寄存器提供串行接收引脚(RXDn)状态的确认并设置发送引脚(TXDn)状态。该寄存器只能在异步模式下使用。

TXDn引脚状态由SCR.TE、SPTR.SPB2IO和SPTR.SPB2DT位设置的组合决定，如表27.22所示。

Table 27.22 TXDn引脚状态

SCR.TE的价值	SPTR.SPB2IO的值	SPTR.SPB2DT的值	TXDn引脚状态
0	0	x	Hi-Z (initial value)
0	1	0	低电平输出
0	1	1	高电平输出
1	x	x	串行传输数据输出

x: Don't care.

Note: 仅在异步模式下使用SPTR寄存器。不保证在任何其他模式下使用该寄存器。

27.3 Operation in Asynchronous Mode

Figure 27.2 shows the general format for asynchronous serial communications. One frame consists of a start bit (low level), transmit/receive data, a parity bit, and stop bits (high level). In asynchronous serial communications, the communications line is held in the mark state (high level) when not communicating. The SCI monitors the communications line. When the SCI detects a low, it regards that as a start bit and starts serial communication.

Inside the SCI, the transmitter and receiver are independent units, enabling full-duplex communications. Both the transmitter and receiver have a double-buffered structure in addition to FIFO mode, so that data can be read or written during transmission or reception, enabling continuous data transmission and reception.

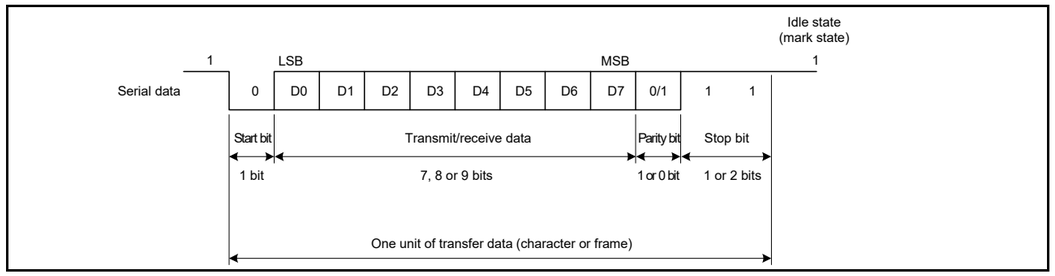


Figure 27.2 Data format in asynchronous serial communications with 8-bit data, parity bit, and 2 stop bits

27.3.1 Serial Data Transfer Format

Table 27.23 lists the serial data transfer formats that can be used in asynchronous mode. Any of the 18 transfer formats can be selected in the SMR and SCMR register settings. For details on the multi-processor function, see section 27.4, Multi-Processor Communication Function.

Table 27.23 Serial transfer formats in asynchronous mode (1 of 2)

SCMR setting	SMR setting				Serial transfer format and frame length												
CHR1	CHR	PE	MP	STOP	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	S	9-bit data									STOP		
0	0	0	0	1	S	9-bit data									STOP	STOP	
0	0	1	0	0	S	9-bit data									P	STOP	
0	0	1	0	1	S	9-bit data									P	STOP	STOP
1	0	0	0	0	S	8-bit data								STOP			
1	0	0	0	1	S	8-bit data								STOP	STOP		

27.3 异步模式下的操作

图27.2显示了异步串行通信的一般格式。一帧由起始位（低电平）、发送接收数据、奇偶校验位和停止位（高电平）组成。在异步串行通信中，通信线在不通信时保持在标记状态（高电平）。SCI监控通信线路。当SCI检测到低电平时，将其视为起始位并开始串行通信。

在SCI内部，发射器和接收器是独立的单元，可实现全双工通信。发送器和接收器除了FIFO模式外，都具有双缓冲结构，从而可以在发送或接收过程中读取或写入数据，从而实现数据的连续发送和接收。

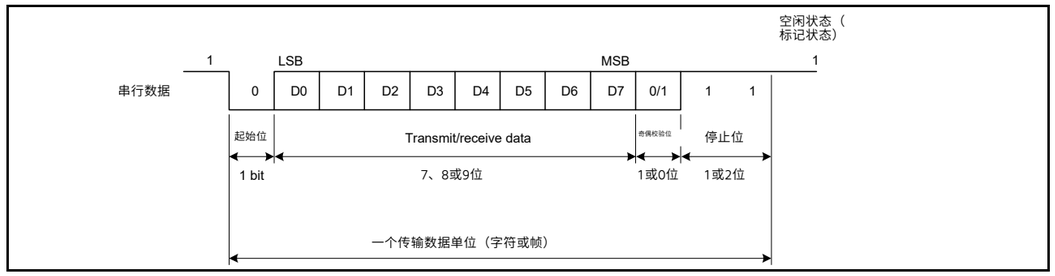


Figure 27.2 异步串行通信中的数据格式，包含8位数据、奇偶校验位和2个停止位

27.3.1 串行数据传输格式

表27.23列出了可以在异步模式下使用的串行数据传输格式。可以在SMR和SCMR寄存器设置中选择18种传输格式中的任何一种。有关多处理器功能的详细信息，请参阅第27.4节，多处理器通信功能。

Table 27.23 异步模式下的串行传输格式（1of2）

SCMR setting	SMR setting				串行传输格式和帧长												
CHR1	CHR	PE	MP	STOP	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	0	0	0	S	9-bit data									STOP		
0	0	0	0	1	S	9-bit data									STOP	STOP	
0	0	1	0	0	S	9-bit data									P	STOP	
0	0	1	0	1	S	9-bit data									P	STOP	STOP
1	0	0	0	0	S	8-bit data								STOP			
1	0	0	0	1	S	8-bit data								STOP	STOP		

Table 27.23 Serial transfer formats in asynchronous mode (2 of 2)

SCMR setting	SMR setting				Serial transfer format and frame length												
CHR1	CHR	PE	MP	STOP	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	1	0	0	S	8-bit data								P	STOP		
1	0	1	0	1	S	8-bit data								P	STOP	STOP	
1	1	0	0	0	S	7-bit data							STOP				
1	1	0	0	1	S	7-bit data							STOP	STOP			
1	1	1	0	0	S	7-bit data							P	STOP			
1	1	1	0	1	S	7-bit data							P	STOP	STOP		
0	0	-	1	0	S	9-bit data									MPB	STOP	
0	0	-	1	1	S	9-bit data									MPB	STOP	STOP
1	0	-	1	0	S	8-bit data								MPB	STOP		
1	0	-	1	1	S	8-bit data								MPB	STOP	STOP	
1	1	-	1	0	S	7-bit data							MPB	STOP			
1	1	-	1	1	S	7-bit data							MPB	STOP	STOP		

S: Start bit
STOP: Stop bit
P: Parity bit
MPB: Multi-processor bit

Table 27.23 异步模式下的串行传输格式(2of2)

SCMR setting	SMR setting				串行传输格式和帧长												
CHR1	CHR	PE	MP	STOP	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	1	0	0	S	8-bit data								P	STOP		
1	0	1	0	1	S	8-bit data								P	STOP	STOP	
1	1	0	0	0	S	7-bit data							STOP				
1	1	0	0	1	S	7-bit data							STOP	STOP			
1	1	1	0	0	S	7-bit data							P	STOP			
1	1	1	0	1	S	7-bit data							P	STOP	STOP		
0	0	-	1	0	S	9-bit data									MPB	STOP	
0	0	-	1	1	S	9-bit data									MPB	STOP	STOP
1	0	-	1	0	S	8-bit data								MPB	STOP		
1	0	-	1	1	S	8-bit data								MPB	STOP	STOP	
1	1	-	1	0	S	7-bit data							MPB	STOP			
1	1	-	1	1	S	7-bit data							MPB	STOP	STOP		

S: 起始位
STOP: 停止位
P: 奇偶校验位
MPB: Multi-processor bit

27.3.2 Receive Data Sampling Timing and Reception Margin in Asynchronous Mode

In asynchronous mode, the SCI operates on a base clock with a frequency of 16 times*1 the bit rate.

In reception, the SCI samples the falling edge of the start bit using the base clock, and performs internal synchronization.

Because receive data is sampled on the rising edge of the 8th pulse*1 of the base clock, data is latched at the middle of each bit, as shown in Figure 27.3. The reception margin in asynchronous mode is determined by the following formula (1):

$$M = \left| (0.5 - \frac{1}{2N}) - (L - 0.5)\ F - \frac{D - 0.5}{N}\ (1 + F) \right| \times 100\ [\%] \cdots \text{Formula (1)}$$

M: Reception margin
N: Ratio of bit rate to clock
N = 16 when SEMR.ABCSE = 0 and SEMR.ABCS = 0
N = 8 when SEMR.ABCS = 1
N = 6 when SEMR.ABCSE = 1
D: Duty cycle of clock (D = 0.5 to 1.0)
L: Frame length (L = 9 to 13)
F: Absolute value of clock frequency deviation

Assuming values of F = 0 and D = 0.5 in formula (1), the reception margin is determined by the following formula:

$$M = \{0.5 - 1/(2 \times 16)\} \times 100\ (\%) = 46.875\%$$

This represents the computed value. Renesas recommends that a margin of 20% to 30% should be allowed in system design.

Note 1. In this example, the SEMR.ABCS bit is 0 and the SEMR.ABCSE is 0. When the ABCS bit is 1 and the ABCSE bit is 0, a frequency of 8 times the bit rate is used as a base clock, and receive data is sampled on the rising edge of the 4th pulse of the base clock.
When the ABCSE bit is 1, a frequency of 6 times the bit rate is used as a base clock, and the receive data is sampled on the rising edge of the 3rd pulse of the base clock.

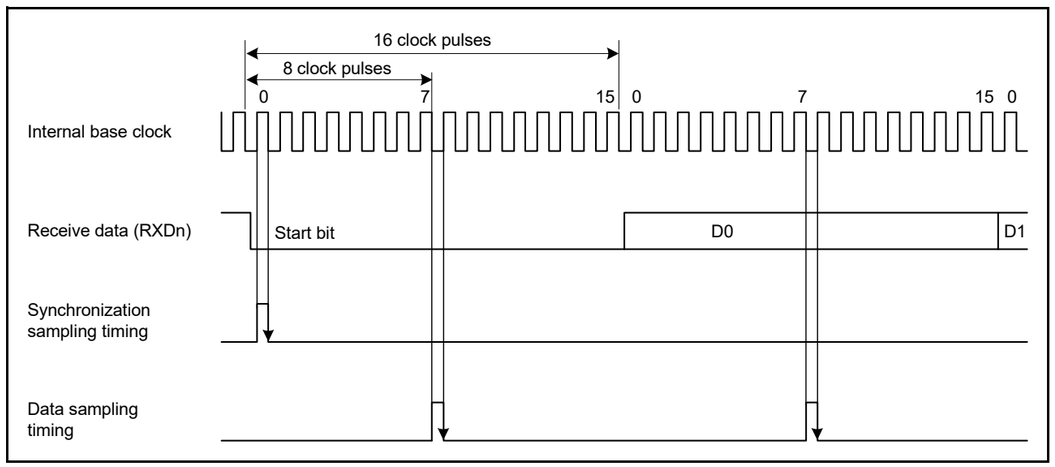


Figure 27.3 Receive data sampling timing in asynchronous mode

27.3.2 异步模式下接收数据采样时序和接收余量

在异步模式下，SCI在频率为16倍*1比特率的基本时钟上运行。

在接收时，SCI使用基本时钟对起始位的下降沿进行采样，并执行内部同步。

因为接收数据是在基本时钟的第8个脉冲*1的上升沿采样的，所以数据在每个位的中间锁存，如图27.3所示。
异步模式下的接收余量由以下公式（1）确定：

$$M = \left| (0.5 - \frac{1}{2N}) - (L - 0.5)\ F - \frac{D - 0.5}{N}\ (1 + F) \right| \times 100\ [\%] \cdots \text{Formula (1)}$$

M：接收余量
N：比特率与时钟的比率
当SEMR.ABCSE=0和SEMR.ABCS=0时N=16
N = 8 when SEMR.ABCS = 1
N = 6 when SEMR.ABCSE = 1
D:时钟占空比(D=0.5to1.0)
L：帧长（L=9到13）
F：时钟频率偏差的绝对值

假设公式（1）中F=0，D=0.5，接收裕量由下式确定：

$$M = \{0.5 - 1/(2 \times 16)\} \times 100\ (\%) = 46.875\%$$

这表示计算值。瑞萨建议在系统设计中应留出20%至30%的余量。

注1.本例中，SEMR.ABCS位为0，SEMR.ABCSE位为0。当ABCS位为1，ABCSE位为0时，使用8倍比特率的频率作为基准时钟，接收数据在基准时钟的第4个脉冲的上升沿采样。当ABCSE位为1时，以6倍比特率的频率作为基准时钟，在基准时钟的第3个脉冲的上升沿对接收数据进行采样。

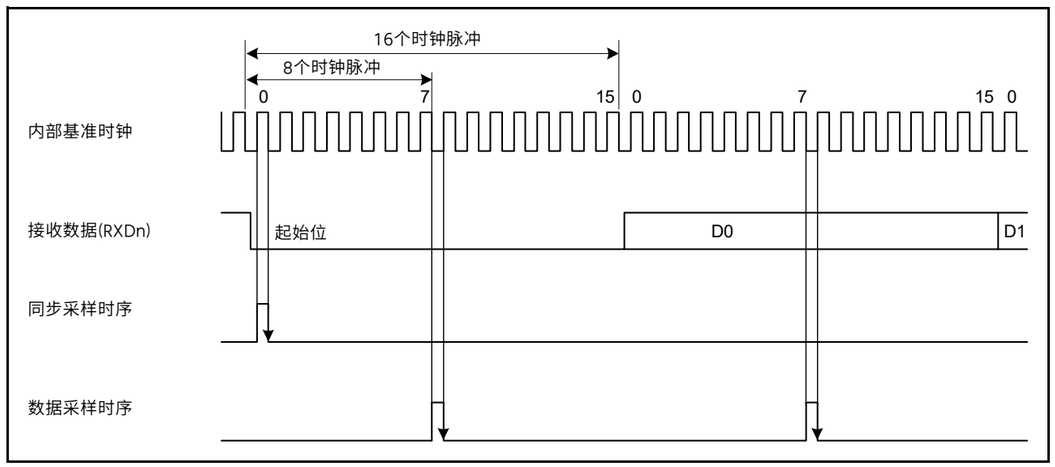


Figure 27.3 异步模式下接收数据采样时序

27.3.3 Clock

Either an internal clock generated by the on-chip baud rate generator or an external clock input to the SCKn pin can be selected as the SCI transfer clock, based on the SMR.CM and SCR.CKE[1:0] bit settings.

When an external clock is input to the SCKn pin, the clock frequency must be 16 times the bit rate (when SEMR.ABCS = 0) or 8 times the bit rate (when SEMR.ABCS = 1).

When the SCI uses its internal clock, the clock can be output from the SCKn pin. The frequency of the clock output in this case is equal to the bit rate, and the phase is such that the rising edge of the clock is in the middle of the transmit data, as Figure 27.4 shows.

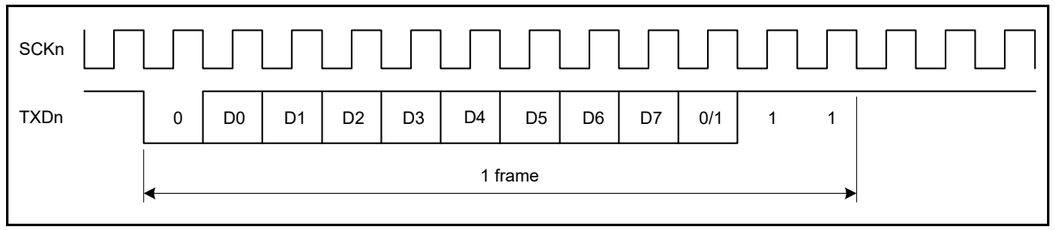


Figure 27.4 Phase relationship between output clock and transmit data in asynchronous mode when SMR.CHR = 0, PE = 1, MP = 0, and STOP = 1

27.3.4 Double-Speed Operation and Frequency of 6 Times the Bit Rate

When the SEMR.ABCS bit is set to 1 and 8 pulses of the base clock for a 1-bit period is selected, the SCI operates on the bit rate that is equal to twice the value when ABCS is set to 0. When the SEMR.BGDM bit is set to 1, the cycle of the base clock is half and the bit rate is double the value when BGDM is set to 0. When the SCR.CKE[1] bit is set to 0 and the on-chip baud rate generator is selected, setting the ABCS and BGDM bits to 1 allows the SCI to operate at a bit rate equal to four times the value when the ABCS and BGDM bits are set to 0. When the SEMR.ABCSE bit is set to 1, the number of basic clock pulses is 6 during a period of 1 bit, and the SCI operates at a bit rate that is equal to 16/3 times the value when SEMR.ABCS, SEMR.BGDM, and SMER.ABCSE are 0.

As shown by formula (1) in section 27.3.2, Receive Data Sampling Timing and Reception Margin in Asynchronous Mode, the reception margin decreases when the ABCS or ABCSE bit in SEMR is set to 1. Therefore, if the target bit rate can be obtained with ABCS or ABCSE set to 0, it is recommended that you use the SCI with ABCS and ABCSE set to 0.

27.3.5 CTS and RTS Functions

The CTS function uses the input on the CTSn_RTSn pin in transmission control. Setting the SPMR.CTSE bit to 1 enables the CTS function. When the CTS function is enabled, driving the CTSn_RTSn pin low causes transmission to start.

Driving the CTSn_RTSn pin high while transmission is in progress does not affect transmission of the current frame.

In the RTS function that uses the output on the CTSn_RTSn pin, a low level is output when reception becomes possible. Conditions for low level and high level output are shown in this section.

[Conditions for low-level output]

(a) Non-FIFO selected when all of the following conditions are satisfied

- The value of the SCR.RE bit is 1
- Reception is not in progress
- There is no receive data yet to be read
- The ORER, FER, and PER flags in the SSR register are all 0.

(b) FIFO selected when all of the following conditions are satisfied

- The value of the SCR.RE bit is 1

27.3.3 Clock

根据SMR.CM和SCR.CKE[1:0]位的设置，可以选择片内波特率发生器产生的内部时钟或输入到SCKn引脚的外部时钟作为SCI传输时钟。

当外部时钟输入到SCKn引脚时，时钟频率必须为比特率的16倍（SEMR.ABCS=0时）或比特率的8倍（SEMR.ABCS=1时）。

当SCI使用其内部时钟时，时钟可以从SCKn引脚输出。在这种情况下，时钟输出的频率等于比特率，并且相位使得时钟的上升沿位于传输数据的中间，如图27.4所示。

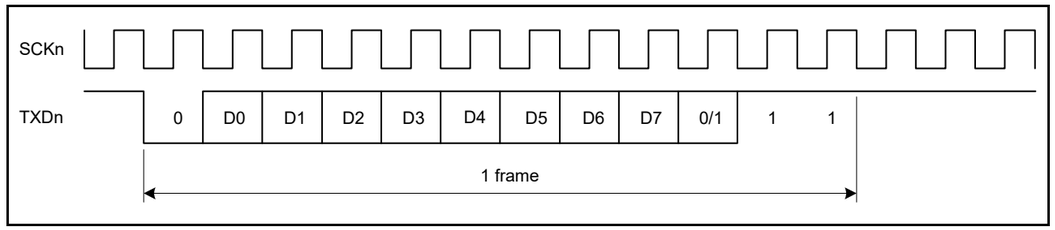


Figure 27.4 异步模式下输出时钟与传输数据的相位关系 SMR.CHR=0，PE=1，MP=0，STOP=1

27.3.4 双倍速操作和6倍比特率的频率

当SEMR.ABCS位设置为1并选择8个基本时钟脉冲持续1位周期时，SCI以等于ABCS设置为0时值的两倍的比特率运行。当SEMR.BGDM位设置为1，基本时钟的周期为BGDM设置为0时的一半，比特率是其值的两倍。当SCR.CKE[1]位设置为0且片上波特率选择速率发生器，将ABCS和BGDM位设置为1允许SCI以等于ABCS和BGDM位设置为0时值的四倍的比特率运行。当SEMR.ABCSE位设置为1时，在1位周期内基本时钟脉冲数为6，SCI以等于SEMR.ABCS、SEMR.BGDM和SMER.ABCSE为0时值的163倍的比特率运行。

如第27.3.2节，异步接收数据采样时序和接收裕度中的公式（1）所示
模式下，SEMR中的ABCS或ABCSE位设置为1时，接收余量减小。因此，如果设置ABCS或ABCSE为0可以获得目标码率，建议您使用设置了ABCS和ABCSE的SCI为0。

27.3.5 CTS和RTS函数

CTS功能在传输控制中使用CTSn_RTSn引脚上的输入。将SPMR.CTSE位设置为1可启用CTS功能。当CTS功能使能时，将CTSn_RTSn引脚驱动为低电平会导致传输开始。

在传输过程中将CTSn_RTSn引脚驱动为高电平不会影响当前帧的传输。

在使用CTSn_RTSn引脚输出的RTS功能中，当可以接收时输出低电平。
本节显示低电平和高电平输出的条件。

[Conditions for low-level output]

(a) 满足以下所有条件时选择非FIFO

- SCR.RE位的值为1
- 接收未进行
- 没有接收数据尚未读取
- SSR寄存器中的ORER、FER和PER标志位均为0。

(b) 满足以下所有条件时选择FIFO

- SCR.RE位的值为1

- The amount of receive data written in FRDRHL is equal to or less than the specified receive triggering number
- The ORER bit in the SSR_FIFO register (ORER in FRDRH) is 0.

[Condition for high-level output]

(a) Non-FIFO selected

- The conditions for low-level output are not satisfied
- When reception is terminated with SCR.RE = 0 without reading the RDR register after reception is complete, RTS remains high. At this time, read the SCR register for dummy values after writing 0 to SCR.RE.

(b) FIFO selected

- The conditions for low-level output are not satisfied.

27.3.6 Address Match (Receive Data Match Detection) Function

The address match function can be used only in asynchronous mode.

If the DCCR.DCME bit is set to 1*4, when one frame of data is received, the SCI compares that received data with the data set in CDR.CMPD. If SCI detects a match between the comparison data (CDR.CMPD*3) and the received data, the SCI can issue the SCIn_RXI interrupt request.

If the SMR.MP bit is set to 0, comparison occurs only for valid data in receive format. In multi-processor mode (SMR.MP bit = 1), if the DCCR.IDSEL bit is set to 1, receive data where the MPB bit is 1 is subject to comparison for address match. Receive data where the MPB bit is 0 is always treated as a mismatch.

If the DCCR.IDSEL bit is set to 0, the SCI performs address match detection regardless of the MPB bit value of the received data. Until the SCI detects a match between the comparison data (CDR.CMPD*3) and the receive data, the received data is skipped (discarded), and the SCI cannot detect a parity error or framing error. When the SCI detects a match, the DCCR.DCME bit is automatically cleared, and the DCCR.DCMF flag is set to 1.

If the DCCR.IDSEL bit is set to 1, the SCR.MPIE bit is automatically cleared. If DCCR.IDSEL is set to 0, the value of the SCR.MPIE bit is retained. If the SCR.RIE bit is set to 1, the SCI issues an SCIn_RXI interrupt request.

If the SCI detects a framing error in the receive data for which a match is detected, the DCCR.DFER bit is set to 1, and if the SCI detects a parity error in that frame, the DCCR.DPER bit is set to 1. The compared receive data is not stored in the RDR register*1, and SSR.RDRF remains at 0.*2

After the SCI detects a match, and DCCR.DCME is automatically cleared, the SCI receives the next data continuously based on the current register setting.

When the DCCR.DFER or DCCR.DPER flag is set, the address match is not performed. Before enabling the address match function, set the DCCR.DFER and DCCR.DPER flags to 0.

Examples of the address match function are shown in Figure 27.5 and Figure 27.6.

Note 1. When FCR.FM = 1, this refers to the FRDRHL register.
Note 2. When FCR.FM = 1, this refers to the SSR_FIFO.RDF flag.
Note 3. This comparative target can select one length of 3 types: CMPD[6:0] with 7-bit length, CMPD[7:0] with 8-bit length, or CMPD[8:0] with 9-bit length.
Note 4. Set the DCCR.DCME bit to 1 before receiving the start bit of the received frame that performs address matching.

- FRDRHL中写入的接收数据量等于或小于指定的接收触发数
- SSR_FIFO寄存器中的ORER位（FRRDH中的ORER）为0。

[Condition for high-level output]

(a) Non-FIFO selected

- 不满足低电平输出的条件
- 当接收结束后接收结束且SCR.RE=0且未读取RDR寄存器时，RTS保持高电平。此时，将0写入SCR.RE后，读取SCR寄存器的虚拟值。

(b) FIFO selected

- 不满足低电平输出的条件。

27.3.6 地址匹配（接收数据匹配检测）功能

地址匹配功能只能在异步模式下使用。

如果DCCR.DCME位设置为1*4，当接收到一帧数据时，SCI会将接收到的数据与CDR.CMPD中设置的数据进行比较。如果SCI检测到比较数据(CDR.CMPD*3)与接收到的数据匹配，则SCI可以发出SCIn_RXI中断请求。

如果SMR.MP位设置为0，则仅对接收格式的有效数据进行比较。在多处理器模式下（SMR.MP位=1），如果DCCR.IDSEL位设置为1，则接收MPB位为1的数据将进行地址匹配比较。MPB位为0的接收数据始终被视为不匹配。

如果DCCR.IDSEL位设置为0，则SCI执行地址匹配检测，而不管接收数据的MPB位值如何。直到SCI检测到比较数据（CDR.CMPD*3）与接收数据匹配，接收数据被跳过（丢弃），SCI无法检测奇偶校验错误或成帧错误。当SCI检测到匹配时，自动清除DCCR.DCME位，并将DCCR.DCMF标志设置为1。

如果DCCR.IDSEL位设置为1，则SCR.MPIE位自动清零。如果DCCR.IDSEL设置为0，则保留SCR.MPIE位的值。如果SCR.RIE位设置为1，则SCI发出SCIn_RXI中断请求。

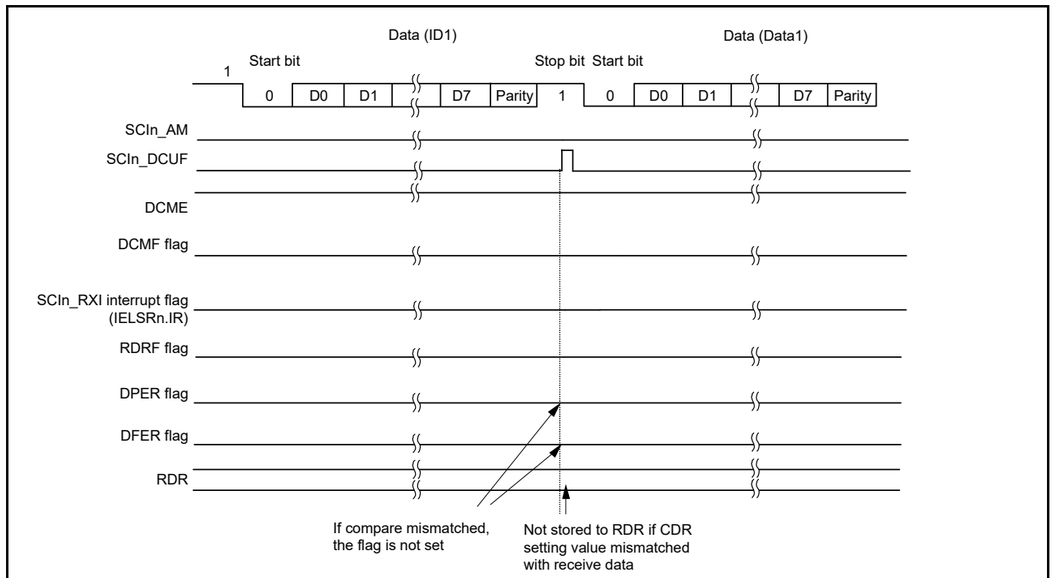
如果SCI在检测到匹配的接收数据中检测到帧错误，则DCCR.DFER位设置为1，如果SCI在该帧中检测到奇偶校验错误，则DCCR.DPER位设置为1。比较后的接收数据不存入RDR寄存器*1，SSR.RDRF保持为0。*2

SCI检测到匹配后，DCCR.DCME自动清零，SCI根据当前寄存器设置连续接收下一个数据。

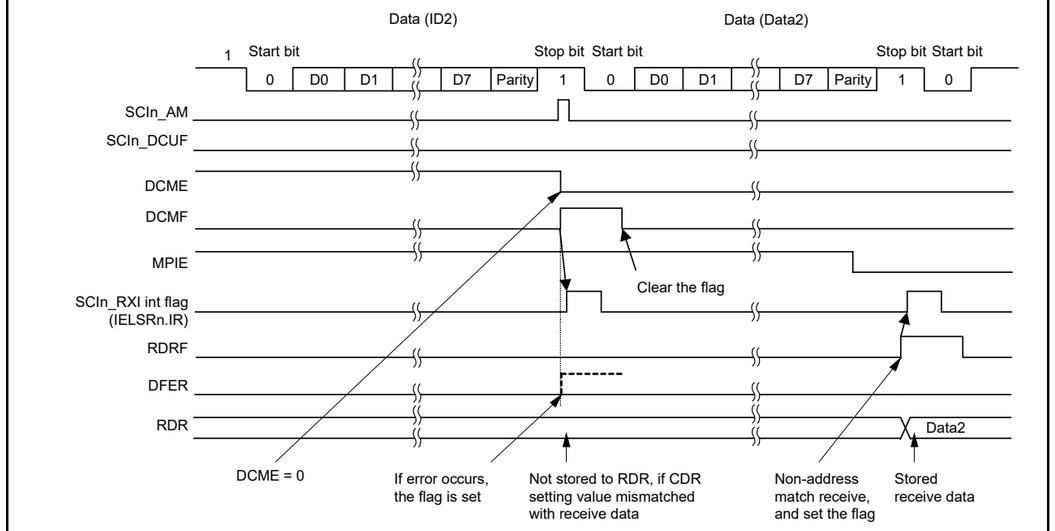
当设置DCCR.DFER或DCCR.DPER标志时，不执行地址匹配。在启用地址匹配功能之前，将DCCR.DFER和DCCR.DPER标志设置为0。

地址匹配函数的例子如图27.5和图27.6所示。

注1.当FCR.FM=1时，指的是FRDRHL寄存器。
注2.当FCR.FM=1时，这指的是SSR_FIFO.RDF标志。
注3.此比较目标可以选择3种长度中的一种：7位长度的CMPD[6:0]、8位长度的CMPD[7:0]或9位长度的CMPD[8:0].注4.在接收到执行地址匹配的接收帧的起始位之前，将DCCR.DCME位设置为1。

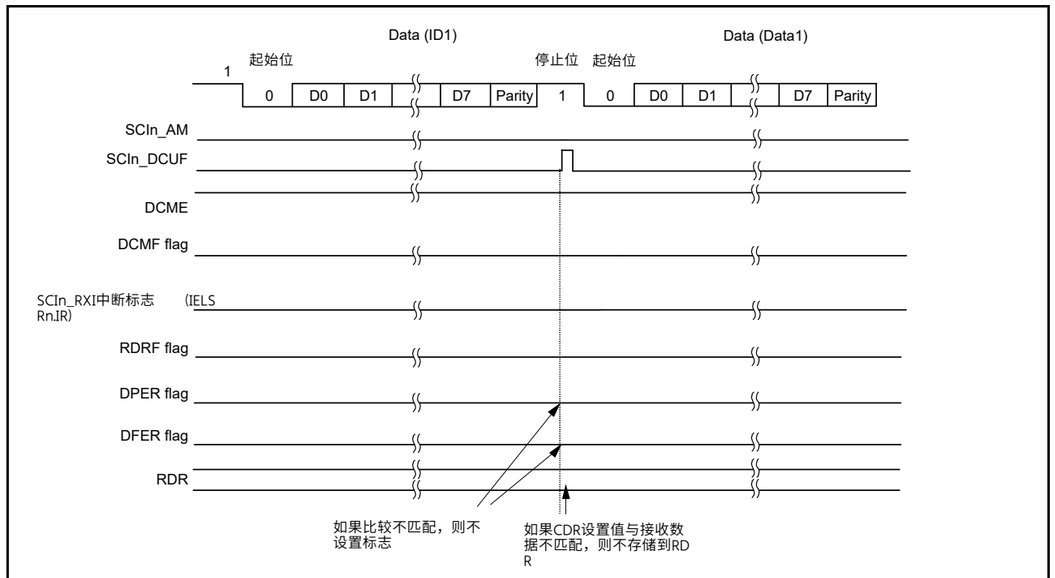


(a) Example of compare mismatched between receive data and CDR (8-bit length/parity/non-multi-processor mode)

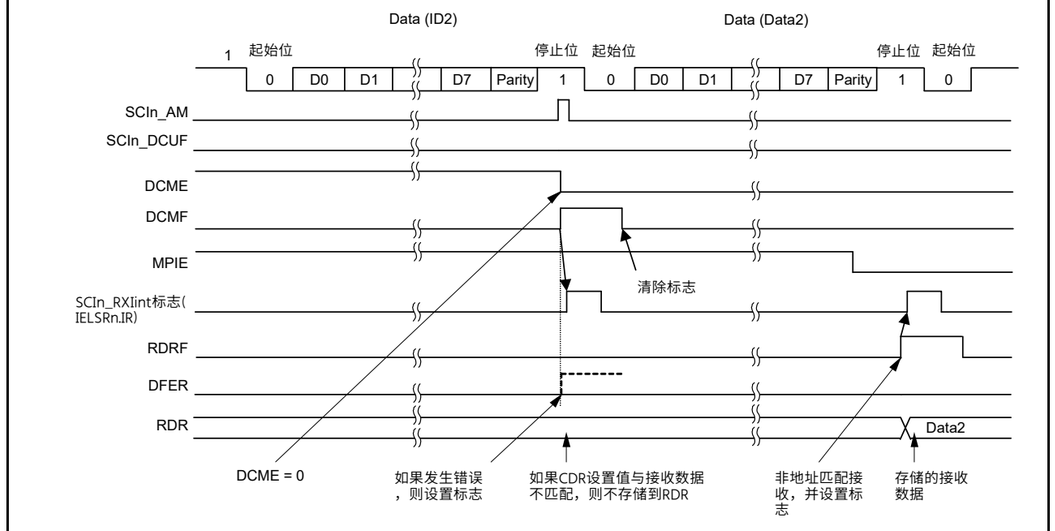


(b) Example of compare matched between receive data and CDR (8-bit length/parity/non-multi-processor mode)

Figure 27.5 Example of address match (1) in non-multi-processor mode

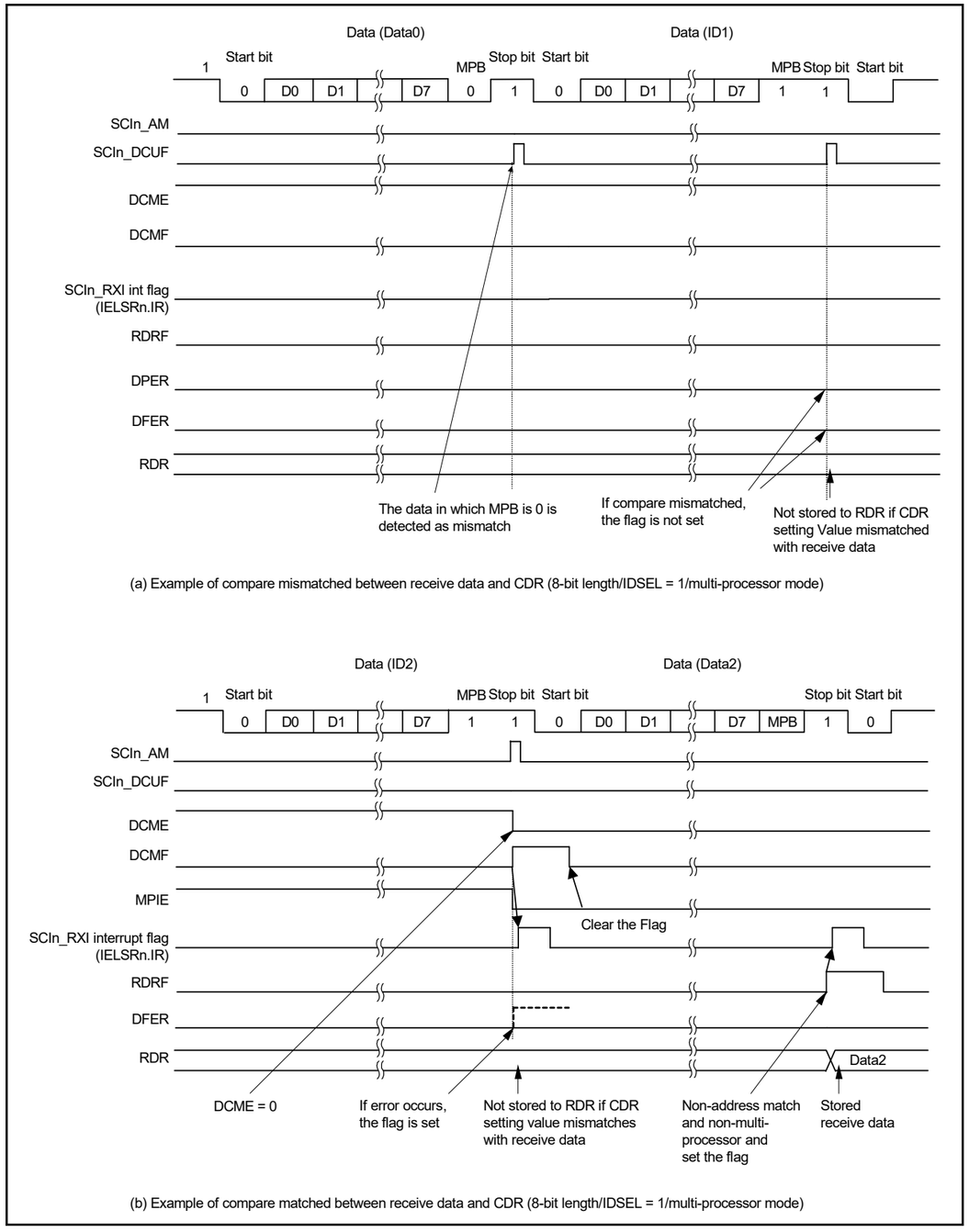


(a)接收数据和CDR比较不匹配的示例（8位长度奇偶校验非多处理器模式）



(b)接收数据与CDR比较匹配示例（8位长度奇偶校验非多处理器模式）

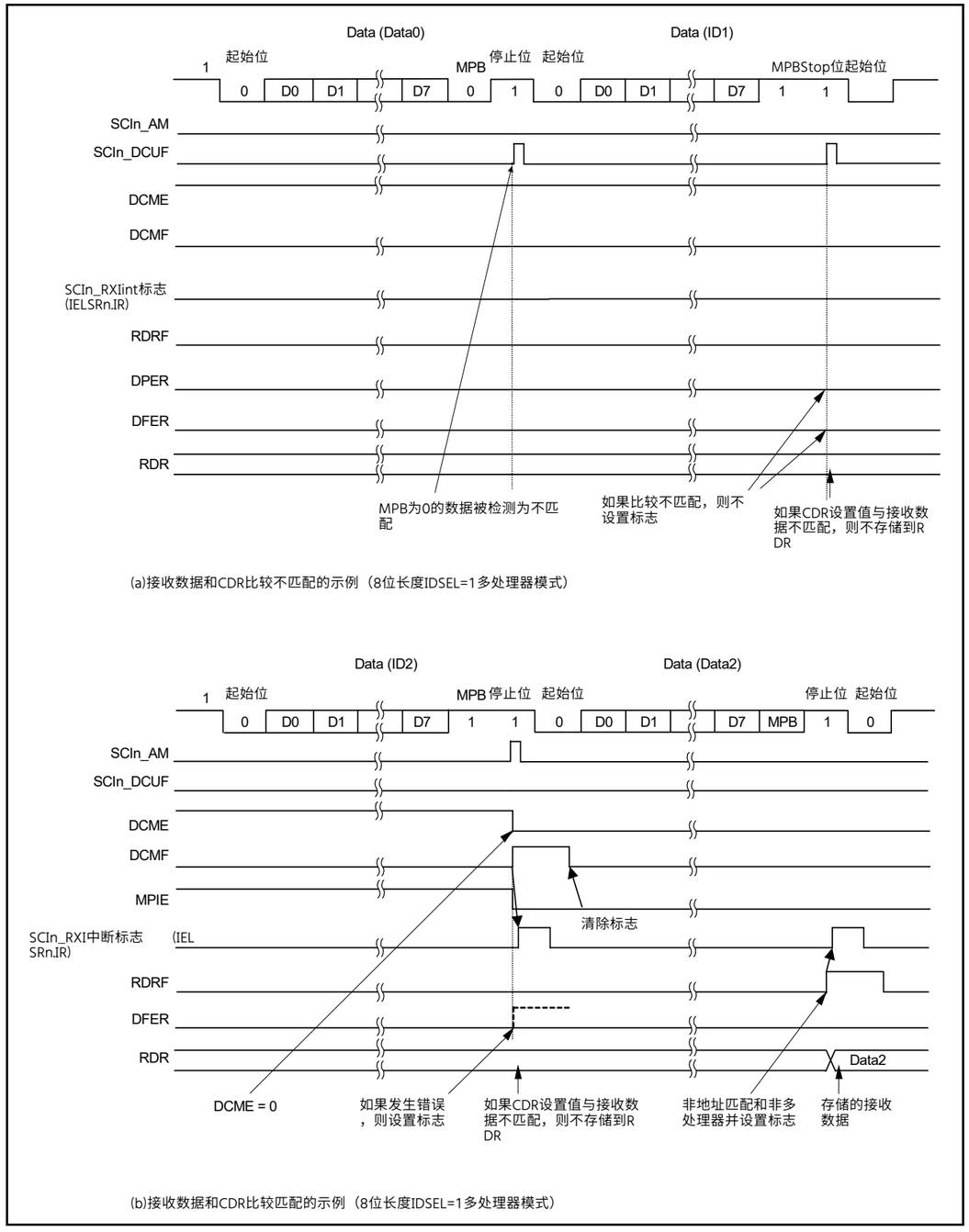
Figure 27.5 非多处理器模式下的地址匹配示例（1）



(a) Example of compare mismatched between receive data and CDR (8-bit length/IDSEL = 1/multi-processor mode)

(b) Example of compare matched between receive data and CDR (8-bit length/IDSEL = 1/multi-processor mode)

Figure 27.6 Example of address match (2) multi-processor mode



(a)接收数据和CDR比较不匹配的示例（8位长度IDSEL=1多处理器模式）

(b)接收数据和CDR比较匹配的示例（8位长度IDSEL=1多处理器模式）

Figure 27.6 地址匹配示例（二）多处理器模式

27.3.7 SCI Initialization in Asynchronous Mode

Before transmitting and receiving data, start by writing the initial value 00h to the SCR register, then continue through to the SCI initialization procedure (select non-FIFO or FIFO) shown in Figure 27.7 and Figure 27.8. Whenever the operating mode or transfer format is to be changed, the SCR register must be initialized before the change is made.

When the external clock is used in asynchronous mode, ensure that the clock signal is supplied during initialization.

Note: When the SCR.RE bit is set to 0, the ORER, FER, RDRF, RDF, PER, and DR flags in SSR/SSR_FIFO, and the RDR and RDRHL registers are not initialized. When the SCR.TE bit is set to 0, the TEND flag for the selected FIFO buffer is not initialized.

Note: Switching the value of the SCR.TE bit from 1 to 0 or 0 to 1 while the SCR.TIE bit is 1 leads to the generation of an SCIn_TXI interrupt request.

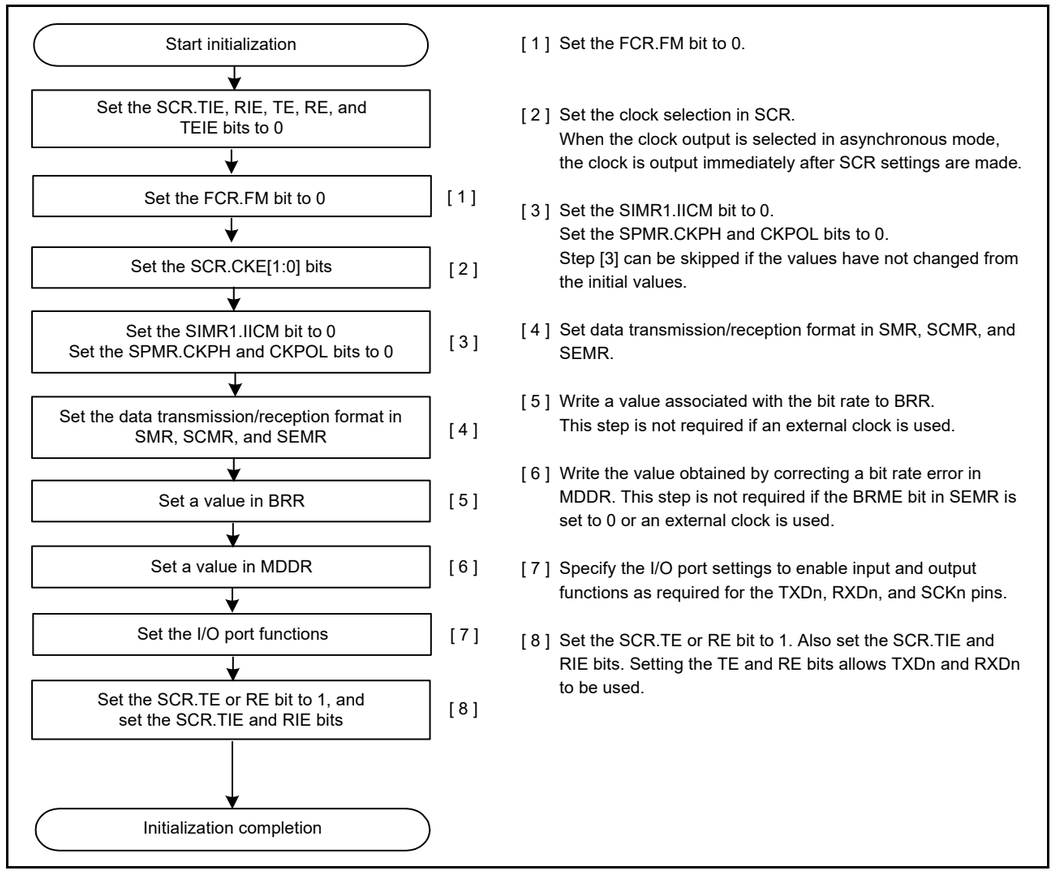


Figure 27.7 Example SCI initialization flow in asynchronous mode with non-FIFO selected

27.3.7 异步模式下的SCI初始化

在发送和接收数据之前，首先将初始值00h写入SCR寄存器，然后继续进行图27.7和图27.8所示的SCI初始化过程（选择非FIFO或FIFO）。每当要更改操作模式或传输格式时，必须在更改之前初始化SCR寄存器。

在异步模式下使用外部时钟时，请确保在初始化期间提供时钟信号。

Note: 当SCR.RE位设置为0时，SSRSSR_FIFO中的ORER、FER、RDRF、RDF、PER和DR标志，以及RDR和RDRHL寄存器未初始化。当SCR.TE位设置为0时，选择的TEND标志FIFO缓冲区未初始化。

Note: 当SCR.TIE位为1时，将SCR.TE位的值从1切换到0或0到1会导致生成SCIn_TXI中断请求。

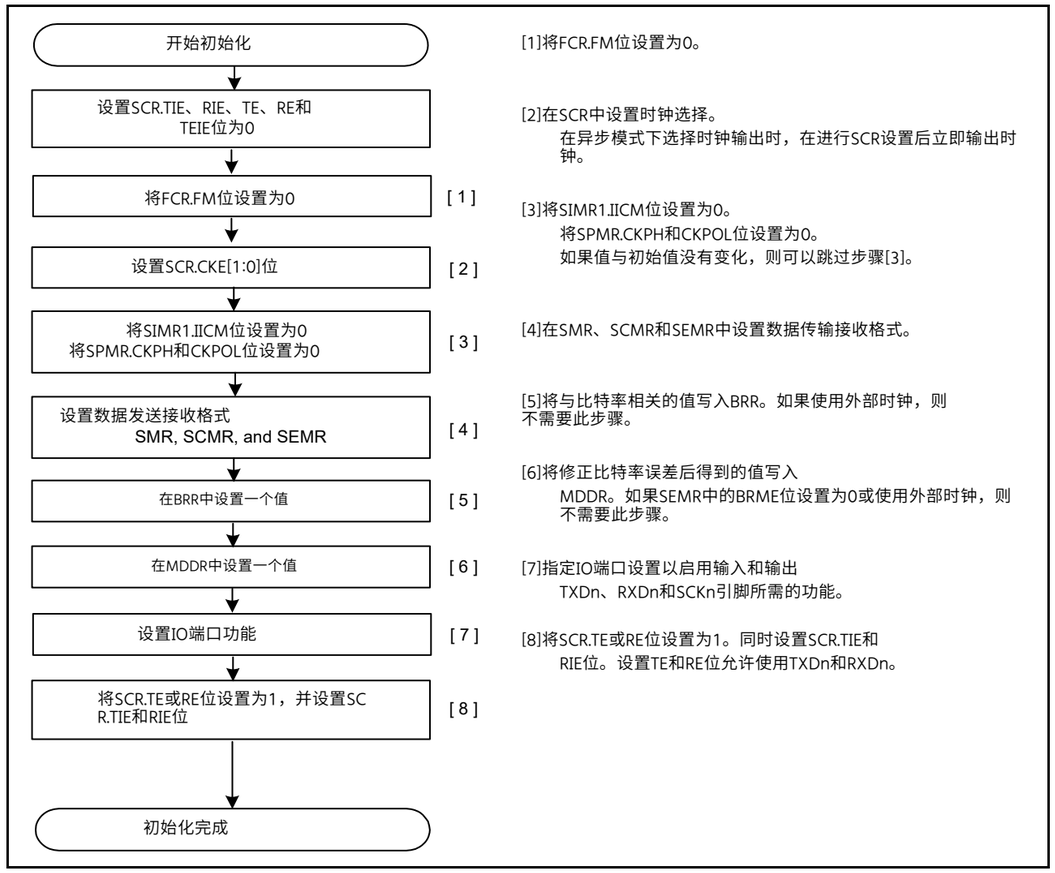


Figure 27.7 选择非FIFO的异步模式下的示例SCI初始化流程

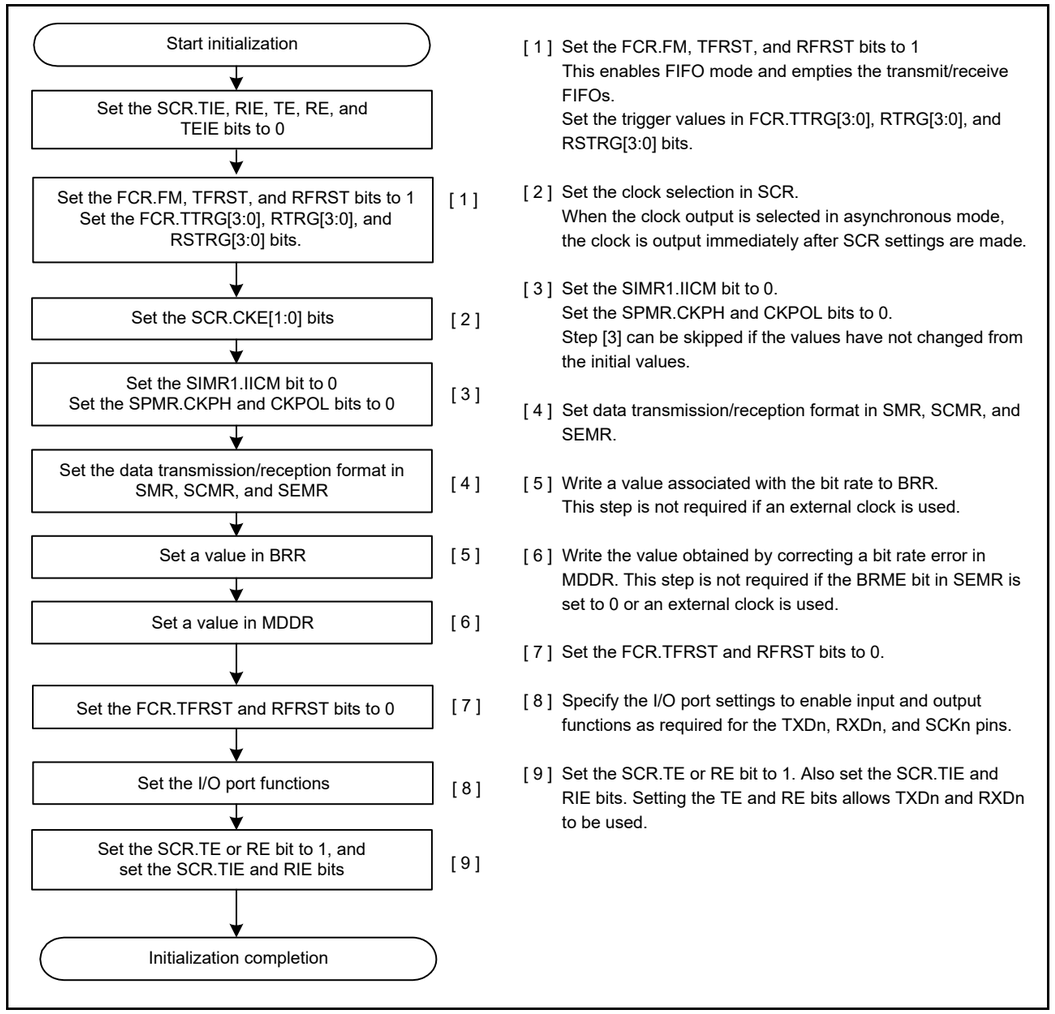


Figure 27.8 Example SCI initialization flow in synchronous mode with FIFO selected

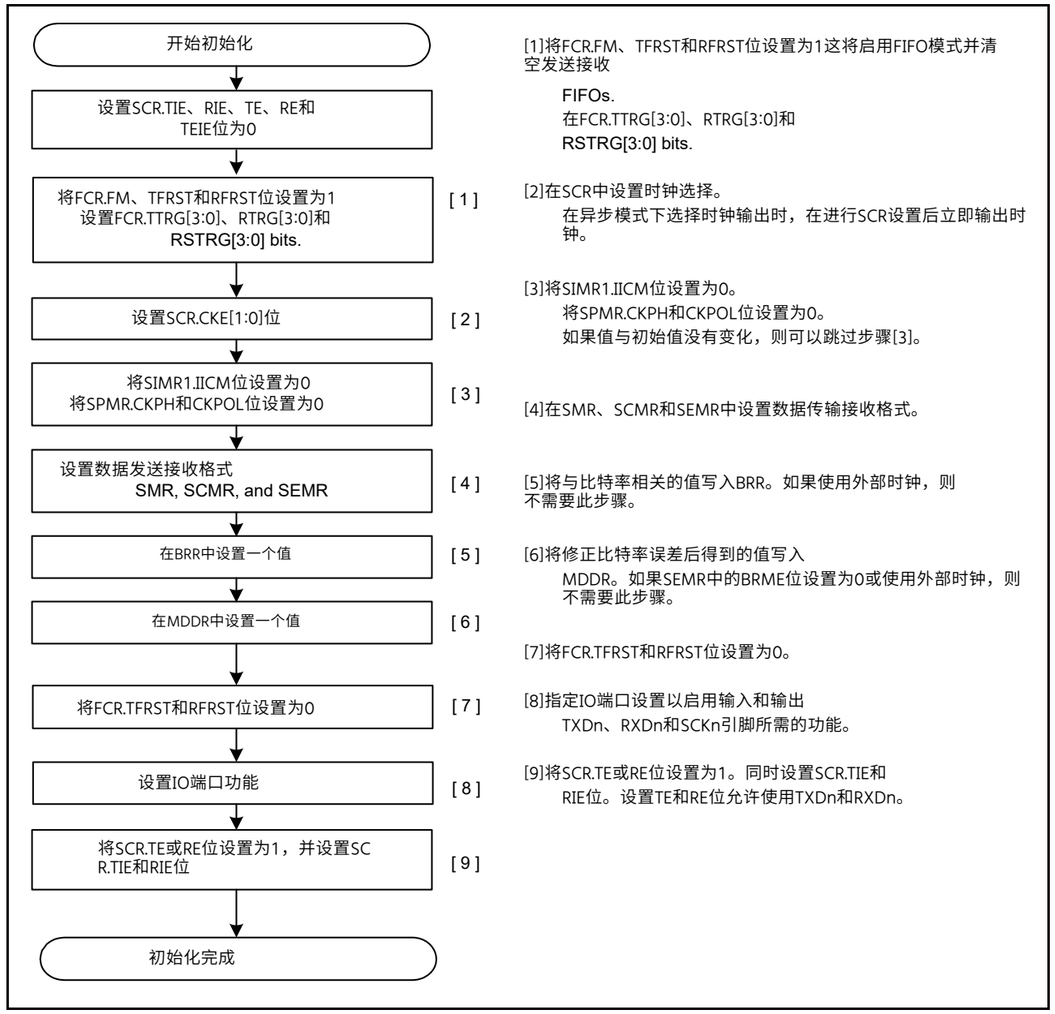


Figure 27.8 选择FIFO的同步模式下的SCI初始化流程示例

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27.3.8 Serial Data Transmission in Asynchronous Mode

(1) Non-FIFO selected

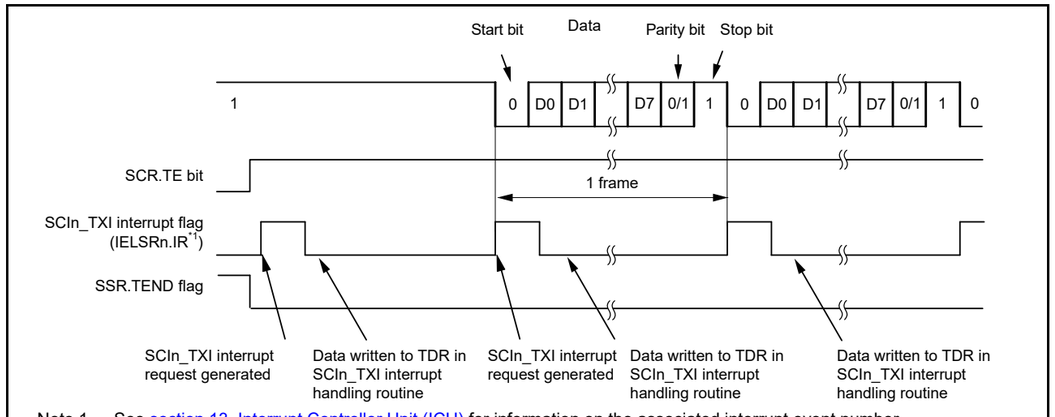
Figure 27.9, Figure 27.10, and Figure 27.11 show examples of serial transmission in asynchronous mode.

In serial transmission, the SCI operates as described in this section. When the SCR.TE bit is set to 1, the high level for one frame (preamble) is output to TXDn.

1. The SCI transfers data from TDR*1 to TSR when data is written to TDR*1 in the SCIn_TXI interrupt handling routine.
   The SCIn_TXI interrupt request at the beginning of transmission is generated when the TE and TIE bits in the SCR are set to 1 simultaneously by a single instruction.
2. Transmission starts after the SPMR.CTSE bit is set to 0 (CTS function is disabled) or a low level on the CTSn_RTSn pin causes data transfer from TDR*1 to TSR. If the SCR.TIE bit is 1, an SCIn_TXI interrupt request is generated. Continuous transmission is possible by writing the next transmit data to TDR*1 in the SCIn_TXI interrupt handling routine before transmission of the current transmit data is complete. When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 (an SCIn_TXI interrupt request is disabled) and the SCR.TEIE bit to 1 (an SCIn_TEI interrupt request is enabled) after the last of the data to be transmitted is written to TDR*1 from the handling routine for SCIn_TXI requests.
3. Data is sent from the TXDn pin in the following order:
   - Start bit
   - Transmit data
   - Parity bit or multi-processor bit (can be omitted depending on the format)
   - Stop bit.
4. The SCI checks for an update of the TDR register on the output of the stop bit.
5. When TDR is updated, setting the SPMR.CTSE bit to 0 (CTS function is disabled) or a low-level input on the CTSn_RTSn pin, causes the transfer of the next transmit data from TDR*1 to TSR and transmission of the stop bit, after which serial transmission of the next frame starts.
6. If TDR is not updated, the SSR.TEND flag is set to 1, the stop bit is sent, and the mark state is entered, where 1 is output. If the SCR.TEIE bit is 1, the SSR.TEND flag is set to 1 and an SCIn_TEI interrupt request is generated.

Note 1. Only write data to the TDRHL register when 9-bit data length is selected.

Figure 27.9, Figure 27.10, and Figure 27.11 show examples of serial transmission in asynchronous mode.



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

Figure 27.9 Example of operation for serial transmission in asynchronous mode (1) with 8-bit data, parity bit, 1 stop bit, CTS function not used, and at the beginning of transmission

27.3.8 异步模式下的串行数据传输

(1) Non-FIFO selected

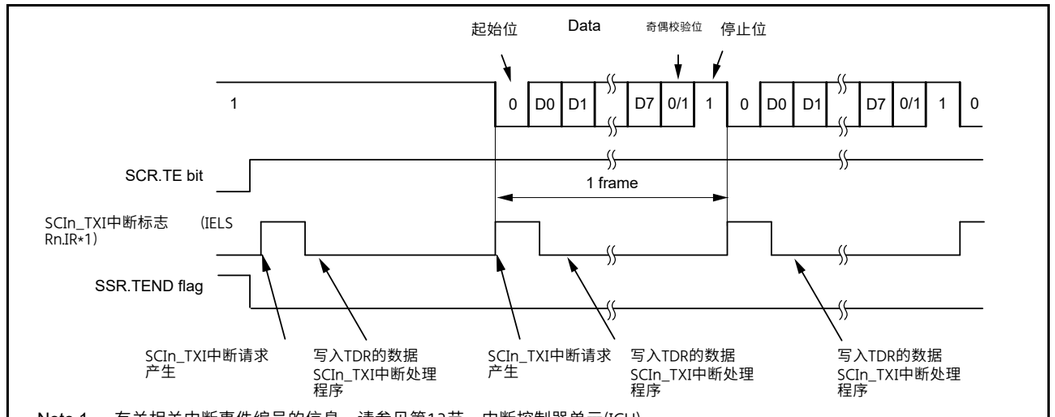
图27.9、图27.10和图27.11显示了异步模式下的串行传输示例。

在串行传输中，SCI的操作如本节所述。当SCR.TE位设置为1时，一帧（前导码）的高电平输出到TXDn。

1. 当在SCIn_TXI中断处理程序中将数据写入TDR*1时，SCI将数据从TDR*1传输到TSR。当SCR中的TE和TIE位通过一条指令同时设置为1时，会在传输开始时产生SCIn_TXI中断请求。
2. 在SPMR.CTSE位设置为0（禁用CTS功能）或低电平后开始发送CTSn_RTSn引脚导致数据从TDR*1传输到TSR。如果SCR.TIE位为1，则产生SCIn_TXI中断请求。在当前发送数据的发送完成之前，通过在SCIn_TXI中断处理例程中将下一个发送数据写入TDR*1，可以进行连续发送。当使用SCIn_TEI中断请求时，在要发送的最后一个数据完成后，将SCR.TIE位设置为0（禁用SCIn_TXI中断请求）并将SCR.TEIE位设置为1（启用SCIn_TEI中断请求）从SCIn_TXI请求的处理例程写入TDR*1。
3. 数据按以下顺序从TXDn引脚发送：
   - 起始位
   - 传输数据
   - 奇偶校验位或多处理器位（可根据格式省略）
   - 停止位。
4. SCI在停止位的输出上检查TDR寄存器的更新。
5. 更新TDR时，将SPMR.CTSE位设置为0（禁用CTS功能）或在CTSn_RTSn引脚，使下一个传输数据从TDR*1传输到TSR并传输停止位，然后开始下一帧的串行传输。
6. 如果TDR没有更新，则SSR.TEND标志设置为1，发送停止位，并进入标记状态，其中输出1。如果SCR.TEIE位为1，则SSR.TEND标志设置为1，并产生SCIn_TEI中断请求。

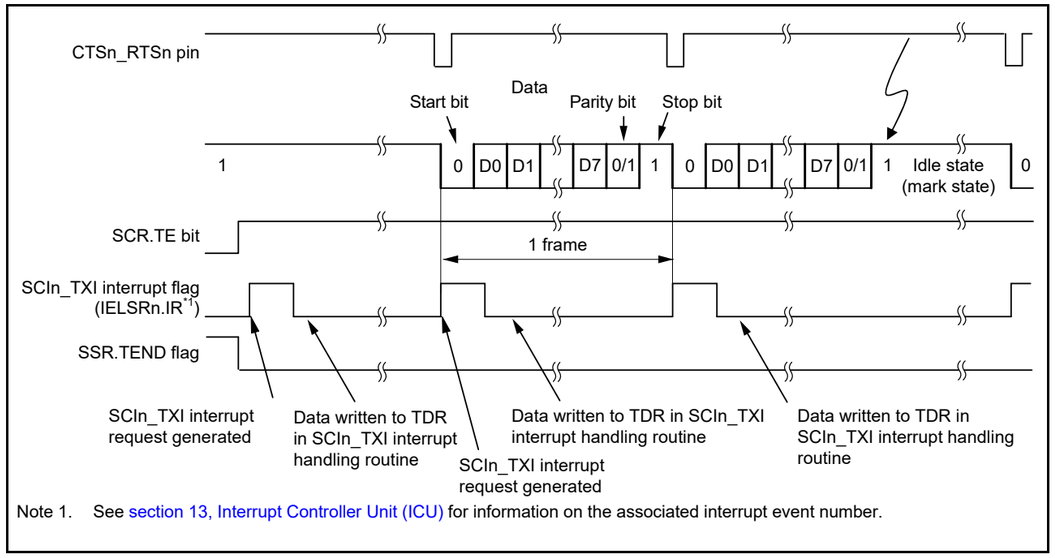
注意1.选择9位数据长度时，仅将数据写入TDRHL寄存器。

图27.9、图27.10和图27.11显示了异步模式下的串行传输示例。



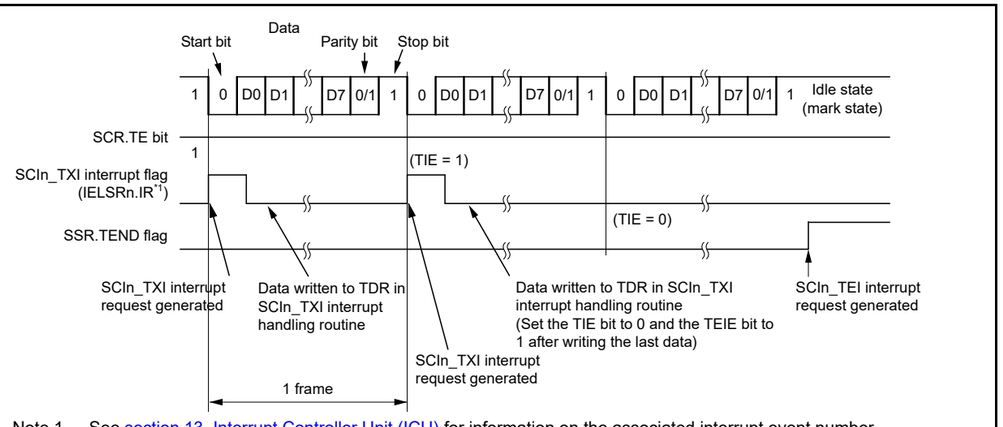
Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.9 异步模式下串行传输的操作示例(1)8位数据、奇偶校验位、1个停止位、未使用CTS功能以及传输开始时



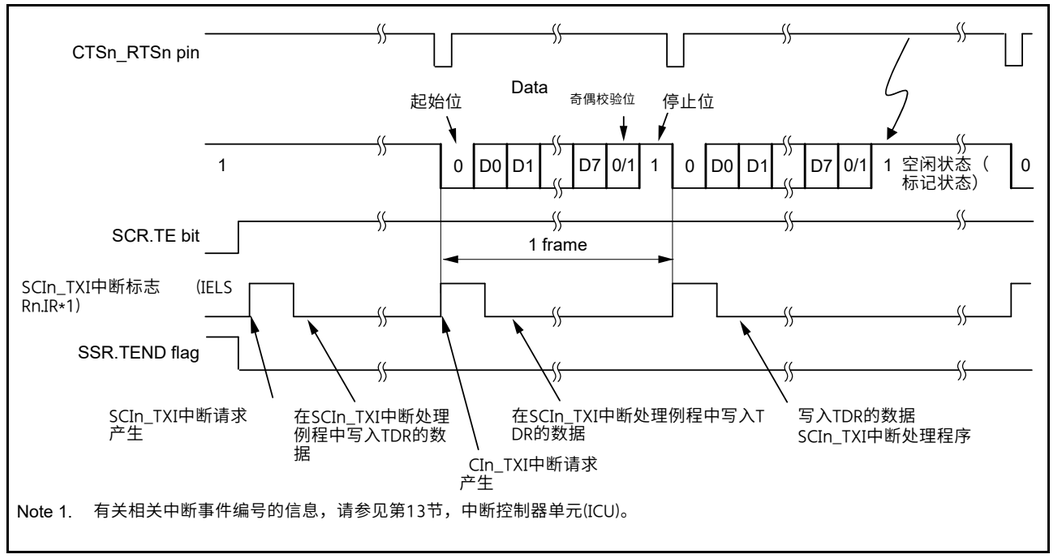
Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

Figure 27.10 Example of operation for serial transmission in asynchronous mode (2) with 8-bit data, parity bit, 1 stop bit, CTS function used, and at the beginning of transmission



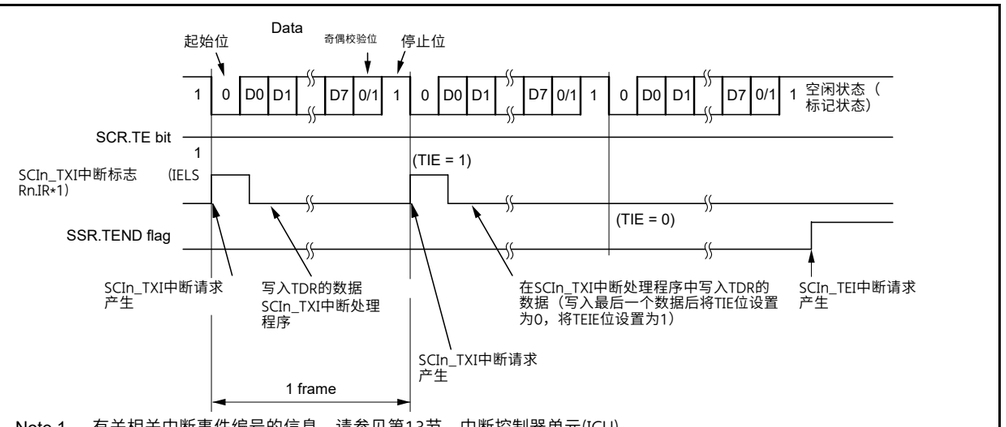
Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

Figure 27.11 Example of operation for serial transmission in asynchronous mode (3) with 8-bit data, parity bit, 1 stop bit, CTS function not used, and from the middle of transmission until transmission completion



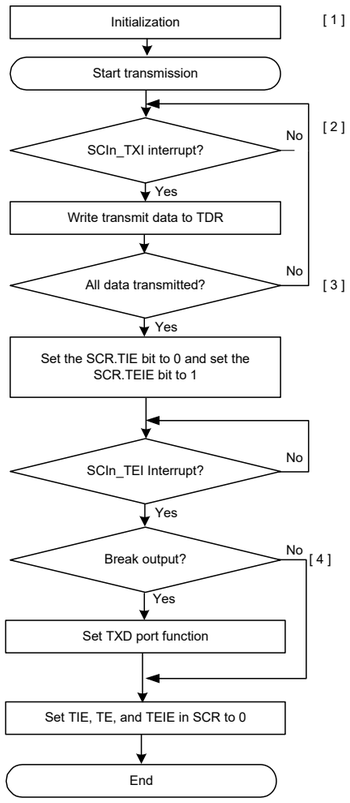
Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.10 8位数据、奇偶校验位、1个停止位、使用CTS功能、传输开始时的异步模式串行传输操作示例(2)



Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.11 8位数据、奇偶校验位、1个停止位、未使用CTS功能的异步模式串行传输操作示例(3)，从传输中间到传输完成



[1] SCI Initialization:
Set data transmission.
After the SCR.TE bit is set to 1, 1 is output for a frame (preamble), and transmission is enabled.

[2] Transmit data write to TDR by an SCIn_TXI interrupt request. When transmit data is transferred from TDR to TSR, a transmit data empty interrupt (SCIn_TXI) request is generated. Write transmit data to TDR while in the SCIn_TXI interrupt processing routine.

[3] Serial transmission continuation procedure:
To continue serial transmission, write transmit data to TDR once using an SCIn_TXI interrupt request. Transmit data can also be written to TDR by activating the DMAC or DTC.
When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 and the SCR.TEIE bit to 1 after the last of the data to be transmitted is written to TDR.

[4] Break output at the end of serial transmission:
To output a break in serial transmission, after setting the output state (low-level output) of TXDn pin using the SPTR.SPB2IO and SPTR.SPB2DT bits, set the SCR.TE bit to 0.

Note: The TDR register becomes the TDRHL register when 9-bit data length is selected.

Figure 27.12 Example of serial transmission flow in asynchronous mode with non-FIFO selected

(2) FIFO selected

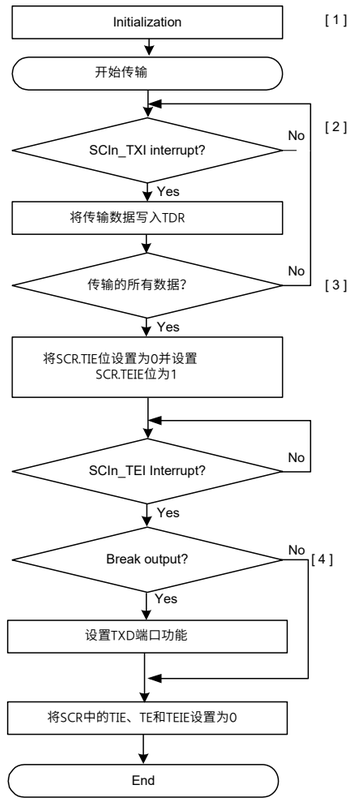
Figure 27.13 shows an example of a data format that is written to FTDRH and FTDRL in asynchronous mode.

Data that corresponds to the data length is set to FTDRH and FTDRL. Write 0 for unused bits. Write in order from FTDRH to FTDRL.

Data Length	Register Setting		Transmit data in FTDRH, FTDRL															
			FTDRHL															
			FTDRH								FTDRL							
	SCMR.CHR1	SMR.CHR	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
7 bits	1	0	—	—	—	—	—	—	—	—	—	7-bit transmit data						
8 bits	1	1	—	—	—	—	—	—	—	—	8-bit transmit data							
9 bits	0	Don't care	—	—	—	—	—	—	—	9-bit transmit data								

—: Invalid. The write value should be 0.

Figure 27.13 Data format written to FTDRH and FTDRL with FIFO selected



[1] SCI Initialization:
设置数据传输。
SCR.TE位设置为1后，为一个帧（前导码）输出1，并启用传输。

[2]通过SCIn_TXI中断请求将数据写入TDR。当发送数据从TDR传输到TSR时，会产生发送数据空中断(SCIn_TXI)请求。在SCIn_TXI中断处理程序中将发送数据写入TDR。

[3]串行传输继续程序：
要继续串行传输，请使用SCIn_TXI中断请求将传输数据写入TDR一次。
也可以通过激活DMAC或DTC将传输数据写入TDR。当SCIn_TEI中断请求正在使用时，设置

在将要发送的最后一个数据写入TDR后，SCR.TIE位为0，SCR.TEIE位为1。

[4]串行传输结束时中断输出：
要在串行传输中输出中断，在使用SPTR.SPB2IO和SPTR.SPB2DT位设置TXDn引脚的输出状态（低电平输出）后，将SCR.TE位设置为0。

Note: 选择9位数据长度时，TDR寄存器成为TDRHL寄存器。

Figure 27.12 选择非FIFO的异步模式下串行传输流示例

(2) FIFO selected

图27.13显示了以异步模式写入FTDRH和FTDRL的数据格式示例。

与数据长度对应的数据设置为FTDRH和FTDRL。为未使用的位写入0。从以下顺序写FTDRH to FTDRL.

数据长度	寄存器设置		在FTDRH、FTDRL中传输数据															
			FTDRHL															
			FTDRH								FTDRL							
	SCMR.CHR1	SMR.CHR	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
7 bits	1	0	—	—	—	—	—	—	—	—	—	7位传输数据						
8 bits	1	1	—	—	—	—	—	—	—	—	8位传输数据							
9 bits	0	不在乎	—	—	—	—	—	—	—	9位传输数据								

–：无效的。写入值应为0。

Figure 27.13 选择FIFO写入FTDRH和FTDRL的数据格式

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In serial transmission, the SCI operates as described in this section. When the TE bit is set to 1, the high level for one frame (preamble) is output to TXD.

1. The SCI transfers data from FTDRL*1 to TSR when data is written to FTDRL*1 in the SCIn_TXI interrupt handling routine. The amount of data that can be written to FTDRL is 16 minus FDR.T[4:0] bytes. The SCIn_TXI interrupt request at the beginning of transmission is generated when the TE and TIE bits in SCR are set to 1 simultaneously by a single instruction.
2. Transmission starts after the SPMR.CTSE bit is set to 0 (CTS function is disabled) or a low level on the CTSn_RTSn pin causes data transfer from FTDRL*1 to TSR. When the amount of transmit data written in FTDRL is equal to or less than the specified transmit triggering number, SSR_FIFO.TDFE is set to 1. If the SCR.TIE bit is 1, an SCIn_TXI interrupt request is generated. Continuous transmission is possible by writing the next transmit data to FTDRL*1 in the SCIn_TXI interrupt handling routine before transmission of the current transmit data is complete. When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 (an SCIn_TXI interrupt request is disabled) and the SCR.TEIE bit to 1 (an SCIn_TEI interrupt request is enabled) after the last of the data to be transmitted is written to FTDRL*1 *2 from the handling routine for SCIn_TXI requests.
3. Data is sent from the TXDn pin in the following order:
   - Start bit
   - Transmit data
   - Parity bit or multi-processor bit (can be omitted depending on the format)
   - Stop bit.
4. On output of the stop bit, the SCI checks whether non-transmitted data remains in FTDRL*3.
5. When data is set to FTDRL*3, setting the SPMR.CTSE bit to 0 (CTS function is disabled) or a low-level input on the CTSn_RTSn pin causes transfer of the next transmit data from FTDRL*1 to TSR and transmission of the stop bit, after which serial transmission of the next frame starts.
6. If data is not set in FTDRL*3, the TEND flag in SSR_FIFO is set to 1, the stop bit is sent, and the mark state is entered where 1 is output. If the SCR.TEIE bit is 1, the SSR_FIFO.TEND flag is set to 1 and an SCIn_TEI interrupt request is generated.

Note 1. Write data to the FTDRH and FTDRL registers when 9-bit data length is selected.
Note 2. Write data in order from FTDRH to FTDRL when 9-bit data length is selected.
Note 3. The SCI only checks for an update to the FTDRL register and not the FTDRH register when 9-bit data length is selected.

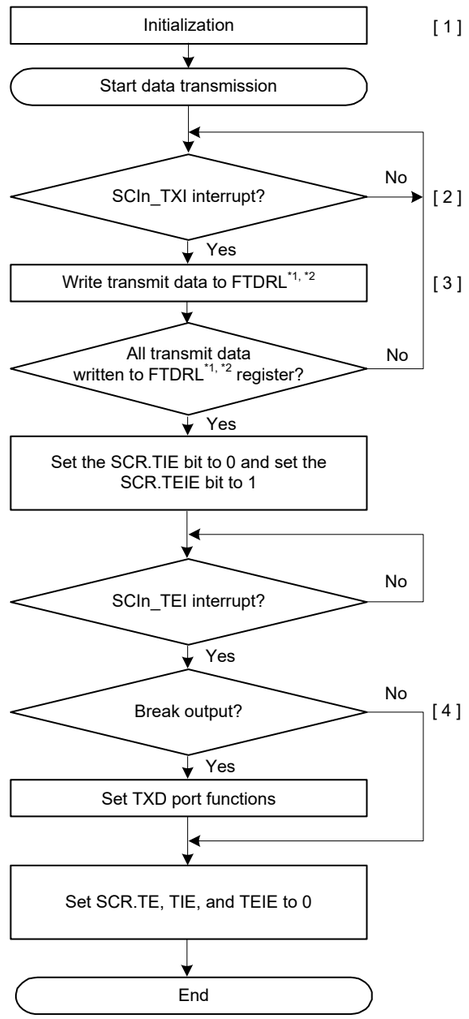
Figure 27.14 shows an example flow of serial transmission in asynchronous mode with FIFO selected.

在串行传输中，SCI的操作如本节所述。当TE位设置为1时，一帧（前导码）的高电平输出到TXD。

1. 在SCIn_TXI中断处理例程中将数据写入FTDRL*1时，SCI将数据从FTDRL*1传输到TSR。可写入FTDRL的数据量为16减去FDR.T[4:0]字节。当一条指令同时将SCR中的TE和TIE位设置为1时，会在传输开始时产生SCIn_TXI中断请求。
2. 在SPMR.CTSE位设置为0（禁用CTS功能）或低电平后开始发送CTSn_RTSn引脚导致数据从FTDRL*1传输到TSR。当写入FTDRL的发送数据量等于或小于指定的发送触发数时，SSR_FIFO.TDFE设置为1。如果SCR.TIE位为1，则产生SCIn_TXI中断请求。在当前传输数据传输完成之前，通过在SCIn_TXI中断处理例程中将下一个传输数据写入FTDRL*1可以实现连续传输。当使用SCIn_TEI中断请求时，在要发送的最后一个数据完成后，将SCR.TIE位设置为0（禁用SCIn_TXI中断请求）并将SCR.TEIE位设置为1（启用SCIn_TEI中断请求）从SCIn_TXI请求的处理例程写入FTDRL*1*2。
3. 数据按以下顺序从TXDn引脚发送：
   - 起始位
   - 传输数据
   - 奇偶校验位或多处理器位（可根据格式省略）
   - 停止位。
4. 在停止位输出时，SCI检查未传输的数据是否保留在FTDRL*3中。
5. 当数据设置为FTDRL*3时，将SPMR.CTSE位设置为0（禁用CTS功能）或CTSn_RTSn引脚上的低电平输入会导致下一个传输数据从FTDRL*1传输到TSR并传输停止位，之后开始下一帧的串行传输。
6. 如果FTDRL*3中未设置数据，则将SSR_FIFO中的TEND标志设置为1，发送停止位，并在输出1时进入标记状态。如果SCR.TEIE位为1，则SSR_FIFO.TEND标志设置为1，并产生SCIn_TEI中断请求。

注意1.选择9位数据长度时，将数据写入FTDRH和FTDRL寄存器。
注2.选择9位数据长度时，按从FTDRH到FTDRL的顺序写入数据。
注意3.SCI仅检查对FTDRL寄存器的更新，而不是选择9位数据长度时的FTDRH寄存器。

图27.14显示了选择FIFO的异步模式下串行传输的示例流程。



[1] SCI initialization:
Set data transmission.
After the SCR.TE bit is set to 1, 1 is output for a frame (preamble), and transmission is enabled.

[2] Transmit data write to FTDRL*1 by an SCIn_TXI interrupt request:
For data transmission from FTDRL to TSR, when the amount of transmit data written in FTDRL is equal to or less than the specified transmit triggering number, a transmit data FIFO empty interrupt (SCIn_TXI) request is generated. Write transmit data to FTDRL*1, *2 once in the SCIn_TXI interrupt handling routine.

[3] Serial transmission continuation procedure:
To continue serial transmission, write all transmit data to FTDRL using an SCIn_TXI interrupt request and clear the SSR_FIFO.TDFE flag to 0. It is possible to write 16 minus the amount of data stored in the transmit FIFO. Transmit data can also be written to FTDRL by activating the DMAC or DTC. When data is written to FTDRL by DMAC or DTC, the TDFE flag is cleared automatically. Therefore, do not write to the TDFE flag.
When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 and the SCR.TEIE bit to 1 after the last of the data to be transmitted is written to FTDRL.

[4] Break output at the end of serial transmission:
To output a break in serial transmission, after setting the output state (low-level output) of the TXDn pin using SPTR.SPB2IO and SPTR.SPB2DT bits, set the SCR.TE bit to 0.

Note 1. When data length is 9 bits, FTDRH and FTDRL registers are used.
Note 2. When data length is 9 bits, write in order from FTDRH to FTDRL.

Figure 27.14 Example of serial transmission flow in asynchronous mode with FIFO selected

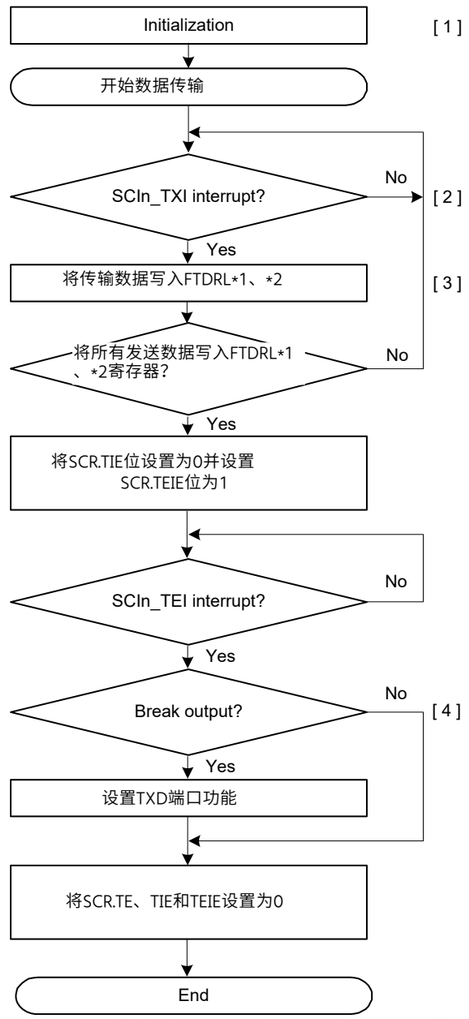
27.3.9 Serial Data Reception in Asynchronous Mode

(1) Non-FIFO selected

Figure 27.15 and Figure 27.16 show an example of the operation for serial data reception in asynchronous mode.

In serial data reception, the SCI operates as follows:

1. When the value of the SCR.RE bit becomes 1, the output signal on the CTSn_RTSn pin goes low.
2. When the SCI monitors the communications line and detects a start bit, it performs internal synchronization, stores receive data in RSR, and checks the parity bit and stop bit.
3. If an overrun error occurs, the SSR.ORER flag is set to 1. If the SCR.RIE bit is 1, an SCIn_ERI interrupt request is generated. Receive data is not transferred to RDR*1.



[1] SCI initialization:
设置数据传输。
SCR.TE位设置为1后，为一个帧（前导码）输出1，并启用传输。

[2] 通过SCIn_TXI中断请求将数据写入FTDRL*1：对于从FTDRL到TSR的数据传输，当写入FTDRL的发送数据量等于或小于指定的发送触发数时，发送数据FIFO空中断（SCIn_TXI)请求生成。在SCIn_TXI中断处理例程中将发送数据写入FTDRL*1、*2一次。

[3] 串行传输继续过程：
要继续串行传输，请将所有传输数据写入FTDRL使用SCIn_TXI中断请求并将SSR_FIFO.TDFE标志清除为0。可以写入16减去发送FIFO中存储的数据量。也可以通过激活DMAC或DTC将传输数据写入FTDRL。当数据通过DMAC或DTC写入FTDRL时，TDFE标志自动清零。因此，不要写入TDFE标志。

当SCIn_TEI中断请求正在使用时，设置
在将要传输的最后一个数据写入FTDRL后，SCR.TIE位为0，SCR.TEIE位为1。

[4] 串行传输结束时中断输出：
要在串行传输中输出中断，在使用SPTR.SPB2IO和SPTR.SPB2DT位设置TXDn引脚的输出状态（低电平输出）后，将SCR.TE位设置为0。

Note 1. 当数据长度为9位时，使用FTDRH和FTDRL寄存器。
Note 2. 当数据长度为9位时，按照FTDRH到FTDRL的顺序写入。

Figure 27.14 选择FIFO的异步模式下串行传输流程示例

27.3.9 异步模式下的串行数据接收

(1) Non-FIFO selected

图27.15和图27.16显示了异步模式下串行数据接收操作的示例。

在串行数据接收中，SCI操作如下：

1. 当SCR.RE位的值变为1时，CTSn_RTSn引脚上的输出信号变为低电平。
2. 当SCI监视通信线路并检测到起始位时，它会执行内部同步，将接收数据存储在RSR中，并检查奇偶校验位和停止位。
3. 如果发生溢出错误，则SSR.ORER标志设置为1。如果SCR.RIE位为1，则产生SCIn_ERI中断请求。接收数据不传输到RDR*1。

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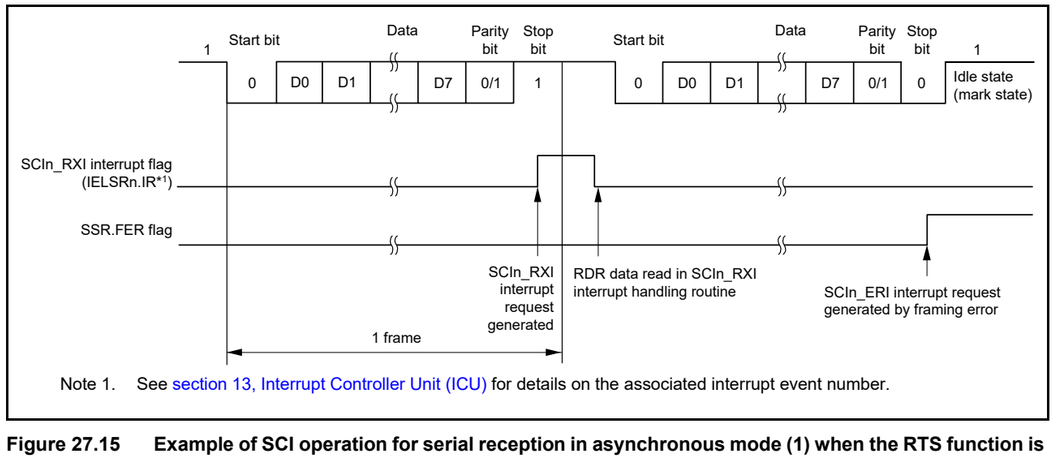
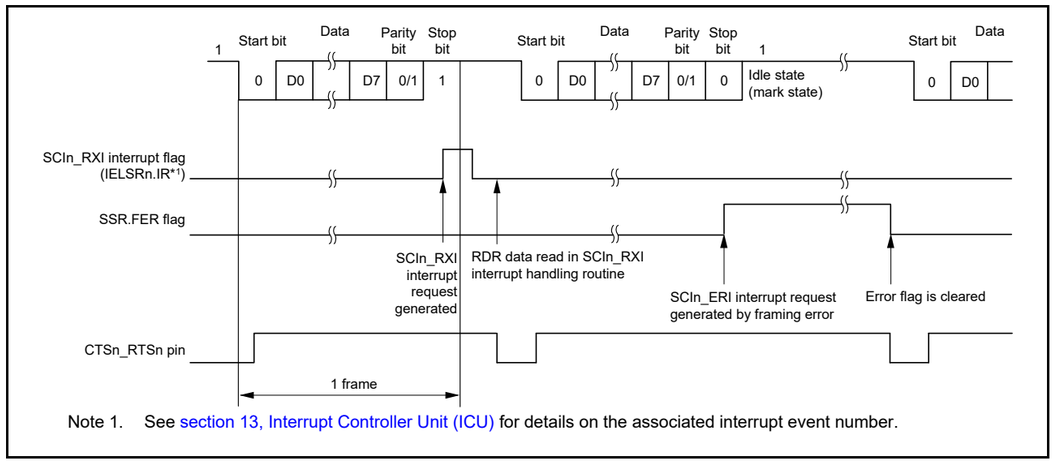
4. If a parity error is detected, the SSR.PER flag is set to 1 and receive data is transferred to RDR*1. If the SCR.RIE bit is 1, an SCIn_ERI interrupt request is generated.
5. If a frame error is detected, the SSR.FER flag is set to 1 and receive data is transferred to RDR*1. If the SCR.RIE bit is 1, an SCIn_ERI interrupt request is generated.
6. When reception finishes successfully, receive data is transferred to RDR*1. If the SCR.RIE bit is 1, an SCIn_RXI interrupt request is generated. Continuous reception is enabled by reading the receive data transferred to RDR in the SCIn_RXI interrupt handling routine before reception of the next receive data completes. Reading the received data that was transferred to RDR causes the CTSn_RTSn pin to output low.

Note 1. Only read data in the RDRHL register when 9-bit data length is selected.



Note 1. See section 13, Interrupt Controller Unit (ICU) for details on the associated interrupt event number.

Figure 27.15 Example of SCI operation for serial reception in asynchronous mode (1) when the RTS function is not used, and with 8-bit data, parity bit, and 1 stop bit



Note 1. See section 13, Interrupt Controller Unit (ICU) for details on the associated interrupt event number.

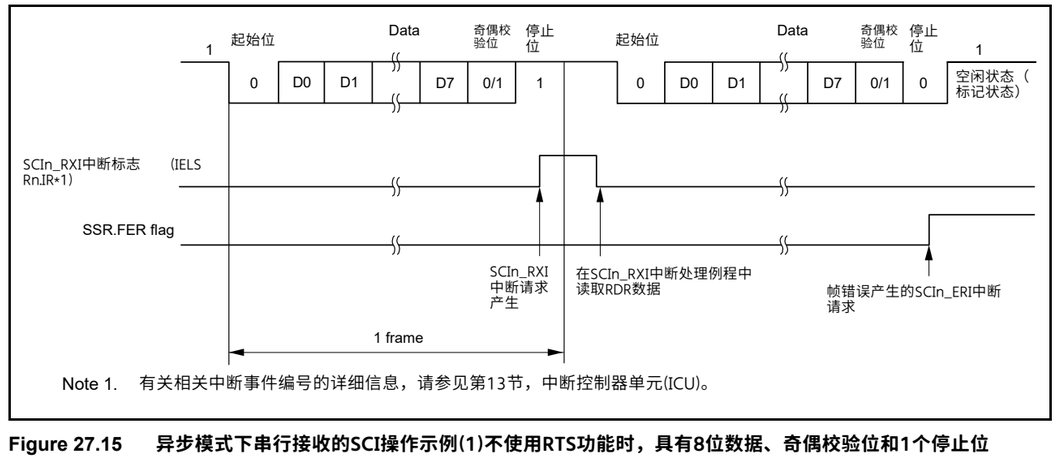
Figure 27.16 Example of SCI operation for serial reception in asynchronous mode (2) when RTS function is used, and with 8-bit data, parity bit, and 1 stop bit

Table 27.24 lists the states of the flags in the SSR register and receive data handling when a receive error is detected.

If a receive error is detected, an SCIn_ERI interrupt request is generated but an SCIn_RXI interrupt request is not generated. Data reception cannot be resumed while the receive error flag is 1. Also, set the ORER, FER, and PER flags to 0 before resuming reception. In addition, be sure to read the RDR or RDRHL register during overrun error processing.

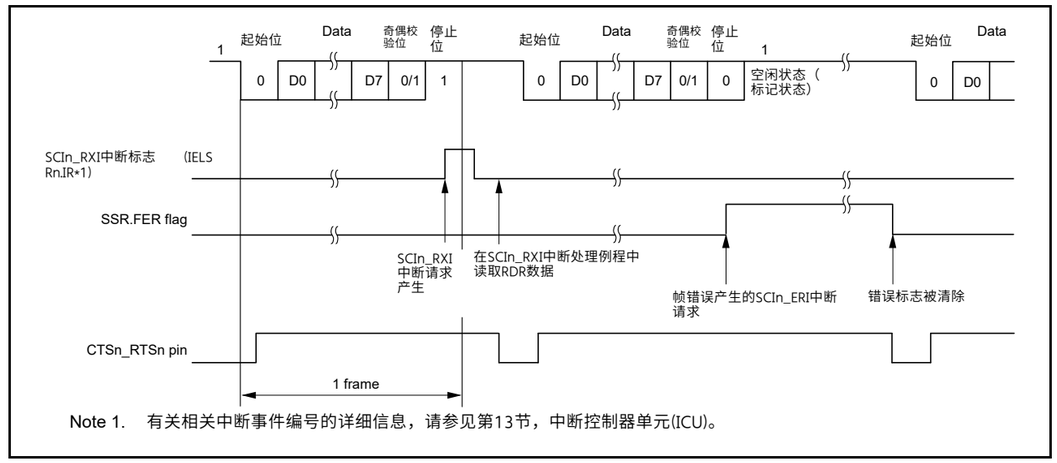
4. 如果检测到奇偶校验错误，则将SSR.PER标志设置为1，并将接收数据传输到RDR*1。如果SCR.RIE位为1，则产生SCIn_ERI中断请求。
5. 如果检测到帧错误，则将SSR.FER标志设置为1，并将接收数据传输到RDR*1。如果SCR.RIE位为1，则产生SCIn_ERI中断请求。
6. 当接收成功完成时，接收数据被传输到RDR*1。如果SCR.RIE位为1，则产生SCIn_RXI中断请求。在接收下一个接收数据完成之前，通过在SCIn_RXI中断处理例程中读取传输到RDR的接收数据来启用连续接收。读取传输到RDR的接收数据会导致CTSn_RTSn引脚输出低电平。

注1.选择9位数据长度时，仅读取RDRHL寄存器中的数据。



Note 1. 有关相关中断事件编号的详细信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.15 异步模式下串行接收的SCI操作示例(1)不使用RTS功能时，具有8位数据、奇偶校验位和1个停止位



Note 1. 有关相关中断事件编号的详细信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.16 使用RTS功能，8位数据、奇偶校验位和1个停止位时，异步模式下串行接收的SCI操作示例(2)

表27.24列出了SSR寄存器中标志的状态以及检测到接收错误时的接收数据处理。

如果检测到接收错误，则会产生SCIn_ERI中断请求，但不会产生SCIn_RXI中断请求。接收错误标志为1时无法恢复数据接收。此外，在恢复接收前，请将ORER、FER和PER标志设置为0。此外，请务必在溢出错误处理期间读取RDR或RDRHL寄存器。

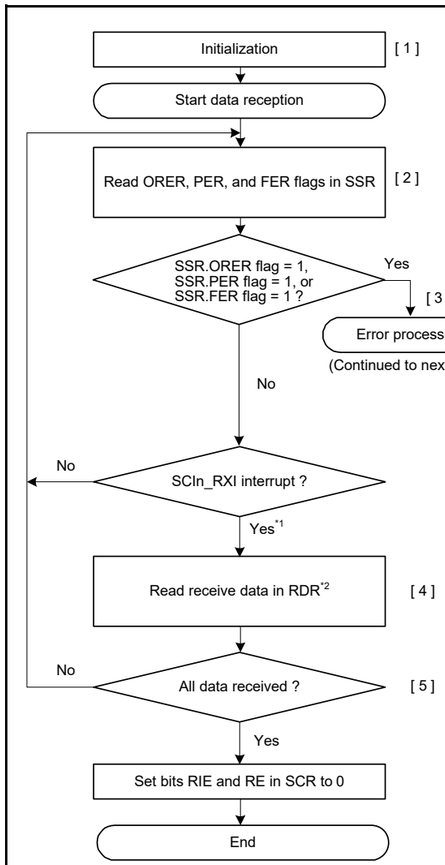
When a reception is forcibly terminated by setting the SCR.RE bit to 0 during operation, read the RDR or RDRHL register because the received data that is not yet read might be left in RDR or RDRHL.

Figure 27.17 and Figure 27.18 show example flows for serial data reception.

Table 27.24 Flags in SSR Status Register and receive data handling

Flags in the SSR Status Register				
ORER	**FER**	**PER**	**Receive data**	**Receive error type**
1	0	0	Lost	Overrun error
0	1	0	Transferred to RDR	Framing error
0	0	1	Transferred to RDR	Parity error
1	1	0	Lost	Overrun error + framing error
1	0	1	Lost	Overrun error + parity error
0	1	1	Transferred to RDR	Framing error + parity error
1	1	1	Lost	Overrun error + framing error + parity error

Note 1. Only read data in the RDRHL register when 9-bit data length is selected.



[1] SCI initialization:
Set data reception.

[2] [3] Receive error processing and break detection:
If a receive error occurs, an SCIn_ERI interrupt is generated. The error type is identified by reading the ORER, PER, and FER flags in SSR. After performing the appropriate error processing, be sure to set the ORER, PER, and FER flags to 0. Reception cannot be resumed if any of these flags is set to 1. For a framing error, a break can be detected by reading the value of the input port associated with the RXDn pin.

[4] Read the receive data in RDR once in the SCIn_RXI interrupt handling routine.

[5] Serial reception continuation procedure:
To continue serial reception, before the stop bit of the current frame is received, read data from RDR in the SCIn_RXI interrupt processing routine. The RDR data can also be read by activating the DMAC or DTC.

Note 1. Do not set RE to 0 before reading RDR.
Note 2. The RDR register becomes the RDRHL register when 9-bit data length is selected.

Figure 27.17 Example flow of serial reception in asynchronous mode with non-FIFO selected (1)

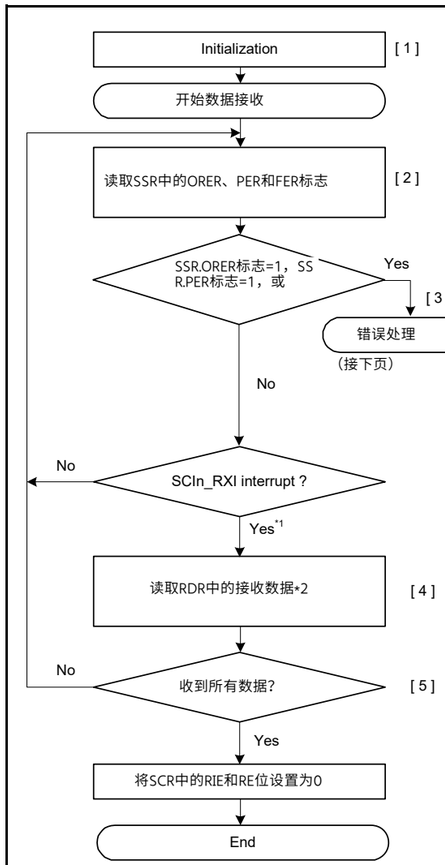
如果在操作期间通过将SCR.RE位设置为0来强制终止接收，请读取RDR或RDRHL寄存器，因为尚未读取的接收数据可能留在RDR或RDRHL中。

图27.17和图27.18显示了串行数据接收的示例流程。

Table 27.24 SSR状态寄存器中的标志和接收数据处理

SSR状态寄存器中的标志				
ORER	**FER**	**PER**	**接收数据**	**接收错误类型**
1	0	0	Lost	溢出错误
0	1	0	转移到RDR	构图错误
0	0	1	转移到RDR	奇偶校验错误
1	1	0	Lost	溢出错误+成帧错误
1	0	1	Lost	溢出错误+奇偶校验错误
0	1	1	转移到RDR	成帧错误+奇偶校验错误
1	1	1	Lost	溢出错误+帧错误+奇偶校验错误

Note 1. 仅在选择9位数据长度时读取RDRHL寄存器中的数据。



[1] SCI initialization:
设置数据接收。

[2][3]接收错误处理和断线检测：
如果发生接收错误，则会产生SCIn_ERI中断。错误类型通过读取SSR中的ORER、PER和FER标志来识别。执行适当的错误处理后，请务必将ORER、PER和FER标志设置为0。如果这些标志中的任何一个设置为1，则无法恢复接收。对于 帧错误，可以通过读取值来检测中断与RXDn引脚相关的输入端口。

[4] 在SCIn_RXI中断处理程序中读取一次RDR中的接收数据。

[5] 串行接收继续过程：
要继续串行接收，在接收到当前帧的停止位之前，在SCIn_RXI中断处理程序中从RDR中读取数据。RDR数据也可以通过激活DMAC或DTC来读取。

Note 1. 在读取RDR之前不要将RE设置为0。
Note 2. 选择9位数据长度时，RDR寄存器成为RDRHL寄存器。

Figure 27.17 选择非FIFO的异步模式下串行接收示例流程(1)

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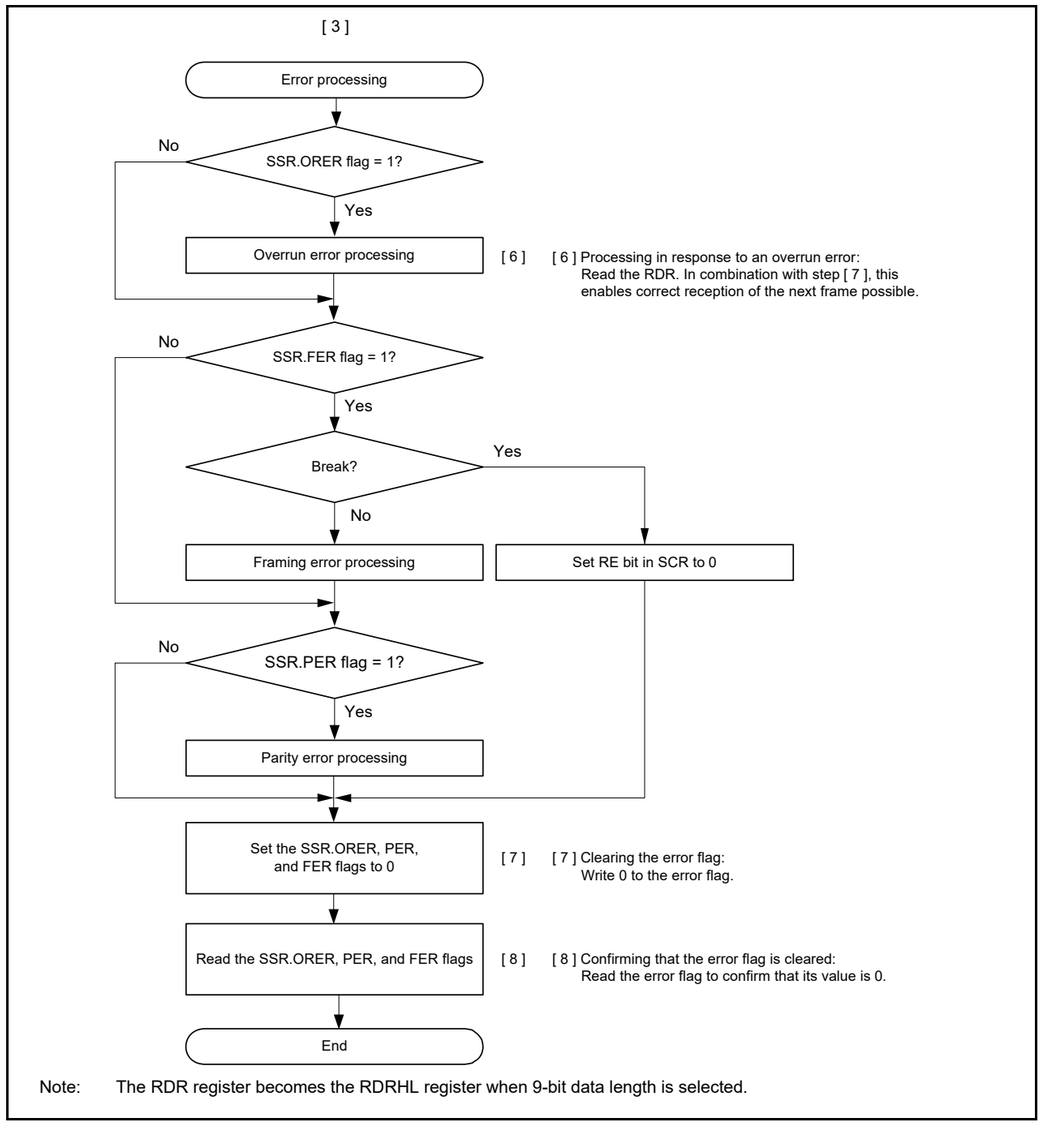


Figure 27.18 Example flow of serial reception in asynchronous mode with non-FIFO selected (2)

(2) FIFO selected

Figure 27.19 shows an example of a data format that is written to FRDRH and FRDRL in asynchronous mode.

In asynchronous mode, 0 is written to the MPB flag in FRDRH. Data that corresponds to the data length is written to FRDRH and FRDRL. Unused bits are written as 0. Read in the order from FRDRH to FRDRL. If software reads FRDRL, the SCI updates FER, PER, and receive data (RDAT[8:0]) in FRDRL with the next data. The RDF, ORER, and DR flags in FRDRH always reflect the associated flags in the SSR_FIFO register.

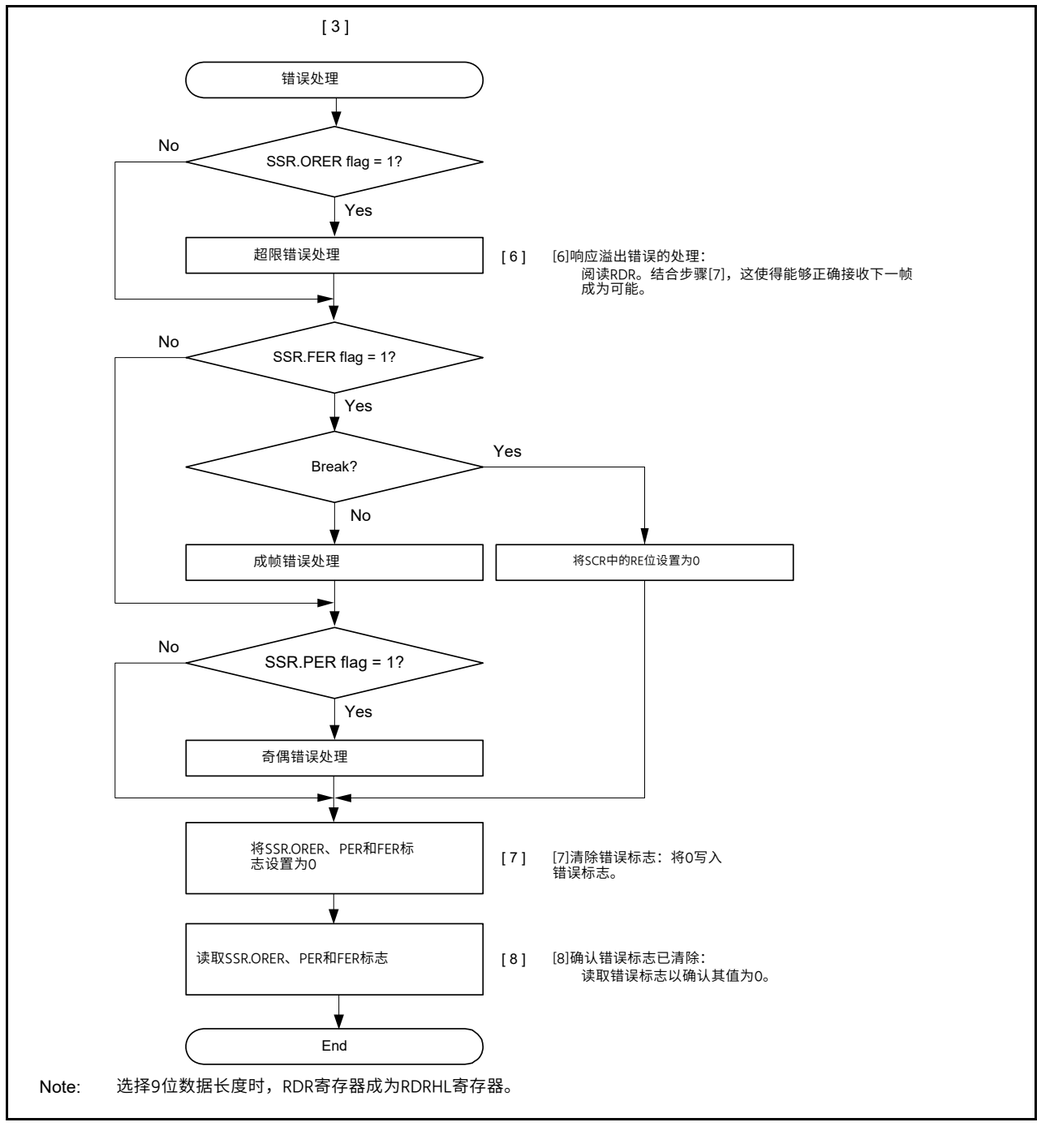


Figure 27.18 选择非FIFO的异步模式下串行接收示例流程(2)

(2) FIFO selected

图27.19显示了以异步模式写入FRDRH和FRDRL的数据格式示例。

在异步模式下，将0写入FRDRH中的MPB标志。对应数据长度的数据被写入FRDRH和FRDRL。未使用的位写入0。按照从FRDRH到FRDRL的顺序读取。如果软件读取FRDRL，SCI更新FER、PER，并用下一个数据接收FRDRL中的数据（RDAT[8:0]）。RDF、ORER和FRDRH中的DR标志始终反映SSR_FIFO寄存器中的相关标志。

Data Length	Register Setting		Receive data in FRDRH, FRDRL															
			FRDRHL															
			FRDRH								FRDRL							
	SCMR.CHR1	SMR.CHR	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
7 bits	1	0	—	RDF	ORER	FER	PER	DR	0	0	0	7-bit receive data						
8 bits	1	1	—	RDF	ORER	FER	PER	DR	0	0	8-bit receive data							
9 bits	0	Don't care	—	RDF	ORER	FER	PER	DR	0	9-bit receive data								

Note: 0 is always read for MPB flag (FRDRH[1]).
When data length is 7 bits, 0 is always read for FRDRH[0] and FRDRL[7].
When data length is 8 bits, 0 is always read for FRDRH[0].
FRDRH[7] bit is read as an indefinite value.

Figure 27.19 Data format stored in FRDRH and FRDRL with FIFO selected

In serial data reception, the SCI operates as follows:

1. When the value of the SCR.RE bit becomes 1, the output signal on the CTSn_RTSn pin goes low.
2. When the SCI monitors the communications line and detects a start bit, it performs internal synchronization, stores receive data in the RSR register, and checks the parity bit and stop bit.
3. When the FRDRL register is full, an overrun error occurs. If an overrun error occurs, the SSR_FIFO.ORER flag is set to 1. When the SCR.RIE bit is 1, an SCIn_ERI interrupt request is generated. Receive data is not transferred to FRDRL*1.
4. If a parity error is detected, the PER flag and receive data are transferred to FRDRL*1. When the RIE bit is set to 1, an SCIn_ERI interrupt request is generated.
5. If a frame error is detected, the FER flag and receive data are transferred to FRDRL*1. When the RIE bit is set to 1, an SCIn_ERI interrupt request is generated.
6. After a framing error is detected and when SCI detects that the continuous receive data is for one frame, reception stops.
7. When the amount of data stored in the FRDRL register falls below the specified receive triggering number, and the next data is not received after 15 ETUs from the last stop bit in asynchronous mode, the SSR_FIFO.DR bit is set to 1. When the RIE bit is 1 and the FCR.DRES bit is 0, the SCI generates an SCIn_RXI interrupt request. When the FCR.DRES bit is 1, SCI generates an SCIn_ERI interrupt request.
8. When reception finishes successfully, receive data is transferred to FRDRL*1. The RDF bit is set to 1 when the amount of receive data written to FRDRHL is equal to or greater than the specified receive triggering number. When the SCR.RIE bit is 1, an SCIn_RXI interrupt request is generated. Continuous reception is enabled by reading the receive data transferred to FRDRL*2 in the SCIn_RXI interrupt handling routine, before an overrun error occurs. If the received data that is transferred to FRDRL*3 is less than the RTS trigger number, the CTSn_RTSn pin outputs low.

Note 1. Only read the data in the FRDRH and FRDRL registers when 9-bit data length is selected.
Note 2. Read the data in the order from FRDRH to FRDRL when 9-bit data length is selected.
Note 3. The SCI only checks for an update to the FRDRL register and not to the FRDRH register when 9-bit data length is selected.

数据长度	寄存器设置		在FRDRH、FRRDL中接收数据															
			FRDRHL															
			FRDRH								FRDRL							
	SCMR.CHR1	SMR.CHR	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
7 bits	1	0	—	RDF	ORER	FER	PER	DR	0	0	0	7位接收数据						
8 bits	1	1	—	RDF	ORER	FER	PER	DR	0	0	8位接收数据							
9 bits	0	不在乎	—	RDF	ORER	FER	PER	DR	0	9位接收数据								

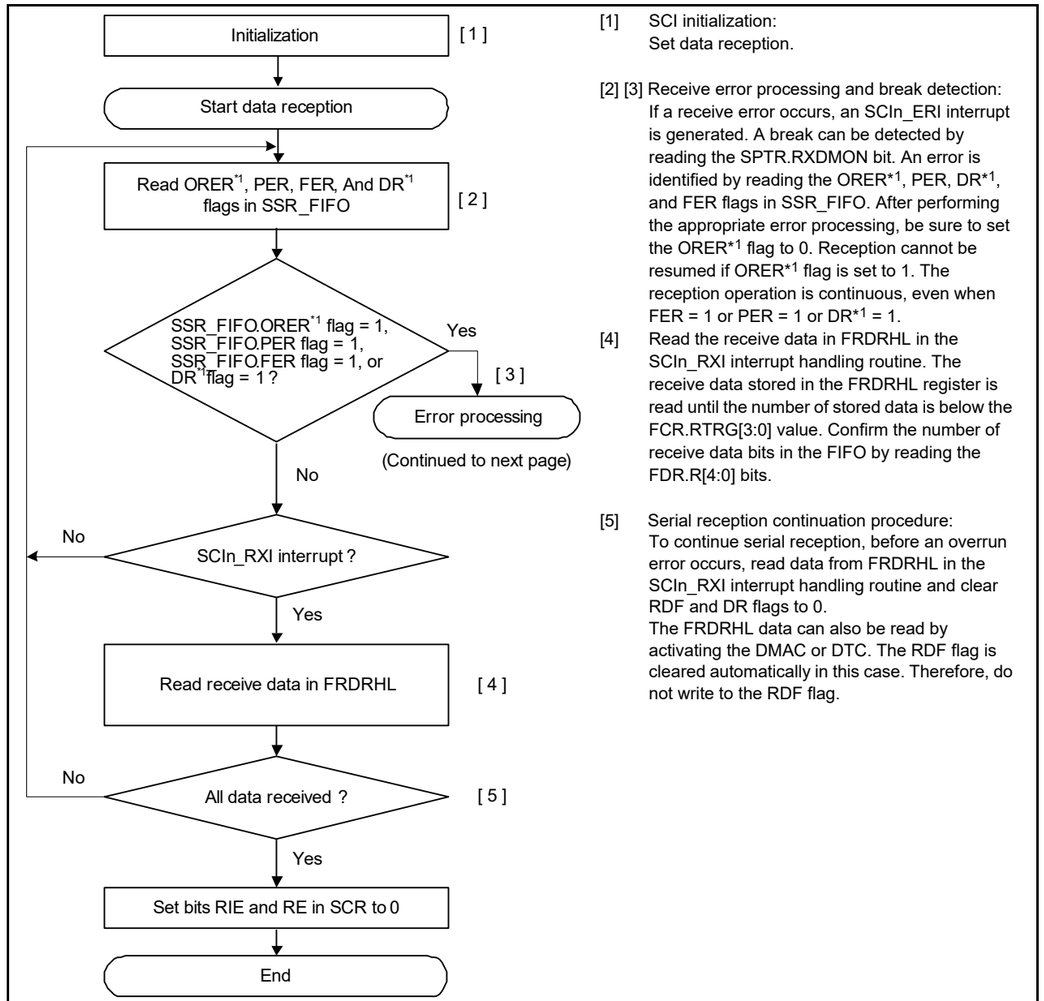
Note: MPB标志(FRDRH[1])总是读取0。当数据长度为7位时，FRRDH[0]和FRDRL[7]总是读取0。
当数据长度为8位时，FRRDH[0]总是读取0。
FRDRH[7]位被读取为不定值。

Figure 27.19 存储在FRDRH和FRDRL中的数据格式，选择了FIFO

在串行数据接收中，SCI操作如下：

1. 当SCR.RE位的值变为1时，CTSn_RTSn引脚上的输出信号变为低电平。
2. 当SCI监视通信线路并检测到一个起始位时，它会执行内部同步，将接收数据存储在RSR寄存器中，并检查奇偶校验位和停止位。
3. 当FRDRL寄存器已满时，会发生溢出错误。如果发生溢出错误，则SSR_FIFO.ORER标志设置为1。当SCR.RIE位为1时，将产生SCIn_ERI中断请求。接收数据不传输到FRDRL*1。
4. 如果检测到奇偶校验错误，则将PER标志和接收数据传输到FRDRL*1。当RIE位设置为1时，将产生SCIn_ERI中断请求。
5. 如果检测到帧错误，则将FER标志和接收数据传输到FRDRL*1。当RIE位设置为1时，将产生SCIn_ERI中断请求。
6. 检测到帧错误后，当SCI检测到连续接收数据为一帧时，接收停止。
7. 当存储在FRDRL寄存器中的数据量低于指定的接收触发数，并且在异步模式下距离最后一个停止位15个ETU后没有接收到下一个数据时，SSR_FIFO.DR位设置为1。当RIE位为1且FCR.DRES位为0，SCI产生一个SCIn_RXI中断请求。当FCR.DRES位为1时，SCI产生一个SCIn_ERI中断请求。
8. 当接收成功完成时，接收数据被传输到FRDRL*1。当写入FRDRHL的接收数据量等于或大于指定的接收触发数时，RDF位设置为1。当SCR.RIE位为1时，产生SCIn_RXI中断请求。在发生溢出错误之前，通过在SCIn_RXI中断处理程序中读取传输到FRDRL*2的接收数据来启用连续接收。如果传送到FRDRL*3的接收数据小于RTS触发数，CTSn_RTSn引脚输出低电平。

注1.选择9位数据长度时，仅读取FRDRH和FRDRL寄存器中的数据。
注2.选择9位数据长度时，按照FRDRH到FRDRL的顺序读取数据。
Note3.TheSCIonlychecksforanupdatetotheFRDRLregisterandnottotheFRDRHregisterwhen9-bitdatalengthisselected.



[1] SCI initialization:
Set data reception.

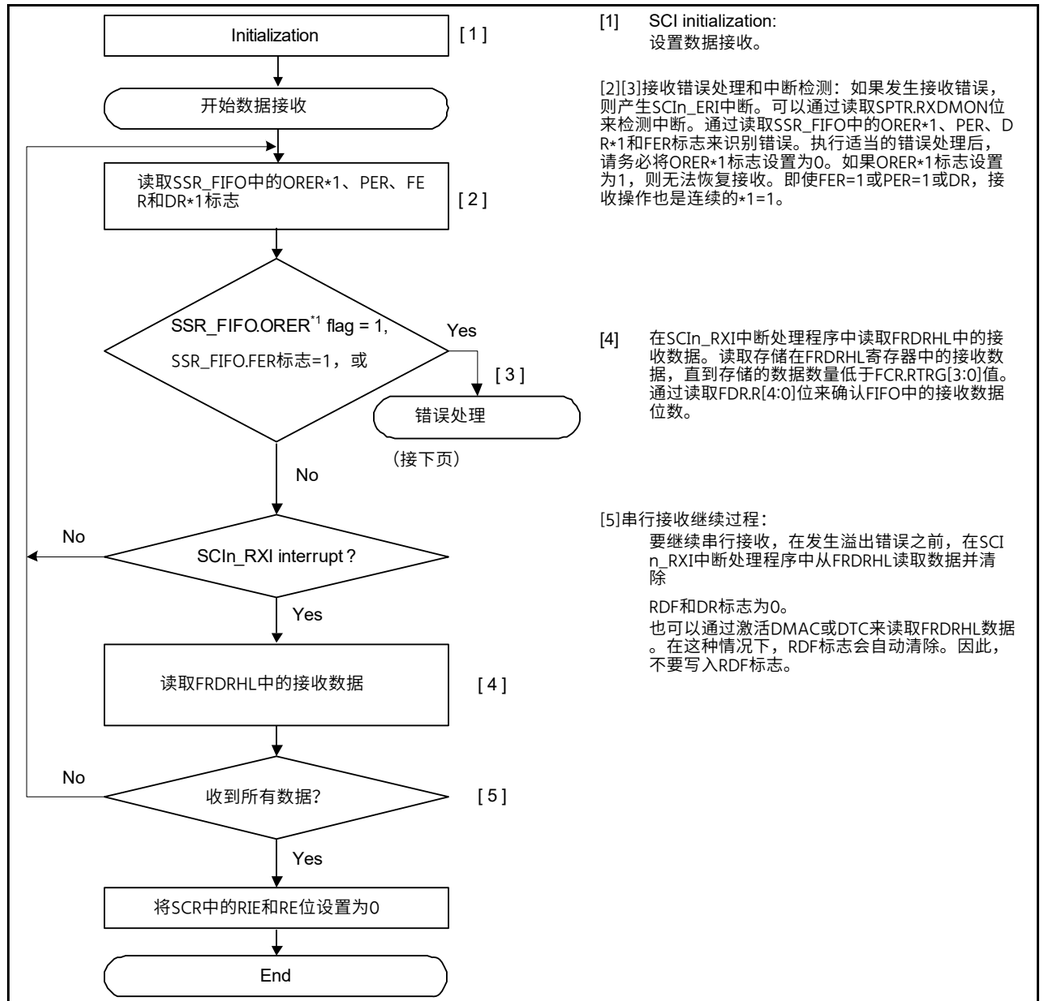
[2] [3] Receive error processing and break detection:
If a receive error occurs, an SCIn_ERI interrupt is generated. A break can be detected by reading the SPTR.RXDMON bit. An error is identified by reading the ORER*1, PER, DR*1, and FER flags in SSR_FIFO. After performing the appropriate error processing, be sure to set the ORER*1 flag to 0. Reception cannot be resumed if ORER*1 flag is set to 1. The reception operation is continuous, even when FER = 1 or PER = 1 or DR*1 = 1.

[4] Read the receive data in FRDRHL in the SCIn_RXI interrupt handling routine. The receive data stored in the FRDRHL register is read until the number of stored data is below the FCR.RTRG[3:0] value. Confirm the number of receive data bits in the FIFO by reading the FDR.R[4:0] bits.

[5] Serial reception continuation procedure:
To continue serial reception, before an overrun error occurs, read data from FRDRHL in the SCIn_RXI interrupt handling routine and clear RDF and DR flags to 0.
The FRDRHL data can also be read by activating the DMAC or DTC. The RDF flag is cleared automatically in this case. Therefore, do not write to the RDF flag.

Note 1. Can be read by the FRDRHL.ORER and DR flags.

Figure 27.20 Example flow of serial reception in asynchronous mode with FIFO selected (1)



[1] SCI initialization:
设置数据接收。

[2][3]接收错误处理和中断检测：如果发生接收错误，则产生SCIn_ERI中断。可以通过读取SPTR.RXDMON位来检测中断。通过读取SSR_FIFO中的ORER*1、PER、DR*1和FER标志来识别错误。执行适当的错误处理后，请务必将ORER*1标志设置为0。如果ORER*1标志设置为1，则无法恢复接收。即使FER=1或PER=1或DR，接收操作也是连续的*1=1。

[4] 在SCIn_RXI中断处理程序中读取FRDRHL中的接收数据。读取存储在FRDRHL寄存器中的接收数据，直到存储的数据数量低于FCR.RTRG[3:0]值。通过读取FDR.R[4:0]位来确认FIFO中的接收数据位数。

[5]串行接收继续过程：
要继续串行接收，在发生溢出错误之前，在SCIn_RXI中断处理程序中从FRDRHL读取数据并清除
RDF和DR标志为0。
也可以通过激活DMAC或DTC来读取FRDRHL数据。在这种情况下，RDF标志会自动清除。因此，不要写入RDF标志。

Note 1. 可以通过FRDRHL.ORER和DR标志读取。

Figure 27.20 选择FIFO的异步模式下串行接收示例流程(1)

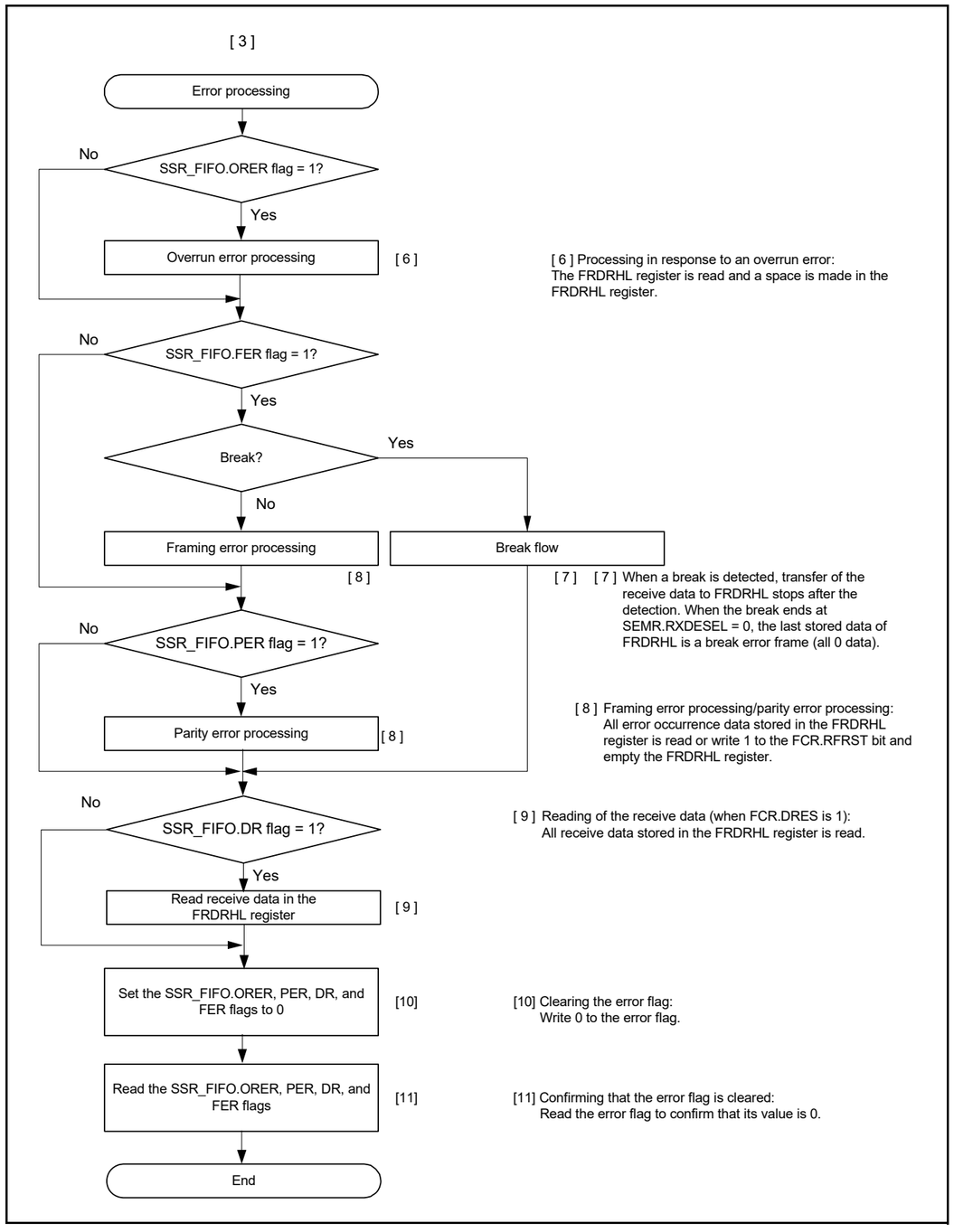


Figure 27.21 Example flow of serial reception in asynchronous mode with FIFO selected (2)

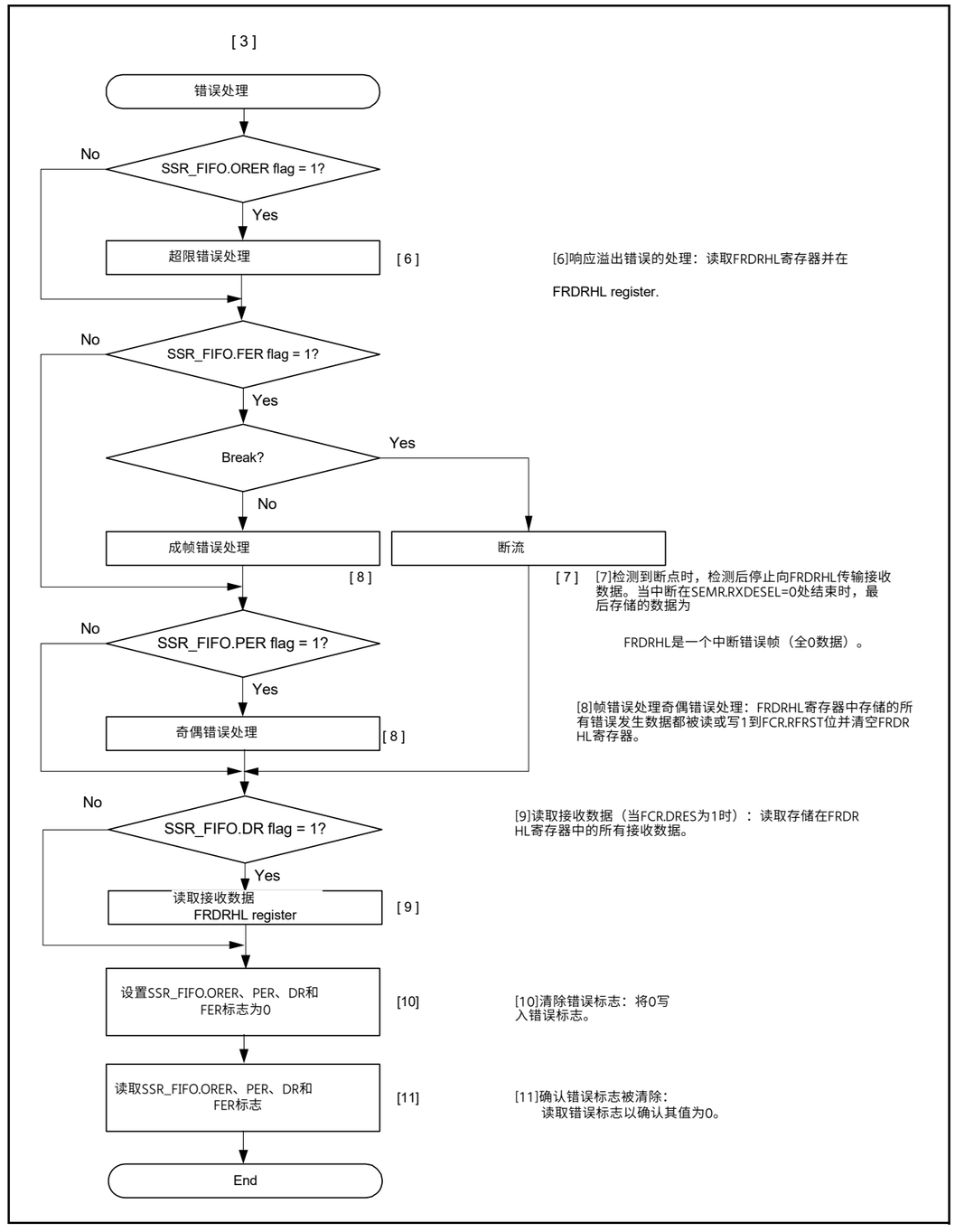


Figure 27.21 选择FIFO的异步模式下串行接收示例流程(2)

27.4 Multi-Processor Communication Function

The multi-processor communication function enables the SCI to transmit and receive data by sharing a communication line between multiple processors, using asynchronous serial communication in which the multi-processor bit is added. In multi-processor communication, a unique ID code is allocated to each receiving station. Serial communication cycles consist of an ID transmission cycle to specify the receiving station and a data transmission cycle to transmit data to the specified receiving station.

The multi-processor bit is used to distinguish between the ID transmission cycle and the data transmission cycle:

- When the multi-processor bit is set to 1, the transmission cycle is the ID transmission cycle
- When the multi-processor bit is set to 0, the transmission cycle is the data transmission cycle.

Figure 27.22 shows an example of communication between processors using a multi-processor format. First, a transmitting station transmits communication data in which the multi-processor bit set to 1, is added to the ID code of the receiving station. Next, the transmitting station transmits communication data in which the multi-processor bit set to 0, is added to the transmit data. After receiving communication data with the multi-processor bit set to 1, the receiving station compares the received ID with the ID of the receiving station itself. If the two match, the receiving station receives communication data that is subsequently transmitted. If the received ID does not match with the ID of the receiving station, the receiving station skips the communication data until it receives data again in which the multi-processor bit is set to 1.

(1) Non-FIFO selected

To support this function, the SCI provides the SCR.MPIE bit. When the MPIE bit is set to 1, the following operations are disabled until the reception of data in which the multi-processor bit is set to 1:

- Transfer of receive data from the RSR to the RDR (the RDRHL register when 9-bit data length is selected)
- Detection of a receive error
- Setting of the respective RDRF, ORER, and FER status flags in the SSR register.

When the SCI receives a character in which the multi-processor bit is set to 1, the SSR.MPBT bit is set to 1 and the SCR.MPIE bit is automatically cleared, returning the SCI to non-multi-processor reception operation. An SCIn_RXI interrupt is generated if the RIE bit in SCR is set.

When the multi-processor format is specified, the parity bit function is disabled. Apart from this, there is no difference from operation in non-multi-processor asynchronous mode. The clock used for multi-processor communication is the same as the clock used in non-multi-processor asynchronous mode.

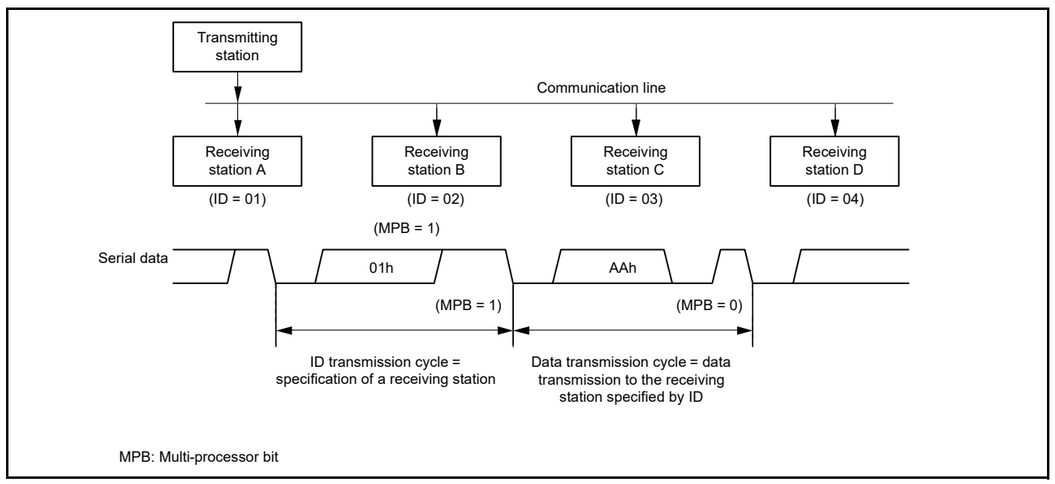


Figure 27.22 Example of communication using multi-processor format with transmission of data AAh to receiving station A

27.4 多处理器通信功能

多处理器通信功能使SCI通过在多个处理器之间共享一条通信线路，使用添加了多处理器位的异步串行通信来发送和接收数据。在多处理器通信中，为每个接收站分配一个唯一的ID代码。串行通信周期由指定接收站的ID传输周期和向指定接收站传输数据的数据传输周期组成。

多处理器位用于区分ID传输周期和数据传输周期：

- 当多处理器位设置为1时，发送周期为ID发送周期
- 当多处理器位设置为0时，传输周期为数据传输周期。

图27.22显示了使用多处理器格式的处理器之间的通信示例。首先，发送站发送将多处理器位设置为1的通信数据，该通信数据被添加到接收站的ID码。接着，发送站发送将多处理器位设置为0的通信数据被添加到发送数据。接收站接收到多处理器位设置为1的通信数据后，将接收到的ID与接收站自身的ID进行比较。如果两者匹配，则接收站接收随后发送的通信数据。如果接收到的ID与接收站的ID不匹配，则接收站跳过通信数据，直到再次接收到多处理器位设置为1的数据。

(1) Non-FIFO selected

为了支持这个功能，SCI提供了SCR.MPIE位。当MPIE位设置为1时，以下操作被禁止，直到接收到多处理器位设置为1的数据：

- 将接收数据从RSR传输到RDR（选择9位数据长度时的RDRHL寄存器）
- 检测接收错误
- 在SSR寄存器中设置相应的RDRF、ORER和FER状态标志。

当SCI接收到多处理器位设置为1的字符时，SSR.MPBT位设置为1，并且SCR.MPIE位自动清零，将SCI返回到非多处理器接收操作。如果SCR中的RIE位置位，则会产生SCIn_RXI中断。

当指定多处理器格式时，奇偶校验位功能被禁用。除此之外，与非多处理器异步模式下的操作没有区别。多处理器通信使用的时钟与非多处理器异步模式使用的时钟相同。

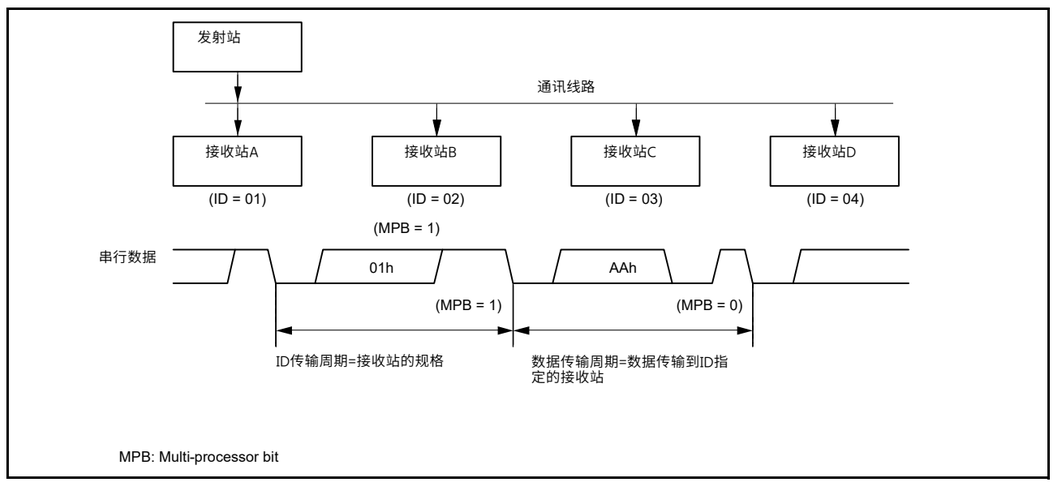


Figure 27.22 使用多处理器格式的通信示例，将数据AAh传输到接收站A

(2) FIFO selected

For data transmission, software must write data to FTDRHL.MPBT that corresponds to transmit data in FTDRHL.TDAT. For data reception, the multi-processor bit that is part of the receive data is written to FRDRHL.MPB, and receive data is written to FRDRL.

When the MPIE bit is set to 1, the following operations are disabled until reception of data in which the multi-processor bit is set to 1:

- Transfer of receive data from RSR to FRDRHL
- Detection of a receive error
- Break
- Setting of the respective RDF, ORER, and FER status flags in the SSR_FIFO register.

On receiving an 8-bit character in which the multi-processor bit is set to 1, the FRDRHL.MPB bit is set to 1 and receive data is written to FRDRHL.RDAT. The SCR.MPIE bit is automatically cleared, therefore returning the SCI to non-multi-processor reception operation. An SCIn_RXI interrupt is generated if the RIE bit in SCR is set.

When the multi-processor format is specified, the parity bit function is disabled. Apart from this, there is no difference from operation in non multi-processor asynchronous mode with non-FIFO selected.

27.4.1 Multi-Processor Serial Data Transmission

(1) Non-FIFO selected

Figure 27.23 shows an example flow of multi-processor data transmission. In the ID transmission cycle, the ID must be transmitted with the SSR.MPBT bit set to 1. In the data transmission cycle, the data must be transmitted with the MPBT bit set to 0. The rest of the operations are the same as in asynchronous mode.

(2) FIFO selected

对于数据传输，软件必须将数据写入与FTDRHL.TDAT中的传输数据相对应的FTDRHL.MPBT。对于数据接收，作为接收数据一部分的多处理器位被写入FRDRHL.MPB，接收数据被写入FRDRL。

当MPIE位设置为1时，以下操作被禁止，直到接收到多处理器位设置为1的数据：

- 将接收数据从RSR传输到FRDRHL
- 检测接收错误
- Break
- 在SSR_FIFO寄存器中设置相应的RDF、ORER和FER状态标志。

在接收到多处理器位设置为1的8位字符时，FRDRHL.MPB位设置为1，并且接收数据写入FRDRHL.RDAT。SCR.MPIE位自动清零，因此将SCI返回到非多处理器接收操作。如果SCR中的RIE位置位，则会产生SCIn_RXI中断。

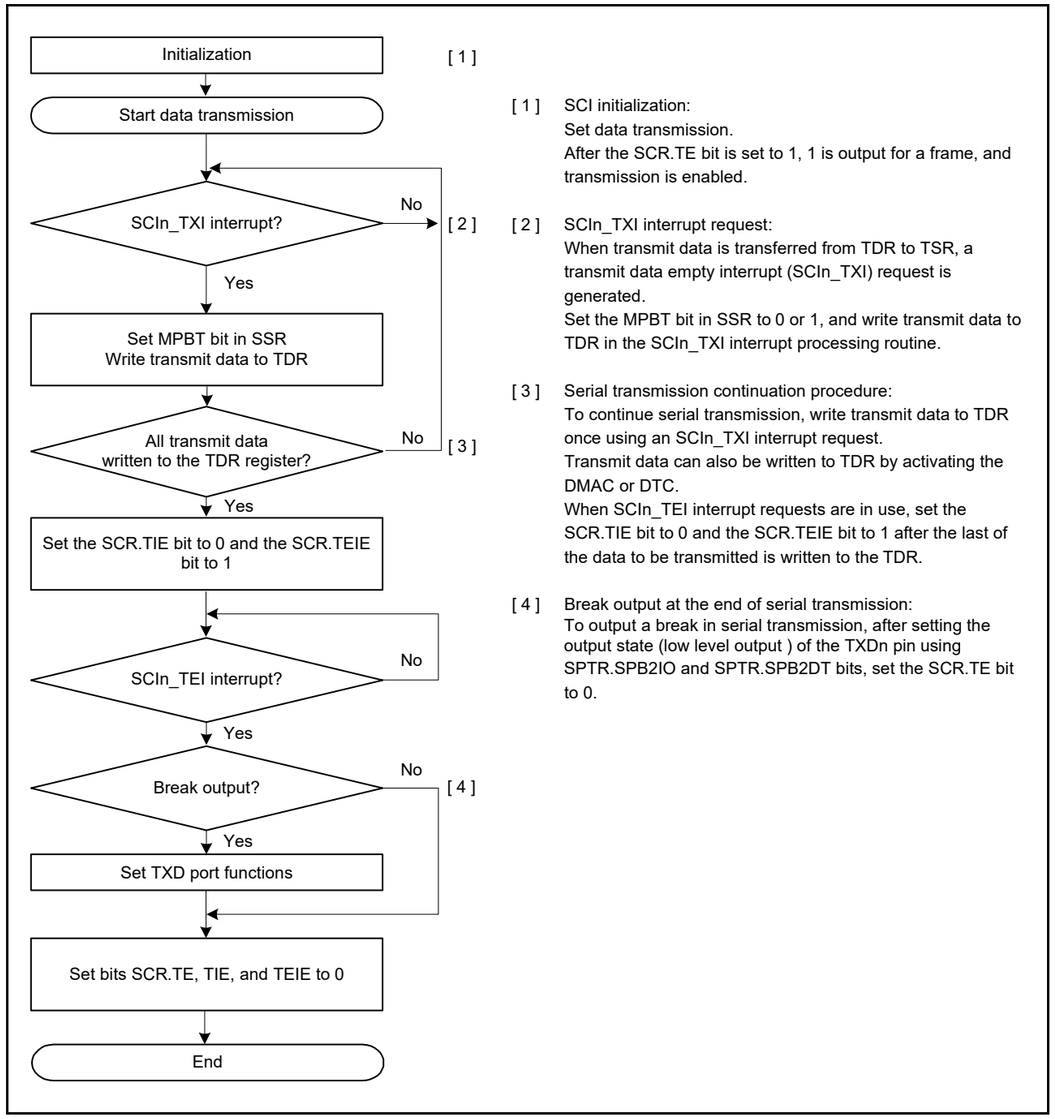
当指定多处理器格式时，奇偶校验位功能被禁用。除此之外，与选择非FIFO的非多处理器异步模式下的操作没有区别。

27.4.1 多处理器串行数据传输

(1) Non-FIFO selected

图27.23显示了一个多处理器数据传输的示例流程。在ID传输周期，ID必须在SSR.MPBT位设置为1的情况下传输。在数据传输周期，数据必须在MPBT位设置为0的情况下传输。其余操作与中相同异步模式。

RA生态工作室



[1] SCI initialization:
Set data transmission.
After the SCR.TE bit is set to 1, 1 is output for a frame, and transmission is enabled.

[2] SCIn_TXI interrupt request:
When transmit data is transferred from TDR to TSR, a transmit data empty interrupt (SCIn_TXI) request is generated.
Set the MPBT bit in SSR to 0 or 1, and write transmit data to TDR in the SCIn_TXI interrupt processing routine.

[3] Serial transmission continuation procedure:
To continue serial transmission, write transmit data to TDR once using an SCIn_TXI interrupt request.
Transmit data can also be written to TDR by activating the DMAC or DTC.
When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 and the SCR.TEIE bit to 1 after the last of the data to be transmitted is written to the TDR.

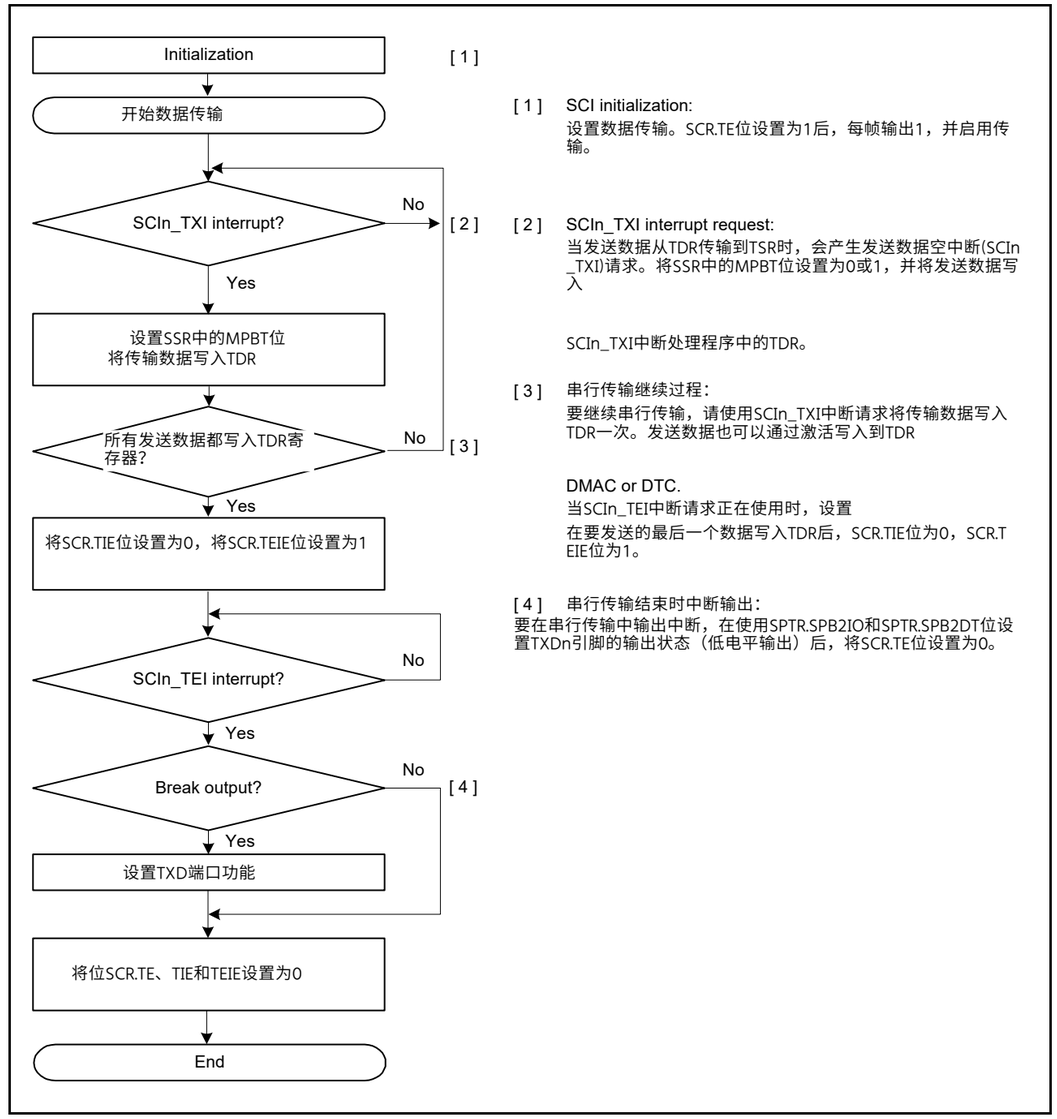
[4] Break output at the end of serial transmission:
To output a break in serial transmission, after setting the output state (low level output) of the TXDn pin using SPTR.SPB2IO and SPTR.SPB2DT bits, set the SCR.TE bit to 0.

Figure 27.23 Example flow of multi-processor serial transmission with non-FIFO selected

(2) FIFO selected

Figure 27.24 shows an example of the data format that is written to FTDRH and FTDRL in multi-processor mode.

The FTDRH.MPBT bit is set to 1. Data is set to FTDRH and FTDRL with the correct data length. Write 0 for unused bits. Write in the order from FTDRH to FTDRL.



[1] SCI initialization:
设置数据传输。SCR.TE位设置为1后，每帧输出1，并启用传输。

[2] SCIn_TXI interrupt request:
当发送数据从TDR传输到TSR时，会产生发送数据空中断(SCIn_TXI)请求。将SSR中的MPBT位设置为0或1，并将发送数据写入

SCIn_TXI中断处理程序中的TDR。

[3] 串行传输继续过程：
要继续串行传输，请使用SCIn_TXI中断请求将传输数据写入TDR一次。发送数据也可以通过激活写入到TDR

DMAC or DTC.
当SCIn_TEI中断请求正在使用时，设置
在要发送的最后一个数据写入TDR后，SCR.TIE位为0，SCR.TEIE位为1。

[4] 串行传输结束时中断输出：
要在串行传输中输出中断，在使用SPTR.SPB2IO和SPTR.SPB2DT位设置TXDn引脚的输出状态（低电平输出）后，将SCR.TE位设置为0。

Figure 27.23 选择非FIFO的多处理器串行传输示例流程

(2) FIFO selected

图27.24显示了在多处理器模式下写入FTDRH和FTDRL的数据格式示例。

FTDRH.MPBT位设置为1。数据设置为具有正确数据长度的FTDRH和FTDRL。为未使用的位写入0。按照从FTDRH到FTDRL的顺序写入。

Data Length	Register Setting		Transmit data in FTDRH, FTDRL															
			FTDRHL															
			FTDRH								FTDRL							
	SCMR.CHR1	SMR.CHR	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
7 bits	1	0	—	—	—	—	—	—	MPBT	—	—	7-bit transmit data						
8 bits	1	1	—	—	—	—	—	—	MPBT	—	8-bit transmit data							
9 bits	0	Don't care	—	—	—	—	—	—	MPBT	9-bit transmit data								

—: Invalid. The write value should be 0.

Figure 27.24 Data format written to FTDRH and FTDRL in multi-processor mode with FIFO selected

Figure 27.25 shows an example flow of multi-processor data transmission with FIFO selected. In the ID transmission cycle, the ID must be transmitted with the FTDRH.MPBT bit set to 1. In the data transmission cycle, data must be transmitted with the MPBT bit set to 0. The rest of the operations are the same as in asynchronous mode with non-FIFO selected.

[1] SCI initialization:
Set data transmission.
After the SCR.TE bit is set to 1, 1 is output for a frame, and transmission is enabled.

[2] Transmit data write to FTDRHL by an SCIn_TXI interrupt request:
For data transmission from FTDRHL to TSR,
when the amount of receive data written in FTDRHL is equal to or less than the specified transmit triggering number,
a transmit data FIFO empty interrupt (SCIn_TXI) request is generated.

[3] Serial transmission continuation procedure:
To continue serial transmission, write transmit data and MPBT to FTDRHL once using an SCIn_TXI interrupt request.
Transmit data can also be written to FTDRHL by activating the DMAC or DTC.
When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 and the SCR.TEIE bit to 1 after the last of the data to be transmitted is written to the FTDRHL.

[4] Break output at the end of serial transmission:
To output a break in serial transmission, after setting the output state (low level output) of TXDn pin using SPTR.SPB2IO and SPTR.SPB2DT bits, set the SCR.TE bit to 0.

Figure 27.25 Example flow of serial transmission in multi-processor mode with FIFO selected

数据长度	寄存器设置		在FTDRH、FTDRL中传输数据															
			FTDRHL															
			FTDRH								FTDRL							
	SCMR.CHR1	SMR.CHR	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
7 bits	1	0	—	—	—	—	—	—	MPBT	—	—	7位传输数据						
8 bits	1	1	—	—	—	—	—	—	MPBT	—	8位传输数据							
9 bits	0	不在乎	—	—	—	—	—	—	MPBT	9位传输数据								

–：无效的。写入值应为0。

Figure 27.24 在选择FIFO的多处理器模式下写入FTDRH和FTDRL的数据格式

图27.25显示了选择FIFO的多处理器数据传输示例流程。在ID传输周期中，必须在FTDRH.MPBT位设置为1的情况下传输ID。在数据传输周期中，必须在MPBT位设置为0的情况下传输数据。其余操作与异步相同选择非FIFO模式。

[1] SCI initialization:
设置数据传输。SCR.TE位设置为1后，每帧输出1，并启用传输。

[2] 通过SCIn_TXI中断请求将数据写入FTDRHL：
对于从FTDRHL到TSR的数据传输，当写入FTDRHL的接收数据量等于或小于指定的发送触发数时，会产生发送数据FIFO空中断（SCIn_TXI）请求。

[3] 串行传输继续过程：
要继续串行传输，请将传输数据和MPBT写入FTDRHL使用一次SCIn_TXI中断请求。
发送数据也可以通过激活
DMAC or DTC.
使用SCIn_TEI中断请求时，将要发送的最后一个数据写入FTDRHL后，将SCR.TIE位设置为0，并将SCR.TEIE位设置为1。

[4] 串行传输结束时中断输出：
要在串行传输中输出中断，在使用SPTR.SPB2IO和SPTR.SPB2DT位设置TXDn引脚的输出状态（低电平输出）后，将SCR.TE位设置为0。

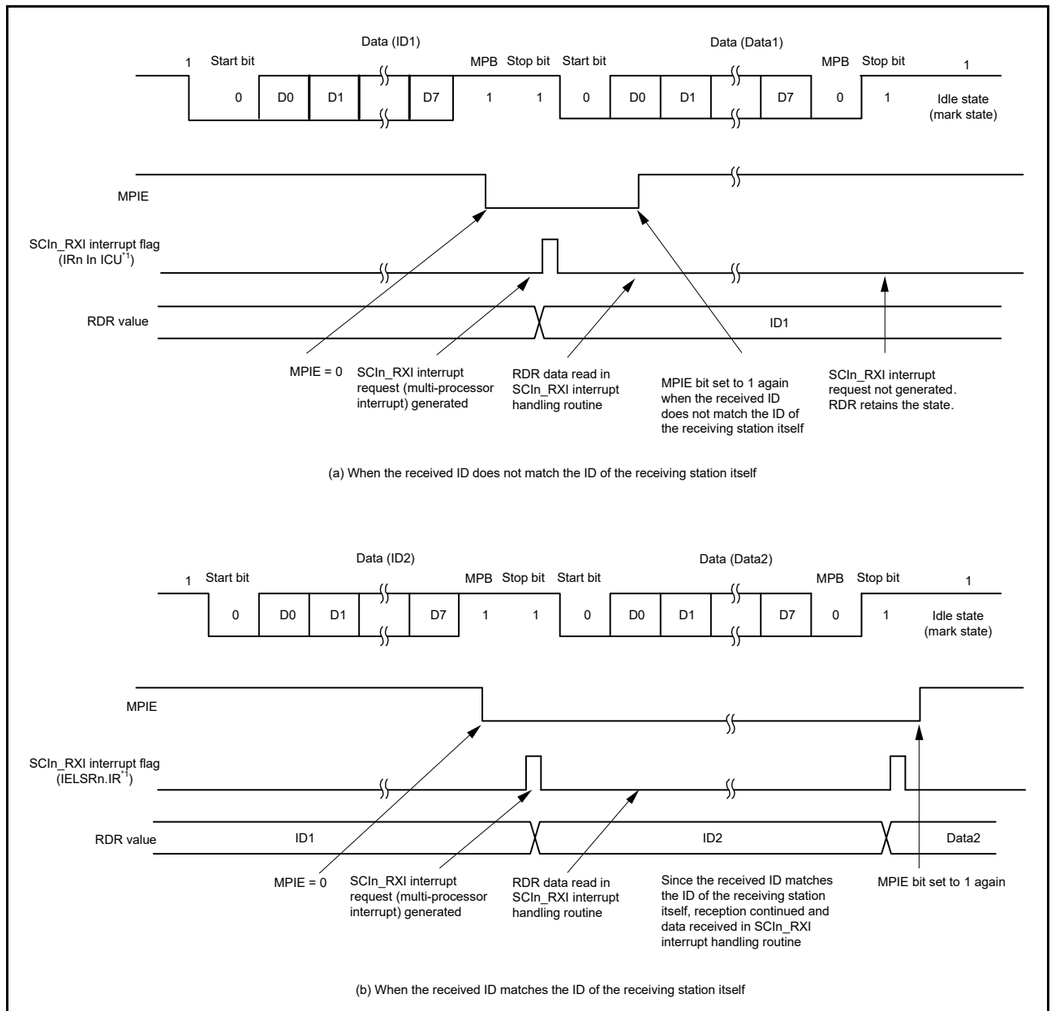
Figure 27.25 选择FIFO的多处理器模式下的串行传输示例流程

27.4.2 Multi-Processor Serial Data Reception

(1) Non-FIFO selected

Figure 27.27 and Figure 27.28 show example flows of multi-processor data reception. When the SCR.MPIE bit is set to 1, reading communication data is skipped until the reception of communication data in which the multi-processor bit is set to 1. When communication data in which the multi-processor bit is set to 1 is received, the received data is transferred to RDR, or RDRHL when 9-bit data length is selected, and the SCIn_RXI interrupt request is generated. The rest of the operations are the same as in asynchronous mode.

Figure 27.26 shows an example of operation for data reception.



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

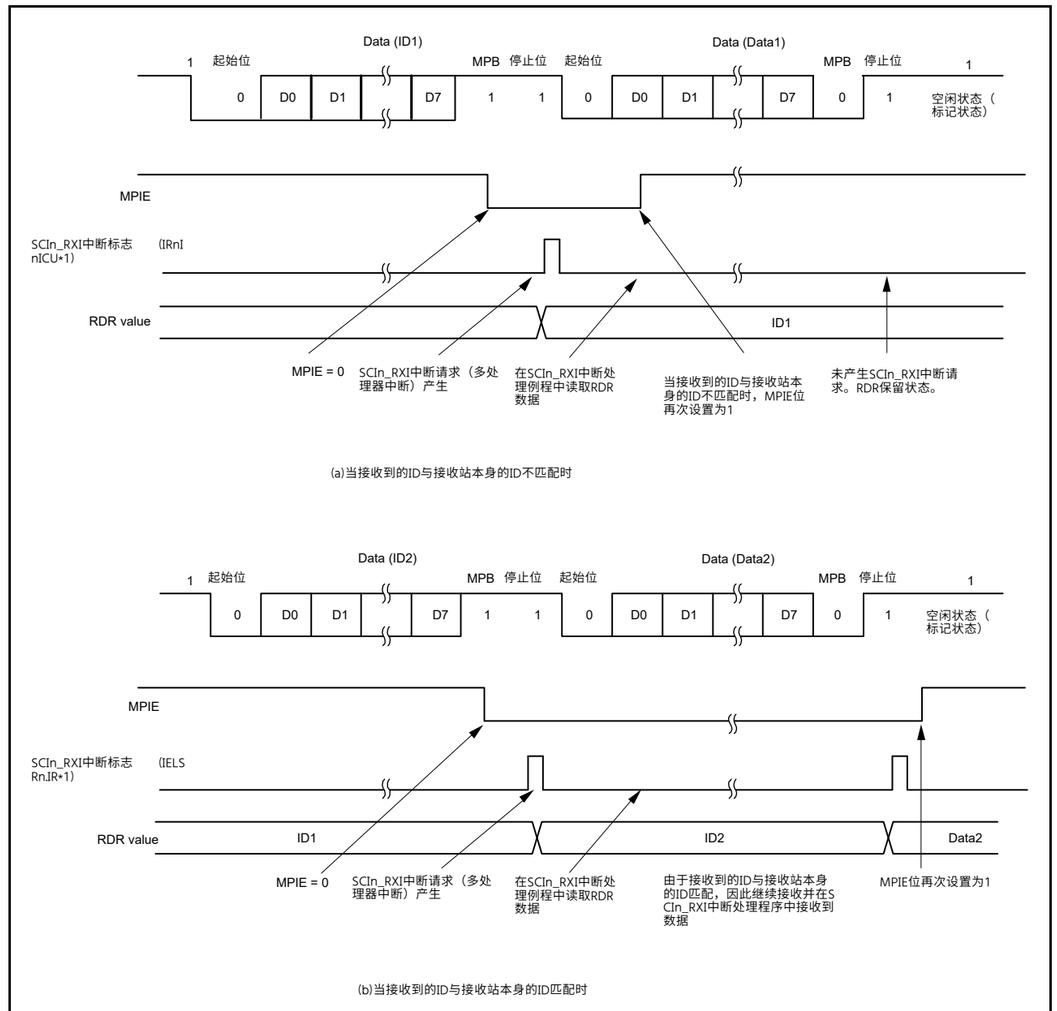
Figure 27.26 Example of SCI reception with 8-bit data, multi-processor bit, and 1 stop bit

27.4.2 多处理器串行数据接收

(1) Non-FIFO selected

图27.27和图27.28显示了多处理器数据接收的示例流程。当SCR.MPIE位设置为1时，将跳过读取通信数据，直到接收到多处理器位设置为1的通信数据。当接收到多处理器位设置为1的通信数据时 thereceiveddataistransferredtoRDR orRDRHLwhen9-bitdatalengthisselected andtheSCIn_RXIinterruptrequestisgenerated.其余操作与异步模式相同。

图27.26显示了数据接收的操作示例。



Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.26 使用8位数据、多处理器位和1个停止位的SCI接收示例

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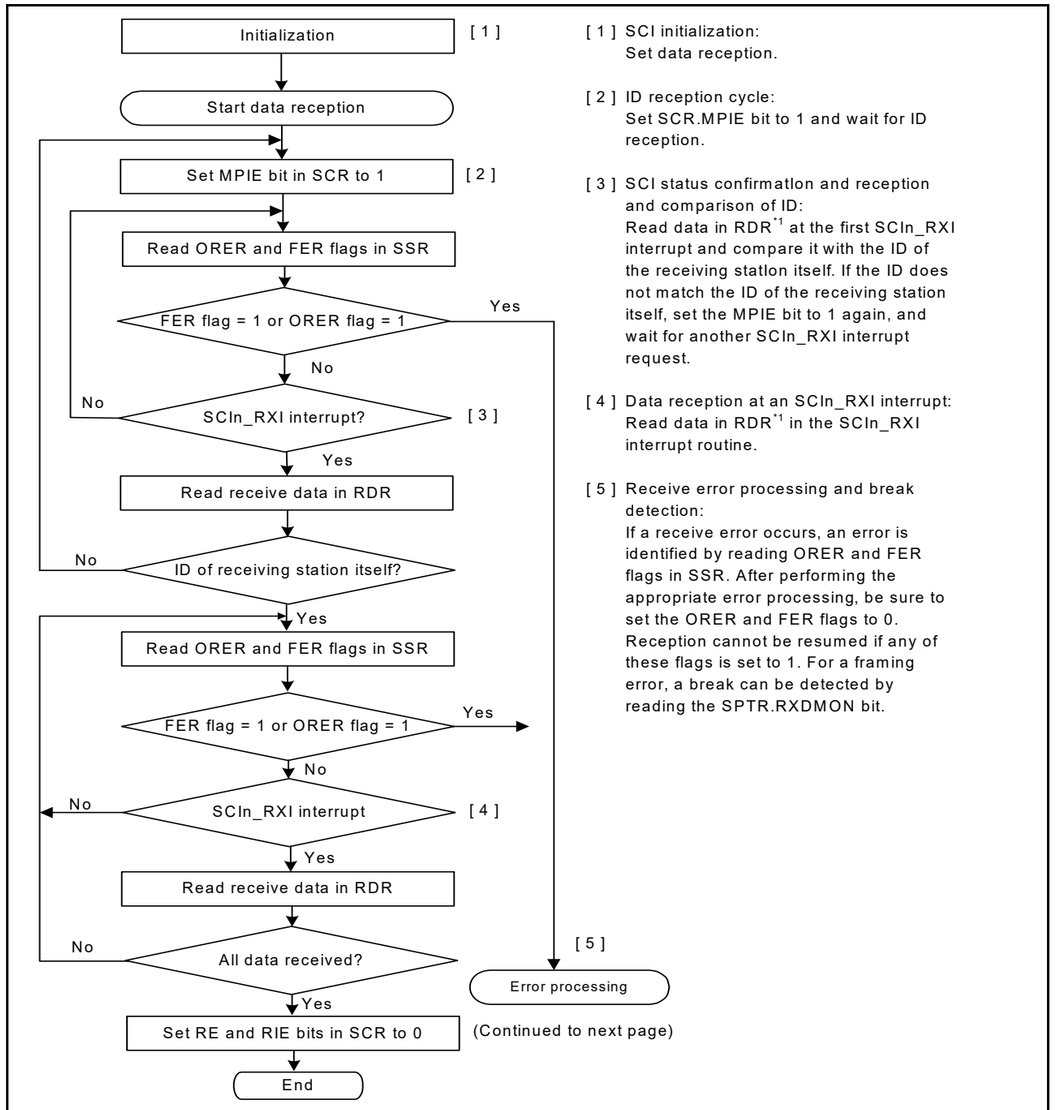


[1] SCI initialization:
Set data reception.

[2] ID reception cycle:
Set SCR.MPIE bit to 1 and wait for ID reception.

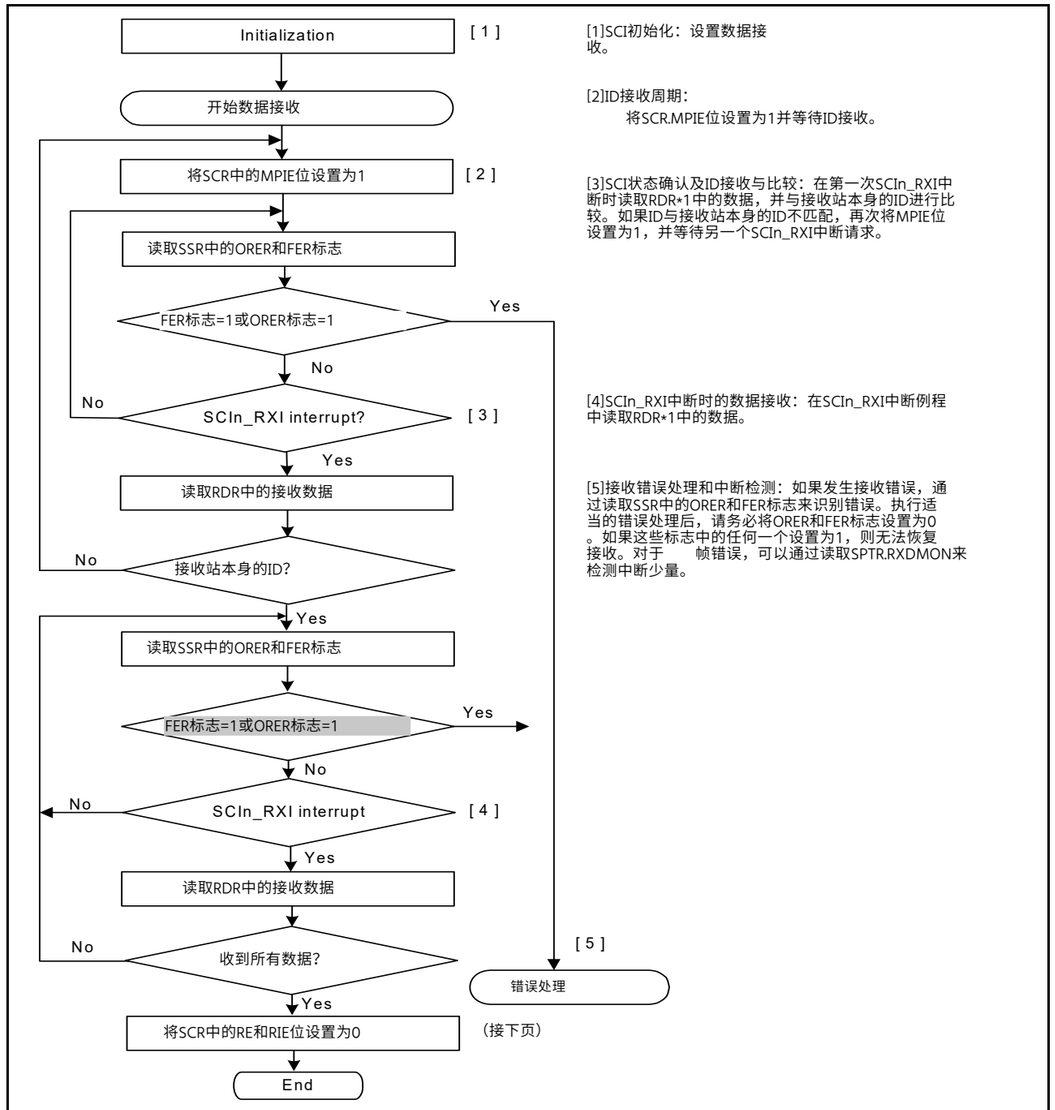
[3] SCI status confirmatIon and reception and comparison of ID:
Read data in RDR*1 at the first SCIn_RXI interrupt and compare it with the ID of the receiving statIon itself. If the ID does not match the ID of the receiving station itself, set the MPIE bit to 1 again, and wait for another SCIn_RXI interrupt request.

[4] Data reception at an SCIn_RXI interrupt:
Read data in RDR*1 in the SCIn_RXI interrupt routine.

[5] Receive error processing and break detection:
If a receive error occurs, an error is identified by reading ORER and FER flags in SSR. After performing the appropriate error processing, be sure to set the ORER and FER flags to 0. Reception cannot be resumed if any of these flags is set to 1. For a framing error, a break can be detected by reading the SPTR.RXDMON bit.

Note 1. The RDR register becomes the RDRHL register when 9-bit data length is selected.

Figure 27.27 Example flow of multi-processor serial reception with non-FIFO selected (1)



[1]SCI初始化：设置数据接收。

[2]ID接收周期：
将SCR.MPIE位设置为1并等待ID接收。

[3]SCI状态确认及ID接收与比较：在第一次SCIn_RXI中断时读取RDR*1中的数据，并与接收站本身的ID进行比较。如果ID与接收站本身的ID不匹配，再次将MPIE位设置为1，并等待另一个SCIn_RXI中断请求。

[4]SCIn_RXI中断时的数据接收：在SCIn_RXI中断例程中读取RDR*1中的数据。

[5]接收错误处理和中断检测：如果发生接收错误，通过读取SSR中的ORER和FER标志来识别错误。执行适当的错误处理后，请务必将ORER和FER标志设置为0。如果这些标志中的任何一个设置为1，则无法恢复接收。对于 帧错误，可以通过读取SPTR.RXDMON来检测中断少量。

Note 1. 选择9位数据长度时，RDR寄存器成为RDRHL寄存器。

Figure 27.27 选择非FIFO的多处理器串行接收示例流程(1)

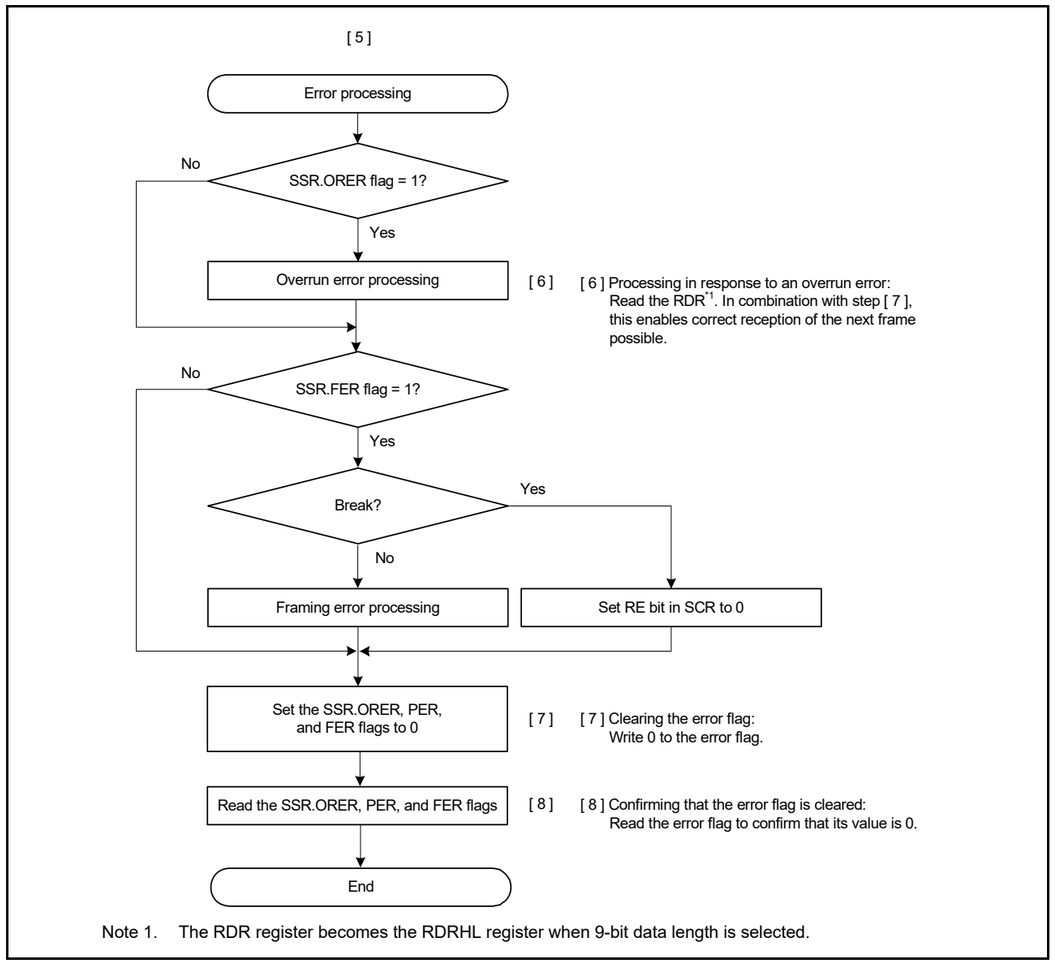


Figure 27.28 Example flow of multi-processor serial reception with non-FIFO selected (2)

(2) FIFO selected

Figure 27.29 shows an example of a data format that is written to FRDRH and FRDRL in multi-processor mode.

In multi-processor mode, the MPB value that is a part of the receive data is written to the FRDRH.MPB flag. A value of 0 is written to the FRDRH.PER flag. Data is written to FRDRH and FRDRL with the correct data length. Unused bits are written with 0.

Read in the order from FRDRH to FRDRL. When software reads the FRDRL register, the SCI updates FER, MPB, and receive data (RDAT[8:0]) in FRDRL with the next data. The RDF, ORER and DR flags in FRDRH always reflect the associated flags in the SSR_FIFO register.

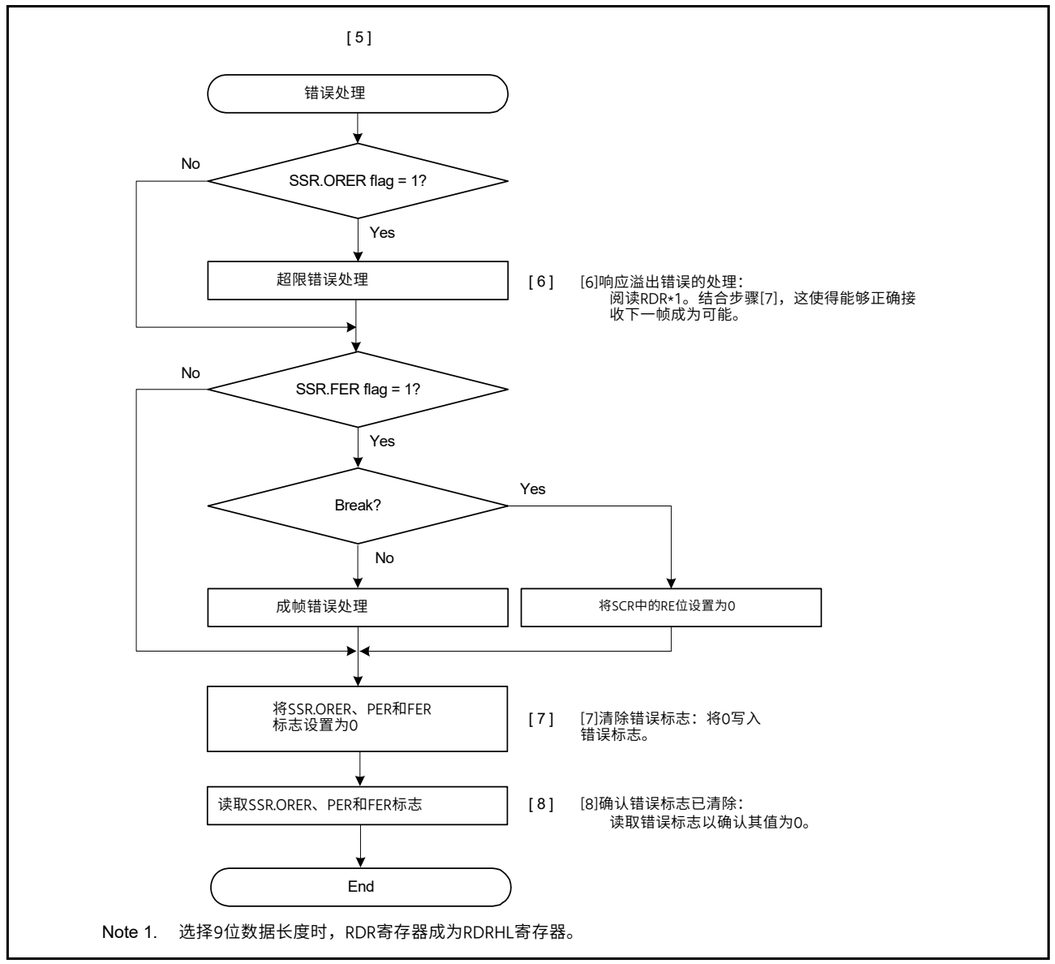


Figure 27.28 选择非FIFO的多处理器串行接收示例流程(2)

(2) FIFO selected

图27.29显示了在多处理器模式下写入FRDRH和FRDRL的数据格式示例。

在多处理器模式下，作为接收数据一部分的MPB值被写入FRDRH.MPB标志。值0写入FRDRH.PER标志。数据以正确的数据长度写入FRDRH和FRDRL。未使用的位用0写入。

按从FRDRH到FRDRL的顺序读取。当软件读取FRDRL寄存器时，SCI用下一个数据更新FER、MPB和FRDRL中的接收数据（RDAT[8:0]）。FRDRH中的RDF、ORER和DR标志始终反映SSR_FIFO寄存器中的相关标志。

Data Length	Register Setting		Receive data in FRDRH, FRDRL															
			FRDRHL															
			FRDRH								FRDRL							
	SCMR.CHR1	SMR.CHR	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
7 bits	1	0	—	RDF	ORER	FER	0	DR	MPB	0	0	7-bit receive data						
8 bits	1	1	—	RDF	ORER	FER	0	DR	MPB	0	8-bit receive data							
9 bits	0	Don't care	—	RDF	ORER	FER	0	DR	MPB	9-bit receive data								

Note: When data length is 7 bits, 0 is always read for FRDRH[0] and FRDRL[7].
When data length is 8 bits, 0 is always read for FRDRH[0].
FRDRH[7] bit is read as an indefinite value.

Figure 27.29 Data format stored to FRDRH and FRDRL in multi-processor mode with FIFO selected

Figure 27.30 shows an example flow for multi-processor data reception with FIFO selected.

When the SCR.MPIE is set to 1, reading communication data is skipped until the reception of communication data in which the multi-processor bit is set to 1. When communication data in which the multi-processor bit is set to 1 is received, the received data, MPB and the associated errors are transferred to the FRDRHL register. The SCR.MPIE bit is automatically cleared and non-multi-processor reception continues.

If a frame error occurs and the SSR_FIFO.FER flag is set to 1, the SCI continues data reception. The rest of the operations are the same as in asynchronous mode with non-FIFO selected.

数据长度	寄存器设置		在FRDRH、FRRDL中接收数据															
			FRDRHL															
			FRDRH								FRDRL							
	SCMR.CHR1	SMR.CHR	b7	b6	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
7 bits	1	0	—	RDF	ORER	FER	0	DR	MPB	0	0	7位接收数据						
8 bits	1	1	—	RDF	ORER	FER	0	DR	MPB	0	8位接收数据							
9 bits	0	不在乎	—	RDF	ORER	FER	0	DR	MPB	9位接收数据								

Note: 当数据长度为7位时，FRRDH[0]和FRDRL[7]总是读取0。
当数据长度为8位时，FRRDH[0]总是读取0。
FRDRH[7]位被读取为不定值。

Figure 27.29 在选择FIFO的多处理器模式下存储到FRDRH和FRDRL的数据格式

图27.30显示了选择FIFO的多处理器数据接收示例流程。

当SCR.MPIE设置为1时，将跳过读取通信数据，直到接收到多处理器位设置为1的通信数据。当接收到多处理器位设置为1的通信数据时，接收到的数据、MPB和相关的错误被传送到FRDRHL寄存器。SCR.MPIE位自动清零，非多处理器接收继续。

如果发生帧错误并且SSR_FIFO.FER标志设置为1，则SCI继续数据接收。其余操作与选择非FIFO的异步模式相同。

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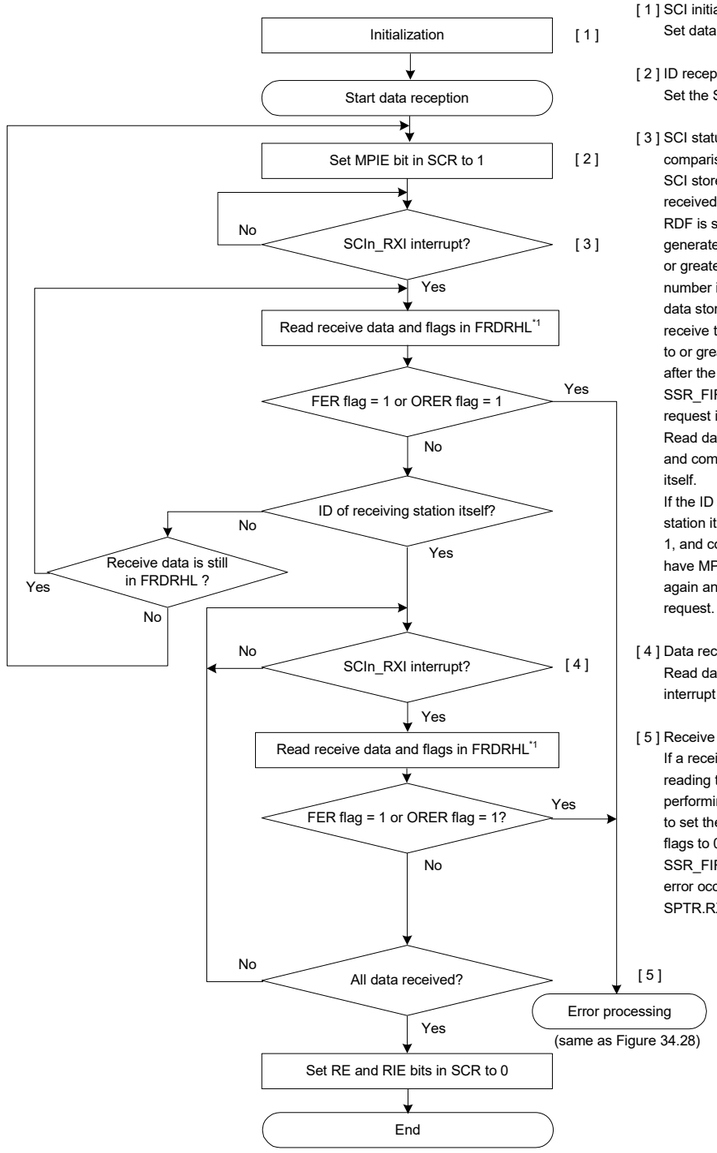


[1] SCI initialization:
Set data reception.

[2] ID reception cycle:
Set the SCR.MPIE bit to 1 and wait for ID reception.

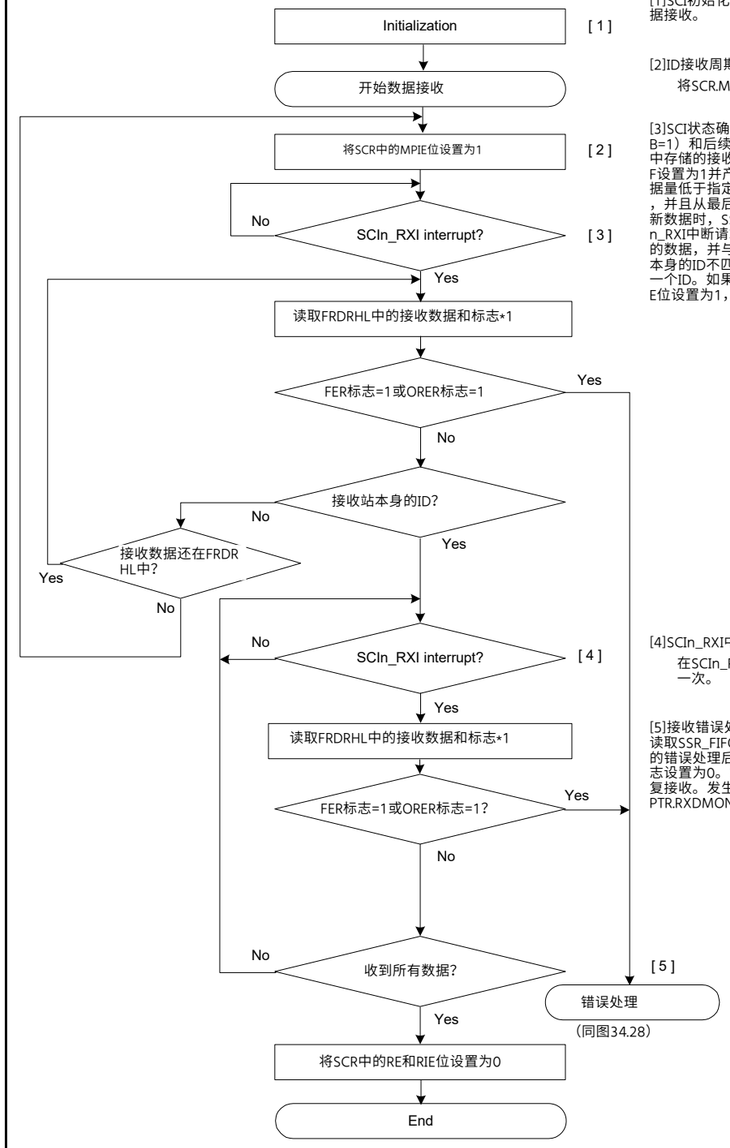
[3] SCI status confirmation and reception and comparison of ID:
SCI stores first data (MPB = 1) and subsequent received data in FRDRHL.
RDF is set to 1 and an SCIn_RXI interrupt request is generated when the amount of receive data equal to or greater than the specified receive triggering number is stored in FRDRHL. When the amount of data stored in FRDRHL falls below the specified receive triggering number and received data is equal to or greater than 1, and no new data is received after the elapse of 15 ETUs from the last stop bit, SSR_FIFO.DR is set to 1. An SCIn_RXI interrupt request is generated when FCR.DRES bit is 0.
Read data in FRDRHL at the first SCIn_RXI interrupt, and compare it with the ID of the receiving station itself.
If the ID does not match the ID of the receiving station itself, the SCI reads until the data with MPB = 1, and compares the next ID. If the data does not have MPB = 1 in FRDRHL, set the MPIE bit to 1 again and wait for another SCIn_RXI interrupt request.

[4] Data reception at an SCIn_RXI interrupt:
Read data in FRDRHL once in the SCIn_RXI interrupt routine.

[5] Receive error processing and break detection:
If a receive error occurs, an error is identified by reading the ORER and FER flags in SSR_FIFO. After performing the appropriate error processing, be sure to set the SSR_FIFO.ORER and SSR_FIFO.FER flags to 0. Reception cannot be resumed if the SSR_FIFO.ORER flag is set to 1. When a framing error occurs, a break can be detected by reading the SPTR.RXDMON bit.

Note 1. If FRDRH and FRDRL are used instead of FRDRHL, read in the order from FRDRH to FRDRL.

Figure 27.30 Example flow of serial reception in multi-processor mode with FIFO selected



[1]SCI初始化：设置数据接收。

[2]ID接收周期：
将SCR.MPIE位设置为1并等待ID接收。

[3]SCI状态确认和ID的接收与比较：SCI将第一个数据（MPB=1）和后续接收到的数据存储在FRDRHL中。当FRDRHL中存储的接收数据量等于或大于指定的接收触发数时，RDF设置为1并产生SCIn_RXI中断请求。当FRDRHL中存储的数据量低于指定的接收触发数且接收到的数据等于或大于1，并且从最后一个停止位开始经过15个ETU后没有接收到新数据时，SSR_FIFO.DR设置为1.FCR.DRES位为0时产生SCIn_RXI中断请求。在第一个SCIn_RXI中断时读取FRDRHL中的数据，并与接收站本身的ID进行比较。如果ID与接收站本身的ID不匹配，则SCI读取直到MPB=1的数据，并比较下一个ID。如果数据在FRDRHL中没有MPB=1，则再次将MPIE位设置为1，并等待另一个SCIn_RXI中断请求。

[4]SCIn_RXI中断处的数据接收：
在SCIn_RXI中断例程中读取FRDRHL中的数据一次。

[5]接收错误处理和中断检测：如果发生接收错误，则通过读取SSR_FIFO中的ORER和FER标志来识别错误。执行适当的错误处理后，请务必将SSR_FIFO.ORER和SSR_FIFO.FER标志设置为0。如果SSR_FIFO.ORER标志设置为1，则无法恢复接收。发生帧错误时，可以通过以下方式检测中断读取SPTR.RXDMON位。

Note 1. 如果使用FRDRH和FRDRL代替FRDRHL，请按照从FRDRH到FRDRL的顺序读取。

Figure 27.30 选择FIFO的多处理器模式下的串行接收示例流程

27.5 Operation in Clock Synchronous Mode

Figure 27.31 shows the data format for clock synchronous serial data communications.

In clock synchronous mode, data is transmitted or received in synchronization with clock pulses. One character in transfer data consists of 8-bit data. In clock synchronous mode, no parity bit can be added.

In data transmission, the SCI outputs data from one falling edge of the synchronization clock to the next. In data reception, the SCI receives data in synchronization with the rising edge of the synchronization clock. After 8-bit data is output, the transmission line holds the last bit as the output state. When the SPMR.CKPH bit is 1 in slave mode, the transmission line holds the first bit as the output state.

Within the SCI, the transmitter and receiver are independent units, enabling full-duplex communications by using a common clock. Both the transmitter and the receiver have a double-buffered structure, so that the next transmit data can be written during transmission or the previous receive data can be read during reception, enabling continuous data transfer.

However, it is not possible to perform continuous transfer in the fastest bit rate setting (BRR[7:0] = 00h and SMR.CKS[1:0] = 00b). Therefore, when the FIFO is selected, this setting (BRR[7:0] = 00h and SMR.CKS[1:0] = 00b) is not available.

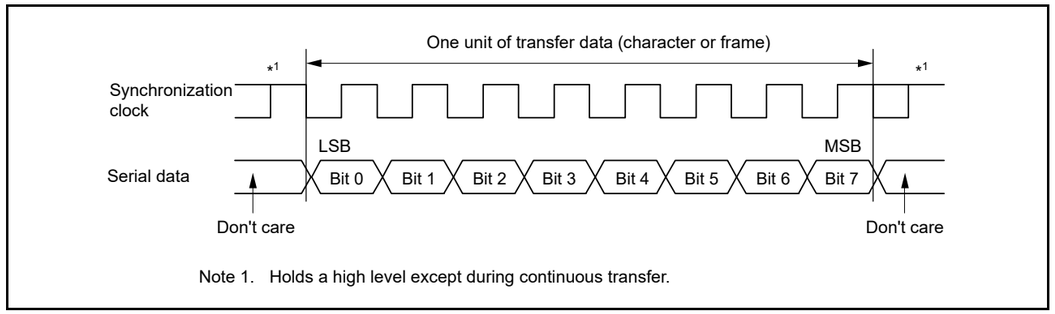


Figure 27.31 Data format in clock synchronous serial communications with LSB-first

27.5.1 Clock

Either an internal clock generated by the on-chip baud rate generator or an external synchronization clock input at the SCKn pin can be selected based on the SCR.CKE[1:0] setting.

When the SCI operates on an internal clock, the synchronization clock is output from the SCKn pin. Eight synchronization clock pulses are output in the transfer of one character. When no transfer is performed, the clock is held high. However, when only data reception is performed while the CTS function is disabled, the synchronization clock output starts when the SCR.RE bit is set to 1. The synchronization clock stops when it is held high*1 and when an overrun error occurs, or when the SCR.RE bit is set to 0.

When only data reception occurs and the CTS function is enabled, the clock output does not start when the SCR.RE bit is set to 1 and the CTSn_RTSn pin input is high. The synchronization clock output starts when the SCR.RE bit is set to 1 and the CTSn_RTSn pin input is low. When the CTSn_RTSn pin input is high on completion of the frame reception, the synchronization clock output stops when it goes high. If the CTSn_RTSn pin input continues to be low, the synchronization clock stops when it goes high*1 and when an overrun error occurs, or when the SCR.RE bit is set to 0.

Note 1. The signal is held high when SPMR.CKPH is 0 and SPMR.CKPOL is 0, or when SPMR.CKPH is 1 and SPMR.CKPOL is 1.
It is held low when SPMR.CKPH is 0 and SPMR.CKPOL is 1, or when SPMR.CKPH is 1 and SPMR.CKPOL is 0.

27.5 时钟同步模式下的操作

图27.31显示了时钟同步串行数据通信的数据格式。

在时钟同步模式下，数据的发送或接收与时钟脉冲同步。传输数据中的一个字符由8位数据组成。在时钟同步模式下，不能添加奇偶校验位。

在数据传输中，SCI从同步时钟的一个下降沿输出数据到下一个下降沿。在数据接收中，SCI与同步时钟的上升沿同步接收数据。8位数据输出后，传输线保持最后一位作为输出状态。当SPMR.CKPH位在从机模式下为1时，传输线保持第一位作为输出状态。

在SCI中，发送器和接收器是独立的单元，通过使用公共时钟实现全双工通信。发送器和接收器都具有双缓冲结构，因此可以在发送过程中写入下一个发送数据或在接收过程中读取上一个接收数据，从而实现数据的连续传输。

但是，在最快的比特率设置（BRR[7:0]=00h和SMR.CKS[1:0]=00b)。Therefore whentheFIFOisselected thissetting(BRR[7:0]=00handSMR.CKS[1:0]=00b)isnot available.

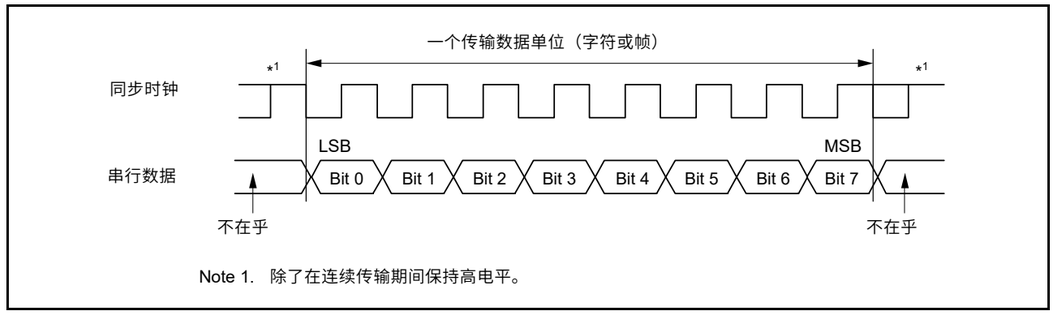


Figure 27.31 LSB优先时钟同步串行通信中的数据格式

27.5.1 Clock

由片内波特率发生器产生的内部时钟或外部同步时钟输入SCKn引脚可根据SCR.CKE[1:0]设置进行选择。

当SCI在内部时钟上运行时，同步时钟从SCKn引脚输出。在一个字符的传输中输出八个同步时钟脉冲。当不执行传输时，时钟保持高电平。但是，当CTS功能禁用时仅执行数据接收时，同步时钟输出会在SCR.RE位设置为1时开始。同步时钟在保持高电平*1和发生溢出错误时停止，或者当SCR.RE位设置为0时。

当仅发生数据接收且CTS功能使能时，当SCR.RE位设置为1且CTSn_RTSn引脚输入为高电平时，时钟输出不会启动。当SCR.RE位设置为1且CTSn_RTSn引脚输入为低电平时，同步时钟输出开始。当CTSn_RTSn引脚输入在帧接收完成时为高电平时，同步时钟输出在其变为高电平时停止。如果CTSn_RTSn引脚输入持续为低电平，则同步时钟在变为高电平*1和发生溢出错误时或当SCR.RE位设置为0时停止。

注1.当SPMR.CKPH为0且SPMR.CKPOL为0或SPMR.CKPH为1且
SPMR.CKPOL is 1.
当SPMR.CKPH为0且SPMR.CKPOL为1或SPMR.CKPH为1且SPMR.CKPOL为0时，它保持低电平。

27.5.2 CTS and RTS Functions

In the CTS function, the CTSn_RTSn pin input controls the start of data reception or transmission when the clock source is the internal clock. Setting the SPMR.CTSE bit to 1 enables the CTS function. When the CTS function is enabled, setting the CTSn_RTSn pin low causes data reception or transmission to start.

Setting the CTSn_RTSn pin high while the data transmission or reception is in progress does not affect transmission or reception of the current frame.

In the RTS function, the CTSn_RTSn pin output is used to request the start of data reception or transmission when the clock source is an external synchronizing clock. The CTSn_RTSn output goes low when serial communication becomes possible. Conditions for output of CTSn_RTSn low and high are as follows:

[Conditions for low output]

(a) Non-FIFO selected when all of the following conditions are satisfied

- The value of the RE or TE bit in the SCR is 1
- When serial communication is enabled
- There is no received data available to be read when the SCR.RE bit is 1
- Transmit data is written when the SCR.TE bit is 1 and SCR.CKE[1] bit is 0
- Data is available for transmission in the TSR register when SCR.TE bit is 1 and SCR.CKE[1] bit is 1
- The ORER flag in SSR is 0.

(b) FIFO selected when all of the following conditions are satisfied

- The value of the RE or TE bit in SCR is 1
- When serial communication is enabled
- The amount of receive data written in FRDRHL is less than the specified CTSn_RTSn output triggering number when SCR.RE = 1
- Data that has not been transmitted is available in FTDRHL when the SCR.TE bit is 1 and the SCR.CKE[1] bit is 0
- Data is available for transmission in the TSR register when the SCR.TE bit is 1 and the SCR.CKE[1] bit is 1
- The ORER flag in SSR_FIFO is 0.

[Condition for high output]

(a) Non-FIFO selected

- The conditions for low output are not satisfied.
- When reception is terminated with SCR.RE = 0 without reading the RDR register after reception is complete, RTS remains high. At this time, read the SCR register for dummy values after writing 0 to SCR.RE.

(b) FIFO selected

- The conditions for low output are not satisfied.

27.5.3 SCI Initialization in Clock Synchronous Mode

Before transmitting and receiving data, start by writing the initial value 00h to the SCR register, then continue through the SCI procedure in 27.5.2 CTS and RTS Functions. Any time the operating mode or transfer format is to be changed, the SCR register must be initialized before the change can be made.

Note: Setting the SCR.RE bit to 0 does not initialize the ORER, FER, RDRF, RDF, PER and DR flags in SSR/SSR_FIFO or the RDR and the RDRHL registers. When the TE bit is set to 0, the TEND flag for the selected FIFO buffer is not initialized.

Note: Switching the value of the SCR.TE bit from 1 to 0 or 0 to 1 when the SCR.TIE bit is 1 generates an SCIn_TXI interrupt request.

27.5.2 CTS和RTS函数

在CTS功能中，当时钟源为内部时钟时，CTSn_RTSn引脚输入控制数据接收或发送的开始。将SPMR.CTSE位设置为1可启用CTS功能。当CTS功能使能时，将CTSn_RTSn引脚设置为低电平会导致数据接收或发送开始。

在数据发送或接收过程中将CTSn_RTSn引脚设置为高电平不会影响当前帧的发送或接收。

在RTS功能中，当时钟源为外部同步时钟时，CTSn_RTSn引脚输出用于请求开始数据接收或发送。当串行通信成为可能时，CTSn_RTSn输出变为低电平。CTSn_RTSn低电平和高电平的输出条件如下：

[低输出的条件]

(a) 满足以下所有条件时选择非FIFO

- SCR中RE或TE位的值为1
- 启用串行通信时
- 当SCR.RE位为1时，没有可读取的接收数据
- 当SCR.TE位为1且SCR.CKE[1]位为0时写入发送数据
- 当SCR.TE位为1且SCR.CKE[1]位为1时，TSR寄存器中的数据可用于传输
- SSR中的ORER标志为0。

(b) 满足以下所有条件时选择FIFO

- SCR中RE或TE位的值为1
- 启用串行通信时
- 当SCR.RE=1时，FRDRHL中写入的接收数据量小于指定的CTSn_RTSn输出触发数
- 当SCR.TE位为1且SCR.CKE[1]位为0时，FTDRHL中的数据可用
- 当SCR.TE位为1且SCR.CKE[1]位为1时，TSR寄存器中的数据可用于传输
- SSR_FIFO中的ORER标志为0。

【高输出条件】

(a) Non-FIFO selected

- 不满足低输出的条件。
- 当接收结束后接收结束且SCR.RE=0且未读取RDR寄存器时，RTS保持高电平。此时，将0写入SCR.RE后，读取SCR寄存器的虚拟值。

(b) FIFO selected

- 不满足低输出的条件。

27.5.3 时钟同步模式下的SCI初始化

在发送和接收数据之前，首先将初始值00h写入SCR寄存器，然后继续执行27.5.2CTS和RTS功能中的SCI程序。任何时候要更改操作模式或传输格式，必须先初始化SCR寄存器，然后才能进行更改。

Note: 将SCR.RE位设置为0不会初始化ORER、FER、RDRF、RDF、PER和DR标志SSRSSR_FIFO或RDR和RDRHL寄存器。当TE位设置为0时，选择的TEND标志FIFO缓冲区未初始化。

Note: 当SCR.TIE位为1时，将SCR.TE位的值从1切换到0或0到1会产生SCIn_TXI中断请求。

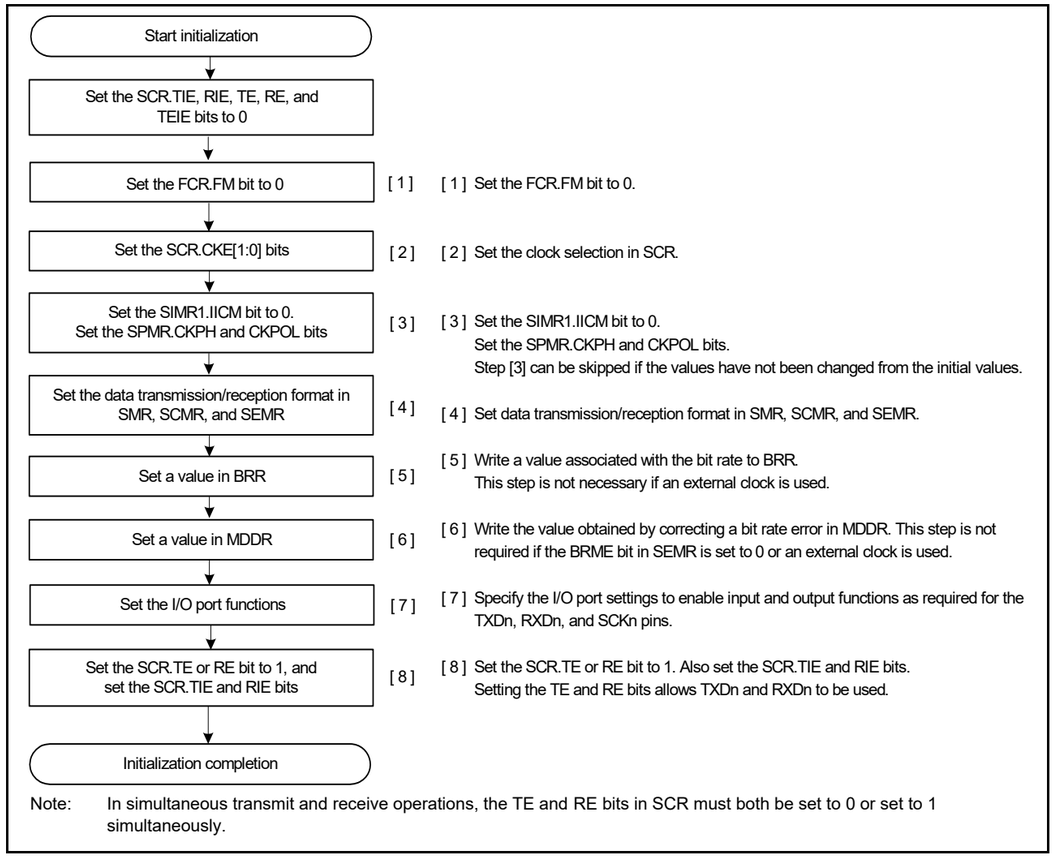


Figure 27.32 Example flow of SCI initialization in clock synchronous mode with non-FIFO selected

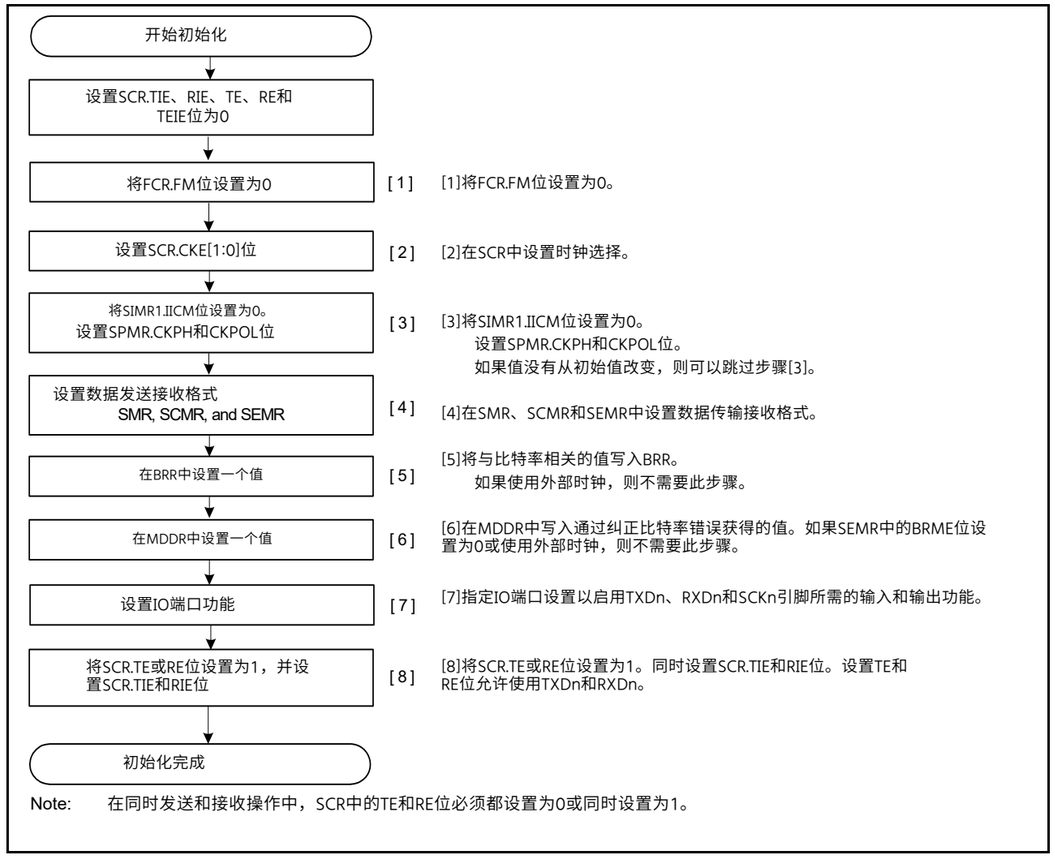


Figure 27.32 在时钟同步模式下选择非FIFO的SCI初始化示例流程

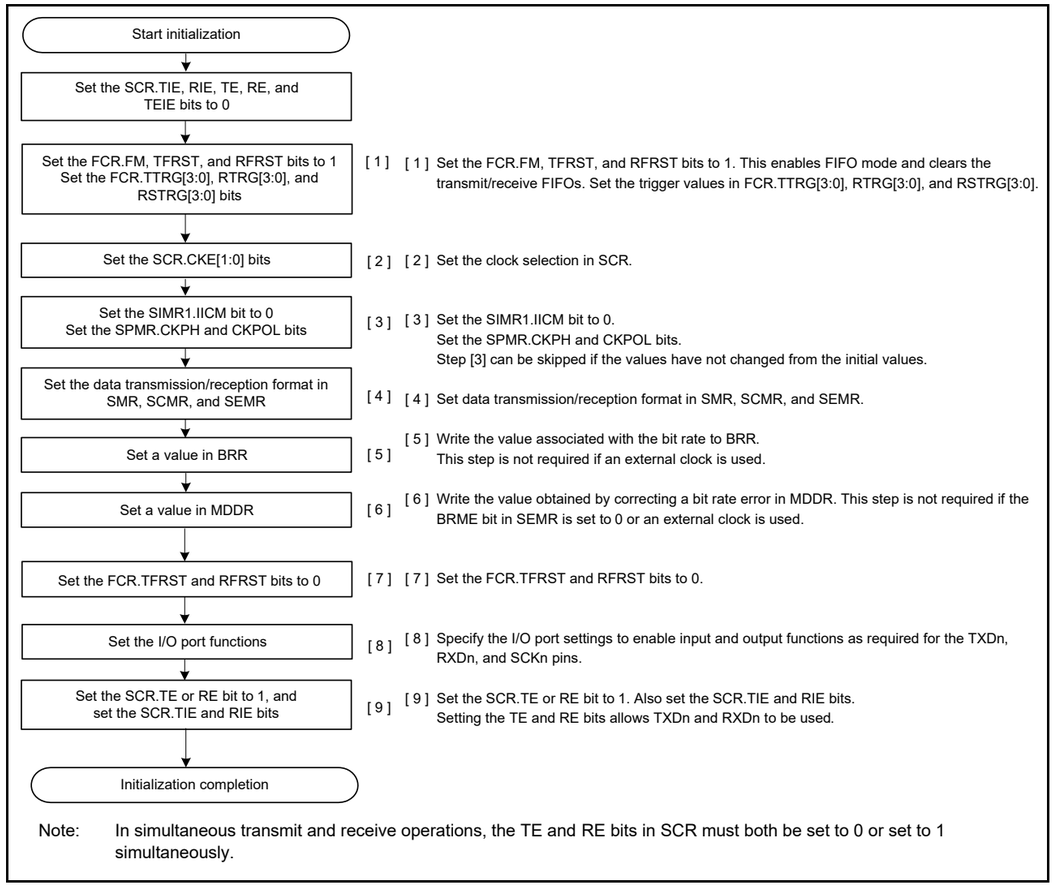


Figure 27.33 Example flow of SCI initialization in clock synchronous mode with FIFO selected

27.5.4 Serial Data Transmission in Clock Synchronous Mode

(1) Non-FIFO selected

Figure 27.34, Figure 27.35, and Figure 27.36 show examples of serial transmission in clock synchronous mode.

In serial data transmission, the SCI operates as follows:

1. The SCI transfers data from the TDR register to the TSR register when data is written to TDR in the SCIn_TXI interrupt handling routine. The SCIn_TXI interrupt request at the beginning of transmission is generated when the TE bit is set to 1, but only after the SCR.TIE bit is also set to 1, or when SCR.TE and SCR.TIE are both set to 1 simultaneously by a single instruction.
2. After transferring data from TDR to TSR, the SCI starts transmission. When the SCR.TIE bit is set to 1, an SCIn_TXI interrupt request is generated. Continuous transmission is enabled by writing the next transmit data to TDR in the SCIn_TXI interrupt handling routine before transmission of the current transmit data is complete. When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 and the SCR.TEIE bit to 1 after the last of the data to be transmitted is written to the TDR register from the handling routine for SCIn_TXI requests.
3. 8-bit data is sent from the TXDn pin in synchronization with the output clock when the clock output mode is specified, and in synchronization with the input clock, when the use of an external clock is specified. Output of the clock signal is suspended until the input CTS signal is low and while the SPMR.CTSE bit is 1.
4. The SCI checks for updates to the TDR register on the output of the last bit.

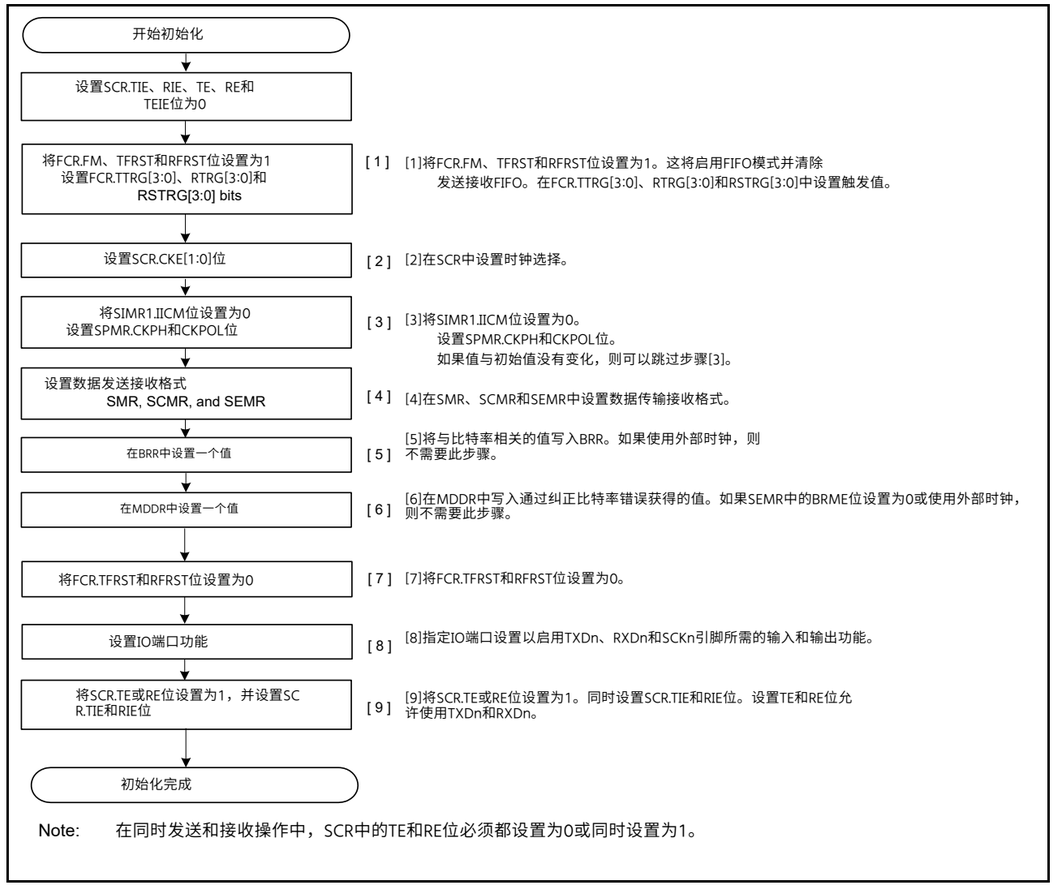


Figure 27.33 选择FIFO的时钟同步模式下的SCI初始化示例流程

27.5.4 时钟同步模式下的串行数据传输

(1) Non-FIFO selected

图27.34、图27.35和图27.36显示了时钟同步模式下的串行传输示例。

在串行数据传输中，SCI操作如下：

1. 当数据在SCIn_TXI中断处理程序中写入TDR时，SCI将数据从TDR寄存器传输到TSR寄存器。发送开始时的SCIn_TXI中断请求在TE位设置为1时产生，但仅在SCR.TIE位也设置为1之后，或者当SCR.TE和SCR.TIE同时设置为1时一条指令。
2. 将数据从TDR传输到TSR后，SCI开始传输。当SCR.TIE位设置为1时，一个SCIn_TXI中断请求产生。通过将下一个传输数据写入启用连续传输在当前发送数据传输完成之前的SCIn_TXI中断处理例程中的TDR。使用SCIn_TEI中断请求时，在SCIn_TXI请求的处理例程中将要发送的最后一个数据写入TDR寄存器后，将SCR.TIE位设置为0，并将SCR.TEIE位设置为1。
3. 指定时钟输出模式时，从TXDn引脚发送8位数据，与输出时钟同步；当指定使用外部时钟时，与输入时钟同步。时钟信号的输出暂停，直到输入CTS信号为低电平并且SPMR.CTSE位为1。
4. SCI在最后一位的输出上检查TDR寄存器的更新。

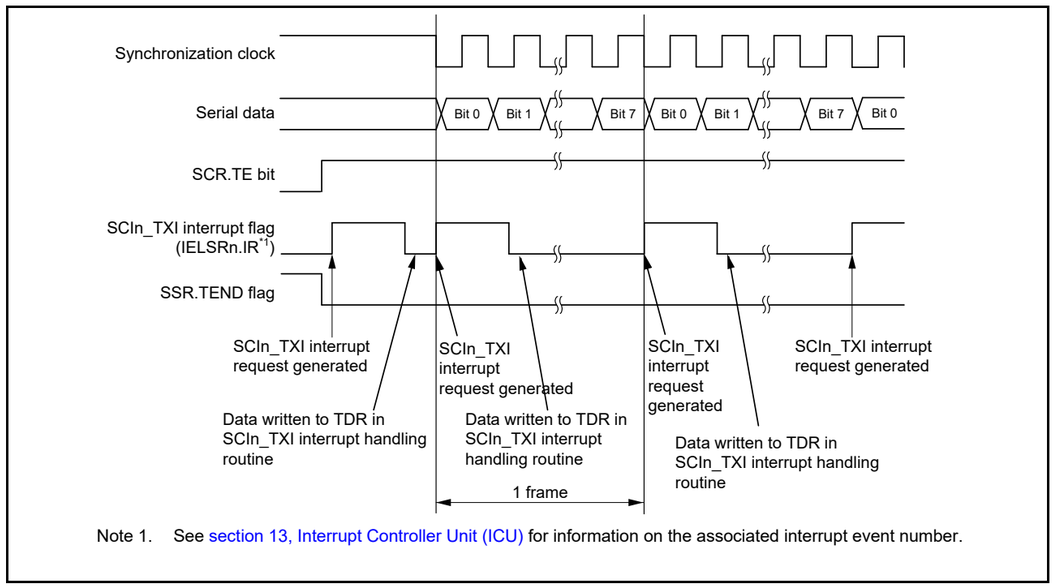
RA生态工作室

5. When the TDR register is updated, the next transmit data is transferred from TDR to TSR, and serial transmission of the next frame starts.
6. If TDR is not updated, the SSR.TEND flag is set to 1. The TXDn pin keeps the output state of the last bit. If the SCR.TEIE bit is 1, an SCIn_TEI interrupt request is generated and the SCKn pin is held high.

Figure 27.34, Figure 27.35, and Figure 27.36 show example flows of serial data transmission.

Transmission does not start while a receive error flag (ORER, FER, or PER in SSR) is set to 1. Be sure to set the receive error flags to 0 before starting transmission.

Note: Setting the SCR.RE bit to 0 does not clear the receive error flags.



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

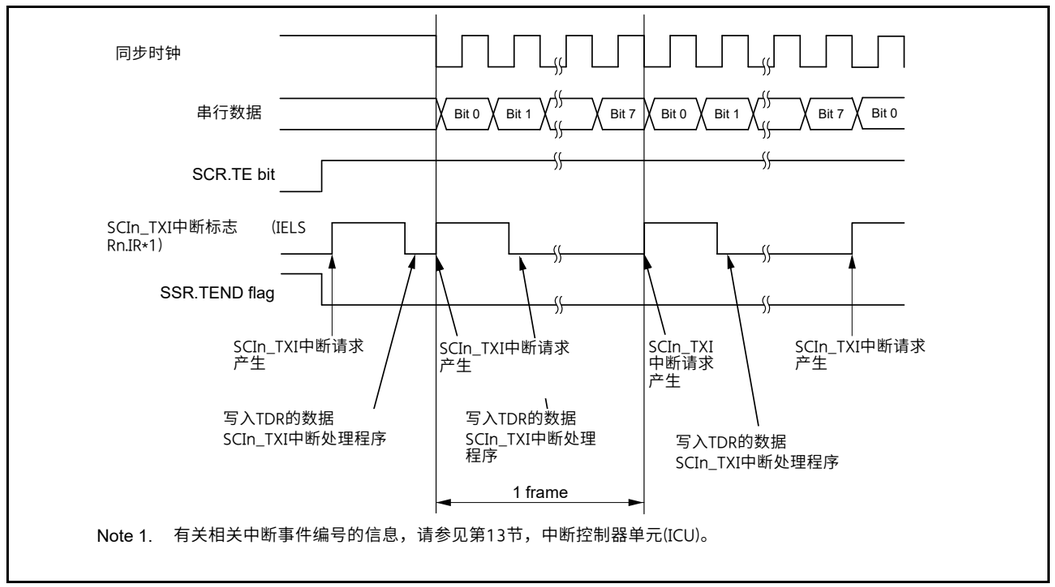
Figure 27.34 Example of serial data transmission in clock synchronous mode when the CTS function is not used at the beginning of transmission

5. 当更新TDR寄存器时，下一个发送数据从TDR传输到TSR，并开始下一帧的串行传输。
6. 如果TDR未更新，则SSR.TEND标志设置为1。TXDn引脚保持最后一位的输出状态。如果SCR.TEIE位为1，产生SCIn_TEI中断请求且SCKn引脚保持高电平。

图27.34、图27.35和图27.36显示了串行数据传输的示例流程。

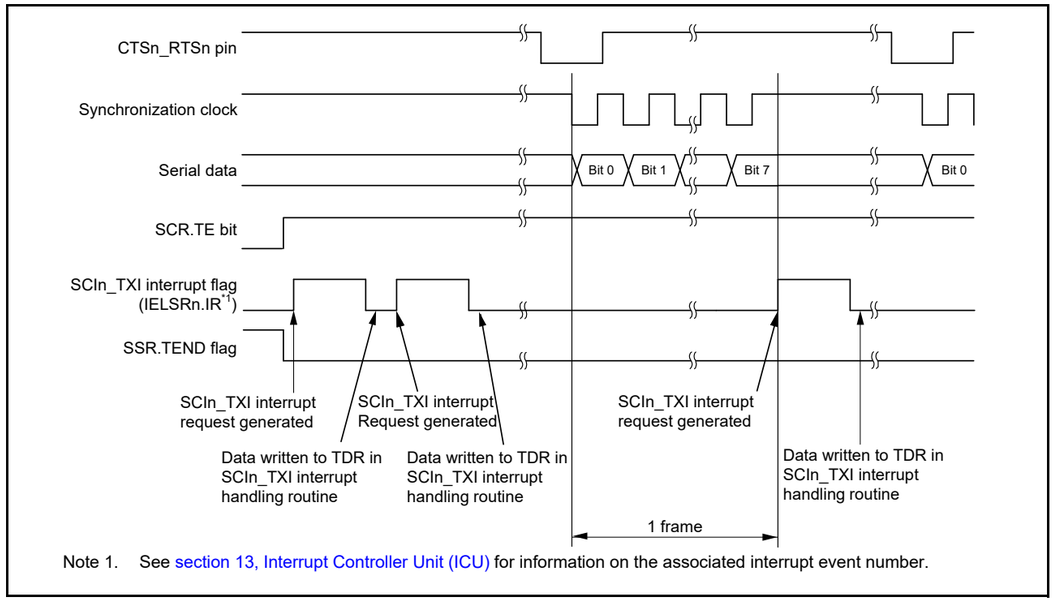
当接收错误标志（SSR中的ORER、FER或PER）设置为1时，发送不会开始。请务必在开始发送之前将接收错误标志设置为0。

Note: 将SCR.RE位设置为0不会清除接收错误标志。



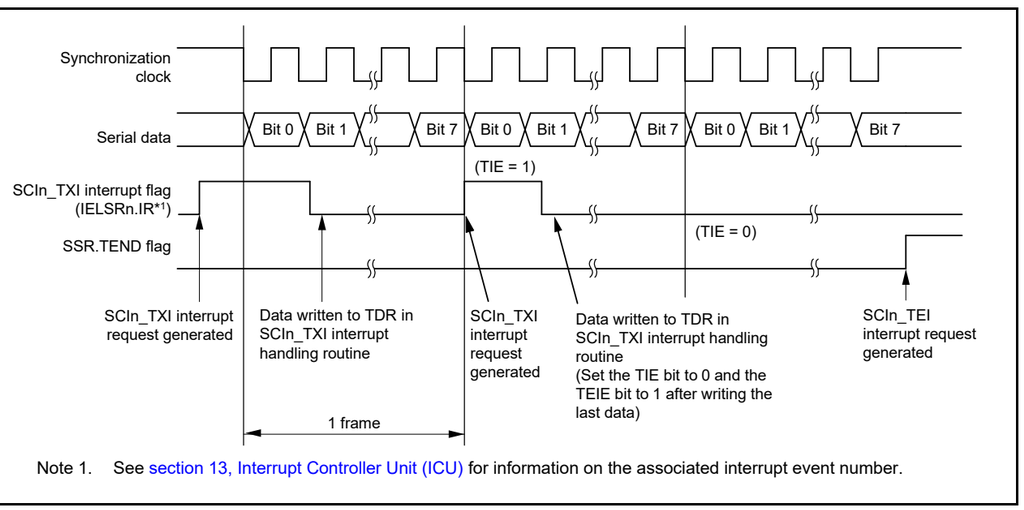
Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.34 传输开始时未使用CTS功能时时钟同步模式下的串行数据传输示例



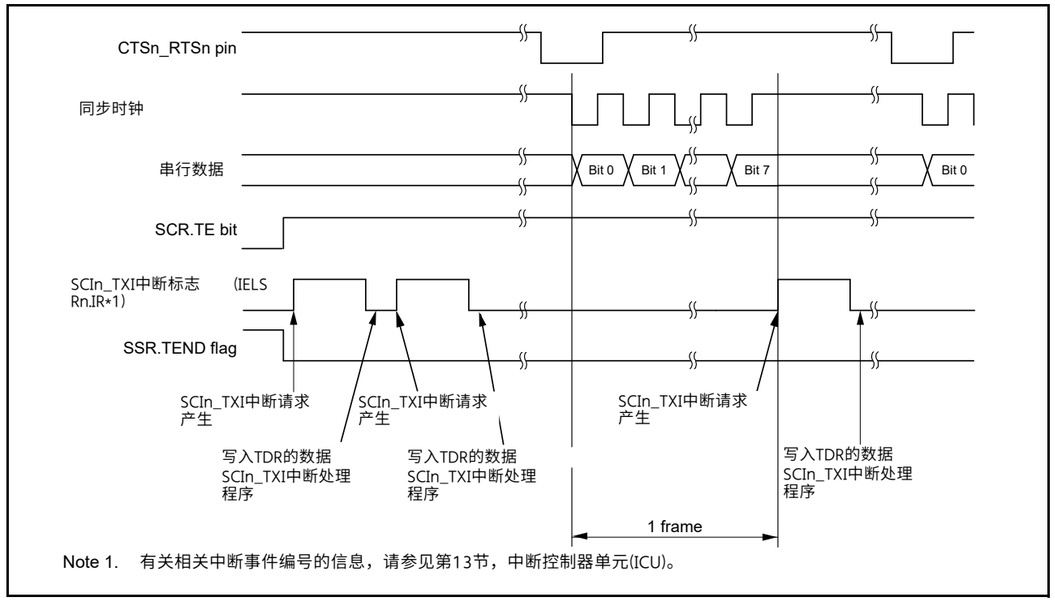
Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

Figure 27.35 Example of serial data transmission in clock synchronous mode when the CTS function is used at the beginning of transmission



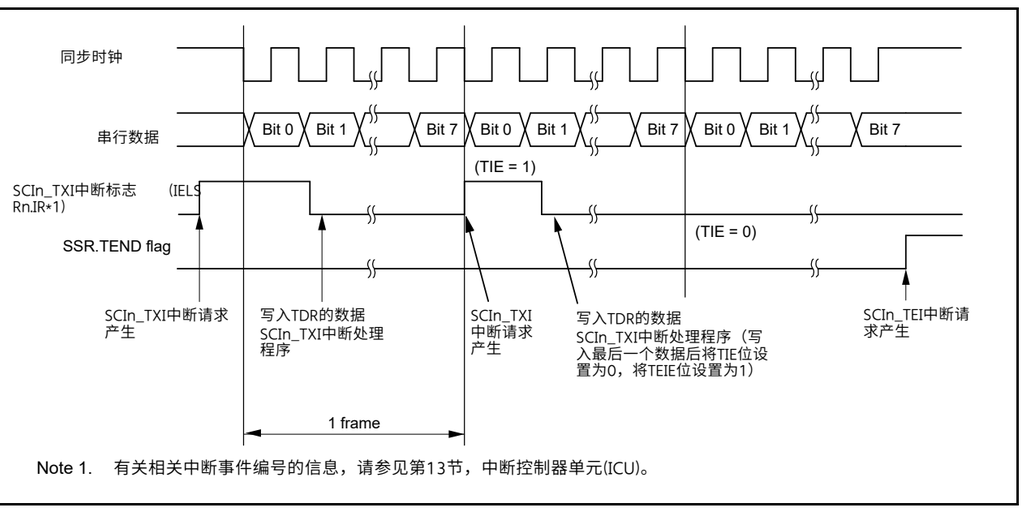
Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

Figure 27.36 Example of serial data transmission in clock synchronous mode from the middle of transmission until transmission completion



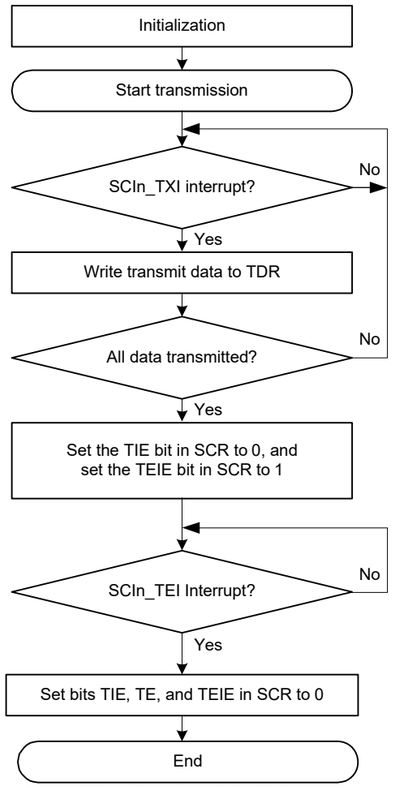
Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.35 传输开始时使用CTS功能时时钟同步模式下的串行数据传输示例



Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.36 从传输中间到传输完成的时钟同步模式下的串行数据传输示例



[1] [1] SCI initialization:
Set data transmission.

[2] [2] Write transmit data to TDR by an SCIn_TXI interrupt request:
When data transmission is transferred from TDR to TSR, a transmit data empty interrupt (SCIn_TXI) request is generated.
Transmit data is written to TDR once from the handling routine for SCIn_TXI requests.

[3] Serial transmission continuation procedure:
To continue serial transmission, write transmit data to TDR on accepting a transmit data empty interrupt (SCIn_TXI) request.
Transmit data can also be written to TDR by activating the DMAC or DTC by the SCIn_TXI interrupt request.

[3] When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 and the SCR.TEIE bit to 1 after the last of the data to be transmitted is written to TDR.

Note: When the external clock is in use (the value of the SCR.CKE[1:0] bits is 10b or 11b), the rising edge on the SCK pin for the last bit sets the SSR.TEND flag to 1. Setting the SCR.TE bit to 0 immediately after this might lead to insufficient received data hold time on the receiver side.

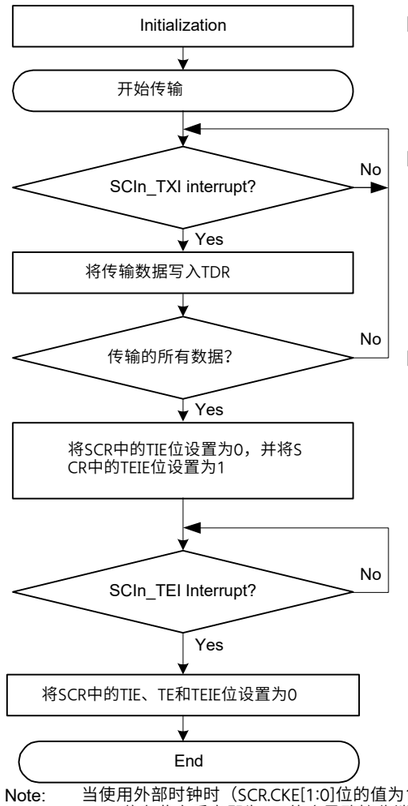
Figure 27.37 Example flow of serial transmission in clock synchronous mode with non-FIFO selected

(2) FIFO selected

Figure 27.38 shows an example of serial transmission in clock synchronous mode with FIFO selected.

In serial data transmission, the SCI operates as follows:

1. The SCI transfers data from the FTDRL*1 register to the TSR register when data is written to FTDRL*1 in the SCIn_TXI interrupt handling routine. The amount of data that can be written to FTDRL is 16 minus FDR.T[4:0] bytes. The SCIn_TXI interrupt request at the beginning of transmission is generated when the SCR.TE bit is set to 1, but only after the SCR.TIE bit is also set to 1, or when SCR.TE and SCR.TIE are both set to 1 simultaneously by a single instruction.
2. After transferring data from FTDRL to TSR, the SCI starts transmission. When the amount of transmit data written in FTDRL is equal to or less than the specified transmit triggering number, the SSR_FIFO.TDFE is set to 1. When the SCR.TIE bit is set to 1, an SCIn_TXI interrupt request is generated. Continuous transmission is enabled by writing the next transmit data to FTDRL in the SCIn_TXI interrupt handling routine before transmission of the current transmit data is complete. When SCIn_TEI interrupt requests are in use, set the SCR.TIE bit to 0 and the SCR.TEIE bit to 1 after the last of the data to be transmitted is written to the FTDRL from the handling routine for SCIn_TXI requests.
3. 8-bit data is sent from the TXDn pin in synchronization with the output clock when the clock output mode is specified and in synchronization with the input clock when the use of an external clock is specified. Output of the clock signal is suspended until the input CTS signal is low and while the SPMR.CTSE bit is 1.



[1] [1]SCI初始化：设置数据传输。

[2]通过SCIn_TXI中断请求将发送数据写入TDR：当数据从TDR传输到TSR时，会产生发送数据空中断（SCIn_TXI）请求。传输数据从处理例程写入TDR一次

[2] SCIn_TXI requests.

[3]串行传输继续程序：要继续串行传输，在接受传输数据空中断（SCIn_TXI）请求时将传输数据写入TDR。发送数据也可以通过SCIn_TXI中断请求激活DMAC或DTC写入TDR。

[3] 使用SCIn_TEI中断请求时，将要发送的最后一个数据写入TDR后，将SCR.TIE位设置为0，并将SCR.TEIE位设置为1。

Note: 当使用外部时钟时（SCR.CKE[1:0]位的值为10b或11b），SCK引脚上最后一位的上升沿将SSR.TEND标志设置为1。设置SCR.TE位在此之后立即为0可能会导致接收端接收数据保持时间不足。

Figure 27.37 选择非FIFO的时钟同步模式下的串行传输示例流程

(2) FIFO selected

图27.38显示了选择FIFO的时钟同步模式下的串行传输示例。

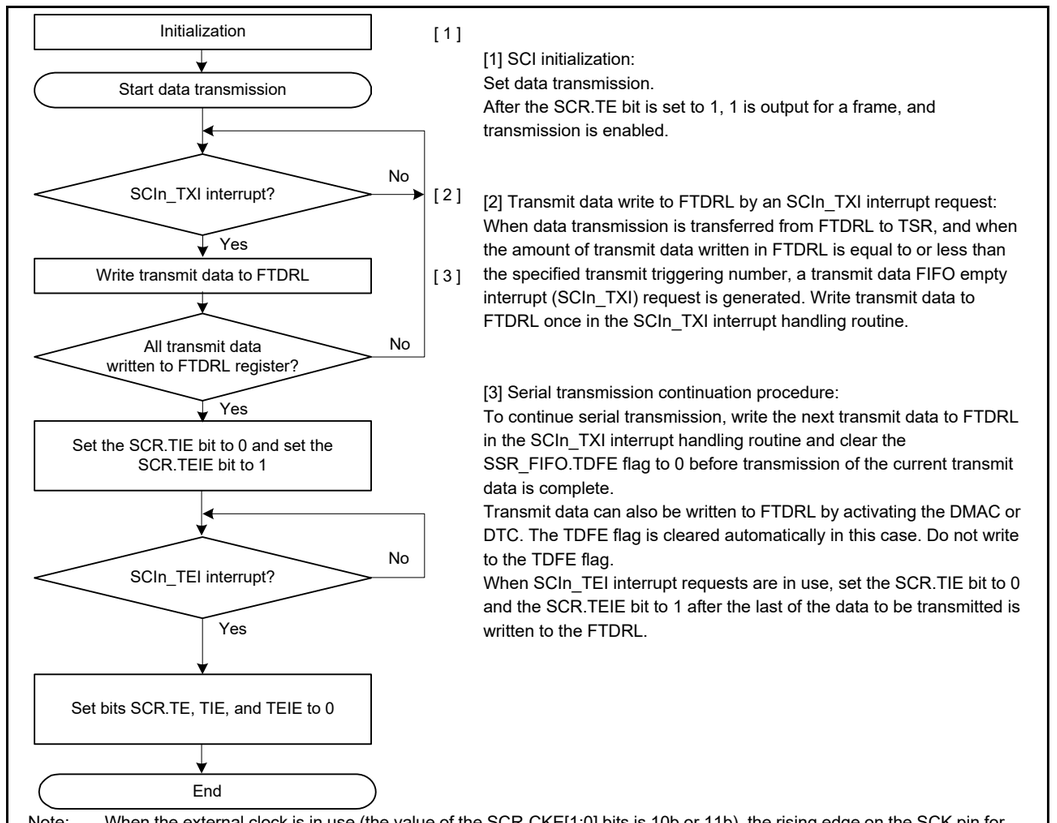
在串行数据传输中，SCI操作如下：

1. 当数据写入FTDRL*1时，SCI将数据从FTDRL*1寄存器传输到TSR寄存器
   SCIn_TXI中断处理程序。可写入FTDRL的数据量为16减去FDR.T[4:0]字节。发送开始时的SCIn_TXI中断请求在SCR.TE位设置为1时产生，但仅在SCR.TIE位也设置为1之后，或者当SCR.TE和SCR.TIE均设置为1时同时通过一条指令。
2. 将数据从FTDRL传输到TSR后，SCI开始传输。当写入FTDRL的发送数据量等于或小于指定的发送触发数时，SSR_FIFO.TDFE设置为1。当SCR.TIE位设置为1时，产生SCIn_TXI中断请求。在当前发送数据的发送完成之前，通过在SCIn_TXI中断处理例程中将下一个发送数据写入FTDRL来启用连续发送。当使用SCIn_TEI中断请求时，在将要传输的最后一个数据从处理例程写入FTDRL后，将SCR.TIE位设置为0，并将SCR.TEIE位设置为1。

   SCIn_TXI requests.
3. 指定时钟输出模式时，与输出时钟同步，指定使用外部时钟时，与输入时钟同步，从TXDn引脚发送8位数据。时钟信号的输出暂停，直到输入CTS信号为低电平并且SPMR.CTSE位为1。

4. The SCI checks whether non-transmitted data remains in FTDRL on the output of the stop bit.
5. When FTDRL is updated, the next transmit data is transferred from FTDRL to TSR and serial transmission of the next frame starts.
6. If FTDRL is not updated, the SSR_FIFO.TEND flag is set to 1. The TXDn pin keeps the output state of the last bit. If the SCR.TEIE bit is 1, an SCIn_TEI interrupt request is generated and the SCKn pin is held high.

Note 1. In clock synchronous mode, FTDRH is not used.



Note: When the external clock is in use (the value of the SCR.CKE[1:0] bits is 10b or 11b), the rising edge on the SCK pin for the last bit sets the SSR_FIFO.TEND flag to 1. Setting the SCR.TE bit to 0 immediately after this might lead to insufficient hold time for received data on the receiver side.

Figure 27.38 Example flow of serial transmission in clock synchronous mode with FIFO selected

27.5.5 Serial Data Reception in Clock Synchronous Mode

(1) Non-FIFO selected

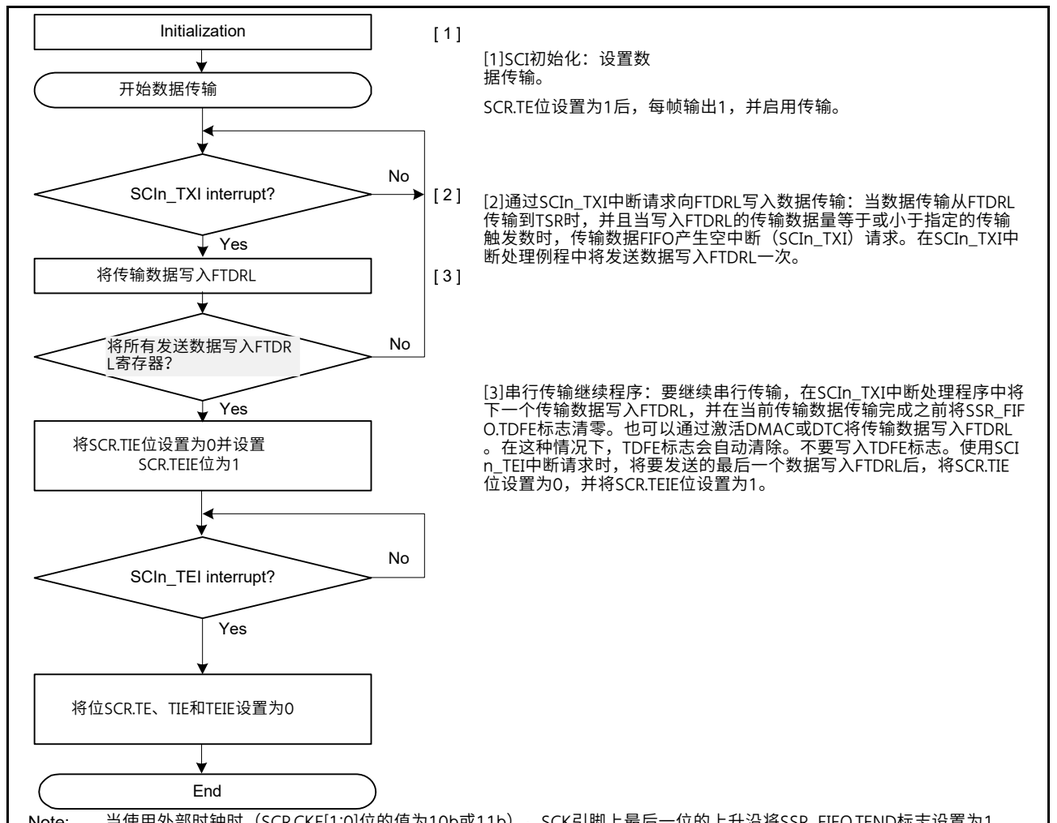
Figure 27.39 and Figure 27.40 show examples of SCI operation for serial reception in clock synchronous mode.

In serial data reception, the SCI operates as follows:

1. When the value of the SCR.RE bit becomes 1, the CTSn_RTSn pin goes low.
2. The SCI performs internal initialization and starts receiving data in synchronization with a synchronization clock input or output, and stores the receive data in the RSR register.
3. If an overrun error occurs, the SSR.ORER flag is set to 1. If the SCR.RIE bit is 1, an SCIn_ERI interrupt request is

4. SCI在停止位的输出上检查未传输的数据是否保留在FTDRL中。
5. 当FTDRL被更新时，下一个传输数据从FTDRL传输到TSR并开始下一帧的串行传输。
6. 如果FTDRL未更新，则SSR_FIFO.TEND标志设置为1。TXDn引脚保持最后一位的输出状态。
   如果SCR.TEIE位为1，则产生SCIn_TEI中断请求并且SCKn引脚保持高电平。

注1.在时钟同步模式下，不使用FTDRH。



Note: 当使用外部时钟时（SCR.CKE[1:0]位的值为10b或11b），SCK引脚上最后一位的上升沿将SSR_FIFO.TEND标志设置为1。设置SCR.TE位在此之后立即为0可能会导致接收端接收数据的保持时间不足。

Figure 27.38 选择FIFO的时钟同步模式下的串行传输示例流程

27.5.5 时钟同步模式下的串行数据接收

(1) Non-FIFO selected

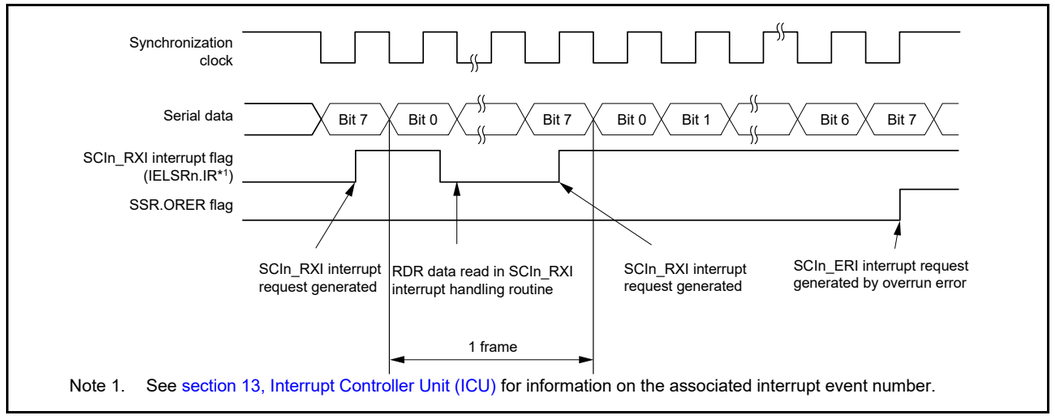
图27.39和图27.40显示了时钟同步模式下串行接收的SCI操作示例。

在串行数据接收中，SCI操作如下：

1. 当SCR.RE位的值变为1时，CTSn_RTSn引脚变为低电平。
2. SCI执行内部初始化并与同步时钟输入或输出同步开始接收数据，并将接收数据存储在RSR寄存器中。
3. 如果发生溢出错误，则SSR.ORER标志设置为1。如果SCR.RIE位为1，则SCIn_ERI中断请求

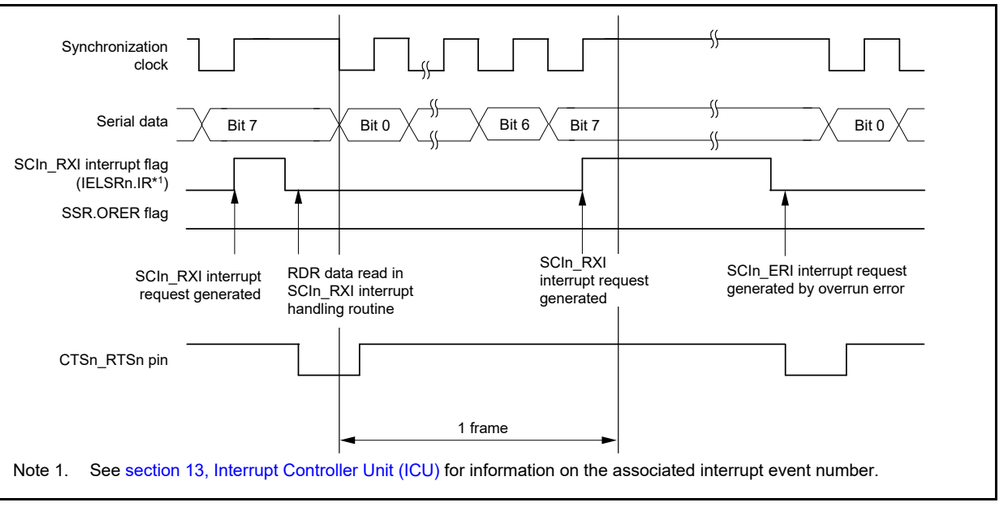
generated. Receive data is not transferred to the RDR register.

4. When reception completes successfully, receive data is transferred to the RDR register. If the SCR.RIE bit is 1, an SCIn_RXI interrupt request is generated. Continuous reception is enabled by reading the received data transferred to the RDR register in the SCIn_RXI interrupt handling routine before the reception of the next receive data completes. Reading the received data from RDR causes the CTSn_RTSn pin to output low.



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

Figure 27.39 Example operation of serial reception in clock synchronous mode (1) when the RTS function is not used



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

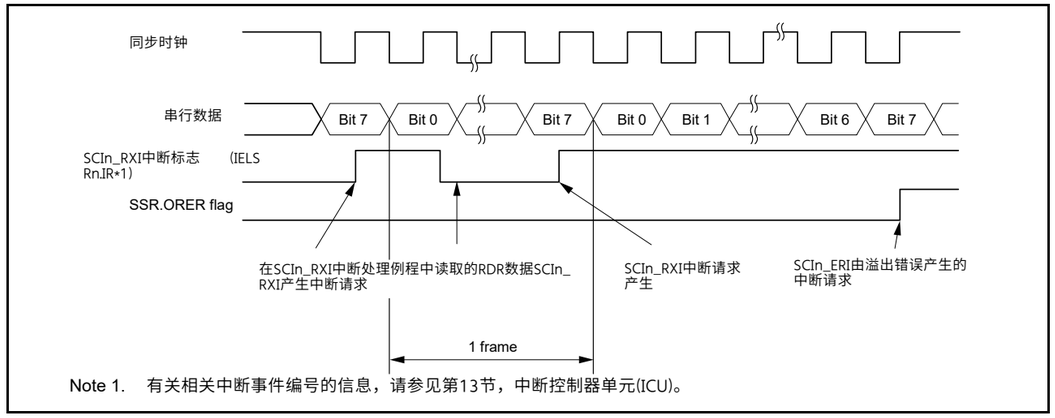
Figure 27.40 Example operation of serial reception in clock synchronous mode (2) when RTS function is used

Data transfer cannot resume while the receive error flag is 1. Therefore, clear the ORER, FER, and PER flags in the SSR register to 0 before resuming data reception. Additionally, be sure to read the RDR register during overrun error processing. When a data reception is forcibly terminated by setting the SCR.RE bit to 0 during operation, read the RDR register because received data that is not yet read might be left in the RDR register.

Figure 27.41 shows an example flow of serial data reception.

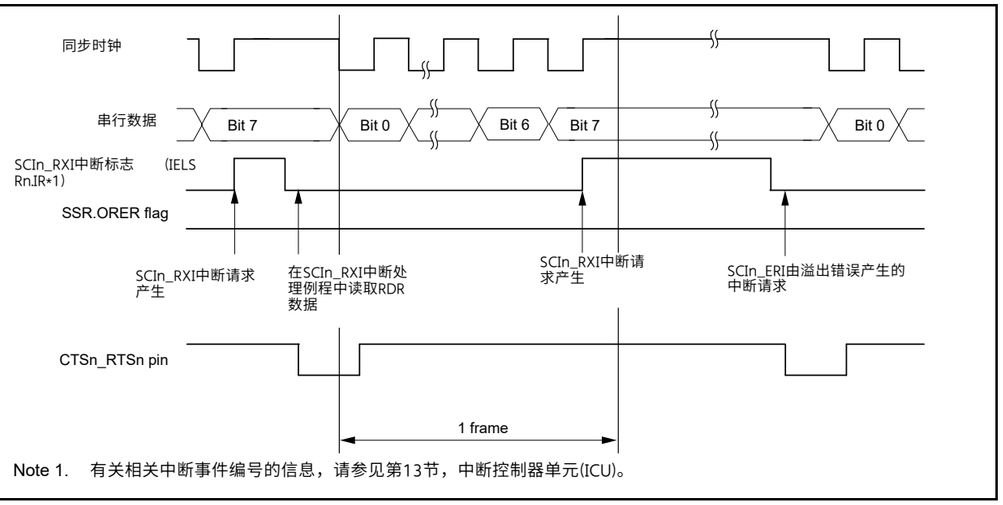
生成。接收数据不传送到RDR寄存器。

4. 当接收成功完成时，接收数据被传送到RDR寄存器。如果SCR.RIE位为1，则产生SCIn_RXI中断请求。在下一个接收数据的接收完成之前，通过在SCIn_RXI中断处理程序中读取传输到RDR寄存器的接收数据来启用连续接收。从RDR读取接收到的数据会导致CTSn_RTSn引脚输出低电平。



Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.39 不使用RTS功能时时钟同步模式下串行接收的示例操作(1)

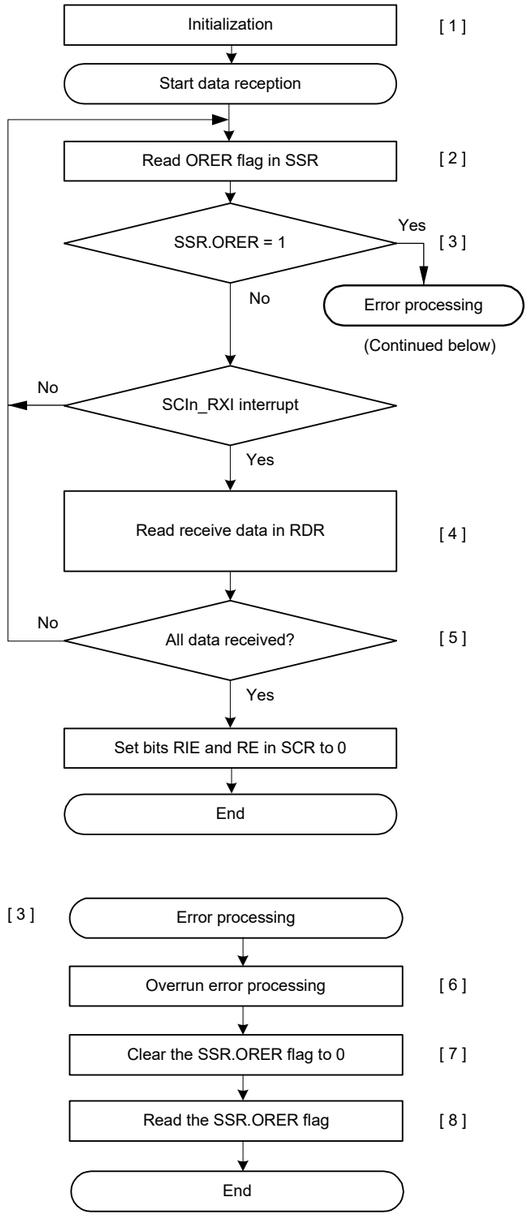


Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.40 使用RTS功能时时钟同步模式下串行接收的示例操作(2)

接收错误标志为1时无法恢复数据传输。因此，在恢复数据接收之前，将SSR寄存器中的ORER、FER和PER标志清除为0。此外，请务必在溢出错误处理期间读取RDR寄存器。如果在操作期间通过将SCR.RE位设置为0来强制终止数据接收，请读取RDR寄存器，因为尚未读取的接收数据可能会留在RDR寄存器中。

图27.41显示了串行数据接收的示例流程。



[1] SCI initialization:
Set the input port for pins to be used as RXDn pins.

[2] [3] Receive error processing:
If a receive error occurs, read the ORER flag in SSR, perform the relevant error processing, then set the ORER flag to 0. Data reception cannot resume while the ORER flag is 1.

[4] Read the receive data in RDR once in the receive data full interrupt (SCIn_RXI) request handling routine.

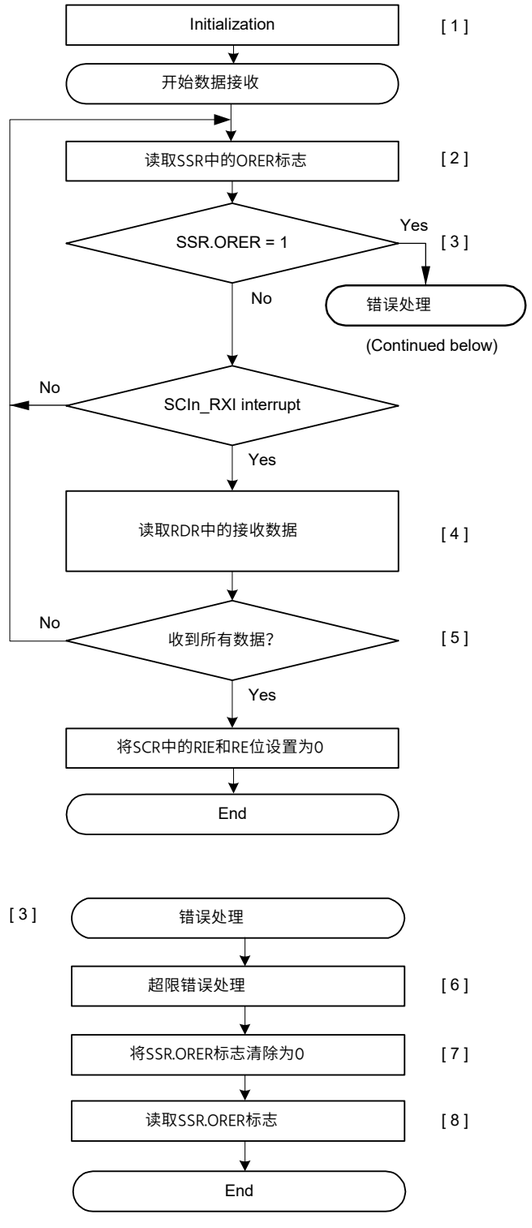
[5] Serial reception continuation procedure:
To continue serial reception, before the MSB bit [7] of the current frame is received, finish reading the receive data in RDR. The RDR data can also be read by activating the DMAC or DTC by an SCIn_RXI interrupt request.

[6] Processing in response to an overrun error:
Read the RDR. In combination with step [7], this enables correct reception of the next frame possible.

[7] Clearing the error flag:
Write 0 to the error flag.

[8] Confirming that the error flag is cleared:
Read the error flag to confirm that its value is 0.

Figure 27.41 Example flow of serial reception in clock synchronous mode with non-FIFO selected



[1] SCI initialization:
将引脚的输入端口设置为RXDn引脚。

[2] [3]接收错误处理：如果发生接收错误，读取SSR中的ORER标志，进行相应的错误处理，然后将ORER标志置0。当ORER标志为1时，数据接收不能恢复。

[4] 在接收数据完全中断(SCIn_RXI)请求处理程序中读取一次RDR中的接收数据。

[5] 串行接收继续过程：
要继续串行接收，在接收到当前帧的MSB位[7]之前，完成读取RDR中的接收数据。RDR数据也可以通过SCIn_RXI中断请求激活DMAC或DTC来读取。

[6] 响应溢出错误的处理：读取RDR。结合步骤[7]，这使得下一帧的正确接收成为可能。

[7] 清除错误标志：将0写入错误标志。

[8] 确认错误标志已清除：
读取错误标志以确认其值为0。

Figure 27.41 选择非FIFO的时钟同步模式下的串行接收示例流程

(2) FIFO selected

Figure 27.42 shows an example of serial reception in clock synchronous mode with FIFO selected.

In serial data reception, the SCI operates as follows:

1. When the value of the SCR.RE bit becomes 1, the CTSn_RTSn pin goes low.
2. The SCI performs internal initialization and starts receiving data in synchronization with a synchronization clock input or output, and stores the receive data in RSR.
3. If an overrun error occurs, the ORER flag in SSR_FIFO is set to 1. If the SCR.RIE bit is 1, an SCIn_ERI interrupt request is generated. Receive data is not transferred to the FRDRL*1 register.
4. When data reception completes successfully, the receive data is transferred to the FRDRL*1 register. The RDF bit is set to 1 when the amount of the receive data stored in FRDRL is equal to or greater than the specified receive triggering number. If the SCR.RIE bit is 1, an SCIn_RXI interrupt request is generated. Continuous data reception is enabled by reading the receive data transferred to FRDRL*2 in the SCIn_RXI interrupt handling routine before an overrun error occurs. If the amount of received data that is transferred to FRDRL is less than the RTS trigger number, the CTSn_RTSn pin goes low.

Note 1. In clock synchronous mode, FRDRH is not used.
Note 2. Read data in the order from FRDRH to FRDRL when RDF and ORER are read with receive data.

(2) FIFO selected

图27.42显示了选择FIFO的时钟同步模式下的串行接收示例。

在串行数据接收中，SCI操作如下：

1. 当SCR.RE位的值变为1时，CTSn_RTSn引脚变为低电平。
2. SCI执行内部初始化并与同步时钟输入或输出同步开始接收数据，并将接收数据存储在RSR中。
3. 如果发生溢出错误，则SSR_FIFO中的ORER标志设置为1。如果SCR.RIE位为1，则产生SCIn_ERI中断请求。接收数据不传送到FRDRL*1寄存器。
4. 当数据接收成功完成时，接收数据被传送到FRDRL*1寄存器。当存储在FRDRL中的接收数据量等于或大于指定的接收触发数时，RDF位设置为1。如果SCR.RIE位为1，则产生SCIn_RXI中断请求。在发生溢出错误之前，通过在SCIn_RXI中断处理例程中读取传输到FRDRL*2的接收数据来启用连续数据接收。如果传输到FRDRL的接收数据量小于RTS触发数，则CTSn_RTSn引脚变为低电平。

注1.在时钟同步模式下，不使用FRDRH。
注2.RDF和ORER与接收数据一起读取时，按照从FRDRH到FRDRL的顺序读取数据。

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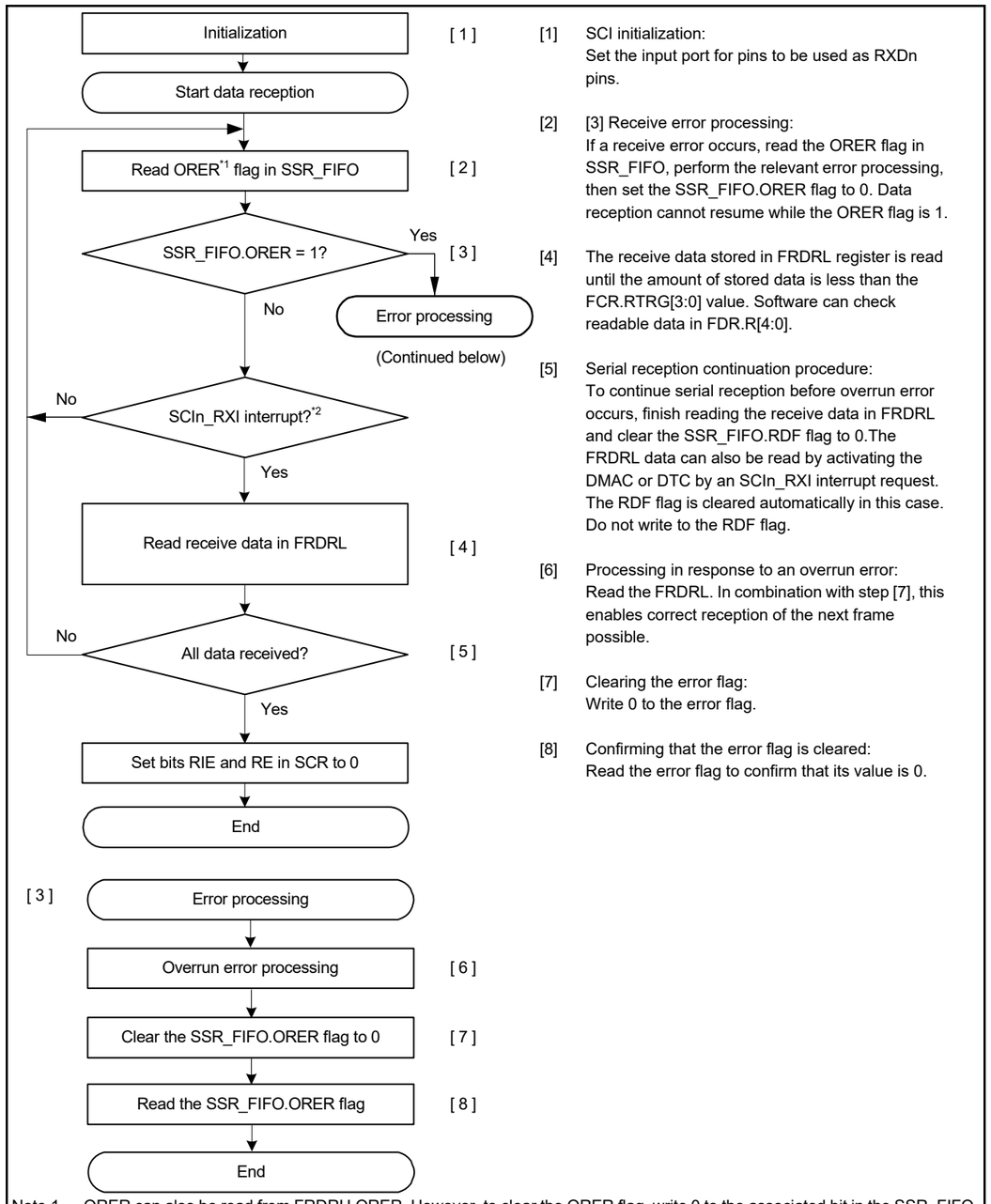


[1] SCI initialization:
Set the input port for pins to be used as RXDn pins.

[2] [3] Receive error processing:
If a receive error occurs, read the ORER flag in SSR_FIFO, perform the relevant error processing, then set the SSR_FIFO.ORER flag to 0. Data reception cannot resume while the ORER flag is 1.

[4] The receive data stored in FRDRL register is read until the amount of stored data is less than the FCR.RTRG[3:0] value. Software can check readable data in FDR.R[4:0].

[5] Serial reception continuation procedure:
To continue serial reception before overrun error occurs, finish reading the receive data in FRDRL and clear the SSR_FIFO.RDF flag to 0.The FRDRL data can also be read by activating the DMAC or DTC by an SCIn_RXI interrupt request. The RDF flag is cleared automatically in this case. Do not write to the RDF flag.

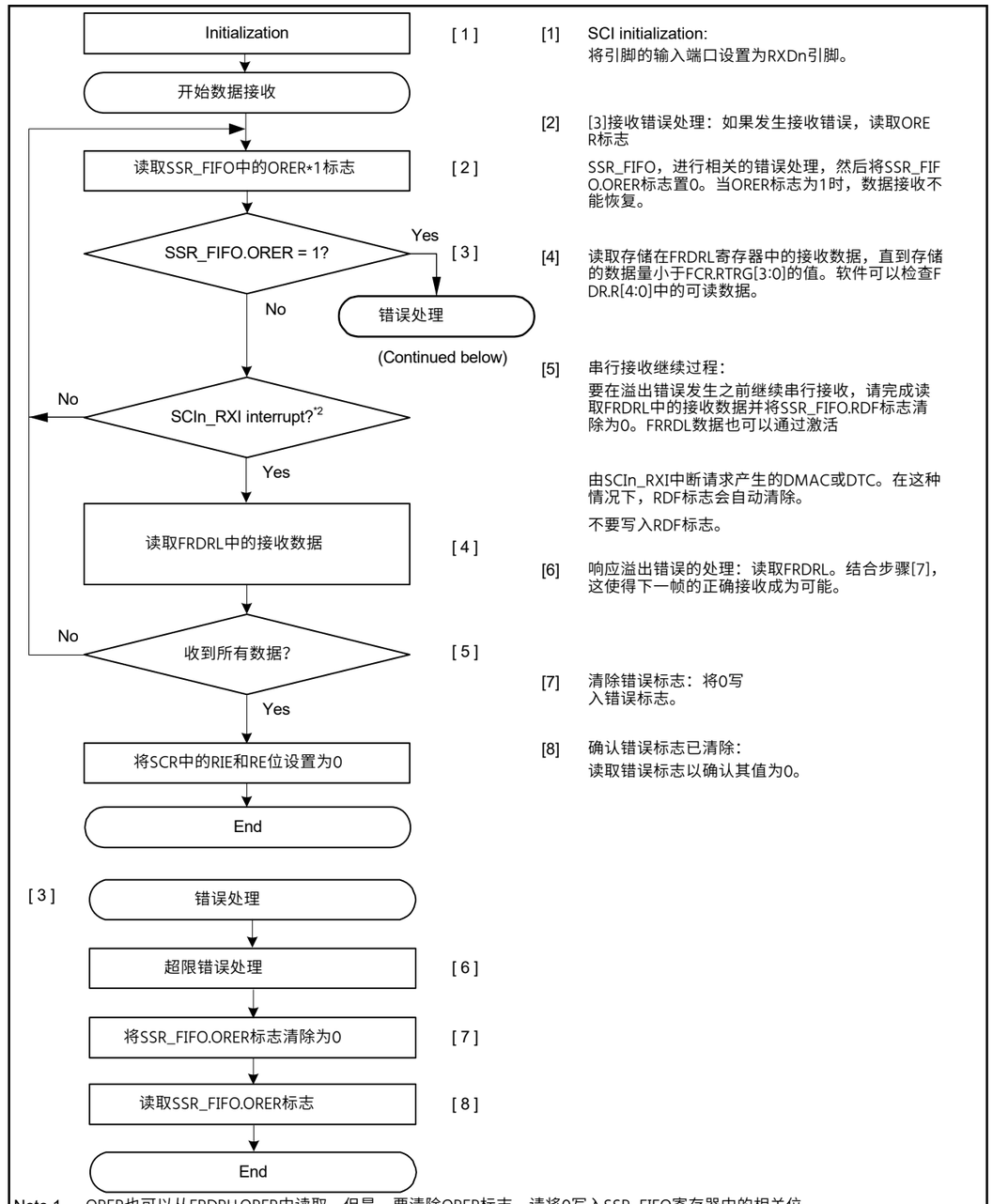
[6] Processing in response to an overrun error:
Read the FRDRL. In combination with step [7], this enables correct reception of the next frame possible.

[7] Clearing the error flag:
Write 0 to the error flag.

[8] Confirming that the error flag is cleared:
Read the error flag to confirm that its value is 0.

Note 1. ORER can also be read from FRDRH.ORER. However, to clear the ORER flag, write 0 to the associated bit in the SSR_FIFO register.
Note 2. All receive data is an integer multiple of the FIFO triggering number.

Figure 27.42 Example flow of serial reception in clock synchronous mode with FIFO selected



[1] SCI initialization:
将引脚的输入端口设置为RXDn引脚。

[2] [3]接收错误处理：如果发生接收错误，读取ORER标志
SSR_FIFO，进行相关的错误处理，然后将SSR_FIFO.ORER标志置0。当ORER标志为1时，数据接收不能恢复。

[4] 读取存储在FRDRL寄存器中的接收数据，直到存储的数据量小于FCR.RTRG[3:0]的值。软件可以检查FDR.R[4:0]中的可读数据。

[5] 串行接收继续过程：
要在溢出错误发生之前继续串行接收，请完成读取FRDRL中的接收数据并将SSR_FIFO.RDF标志清除为0。FRRDL数据也可以通过激活
由SCIn_RXI中断请求产生的DMAC或DTC。在这种情况下，RDF标志会自动清除。
不要写入RDF标志。

[6] 响应溢出错误的处理：读取FRDRL。结合步骤[7]，这使得下一帧的正确接收成为可能。

[7] 清除错误标志：将0写入错误标志。

[8] 确认错误标志已清除：
读取错误标志以确认其值为0。

Note 1. ORER也可以从FRDRH.ORER中读取。但是，要清除ORER标志，请将0写入SSR_FIFO寄存器中的相关位。
Note 2. 所有接收数据都是FIFO触发数的整数倍。

Figure 27.42 选择FIFO的时钟同步模式下的串行接收示例流程

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27.5.6 Simultaneous Serial Data Transmission and Reception in Clock Synchronous Mode

(1) Non-FIFO selected

Figure 27.43 shows an example flow of simultaneous serial transmission and reception operations in clock synchronous mode. After initializing the SCI, use the following procedure for simultaneous serial data transmission and reception operations.

To switch from transmit mode to simultaneous transmit and receive mode:

1. Check that the SCI completes the data transmission by verifying that the SSR.TEND flag is set to 1.
2. Initialize the SCR register and then set the TIE, RIE, TE, and RE bits in the SCR register to 1 simultaneously with a single instruction.

To switch from receive mode to simultaneous transmit and receive mode:

1. Check that the SCI completes the data reception.
2. Set the RIE and RE bits in the SCR register to 0, then check that the receive error flag ORER in the SSR register is 0.
3. Set the TIE, RIE, TE, and RE bits in the SCR register to 1 simultaneously with a single instruction.

27.5.6 时钟同步的同时串行数据发送和接收 Mode

(1) Non-FIFO selected

图27.43显示了时钟同步模式下同时串行发送和接收操作的示例流程。初始化SCI后，使用以下程序同时进行串行数据发送和接收操作。

从发送模式切换到同时发送和接收模式：

1. 通过验证SSR.TEND标志是否设置为1来检查SCI是否完成了数据传输。
2. 初始化SCR寄存器，然后用一条指令同时将SCR寄存器中的TIE、RIE、TE和RE位设置为1。

从接收模式切换到同时发送和接收模式：

1. 检查SCI是否完成数据接收。
2. 将SCR寄存器中的RIE和RE位设置为0，然后检查SSR寄存器中的接收错误标志ORER是否为0。
3. 通过一条指令同时将SCR寄存器中的TIE、RIE、TE和RE位设置为1。

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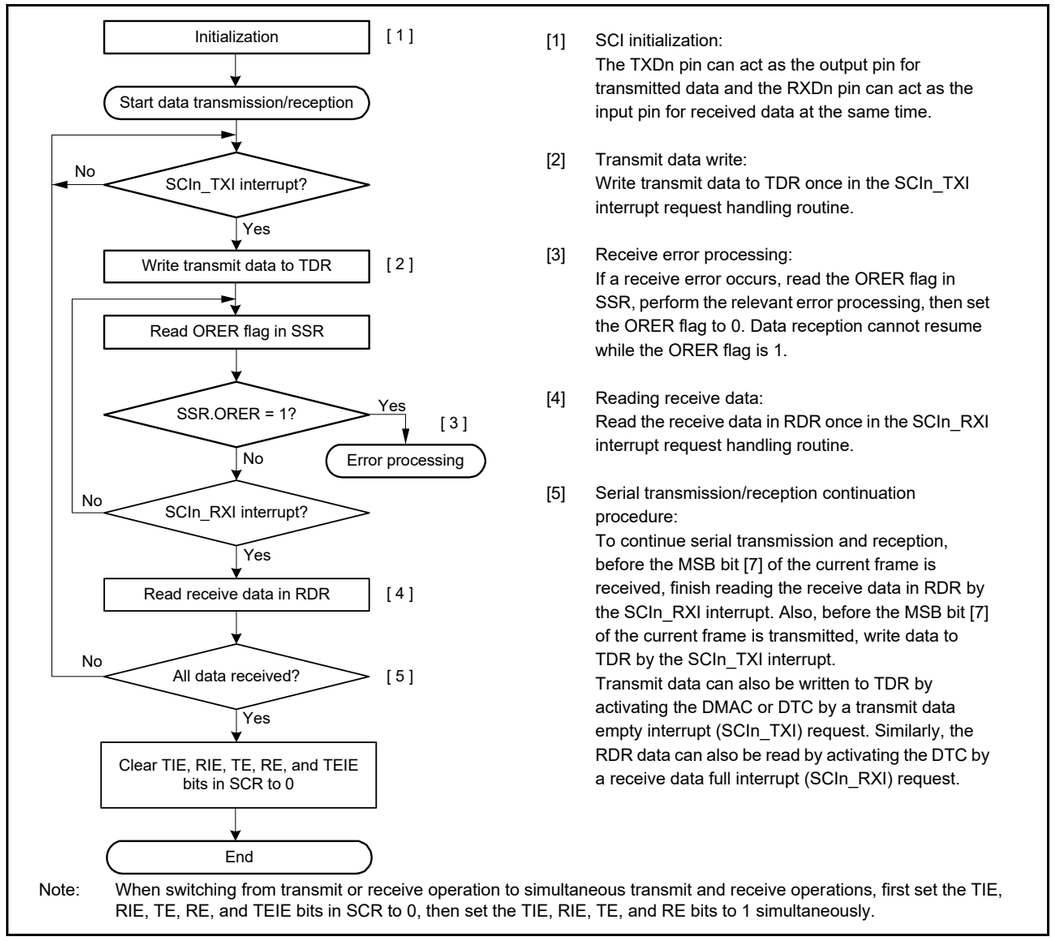


[1] SCI initialization:
The TXDn pin can act as the output pin for transmitted data and the RXDn pin can act as the input pin for received data at the same time.

[2] Transmit data write:
Write transmit data to TDR once in the SCIn_TXI interrupt request handling routine.

[3] Receive error processing:
If a receive error occurs, read the ORER flag in SSR, perform the relevant error processing, then set the ORER flag to 0. Data reception cannot resume while the ORER flag is 1.

[4] Reading receive data:
Read the receive data in RDR once in the SCIn_RXI interrupt request handling routine.

[5] Serial transmission/reception continuation procedure:
To continue serial transmission and reception, before the MSB bit [7] of the current frame is received, finish reading the receive data in RDR by the SCIn_RXI interrupt. Also, before the MSB bit [7] of the current frame is transmitted, write data to TDR by the SCIn_TXI interrupt.
Transmit data can also be written to TDR by activating the DMAC or DTC by a transmit data empty interrupt (SCIn_TXI) request. Similarly, the RDR data can also be read by activating the DTC by a receive data full interrupt (SCIn_RXI) request.

Note: When switching from transmit or receive operation to simultaneous transmit and receive operations, first set the TIE, RIE, TE, RE, and TEIE bits in SCR to 0, then set the TIE, RIE, TE, and RE bits to 1 simultaneously.

Figure 27.43 Example flow of simultaneous serial transmission and reception in clock synchronous mode with non-FIFO selected

(2) FIFO selected

Figure 27.44 shows an example flow of simultaneous serial transmit and receive operations in clock synchronous mode with FIFO selected.

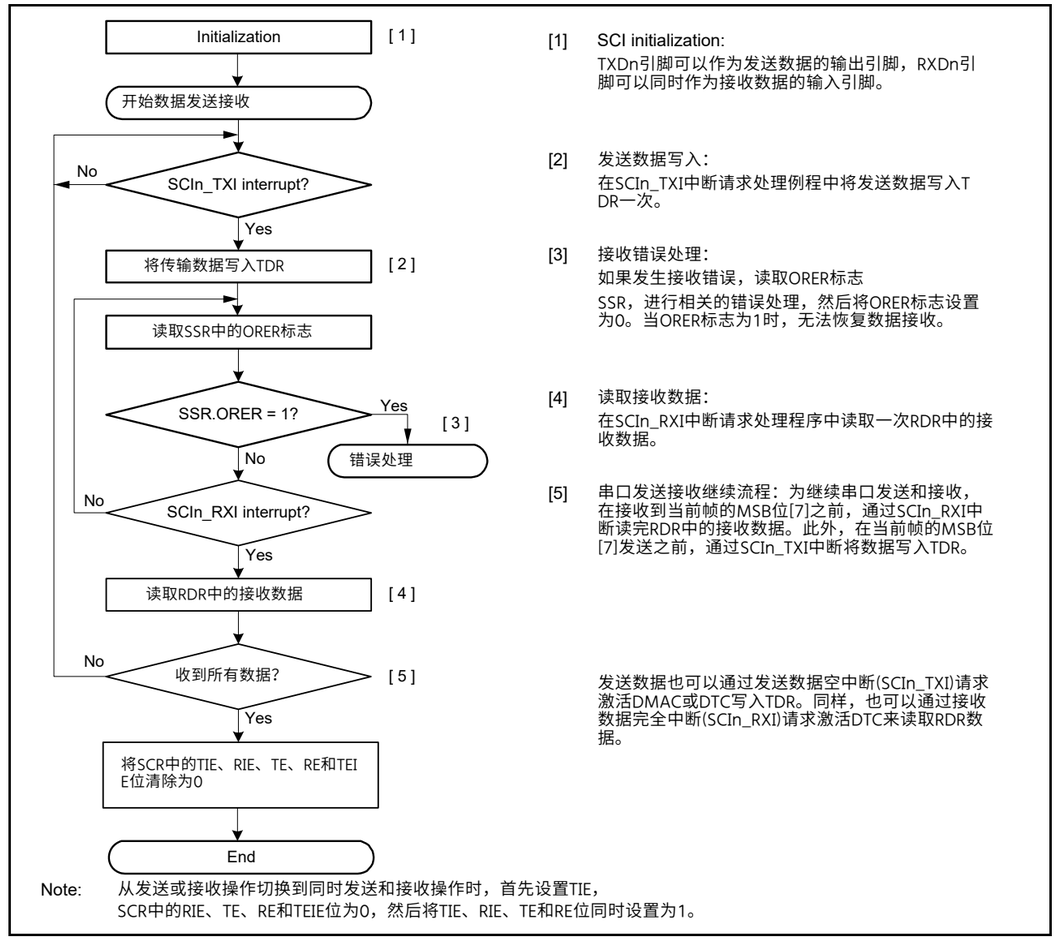
After initializing the SCI, use the following procedure for simultaneous serial data transmit and receive operations.

To switch from transmit mode to simultaneous transmit and receive mode:

1. Check that the SCI completes the transmission by verifying that the TEND flag in SSR_FIFO is set to 1.
2. Initialize the SCR register, then set the TIE, RIE, TE, and RE bits in the SCR register to 1 simultaneously with a single instruction.

To switch from receive mode to simultaneous transmit and receive mode:

1. Check that the SCI completes the reception.
2. Set the RIE and RE bits to 0, then check that the receive error flag ORER in SSR_FIFO is 0.
3. Set the TIE, RIE, TE, and RE bits in SCR register to 1 simultaneously with a single instruction.



[1] SCI initialization:
TXDn引脚可以作为发送数据的输出引脚，RXDn引脚可以同时作为接收数据的输入引脚。

[2] 发送数据写入：
在SCIn_TXI中断请求处理例程中将发送数据写入TDR一次。

[3] 接收错误处理：
如果发生接收错误，读取ORER标志
SSR，进行相关的错误处理，然后将ORER标志设置为0。当ORER标志为1时，无法恢复数据接收。

[4] 读取接收数据：
在SCIn_RXI中断请求处理程序中读取一次RDR中的接收数据。

[5] 串口发送接收继续流程：为继续串口发送和接收，在接收到当前帧的MSB位[7]之前，通过SCIn_RXI中断读完RDR中的接收数据。此外，在当前帧的MSB位[7]发送之前，通过SCIn_TXI中断将数据写入TDR。

发送数据也可以通过发送数据空中断(SCIn_TXI)请求激活DMAC或DTC写入TDR。同样，也可以通过接收数据完全中断(SCIn_RXI)请求激活DTC来读取RDR数据。

Note: 从发送或接收操作切换到同时发送和接收操作时，首先设置TIE，SCR中的RIE、TE、RE和TEIE位为0，然后将TIE、RIE、TE和RE位同时设置为1。

Figure 27.43 选择非FIFO的时钟同步模式下同时串行发送和接收的示例流程

(2) FIFO selected

图27.44显示了在时钟同步模式下同时串行发送和接收操作的示例流程，并选择了FIFO。

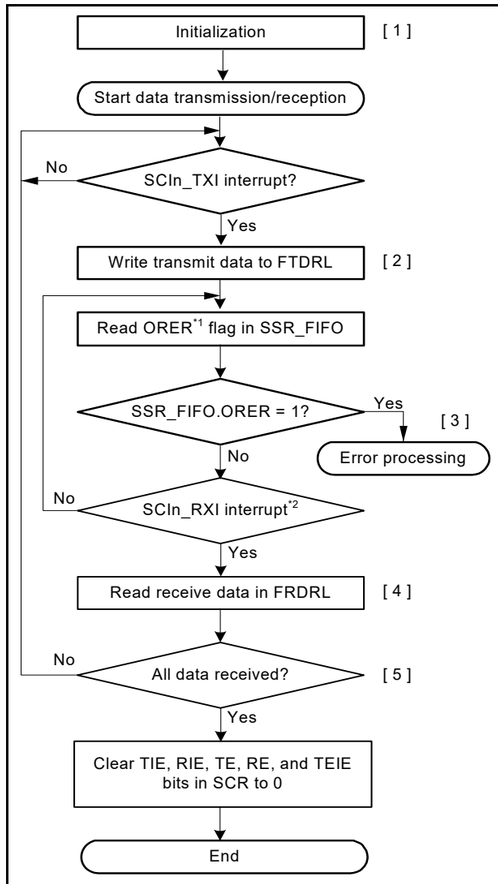
初始化SCI后，使用以下程序同时进行串行数据发送和接收操作。

从发送模式切换到同时发送和接收模式：

1. 通过验证SSR_FIFO中的TEND标志是否设置为1来检查SCI是否完成了传输。
2. 初始化SCR寄存器，然后用一条指令同时将SCR寄存器中的TIE、RIE、TE和RE位设置为1。

从接收模式切换到同时发送和接收模式：

1. 检查SCI是否完成接收。
2. 将RIE和RE位设置为0，然后检查SSR_FIFO中的接收错误标志ORER是否为0。
3. 用一条指令同时将SCR寄存器中的TIE、RIE、TE和RE位设置为1。



[1] SCI initialization:
The TXDn pin can act as the output pin for transmitted data and the RXDn pin can act as the input pin for received data at the same time.

[2] Transmit data write:
Write transmit data to FTDRL in the SCIn_TXI interrupt request handling routine. The amount of transmit data that can be written is 16 bits, which is the number of stored transmit data in the FIFO.

[3] Receive error processing:
If a receive error occurs, read the ORER flag in SSR_FIFO, perform the relevant error processing, and then set the ORER flag to 0. Data reception cannot resume while the ORER flag is 1.

[4] Reading receive data:
The receive data stored in FRDRL register is read until the number of stored data is less than the FCR.RTRG value. Software can check readable data in FDR.R[4:0].

[5] Serial transmission/reception continuation procedure:
To continue serial reception, before overrun error occurs, finish reading the receive data in FRDRL and clear the SSR_FIFO.RDF flag to 0. To continue serial transmission, before transmission of the current transmit data is finished, write the next transmit data to FTDRL in the SCIn_TXI interrupt handling routine and clear the SSR_FIFO.TDFE flag to 0.
Transmit data can also be written to FTDRL by activating the DMAC or DTC by a transmit FIFO data empty interrupt (SCIn_TXI) request. Similarly, the FRDRL data can also be read by activating the DMAC or DTC by a receive FIFO data full interrupt (SCIn_RXI) request. The RDF and TDFE flags are cleared automatically in this case.
Do not write to the RDF and TDFE flags.

Note 1. ORER can also read from FRDRH.ORER. To clear the ORER flag, write 0 to SSR_FIFO.ORER.
Note 2. The total receive data amount must be an integral multiple of the FIFO triggering number.

Figure 27.44 Example flow of simultaneous serial transmission and reception in clock synchronous mode with FIFO selected

27.6 Operation in Smart Card Interface Mode

The SCI supports smart card (IC card) interfaces conforming to ISO/IEC 7816-3 (standard for Identification Cards), as an extended function of the SCI.

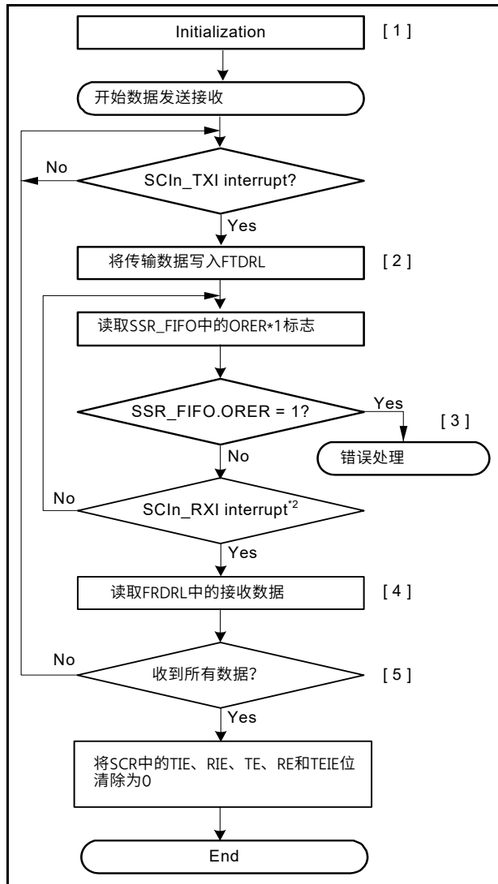
Smart card interface mode can be selected using the appropriate register.

27.6.1 Example Connection

Figure 27.45 shows an example connection between a smart card (IC card) and the MCU.

Because the MCU communicates with an IC card using a single transmission line, interconnect the TXDn and RXDn pins and pull up the data transmission line to VCC using a resistor, as shown in Figure 27.45.

Setting the TE and RE bits in the SCR_SMCI register to 1 with an IC card disconnected enables closed-loop transmission or reception, allowing self-diagnosis. To supply an IC card with the clock pulses generated by the SCI, input the SCKn pin output to the CLK pin of an IC card. The output port of the MCU can be used to output a reset signal.



[1] SCI initialization:
TXDn引脚可以作为发送数据的输出引脚，RXDn引脚可以同时作为接收数据的输入引脚。

[2] 发送数据写入：
在SCIn_TXI中断请求处理例程中将发送数据写入FTDRL。可写入的发送数据量为16位，即FIFO中存储的发送数据的数量。

[3] 接收错误处理：
如果发生接收错误，则读取SSR_FIFO中的ORER标志位，进行相关的错误处理，然后将ORER标志位设置为0。

ORER标志为1。

[4] 读取接收数据：
读取FRDRL寄存器中存储的接收数据，直到存储的数据数量小于FCR.RTRG值。软件可以检查FDR.R[4:0]中的可读数据。

[5] 串行发送接收继续程序：
继续串口接收，在溢出错误发生前，完成FRRDL中接收数据的读取并将SSR_FIFO.RDF标志清0。继续串口发送，在当前发送数据发送完成之前，将下一个发送数据写入FTDRL中SCIn_TXI中断处理例程并将SSR_FIFO.TDFE标志清除为0。发送数据也可以通过发送FIFO数据空中断(SCIn_TXI)请求激活DMAC或DTC写入FTDRL。同样，也可以通过接收FIFO数据满中断(SCIn_RXI)请求激活DMAC或DTC来读取FRDRL数据。在这种情况下，RDF和TDFE标志会自动清除。不要写入RDF和TDFE标志。

Note 1. ORER也可以从FRDRH.ORER中读取。要清除ORER标志，请将0写入SSR_FIFO.ORER。
Note 2. 总接收数据量必须是FIFO触发数的整数倍。

Figure 27.44 时钟同步模式下同时串行发送和接收的示例流程 FIFO selected

27.6 智能卡接口模式下的操作

SCI支持符合ISOIEC7816-3（识别卡标准）的智能卡（IC卡）接口，作为SCI的扩展功能。

可以使用适当的寄存器选择智能卡接口模式。

27.6.1 示例连接

图27.45显示了智能卡（IC卡）和MCU之间的示例连接。

由于MCU使用单条传输线与IC卡通信，因此将TXDn和RXDn引脚互连，并使用电阻将数据传输线上拉到VCC，如图27.45所示。

在断开IC卡的情况下将SCR_SMCI寄存器中的TE和RE位设置为1可启用闭环发送或接收，从而实现自诊断。要将SCI产生的时钟脉冲提供给IC卡，请将SCKn引脚输出输入到IC卡的CLK引脚。MCU的输出端口可用于输出复位信号。

RA生态工作室

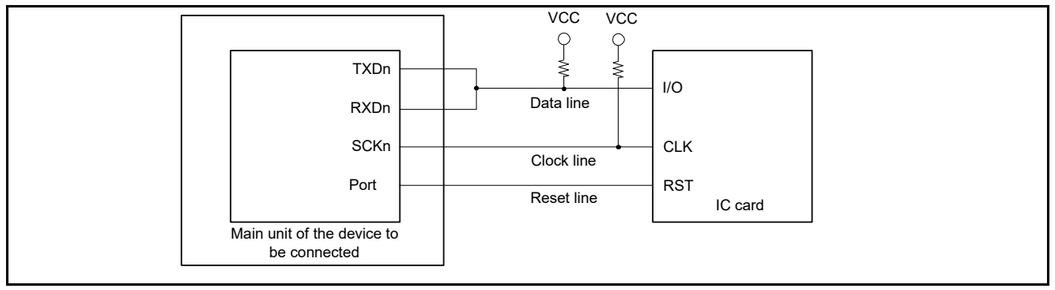


Figure 27.45 Example connection with a smart card (IC card)

27.6.2 Data Format (Except in Block Transfer Mode)

Figure 27.46 shows the data transfer formats in smart card interface mode.

The data transfer format is as follows:

- One frame consists of 8-bit data and a parity bit in asynchronous mode
- During transmission, a value of at least 2 ETUs (elementary time unit, which is the time required to transfer 1 bit) is set as a guard time from the end of the parity bit until the start of the next frame
- If a parity error is detected during reception, a low error signal is output for 1 ETU after 10.5 ETUs elapse from the start bit
- If an error signal is sampled during transmission, the same data is automatically retransmitted after at least 2 ETUs.

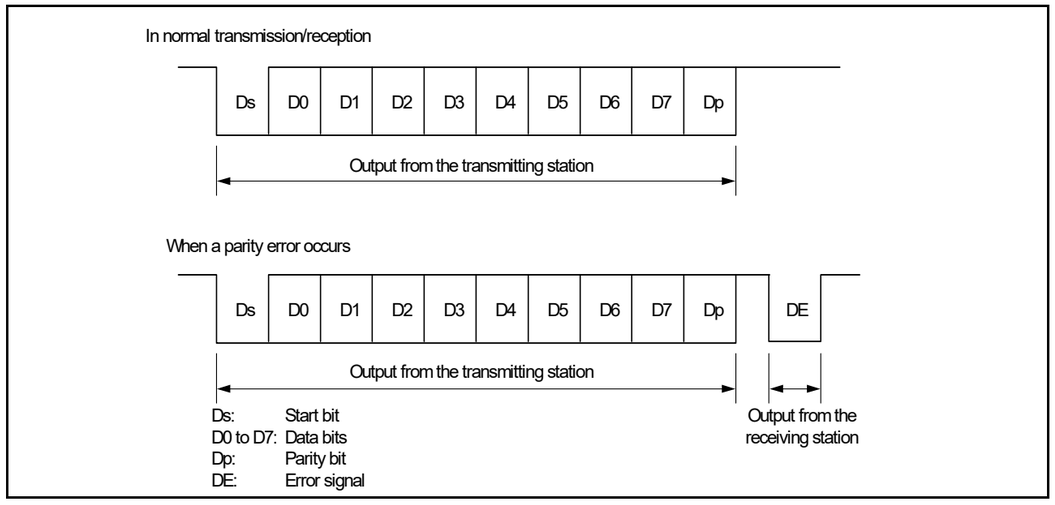


Figure 27.46 Data formats in smart card interface mode

For communication with IC cards of the direct convention type and inverse convention type, follow the procedures in this section.

(1) Direct convention type

For the direct convention type, logic levels 1 and 0 correspond to the Z and A states, respectively, and data is transferred with LSB-first for the start character, as shown in Figure 27.47. Therefore, data in the start character in Figure 27.47 is 3Bh.

When using the direct convention type, write 0 to both the SDIR and SINV bits in SCMR. Write 0 to the PM bit in SMR_SMCI to use even parity, which is recommended by the smart card standard.

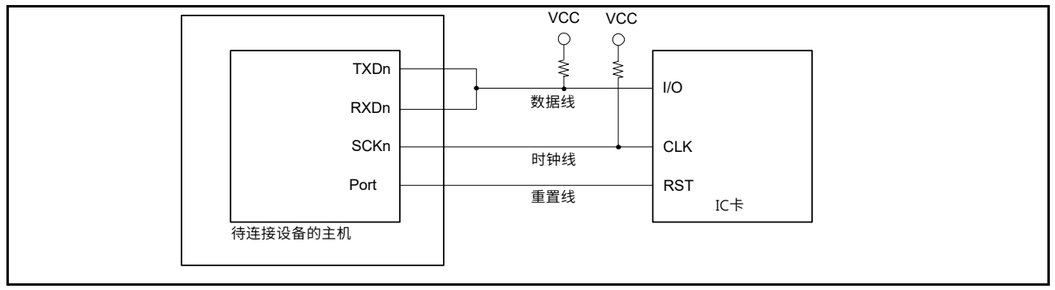


Figure 27.45 与智能卡（IC卡）的连接示例

27.6.2 数据格式（块传输模式除外）

图27.46显示了智能卡接口模式下的数据传输格式。

数据传输格式如下：

- 一帧由异步模式下的8位数据和一个奇偶校验位组成
- 在传输过程中，至少2个ETU（基本时间单位，即传输1位所需的时间）的值被设置为从奇偶校验位结束到下一帧开始的保护时间
- 如果在接收期间检测到奇偶校验错误，则在从起始位经过10.5ETU后输出1ETU的低错误信号
- 如果在传输过程中对错误信号进行采样，则在至少2个ETU后会自动重新传输相同的数据。

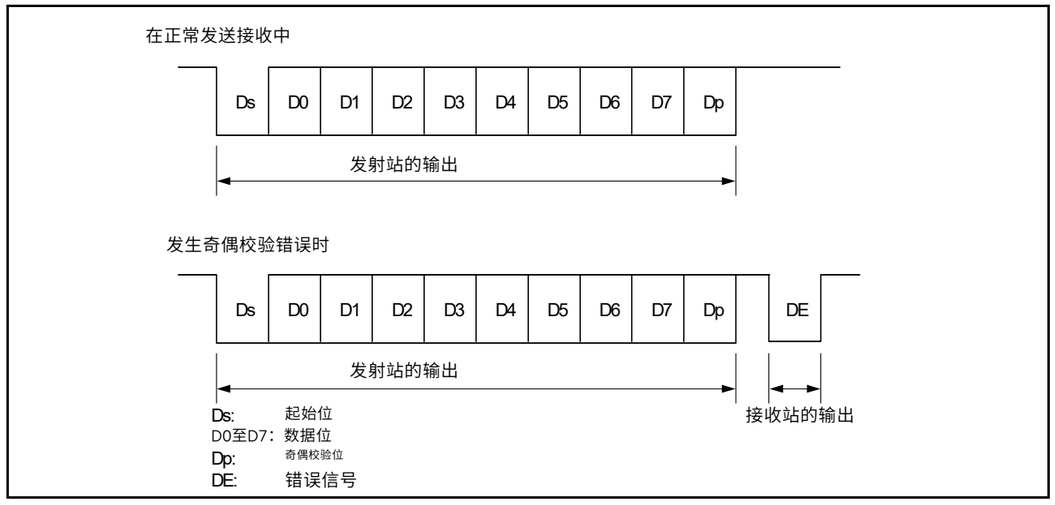


Figure 27.46 智能卡接口模式下的数据格式

与直接约定型和逆约定型的IC卡进行通信时，请按照本节的步骤进行。

(1) 直接约定型

对于直接约定类型，逻辑电平1和0分别对应于Z和A状态，数据以LSB-first作为起始字符传输，如图27.47所示。因此，图27.47中起始字符中的数据为3Bh。

使用直接约定类型时，将0写入SCMR中的SDIR和SINV位。将0写入PM位SMR_SMCI使用智能卡标准推荐的偶校验。

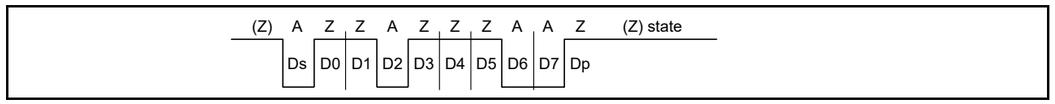


Figure 27.47 Direct convention with SDIR in SCMR = 0, SINV in SCMR = 0, and PM in SMR_SMCI = 0

(2) Inverse convention type

For the inverse convention type, logic levels 1 and 0 indicate the A and Z states respectively, and data is transferred with MSB-first as the start character, as shown in Figure 27.48. Therefore, data in the start character in Figure 27.48 is 3Fh.

When using the inverse convention type, write 1 to both the SCMR.SDIR and SCMR.SINV bits. The parity bit is at logic level 0 to produce even parity, which is required by the smart card standard, and corresponds to the Z state. Because the SINV bit only inverts data bits D7 to D0, write 1 to the PM bit in SMR_SMCI to invert the parity bit for both transmission and reception.

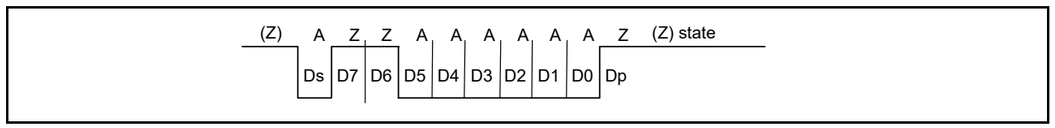


Figure 27.48 Inverse convention with SDIR in SCMR = 1, SINV in SCMR = 1, and PM in SMR_SMCI = 1

27.6.3 Block Transfer Mode

Block transfer mode differs from non-block transfer mode of the smart card interface mode as follows:

- If a parity error is detected during reception, no error signal is output. Because the PER flag in SSR_SMCI is set by error detection, clear the PER flag before receiving the parity bit of the next frame.
- During transmission, at least 1 ETU is set as a guard time from the end of the parity bit until the start of the next frame
- Because the same data is not retransmitted, the TEND flag in SSR_SMCI is set to 11.5 ETUs after transmission starts
- In block transfer mode, the ERS flag in SSR_SMCI indicates the error signal status as in non-block transfer mode of smart card interface mode, but the flag is read as 0 because no error signal is transferred.

27.6.4 Receive Data Sampling Timing and Reception Margin

Only the clock generated by the on-chip baud rate generator can be used as a transfer clock in smart card interface mode.

In this mode, the SCI can operate on a base clock with a frequency of 32, 64, 372, 256, 93, 128, 186, or 512 times the bit rate according to the SCMR.BCP2 and SMR_SMCI.BCP[1:0] bit settings.

For data reception, the falling edge of the start bit is sampled with the base clock to perform synchronization.

Receive data is sampled on the 16^{th}, 32^{nd}, 186^{th}, 128^{th}, 46^{th}, 64^{th}, 93^{rd}, and 256^{th} rising edges of the base clock so that it can be latched at the middle of each bit as shown in Figure 27.49. The reception margin is determined by the following formula:

$$M = \left| (0.5 - \frac{1}{2N}) - (L - 0.5)F - \frac{|D - 0.5|}{N}(1 + F) \right| \times 100\ [\%]$$

M: Reception margin (%)

N: Ratio of bit rate to clock (N = 32, 64, 372, 256)

D: Duty cycle of clock (D = 0 to 1.0)

L: Frame length (L = 10)

F: Absolute value of clock frequency deviation

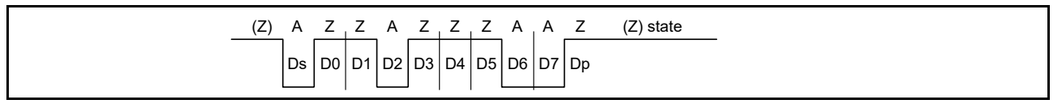


Figure 27.47 与SCMR=0中的SDIR、SCMR=0中的SINV和SMR_SMCI=0中的PM的直接约定

(2) 逆约定型

对于逆约定类型，逻辑电平1和0分别表示A和Z状态，数据通过
MSB-first作为起始字符，如图27.48所示。因此，图27.48中起始字符中的数据为3Fh。

使用逆约定类型时，将1写入SCMR.SDIR和SCMR.SINV位。奇偶校验位处于逻辑电平0以产生偶校验，这是智能卡标准所要求的，并且对应于Z状态。由于SINV位仅将数据位D7反转为D0，因此向SMR_SMCI中的PM位写入1以反转发送和接收的奇偶校验位。

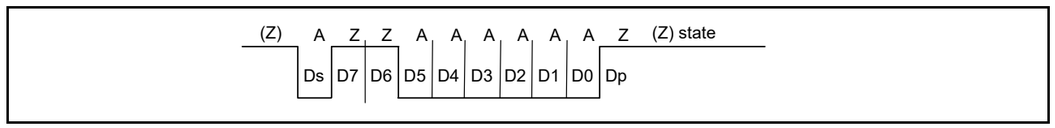


Figure 27.48 SCMR=1中的SDIR、SCMR=1中的SINV和SMR_SMCI=1中的PM的逆约定

27.6.3 块传输模式

块传输模式与智能卡接口模式的非块传输模式的区别如下：

- 如果在接收期间检测到奇偶校验错误，则不输出错误信号。因为SSR_SMCI中的PER标志是由错误检测设置的，所以在接收下一帧的奇偶校验位之前清除PER标志。
- 在传输过程中，从奇偶校验位结束到下一帧开始至少设置1个ETU作为保护时间
- 因为没有重传相同的数据，所以在传输开始后SSR_SMCI中的TEND标志设置为11.5ETU
- 在块传输模式下，SSR_SMCI中的ERS 标志指示错误信号状态，与智能卡接口模式的非块传输模式一样，但该标志被读取为0，因为没有传输错误信号。

27.6.4 接收数据采样时序和接收裕量

只有片内波特率发生器产生的时钟可以用作智能卡接口模式下的传输时钟。

在此模式下，SCI可以在频率为32、64、372、256、93、128、186或512倍比特率的基本时钟上运行，具体取决于SCMR.BCP2和SMR_SMCI.BCP[1:0]位设置。

对于数据接收，起始位的下降沿与基本时钟一起采样以执行同步。

接收数据在基本时钟的第16 32 186 128 46 64 93和256个上升沿采样，以便在每个位的中间锁存，如图所示在图27.49中。接收余量由以下公式确定：

$$M = \left| (0.5 - \frac{1}{2N}) - (L - 0.5)F - \frac{|D - 0.5|}{N}(1 + F) \right| \times 100\ [\%]$$

M：接收余量（%）

N：比特率与时钟的比率（N=32、64、372、256）

D：时钟的占空比（D=0到1.0）

L：帧长（L=10）

F：时钟频率偏差的绝对值

Assuming values of F = 0, D = 0.5, and N = 372 in the specified formula, the reception margin is determined by the following formula:

M = {0.5 - 1/(2 × 372)} × 100 [%] = 49.866%

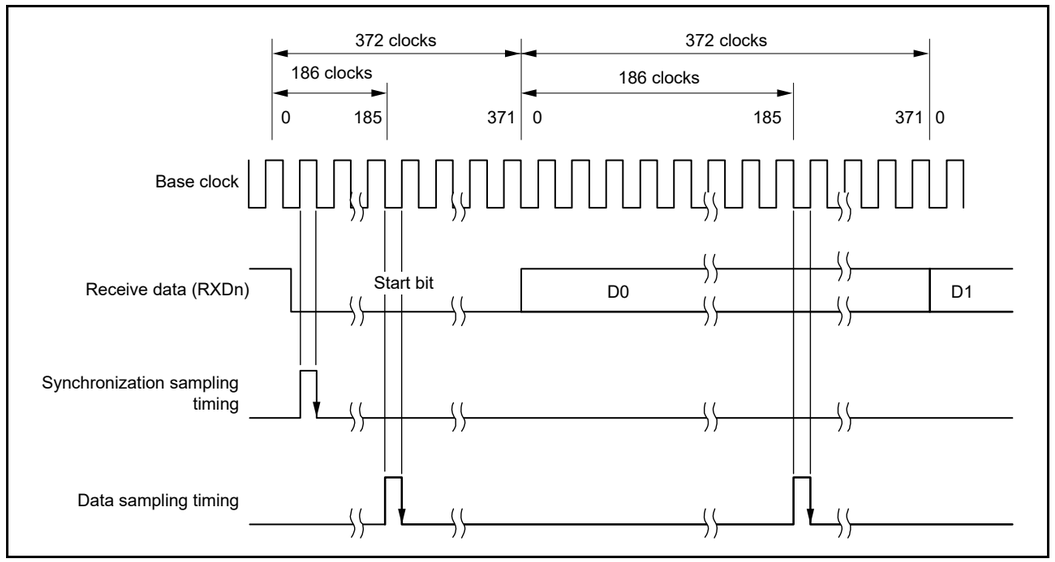


Figure 27.49 Receive data sampling timing in smart card interface mode when clock frequency is 372 times the bit rate

27.6.5 SCI Initialization

Before transmitting and receiving data, write the initial value 00h in the SCR_SMCI register and initialize the SCI using the example flow shown in Figure 27.50.

Be sure to set the initial value in the TIE, RIE, TE, RE, and TEIE bits in the SCR_SMCI register before switching from transmission to reception mode or from reception to transmission mode. When the SCR_SMCI.RE bit is set to 0, the RDR register is not initialized.

To change from reception mode to transmission mode, first check that the reception is complete, then initialize the SCI. At the end of initialization, set TE = 1 and RE = 0. Reception completion can be verified by reading the SCIn_RXI request, ORER, or PER flag in SSR_SMCI.

To change transmission mode to reception mode, first check that the transmission is complete, then initialize the SCI. At the end of the initialization, set TE = 0 and RE = 1. Transmission completion can be verified by reading the TEND flag in SSR_SMCI.

假设指定公式中的F=0、D=0.5和N=372的值，则接收裕度由以下公式确定：

M = {0.5 - 1/(2 × 372)} × 100 [%] = 49.866%

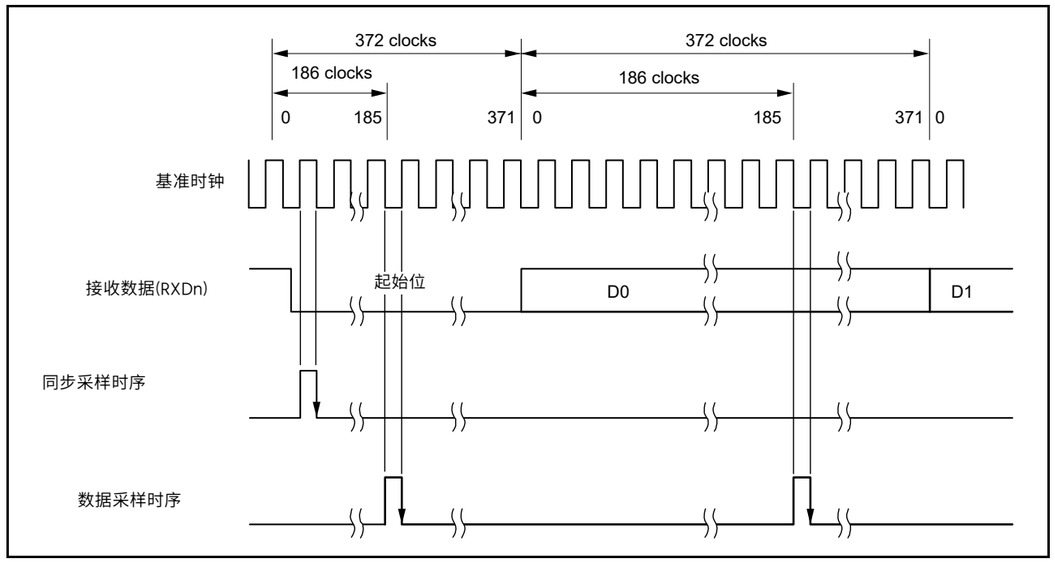


Figure 27.49 时钟频率为372倍比特率时智能卡接口模式下的接收数据采样时序

27.6.5 SCI初始化

在发送和接收数据之前，将初始值00h写入SCR_SMCI寄存器并使用图27.50所示的示例流程初始化SCI。

在从发送模式切换到接收模式或从接收模式切换到发送模式之前，请务必在SCR_SMCI寄存器的TIE、RIE、TE、RE和TEIE位中设置初始值。当SCR_SMCI.RE位设置为0时，RDR寄存器未初始化。

要从接收模式更改为发送模式，首先检查接收是否完成，然后初始化SCI。
在初始化结束时，设置TE=1和RE=0。可以通过读取SSR_SMCI中的SCIn_RXI请求、ORER或PER标志来验证接收是否完成。

要将传输模式更改为接收模式，首先检查传输是否完成，然后初始化SCI。在初始化结束时，设置TE=0和RE=1。可以通过读取SSR_SMCI中的TEND标志来验证传输完成。

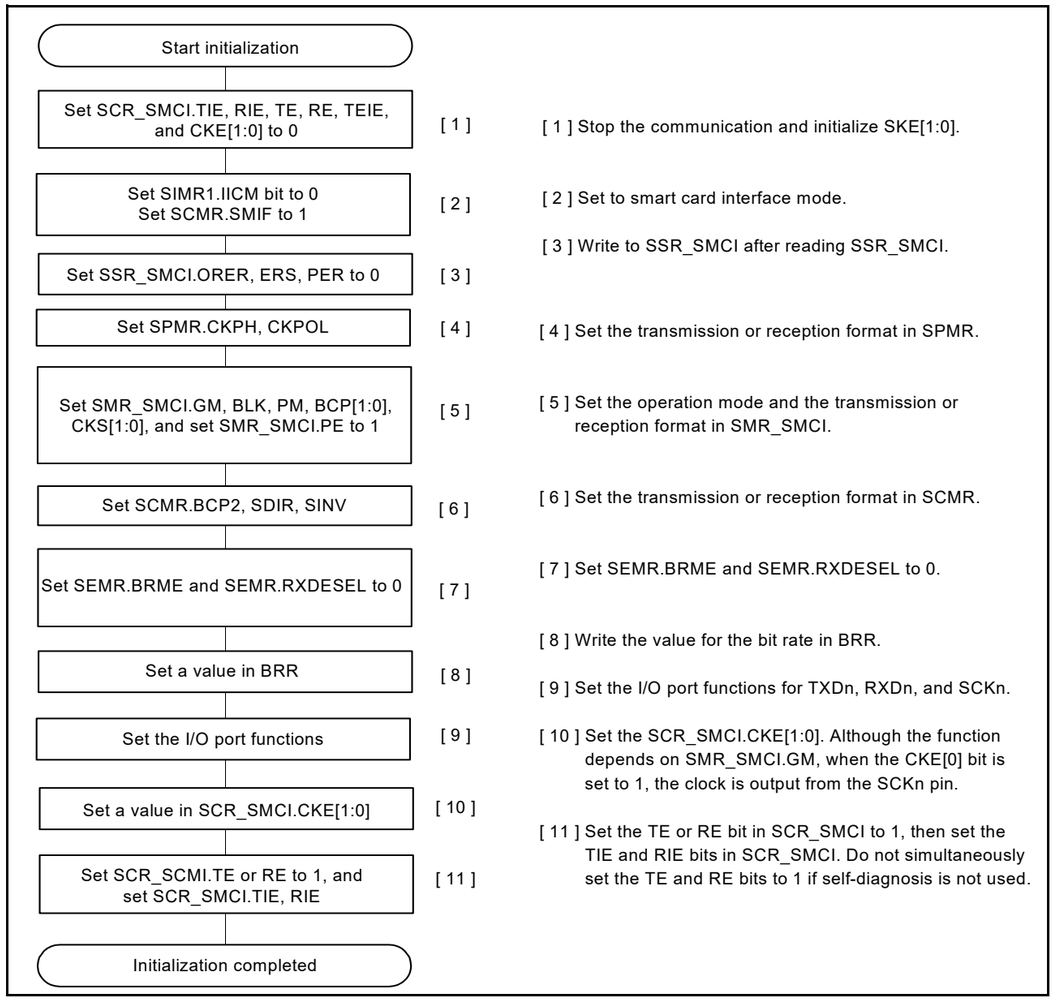


Figure 27.50 Example flow of SCI initialization in smart card interface mode

Figure 27.51 shows a timing diagram when data transmission is performed by transitioning to smart card interface mode according to the flow in Figure 27.50. Figure 27.51 shows when the GM bit in SMR_SMCI is set to 0. The timing in Figure 27.51 shows when the port is connected as SCKn and TXDn, the pins are Hi-Z because the CKE[0] bit in SCR_SMCI is 0.

Start the clock output to the SCK pin by setting the CKE[0] bit in SCR_SMCI to 1, then start data transmission by writing the transmit data after setting the TE bit in SCR_SMCI to 1. When the TE bit in SCR_SMCI changes from 0 to 1, there is a preamble period for one frame before data transmission starts. In smart card interface mode, the TXDn pin is Hi-Z when there is a preamble period. Pull-up or pull-down for the SCKn and TXDn pins is required outside the MCU.

In smart card interface mode, even when the TE and RE bits in SCR_SMCI are 0, the clock is continuously output if the clock output setting is used.

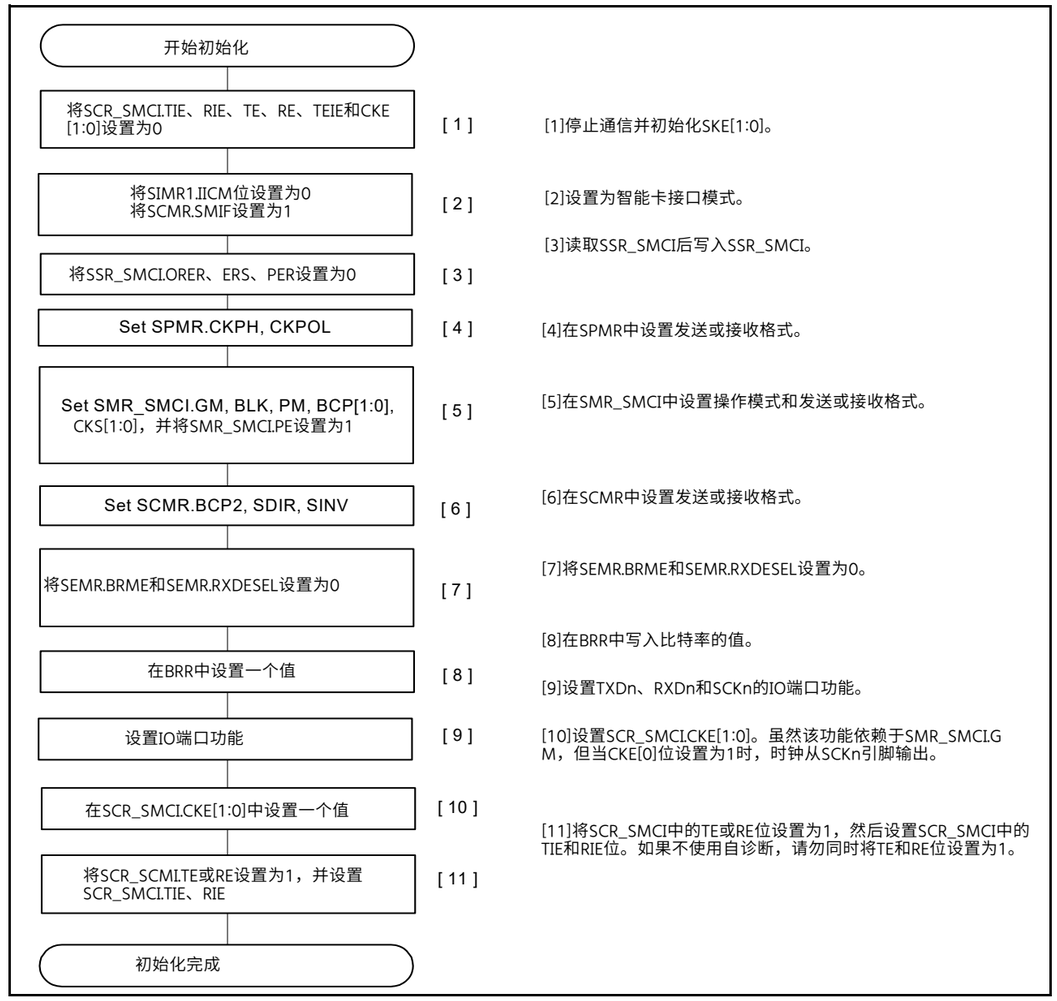


Figure 27.50 智能卡接口模式下SCI初始化流程示例

图27.51显示了当按照图27.50中的流程通过转换到智能卡接口模式来执行数据传输时的时序图。图27.51显示了SMR_SMCI中的GM位设置为0时。图27.51中的时序显示了当端口连接为SCKn和TXDn时，引脚为Hi-Z，因为CKE[0]位在

SCR_SMCI is 0.

将SCR_SMCI中的CKE[0]位设置为1，开始向SCK引脚输出时钟，然后将SCR_SMCI中的TE位设置为1后，通过写入发送数据开始数据传输。当SCR_SMCI中的TE位从0变为如图1所示，在数据传输开始之前有一帧的前导周期。在智能卡接口模式下，当有前导周期时，TXDn引脚为Hi-Z。SCKn和TXDn引脚的上拉或下拉需要在MCU外部进行。

在智能卡接口模式下，即使SCR_SMCI中的TE和RE位为0，如果使用时钟输出设置，时钟也会持续输出。

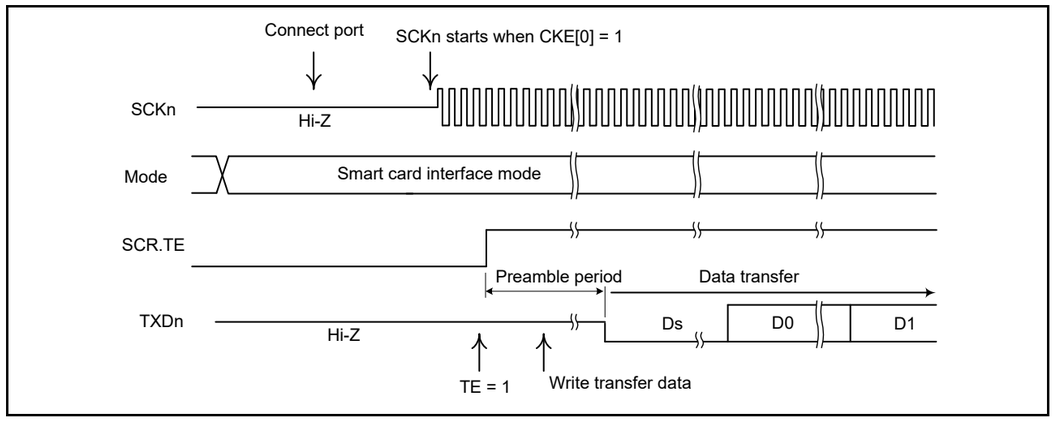


Figure 27.51 Example timing of data transmission in smart card interface mode

27.6.6 Serial Data Transmission (Except in Block Transfer Mode)

Serial data transmission in smart card interface mode (except in block transfer mode) is different from that in non-smart card interface mode, in that an error signal is sampled and data can be retransmitted in smart card mode. Figure 27.52 shows the data retransfer operation during transmission.

In Figure 27.52:

- [1] indicates when an error signal from the receiver end is sampled after 1-frame data is transmitted, the SSR_SMCI.ERS flag is set to 1. If the SCR_SMCI.RIE bit is 1, an SCIn_ERI interrupt request is generated. Clear the ERS flag to 0 before the next parity bit is sampled.
- [2] indicates for a frame in which an error signal is received, the SSR_SMCI.TEND flag is not set. Data is retransferred from TDR to TSR, allowing automatic data retransmission.
- [3] indicates if no error signal is returned from the receiver, the ERS flag is not set to 1.
- [4] indicates the SCI determines that the transmission of 1-frame data, including the retransfer, is complete, and the TEND flag is set. If the SCR_SMCI.TIE bit is 1, an SCIn_TXI interrupt request is generated. Write transmit data to the TDR to start transmission of the next data.

Figure 27.54 shows an example flow of serial transmission. All the processing steps are automatically performed using an SCIn_TXI interrupt request to activate the DMAC or DTC.

When the SSR_SMCI.TEND flag is set to 1 in transmission and when the SCR_SMCI.TIE bit is 1, an SCIn_TXI interrupt request is generated.

The DMAC or DTC is activated by an SCIn_TXI interrupt request if the SCIn_TXI interrupt request is previously specified as a source of DMAC or DTC activation, allowing the transfer of transmit data. The TEND flag is automatically set to 0 when the DMAC or DTC transfers data.

If an error occurs, the SCI automatically retransmits the same data. During this retransmission, the TEND flag is kept at 0 and the DMAC or DTC is not activated. Therefore, the SCI and DMAC or DTC automatically transmit the specified number of bytes, including retransmission when an error occurs. Because the ERS flag is not automatically cleared, set the RIE bit to 1 to enable an SCIn_ERI interrupt request generation when an error occurs, and clear the ERS flag to 0.

When transmitting or receiving data using the DMAC or DTC, always enable the DMAC or DTC before setting the SCI.

For DMAC or DTC settings, see section 16, DMA Controller (DMAC) and section 17, Data Transfer Controller (DTC).

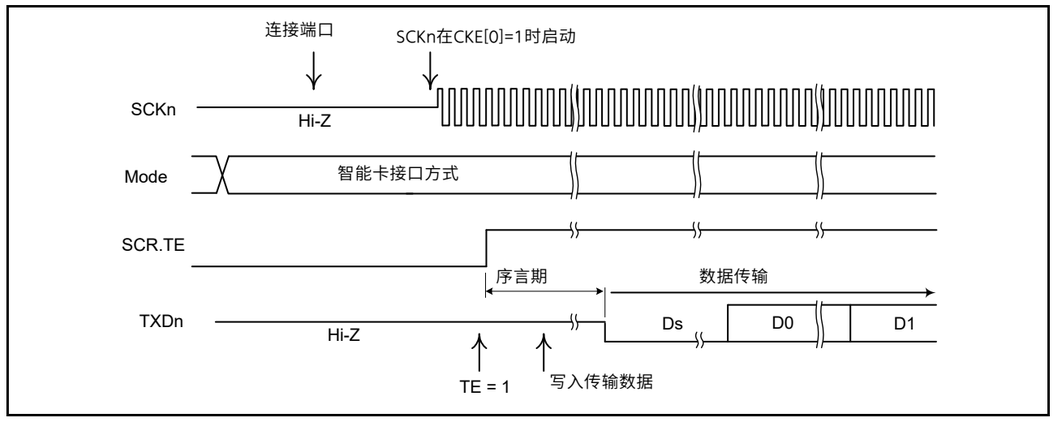


Figure 27.51 智能卡接口模式下数据传输时序示例

27.6.6 串行数据传输（块传输模式除外）

智能卡接口模式下的串行数据传输（块传输模式除外）与非智能卡接口模式下的串行数据传输不同之处在于，在智能卡模式下对错误信号进行采样，数据可以重传。图27.52显示了传输过程中的数据重传操作。

在图27.52中：

- [1]表示在发送1帧数据后，当从接收端采样到错误信号时，SSR_SMCI.ERS标志置1。如果SCR_SMCI.RIE位为1，则产生SCIn_ERI中断请求。在采样下一个奇偶校验位之前将ERS 标志清零。
- [2]表示对于接收到错误信号的帧，未设置SSR_SMCI.TEND标志。数据从TDR重新传输到TSR，允许自动数据重新传输。
- [3]表示如果接收器没有返回错误信号，则ERS 标志不设置为1。
- [4]表示SCI确定1帧数据的传输（包括重传）已完成，并且设置了TEND标志。如果SCR_SMCI.TIE位为1，则产生SCIn_TXI中断请求。将传输数据写入TDR以开始传输下一个数据。

图27.54显示了串行传输的示例流程。所有处理步骤都使用SCIn_TXI中断请求自动执行以激活DMAC或DTC。

当发送中SSR_SMCI.TEND标志设置为1且SCR_SMCI.TIE位为1时，将产生SCIn_TXI中断请求。

如果SCIn_TXI中断请求先前被指定为DMAC或DTC激活源，则DMAC或DTC由SCIn_TXI中断请求激活，从而允许传输发送数据。当DMAC或DTC传输数据时，TEND标志自动设置为0。

如果发生错误，SCI会自动重新传输相同的数据。在此重传期间，TEND标志保持为0，并且不激活DMAC或DTC。因此，SCI和DMAC或DTC会自动传输指定的字节数，包括发生错误时的重传。因为ERS 标志不会自动清除，所以将RIE位设置为1以在发生错误时启用SCIn_ERI中断请求生成，并将ERS 标志清除为0。

使用DMAC或DTC发送或接收数据时，请务必在设置SCI之前启用DMAC或DTC。

对于DMAC或DTC设置，请参阅第16节，DMA控制器(DMAC)和第17节，数据传输控制器(DTC)。

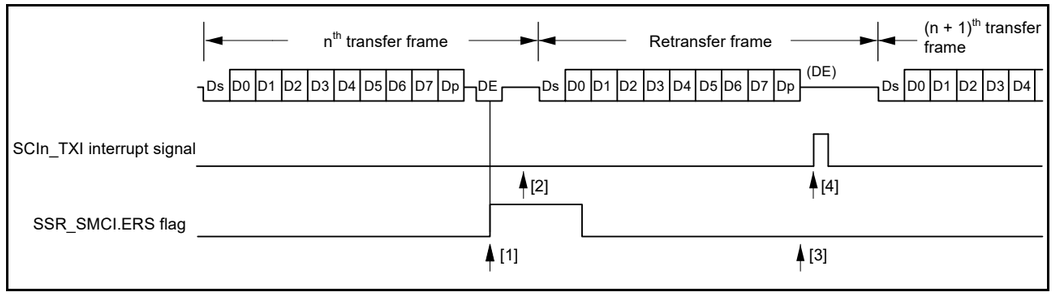


Figure 27.52 Data retransfer operation in SCI transmission mode

Note: The SSR_SMCI.TEND flag is set at different timings depending on the SMR_SMCI.GM bit setting.

Figure 27.53 shows the TEND flag generation timing.

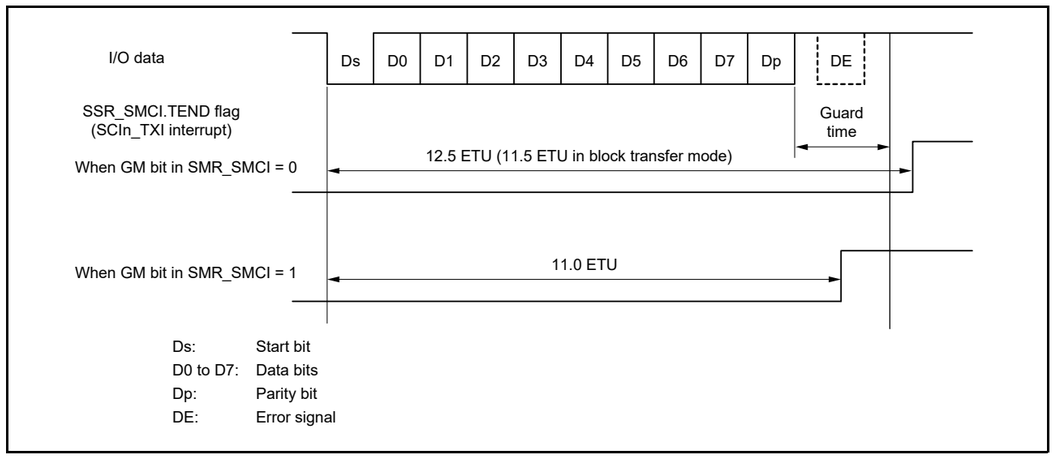


Figure 27.53 SSR.TEND flag generation timing during transmission

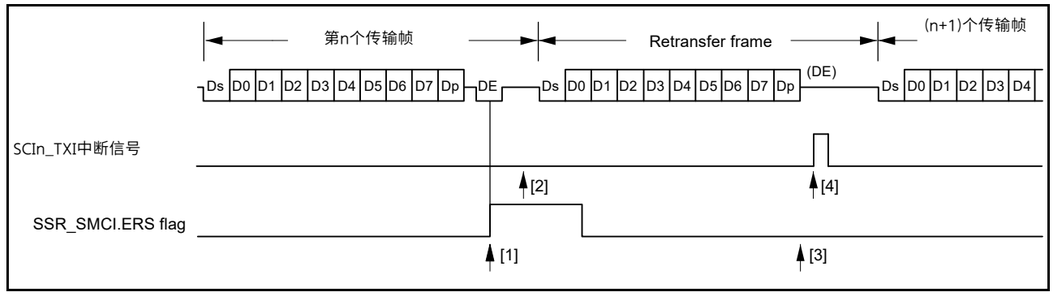


Figure 27.52 SCI传输模式下的数据重传操作

Note: SSR_SMCI.TEND标志根据SMR_SMCI.GM位设置在不同的时间设置。

图27.53显示了TEND标志生成时序。

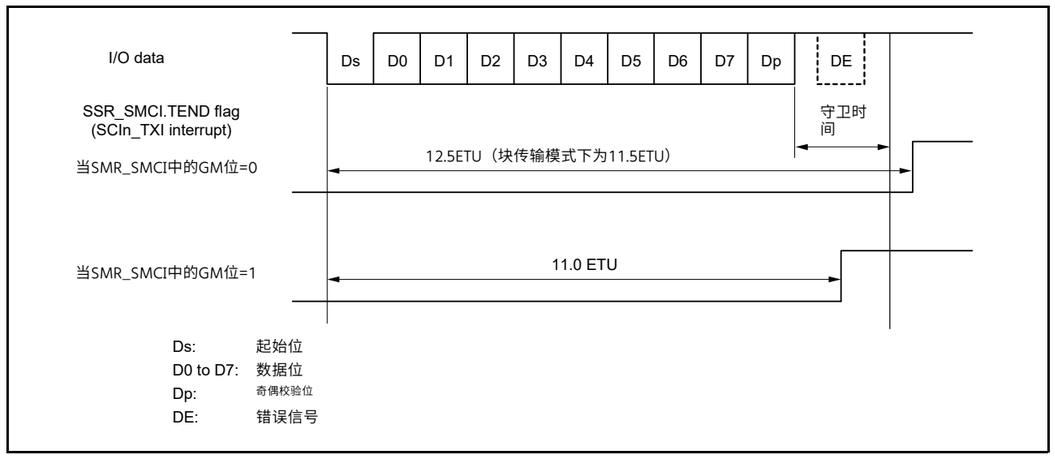


Figure 27.53 发送期间的SSR.TEND标志生成时序

Figure 27.54 Example flow of smart card interface transmission

27.6.7 Serial Data Reception (Except in Block Transfer Mode)

Serial data reception in smart card interface mode is similar to that in non-smart card interface mode. Figure 27.55 shows the data retransfer operation in reception mode.

- [1] indicates if a parity error is detected in the receive data, the SSR_SMCI.PER flag is set to 1. When the SCR_SMCI.RIE bit is 1, an SCIn_ERI interrupt request is generated. Clear the PER flag to 0 before the next parity bit is sampled.
- [2] indicates for a frame in which a parity error is detected, no SCIn_RXI interrupt is generated.
- [3] indicates when no parity error is detected, the SCR_SMCI.PER flag is not set to 1.
- [4] indicates the data is determined to be received successfully. When the SCR_SMCI.RIE bit is 1, an SCIn_RXI interrupt request is generated.

Figure 27.56 shows an example flow of serial data reception. All the processing steps are automatically performed using an SCIn_RXI interrupt request to activate the DMAC or DTC.

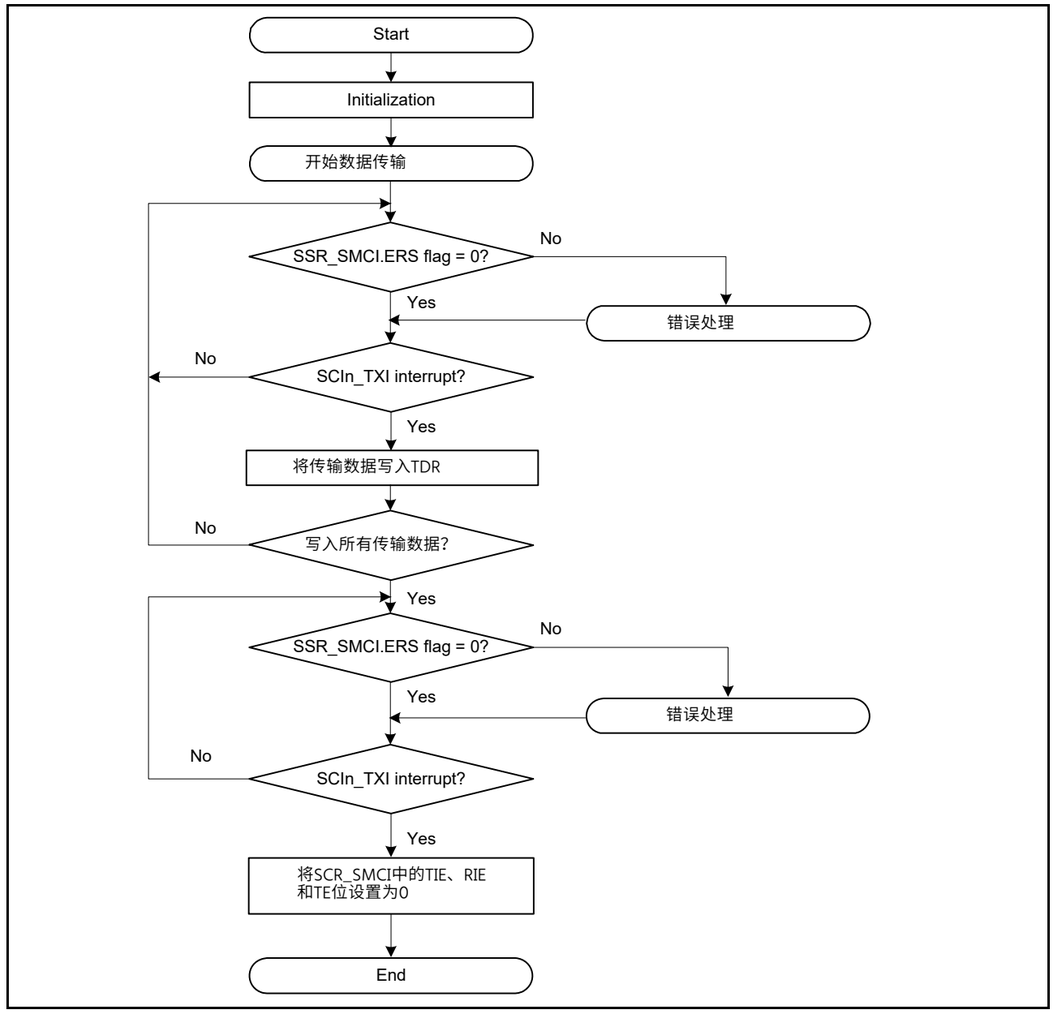


Figure 27.54 智能卡接口传输示例流程

27.6.7 串行数据接收（块传输模式除外）

智能卡接口模式下的串行数据接收与非智能卡接口模式下的串行数据接收类似。图27.55显示了接收模式下的数据重传操作。

- [1]表示如果在接收数据中检测到奇偶校验错误，则SSR_SMCI.PER标志设置为1。当SCR_SMCI.RIE位为1时，产生SCIn_ERI中断请求。在采样下一个奇偶校验位之前将PER标志清零。
- [2]表示对于检测到奇偶校验错误的帧，不产生SCIn_RXI中断。
- [3]表示当没有检测到奇偶校验错误时，SCR_SMCI.PER标志不设置为1。
- [4]表示确定数据接收成功。当SCR_SMCI.RIE位为1时，产生SCIn_RXI中断请求。

图27.56显示了串行数据接收的示例流程。所有处理步骤都使用SCIn_RXI中断请求自动执行以激活DMAC或DTC。

In reception, setting the RIE bit to 1 allows an SCIn_RXI interrupt request to be generated. The DMAC or DTC is activated by an SCIn_RXI interrupt request if the SCIn_RXI interrupt request is previously specified as a source of DMAC or DTC activation, allowing the transfer of receive data.

If an error occurs during reception and either the ORER or PER flag in SSR_SMCI is set to 1, a receive error interrupt (SCIn_ERI) request is generated. Clear the error flag after the error occurrence. If an error occurs, the DMAC or DTC is not activated and receive data is skipped. Therefore, the number of bytes of receive data specified in the DMAC or DTC is transferred.

If a parity error occurs and the PER flag is set to 1 during reception, the receive data is transferred to RDR, therefore allowing the data to be read.

When a reception is forced to terminate by setting SCR_SMCI.RE to 0 during operation, read the RDR register because the received data that is not yet read might be left in the RDR.

Note: For operations in block transfer mode, see section 27.3.9, Serial Data Reception in Asynchronous Mode.

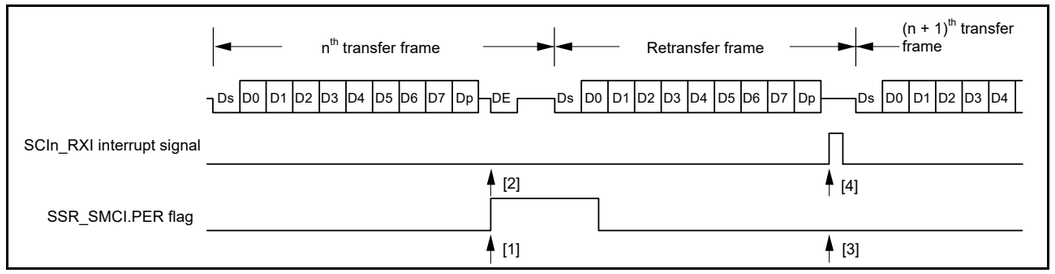


Figure 27.55 Data retransfer operation in SCI reception mode

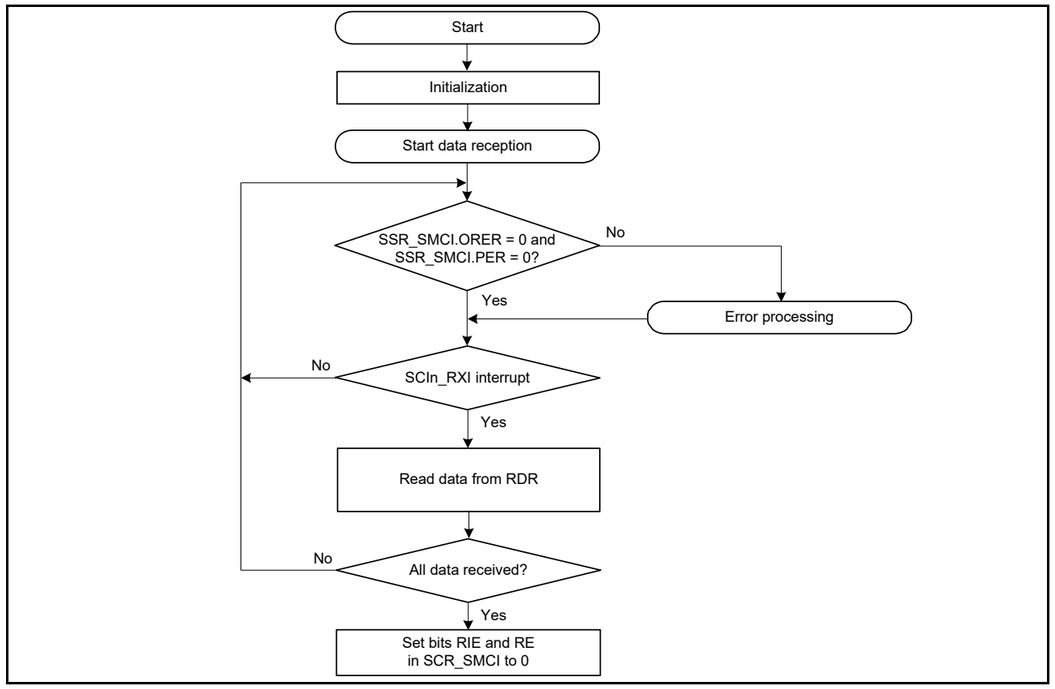


Figure 27.56 Example flow of smart card interface reception

在接收时，将RIE位设置为1允许产生SCIn_RXI中断请求。如果SCIn_RXI中断请求先前被指定为DMAC或DTC激活源，则DMAC或DTC由SCIn_RXI中断请求激活，从而允许传输接收数据。

如果接收期间发生错误并且SSR_SMCI中的ORER或PER标志设置为1，则会生成接收错误中断(SCIn_ERI)请求。错误发生后清除错误标志。如果发生错误，则不激活DMAC或DTC并跳过接收数据。因此，将传输DMAC或DTC中指定的接收数据字节数。

如果在接收过程中发生奇偶校验错误并且PER标志设置为1，则接收数据将传输到RDR，因此可以读取数据。

如果在操作期间通过将SCR_SMCI.RE设置为0来强制终止接收，请读取RDR寄存器，因为尚未读取的已接收数据可能留在RDR中。

Note: 有关块传输模式下的操作，请参见第27.3.9节，异步模式下的串行数据接收。

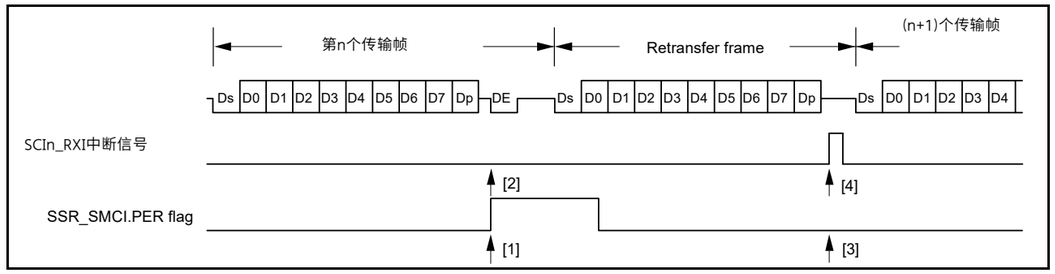


Figure 27.55 SCI接收模式下的数据重传操作

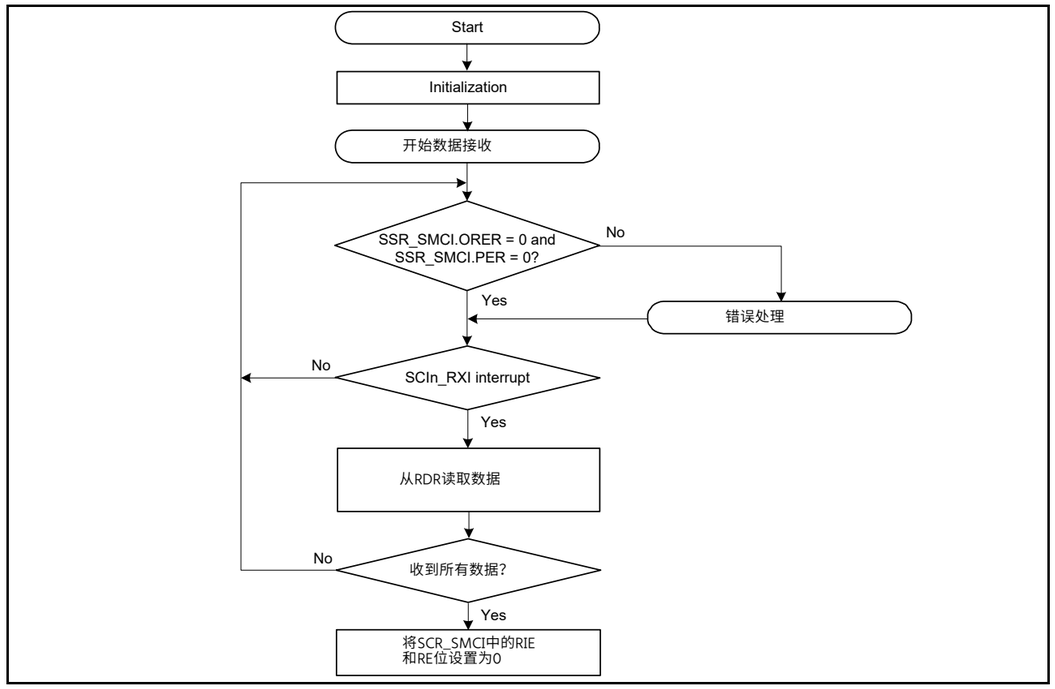


Figure 27.56 智能卡接口接收示例流程

27.6.8 Clock Output Control

When the GM bit in SMR_SMCI is set to 1, the clock output can be controlled by the CKE[1: 0] bits in SCR_SMCI. For details on the CKE[1:0] bits, see section 27.2.12, Serial Control Register for Smart Card Interface Mode (SCR_SMCI) (SCMR.SMIF = 1). When setting the clock output, the base clock described in section 27.6.4, Receive Data Sampling Timing and Reception Margin is output.

Figure 27.57 shows an example timing for the clock output control when the CKE[1] bit in SCR_SMCI is set to 0 and the CKE[0] bit in SCR_SMCI is controlled.

When the GM bit in SMR_SMCI is 0, output control by the CKE[0] bit in SCR_SMCI is immediately reflected in the SCK pin, so there is a possibility that pulses with an unintended width might be output from the SCK pin.

When the GM bit in SMR_SMCI is 1, the clock with the same pulse width as the base clock is output even if the CKE[0] bit in SCR_SMCI is changed.

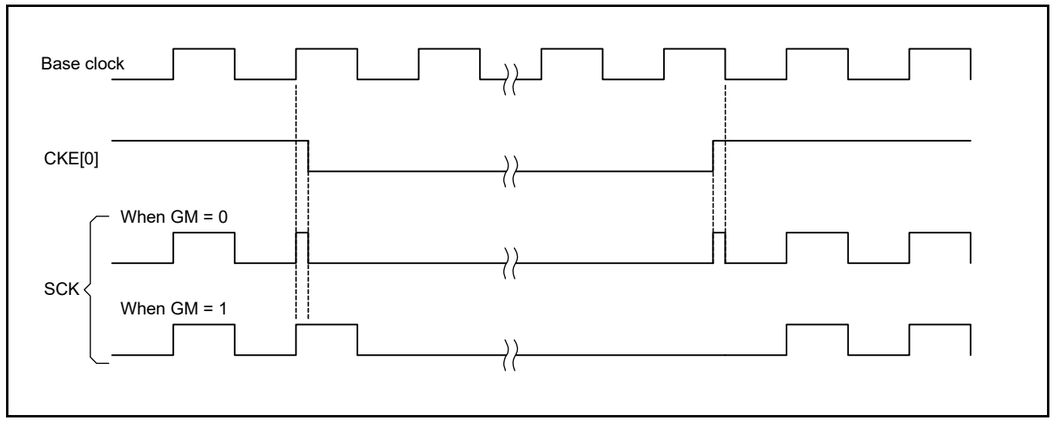


Figure 27.57 Clock output control

27.7 Operation in Simple IIC Mode

Simple I2C bus format is composed of 8 data bits and an acknowledge bit. By continuing into a slave-address frame after a start condition or restart condition, a master device can specify a slave device as a partner for communications. The currently specified slave device remains valid until a new slave device is specified or a stop condition is satisfied. The 8 data bits in all frames are transmitted in order from the MSB.

The I2C bus format and timing are shown in Figure 27.58 and Figure 27.59.

27.6.8 时钟输出控制

当SMR_SMCI中的GM位设置为1时，时钟输出可由SCR_SMCI中的CKE[1:0]位控制。有关CKE[1:0]位的详细信息，请参见第27.2.12节，智能卡接口模式的串行控制寄存器(SCR_SMCI)(SCMR.SMIF=1)。设置时钟输出时，输出第27.6.4节"接收数据采样时序和接收余量"中描述的基本时钟。

图27.57显示了当SCR_SMCI中的CKE[1]位设置为0且控制SCR_SMCI中的CKE[0]位。

当SMR_SMCI中的GM位为0时，SCR_SMCI中CKE[0]位的输出控制立即反映在SCK引脚，因此有可能会从SCK引脚输出具有意外宽度的脉冲。

当SMR_SMCI中的GM位为1时，即使SCR_SMCI中的CKE[0]位发生变化，也会输出与基本时钟脉冲宽度相同的时钟。

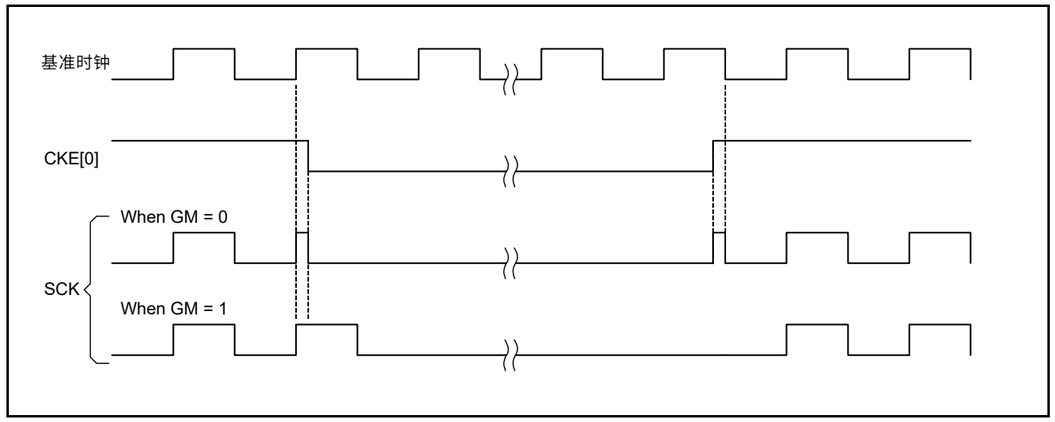


Figure 27.57 时钟输出控制

27.7 简单IIC模式下的操作

简单I2C总线格式由8个数据位和一个确认位组成。通过在启动条件或重启条件之后继续进入从地址帧，主设备可以指定从设备作为通信伙伴。当前指定的从设备保持有效，直到指定新的从设备或满足停止条件。所有帧中的8个数据位从MSB开始按顺序传输。

I2C总线格式和时序如图27.58和图27.59所示。

RA生态工作室

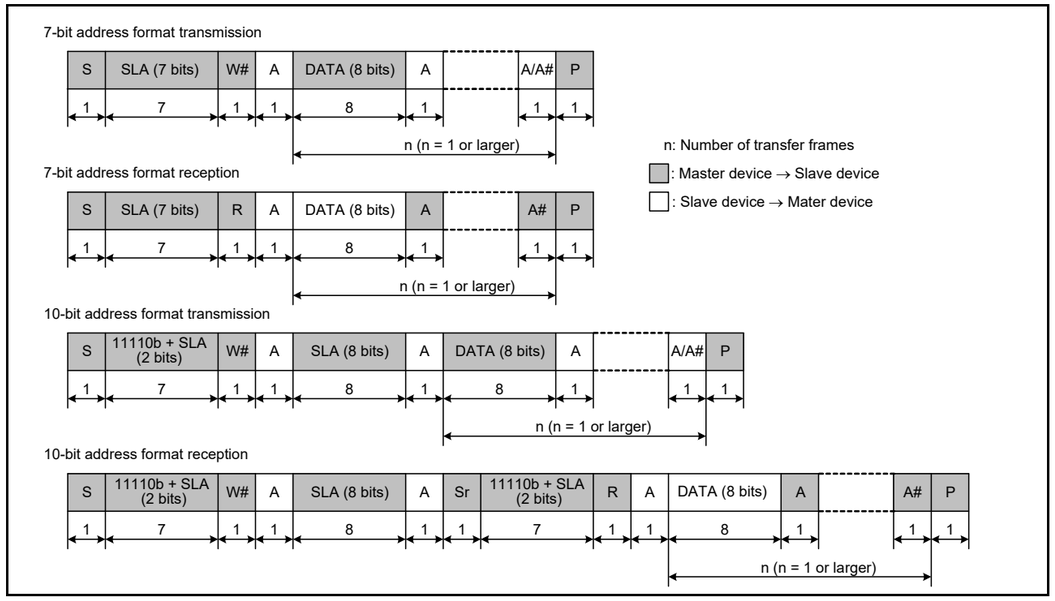


Figure 27.58 I²C bus format

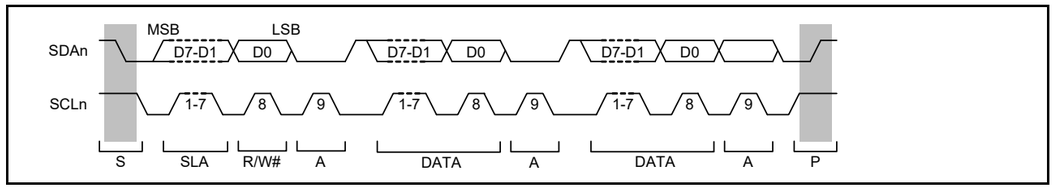


Figure 27.59 I²C bus timing when SLA is 7 bits

S: Indicates a start condition, when the master device changes the level on the SDAn line from high to low while the SCLn line is high.

SLA: Indicates a slave address, by which the master device selects a slave device.

R/W#: Indicates the direction of transfer (reception or transmission). The value 1 indicates transfer from the slave device to the master device and 0 indicates transfer from the master device to the slave device.

A/A#: Indicates an acknowledge bit. This is returned by the slave device for master transmission and by the master device for master reception. Return low indicates ACK and return high indicates NACK.

Sr: Indicates a restart condition when the master device changes the level on the SDAn line from high to low while the SCLn line is high and after the setup time elapses.

DATA: Indicates the data being received or transmitted.

P: Indicates a stop condition, when the master device changes the level on the SDAn line from low to high while the SCLn line is high.

27.7.1 Generation of Start, Restart, and Stop Conditions

Writing 1 to the SIMR3.IICSTAREQ bit causes the generation of a start condition. The generation of a start condition proceeds through the following operations:

- The level on the SDAn line falls (from high level to low level) and the SCLn line is kept in the released state
- The hold time for the start condition is set as half of a bit period at the bit rate determined by the BRR setting

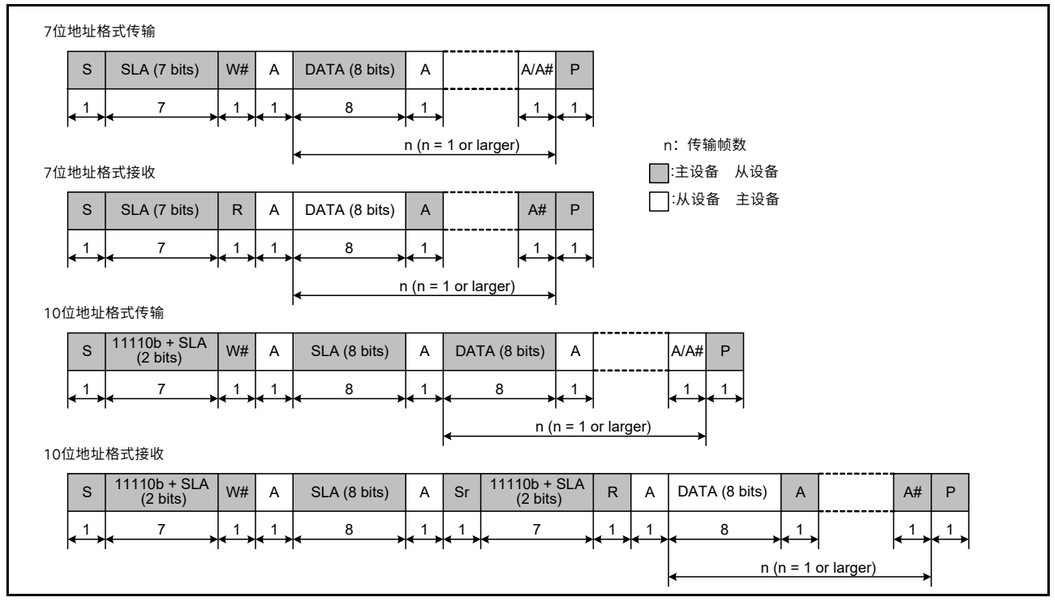


Figure 27.58 I2C总线格式

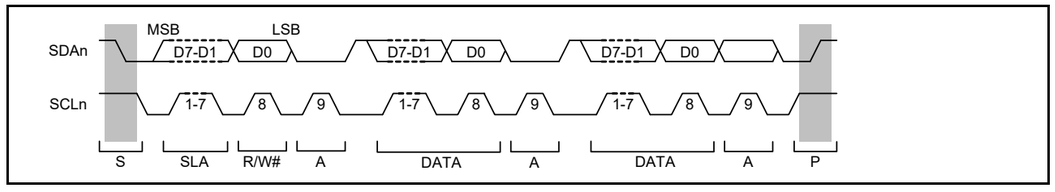


Figure 27.59 SLA为7位时的I2C总线时序

S: 当主设备在SCLn线为高时将SDAn线上的电平从高电平变为低电平时，表示启动条件。

SLA: 指示从地址，主设备通过该地址选择从设备。

R/W#: 指示传输方向（接收或传输）。值1表示从从设备传输到主设备，0表示从主设备传输到从设备。

AA#：表示确认位。这由从设备返回用于主传输，并由主设备返回用于主接收。返回低电平表示ACK，返回高电平表示NACK。

Sr：当主设备将SDAn线上的电平从高电平变为低电平而SCLn线为高电平且经过设置时间后，表示重启条件。

DATA: 表示正在接收或发送的数据。

P：表示停止条件，当主设备将SDAn线上的电平从低电平变为高电平而SCLn线为高电平时。

27.7.1 启动、重启和停止条件的生成

将1写入SIMR3.IICSTAREQ位会导致产生启动条件。开始条件的生成通过以下操作进行：

- SDAn线上的电平下降（从高电平到低电平），SCLn线保持在释放状态
- 开始条件的保持时间设置为比特周期的一半，比特率由BRR设置确定

- The level on the SCLn line falls (from high level to low level), the IICSTAREQ bit in SIMR3 is set to 0, and a start-condition generated interrupt is output.

Writing 1 to the IICRSTAREQ bit in SIMR3 causes the generation of a restart condition. The generation of a restart condition proceeds through the following operations:

- The SDAn line is released and the SCLn line is kept at a low level
- The period at low level for the SCLn line is set as half of a bit period at the bit rate determined by the BRR setting
- The SCLn line is released (transition from low level to high level)
- When a high level is detected on the SCLn line, the setup time for the restart condition is set as half of a bit period at the bit rate determined by the BRR setting
- The level on the SDAn line falls (from high level to low level)
- The hold time for the restart condition is set as half of a bit period at the bit rate determined by the BRR setting
- The level on the SCLn line falls (from high level to low level), the SIMR3.IICRSTAREQ bit is set to 0, and a restart-condition generated interrupt is output.

Writing 1 to the SIMR3.IICSTPREQ bit causes the generation of a stop condition. The generation of a stop condition proceeds through the following operations:

- The level on the SDAn line falls (from high level to low level) and the SCLn line is kept at a low level
- The period at low level for the SCLn line is set as half of a bit period at the bit rate determined by the BRR setting
- The SCLn line is released (transition from low level to high level)
- When a high level is detected on the SCLn line, the setup time for the stop condition is set as half of a bit period at the bit rate determined by the BRR setting
- The SDAn line is released (transition from low level to high level), the SIMR3.IICSTPREQ bit is set to 0, and a stop-condition generated interrupt is output.

Figure 27.60 shows the timing of operations in the generation of start, restart, and stop conditions.

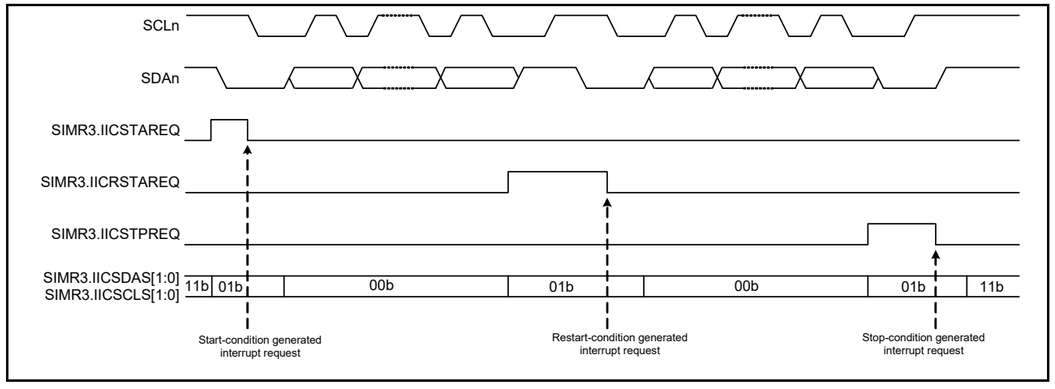


Figure 27.60 Timing of operations to generate start, restart, and stop conditions

27.7.2 Clock Synchronization

The SCLn line can be driven low if a wait is inserted by a slave device at the other side of the transfer. Setting the SIMR2.IICCSC bit to 1 allows clock synchronization control when a difference arises between the levels of the internal SCLn clock signal and the level being input on the SCLn pin.

When the SIMR2.IICCSC bit is set to 1, the level of the internal SCLn clock signal changes from low to high. Counting to determine the period at a high level stops while the low level is being input on the SCLn pin. Counting to determine the period at a high level starts after the input on the SCLn pin transitions to the high level.

- SCLn线上的电平下降（从高电平变为低电平），SIMR3中的IICSTAREQ位设置为0，并输出起始条件产生的中断。

将1写入SIMR3中的IICRSTAREQ位会导致产生重启条件。重新启动条件的生成通过以下操作进行：

- SDAn线被释放，SCLn线保持低电平
- SCLn线的低电平周期设置为比特周期的一半，比特率由BRR设置确定
- SCLn线被释放（从低电平转变为高电平）
- 当在SCLn线上检测到高电平时，重新启动条件的建立时间设置为比特周期的一半，比特率由BRR设置确定
- SDAn线上的电平下降（从高电平到低电平）
- 重启条件的保持时间设置为比特周期的一半，比特率由BRR设置确定
- SCLn线上的电平下降（从高电平变为低电平），SIMR3.IICRSTAREQ位设置为0，并输出重启条件产生的中断。

将1写入SIMR3.IICSTPREQ位会导致产生停止条件。停止条件的生成通过以下操作进行：

- SDAn线上的电平下降（从高电平到低电平），SCLn线保持在低电平
- SCLn线的低电平周期设置为比特周期的一半，比特率由BRR设置确定
- SCLn线被释放（从低电平转变为高电平）
- 当在SCLn线上检测到高电平时，停止条件的建立时间设置为由BRR设置确定的比特率的半个比特周期
- SDAn线被释放（从低电平转换为高电平），SIMR3.IICSTPREQ位设置为0，并输出停止条件产生的中断。

图27.60显示了生成启动、重新启动和停止条件的操作时序。

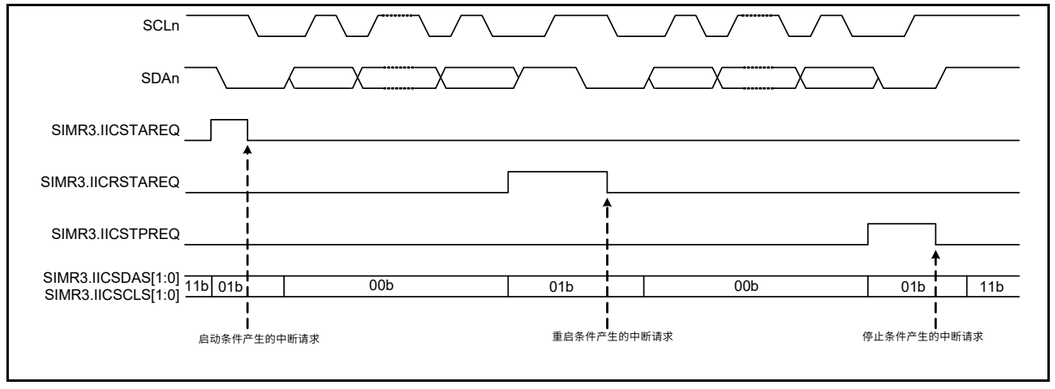


Figure 27.60 生成启动、重启和停止条件的操作时序

27.7.2 时钟同步

如果从设备在传输的另一侧插入等待，则可以将SCLn线驱动为低电平。设置当内部电平之间出现差异时，SIMR2.IICCSC位为1允许时钟同步控制SCLn时钟信号和输入到SCLn引脚的电平。

当SIMR2.IICCSC位设置为1时，内部SCLn时钟信号的电平由低变为高。当SCLn引脚输入低电平时，停止计数以确定高电平周期。在SCLn引脚上的输入转换为高电平后，开始计数以确定高电平的周期。

The interval from the time until counting, to determine the period at high level that starts on the transition of the SCLn pin to the high level, is the total of the delay of SCLn output, delay for noise filtering of the input on the SCLn pin (2 or 3 cycles of sampling clock for the noise filter), and delay for internal processing (1 or 2 PCLKA cycles). The period at high level of the internal SCLn clock is extended even when other devices are not placing the low level on the SCLn line.

If the SIMR2.IICCSC bit is 1, synchronization is obtained for the transmission and reception of data by taking the logical AND of the input on the SCLn pin and the internal SCLn clock. If the SIMR2.IICCSC bit is 0, synchronization with the internal SCLn clock is obtained for the transmission and reception of data.

If a slave device inserts a wait period into the interval until the transition of the internal SCLn clock signal from the low to the high level after a request for the generation of a start, restart, or stop condition is issued, the time until generation is prolonged by that period.

If a slave device inserts a wait period after a transition of the internal SCLn clock signal from the low to the high level, although the generation-completed interrupt is issued without stopping the waiting period, generation of the condition itself is not guaranteed. Figure 27.61 shows an example of operation to synchronize the clocks.

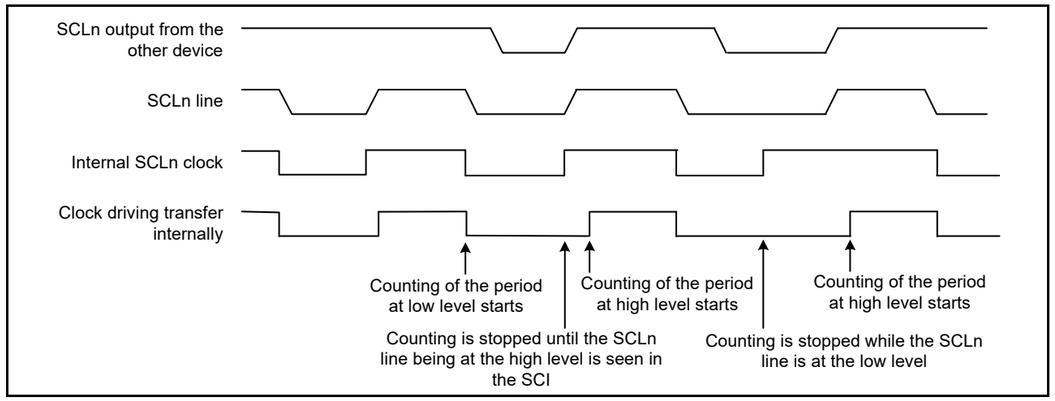


Figure 27.61 Example of operations for clock synchronization

27.7.3 SDA Output Delay

The SIMR1.IICDL[4:0] bits can be used to set a delay for the output on the SDAn pin relative to the falling edges of output on the SCLn pin. Delay settings from 0 to 31 are selectable. The delay settings represent periods of the associated numbers of cycles of the clock signal from the on-chip baud rate generator (derived by frequency-dividing the base clock, PCLKA, by the divisor selected in the SMR.CKS[1:0] bits). A delay for output on the SDAn pin applies to the start condition/restart condition/stop condition signal, 8-bit transmit data, and an acknowledge bit.

If the SDA output delay is shorter than the time required for the level on the SCLn pin to fall, the change of the output on the SDAn pin starts while the output level on the SCLn pin is falling, creating a possibility of erroneous operation of slave devices. Ensure that the settings for output delay on the SDAn pin specify a time period greater than the time that the output on the SCLn pin takes to fall (300 ns for IIC in standard mode and fast mode).

Figure 27.62 shows the timing of delays in SDA output.

从时间到计数的时间间隔，确定从SCLn引脚转换为高电平开始的高电平周期，是SCLn输出延迟的总和，SCLn引脚输入的噪声过滤延迟（噪声滤波器的采样时钟为2或3个周期），内部处理的延迟（1或2个PCLKA周期）。即使其他设备没有将低电平置于SCLn线上，内部SCLn时钟的高电平周期也会延长。

如果SIMR2.IICCSC位为1，则通过对SCLn引脚上的输入和内部SCLn时钟进行逻辑与来获得数据发送和接收的同步。如果SIMR2.IICCSC位为0，则与内部SCLn时钟同步以进行数据的发送和接收。

如果从设备在发出启动、重启或停止条件的生成请求后，在内部SCLn时钟信号从低电平转变为高电平之前的间隔中插入一个等待周期，则直到生成的时间为延长了那个时期。

如果从设备在内部SCLn时钟信号从低电平转换到高电平之后插入等待周期，尽管在不停止等待周期的情况下发出生成完成中断，但不能保证条件本身的生成。图27.61显示了同步时钟的操作示例。

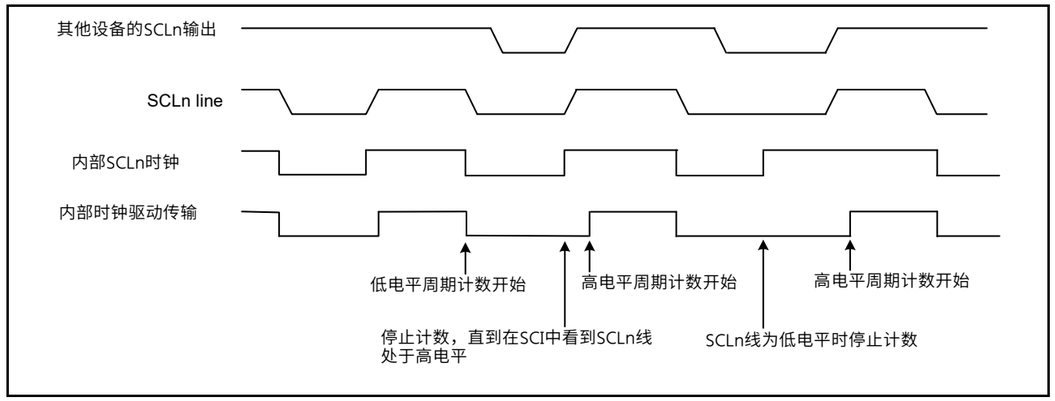


Figure 27.61 时钟同步操作示例

27.7.3 SDA输出延迟

SIMR1.IICDL[4:0]位可用于设置SDAn引脚输出相对于SCLn引脚输出下降沿的延迟。可选择从0到31的延迟设置。延迟设置表示来自片内波特率发生器的时钟信号的相关周期数的周期（通过将基本时钟PCLKA除以在SMR.CKS[1:0]位中选择的除数分频得出）。SDAn引脚上的输出延迟适用于启动条件重启条件停止条件信号、8位发送数据和确认位。

如果SDA输出延迟小于SCLn引脚电平下降所需的时间，则SDAn引脚上的输出变化会在SCLn引脚上的输出电平下降时开始，从而产生从机错误操作的可能性设备。确保SDAn引脚上的输出延迟设置指定的时间段大于SCLn引脚上的输出下降所需的时间（标准模式和快速模式下的IIC为300ns）。

图27.62显示了SDA输出的延迟时间。

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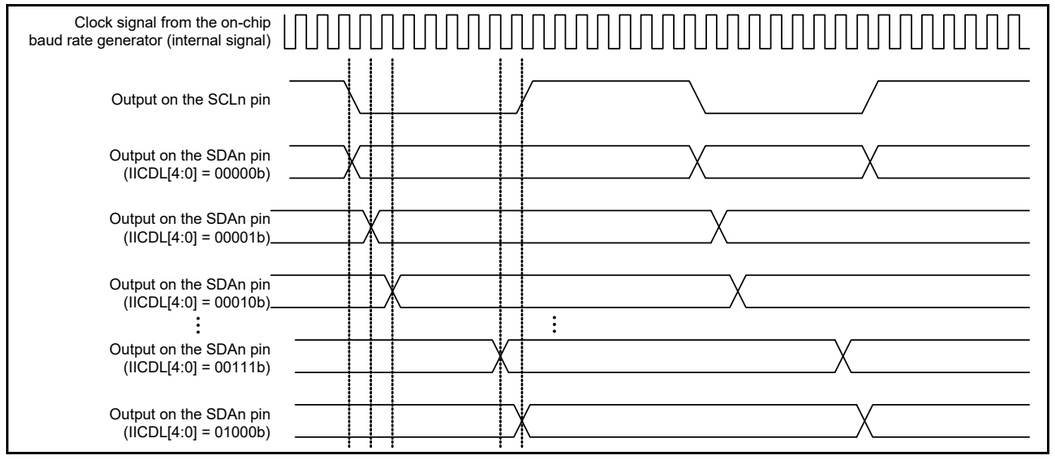


Figure 27.62 Timing of delays in SDA output

27.7.4 SCI Initialization in Simple IIC Mode

Before transferring data, write the initial value of 00h to SCR and initialize the interface as shown in the example in Figure 27.63. Before making any changes to the operating mode or transfer format, be sure to set SCR to its initial value. In simple IIC mode, the open-drain setting for the communication ports should be made on the port side.

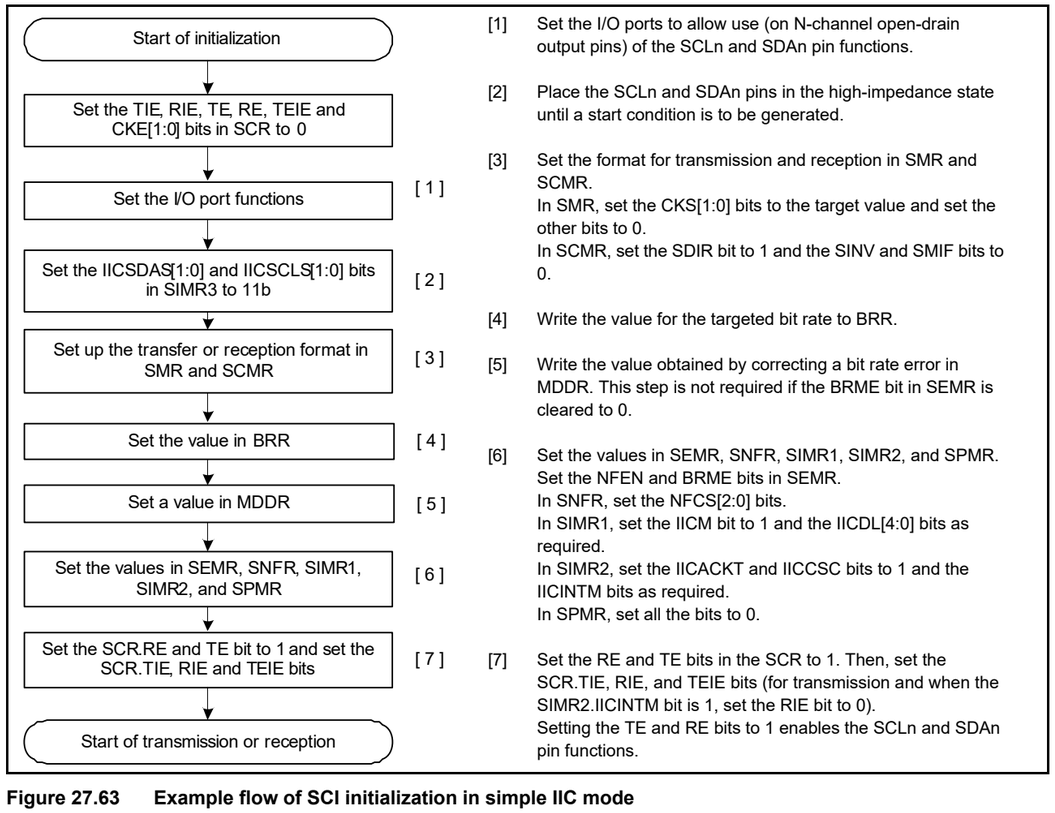


Figure 27.63 Example flow of SCI initialization in simple IIC mode

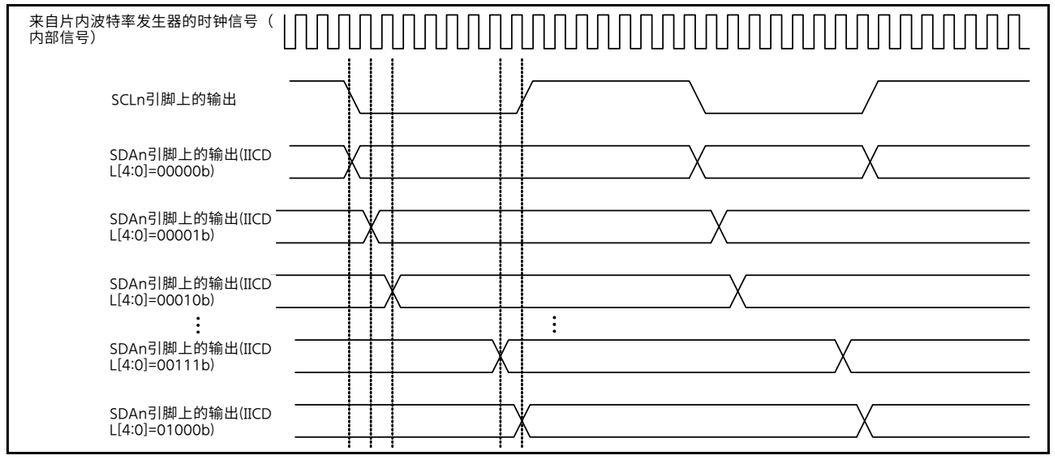


Figure 27.62 SDA输出的延迟时间

27.7.4 简单IIC模式下的SCI初始化

在传输数据之前，将初始值00h写入SCR并初始化接口，如示例中所示
图27.63。在对操作模式或传输格式进行任何更改之前，请务必将SCR设置为其初始值。
在简单IIC模式下，通信端口的开漏设置应在端口侧进行。

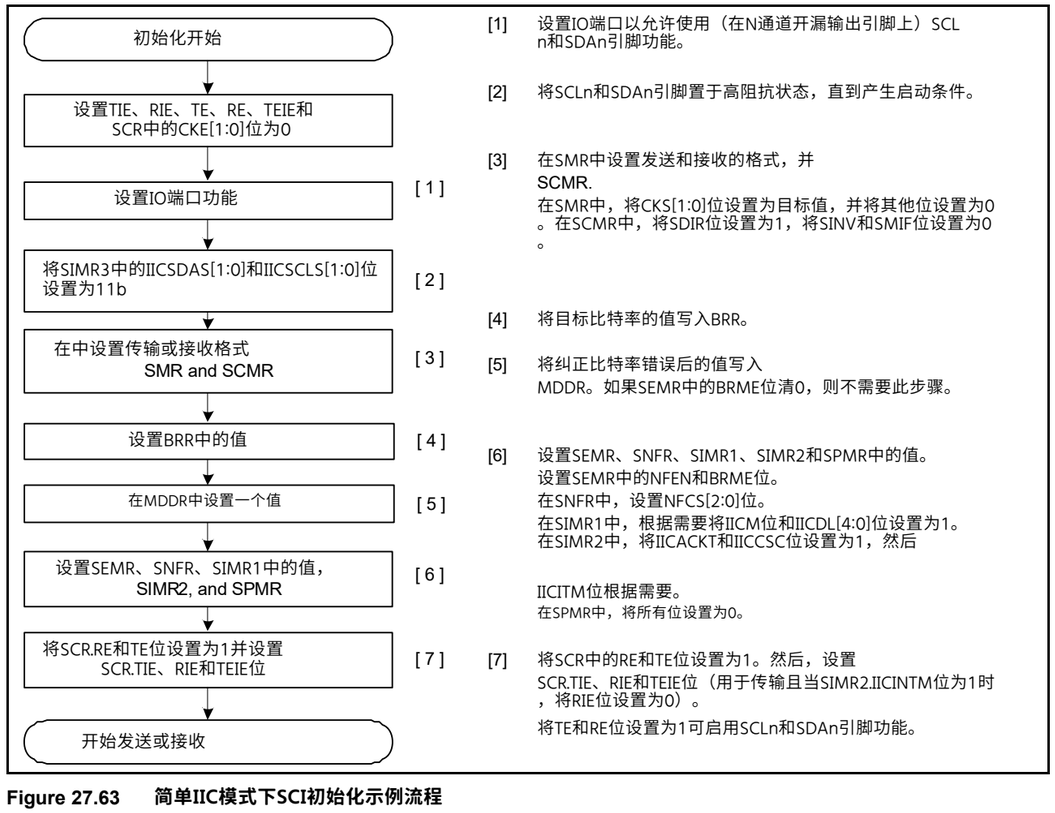


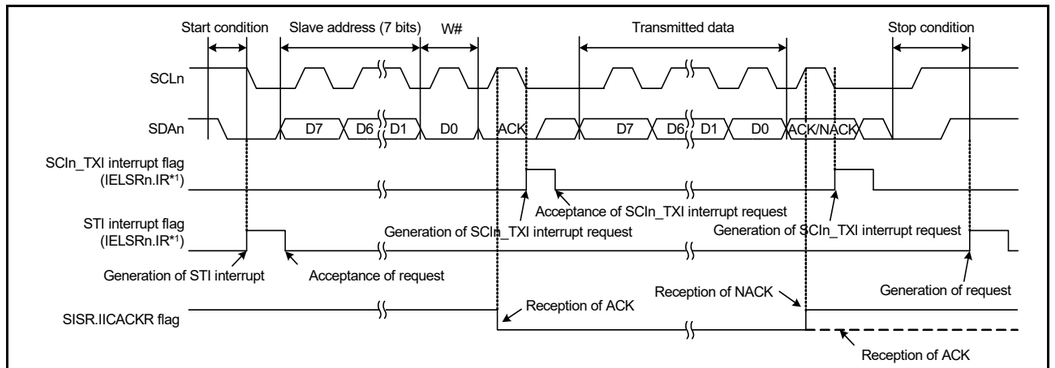
Figure 27.63 简单IIC模式下SCI初始化示例流程

27.7.5 Operation in Master Transmission in Simple IIC Mode

Figure 27.64 and Figure 27.65 show examples of master transmission and Figure 27.66 shows an example flow of data transmission. The value of the SIMR2.IICINTM bit is assumed to be 1 (use reception and transmission interrupts) and the value of the SCR.RIE bit is assumed to be 0 (SCIn_RXI and SCIn_ERI interrupt requests are disabled). See Table 27.29 for more information on the STI interrupt.

When 10-bit slave addresses are in use, steps [3] and [4] in Figure 27.66 are repeated twice.

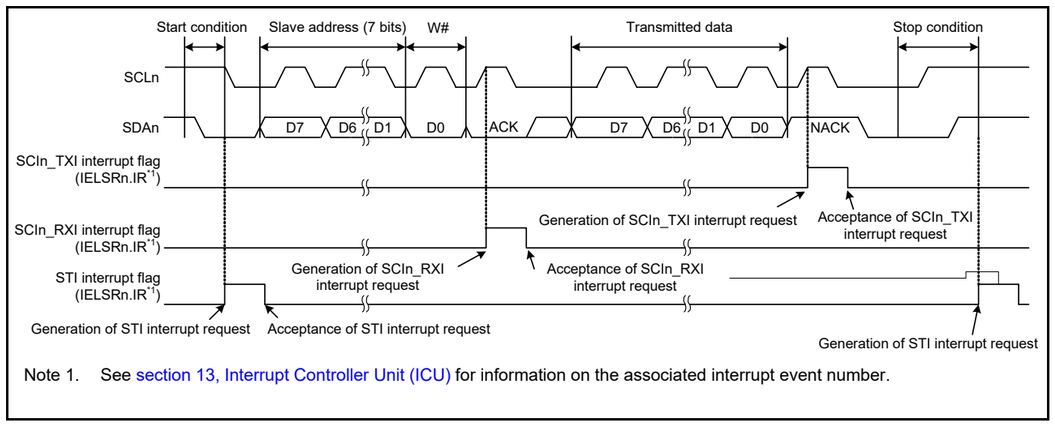
In simple IIC mode, the transmit data empty interrupt (SCIn_TXI) is generated when communication of one frame is complete, unlike the timing of the SCIn_TXI interrupt request generation during clock synchronous transmission.



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

Figure 27.64 Example 1 operation for master transmission in simple IIC mode with 7-bit slave addresses, transmission interrupts, and reception interrupts

When the SIMR2.IICINTM bit is set to 0, using ACK/NACK interrupts during master transmission, the DMAC or DTC is activated by the ACK interrupt as the trigger and the required number of data bytes are transmitted. When a NACK is received, error processing such as transmission stop and retransmission is performed using the NACK interrupt as the trigger.



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

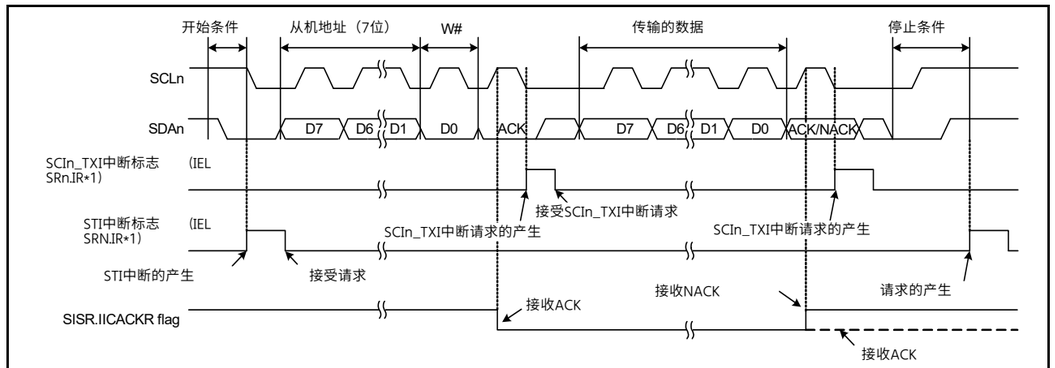
Figure 27.65 Example 2 operation for master transmission in simple IIC mode with 7-bit slave addresses, ACK interrupts, and NACK interrupts

27.7.5 简单IIC模式下的主传输操作

图27.64和图27.65显示了主机传输的示例，图27.66显示了数据传输的示例流程。SIMR2.IICINTM位的值假定为1（使用接收和发送中断），SCR.RIE位的值假定为0（SCIn_RXI和SCIn_ERI中断请求被禁用）。有关STI中断的更多信息，请参见表27.29。

当使用10位从机地址时，图27.66中的步骤[3]和[4]重复两次。

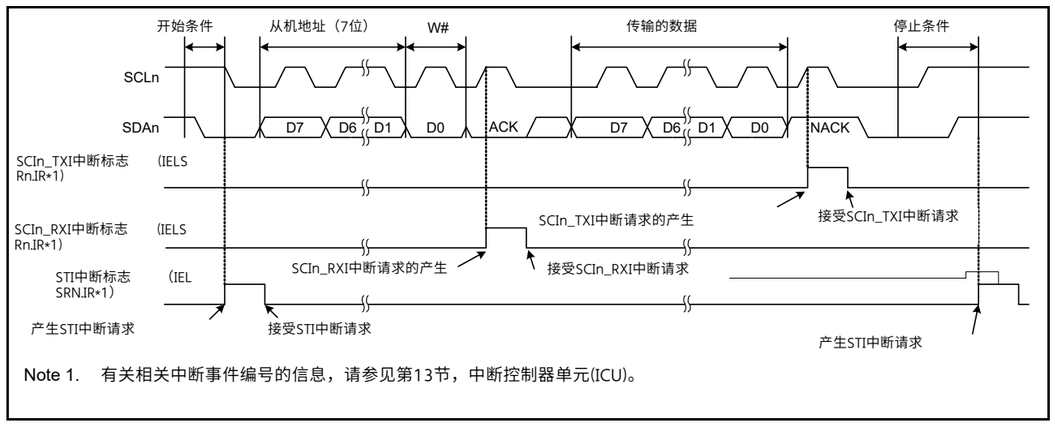
在简单IIC模式下，发送数据空中断(SCIn_TXI)在一帧通信完成时产生，与时钟同步传输期间的SCIn_TXI中断请求产生的时序不同。



Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

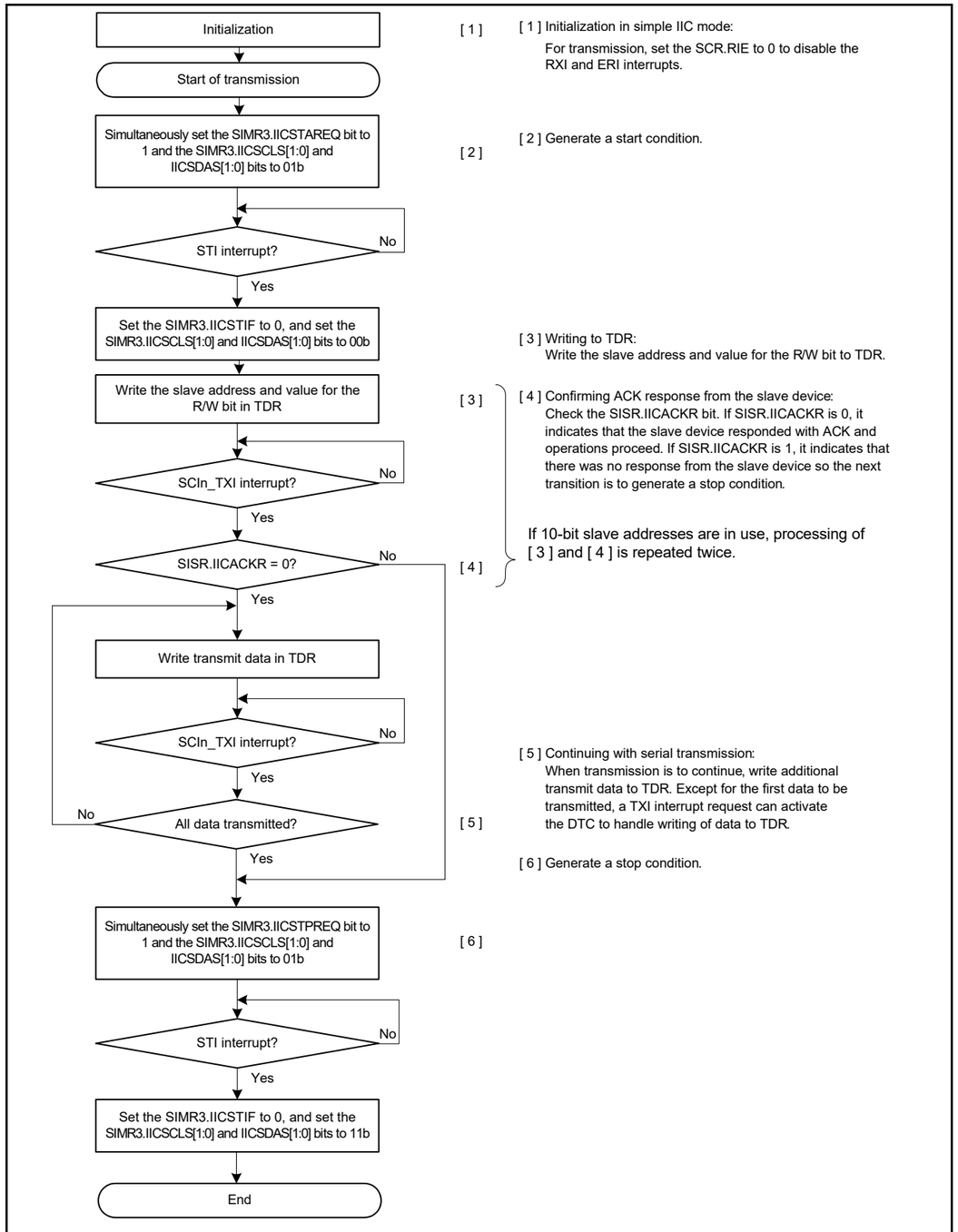
Figure 27.64 示例1简单IIC模式下的主机发送操作，具有7位从机地址、发送中断和接收中断

当SIMR2.IICINTM位设置为0时，在主机发送期间使用ACKNACK中断，DMAC或DTC由ACK中断作为触发器激活，并发送所需数量的数据字节。接收到NACK时，以NACK中断为触发进行发送停止、重发等错误处理。



Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.65 示例2简单IIC模式下的主机传输操作，具有7位从机地址、ACK中断和NACK中断



[1] Initialization in simple IIC mode:
For transmission, set the SCR.RIE to 0 to disable the RXI and ERI interrupts.

[2] Generate a start condition.

[3] Writing to TDR:
Write the slave address and value for the R/W bit to TDR.

[4] Confirming ACK response from the slave device:
Check the SISR.IICACKR bit. If SISR.IICACKR is 0, it indicates that the slave device responded with ACK and operations proceed. If SISR.IICACKR is 1, it indicates that there was no response from the slave device so the next transition is to generate a stop condition.

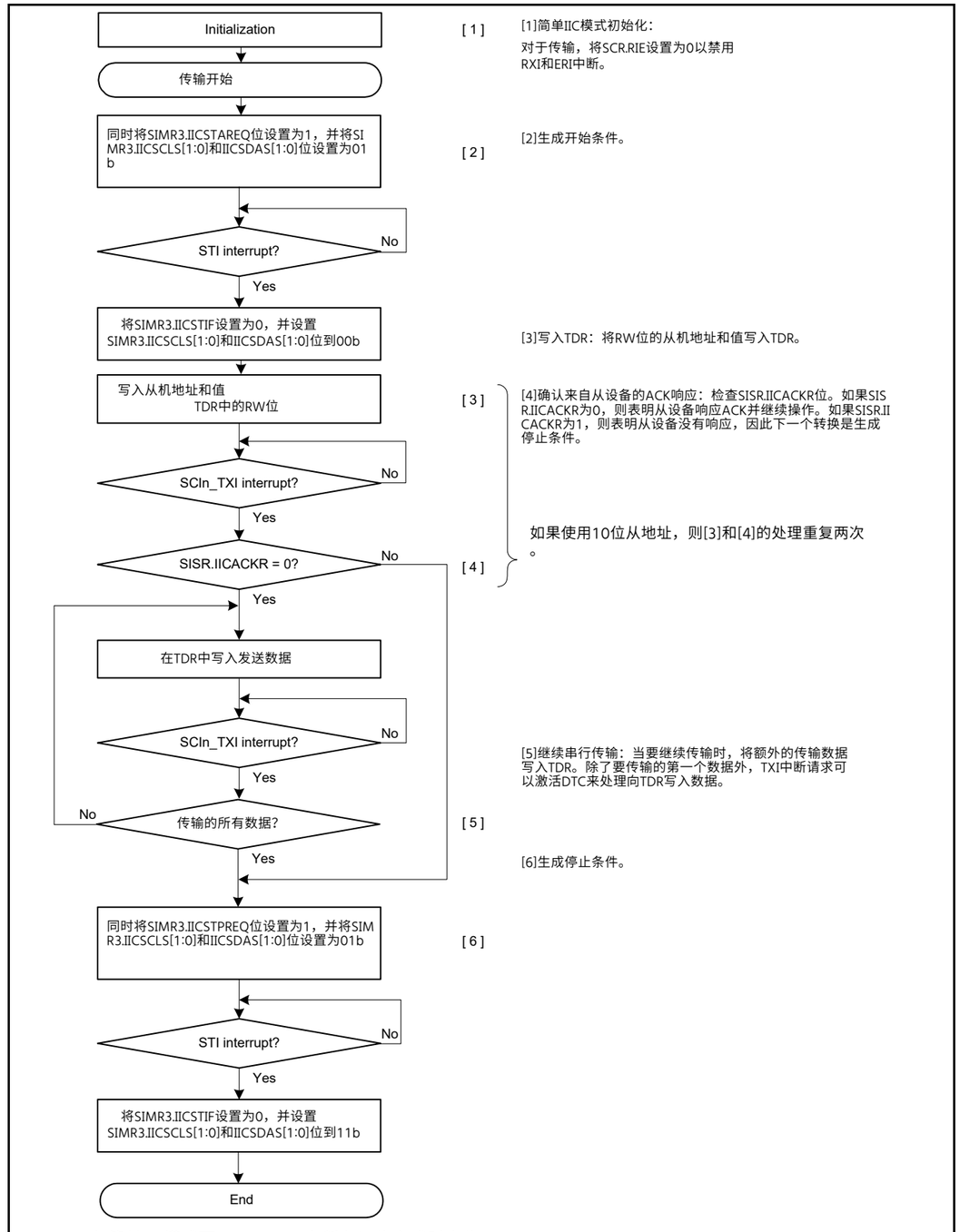
If 10-bit slave addresses are in use, processing of [3] and [4] is repeated twice.

[5] Continuing with serial transmission:
When transmission is to continue, write additional transmit data to TDR. Except for the first data to be transmitted, a TXI interrupt request can activate the DTC to handle writing of data to TDR.

[6] Generate a stop condition.

Note: In simple IIC mode, the SCIn_TXI interrupt is generated when communication completes

Figure 27.66 Example flow of master transmission in simple IIC mode with transmission interrupts and reception interrupts



[1]简单IIC模式初始化：
对于传输，将SCR.RIE设置为0以禁用RXI和ERI中断。

[2]生成开始条件。

[3]写入TDR：将RW位的从机地址和值写入TDR。

[4]确认来自从设备的ACK响应：检查SISR.IICACKR位。如果SISR.IICACKR为0，则表明从设备响应ACK并继续操作。如果SISR.IICACKR为1，则表明从设备没有响应，因此下一个转换是生成停止条件。

如果使用10位从地址，则[3]和[4]的处理重复两次。

[5]继续串行传输：当要继续传输时，将额外的传输数据写入TDR。除了要传输的第一个数据外，TXI中断请求可以激活DTC来处理向TDR写入数据。

[6]生成停止条件。

Note: 在简单IIC模式下，SCIn_TXI中断在通信完成时产生

Figure 27.66 带有发送中断和接收中断的简单IIC模式下的主机发送示例流程

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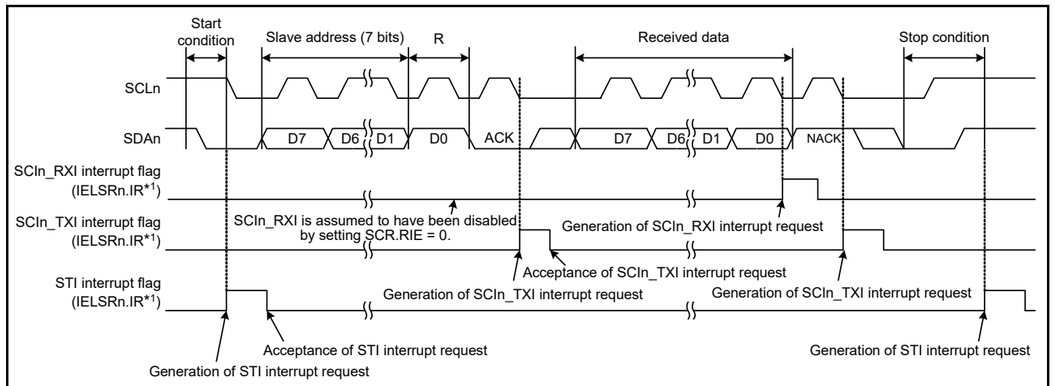
27.7.6 Master Reception in Simple IIC Mode

Figure 27.67 shows an example of master reception operation in simple IIC mode and Figure 27.68 shows an example flow of master reception.

The value of the SIMR2.IICINTM bit is assumed to be 1, using reception and transmission interrupts.

In simple IIC mode, the transmit data empty interrupt (SCIn_TXI) is generated when communication of one frame is complete, unlike the timing of the SCIn_TXI interrupt request generation timing during clock synchronous transmission.



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the corresponding interrupt event number.

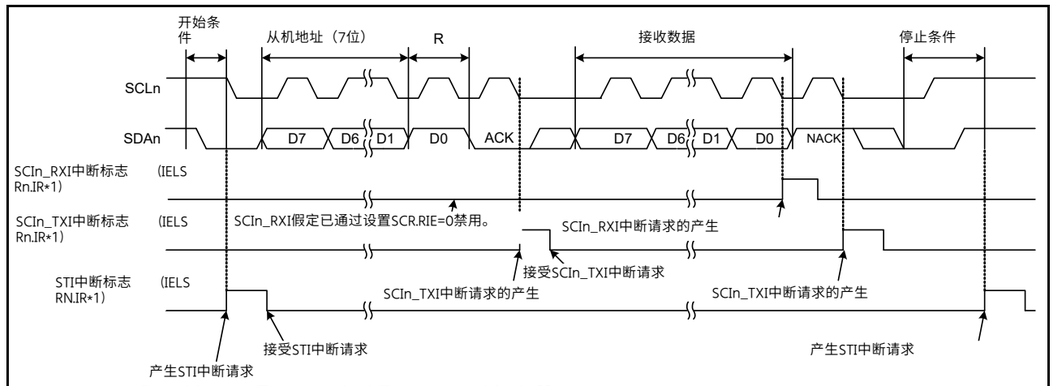
Figure 27.67 Example operation for master reception in simple IIC mode with 7-bit slave addresses, transmission interrupts, and reception interrupts

27.7.6 简单IIC模式下的主接收

图27.67显示了简单IIC模式下的主机接收操作示例，图27.68显示了主机接收的示例流程。

SIMR2.IICINTM位的值假定为1，使用接收和发送中断。

在简单IIC模式下，发送数据空中断(SCIn_TXI)在一帧通信完成时产生，与时钟同步传输期间的SCIn_TXI中断请求产生时序不同。



Note 1. 有关相应中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.67 简单IIC模式下主机接收的示例操作，具有7位从机地址、发送中断和接收中断

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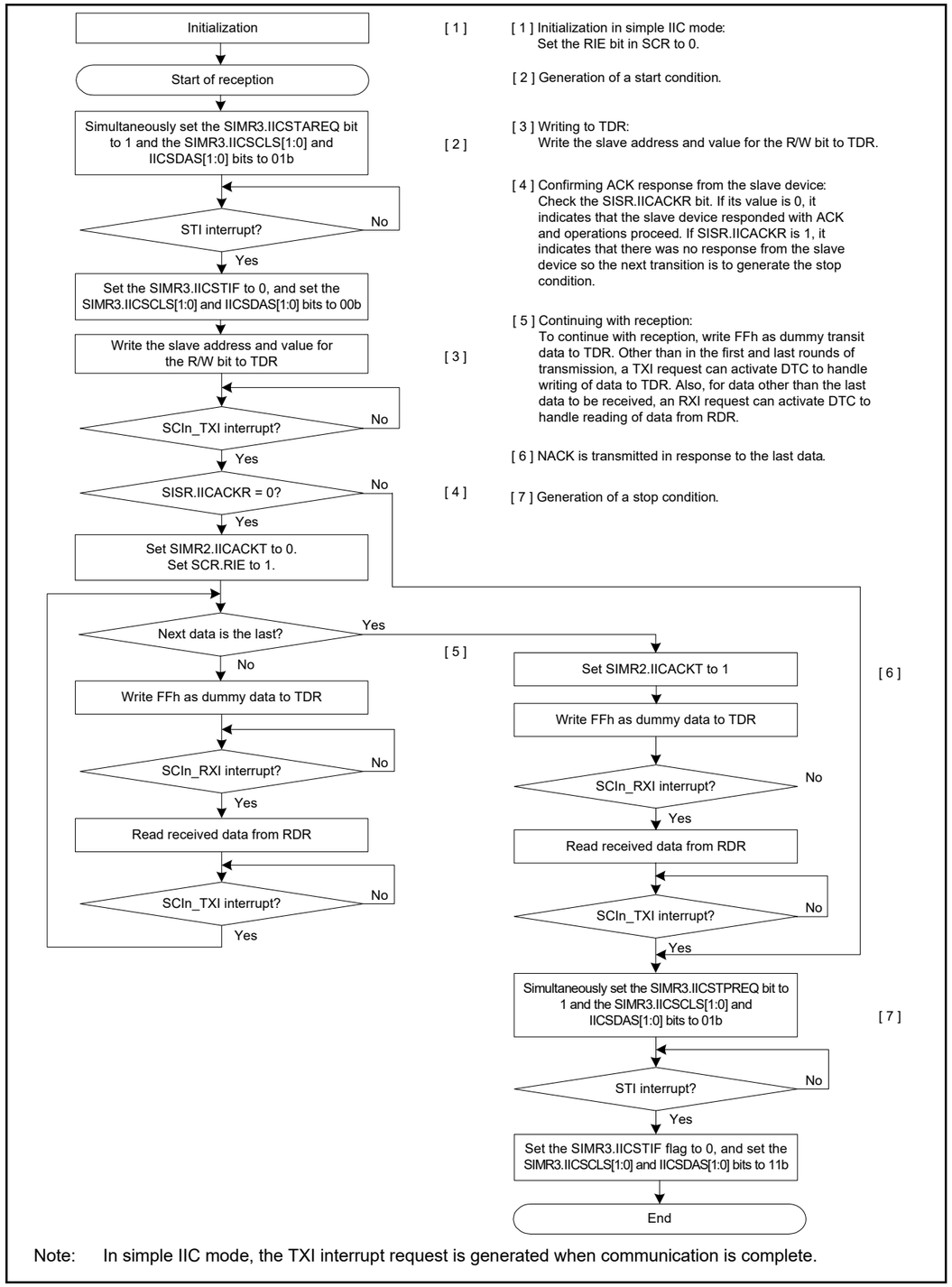


[1] Initialization in simple IIC mode:
Set the RIE bit in SCR to 0.

[2] Generation of a start condition.

[3] Writing to TDR:
Write the slave address and value for the R/W bit to TDR.

[4] Confirming ACK response from the slave device:
Check the SISR.IICACKR bit. If its value is 0, it indicates that the slave device responded with ACK and operations proceed. If SISR.IICACKR is 1, it indicates that there was no response from the slave device so the next transition is to generate the stop condition.

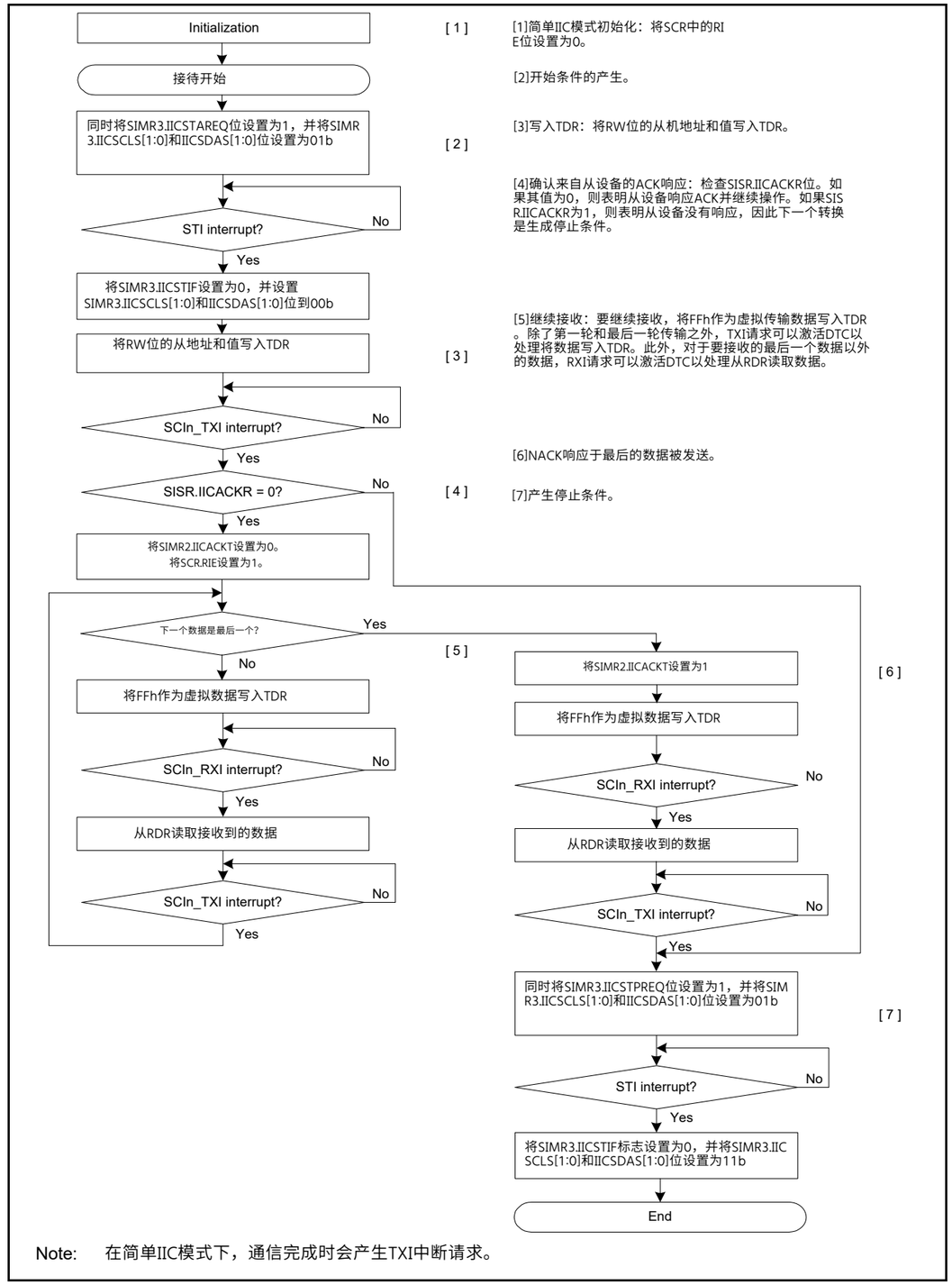
[5] Continuing with reception:
To continue with reception, write FFh as dummy transit data to TDR. Other than in the first and last rounds of transmission, a TXI request can activate DTC to handle writing of data to TDR. Also, for data other than the last data to be received, an RXI request can activate DTC to handle reading of data from RDR.

[6] NACK is transmitted in response to the last data.

[7] Generation of a stop condition.

Note: In simple IIC mode, the TXI interrupt request is generated when communication is complete.

Figure 27.68 Example flow of master reception in simple IIC mode with transmission interrupts and reception interrupts



[1]简单IIC模式初始化：将SCR中的RIE位设置为0。

[2]开始条件的产生。

[3]写入TDR：将RW位的从机地址和值写入TDR。

[4]确认来自从设备的ACK响应：检查SISR.IICACKR位。如果其值为0，则表明从设备响应ACK并继续操作。如果SISR.IICACKR为1，则表明从设备没有响应，因此下一个转换是生成停止条件。

[5]继续接收：要继续接收，将FFh作为虚拟传输数据写入TDR。除了第一轮和最后一轮传输之外，TXI请求可以激活DTC以处理将数据写入TDR。此外，对于要接收的最后一个数据以外的数据，RXI请求可以激活DTC以处理从RDR读取数据。

[6]NACK响应于最后的数据被发送。

[7]产生停止条件。

Note: 在简单IIC模式下，通信完成时会产生TXI中断请求。

Figure 27.68 带有发送中断和接收中断的简单IIC模式下的主机接收示例流程

27.8 Operation in Simple SPI Mode

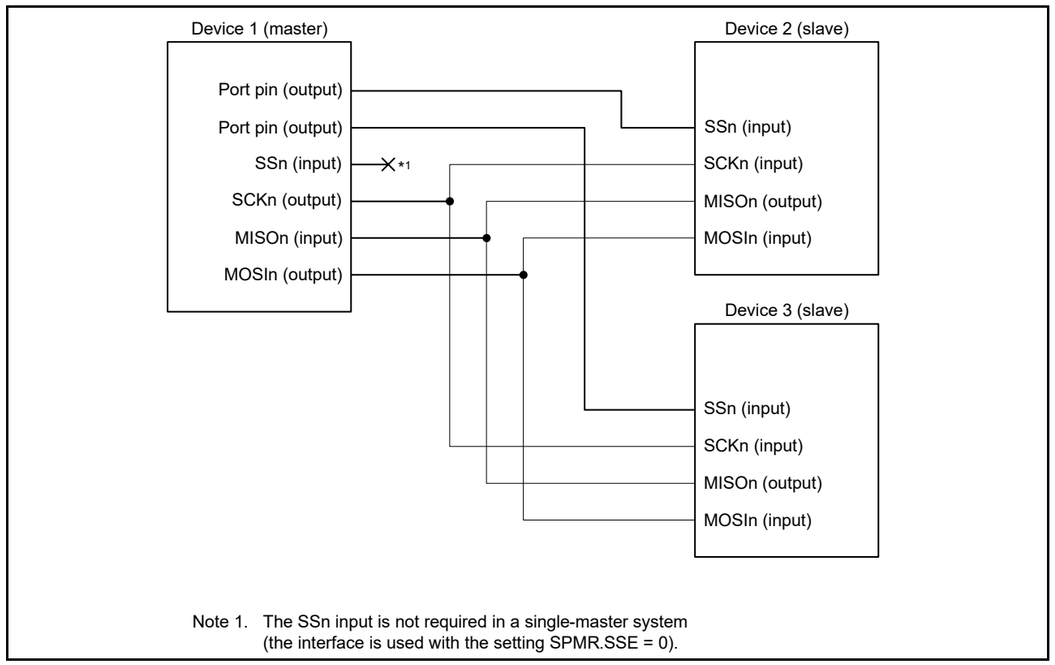
As an extended function, the SCI supports a simple SPI mode that handles transfer between one or multiple master devices and multiple slave devices.

To place the SCI in simple SPI mode, use the settings for clock synchronous mode (SCMR.SMIF = 0, SIMR1.IICM = 0, SMR.CM = 1) and set the SPMR.SSE bit to 1. When the configuration only has a single master, the SSn pin function on the master side is not required to connect the device used as the master in simple SPI mode. Therefore, set the SPMR.SSE bit to 0 in this case.

Figure 27.69 shows an example of connections in simple SPI mode. Use a general port pin to produce the SSn output signal from the master.

In simple SPI mode, data is transferred in synchronization with clock pulses in the same way as in clock synchronous mode. One character of transfer data consists of 8 bits of data, and parity bits cannot be appended. The data can be inverted by setting the SCMR.SINV bit to 1.

Because the receiver and transmitter are independent of each other within the SCI module, full-duplex communications are possible, with a common clock signal. Additionally, because both the transmitter and receiver have a buffered structure, it is possible to write the next transmit data while transmission is in progress and also read previously received data while reception is in progress. This enables continuous transfer.



Note 1. The SSn input is not required in a single-master system (the interface is used with the setting SPMR.SSE = 0).

Figure 27.69 Example connections using simple SPI mode in single master mode with SPMR.SSE bit = 0

27.8.1 States of Pins in Master and Slave Modes

The direction (input or output) of pins for the simple SPI mode interface differs according to whether the device is a master (SCR.CKE[1:0] = 00b or 01b and SPMR.MSS = 0) or slave (SCR.CKE[1:0] = 10b or 11b and SPMR.MSS = 1).

Table 27.25 lists the relationship between the pin states, mode, and input level on the SSn pin.

27.8 简单SPI模式下的操作

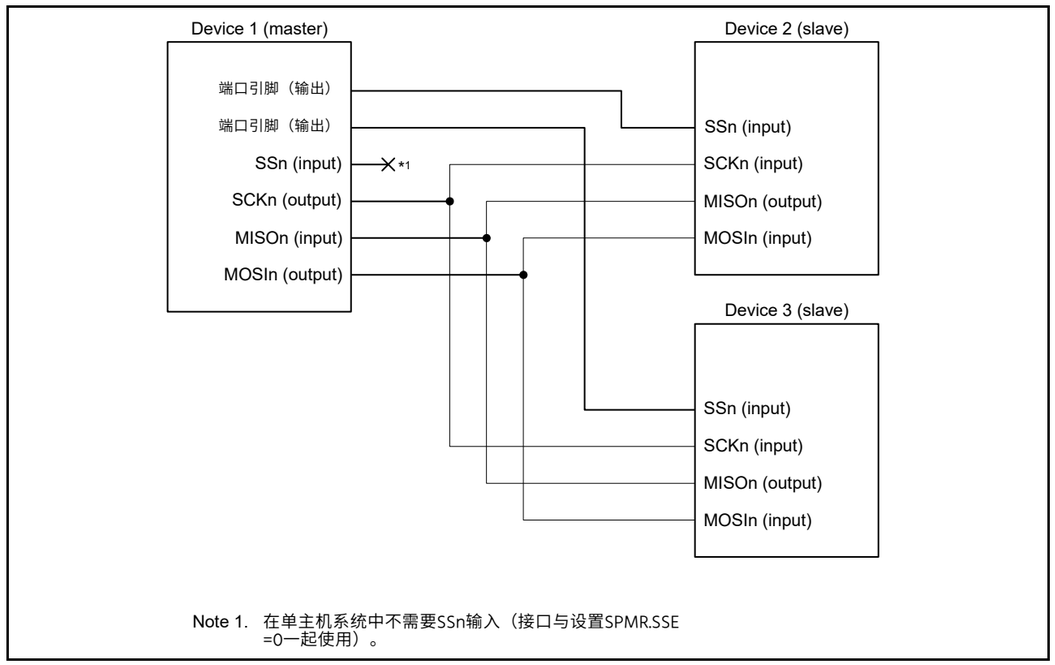
作为一项扩展功能，SCI支持简单的SPI模式，用于处理一个或多个主设备与多个从设备之间的传输。

要将SCI置于简单SPI模式，请使用时钟同步模式的设置（SCMR.SMIF=0，SIMR1.IICM=0，SMR.CM=1）并将SPMR.SSE位设置为1。当配置只有单主控，在简单SPI模式下连接作为主控的设备不需要主控侧的SSn引脚功能。因此，在这种情况下，将SPMR.SSE位设置为0。

图27.69显示了简单SPI模式下的连接示例。使用通用端口引脚从主机产生SSn输出信号。

在简单SPI模式下，数据与时钟脉冲同步传输，方式与时钟同步模式相同。1个字符的传输数据由8位数据组成，不能附加奇偶校验位。可以通过将SCMR.SINV位设置为1来反转数据。

由于接收器和发送器在SCI模块中相互独立，因此可以使用公共时钟信号进行全双工通信。此外，由于发送器和接收器都具有缓冲结构，因此可以在发送过程中写入下一个发送数据，并在接收过程中读取先前接收到的数据。这使得连续传输成为可能。



Note 1. 在单主机系统中不需要SSn输入（接口与设置SPMR.SSE=0一起使用）。

Figure 27.69 在SPMR.SSE位=0的单主模式下使用简单SPI模式的示例连接

27.8.1 主从模式下的引脚状态

简单SPI模式接口的引脚方向（输入或输出）根据设备是主设备（SCR.CKE[1:0]=00b或01b且SPMR.MSS=0）还是从设备（SCR.CKE）而不同[1:0]=10b或11b且SPMR.MSS=1)。

表27.25列出了SSn引脚上的引脚状态、模式和输入电平之间的关系。

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Table 27.25 Pin states by mode and input level on the SSn pin

Mode	Input on SSn pin	State of TXDn pin	State of RXDn pin	State of SCKn pin
Master mode*1	High level (transfer can proceed)	Output for data transmission*2	Input for received data	Clock output*3
	Low level (transfer cannot proceed)	High-impedance	Input for received data (but disabled)	High-impedance
Slave mode	High level (transfer cannot proceed)	Input for received data (but disabled)	High-impedance	Clock input (but disabled)
	Low level (transfer can proceed)	Input for received data	Output for data transmission	Clock input

Note 1. When there is only a single master (SPMR.SSE = 0), transfer is possible regardless of the input level on the SSn pin. This is equivalent to the input of a high level on the SSn pin. Because the SSn pin function is not required, the pin is available for other purposes.
Note 2. The MOSIn pin output is in a high-impedance state when serial transmission is disabled (SCR.TE = 0).
Note 3. The SCKn pin output is in a high-impedance state when serial transmission is disabled (SCR.TE and RE = 00b) in a multi-master configuration (SPMR.SSE = 1).

27.8.2 SS Function in Master Mode

Setting the SCR.CKE[1:0] bits to 00b and the SPMR.MSS bit to 0 selects master operation. The SSn pin is not used in single-master configurations (SPMR.SSE = 0), so transmission or reception can proceed regardless of the value of the SSn pin.

When the level on the SSn pin is high in a multi-master configuration (SPMR.SSE = 1), a master device outputs clock signals from the SCKn pin before starting transmission or reception to indicate that there are no other masters or another master is performing reception or transmission.

When the level on the SSn pin is low in a multi-master configuration (SPMR.SSE = 1), there are other masters, and this indicates that transmission or reception is in progress. The MOSIn output and SCKn pins are placed in a high-impedance state and starting transmission or reception is not possible. In addition, the value of the SPMR.MFF bit is 1, indicating a mode fault error. In a multi-master configuration, start error processing by reading the SPMR.MFF flag. Even if a mode fault error occurs while transmission or reception is in progress, transmission or reception does not stop, but the MOSIn and SCKn outputs are placed in the high-impedance state after completion of the transfer. Use a general port pin to produce the SS output signal from the master.

27.8.3 SS Function in Slave Mode

Setting the SCR.CKE[1:0] bits to 10b and the SPMR.MSS bit to 1 selects slave operation. When the level on the SSn pin is high, the MISOn output pin is in a high-impedance state and the clock input through the SCKn pin is ignored. When the level on the SSn pin is low, clock input through the SCKn pin is valid and transmission or reception can proceed.

If the input on the SSn pin changes from low to high during transmission or reception, the MISOn output pin is placed in a high-impedance state. Meanwhile, the internal processing for transmission or reception continues at the rate of the clock input through the SCKn pin until processing for the current transmitted or received character is complete, after which it stops, and the appropriate interrupt (SCIn_TXI, SCIn_RXI, or SCIn_TEI) is then generated.

27.8.4 Relationship between Clock and Transmit/Receive Data

The CKPOL and CKPH bits in the SPMR can be used to set up the clock for use in transmission and reception in four different ways. The relation between the clock signal and the transmission and reception of data is shown in Figure 27.70. The relation is the same for both master and slave operation. This is the same as when the level on the SSn pin is high.

Table 27.25 SSn引脚上的模式和输入电平的引脚状态

Mode	SSn引脚上的输入	TXDn引脚状态	RXDn引脚状态	SCKn引脚状态
Master mode*1	高电平（可以进行转移）	数据传输输出*2	接收数据的输入	Clock output*3
	低电平（传输无法进行）	High-impedance	接收数据的输入（但禁用）	High-impedance
从机模式	高电平（传输无法进行）	接收数据的输入（但禁用）	High-impedance	时钟输入（但禁用）
	低电平（可以继续传输）	接收数据的输入	数据传输输出	时钟输入

注1.当只有一个主机(SPMR.SSE=0)时，无论SSn引脚上的输入电平如何，都可以进行传输。这相当于在SSn引脚上输入高电平。由于不需要SSn引脚功能，因此该引脚可用于其他用途。注2.当串行传输被禁用(SCR.TE=0)时，MOSIn引脚输出处于高阻抗状态。

注3.在多主机配置(SPMR.SSE=1)中禁用串行传输(SCR.TE和RE=00b)时，SCKn引脚输出处于高阻抗状态。

27.8.2 主控模式下的SS功能

将SCR.CKE[1:0]位设置为00b并将SPMR.MSS位设置为0选择主机操作。SSn引脚不用于单主机配置(SPMR.SSE=0)，因此无论SSn引脚的值如何，都可以进行发送或接收。

在多主机配置（SPMR.SSE=1）中，当SSn引脚上的电平为高电平时，主机在开始发送或接收之前从SCKn引脚输出时钟信号，以指示没有其他主机或另一个主机在进行接收或发送。

在多主机配置中（SPMR.SSE=1），当SSn引脚上的电平为低电平时，还有其他主机，这表明正在发送或接收。MOSIn输出和SCKn引脚处于高阻抗状态，无法开始发送或接收。此外，SPMR.MFF位的值为1，表示模式故障错误。在多主机配置中，通过读取SPMR.MFF标志开始错误处理。即使在发送或接收过程中发生模式故障错误，发送或接收也不会停止，而是在传输完成后将MOSIn和SCKn输出置于高阻抗状态。使用通用端口引脚从主机产生SS输出信号。

27.8.3 从模式下的SS功能

将SCR.CKE[1:0]位设置为10b并将SPMR.MSS位设置为1选择从机操作。当SSn引脚上的电平为高电平时，MISOn输出引脚处于高阻状态，通过SCKn引脚输入的时钟被忽略。当SSn引脚为低电平时，通过SCKn引脚输入的时钟有效，可以进行发送或接收。

如果SSn引脚上的输入在发送或接收期间从低电平变为高电平，则MISOn输出引脚处于高阻抗状态。同时，发送或接收的内部处理以通过SCKn引脚输入的时钟速率继续，直到对当前发送或接收字符的处理完成，之后它停止，并且适当的中断（SCIn_TXI、SCIn_RXI或SCIn_TEI）然后生成。

27.8.4 时钟与发送接收数据的关系

SPMR中的CKPOL和CKPH位可用于以四种不同的方式设置用于发送和接收的时钟。时钟信号与数据收发的关系如图27.70所示。主从操作的关系是相同的。这与SSn引脚上的电平为高电平时相同。

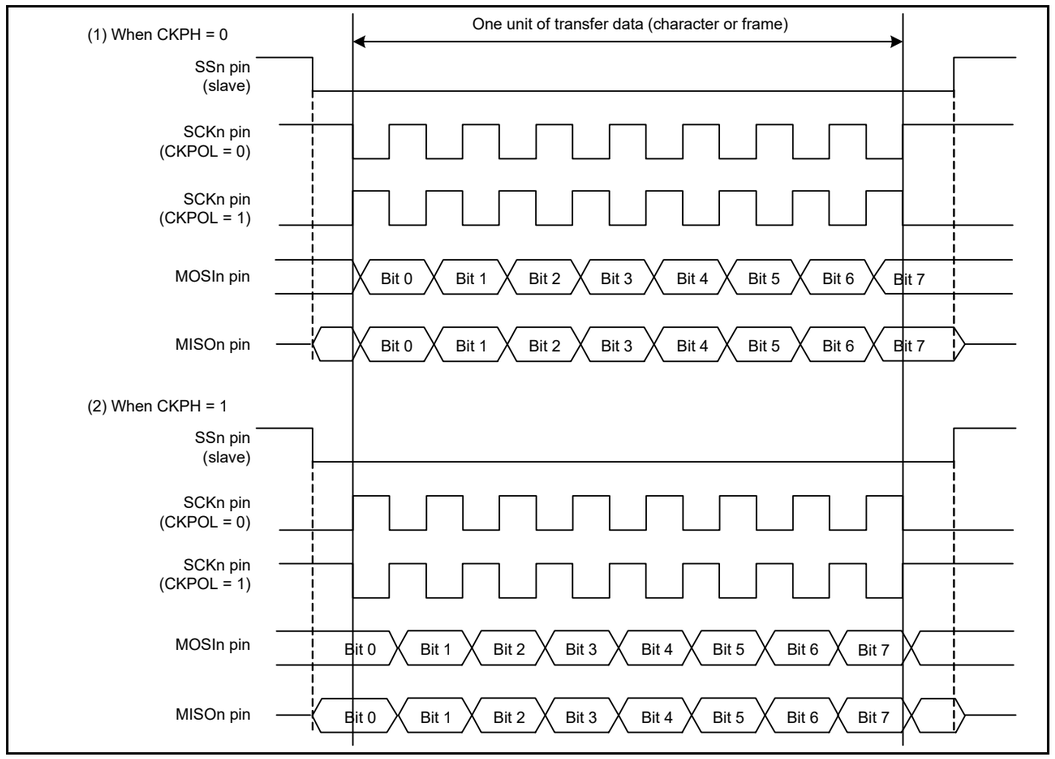


Figure 27.70 Relation between clock signal and transmit or receive data in simple SPI mode

27.8.5 SCI Initialization in Simple SPI Mode

Initialization in simple SPI mode is the same as in clock synchronous mode. See Figure 27.32 for an example initialization flow. The CKPOL and CKPH bits in the SPMR must be set to ensure that the selected clock signal configuration is suitable for both master and slave devices.

Always initialize the SCR register before making any changes to the operating mode or transfer format.

Note: Only the RE bit is set to 0. The SSR.ORER, FER, PER, and RDR flags are not initialized.

Changing the value of the TE bit from 1 to 0 or from 0 to 1 when the TIE bit in the SCR register is 1 at the same time, leads to the generation of a transmit data empty interrupt (SCIn_TXI).

27.8.6 Transmission and Reception of Serial Data in Simple SPI Mode

In master operation, ensure that the SSn pin of the slave device on the other side of the transfer is at a low level before starting the transfer and at a high level on completion of the transfer. Otherwise, the procedures are the same as in clock synchronous mode.

27.9 Bit Rate Modulation Function

Using the bit rate modulation function, the bit rate can be evenly corrected using the number specified in the MDDR register when PCLKA is selected in the CKS[1:0] bits in SMR/SMR_SMCI.

Figure 27.71 shows an example where PCLKA is selected in the CKS[1:0] bits in SMR/SMR_SMCI, the BRR bit is set to 0, and the MDDR is set to 160 in asynchronous mode. In this example, the cycle of the base clock is evenly corrected (256/160) and the bit rate is also corrected (160/256).

Note: Enabling an internal clock causes bias and expansion. Contraction is generated in the pulse width of the internal base clock.

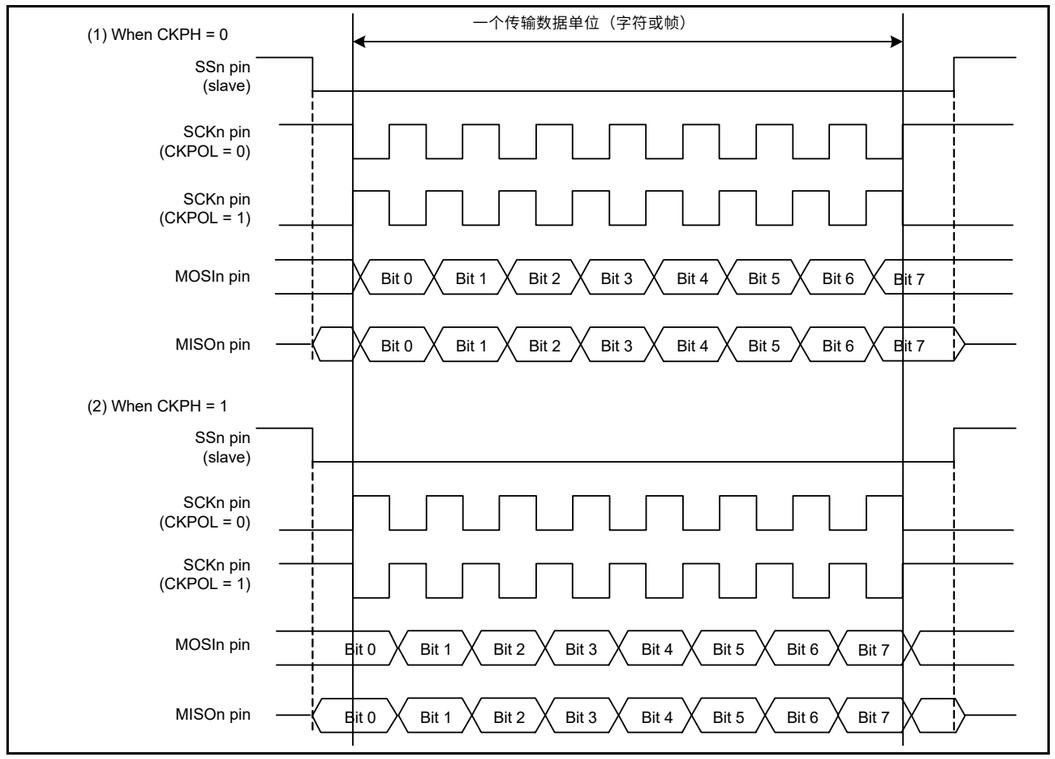


Figure 27.70 简单SPI模式下时钟信号与发送或接收数据的关系

27.8.5 简单SPI模式下的SCI初始化

简单SPI模式的初始化与时钟同步模式相同。有关示例初始化流程，请参见图27.32。必须设置SPMR中的CKPOL和CKPH位，以确保所选时钟信号配置适用于主器件和从器件。

在对操作模式或传输格式进行任何更改之前，始终初始化SCR寄存器。

Note: 只有RE位设置为0。SSR.ORER、FER、PER和RDR标志未初始化。

当SCR寄存器中的TIE位同时为1时，将TE位的值从1更改为0或从0更改为1，会导致产生发送数据空中断（SCIn_TXI）。

27.8.6 简单SPI模式下串行数据的发送和接收

在主机操作中，确保传输另一侧的从设备的SSn引脚在开始传输之前为低电平，在传输完成时为高电平。否则，过程与时钟同步模式相同。

27.9 比特率调制功能

使用比特率调制功能，当在SMRSMR_SMCI的CKS[1:0]位中选择PCLKA时，可以使用MDDR寄存器中指定的数字均匀地校正比特率。

图27.71显示了在SMRSMR_SMCI的CKS[1:0]位中选择PCLKA的示例，BRR位设置为0，并且在异步模式下MDDR设置为160。在这个例子中，基本时钟的周期被均匀地校正（256160）并且比特率也被校正（160256）。

Note: 启用内部时钟会导致偏差和扩展。内部基准时钟的脉冲宽度产生收缩。

Do not use this function in clock synchronous mode and in the highest speed settings in simple SPI mode (SMR.CKS[1:0] = 00b, SCR.CKE[1] = 0, and BRR = 0).

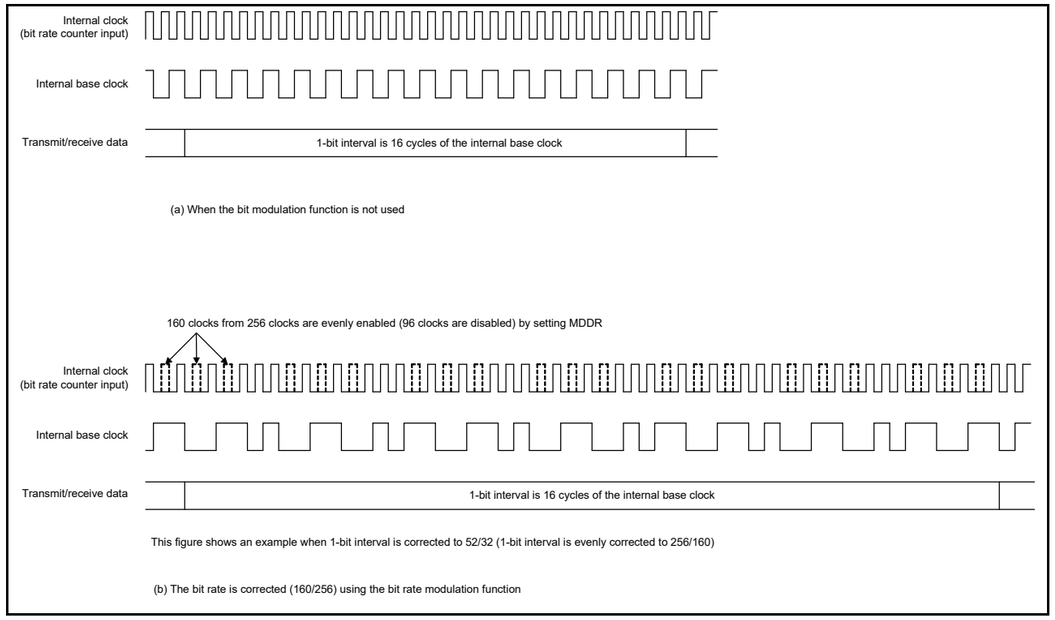


Figure 27.71 Example of internal base clock using bit rate modulation function

27.10 Interrupt Sources

27.10.1 Buffer Operation for SCIn_TXI and SCIn_RXI Interrupts (non-FIFO selected)

If the conditions for an SCIn_TXI and SCIn_RXI interrupt are satisfied while the interrupt status flag in the ICU is 1, the ICU does not output the interrupt request but saves it internally, with a capacity for saving one request per source.

When the interrupt status flag in the ICU becomes 0, the interrupt request retained within the ICU is output. The internally retained interrupt request is automatically discarded when the actual interrupt is output. Clearing of the associated interrupt enable bit (the TIE or RIE bit in the SCR/SCR_SMCI) can also be used to discard an internally retained interrupt request.

27.10.2 Buffer Operation for SCIn_TXI and SCIn_RXI Interrupts (FIFO selected)

When an interrupt status flag in the ICU is set to 1, the SCIn_TXI and SCIn_RXI interrupts do not output interrupt requests to the ICU. When an interrupt status flag of the ICU is set to 0, and if the conditions for SCIn_TXI and SCIn_RXI interrupts are satisfied, an interrupt request is generated.

27.10.3 Interrupts in Asynchronous, Clock Synchronous, and Simple SPI Modes

(1) Non-FIFO selected

Table 27.26 lists interrupt sources in asynchronous, clock synchronous, and simple SPI modes. A different interrupt vector can be assigned to each interrupt source. Individual interrupt sources can be enabled or disabled with the enable bits in the SCR register.

If the SCR.TIE bit is 1, an SCIn_TXI interrupt request is generated when transmit data is transferred from the TDR or TDRHL register*1 to the TSR register. An SCIn_TXI interrupt request can also be generated using a single instruction to set the SCR.TE and SCR.TIE bits to 1 simultaneously. An SCIn_TXI interrupt request can activate the DMAC or DTC to handle data transfer.

不要在时钟同步模式和简单SPI模式的最高速度设置（SMR.CKS[1:0]=00b，SCR.CKE[1]=0和BRR=0）中使用此功能。

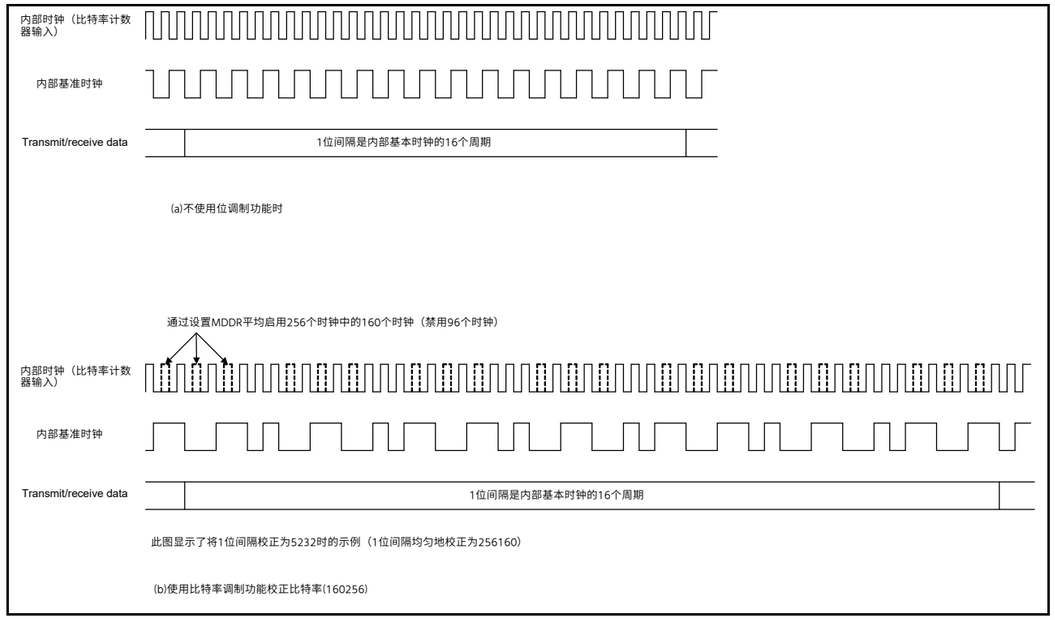


Figure 27.71 使用比特率调制功能的内部基准时钟示例

27.10 中断源

27.10.1 SCIn_TXI和SCIn_RXI中断的缓冲区操作（选择非FIFO）

如果在ICU中的中断状态标志为1时满足SCIn_TXI和SCIn_RXI中断的条件，则ICU不输出中断请求，而是在内部保存，每个源可以保存一个请求。

当ICU中的中断状态标志变为0时，输出ICU中保留的中断请求。当实际中断输出时，内部保留的中断请求会被自动丢弃。清除相关中断使能位（SCRSCR_SMCI中的TIE或RIE位）也可用于丢弃内部保留的中断请求。

27.10.2 SCIn_TXI和SCIn_RXI中断的缓冲区操作（选择FIFO）

当ICU中的中断状态标志设置为1时，SCIn_TXI和SCIn_RXI中断不会向ICU输出中断请求。当ICU的中断状态标志设置为0时，如果满足SCIn_TXI和SCIn_RXI中断的条件，则产生中断请求。

27.10.3 异步、时钟同步和简单SPI模式下的中断

(1) Non-FIFO selected

表27.26列出了异步、时钟同步和简单SPI模式下的中断源。可以为每个中断源分配不同的中断向量。可以使用SCR寄存器中的启用位启用或禁用各个中断源。

如果SCR.TIE位为1，则当发送数据从TDR传输或TDRHL寄存器*1到TSR寄存器。也可以使用一条指令同时将SCR.TE和SCR.TIE位设置为1来生成SCIn_TXI中断请求。SCIn_TXI中断请求可以激活DMAC或DTC来处理数据传输。

An SCIn_TXI interrupt request is not generated by setting the SCR.TE bit to 1 when SCR.TIE is 0 or by setting the SCR.TIE bit to 1 when the SCR.TE is 1.*2

When new data is not written by the time of transmission of the last bit of the current transmit data and SCR.TEIE is 1, the SSR.TEND flag sets to 1 and an SCIn_TEI interrupt request is generated. Additionally, when SCR.TE is 1, the SSR.TEND flag retains the value 1 until more transmit data are written to the TDR or TDRHL register*1, and setting SCR.TEIE to 1 leads to the generation of an SCIn_TEI interrupt request.

Writing data to the TDR or TDRHL register*1 leads to clearing of the SSR.TEND flag and, after a certain time, discarding of the SCIn_TEI interrupt request.

If the SCR.RIE bit is 1, an SCIn_RXI interrupt request is generated when received data is stored in the RDR register. An SCIn_RXI interrupt request can activate the DMAC or DTC to handle data transfer.

Setting any of the ORER, FER, and PER flags in the SSR register to 1 while the SCR.RIE bit is 1 leads to the generation of an SCIn_ERI interrupt request. An SCIn_RXI interrupt request is not generated at this time. Clearing all three flags (ORER, FER, and PER) leads to discarding of the SCIn_ERI interrupt request.

(2) FIFO selected

Table 27.27 lists the interrupt sources in FIFO selected mode.

If the SCR.TIE bit is 1, an SCIn_TXI interrupt request is generated when the amount of stored data in the FTDRL register becomes equal to or less than the threshold value indicated in FCR.TTRG. An SCIn_TXI interrupt request can also be generated by using a single instruction to set the SCR.TE and SCR.TIE bits to 1 simultaneously.

An SCIn_TXI interrupt request is not generated by setting SCR.TE to 1 when SCR.TIE is 0 or by setting SCR.TIE to 1 when SCR.TE is 1.

If SCR.TEIE is 1 and if the next data is not written to the FTDRL register by the time the last bit of the transmit data is sent, the SSR_FIFO.TEND flag is set to 1 and the SCIn_TEI interrupt request is generated.

If SCR.RIE is 1, the SCIn_RXI interrupt request is generated when the amount of stored data in the FRDRL register becomes equal to or greater than the threshold value indicated in FCR.RTRG. When RTRG is 0, an SCIn_RXI interrupt does not occur even when the amount of data in the receive FIFO is equal to 0.

If the SCR.RIE bit is 1, when the SSR_FIFO.ORER flag is set to 1 or data with a framing error or a parity error is stored in the FRDRL register, the SCIn_ERI interrupt request is generated. When the amount of data stored in the FRDRL register is at or above the threshold value, the SCIn_RXI interrupt request is also generated. The SCIn_ERI interrupt request can be canceled, in which case the SSR_FIFO.ORER, FER, and PER flags are all cleared.

Note 1. When asynchronous mode and 9-bit data length are selected.
Note 2. To temporarily prohibit the SCIn_TXI interrupts on transmission of the last of the data when a new round of transmission is to be started, after handling the transmission-completed interrupt, control the activation of the interrupt by using the interrupt request enable bit in the ICU rather than using the SCR.TIE bit. This approach can prevent the suppression of the SCIn_TXI interrupt requests in the transfer of new data.

Table 27.26 SCI interrupt sources with non-FIFO selected

Name	Interrupt source	Interrupt flag	Interrupt enable	DTC activation	DMAC activation
SCIn_ERI	Receive error*1	ORER, FER, PER, DFER, DPER	RIE	Not possible	Not possible
SCIn_RXI	Receive data full	RDRF	RIE	Possible	Possible
	Address match	DCMF	RIE	Possible	Possible
SCIn_AM	Address match	DCMF	-	Possible	Possible
SCIn_TXI	Transmit data empty	TDRE	TIE	Possible	Possible
SCIn_TEI	Transmit end	TEND	TEIE	Not possible	Not possible

Note 1. The interrupt flag is only ORER when in clock synchronous mode and simple SPI mode.

当SCR.TIE为0时将SCR.TE位设置为1或通过设置
当SCR.TE为1时，SCR.TIE位为1。*2

如果在当前发送数据的最后一位发送时没有写入新数据且SCR.TEIE为1，则SSR.TEND标志设置为1，并产生SCIn_TEI中断请求。此外，当SCR.TE为1时，SSR.TEND标志保持值1，直到有更多发送数据写入TDR或TDRHL寄存器*1，并且设置

SCR.TEIE为1导致产生SCIn_TEI中断请求。

将数据写入TDR或TDRHL寄存器*1会导致SSR.TEND标志清零，并在一定时间后丢弃SCIn_TEI中断请求。

如果SCR.RIE位为1，则当接收到的数据存储在RDR寄存器中时会产生SCIn_RXI中断请求。一个SCIn_RXI中断请求可以激活DMAC或DTC来处理数据传输。

当SCR.RIE位为1时，将SSR寄存器中的任何ORER、FER和PER标志设置为1会导致产生SCIn_ERI中断请求。此时不产生SCIn_RXI中断请求。清除所有三个标志（ORER、FER和PER）会导致丢弃SCIn_ERI中断请求。

(2) FIFO selected

表27.27列出了FIFO选择模式下的中断源。

如果SCR.TIE位为1，则当FTDRL寄存器中存储的数据量等于或小于FCR.TTRG中指示的阈值时，将产生SCIn_TXI中断请求。通过使用一条指令同时将SCR.TE和SCR.TIE位设置为1，也可以生成SCIn_TXI中断请求。

当SCR.TIE为0时将SCR.TE设置为1，或者当SCR.TE为1时将SCR.TIE设置为1，不会产生SCIn_TXI中断请求。

如果SCR.TEIE为1，并且在发送数据的最后一位时下一个数据未写入FTDRL寄存器，则SSR_FIFO.TEND标志设置为1，并产生SCIn_TEI中断请求。

如果SCR.RIE为1，则当FRDRL寄存器中存储的数据量等于或大于FCR.RTRG中指示的阈值时，将产生SCIn_RXI中断请求。当RTRG为0时，即使接收FIFO中的数据量等于0，也不会发生SCIn_RXI中断。

如果SCR.RIE位为1，当SSR_FIFO.ORER标志设置为1或帧错误或奇偶校验错误的数据存储在FRDRL寄存器中时，将产生SCIn_ERI中断请求。当FRDRL寄存器中存储的数据量等于或高于阈值时，也会产生SCIn_RXI中断请求。SCIn_ERI中断请求可以被取消，在这种情况下SSR_FIFO.ORER、FER和PER标志都被清除。

注意1.选择异步模式和9位数据长度时。
注2.为在新一轮传输开始时暂时禁止SCIn_TXI中断对最后一个数据的传输，在处理完传输完成中断后，使用中断请求使能位控制中断的激活。ICU而不是使用SCR.TIE位。这种方法可以防止在传输新数据时抑制SCIn_TXI中断请求。

Table 27.26 选择了非FIFO的SCI中断源

Name	中断源	中断标志	中断使能	DTC activation	DMAC activation
SCIn_ERI	Receive error*1	ORER、FER、PER、DFER, DPER	RIE	不可能	不可能
SCIn_RXI	接收数据已满	RDRF	RIE	Possible	Possible
	地址匹配	DCMF	RIE	Possible	Possible
SCIn_AM	地址匹配	DCMF	-	Possible	Possible
SCIn_TXI	传输数据为空	TDRE	TIE	Possible	Possible
SCIn_TEI	发射端	TEND	TEIE	不可能	不可能

注1.仅在时钟同步模式和简单SPI模式下中断标志为ORER。

Table 27.27 SCI interrupt sources with FIFO selected

Name	Interrupt source	Interrupt flag	Interrupt enable	DTC activation	DMAC activation
SCIn_ERI	Receive error*1	ORER, FER, PER, DFER, DPER	RIE	Not possible	Not possible
		DR (when FCR.DRES = 1)	RIE	Not possible	Not possible
SCIn_RXI	Receive data full	RDF	RIE	Possible	Possible
	Receive data ready	DR (when FCR.DRES = 0)	RIE	Possible	Possible
	Address match	DCMF	RIE	Possible	Possible
SCIn_AM	Address match	DCMF	-	Possible	Possible
SCIn_TXI	Transmit data empty	TDFE	TIE	Possible	Possible
SCIn_TEI	Transmit end	TEND	TEIE	Not possible	Not possible

Note 1. The interrupt flag is only ORER when in clock synchronous mode and simple SPI mode.

27.10.4 Interrupts in Smart Card Interface Mode

Table 27.28 lists the interrupt sources in smart card interface mode. A transmit end interrupt (SCIn_TEI) request and an address match (SCIn_AM) request cannot be used in this mode.

Table 27.28 SCI Interrupt sources in smart card interface mode

Name	Interrupt source	Interrupt flag	Interrupt enable	DTC activation	DMAC activation
SCIn_ERI	Receive error or error signal detection	ORER, FER, ERS	RIE	Not possible	Not possible
SCIn_RXI	Receive data full	RDRF	RIE	Possible	Possible
SCIn_TXI	Transmit end	TEND	TIE	Possible	Possible

Data transmission or reception using the DMAC or DTC is also possible in smart card interface mode. In transmission, when the SSR_SMCI.TEND flag is set to 1, an SCIn_TXI interrupt request is generated. The SCIn_TXI interrupt request activates the DMAC or DTC, allowing the transfer of transmit data if the SCIn_TXI request is previously specified as a source for DMAC or DTC activation. The TEND flag is automatically set to 0 when the DMAC or DTC transfers the data.

If an error occurs, the SCI automatically retransmits the same data. During the retransmission, the TEND flag is kept at 0 and the DMAC or DTC is not activated. Therefore, the SCI and DMAC or DTC automatically transmit the specified number of bytes, including retransmission when errors occur. However, the SSR_SMCI.ERS flag is not automatically cleared to 0 at error occurrence. Therefore, the ERS flag must be cleared by previously setting the SCR_SMCI.RIE bit to 1 to enable an SCIn_ERI interrupt request to be generated at error occurrence.

When transmitting or receiving data using the DMAC or DTC, always enable the DMAC or DTC before setting the SCI. For DMAC or DTC settings, see section 16, DMA Controller (DMAC) and section 17, Data Transfer Controller (DTC).

In reception, an SCIn_RXI interrupt request is generated when receive data is set to RDR. The SCIn_RXI interrupt request activates the DMAC or DTC, allowing transfer of receive data if the SCIn_RXI request is previously specified as a source of DMAC or DTC activation. If an error occurs, the error flag is set. Therefore, the DMAC or DTC is not activated and an SCIn_ERI interrupt request is issued to the CPU instead. The error flag must be cleared.

27.10.5 Interrupts in Simple IIC Mode

Table 27.29 lists the interrupt sources in simple IIC mode. The STI interrupt is allocated to the transmit end interrupt (SCIn_TEI) request. The receive error interrupt (SCIn_ERI) and the address match (SCIn_AM) request cannot be used.

The DMAC or DTC can also be used to handle transfer in simple IIC mode.

When the SIMR2.IICINTM bit is 1:

- An SCIn_RXI request is generated on the falling edge of the SCLn signal for the 8th bit. If SCIn_RXI is previously

Table 27.27 选择了FIFO的SCI中断源

Name	中断源	中断标志	中断使能	DTC activation	DMAC activation
SCIn_ERI	Receive error*1	ORER、FER、PER、DFER, DPER	RIE	不可能	不可能
		DR (when FCR.DRES = 1)	RIE	不可能	不可能
SCIn_RXI	接收数据已满	RDF	RIE	Possible	Possible
	接收数据就绪	DR (when FCR.DRES = 0)	RIE	Possible	Possible
	地址匹配	DCMF	RIE	Possible	Possible
SCIn_AM	地址匹配	DCMF	-	Possible	Possible
SCIn_TXI	传输数据为空	TDFE	TIE	Possible	Possible
SCIn_TEI	发射端	TEND	TEIE	不可能	不可能

注1.仅在时钟同步模式和简单SPI模式下中断标志为ORER。

27.10.4 智能卡接口模式中的中断

表27.28列出了智能卡接口模式下的中断源。在此模式下不能使用发送结束中断(SCIn_TEI)请求和地址匹配(SCIn_AM)请求。

Table 27.28 智能卡接口模式下的SCI中断源

Name	中断源	中断标志	中断使能	DTC activation	DMAC activation
SCIn_ERI	接收错误或错误信号检测	ORER、FER、ERS	RIE	不可能	不可能
SCIn_RXI	接收数据已满	RDRF	RIE	Possible	Possible
SCIn_TXI	发射端	TEND	TIE	Possible	Possible

在智能卡接口模式下也可以使用DMAC或DTC进行数据传输或接收。在发送过程中，当SSR_SMCI.TEND标志设置为1时，会产生一个SCIn_TXI中断请求。SCIn_TXI中断请求激活DMAC或DTC，如果之前将SCIn_TXI请求指定为DMAC或DTC激活源，则允许传输数据。当DMAC或DTC传输数据时，TEND标志自动设置为0。

如果发生错误，SCI会自动重新传输相同的数据。在重传期间，TEND标志保持为0，并且不激活DMAC或DTC。因此，SCI和DMAC或DTC会自动传输指定的字节数，包括发生错误时的重传。但是，发生错误时，SSR_SMCI.ERS标志不会自动清除为0。因此，必须通过预先将SCR_SMCI.RIE位设置为1来清除ERS 标志，以在发生错误时启用SCIn_ERI中断请求。

使用DMAC或DTC发送或接收数据时，请务必在设置SCI之前启用DMAC或DTC。对于DMAC或DTC设置，请参阅第16节，DMA控制器(DMAC)和第17节，数据传输控制器(DTC)。

在接收中，当接收数据设置为RDR时会产生SCIn_RXI中断请求。SCIn_RXI中断请求激活DMAC或DTC，如果之前将SCIn_RXI请求指定为DMAC或DTC激活源，则允许传输接收数据。如果发生错误，则设置错误标志。因此，不会激活DMAC或DTC，而是向CPU发出SCIn_ERI中断请求。必须清除错误标志。

27.10.5 简单IIC模式下的中断

表27.29列出了简单IIC模式下的中断源。STI中断分配给发送结束中断(SCIn_TEI)请求。不能使用接收错误中断(SCIn_ERI)和地址匹配(SCIn_AM)请求。

DMAC或DTC也可用于处理简单IIC模式下的传输。

当SIMR2.IICINTM位为1时：

- SCIn_RXI请求在第8位的SCLn信号的下降沿产生。如果SCIn_RXI之前是

set up as an activation source for the DMAC or DTC, the SCIn_RXI request activates the DMAC or DTC to handle transfer of the received data.

- An SCIn_TXI request is generated on the falling edge of the SCLn signal for the 9th bit (acknowledge bit). If SCIn_TXI is previously set up as an activation source for the DMAC or DTC, the SCIn_TXI request activates the DMAC or DTC to handle transfer of the transmit data.

When the SIMR2.IICINTM bit is 0:

- An SCIn_RXI request (ACK detection) is generated if the input on the SDAn pin is low on the rising edge of the SCLn signal for the 9th bit (acknowledge bit)
- An SCIn_TXI request (NACK detection) is generated if the input on the SDAn pin is high on the rising edge of the SCLn signal for the 9th bit (acknowledge bit)
- If SCIn_RXI is previously set up as an activation source for the DMAC or DTC, the SCIn_RXI request activates the DMAC or DTC to handle the transfer of the received data.

If the DMAC or DTC is used for data transfer in reception or transmission, always set up and enable the DMAC or DTC before setting up the SCI.

When the IICSTAREQ, IICRSTAREQ, and IICSTPREQ bits in SIMR3 are used to generate a start condition, restart condition, or stop condition, the STI request is issued when generation is complete.

Table 27.29 SCI interrupt sources in simple IIC mode

Name	Interrupt source	Interrupt flag	Interrupt enable	DTC activation	DMAC activation
SCIn_RXI	Reception, ACK detection	-	RIE	Possible	Possible
SCIn_TXI	Transmission, NACK detection	-	TIE	Possible	Possible
STIn	Completion of generation of a start, restart, or stop condition	IICSTIF	TEIE	Not possible	Not possible

Note 1. Activation of the DTC is only possible when the SIMR2.IICINTM bit is 1 (use reception and transmission interrupts).

27.11 Event Linking

By using interrupt request signals as event signals, the SCI can provide linked operation through the Event Link Controller (ELC) for modules selected in advance.

Event signals can be output regardless of the values of the associated interrupt request enable bits.

(1) Error event output (receive error or error signal detected)

- Indicates abnormal termination because of a parity error during reception in asynchronous mode
- Indicates abnormal termination because of a framing error during reception in asynchronous mode
- Indicates abnormal termination because of an overrun error during reception
- Indicates detection of the error signal during transmission in smart card interface mode
- Indicates that when the SSR_FIFO.FER and PER flags are 0, and receive data less than the receive FIFO data trigger number is in the receive FIFO buffer, 15 ETUs elapse when FIFO is selected and the FCR.DRES bit is 1.

(2) Receive data full event output

- Indicates that ACK is detected if the SIMR2.IICINTM bit is 0 in simple IIC mode
- Indicates that the 8th bit SCLn falling edge is detected if the SIMR2.IICINTM bit is 1 in simple IIC mode
- When the SIMR2.IICINTM bit is 1 during master transmission in simple IIC mode, set the ELC so that receive data full events are not used.

设置为DMAC或DTC的激活源时，SCIn_RXI请求将激活DMAC或DTC以处理接收数据的传输。

- SCIn_TXI请求在第9位（确认位）的SCLn信号的下降沿生成。如果SCIn_TXI先前设置为DMAC或DTC的激活源，SCIn_TXI请求激活DMAC或DTC来处理传输数据的传输。

当SIMR2.IICINTM位为0时：

- 如果SDAn引脚上的输入在第9位的SCLn信号（确认位）
- 如果SDAn引脚上的输入在第9位的SCLn信号（确认位）
- 如果SCIn_RXI先前设置为DMAC或DTC的激活源，则SCIn_RXI请求会激活DMAC或DTC来处理接收数据的传输。

如果DMAC或DTC用于接收或传输中的数据传输，请始终在设置SCI之前设置并启用DMAC或DTC。

当SIMR3中的IICSTAREQ、IICRSTAREQ和IICSTPREQ位用于生成开始条件、重新启动条件或停止条件时，生成完成时会发出STI请求。

Table 27.29 简单IIC模式下的SCI中断源

Name	中断源	中断标志	中断使能	DTC activation	DMAC activation
SCIn_RXI	接收、ACK检测	-	RIE	Possible	Possible
SCIn_TXI	传输、NACK检测	-	TIE	Possible	Possible
STIn	完成启动、重新启动或停止条件的生成	IICSTIF	TEIE	不可能	不可能

注1.只有当SIMR2.IICINTM位为1（使用接收和发送中断）时，才能激活DTC。

27.11 事件链接

通过使用中断请求信号作为事件信号，SCI可以通过EventLink提供链接操作预先选择的模块的控制器(ELC)。

无论相关中断请求使能位的值如何，都可以输出事件信号。

(1) 错误事件输出（接收错误或检测到错误信号）

- 表示在异步模式下接收期间由于奇偶校验错误而异常终止
- 指示在异步模式下接收期间由于帧错误而异常终止
- 表示接收期间由于溢出错误而异常终止
- 指示在智能卡接口模式下传输期间检测到错误信号
- 表示当SSR_FIFO.FER和PER标志为0且接收数据小于接收FIFO数据触发数在接收FIFO缓冲区时，选择FIFO且FCR.DRES位为1时经过15个ETU。

(2) 接收数据满事件输出

- 如果SIMR2.IICINTM位在简单IIC模式下为0，则表示检测到ACK
- 表示如果SIMR2.IICINTM位在简单IIC模式下为1，则检测到第8位SCLn下降沿
- 当SIMR2.IICINTM位在简单IIC模式下主机发送期间为1时，设置ELC以便不使用接收数据满事件。

(a) Non-FIFO selected

- Indicates that received data is set in the Receive Data Register (RDR or RDRHL).

(b) FIFO selected

- Using this event output is prohibited.

(3) Transmit data empty event output

- Indicates that the SCR/SCR_SMCI.TE bit changed from 0 to 1
- Indicates that transmission is complete in smart card interface mode
- Indicates that NACK is detected if the SIMR2.IICINTM bit is 0 in simple IIC mode
- Indicates that the 9th-bit SCLn falling edge is detected if the SIMR2.IICINTM bit is 1 in simple IIC mode.

(a) Non-FIFO selected

- Indicates that transmit data is transferred from the Transmit Data Register (TDR or TDRHL) to the Transmit Shift Register (TSR).

(b) FIFO selected

- Using this event output is prohibited.

(4) Transmit end event output

- Indicates the completion of transmission
- Indicates that the starting condition, restart condition, or stop condition is generated in simple IIC mode

Note: When FIFO is selected, using this event output is prohibited.

(5) Address match event output

- Indicates a match of the comparison data (CDR.CMPD) with one frame of receive data when DCCR.DCME is set to 1 in asynchronous mode, including multi-processor mode.

27.12 Address Mismatch Event Output (SCI0_DCUF)

The address mismatch event output, SCI0_DCUF, indicates a mismatch of the comparison data (CDR.CMPD) with one frame of receive data when DCCR.DCME is set to 1 in asynchronous mode, including multi-processor mode. This event can be used for snooze end request only.

27.13 Noise Cancellation Function

Figure 27.72 shows the configuration of the noise filter used for noise cancellation. The noise filter consists of a 2-stage flip-flop circuit and a match detection circuit. When the input signals of the noise filter and the output signals of the 2-stage flip-flop circuits completely match, the matched level is an internal signal. Unless a match occurs, the previous value is retained. When the same level is retained for 3 cycles or longer on the sampling clock of the noise filter, it is considered as a valid receive signal. A change in pulse for 3 cycles or shorter is considered as noise and not as a receive signal.

When SEMR.ABCS = 0 and SEMR.ABCSE = 0, the cycle is 1/16 the period of 1 transfer bit.

When SEMR.ABCS = 1 and SEMR.ABCSE = 0, the cycle is 1/8 the period of 1 transfer bit.

When SEMR.ABCSE = 1, the cycle is 1/6 the period of 1 transfer bit.

In asynchronous mode, the noise cancellation function can be applied to the receive signal input on the RXDn pin. The receive level of the RXDn is sampled in the flip-flop circuit of the noise filter on the base clock of the asynchronous mode.

In simple IIC mode, the noise cancellation function can be used for each input on SDAn and SCLn. The sampling clock for the noise cancellation function is selected in the SNFR.NFCS[2:0] bit by dividing the baud rate generator source clock by 1, 2, 4, or 8.

If the base clock is stopped with the noise filter enabled and the base clock input is restarted again, the noise filter

(a) Non-FIFO selected

- 表示接收数据设置在接收数据寄存器（RDR或RDRHL）中。

(b) FIFO selected

- 禁止使用此事件输出。

(3) 传输数据空事件输出

- 表示SCRSCR_SMCI.TE位由0变为1
- 表示在智能卡接口模式下传输完成
- 如果SIMR2.IICINTM位在简单IIC模式下为0，则表示检测到NACK
- 表示如果SIMR2.IICINTM位在简单IIC模式下为1，则检测到第9位SCLn下降沿。

(a) Non-FIFO selected

- 表示发送数据从发送数据寄存器（TDR或TDRHL）传输到发送移位 Register (TSR).

(b) FIFO selected

- 禁止使用此事件输出。

(4) 发送结束事件输出

- 表示传输完成
- 指示在简单IIC模式下生成启动条件、重启条件或停止条件

Note: 选择FIFO时，禁止使用该事件输出。

(5) 地址匹配事件输出

- 当DCCR.DCME在异步模式（包括多处理器模式）下设置为1时，表示比较数据(CDR.CMPD)与一帧接收数据的匹配。

27.12 地址不匹配事件输出(SCI0_DCUF)

地址不匹配事件输出SCI0_DCUF指示当DCCR.DCME在异步模式（包括多处理器模式）下设置为1时比较数据(CDR.CMPD)与一帧接收数据不匹配。此事件仅可用于贪睡结束请求。

27.13 降噪功能

图27.72显示了用于噪声消除的噪声滤波器的配置。噪声滤波器由一个2级触发器电路和一个匹配检测电路组成。当噪声滤波器的输入信号与2级触发器电路的输出信号完全匹配时，匹配电平为内部信号。除非发生匹配，否则将保留先前的值。当相同电平在噪声滤波器的采样时钟上保持3个周期或更长时间时，它被认为是有效的接收信号。3个周期或更短的脉冲变化被认为是噪声而不是接收信号。

当SEMR.ABCS=0且SEMR.ABCSE=0时，周期为1161个传输位的周期。

当SEMR.ABCS=1和SEMR.ABCSE=0时，周期为181个传输位的周期。

当SEMR.ABCSE=1时，周期为161个传输位的周期。

在异步模式下，可以对RXDn引脚上的接收信号输入应用噪声消除功能。RXDn的接收电平在异步模式的基本时钟上在噪声滤波器的触发器电路中进行采样。

在简单IIC模式下，可以对SDAn和SCLn上的每个输入使用噪声消除功能。通过将波特率发生器源时钟除以1、2、4或8，在SNFR.NFCS[2:0]位中选择噪声消除功能的采样时钟。

如果在启用噪声滤波器的情况下停止基本时钟并且再次重新启动基本时钟输入，则噪声滤波器

operation resumes from the state where the clock was stopped. When SCR.TE and SCR.RE are set to 0 during base clock input, all of the noise filter flip-flop values are initialized to 1. Accordingly, if the input data is 1 when reception operation resumes, the function determines that a level match is detected and the result is an internal signal. When the level being input corresponds to 0, the initial output of the noise filter is retained until the level matches in 3 consecutive sampling cycles.

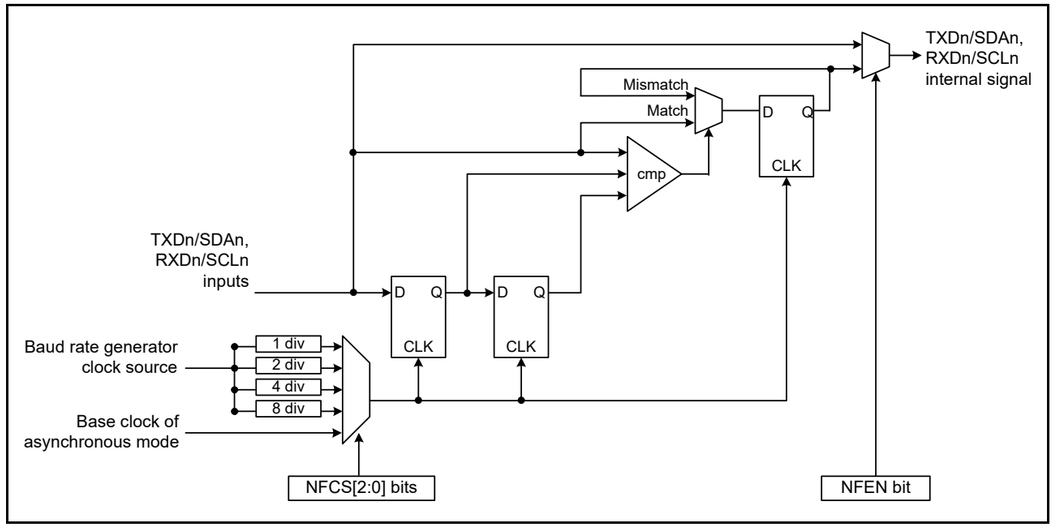


Figure 27.72 Digital noise filter circuit block diagram

27.14 Usage Notes

27.14.1 Settings for the Module-Stop State

The Module Stop Control Register B (MSTPCRB) can enable or disable SCI operation. The SCI is initially stopped after a reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

27.14.2 SCI Operation during Low Power State

(1) Transmission

When setting the module to the stopped state or in transition to Software Standby, stop the operation (by setting the TIE, TE, and TEIE bits in the SCR/SCR_SMCI to 0) after switching the TXDn pin to the general I/O port pin function. When setting the I/O port as an SCI connection, the SPTR register can control the state of the TXDn pin. Setting the TE bit to 0 initializes the TSR register. The TEND bit in the SSR/SSR_SMCI is initialized to 1 with non-FIFO selected. The value is saved with FIFO selected. Depending on the port settings and the SPTR register settings, output pins might output the level before a transition to the low power state is made after release from the module-stop state or Software Standby mode. When transitions to these states are made during transmission, the transmitted data becomes indeterminate.

To transmit data in the same transmission mode after cancellation of the low power state:

1. Set the TE bit to 1.
2. Read SSR/SSR_FIFO/SSR_SMCI.
3. Write data to TDR sequentially to start data transmission.

To transmit data with a different transmission mode, initialize the SCI first.

Figure 27.73 shows an example flow of transition to Software Standby mode during transmission. Figure 27.74 and Figure 27.75 show the port pin states during transition to Software Standby mode.

Before specifying the module-stop state or making a transition to Software Standby mode from the transmission mode

操作从时钟停止的状态恢复。当SCR.TE和SCR.RE在基本时钟输入期间设置为0时，所有噪声滤波器触发器值都被初始化为1。因此，如果在接收操作恢复时输入数据为1，则该函数确定一个电平检测到匹配，结果是一个内部信号。当输入的电平对应于0时，保留噪声滤波器的初始输出，直到电平在3个连续采样周期内匹配。

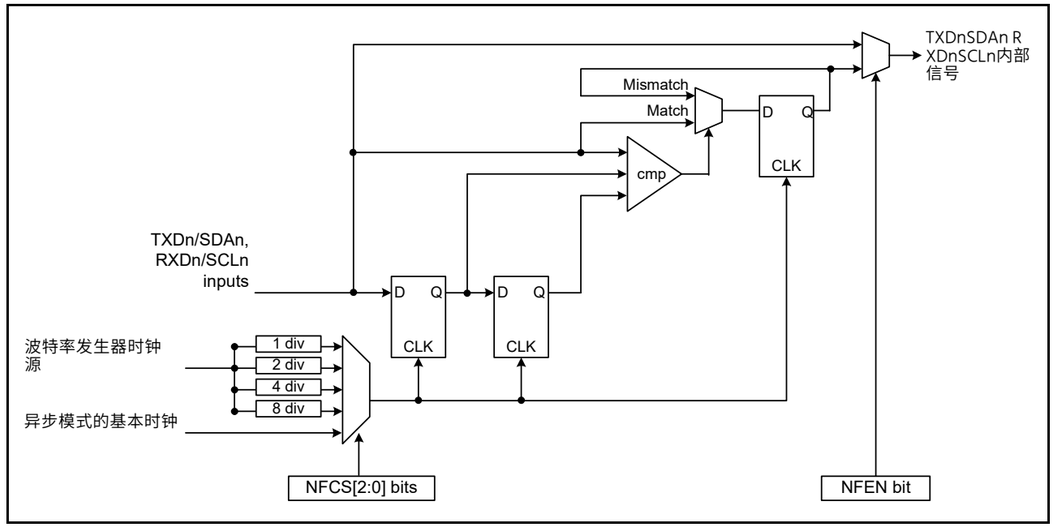


Figure 27.72 数字噪声滤波器电路框图

27.14 使用说明

27.14.1 模块停止状态的设置

模块停止控制寄存器B(MSTPCRB)可以启用或禁用SCI操作。SCI在复位后最初停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

27.14.2 低功耗状态下的SCI操作

(1) Transmission

将模块设置为停止状态或转换到软件待机时，在将TXDn引脚切换到通用IO端口引脚功能后停止操作（通过将SCRSCR_SMCI中的TIE、TE和TEIE位设置为0）。当设置IO口为SCI连接时，SPTR寄存器可以控制TXDn引脚的状态。将TE位设置为0初始化TSR寄存器。SSRSSR_SMCI中的TEND位在选择非FIFO时初始化为1。该值在选择FIFO的情况下保存。根据端口设置和SPTR寄存器设置，输出引脚可能会在从模块停止状态或软件待机模式释放后转换到低功耗状态之前输出电平。在传输过程中转换到这些状态时，传输的数据变得不确定。

在取消低功耗状态后以相同的传输模式传输数据：

1. 将TE位设置为1。
2. Read SSR/SSR_FIFO/SSR_SMCI.
3. 将数据顺序写入TDR以开始数据传输。

要以不同的传输模式传输数据，请先初始化SCI。

图27.73显示了传输期间转换到软件待机模式的示例流程。图27.74和图27.75显示了转换到软件待机模式期间的端口引脚状态。

在指定模块停止状态或从传输模式转换到软件待机模式之前

using DTC transfer, stop the transmit operations (TE = 0). To start transmission after cancellation using the DTC, set the TE bit to 1. The SCIn_TXI interrupt flag is set to 1 and transmission starts using the DTC.

(2) Reception

(a) When address match function is not used as a wakeup condition

Before specifying the module-stop state or making a transition to Software Standby mode, stop the receive operations (RE = 0 in SCR/SCR_SMCI). If transition is made during data reception, the received data is invalid.

Figure 27.76 shows an example flow for transition to Software Standby mode during reception.

(b) When address match function is used as a wakeup condition

Before specifying the module-stop state or making a transition to Software Standby mode:

1. Set the operations after cancellation of the low power state.
2. Set CDR.CMPD and DCCR.DCME to 1.
3. Set the receive operations (RE = 1 in SCR/SCR_SMCI).
4. Set the module-stop state or Software Standby mode.

When the SCI transfers to the low power mode, if the receive data pin (RXD) is at the low level, set SEMR.RXDESEL to 0. When setting SEMR.RXDESEL to 1, there is a possibility that a start bit (falling edge of RXDn pin) cannot be detected on release of the low power mode.

Figure 27.77 shows an example flow of transition to Software Standby mode during reception with address match.

(c) When using SCI0 in Snooze mode

When using SCI0 in Snooze mode, some restrictions apply, including maximum bit rates. For details, see section 11, Low Power Modes.

使用DTC传输，停止传输操作(TE=0)。要在使用DTC取消后开始发送，请将TE位设置为1。SCIn_TXI中断标志 设置为1并使用DTC开始发送。

(2) Reception

(a) 当地址匹配功能不用作唤醒条件时

在指定模块停止状态或转换到软件待机模式之前，停止接收操作（SCRSCR_SMCI中的RE=0）。如果在数据接收期间进行转换，则接收到的数据无效。

图27.76显示了接收期间转换到软件待机模式的示例流程。

(b) 当地址匹配功能用作唤醒条件时

在指定模块停止状态或转换到软件待机模式之前：

1. 设置取消低功耗状态后的操作。
2. 将CDR.CMPD和DCCR.DCME设置为1。
3. 设置接收操作（在SCRSCR_SMCI中RE=1）。
4. 设置模块停止状态或软件待机模式。

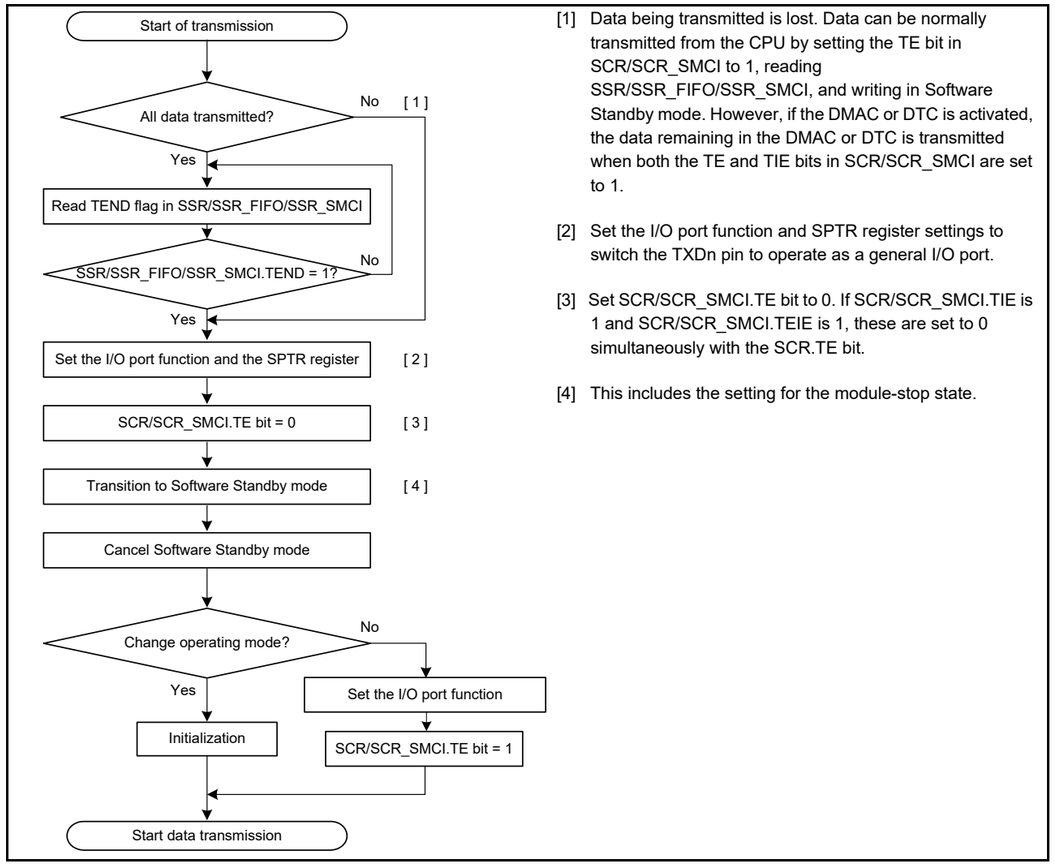
当SCI转移到低功耗模式时，如果接收数据引脚(RXD)处于低电平，则将SEMR.RXDESEL设置为0。当设置SEMR.RXDESEL为1时，可能会出现起始位（下降沿RXDn引脚）不能在低功耗模式释放时被检测到。

图27.77显示了在地址匹配的接收期间转换到软件待机模式的示例流程。

(c) 在贪睡模式下使用SCI0时

在贪睡模式下使用SCI0时，有一些限制，包括最大比特率。有关详细信息，请参阅第11节，低功耗模式。

RA生态工作室



[1] Data being transmitted is lost. Data can be normally transmitted from the CPU by setting the TE bit in SCR/SCR_SMCI to 1, reading SSR/SSR_FIFO/SSR_SMCI, and writing in Software Standby mode. However, if the DMAC or DTC is activated, the data remaining in the DMAC or DTC is transmitted when both the TE and TIE bits in SCR/SCR_SMCI are set to 1.

[2] Set the I/O port function and SPTR register settings to switch the TXDn pin to operate as a general I/O port.

[3] Set SCR/SCR_SMCI.TE bit to 0. If SCR/SCR_SMCI.TIE is 1 and SCR/SCR_SMCI.TEIE is 1, these are set to 0 simultaneously with the SCR.TE bit.

[4] This includes the setting for the module-stop state.

Figure 27.73 Example flow of transition to Software Standby mode during transmission

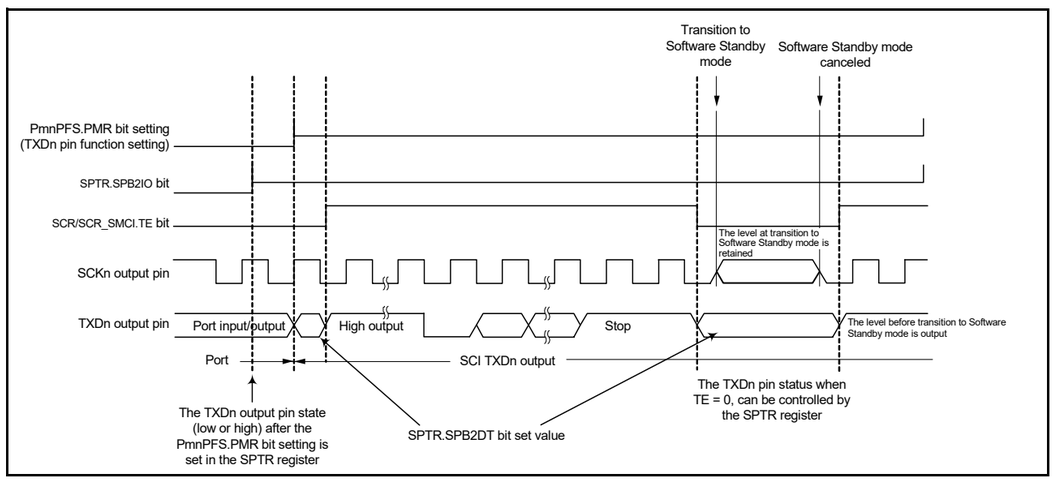
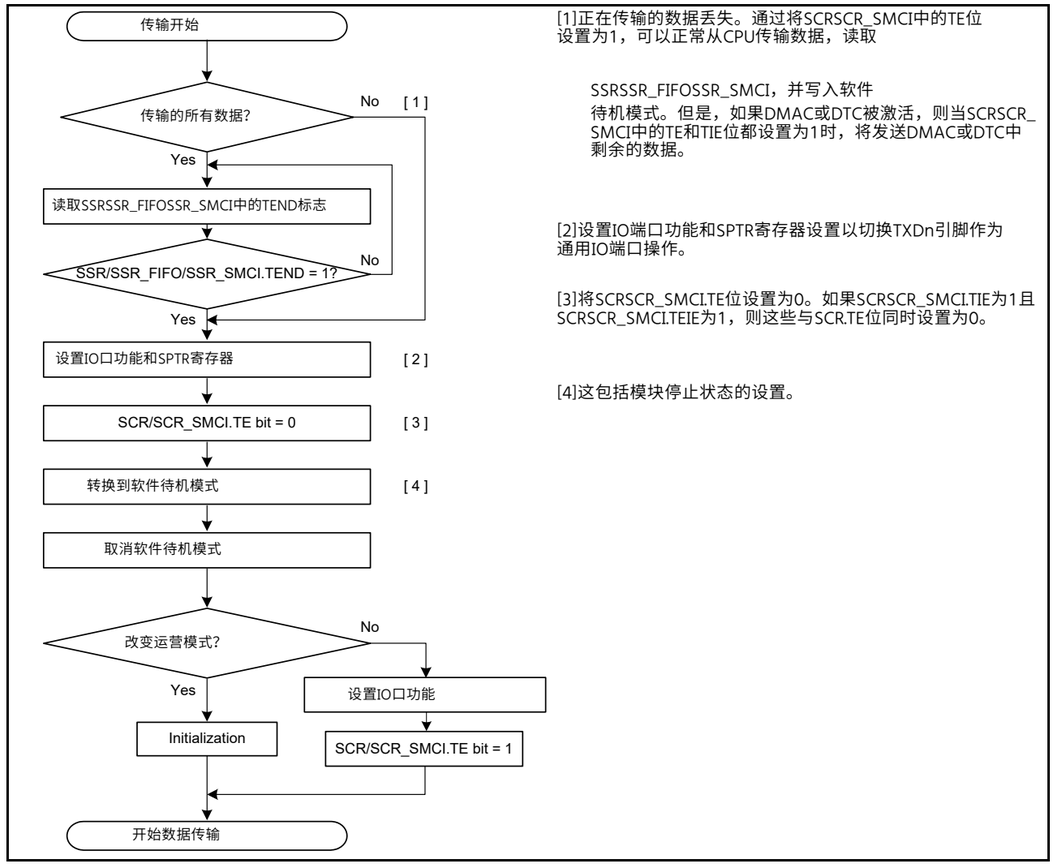


Figure 27.74 Port pin states during transition to Software Standby mode with internal clock and asynchronous transmission



[1]正在传输的数据丢失。通过将SCRSCR_SMCI中的TE位设置为1，可以正常从CPU传输数据，读取

SSRSSR_FIFOSSR_SMCI，并写入软件待机模式。但是，如果DMAC或DTC被激活，则当SCRSCR_SMCI中的TE和TIE位都设置为1时，将发送DMAC或DTC中剩余的数据。

[2]设置IO端口功能和SPTR寄存器设置以切换TXDn引脚作为通用IO端口操作。

[3]将SCRSCR_SMCI.TE位设置为0。如果SCRSCR_SMCI.TIE为1且SCRSCR_SMCI.TEIE为1，则这些与SCR.TE位同时设置为0。

[4]这包括模块停止状态的设置。

Figure 27.73 传输期间转换到软件待机模式的示例流程

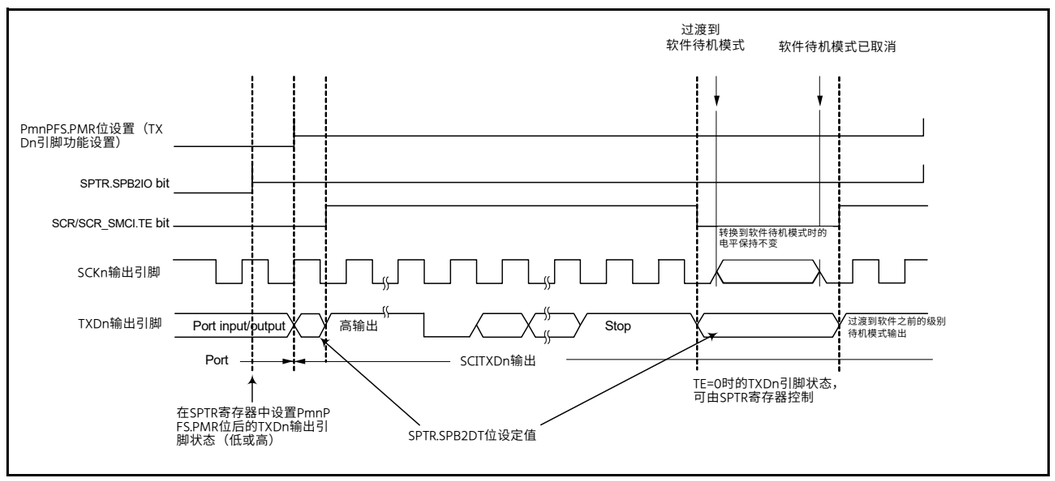


Figure 27.74 转换到内部时钟和异步传输的软件待机模式期间的端口引脚状态

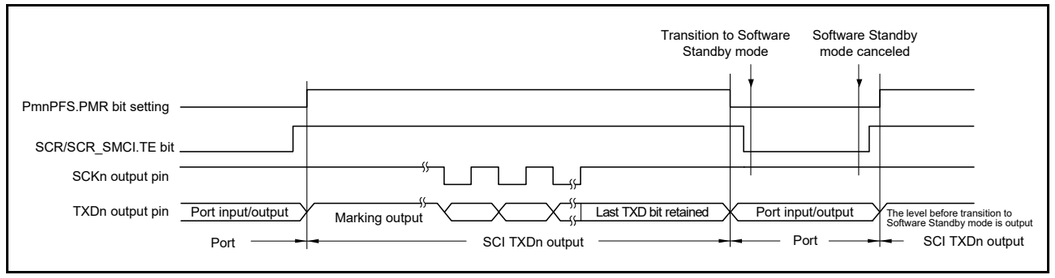


Figure 27.75 Port pin states during transition to Software Standby mode with internal clock and clock synchronous transmission

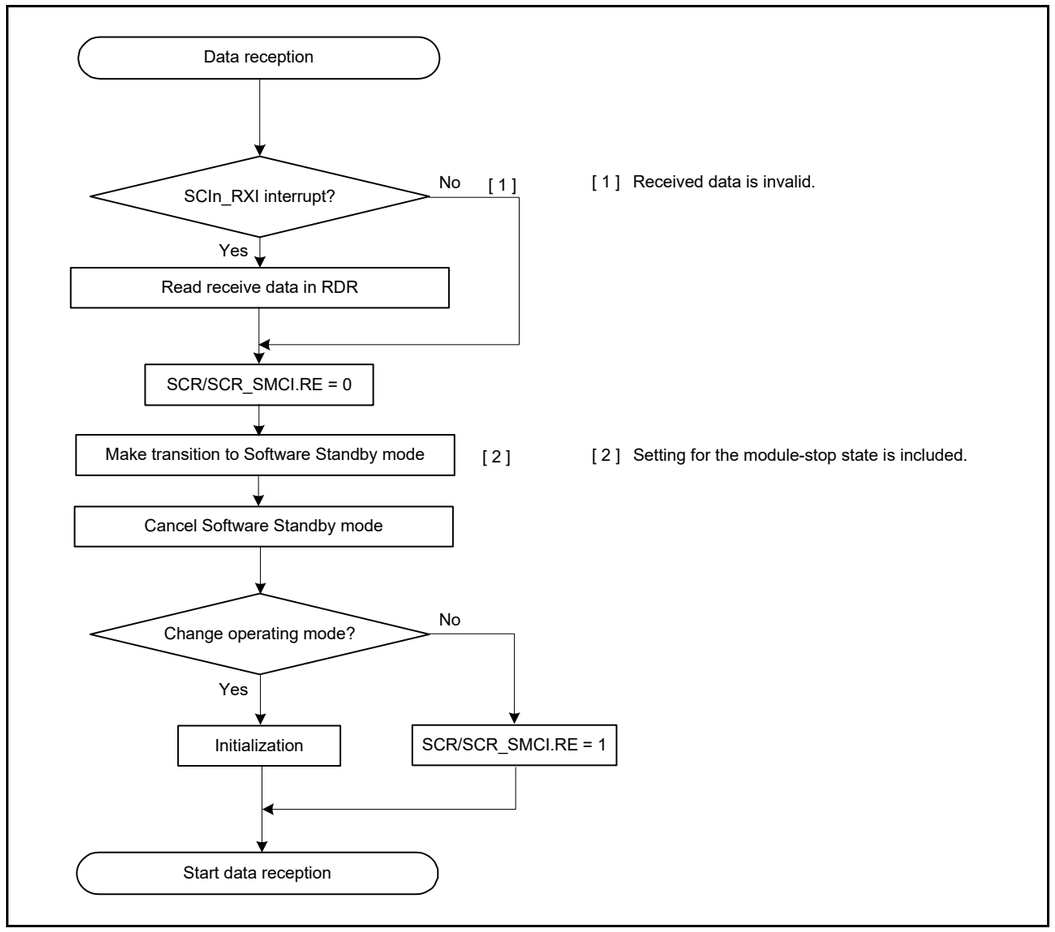


Figure 27.76 Example flow of transition to Software Standby mode during reception

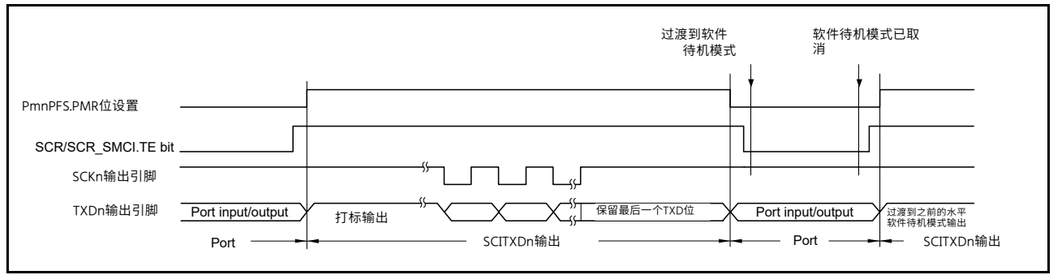


Figure 27.75 通过内部时钟和时钟同步传输转换到软件待机模式期间的端口引脚状态

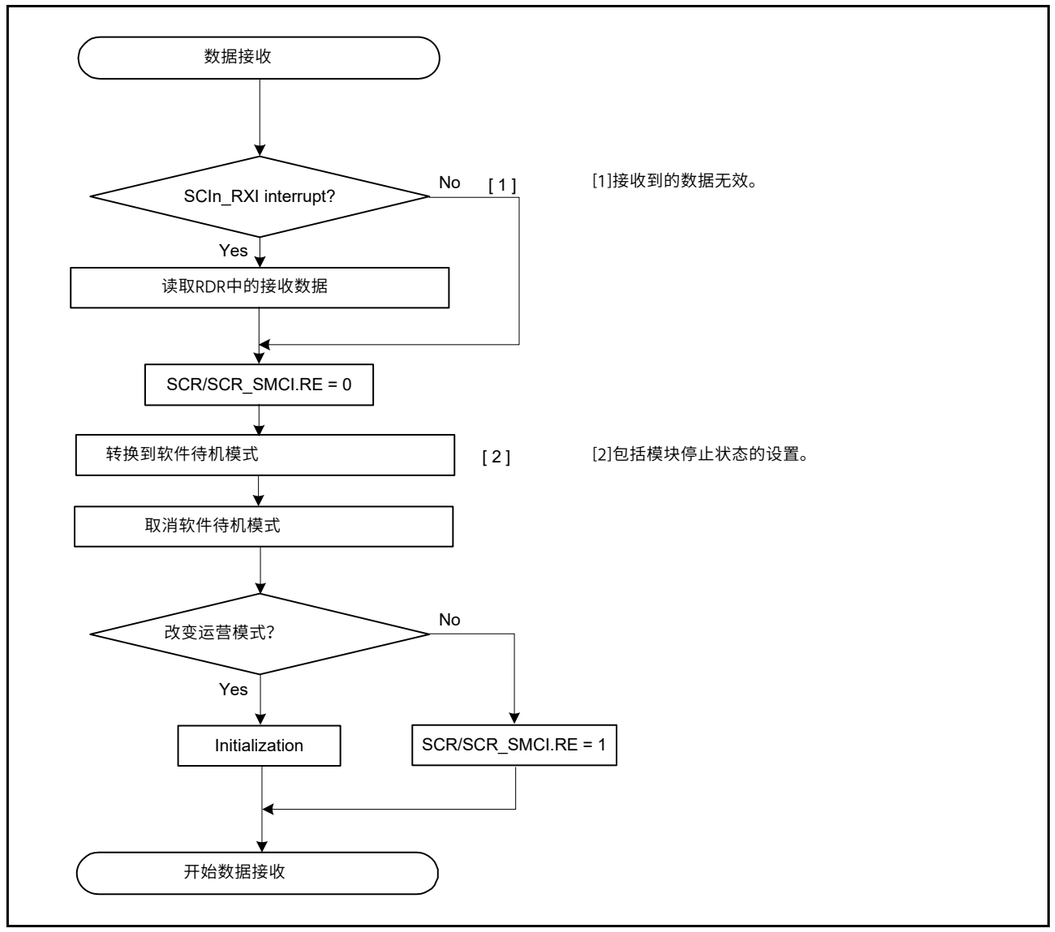
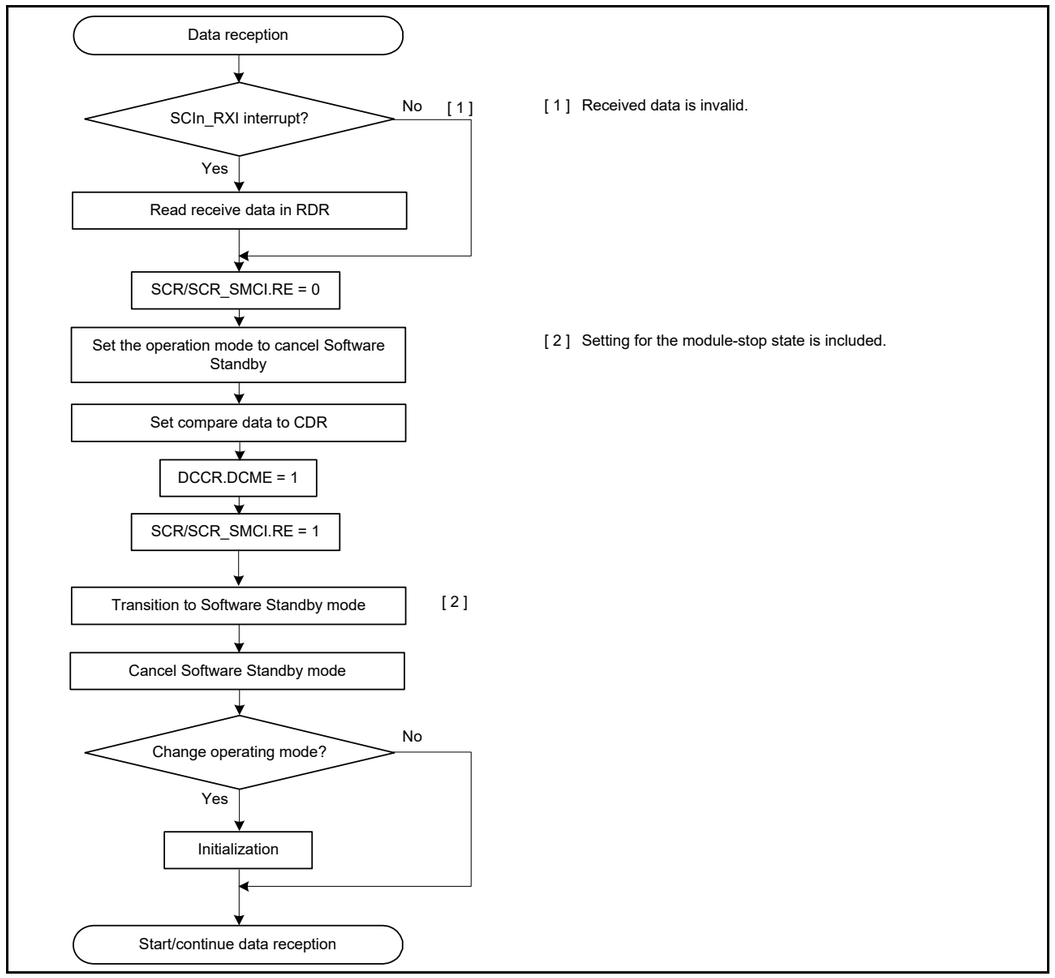


Figure 27.76 接收期间转换到软件待机模式的示例流程



[1] Received data is invalid.

[2] Setting for the module-stop state is included.

Figure 27.77 Example flow of transition to Software Standby mode during reception with address match

27.14.3 Break Detection and Processing

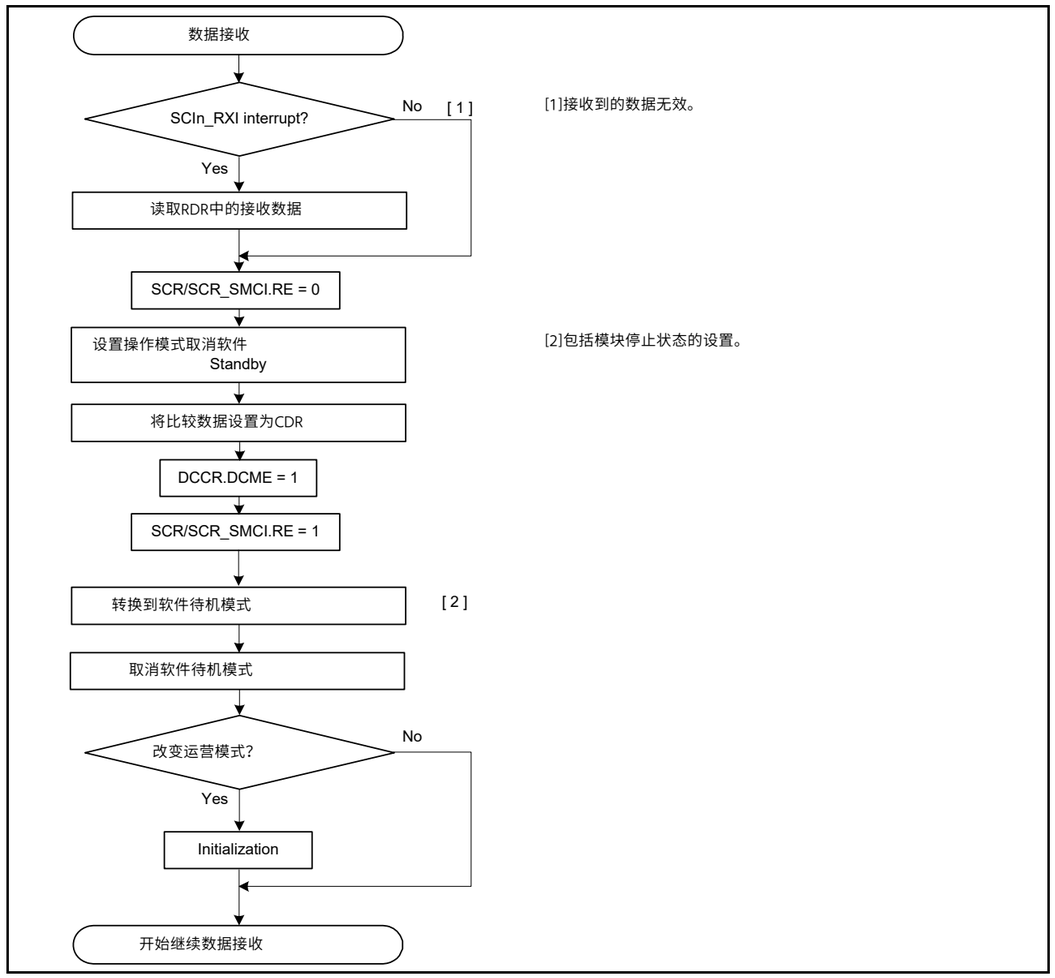
(1) Non-FIFO selected

When a framing error is detected, a break can be detected by reading the RXDn pin value directly. In a break, the input from the RXDn pin becomes all 0s, and the SSR.FER flag is set to 1 to indicate a framing error. The SSR.PER flag might also be set to 1 to indicate a parity error. The SCI continues the receive operation even after a break is received. Therefore, even if the FER flag is 0, indicating that no framing error occurred, it is set to 1 again. When the SEMR.RXDESEL bit is 1, the SCI sets the SSR.FER flag to 1 and stops the receiving operations until a start bit of the next data frame is detected. If the SSR.FER flag is set to 0, the SSR.FER flag retains 0 during the break.

When the RXDn pin is set to 1 and the break ends, detecting the beginning of the start bit on the first falling edge of the RXDn pin allows the SCI to start the receiving operation.

(2) FIFO selected

After a framing error is detected and when the SCI detects that continuous receive data is 0 for one frame, reception stops. When a framing error is detected, a break can be detected by reading the SPTR.RXDMON bit value. After the RXD signal is in the mark state and the break ends, data reception to the FRDRHL register resumes.



[1]接收到的数据无效。

[2]包括模块停止状态的设置。

Figure 27.77 在地址匹配的接收期间转换到软件待机模式的示例流程

27.14.3 断裂检测和处理

(1) Non-FIFO selected

当检测到帧错误时，可以通过直接读取RXDn引脚值来检测中断。在中断时，来自RXDn引脚的输入变为全0，并且SSR.FER标志设置为1以指示帧错误。SSR.PER标志也可能设置为1以指示奇偶校验错误。即使在收到中断后，SCI仍继续接收操作。因此，即使FER标志为0，表示没有发生帧错误，它也会再次设置为1。当。。。的时候

SEMR.RXDESEL位为1，SCI设置SSR.FER标志为1并停止接收操作，直到检测到下一个数据帧的起始位。如果SSR.FER标志设置为0，则SSR.FER标志在中断期间保持0。

当RXDn引脚设置为1且中断结束时，在第一个下降沿检测起始位的开始
RXDn引脚允许SCI开始接收操作。

(2) FIFO selected

检测到帧错误后，当SCI检测到一帧连续接收数据为0时，接收停止。当检测到帧错误时，可以通过读取SPTR.RXDMON位的值来检测中断。在RXD信号处于标记状态并且中断结束后，重新接收到FRDRHL寄存器的数据。

27.14.4 Mark State and Production of Breaks

When the SCR/SCR_SMCI.TE bit is 0, disabling serial transmission, the state of the TXDn pin can be set using the SPTR.SPB2IO and SPTR.SPB2DT bits. With this approach, a TXDn pin can be placed in the mark state to transmit a break.

Before setting the SCR/SCR_SMCI.TE bit to 1, enabling serial transmission, set the SPB2IO and SPB2DT bits to put the communication line in the mark state (the state of 1), and change the TxDn pin using the I/O port function. To output a break on data transmission, after setting the TXDn pin to output 0 by setting the SPB2IO and SPB2DT bits, change the TXDn pin using the I/O port function and set the SCR/SCR_SMCI.TE bit to 0. When the SCR/SCR_SMCI.TE bit is set to 0, the transmitter is initialized regardless of the current state of transmission.

27.14.5 Receive Error Flags and Transmit Operation in Clock Synchronous and Simple SPI Modes

Transmission cannot start when a receive error flag (ORER) in SSR/SSR_FIFO is set to 1, even if data is written to TDR or FTDRL*1. Be sure to set the receive error flags to 0 before starting transmission.

Note: The receive error flags cannot be set to 0 when serial reception is disabled by setting the RE bit in SCR/SCR_SMCI to 0.

Note 1. Do not use the FTDRH register in simple SPI mode.

27.14.6 Restrictions on Clock Synchronous Transmission in Clock Synchronous Mode and Simple SPI Mode

When the external clock source is used as a synchronization clock, the following restrictions apply.

(1) Start of transmission

Wait at least the following time from writing transmit data to TDR to the start of the external clock input:

1 PCLKA cycle + data output delay time for the slave (t_{DO}) + setup time for the master (t_{SU}).

See Figure 27.78.

(2) Continuous transmission

Write the next transmit data to TDR or TDRHL before the falling edge of the transmit clock for bit [7]. See Figure 27.78.

When updating TDR after bit [7] starts to transmit, update TDR while the synchronization clock is in the low-level period, and set the high-level width of the transmit clock, bit [7] (D7) to 4 PCLKA cycles or longer. See Figure 27.78.

27.14.4 标记状态和产生的中断

当SCRSCR_SMCI.TE位为0时，禁用串行传输，TXDn引脚的状态可以使用SPTR.SPB2IO和SPTR.SPB2DT位。使用这种方法，可以将TXDn引脚置于标记状态以发送中断。

在设置SCRSCR_SMCI.TE位为1，使能串行传输之前，设置SPB2IO和SPB2DT位使通信线处于标记状态（状态为1），并使用IO端口功能更改TxDn引脚。要输出数据传输中断，通过设置SPB2IO和SPB2DT位将TXDn引脚设置为输出0后，使用IO端口功能更改TXDn引脚并将SCRSCR_SMCI.TE位设置为0。当SCRSCR_SMCI.TE位设置为0，无论当前的传输状态如何，都初始化发送器。

27.14.5 在时钟同步和简单的接收错误标志和发送操作SPI模式

当SSRSSR_FIFO中的接收错误标志(ORER)设置为1时，传输无法开始，即使数据写入TDR或FTDRL*1也是如此。确保在开始传输之前将接收错误标志设置为0。

Note: 当通过设置RE位禁用串行接收时，接收错误标志不能设置为0
SCR/SCR_SMCI to 0.

注1.不要在简单SPI模式下使用FTDRH寄存器。

27.14.6 时钟同步模式和简单SPI模式下时钟同步传输的限制

当外部时钟源用作同步时钟时，有以下限制。

(1) 传输开始

从将发送数据写入TDR到外部时钟输入开始，至少等待以下时间：

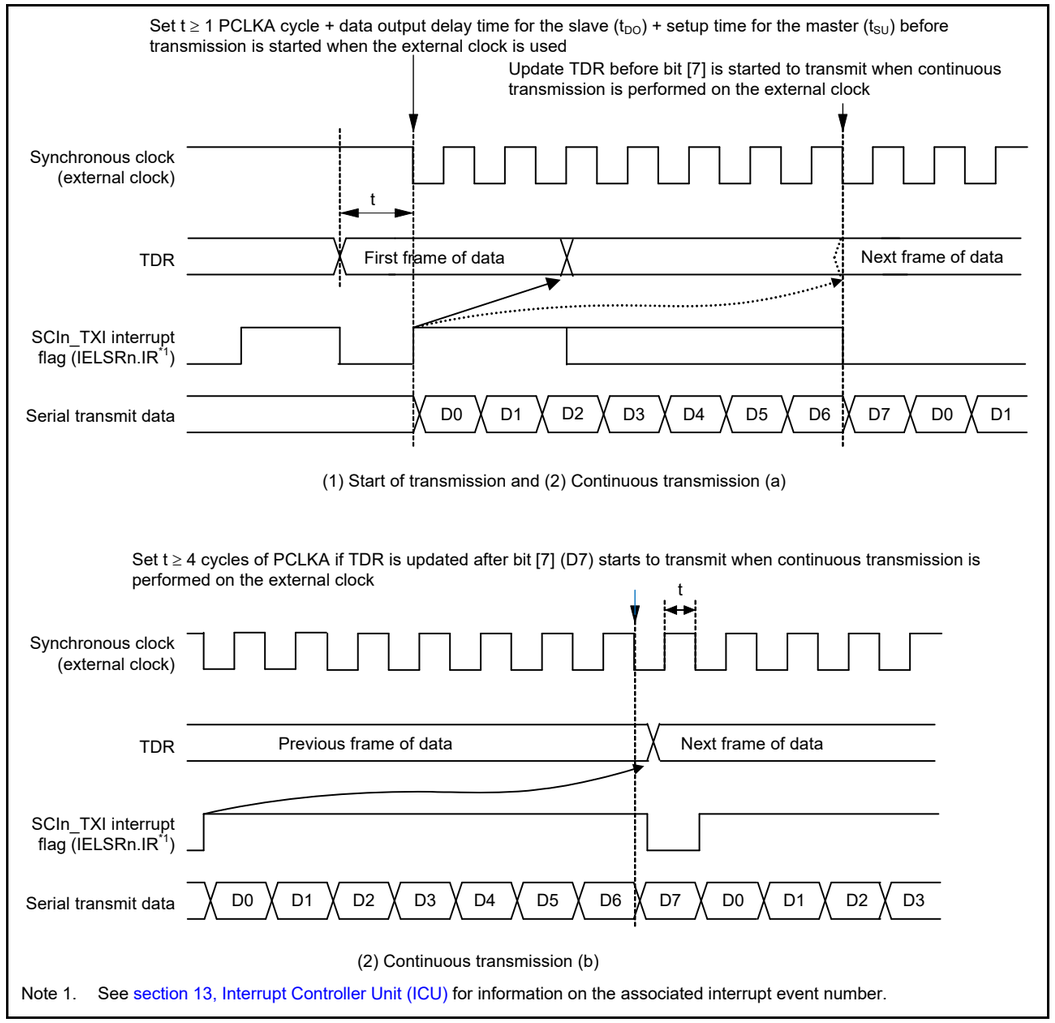
1个PCLKA周期+从机的数据输出延迟时间(tDO)+主机的建立时间(tSU)。

请参见图27.78。

(2) 连续传输

在位[7]的发送时钟下降沿之前将下一个发送数据写入TDR或TDRHL。请参见图27.78。

在bit[7]开始发送后更新TDR时，在同步时钟处于低电平周期时更新TDR，并将发送时钟bit[7]（D7）的高电平宽度设置为4个PCLKA周期或更长。请参见图27.78。



Note 1. See section 13, Interrupt Controller Unit (ICU) for information on the associated interrupt event number.

Figure 27.78 Restrictions on the use of external clock in clock synchronous transmission

27.14.7 Restrictions on Using DMAC or DTC

During transmission or reception operations using the DMAC or DTC, do not set transfer data for the DMAC/DTC.

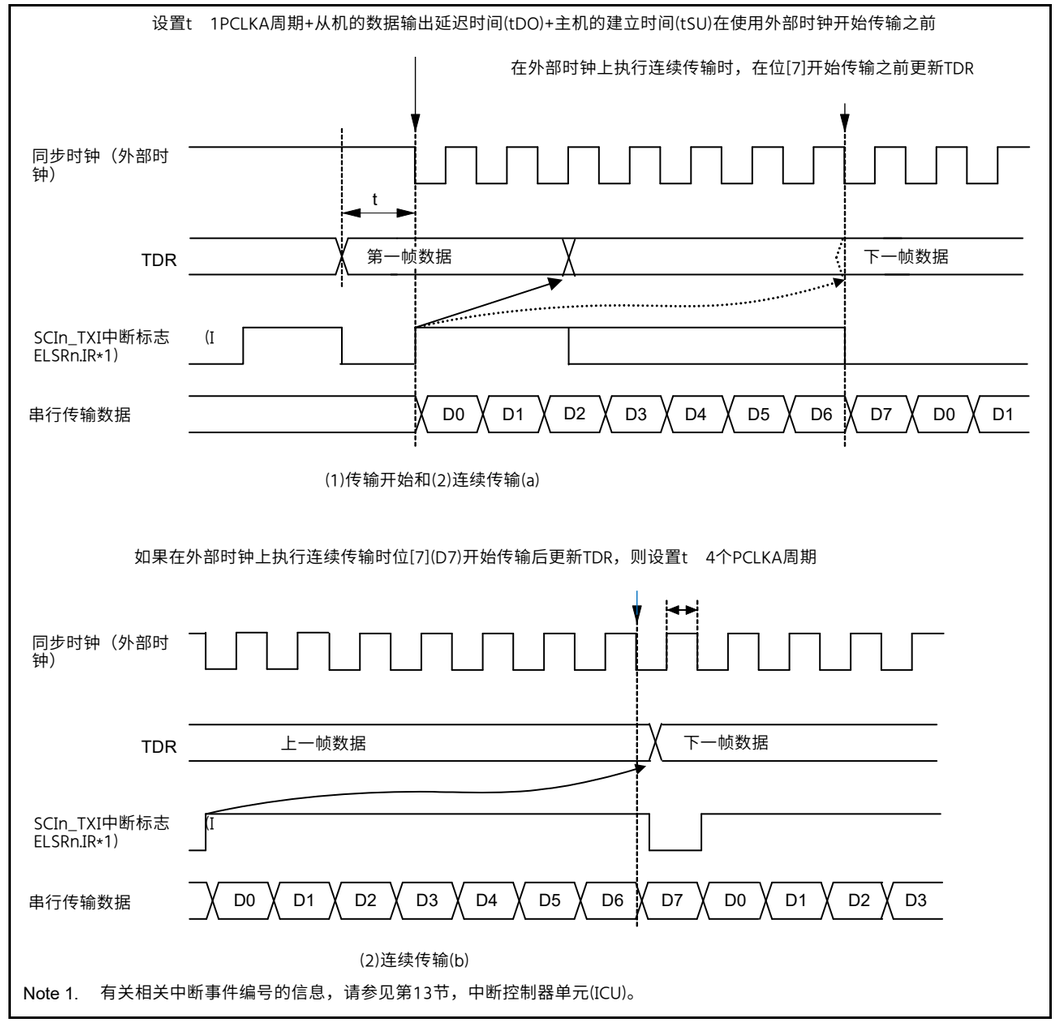
(1) Writing data to TDR (FTDRHL)

(a) Non-FIFO selected

Data can be written to TDR and TDRHL. However, if new data is written to TDR or TDRHL when transmit data remains in TDR or TDRHL, the previous data in TDR and TDRHL is lost because it was not yet transferred to TSR. When using DMAC or DTC, be sure to write transmit data to TDR or TDRHL in the SCIn_TXI interrupt request handling routine.

(b) FIFO selected

It is possible to write data to the FTDRH and FTDRL registers when SCR.TE is 1. Confirm the amount of writable data using the FDR.T[4:0] bits.



Note 1. 有关相关中断事件编号的信息，请参见第13节，中断控制器单元(ICU)。

Figure 27.78 时钟同步传输中使用外部时钟的限制

27.14.7 使用DMAC或DTC的限制

在使用DMAC或DTC进行发送或接收操作期间，请勿为DMACDTC设置传输数据。

(1) 将数据写入TDR(FTDRHL)

(a) Non-FIFO selected

数据可以写入TDR和TDRHL。但是，如果在发送数据仍保留在TDR或TDRHL中时将新数据写入TDR或TDRHL，则TDR和TDRHL中的先前数据将丢失，因为它尚未传输到TSR。使用DMAC或DTC时，请务必在SCIn_TXI中断请求处理程序中将发送数据写入TDR或TDRHL。

(b) FIFO selected

当SCR.TE为1时，可以将数据写入FTDRH和FTDRL寄存器。使用FDR.T[4:0]位确认可写入的数据量。

(2) Reading data from RDR (FRDRHL)

When using the DMAC or DTC to read RDR and RDRHL, be sure to set the receive data full interrupt (SCIn_RXI) as the activation source of the relevant SCI channel.

27.14.8 Notes on Starting Transfer

When transfer starts while the Interrupt Status flag (IELSRn.IR) in the ICU is 1, follow the procedure in this section to clear interrupt requests before permitting operations (by setting the SCR/SCR_SMCI.TE or SCR/SCR_SMCI.RE bit to 1).

For details on the Interrupt Status flag, see section 13, Interrupt Controller Unit (ICU).

1. Confirm that the transfer stopped (the SCR/SCR_SMCI.TE or SCR/SCR_SMCI.RE bit is 0).
2. Set the associated interrupt enable bit (SCR/SCR_SMCI.TIE or SCR/SCR_SMCI.RIE) to 0.
3. Read the associated interrupt enable bit (SCR/SCR_SMCI.TIE or SCR/SCR_SMCI.RIE bit) to check that it is 0.
4. Set the Interrupt Status flag (IELSRn.IR) in the ICU to 0.

27.14.9 External Clock Input in Clock Synchronous Mode and Simple SPI Mode

In clock synchronous mode and simple SPI mode, the external clock (SCKn) must be input as follows:

High-pulse period, low-pulse period = 2 PCLKA cycles or more, period = 6 PCLKA cycles or more.

27.14.10 Limitations on Simple SPI Mode

(1) Master mode

- Use a resistor to pull up or pull down the clock line matching the initial settings for the transfer clock set in the SPMR.CKPH and CKPOL bits when the SPMR.SSE bit is 1. This prevents the clock line from being placed in the high-impedance state when the SCR.TE bit is set to 0 or unexpected edges from being generated on the clock line when the SCR.TE bit changes from 0 to 1. When the SPMR.SSE bit is 0 in single master mode, pulling up or pulling down the clock line is not required because the clock line is not placed in the high-impedance state even when the SCR.TE bit is set to 0.
- For the clock delay setting (SPMR.CKPH bit is 1), the receive data full interrupt (SCIn_RXI) is generated before the final clock edge on the SCKn pin, as indicated in Figure 27.79. If the TE and RE bits in the SCR register become 0 before the final edge of the clock signal on the SCKn pin, the SCKn pin is placed in the high-impedance state, so the width of the last clock pulse of the transfer clock is shortened. Additionally, an SCIn_RXI interrupt might lead to the input signal on the SSn pin of a connected slave going to the high level before the final edge of the clock signal on the SCKn pin, leading to incorrect operation of the slave.
- In a multi-master configuration, the SCKn pin output goes to high-impedance while the input on the SSn pin is at the low level if a mode fault error occurs while a character is being transferred, stopping supply of the clock signal to the connected slave. Reset the connected slave to avoid misaligned bits when transfer is restarted.

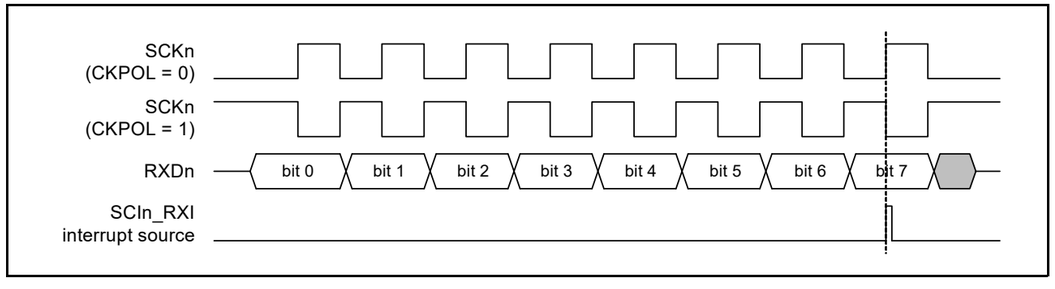


Figure 27.79 Timing of SCIn_RXI interrupt in simple SPI mode with clock delay

(2) 从RDR(FRDRHL)读取数据

使用DMAC或DTC读取RDR和RDRHL时，务必将接收数据满中断（SCIn_RXI）设置为相关SCI通道的激活源。

27.14.8 开始转移注意事项

当ICU中的中断状态标志(IELSRn.IR)为1时开始传输时，请按照本节中的程序在允许操作之前清除中断请求（通过将SCRSCR_SMCI.TE或SCRSCR_SMCI.RE位设置为1）。

有关中断状态标志的详细信息，请参见第13节，中断控制器单元(ICU)。

1. 确认传输已停止（SCRSCR_SMCI.TE或SCRSCR_SMCI.RE位为0）。
2. 将相关的中断使能位（SCRSCR_SMCI.TIE或SCRSCR_SMCI.RIE）设置为0。
3. 读取相关的中断使能位（SCRSCR_SMCI.TIE或SCRSCR_SMCI.RIE位）以检查它是否为0。
4. 将ICU中的中断状态标志(IELSRn.IR)设置为0。

27.14.9 时钟同步模式和简单SPI模式下的外部时钟输入

在时钟同步模式和简单SPI模式下，外部时钟（SCKn）必须输入如下：

高脉冲周期，低脉冲周期=2个PCLKA周期或更多，周期=6个PCLKA周期或更多。

27.14.10 简单SPI模式的限制

(1) 主模式

- 使用电阻上拉或下拉与传输时钟设置的初始设置相匹配的时钟线
当SPMR.SSE位为1时，SPMR.CKPH和CKPOL位。这可以防止当SCR.TE位设置为0时将时钟线置于高阻抗状态，或者在SCR.TE位从0变为1。当SPMR.SSE位在单主机模式下为0时，不需要上拉或下拉时钟线，因为即使在SCR.TE位设置为0。
- 对于时钟延迟设置（SPMR.CKPH位为1），接收数据满中断（SCIn_RXI）在SCKn引脚上的最后一个时钟沿之前产生，如图27.79所示。如果SCR寄存器中的TE和RE位在SCKn引脚上的时钟信号的最后一个边沿之前变为0，则SCKn引脚处于高阻状态，因此传输时钟的最后一个时钟脉冲的宽度为缩短。此外，SCIn_RXI中断可能会导致所连接从机的SSn引脚上的输入信号在SCKn引脚上的时钟信号的最后一个边沿之前变为高电平，从而导致从机的错误操作。
- 在多主机配置中，如果在传输字符时发生模式故障错误，则SCKn引脚输出变为高阻态，而SSn引脚上的输入处于低电平，从而停止向连接的时钟信号提供奴隶。重新启动传输时，重置连接的从机以避免未对齐的位。

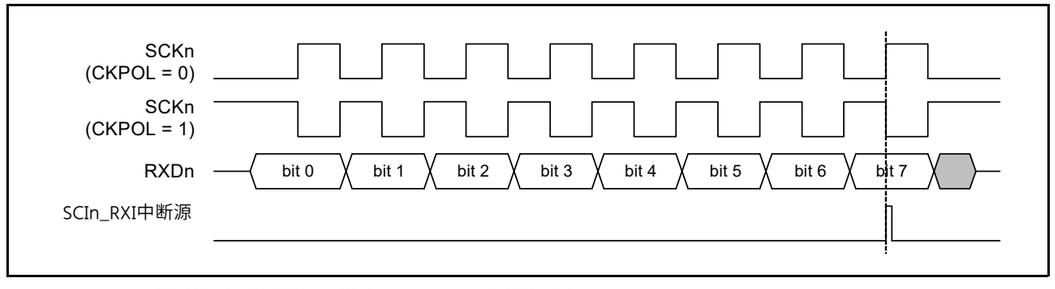


Figure 27.79 带时钟延迟的简单SPI模式下SCIn_RXI中断的时序

(2) Slave mode

- Wait at least the following time from writing transmit data in the TDR register to the start of the external clock input:
  1 PCLKA cycle + data output delay for the slave (t_{DO}) + setup time for the master (t_{SU}).
  Also, wait at least 5 PCLKA cycles from the input of the low level on the SSn pin to the start of the external clock input.
- Provide an external clock signal to the master for the data length for transfer
- Control the input on the SSn pin before the start and after the end of data transfer
- When the input level on the SSn pin changes from low to high while a character is being transferred, set the TE and RE bits in the SCR to 0 and, after restoring the settings, restart transfer of the first byte.

(2) 从机模式

- 从将发送数据写入TDR寄存器到开始外部时钟输入，至少等待以下时间：1个PCLKA周期+从设备的数据输出延迟(tDO)+主设备的建立时间(tSU)。此外，从SSn引脚输入低电平到外部时钟输入开始，至少等待5个PCLKA周期。
- 向主机提供外部时钟信号，用于传输数据长度
- 在数据传输开始之前和结束之后控制SSn引脚上的输入
- 当SSn引脚上的输入电平从低电平变为高电平而字符正在传输时，设置TE和SCR中的RE位为0，并在恢复设置后重新开始传输第一个字节。

RA生态工作室

28. IrDA Interface

28.1 Overview

The IrDA interface sends and receives IrDA data communication waveforms in cooperation with SCI1, according to the IrDA (Infrared Data Association) standard 1.0.

Enabling the IrDA function using the IRE bit in the IRCR register allows the encoding and decoding of the TXD1 and RXD1 signals of the SCI1 to waveforms conforming to the IrDA standard 1.0 (IRTXD1 and IRRXD1 pins).

Connecting the waveforms to an infrared transmitter/receiver implements infrared data communication conforming to the IrDA standard 1.0 system.

With the IrDA standard 1.0 system, data transfer can be started at 9600 bps and the transfer rate can be changed whenever necessary. Because the IrDA interface cannot change the transfer rate automatically, the transfer rate must be changed through software.

Figure 28.1 shows the interaction between the IrDA interface and SCI1.

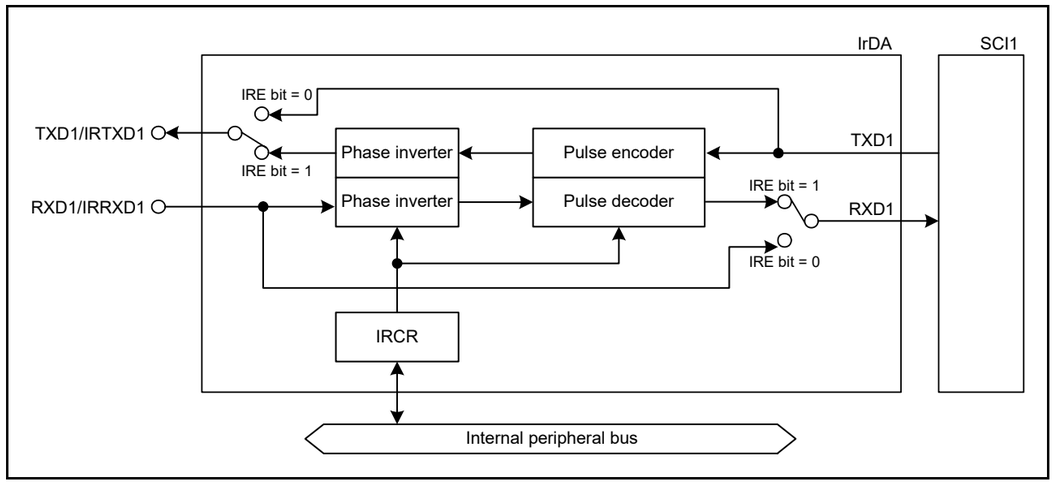


Figure 28.1 Interaction between the IrDA interface and SCI1

Table 28.1 IrDA interface I/O pins

Pin name	I/O	Function
IRTXD1	Output	Data to be transmitted
IRRXD1	Input	Received data

28. IrDA Interface

28.1 Overview

IrDA接口与SCI1配合发送和接收IrDA数据通信波形，根据
IrDA（红外数据协会）标准1.0。

使用IRCR寄存器中的IRE位启用IrDA功能允许对TXD1和
SCI1的RXD1信号转换为符合IrDA标准1.0的波形（IRTXD1和IRRXD1引脚）。

将波形连接到红外发射器接收器可实现符合IrDA标准1.0系统的红外数据通信。

使用IrDA标准1.0系统，可以以9600bps开始数据传输，并且可以随时更改传输速率。因为IrDA接口不能自动改变传输速率，所以必须通过软件来改变传输速率。

图28.1显示了IrDA接口和SCI1之间的交互。

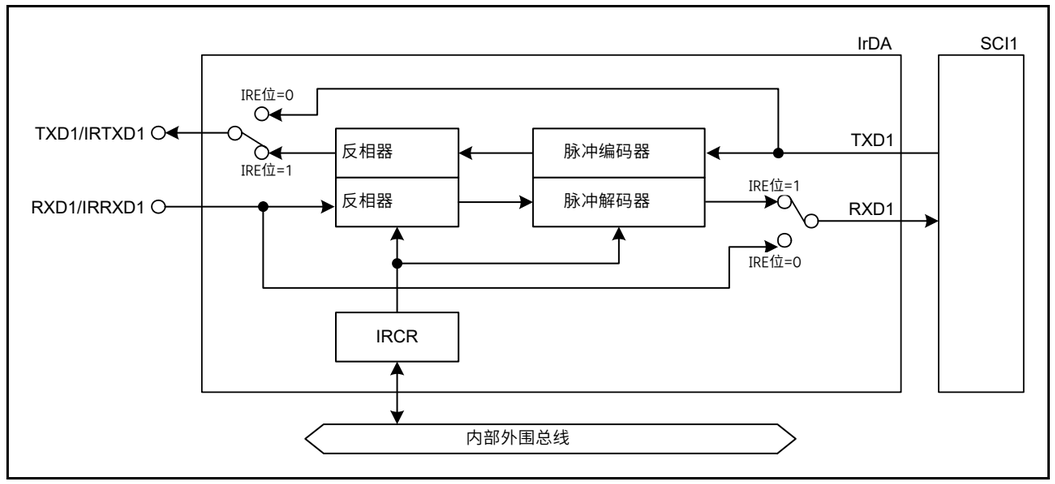


Figure 28.1 IrDA接口与SCI1之间的交互

Table 28.1 IrDA接口IO引脚

引脚名称	I/O	Function
IRTXD1	Output	要传输的数据
IRRXD1	Input	接收数据

RA生态工作室

28.2 Register Descriptions

28.2.1 IrDA Control Register (IRCR)

Address(es): IRDA.IRCR 4007 0F00h

	b7	b6	b5	b4	b3	b2	b1	b0
	IRE	—	—	—	IRTXINV	IRRXINV	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b2	IRRXINV	IRRXD Polarity Switching	0: Use IRRXD input as received data as-is 1: Use IRRXD input as received data after the polarity is inverted.	R/W
b3	IRTXINV	IRTXD Polarity Switching	0: Output data to be transmitted to IRTXD as-is 1: Output data to be transmitted IRTXD after the polarity is inverted.	R/W
b6 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	IRE	IrDA Enable	0: Use serial input/output pins for normal serial communication 1: Use serial input/output pins for IrDA data communication.	R/W

Note: The IRCR register values are retained in Sleep, Software Standby, and Deep Software Standby modes.

IRRXINV bit (IRRXD Polarity Switching)

The IRRXINV bit inverts the logic level of the IRRXD input. When inverted, the high-level pulse width is applied to the low-level pulse width.

IRTXINV bit (IRTXD Polarity Switching)

The IRTXINV bit inverts the logic level of the IRTXD output. When inverted, the high-level pulse width is applied to the low-level pulse width.

IRE bit (IrDA Enable)

The IRE bit configures the I/O pins for normal communication mode or IrDA data communication mode.

28.3 Operation

28.3.1 IrDA Interface Setup Procedure

To set up IrDA interface operation:

1. Set the associated pins to IRTXD1 and IRRXD1 in the Pin Function Control Register (PmnPFS.PSEL = 00101b) of the I/O ports function.
2. Specify the peripheral function in the Pin Function Control Register (PmnPFS.PMR = 1) of the I/O ports function.
3. Specify the IrDA function in the IRCR register.
4. Set the SCI1-related registers in the Serial Communications Interface (SCI).

28.3.2 Transmission

During transmission, the signals output from SCI1 (UART frames) are converted to IR frame data through the IrDA interface as shown in Figure 28.2. When the IRCR.IRTXINV bit is 0 and serial data is 0, high-level pulses with 3/16 the width of the bit rate (1-bit width period) are output (initial setting). The standard states that the minimum high-level pulse width must be 1.41 µs and the maximum high-level pulse width must be (3/16 + 2.5%) × bit rate or (3/16 × bit rate) + 1.08 µs. When the serial data is 1, no pulses are output.

28.2 注册说明

28.2.1 IrDA控制寄存器(IRCR)

Address(es): IRDA.IRCR 4007 0F00h

	b7	b6	b5	b4	b3	b2	b1	b0
	IRE	—	—	—	IRTXINV	IRRXINV	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b2	IRRXINV	IRRXD极性切换	0：按原样使用IRRXD输入作为接收数据1：在极性反转后使用IRRXD输入作为接收数据。	R/W
b3	IRTXINV	IRTXD极性切换	0：输出数据按原样发送到IRTXD1：输出数据在极性反转后发送到IRTXD。	R/W
b6 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	IRE	IrDA Enable	0：使用串行输入输出引脚进行正常串行通信1：使用串行输入输出引脚进行IrDA数据通信。	R/W

Note: IRCR寄存器值在休眠、软件待机和深度软件待机模式下保持不变。

IRRXINV位（IRRXD极性切换）

IRRXINV位反转IRRXD输入的逻辑电平。反转时，高电平脉冲宽度应用于低电平脉冲宽度。

IRTXINV位（IRTXD极性切换）

IRTXINV位反转IRTXD输出的逻辑电平。反转时，高电平脉冲宽度应用于低电平脉冲宽度。

IRE位（IrDA使能）

IRE位将IO引脚配置为正常通信模式或IrDA数据通信模式。

28.3 Operation

28.3.1 IrDA接口设置程序

设置IrDA接口操作：

1. 在IO端口功能的引脚功能控制寄存器(PmnPFS.PSEL=00101b)中将相关引脚设置为IRTXD1和IRRXD1。
2. 在IO端口功能的引脚功能控制寄存器(PmnPFS.PMR=1)中指定外设功能。
3. 在IRCR寄存器中指定IrDA功能。
4. 设置串行通信接口(SCI)中与SCI1相关的寄存器。

28.3.2 Transmission

在传输过程中，SCI1输出的信号（UART帧）通过IrDA接口转换为IR帧数据，如图28.2所示。当IRCR.IRTXINV位为0且串行数据为0时，输出具有316位速率宽度（1位宽度周期）的高电平脉冲（初始设置）。标准规定最小高电平脉冲宽度必须为1.41µs，最大高电平脉冲宽度必须为(316+2.5%)×比特率或(316×比特率)+1.08µs。当串行数据为1时，不输出脉冲。

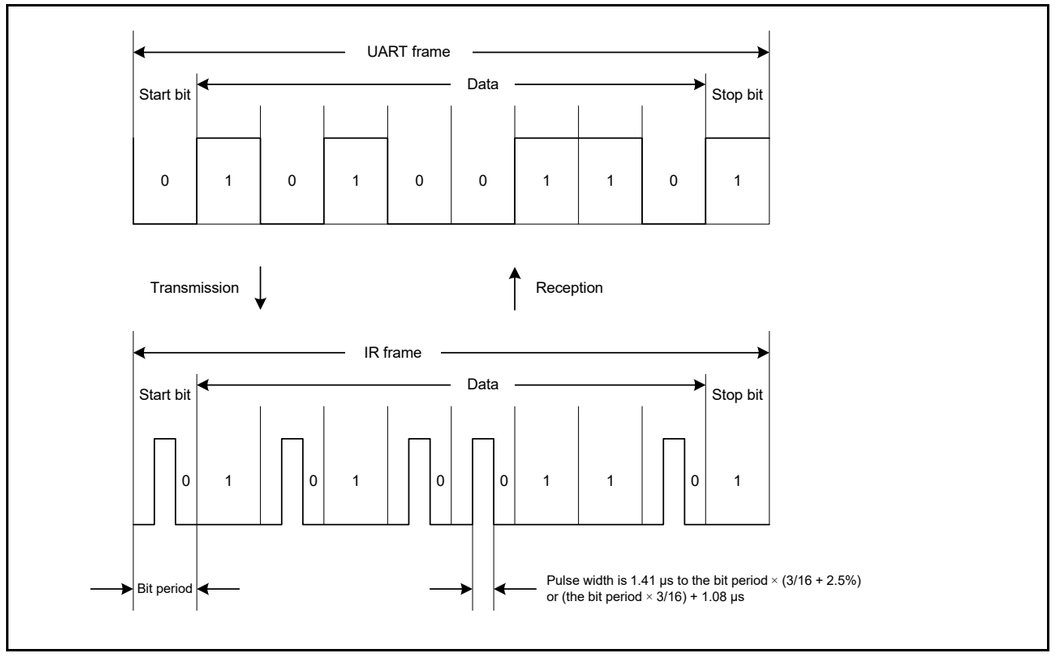


Figure 28.2 IrDA transmission and reception

28.3.3 Reception

During reception, IR frame data is converted to UART frame data through the IrDA interface and is input to SCI1.

Low-level data is input to SCI1 when the IRCR.IRRXINV bit is 0 and a high-level pulse is detected. High-level data is input to SCI1 when no pulse is detected for a 1-bit period.

28.4 Usage Notes

28.4.1 Settings for the Module-Stop State

IrDA operation can be enabled or disabled using the Module Stop Control Register. IrDA is initially stopped after reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

28.4.2 Asynchronous Reference Clock for SCI1

The IrDA receives a clock with frequency 16 times the bit rate from SCI1 and operates in conjunction with SCI1.

When using the IrDA, set the SCI1.SEMR.ABCS bit to 0.

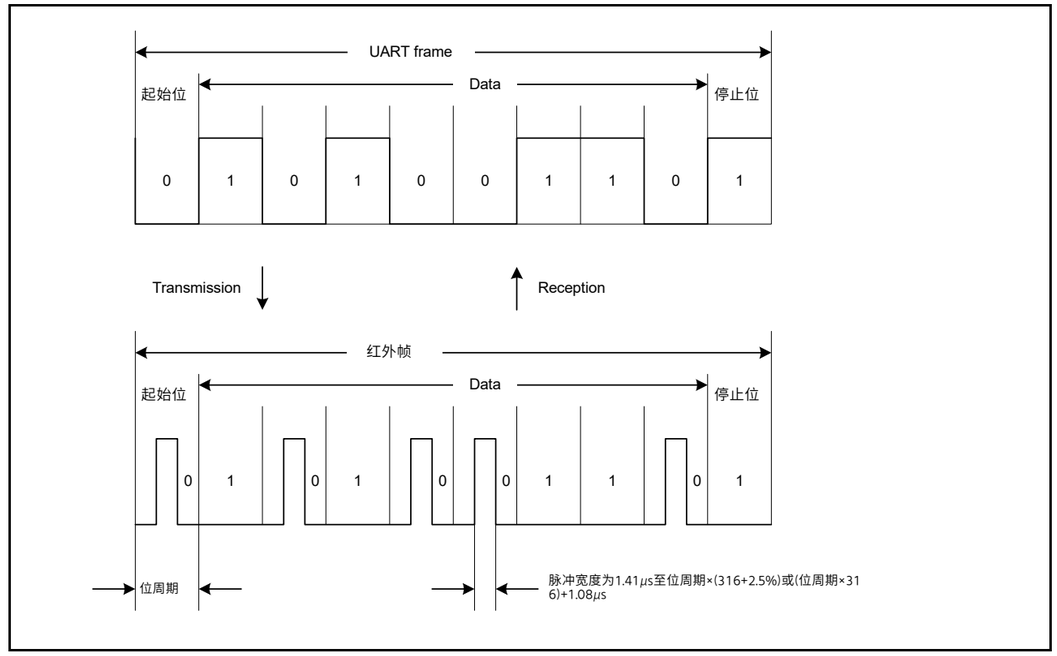


Figure 28.2 IrDA发射和接收

28.3.3 Reception

在接收过程中，IR帧数据通过IrDA接口转换为UART帧数据并输入到SCI1。

当IRCR.IRRXINV位为0且检测到高电平脉冲时，低电平数据输入到SCI1。当1位周期内没有检测到脉冲时，高电平数据输入到SCI1。

28.4 使用说明

28.4.1 模块停止状态的设置

可以使用模块停止控制寄存器启用或禁用IrDA操作。IrDA在复位后最初停止。
释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

28.4.2 SCI1的异步参考时钟

IrDA从SCI1接收频率为比特率16倍的时钟，并与SCI1一起工作。

使用IrDA时，将SCI1.SEMR.ABCS位设置为0。

29. I2C Bus Interface (IIC)

29.1 Overview

The MCU has a 2-channel I2C Bus Interface (IIC) module that conforms with and provides a subset of the NXP I2C bus (Inter-Integrated Circuit) bus interface functions.

Table 29.1 lists the IIC specifications, Figure 29.1 shows a block diagram, and Figure 29.2 shows an example of I/O pin connections to external circuits, with an I2C bus configuration. Table 29.2 lists the I/O pins.

Table 29.1 IIC specifications (1 of 2)

Parameter	Specifications
Communications format	• I2C bus format or SMBus format • Master or slave mode selectable • Automatic securing of the setup times, hold times, and bus-free times for the transfer rate.
Transfer rate	Fast mode plus supported, up to 1 Mbps
SCL clock	For master operation, the duty cycle of the SCL clock is selectable in the range from 4% to 96%
Issuing and detecting conditions	• Start, restart, and stop conditions are automatically generated • Start conditions (including restart conditions) and stop conditions are detectable.
Slave address	• Configurable for up to three different slave addresses • 7-bit and 10-bit address formats supported, including simultaneous use • General call addresses, device ID addresses, and SMBus host addresses detectable.
Acknowledgment	• For transmission, automatic loading of the acknowledge bit. Transfer of the next transmit data can be automatically suspended on detection of a not-acknowledge bit. • For reception, automatic transmission of the acknowledge bit. If a wait between the 8th and 9th clock cycles is selected, software can control the value in the acknowledge field in response to the received value.
Wait function	During reception, the following wait periods are available by holding the SCL clock low: • Waiting between the 8th and 9th clock cycles • Waiting between the 9th clock cycle and the 1st clock cycle of the next transfer.
SDA output delay function	Output timing of transmitted data, including the acknowledge bit, can be delayed
Arbitration	• For multi-master operation: - SCL clock synchronization is possible when conflict occurs with the SCL signal from another master - When issuing the start condition creates conflict on the bus, loss of arbitration is detected by testing for mismatching between the internal signal for the SDA line and the level on the SDA line - In master operation, loss of arbitration is detected by testing for mismatching between the signal on the SDA line and the internal signal for the SDA line • Loss of arbitration because the start condition occurs while the bus is busy is detectable, to prevent the issuing of double start conditions • Loss of arbitration is detectable on transfer of a not-acknowledge bit because the internal signal for the SDA line and the level on the SDA line do not match • Loss of arbitration because mismatching of internal and line levels for data is detectable in slave transmission
Timeout function	Internal detection of long-interval stops of the SCL clock
Noise cancellation	• Digital noise filters for both the SCL and SDA signals • Programmable window for noise cancellation by the filters.
Interrupt sources	• Transfer error or event occurrence (arbitration detection, NACK, timeout, start or restart condition, or stop condition) • Receive data full, including matching with a slave address • Transmit data empty, including matching with a slave address • Transmit end.
Module-stop function	Module-stop state can be set to reduce power consumption
IIC operating modes	• Master transmit • Master receive • Slave transmit • Slave receive.

29. I2C总线接口(IIC)

29.1 Overview

MCU具有2通道I2C总线接口(IIC)模块，该模块符合并提供NXPI2C总线（内部集成电路）总线接口功能的子集。

表29.1列出了IIC规格，图29.1显示了框图，图29.2显示了IO引脚连接到外部电路的示例，具有I2C总线配置。表29.2列出了IO引脚。

Table 29.1 IIC规格(1of2)

Parameter	Specifications
通讯格式	I2C总线格式或SMBus格式 可选择主模式或从模式 自动保护传输速率的设置时间、保持时间和无总线时间。
传输率	支持快速模式，最高1Mbps
SCL clock	对于主机操作，SCL时钟的占空比可在4%至96%的范围内选择
发布和检测条件	自动生成启动、重新启动和停止条件 可检测启动条件（包括重新启动条件）和停止条件。
从机地址	最多可配置三个不同的从属地址 支持7位和10位地址格式，包括同时使用 可检测到广播呼叫地址、设备ID地址和SMBus主机地址。
Acknowledgment	对于传输，自动加载确认位。 检测到未确认位时，可以自动暂停下一个发送数据的传输。 对于接收，确认位的自动传输。 如果选择了第8和第9个时钟周期之间的等待，软件可以控制确认字段中的值以响应接收到的值。
等待功能	在接收期间，通过将SCL时钟保持为低电平可获得以下等待周期： 在第8个和第9个时钟周期之间等待 在第9个时钟周期和下一次传输的第一个时钟周期之间等待。
SDA输出延迟功能	传输数据的输出时序，包括确认位，可以延迟
Arbitration	• For multi-master operation: 当与来自另一个主机的SCL信号发生冲突时，SCL时钟同步是可能的当发出启动条件在总线上产生冲突时，通过测试SDA线的内部信号和SDA线上的电平之间的不匹配来检测仲裁丢失在主机操作中，通过测试SDA线路上的信号与SDA线路的内部信号之间的不匹配来检测仲裁丢失 可检测到由于在总线繁忙时出现启动条件而导致的仲裁丢失，以防止发出双启动条件 由于SDA线路的内部信号和SDA线路上的电平不匹配，在传输未确认位时可检测到仲裁丢失 由于数据的内部和线路电平不匹配，可检测到仲裁丢失在从属传输
超时功能	内部检测SCL时钟的长间隔停止
噪音消除	用于SCL和SDA信号的数字噪声滤波器 用于通过滤波器消除噪声的可编程窗口。
中断源	传输错误或事件发生（仲裁检测、NACK、超时、启动或重启条件或停止条件） 接收数据已满，包括与从地址匹配 传输数据为空，包括与从地址匹配 传输结束。
Module-stop function	可设置模块停止状态以降低功耗
IIC操作模式	主机发送 主机接收 从机发送 从机接收。

Table 29.1 IIC specifications (2 of 2)

Parameter	Specifications
Event link function (output)	• Transfer error or event occurrence (arbitration detection, NACK, timeout, start or restart condition, or stop condition) • Receive data full, including matching with a slave address • Transmit data empty, including matching with a slave address • Transmit end.
Wakeup function*1	CPU can return from Software Standby mode using a wakeup event

Note 1. This function is only available for IIC channel IIC0. IIC1 is not supported.

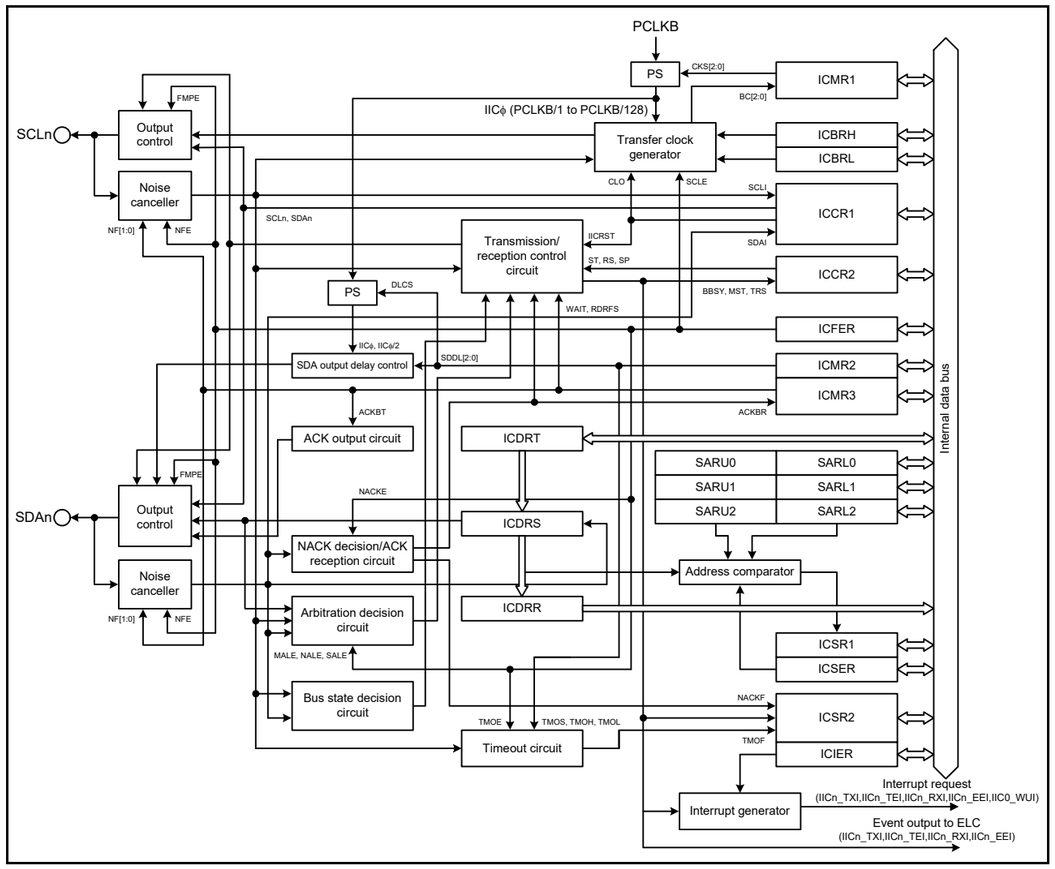


Figure 29.1 IIC block diagram

Table 29.1 IIC规格（2个中的2个）

Parameter	Specifications
事件链接功能（输出）	传输错误或事件发生（仲裁检测、NACK、超时、启动或重启条件或停止条件） 接收数据已满，包括与从地址匹配 传输数据为空，包括与从地址匹配 传输结束。
Wakeup function*1	CPU可以使用唤醒事件从软件待机模式返回

注1.此功能仅适用于IIC通道IIC0。不支持IIC1。

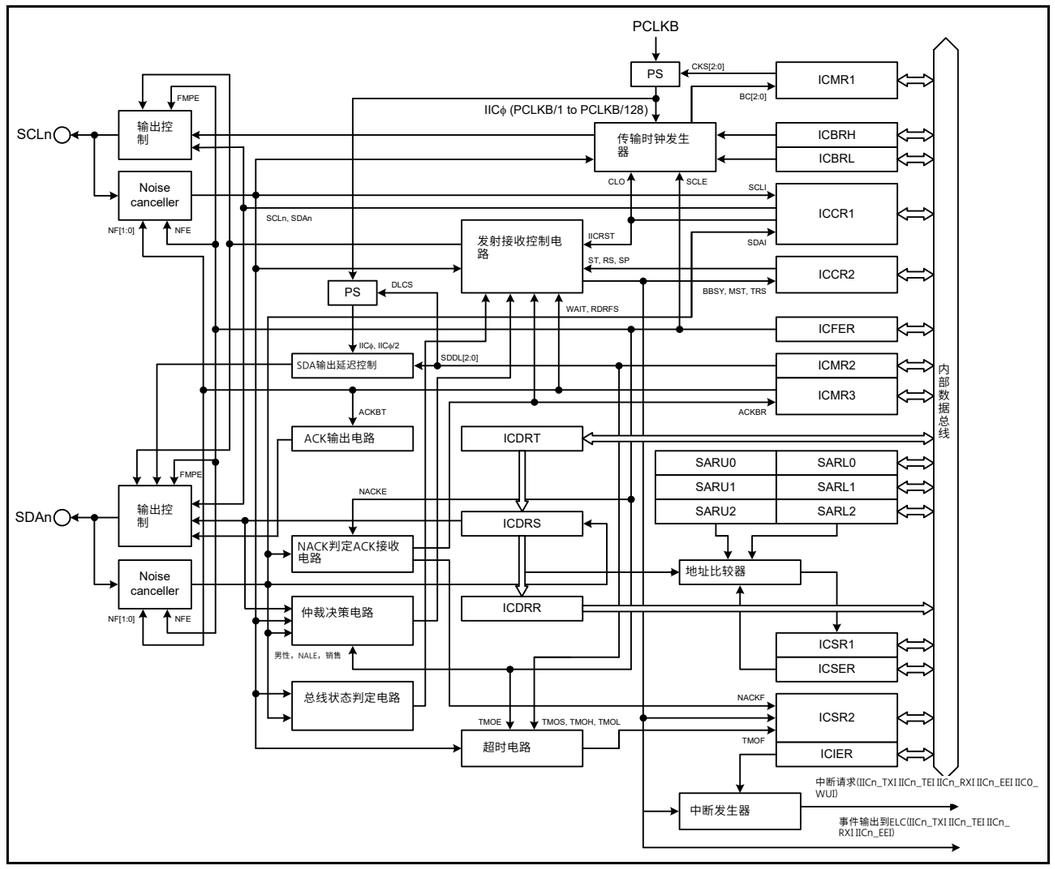


Figure 29.1 IIC框图

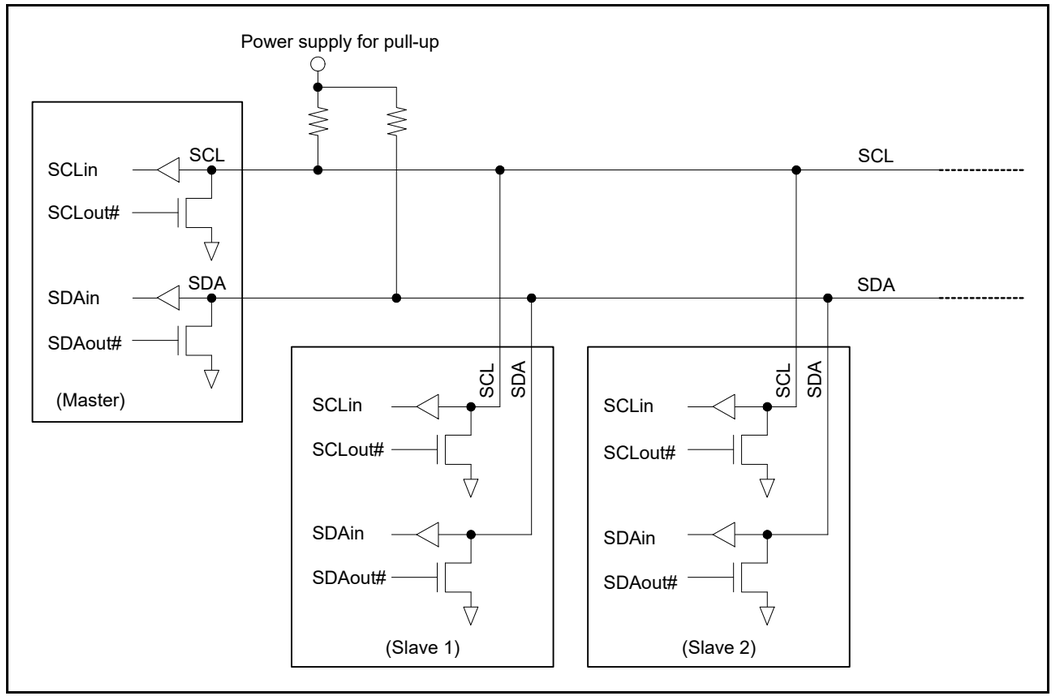


Figure 29.2 I/O pin connection to an external circuit (I2C bus configuration example)

The input level of the signals for IIC is CMOS when I2C bus is selected (ICMR3.SMBS = 0), or TTL when SMBus is selected (ICMR3.SMBS = 1).

Table 29.2 IIC I/O pins

Channel	Pin name	I/O	Function
IIC0	SCL0	I/O	IIC0 serial clock I/O pin
	SDA0	I/O	IIC0 serial data I/O pin
IIC1	SCL1	I/O	IIC1 serial clock I/O pin
	SDA1	I/O	IIC1 serial data I/O pin

29.2 Register Descriptions

29.2.1 I2C Bus Control Register 1 (ICCR1)

Address(es): IIC0.ICCR1 4005 3000h, IIC1.ICCR1 4005 3100h

	b7	b6	b5	b4	b3	b2	b1	b0
	ICE	IICRST	CLO	SOWP	SCLO	SDAO	SCLI	SDAI
Value after reset:	0	0	0	1	1	1	1	1

Bit	Symbol	Bit name	Description	R/W
b0	SDAI	SDA Line Monitor	0: SDAn line is low 1: SDAn line is high.	R

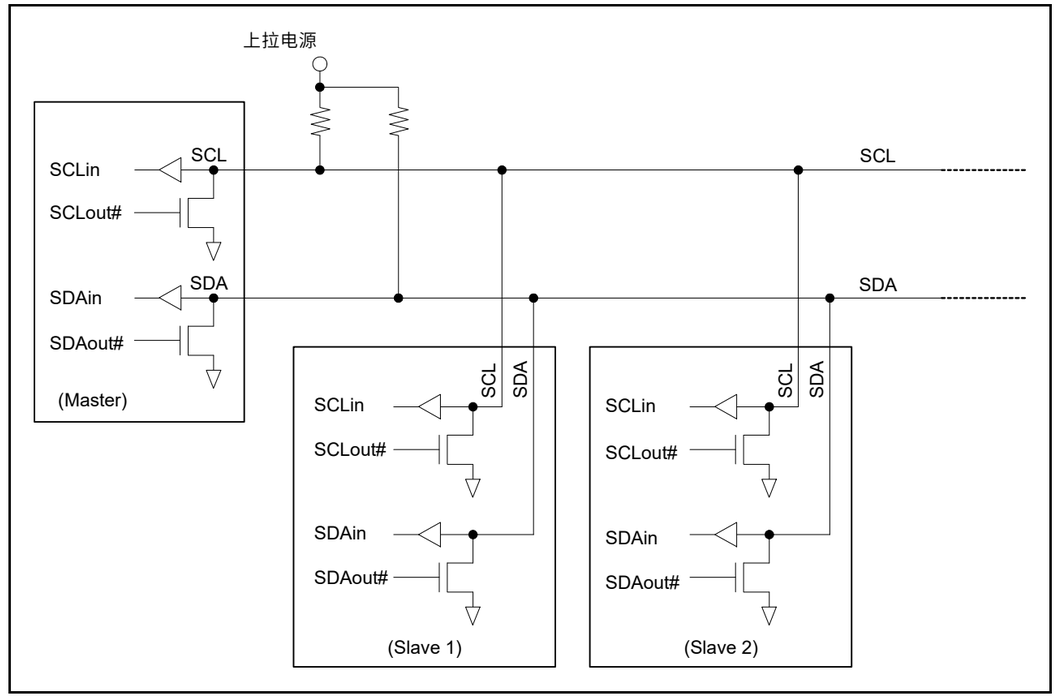


Figure 29.2 IO引脚连接到外部电路（I2C总线配置示例）

TheinputlevelofthesignalsforIICisCMOSwhenI2Cbusisselected(ICMR3.SMBS=0) orTTLwhenSMBusisselected(ICMR3.SMBS=1).

Table 29.2 IIC I/O pins

Channel	引脚名称	I/O	Function
IIC0	SCL0	I/O	IIC0串行时钟IO引脚
	SDA0	I/O	IIC0串行数据IO引脚
IIC1	SCL1	I/O	IIC1串行时钟IO引脚
	SDA1	I/O	IIC1串行数据IO引脚

29.2 注册说明

29.2.1 I2C总线控制寄存器1(ICCR1)

Address(es): IIC0.ICCR1 4005 3000h, IIC1.ICCR1 4005 3100h

	b7	b6	b5	b4	b3	b2	b1	b0
	ICE	IICRST	CLO	SOWP	SCLO	SDAO	SCLI	SDAI
重置后的值：	0	0	0	1	1	1	1	1

Bit	Symbol	位名称	Description	R/W
b0	SDAI	SDA线路监视器	0：SDAn线为低电平1 ：SDAn线为高电平。	R

Bit	Symbol	Bit name	Description	R/W
b1	SCLI	SCL Line Monitor	0: SCLn line is low 1: SCLn line is high.	R
b2	SDAO	SDA Output Control/Monitor	• Read: 0: IIC drives SDAn pin low 1: IIC releases SDAn pin. • Write: 0: IIC drives SDAn pin low 1: IIC releases SDAn pin.	R/W
b3	SCLO	SCL Output Control/Monitor	• Read: 0: IIC drives SCLn pin low 1: IIC releases SCLn pin. • Write: 0: IIC drives SCLn pin low 1: IIC releases SCLn pin. Use an external pull-up resistor to drive the signal high.	R/W
b4	SOWP	SCLO/SDAO Write Protect	0: Write enable SCLO and SDAO bits 1: Write protect SCLO and SDAO bits. This bit is read as 1.	R/W
b5	CLO	Extra SCL Clock Cycle Output	0: Do not output extra SCL clock cycle (default) 1: Output extra SCL clock cycle. This bit clears automatically after 1 clock cycle is output.	R/W
b6	IICRST	IIC-Bus Interface Internal Reset	0: Release IIC reset or internal reset 1: Initiate IIC reset or internal reset. This setting clears the bit counter and the SCLn/SDAn output latch.	R/W
b7	ICE	IIC-Bus Interface Enable	0: Disable (SCLn and SDAn pins in inactive state) 1: Enable (SCLn and SDAn pins in active state). Used in combination with the IICRST bit to select either IIC or internal reset.	R/W

SDAO bit (SDA Output Control/Monitor) and SCLO bit (SCL Output Control/Monitor)

The SDAO and SCLO bits directly control the SDAn and SCLn signals output from the IIC.

When writing to these bits, also write 0 to the SOWP bit. Setting these bits results in input to the IIC by the input buffer. When slave mode is selected, a start condition might be detected and the bus might be released, depending on the bit settings.

Do not rewrite these bits during a start condition, stop condition, restart condition, or during transmission, or reception. Operation after rewriting under the specified conditions is not guaranteed. When reading these bits, the state of signals output from the IIC can be read.

CLO bit (Extra SCL Clock Cycle Output)

The CLO bit allows output of an extra SCL clock cycle for debugging or error processing. Normally, set this bit to 0. Setting this bit to 1 in a normal communication state causes a communication error. For details on this function, see section 29.12.2, Extra SCL Clock Cycle Output Function.

IICRST bit (IIC-Bus Interface Internal Reset)

The IICRST bit initiates an internal state reset of the IIC. Setting this bit to 1 initiates an IIC reset or internal reset. Whether an IIC reset or internal reset is initiated is determined by setting this bit in combination with the ICE bit. Table 29.3 lists the IIC resets.

The IIC reset initializes all registers except ICCR1.ICE and ICCR1.IICRST bits, and internal states of the IIC. In addition to the internal states of the IIC, the internal reset initializes the following:

- Bit counter (ICMR1.BC[2:0] bits)
- I2C Bus Shift Register (ICDRS)
- I2C Bus Status Registers (ICSR1 and ICSR2)
- SDAO and SCLO Output Control/Monitor (ICCR1.SCLO and ICCR1.SDAO bits)
- I2C Bus Control Register 2 (except ICCR2.BBSY bit).

Bit	Symbol	位名称	Description	R/W
b1	SCLI	SCL线路监视器	0：SCLn线低1：SCLn线高。	R
b2	SDAO	SDA Output Control/Monitor	• Read: 0：IIC驱动SDAn引脚为低电平1：IIC释放SDAn引脚。 写： 0：IIC驱动SDAn引脚为低电平 1：IIC释放SDAn引脚。	R/W
b3	SCLO	SCL Output Control/Monitor	• Read: 0：IIC驱动SCLn引脚为低电平1：IIC释放SCLn引脚。 写： 0：IIC驱动SCLn引脚为低电平1：IIC释放SCLn引脚。使用外部上拉电阻将信号驱动为高电平。	R/W
b4	SOWP	SCLOSDAO写保护	0：写使能SCLO和SDAO位1：写保护SCLO和SDAO位。该位读为1。	R/W
b5	CLO	额外的SCL时钟周期输出	0：不输出额外的SCL时钟周期（默认）1：输出额外的SCL时钟周期。该位在输出1个时钟周期后自动清零。	R/W
b6	IICRST	IIC总线接口内部Reset	0：释放IIC复位或内部复位1：启动IIC复位或内部复位。该设置清除位计数器和SCLnSDAn输出锁存器。	R/W
b7	ICE	IIC总线接口使能	0：禁用（SCLn和SDAn引脚处于非活动状态）1：启用（SCLn和SDAn引脚处于活动状态）。与IICRST位结合使用来选择IIC或内部复位。	R/W

SDAO位（SDA输出控制监视器）和SCLO位（SCL输出控制监视器）

SDAO和SCLO位直接控制IIC输出的SDAn和SCLn信号。

写入这些位时，还要向SOWP位写入0。设置这些位会导致输入缓冲器向IIC输入。
选择从模式时，可能会检测到启动条件并释放总线，具体取决于位设置。

不要在开始条件、停止条件、重启条件或发送或接收期间重写这些位。不保证在指定条件下重写后的操作。读取这些位时，可以读取IIC输出的信号状态。

CLO位（额外SCL时钟周期输出）

CLO位允许输出额外的SCL时钟周期用于调试或错误处理。通常，将此位设置为0。
在正常通信状态下将此位设置为1会导致通信错误。有关此功能的详细信息，请参见第29.12.2节，额外SCL时钟周期输出功能。

IICRST位（IIC总线接口内部复位）

IICRST位启动IIC的内部状态复位。将此位设置为1会启动IIC复位或内部复位。
是否启动IIC复位或内部复位由设置该位和ICE位共同决定。表29.3列出了IIC复位。

IIC复位初始化除ICCR1.ICE和ICCR1.IICRST位之外的所有寄存器，以及IIC的内部状态。除了IIC的内部状态之外，内部复位还会初始化以下内容：

- 位计数器（ICMR1.BC[2:0]位）
- I2C总线移位寄存器(ICDRS)
- I2C总线状态寄存器（ICSR1和ICSR2）
- SDAO和SCLO输出控制监视器（ICCR1.SCLO和ICCR1.SDAO位）
- I2C总线控制寄存器2（ICCR2.BBSY位除外）。

For the reset conditions of each register, see section 29.15, State of Registers when Issuing each Condition.

An internal reset initiated with the IICRST bit set to 1 during operation (with the ICE bit set to 1) resets the internal states of the IIC without initializing the port settings and the control and setting registers of the IIC. If the IIC hangs up in a low level output state, resetting the internal states cancels the low level output state and releases the bus with the SCLn pin and SDAn pin at high impedance.

Note: If an internal reset is initiated using the IICRST bit for a bus hang-up that occurs during communication with the master device in slave mode, the slave and master devices might enter different states, because the bit counter information differs. For this reason, do not initiate an internal reset in slave mode. Initiate recovery processing from the master device. If an internal reset is required because the IIC hangs with the SCLn line in a low level output state in slave mode, initiate an internal reset, then issue a restart condition from the master device, or issue a stop condition and resume communication from the start condition. If communication is restarted by initiating a reset solely in the slave device without issuing a start or restart condition from the master device, synchronization is lost because the master and slave devices operate asynchronously.

Table 29.3 IIC resets

IICRST	ICE	State	Specifications
1	0	IIC reset	Resets all registers except ICCR1.ICE and ICCR1.IICRST bits, and the internal states of the IIC
	1	Internal reset	Resets the following: • ICMR1.BC[2:0] bits • ICSR1, ICSR2, ICDRS registers • SDAO and SCLO Output Control/Monitor (ICCR1.SCLO and ICCR1.SDAO bits) • I2C Bus Control Register 2 (except ICCR2.BBSY bit) • Internal states of the IIC.

ICE bit (IIC-Bus Interface Enable)

The ICE bit selects the active or inactive state of the SCLn and SDAn pins. It can also be combined with the IICRST bit to initiate one of two types of resets. See Table 29.3 for the reset types.

Set the ICE bit to 1 when using the IIC. The SCLn and SDAn pins are placed in the active state when the ICE bit is set to 1. Set the ICE bit to 0 when the IIC is not used. The SCLn and SDAn pins are placed in the inactive state when the ICE bit is set to 0. Do not assign the SCLn or SDAn pin to the IIC when setting up the pin function control. Slave address comparison is performed if the pins are assigned to the IIC.

29.2.2 I2C Bus Control Register 2 (ICCR2)

Address(es): IIC0.ICCR2 4005 3001h, IIC1.ICCR2 4005 3101h

	b7	b6	b5	b4	b3	b2	b1	b0
	BBSY	MST	TRS	—	SP	RS	ST	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b1	ST	Start Condition Issuance Request	0: Do not issue a start condition request 1: Issue a start condition request.	R/W
b2	RS	Restart Condition Issuance Request	0: Do not issue a restart condition request 1: Issue a restart condition request.	R/W
b3	SP	Stop Condition Issuance Request	0: Do not issue a stop condition request 1: Issue a stop condition request.	R/W
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b5	TRS	Transmit/Receive Mode	0: Receive mode 1: Transmit mode.	R/W*1

有关每个寄存器的复位条件，请参阅第29.15节，发出每个条件时的寄存器状态。

在操作期间将IICRST位设置为1（ICE位设置为1）启动的内部复位会复位IIC的内部状态，而无需初始化IIC的端口设置以及控制和设置寄存器。如果IIC在低电平输出状态下挂起，复位内部状态会取消低电平输出状态并释放总线，同时SCLn引脚和SDAn引脚处于高阻抗状态。

Note: 如果在从模式下与主设备通信期间发生的总线挂断使用IICRST位启动内部复位，则从设备和主设备可能会进入不同的状态，因为位计数器信息不同。因此，不要在从模式下启动内部复位。从主设备启动恢复处理。如果由于IIC在从机模式下挂起且SCLn线处于低电平输出状态而需要内部复位，则启动内部复位，然后从主设备发出重新启动条件，或发出停止条件并从开始处恢复通信健康）状况。如果通过仅在从设备中启动复位来重新启动通信，而没有从主设备发出启动或重新启动条件，则由于主设备和从设备异步操作而失去同步。

Table 29.3 IIC resets

IICRST	ICE	State	Specifications
1	0	IIC reset	复位除ICCR1.ICE和ICCR1.IICRST位之外的所有寄存器，以及IIC的内部状态
	1	内部复位	复位以下内容： ICMR1.BC[2:0]位 ICSR1、ICSR2、ICDRS寄存器 SDAO和SCLO输出控制监视器（ICCR1.SCLO和ICCR1.SDAO位） I2C总线控制寄存器2（ICCR2.BBSY位除外） IIC的内部状态。

ICE位（IIC总线接口使能）

ICE位选择SCLn和SDAn引脚的有效或无效状态。它也可以与IICRST位结合来启动两种类型的复位中的一种。复位类型见表29.3。

使用IIC时将ICE位设置为1。当ICE位设置为1时，SCLn和SDAn引脚处于活动状态。不使用IIC时，将ICE位设置为0。当ICE位设置为0时，SCLn和SDAn引脚处于非活动状态。在设置引脚功能控制时，不要将SCLn或SDAn引脚分配给IIC。如果引脚分配给IIC，则执行从地址比较。

29.2.2 I2C总线控制寄存器2(ICCR2)

Address(es): IIC0.ICCR2 4005 3001h, IIC1.ICCR2 4005 3101h

	b7	b6	b5	b4	b3	b2	b1	b0
	BBSY	MST	TRS	—	SP	RS	ST	—
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	—	Reserved	该位读取为0。写入值应为0。	R/W
b1	ST	开始条件签发 Request	0：不发出启动条件请求1：发出启动条件请求。	R/W
b2	RS	重启条件发布 Request	0：不发出重启条件请求1：发出重启条件请求。	R/W
b3	SP	停止条件发布 Request	0：不发出停止条件请求1：发出停止条件请求。	R/W
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b5	TRS	Transmit/Receive Mode	0：接收模式1：发送模式。	R/W*1

Bit	Symbol	Bit name	Description	R/W
b6	MST	Master/Slave Mode	0: Slave mode 1: Master mode.	R/W*1
b7	BBSY	Bus Busy Detection Flag	0: I2C bus released (bus free state) 1: I2C bus occupied (bus busy state).	R

Note 1. The MST and TRS bits can be written to when the ICMR1.MTWP bit is set to 1.

ST bit (Start Condition Issuance Request)

The ST bit requests transition to master mode and triggers a start condition.

When this bit is set to 1, a start condition is issued when the BBSY flag is set to 0 (bus free state). For details on issuing a start condition, see section 29.11, Start, Restart, and Stop Condition Issuing Function.

[Setting condition]

- When 1 is written to the ST bit.

[Clearing conditions]

- When 0 is written to the ST bit
- When a start condition is issued (a start condition is detected)
- When the AL (arbitration-lost) flag in ICSR2 is set to 1
- When 1 is written to the IICRST bit in ICCR1 to apply an IIC reset or an internal reset.

Note: Only set the ST bit to 1 (start condition request) when the BBSY flag is set to 0 (bus free state). Arbitration might be lost if the ST bit is set to 1 when the BBSY flag is 1 (bus busy state).

RS bit (Restart Condition Issuance Request)

The RS bit requests that a restart condition be issued in master mode.

When this bit is set to 1 to request a restart condition, a restart condition is issued when the BBSY flag is set to 1 (bus busy state) and the MST bit is set to 1 (master mode). For details on issuing a restart condition, see section 29.11, Start, Restart, and Stop Condition Issuing Function.

[Setting condition]

- When 1 is written to the RS bit with the BBSY flag in ICCR2 set to 1.

[Clearing conditions]

- When 0 is written to the RS bit
- When a restart condition is issued (a start condition is detected)
- When the AL (arbitration-lost) flag in ICSR2 is set to 1
- When 1 is written to the IICRST bit in ICCR1 to apply an IIC reset or an internal reset.

Note: Do not set the RS bit to 1 while issuing a stop condition.
Note: If 1 (restart condition request) is written to the RS bit in slave mode, the restart condition is not issued, but the RS bit remains set to 1. If the operating mode changes to master mode without the bit being cleared, a restart condition might be issued.

SP bit (Stop Condition Issuance Request)

The SP bit requests that a stop condition be issued in master mode.

When this bit is set to 1, a stop condition is issued when the BBSY flag is set to 1 (bus busy state) and the MST bit is set to 1 (master mode). For details on this function, see section 29.11, Start, Restart, and Stop Condition Issuing Function.

[Setting condition]

- When 1 is written to the SP bit with both the BBSY flag and the MST bit in ICCR2 set to 1.

Bit	Symbol	位名称	Description	R/W
b6	MST	Master/Slave Mode	0：从模式1：主模式。	R/W*1
b7	BBSY	总线忙检测标志	0：I2C总线释放（总线空闲状态）1：I2C总线占用（总线忙状态）。	R

Note 1. 当ICMR1.MTWP位设置为1时，可以写入MST和TRS位。

ST位（开始条件发布请求）

ST位请求转换到主模式并触发启动条件。

当该位设置为1时，当BBSY标志设置为0（总线空闲状态）时发出启动条件。有关发出启动条件的详细信息，请参阅第29.11节，启动、重启和停止条件发出功能。

[Setting condition]

- 当1写入ST位时。

[Clearing conditions]

- 当0写入ST位时
- 发出启动条件时（检测到启动条件）
- ICSR2中的AL（仲裁失败）标志设置为1时
- 当向ICCR1中的IICRST位写入1时，应用IIC复位或内部复位。

Note: 仅当BBSY标志设置为0（总线空闲状态）时，才将ST位设置为1（启动条件请求）。如果在BBSY标志为1（总线繁忙状态）时将ST位设置为1，则仲裁可能会丢失。

RS位（重启条件发布请求）

RS位请求在主机模式下发出重启条件。

当该位设置为1以请求重新启动条件时，当BBSY标志设置为1（总线繁忙状态）且MST位设置为1（主模式）时，发出重新启动条件。有关发出重新启动条件的详细信息，请参阅第29.11节，启动、重新启动和停止条件发出功能。

[Setting condition]

- 当ICCR2中的BBSY标志设置为1时，将1写入RS位。

[Clearing conditions]

- 当0写入RS位时
- 发出重新启动条件时（检测到启动条件）
- ICSR2中的AL（仲裁失败）标志设置为1时
- 当向ICCR1中的IICRST位写入1时，应用IIC复位或内部复位。

Note: 发出停止条件时不要将RS位设置为1。
Note: 如果在从模式下将1（重新启动条件请求）写入RS位，则不会发出重新启动条件，但RS位保持设置为1。如果操作模式更改为主模式而未清除该位，则重新启动条件可能会发出。

SP位（停止条件发出请求）

SP位请求在主机模式下发出停止条件。

当该位设置为1时，当BBSY标志设置为1（总线繁忙状态）且MST位设置为1（主模式）时，发出停止条件。有关此功能的详细信息，请参阅第29.11节"启动、重启和停止条件发出功能"。

[Setting condition]

- 当1写入SP位时，且ICCR2中的BBSY标志和MST位都设置为1。

[Clearing conditions]

- When 0 is written to the SP bit
- When a stop condition is issued (a stop condition is detected)
- When the AL (arbitration-lost) flag in ICSR2 is set to 1
- When a start condition and a restart condition are detected
- When 1 is written to the IICRST bit in ICCR1 to apply an IIC reset or an internal reset.

Note: Writing to the SP bit is not possible when the BBSY flag is 0 (bus free state).
Note: Do not set the SP bit to 1 when a restart condition is being issued.

TRS bit (Transmit/Receive Mode)

The TRS bit indicates transmit or receive mode.

The IIC is in receive mode when the TRS bit is 0 and in transmit mode when the bit is 1. The combination of the TRS bit and the MST bit indicates the IIC operating mode.

The value of the TRS bit automatically changes to 1 for transmit mode or 0 for receive mode when a start condition is issued or detected and the R/W# bit is set. Although writing to the TRS bit is possible when the MTWP bit in ICMR1 is set to 1, writing to this bit is not required during normal usage.

[Setting conditions]

- When a start condition is issued normally because of a start condition request (when a start condition is detected with the ST bit set to 1)
- When a restart condition is issued normally because of a restart condition request (when a restart condition is detected with the RS bit set to 1)
- When the R/W# bit appended to the slave address is set to 0 in master mode
- When the address received in slave mode matches the address enabled in ICSER, with the R/W# bit set to 1
- When 1 is written to the TRS bit with the MTWP bit in ICMR1 set to 1.

[Clearing conditions]

- When a stop condition is detected
- When the AL (arbitration-lost) flag in ICSR2 is set to 1
- When the R/W# bit appended to the slave address is set to 1 in master mode
- In slave mode, on a match between the received address and the address enabled in ICSER when the value of the received R/W# bit is 0, including when the received address is the general call address
- In slave mode, when a restart condition is detected (a start condition is detected with ICCR2.BBSY = 1 and ICCR2.MST = 0)
- When 0 is written to the TRS bit with the MTWP bit in ICMR1 set to 1
- When 1 is written to the IICRST bit in ICCR1 to apply an IIC reset or an internal reset.

MST bit (Master/Slave Mode)

The MST bit indicates master or slave mode. The IIC is in slave mode when the MST bit is set to 0 and is in master mode when the bit is set to 1. The combination of the MST bit and the TRS bit indicates the IIC operating mode.

The value of the MST bit automatically changes to 1 for master mode or 0 for slave mode when a start condition is issued, or when a stop condition is issued or detected. Although writing to the MST bit is possible when the MTWP bit in ICMR1 is set to 1, writing to this bit is not required during normal usage.

[Setting conditions]

- When a start condition is issued normally because of a start condition request (when a start condition is detected with the ST bit set to 1)

[Clearing conditions]

- 当0写入SP位时
- 发出停止条件时（检测到停止条件）
- ICSR2中的AL（仲裁失败）标志设置为1时
- 当检测到启动条件和重新启动条件时
- 当向ICCR1中的IICRST位写入1时，应用IIC复位或内部复位。

Note: 当BBSY标志为0（总线空闲状态）时，不能写入SP位。
Note: 发出重启条件时不要将SP位设置为1。

TRS位（发送接收模式）

TRS位指示发送或接收模式。

当TRS位为0时IIC处于接收模式，当该位为1时IIC处于发送模式。TRS位和MST位的组合表示IIC工作模式。

当发出或检测到启动条件并且设置RW#位时，TRS位的值自动更改为1（发送模式）或0（接收模式）。虽然当ICMR1的MTWP位设置为1时可以写入TRS位，但在正常使用期间不需要写入该位。

[Setting conditions]

- 由于启动条件请求而正常发出启动条件时（在ST位设置为1的情况下检测到启动条件时）
- 由于重新启动条件请求而正常发出重新启动条件时（在RS位设置为1的情况下检测到重新启动条件时）
- 当附加到从地址的RW#位在主模式下设置为0时
- 当从机模式接收到的地址与ICSER中使能的地址匹配时，RW#位设置为1
- 当将1写入TRS位且ICMR1中的MTWP位设置为1时。

[Clearing conditions]

- 检测到停止条件时
- ICSR2中的AL（仲裁失败）标志设置为1时
- 当附加到从地址的RW#位在主模式下设置为1时
- 在从机模式下，当接收到的RW#位的值为0时，接收到的地址与ICSER中使能的地址匹配，包括接收到的地址是广播地址时
- 在从模式下，当检测到重启条件时（检测到ICCR2.BBSY=1和ICCR2.MST = 0)
- 当将0写入TRS位且ICMR1中的MTWP位设置为1时
- 当向ICCR1中的IICRST位写入1时，应用IIC复位或内部复位。

MST位（主从模式）

MST位指示主机或从机模式。当MST位设置为0时，IIC处于从机模式，当该位设置为1时，IIC处于主机模式。MST位和TRS位的组合表示IIC工作模式。

当发出启动条件或发出或检测到停止条件时，MST位的值自动变为1（主模式）或0（从模式）。虽然当ICMR1中的MTWP位设置为1时可以写入MST位，但在正常使用期间不需要写入该位。

[Setting conditions]

- 由于启动条件请求而正常发出启动条件时（在ST位设置为1的情况下检测到启动条件时）

- When 1 is written to the MST bit with the MTWP bit in ICMR1 set to 1.

[Clearing conditions]

- When a stop condition is detected
- When the AL (arbitration-lost) flag in ICSR2 is set to 1
- When 0 is written to the MST bit with the MTWP bit in ICMR1 set to 1
- When 1 is written to the IICRST bit in ICCR1 to apply an IIC reset or an internal reset.

BBSY flag (Bus Busy Detection Flag)

The BBSY flag indicates whether the I2C bus is occupied (bus busy state) or released (bus free state).

This flag is set to 1 when the SDAn line changes from high to low with the SCLn line is high, assuming that a start condition was issued.

This flag is set to 0 when the SDAn line changes from low to high with the SCLn line high, if the bus free time (ICBRL setting) start condition is not detected, assuming that a stop condition was issued.

[Setting condition]

- When a start condition is detected.

[Clearing conditions]

- When the bus free time (ICBRL register setting) start condition is not detected after detecting a stop condition
- When 1 is written to the IICRST bit in ICCR1 with the ICE bit in ICCR1 set to 0 (IIC reset).

29.2.3 I2C Bus Mode Register 1 (ICMR1)

Address(es): IIC0.ICMR1 4005 3002h, IIC1.ICMR1 4005 3102h

	b7	b6	b5	b4	b3	b2	b1	b0
	MTWP	CKS[2:0]			BCWP	BC[2:0]		
Value after reset:	0	0	0	0	1	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	BC[2:0]	Bit Counter	b2 b0 0 0: 9 bits 0 0: 1 bits 0 1: 3 bits 0 1: 4 bits 1 0: 5 bits 1 0: 6 bits 1 1: 7 bits 1 1: 8 bits.	R/W*1
b3	BCWP	BC Write Protect	0: Write enable BC[2:0] bits 1: Write protect BC[2:0] bits. This bit is read as 1.	R/W*1
b6 to b4	CKS[2:0]	Internal Reference Clock Select	Select the internal reference clock source (IICϕ) for the IIC. b6 b4 0 0: PCLKB clock 0 0: PCLKB/2 clock 0 1: PCLKB/4 clock 0 1: PCLKB/8 clock 1 0: PCLKB/16 clock 1 0: PCLKB/32 clock 1 1: PCLKB/64 clock 1 1: PCLKB/128 clock.	R/W
b7	MTWP	MST/TRS Write Protect	0: Write protect MST and TRS bits in ICCR2 1: Write enable MST and TRS bits in ICCR2.	R/W

- 当ICMR1中的MTWP位设置为1时，将1写入MST位。

[Clearing conditions]

- 检测到停止条件时
- ICSR2中的AL（仲裁失败）标志设置为1时
- 将0写入MST位且ICMR1中的MTWP位设置为1时
- 当向ICCR1中的IICRST位写入1时，应用IIC复位或内部复位。

BBSY标志（总线忙检测标志）

BBSY标志指示I2C总线是被占用（总线繁忙状态）还是被释放（总线空闲状态）。

当SDAn线从高电平变为低电平且SCLn线为高电平时，该标志设置为1，假设发出了启动条件。

如果未检测到总线空闲时间（ICBRL设置）启动条件，假设发出了停止条件，则当SDAn线从低电平变为高电平而SCLn线为高电平时，该标志设置为0。

[Setting condition]

- 当检测到启动条件时。

[Clearing conditions]

- 在检测到停止条件后未检测到总线空闲时间（ICBRL寄存器设置）启动条件时
- 当ICCR1中的IICRST位写入1且ICCR1中的ICE位设置为0（IIC复位）时。

29.2.3 I2C总线模式寄存器1(ICMR1)

Address(es): IIC0.ICMR1 4005 3002h, IIC1.ICMR1 4005 3102h

	b7	b6	b5	b4	b3	b2	b1	b0
	MTWP	CKS[2:0]			BCWP	BC[2:0]		
重置后的值：	0	0	0	0	1	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	BC[2:0]	位计数器	b2 b0 0 0: 9 bits 0 0: 1 bits 0 1: 3 bits 0 1: 4 bits 1 0: 5 bits 1 0: 6 bits 1 1: 7 bits 1 1: 8 bits.	R/W*1
b3	BCWP	BC写保护	0：写使能BC[2:0]位1：写保护BC[2:0]位。该位读为1。	R/W*1
b6 to b4	CKS[2:0]	内部参考时钟选择	选择IIC的内部参考时钟源(IIC)。b6b4000：PCLKB时钟001：PCLKB2时钟010：PCLKB4时钟011：PCLKB8时钟100：PCLKB16时钟101：PCLKB32时钟110：PCLKB64时钟111：PCLKB128时钟。	R/W
b7	MTWP	MSTTRS写保护	0：写保护ICCR2中的MST和TRS位1：写使能ICCR2中的MST和TRS位。	R/W

Note 1. Rewrite the BC[2:0] bits and set the BCWP bit to 0 at the same time.

BC[2:0] bits (Bit Counter)

The BC[2:0] bits function as a counter that indicates the number of bits remaining to be transferred on detection of a rising edge on the SCLn line. Although BC[2:0] are read/write bits, it is not required to access these bits under normal conditions.

To write to these bits, specify the number of bits to be transferred plus one, for an additional acknowledge bit, between transferred frames when the SCLn line is at a low level.

The value in the BC[2:0] bits returns to 000b at the end of a data transfer, including the acknowledge bit, or when a start or restart condition is detected.

29.2.4 I2C Bus Mode Register 2 (ICMR2)

Address(es): IIC0.ICMR2 4005 3003h, IIC1.ICMR2 4005 3103h

	b7	b6	b5	b4	b3	b2	b1	b0
	DLCS	SDDL[2:0]			—	TMOH	TMOL	TMOS
Value after reset:	0	0	0	0	0	1	1	0

Bit	Symbol	Bit name	Description	R/W
b0	TMOS	Timeout Detection Time Select	0: Select long mode 1: Select short mode.	R/W
b1	TMOL	Timeout L Count Control	0: Disable count while SCLn line is low 1: Enable count while SCLn line is low.	R/W
b2	TMOH	Timeout H Count Control	0: Disable count while SCLn line is high 1: Enable count while SCLn line is high.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6 to b4	SDDL[2:0]	SDA Output Delay Counter	• When ICMR2.DLCS = 0 (IICϕ) b6 b4 0 0 0: No output delay 0 0 1: 1 IICϕ cycle 0 1 0: 2 IICϕ cycles 0 1 1: 3 IICϕ cycles 1 0 0: 4 IICϕ cycles 1 0 1: 5 IICϕ cycles 1 1 0: 6 IICϕ cycles 1 1 1: 7 IICϕ cycles. • When ICMR2.DLCS = 1 (IICϕ/2) b6 b4 0 0 0: No output delay 0 0 1: 1 or 2 IICϕ cycles 0 1 0: 3 or 4 IICϕ cycles 0 1 1: 5 or 6 IICϕ cycles 1 0 0: 7 or 8 IICϕ cycles 1 0 1: 9 or 10 IICϕ cycles 1 1 0: 11 or 12 IICϕ cycles 1 1 1: 13 or 14 IICϕ cycles.	R/W
b7	DLCS	SDA Output Delay Clock Source Select	0: Internal reference clock (IICϕ) selected as the clock source for SDA output delay counter 1: Internal reference clock divided by 2 (IICϕ/2) selected as the clock source for SDA output delay counter.*1	R/W

Note 1. The setting DLCS = 1 (IICϕ/2) is only valid when SCL is low. When SCL is high, the DLCS = 1 setting is invalid and the clock source becomes the internal reference clock (IICϕ).

TMOS bit (Timeout Detection Time Select)

The TMOS bit selects long or short mode for the timeout detection time when the timeout function is enabled (ICFER.TMOE = 1).

Note 1. 重写BC[2:0]位，同时将BCWP位设置为0。

BC[2:0]位（位计数器）

BC[2:0]位用作计数器，指示在检测到SCLn线上的上升沿时要传输的剩余位数。虽然BC[2:0]是读写位，但在正常情况下不需要访问这些位。

要写入这些位，在SCLn线处于低电平时，指定要传输的位数加1，作为附加确认位，在传输的帧之间。

BC[2:0]位中的值在数据传输结束时返回到000b，包括确认位，或者当检测到启动或重启条件时。

29.2.4 I2C总线模式寄存器2(ICMR2)

Address(es): IIC0.ICMR2 4005 3003h, IIC1.ICMR2 4005 3103h

	b7	b6	b5	b4	b3	b2	b1	b0
	DLCS	SDDL[2:0]			—	TMOH	TMOL	TMOS
重置后的值:	0	0	0	0	0	1	1	0

Bit	Symbol	位名称	Description	R/W
b0	TMOS	超时检测时间选择	0：选择长模式1：选择短模式。	R/W
b1	TMOL	超时L计数控制	0：SCLn线为低电平时禁止计数1：SCLn线为低电平时使能计数。	R/W
b2	TMOH	超时H计数控制	0：SCLn线为高时禁止计数1：SCLn线为高时使能计数。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b6 to b4	SDDL[2:0]	SDA输出延迟计数器	当ICMR2.DLCS=0(IIC)b6b4000：无输出延迟001：1IIC 周期010：2IIC 周期011：3IIC 周期100：4IIC周期101：5IIC 周期110：6IIC 周期111：7IIC 周期。 当ICMR2.DLCS=1(IIC 2)b6b4000：无输出延迟001：1或2个IIC 周期010：3或4个IIC周期011：5或6个IIC 周期100：7或8个IIC 周期101：9或10个IIC 周期110：11或12个IIC 周期111：13或14个IIC 周期。	R/W
b7	DLCS	SDA输出延迟时钟源Select	0：选择内部参考时钟(IIC)作为SDA输出延迟计数器的时钟源1：选择内部参考时钟除以2(IIC 2)作为SDA输出延迟计数器的时钟源。*1	R/W

Note 1. 设置DLCS=1(IIC 2)仅在SCL为低电平时有效。当SCL为高电平时，DLCS=1设置无效，时钟源变为内部参考时钟(IIC)。

TMOS位（超时检测时间选择）

当使能超时功能（ICFER.TMOE=1）时，TMOS位为超时检测时间选择长模式或短模式。

When this bit is set to 0, long mode is selected. When it is set to 1, short mode is selected.

In long mode, the timeout detection internal counter functions as a 16 bit-counter. In short mode, the counter functions as a 14-bit counter. While the SCLn line is in the state that enables this counter as specified in the TMOH and TMOL bits, the counter counts up in synchronization with the internal reference clock (IICϕ) as a count source.

For details on this function, see section 29.12.1, Timeout Function.

TMOL bit (Timeout L Count Control)

The TMOL bit enables or disables up-counting on the internal counter of the timeout function while the SCLn line is held low and the timeout function is enabled (ICFER.TMOE = 1).

TMOH bit (Timeout H Count Control)

The TMOH bit enables or disables up-counting on the internal counter of the timeout function while the SCLn line is held high and the timeout function is enabled (ICFER.TMOE = 1).

SDDL[2:0] bits (SDA Output Delay Counter)

The SDDL[2:0] bits can be used to delay the SDA output. This counter works with the clock source selected in the DLCS bit. The SDDL[2:0] setting can be used for all types of SDA output, including the transmission of the acknowledge bit.

Set the SDA output delay to meet the I2C bus standard for the data enable time/acknowledge enable time*1, or the SMBus standard, within [data hold time (300 ns or more + the SCL clock low-level period) - the data setup time (250 ns)]. If a value outside the standard is set, communication between the devices might malfunction or falsely indicate a start or stop condition, depending on the bus state.

For details on this function, see section 29.5, SDA Output Delay Function.

Note 1. Data enable time/acknowledge enable time
3,450 ns for up to 100 kbps: Standard mode (Sm)
900 ns for up to 400 kbps: Fast mode (Fm)
450 ns for up to 1 Mbps: Fast mode plus (Fm+).

29.2.5 I2C Bus Mode Register 3 (ICMR3)

Address(es): IIC0.ICMR3 4005 3004h, IIC1.ICMR3 4005 3104h

	b7	b6	b5	b4	b3	b2	b1	b0
	SMBS	WAIT	RDRFS	ACKWP	ACKBT	ACKBR	NF[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	NF[1:0]	Noise Filter Stage Select	b1 b0 0 0: Filter out noise of up to 1 IICϕ cycle (single-stage filter) 0 1: Filter out noise of up to 2 IICϕ cycles (2-stage filter) 1 0: Filter out noise of up to 3 IICϕ cycles (3-stage filter) 1 1: Filter out noise of up to 4 IICϕ cycles (4-stage filter).	R/W
b2	ACKBR	Receive Acknowledge	0: 0: Received as the acknowledge bit (ACK reception) 1: 1: Received as the acknowledge bit (NACK reception).	R
b3	ACKBT	Transmit Acknowledge	0: Send 0 as the acknowledge bit (ACK transmission) 1: Send 1 as the acknowledge bit (NACK transmission).	R/W*1
b4	ACKWP	ACKBT Write Protect	0: Write protect ACKBT bit 1: Write enable ACKBT bit.	R/W*1
b5	RDRFS	RDRF Flag Set Timing Select	0: Set the RDRF flag on the rising edge of the 9th SCL clock cycle. The SCLn line is not held low on the falling edge of the 8th clock cycle 1: Set the RDRF flag on the rising edge of the 8th SCL clock cycle. The SCLn line is held low on the falling edge of the 8th clock cycle. Low-hold is released by writing to ACKBT.	R/W*2

当该位设置为0时，选择长模式。当设置为1时，选择短模式。

在长模式下，超时检测内部计数器用作16位计数器。在短模式下，计数器用作14位计数器。当SCLn线处于启用TMOH和TMOL位中指定的计数器的状态时，计数器与作为计数源的内部参考时钟(IIC)同步递增计数。

有关此功能的详细信息，请参阅第29.12.1节，超时功能。

TMOL位（超时L计数控制）

TMOL位启用或禁用超时功能内部计数器的递增计数，同时SCLn线保持低电平且启用超时功能(ICFER.TMOE= 1)。

TMOH位（超时H计数控制）

TMOH位启用或禁用超时功能内部计数器的递增计数，同时SCLn线保持高电平且启用超时功能(ICFER.TMOE= 1)。

SDDL[2:0]位（SDA输出延迟计数器）

SDDL[2:0]位可用于延迟SDA输出。该计数器与在DLCS位中选择的时钟源一起工作。SDDL[2:0]设置可用于所有类型的SDA输出，包括确认位的传输。

设置SDA输出延迟以满足数据启用时间确认启用时间*1的I2C总线标准，或
SMBus标准，在[数据保持时间（300ns或更长+SCL时钟低电平周期）数据建立时间（250ns）]内。如果设置了超出标准的值，则设备之间的通信可能会发生故障或错误地指示开始或停止条件，具体取决于总线状态。

有关此功能的详细信息，请参阅第29.5节，SDA输出延迟功能。

注1.数据使能时间确认使能时间
3 450ns，最高100kbps：标准模式(Sm)900ns，
最高400kbps：快速模式(Fm)450ns，最高1Mbps
：加快速模式(Fm+)。

29.2.5 I2C总线模式寄存器3(ICMR3)

Address(es): IIC0.ICMR3 4005 3004h, IIC1.ICMR3 4005 3104h

	b7	b6	b5	b4	b3	b2	b1	b0
	SMBS	WAIT	RDRFS	ACKWP	ACKBT	ACKBR	NF[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	NF[1:0]	噪声过滤级选择	b1b000：过滤最多1个IIC 周期的噪声（单级滤波器）01：最多过滤2个IIC 周期的噪声（2级滤波器）10：最多过滤3个噪声IIC 周期（3级滤波器）11：滤除最多4个IIC 周期（4级滤波器）的噪声。	R/W
b2	ACKBR	接收确认	0：0：作为确认位接收（ACK接收）1：1：作为确认位接收（NACK接收）。	R
b3	ACKBT	发送确认	0：发送0作为确认位（ACK发送）1：发送1作为确认位（NACK发送）。	R/W*1
b4	ACKWP	ACKBT写保护	0：写保护ACKBT位1：写使能ACKBT位。	R/W*1
b5	RDRFS	RDRF标志设置时序Select	0：在第9个SCL时钟周期的上升沿设置RDRF标志。SCLn线在第8个时钟周期的下降沿不保持低电平1：在第8个SCL时钟周期的上升沿设置RDRF标志。SCLn线在第8个时钟周期的下降沿保持低电平。 通过写入ACKBT释放低保持。	R/W*2

Bit	Symbol	Bit name	Description	R/W
b6	WAIT	WAIT	0: No wait The period between 9th clock cycle and first clock cycle is not held low 1: Wait The period between 9th clock cycle and first clock cycle is held low. Low-hold is released by reading ICDRR.	R/W*2
b7	SMBS	SMBus/IIC-Bus Select	0: I2C bus selected 1: SMBus selected.	R/W

Note 1. Write to the ACKBT bit only when the ACKWP bit is 1. If the application writes 1 to both the ACKWP and ACKBT bits at the same time, the ACKBT bit is not set to 1.
Note 2. The WAIT and RDRFS bits are only valid in receive mode (invalid in transmit mode).

NF[1:0] bits (Noise Filter Stage Select)

The NF[1:0] bits select the number of stages in the digital noise filter.

For details on this function, see section 29.6, Digital Noise Filter Circuits.

Note: Set the noise range to be filtered out by the noise filter within a range less than the SCLn line high-level period or low-level period. If the noise range is set to a value of [SCL clock width: high-level period or low-level period, whichever is shorter] - [1.5 internal reference clock (IICϕ) cycles + analog noise filter: 120 ns (reference values)] or more, the SCL clock is regarded as noise by the noise filter function of the IIC, which might prevent the IIC from operating normally.

ACKBR bit (Receive Acknowledge)

The ACKBR bit stores the acknowledge bit information received from the receive device in transmit mode.

[Setting condition]

- When 1 is received as the acknowledge bit with the TRS bit in ICCR2 set to 1.

[Clearing conditions]

- When 0 is received as the acknowledge bit with the TRS bit in ICCR2 set to 1
- When 1 is written to the IICRST bit in ICCR1 while the ICE bit in ICCR1 is 0 (IIC reset).

ACKBT bit (Transmit Acknowledge)

The ACKBT bit sets the acknowledge bit to be sent in receive mode.

[Setting condition]

- When 1 is written to this bit with the ACKWP bit set to 1.

[Clearing conditions]

- When 0 is written to this bit with the ACKWP bit set to 1
- When stop condition request is detected with the SP bit in ICCR2 set to 1
- When 1 is written to the IICRST bit in ICCR1 while the ICE bit in ICCR1 is 0 (IIC reset).

ACKWP bit (ACKBT Write Protect)

The ACKWP bit controls write enabling of the ACKBT bit.

RDRFS bit (RDRF Flag Set Timing Select)

The RDRFS bit selects the RDRF flag set timing in receive mode and also selects whether to hold the SCLn line low on the falling edge of the 8th SCL clock cycle.

When the RDRFS bit is 0, the SCLn line is not held low on the falling edge of the 8th SCL clock cycle, and the RDRF flag is set to 1 on the rising edge of the 9th SCL clock cycle.

When the RDRFS bit is 1, the RDRF flag is set to 1 on the rising edge of the 8th SCL clock cycle, and the SCLn line is held low on the falling edge of the 8th SCL clock cycle. The low-hold of the SCLn line is released by a write to the

Bit	Symbol	位名称	Description	R/W
b6	WAIT	WAIT	0：无需等待 第9个时钟周期和第一个时钟周期之间的周期不保持低电平1：等待 第9个时钟周期和第一个时钟周期之间的周期保持低电平。 通过读取ICDRR释放低保持。	R/W*2
b7	SMBS	SMBus/IIC-Bus Select	0：选择I2C总线1 ：选择SMBus。	R/W

Note 1. 仅当ACKWP位为1时才写入ACKBT位。如果应用程序同时向ACKWP和ACKBT位写入1，则ACKBT位不会设置为1。

Note 2. WAIT和RDRFS位仅在接收模式下有效（在发送模式下无效）。

NF[1:0]位（噪声滤波器级选择）

NF[1:0]位选择数字噪声滤波器的级数。

有关此功能的详细信息，请参阅第29.6节，数字噪声滤波器电路。

Note: 将噪声滤波器滤除的噪声范围设置在小于SCLn线高电平周期或低电平周期的范围内。如果噪声范围设置为[SCL时钟宽度：高电平周期或低电平周期，以较短者为准][1.5内部参考时钟(IIC)周期+模拟噪声滤波器：120ns（参考值）]或以上，SCL时钟会被IIC的噪声过滤功能视为噪声，这可能会导致IIC无法正常工作。

ACKBR位（接收确认）

ACKBR位存储在发送模式下从接收设备接收到的确认位信息。

[Setting condition]

- 当ICCR2中的TRS位设置为1接收到1作为确认位时。

[Clearing conditions]

- 当ICCR2中的TRS位设置为1接收到0作为确认位时
- 当ICCR1中的IICRST位写入1而ICCR1中的ICE位为0时（IIC复位）。

ACKBT位（发送确认）

ACKBT位设置要在接收模式下发送的确认位。

[Setting condition]

- 当1写入该位且ACKWP位设置为1时。

[Clearing conditions]

- 当0写入该位且ACKWP位设置为1时
- 当ICCR2的SP位设置为1时检测到停止条件请求
- 当ICCR1中的IICRST位写入1而ICCR1中的ICE位为0时（IIC复位）。

ACKWP位（ACKBT写保护）

ACKWP位控制ACKBT位的写使能。

RDRFS位（RDRF标志设置时序选择）

RDRFS位选择接收模式下的RDRF标志设置时序，并选择是否在第8个SCL时钟周期的下降沿保持SCLn线为低电平。

当RDRFS位为0时，SCLn线在第8个SCL时钟周期的下降沿不保持低电平，RDRF标志在第9个SCL时钟周期的上升沿设置为1。

当RDRFS位为1时，RDRF标志在第8个SCL时钟周期的上升沿设置为1，并且SCLn线在第8个SCL时钟周期的下降沿保持低电平。SCLn线的低保持通过向

ACKBT bit.

After data is received with this setting, the SCLn line is automatically held low before the acknowledge bit is sent. This enables processing to send ACK (ACKBT = 0) or NACK (ACKBT = 1), based on the receive data.

WAIT bit (WAIT)

The WAIT bit controls whether to forcefully hold the period between the 9th SCL clock cycle and the 1st SCL clock cycle low until the receive data buffer (ICDRR) is completely read each time a single-byte data is received in receive mode.

When the WAIT bit is 0, the receive operation continues without holding the period between the 9th and the 1st SCL clock cycle low. When both the RDRFS and WAIT bits are 0, continuous receive operation is enabled with the double buffer.

When the WAIT bit is 1, the SCLn line is held low from the falling edge of the 9th clock cycle until the ICDRR value is read each time a single-byte data is received. This enables the receive operation in byte units.

Note: When the value of the WAIT bit is to be read, be sure to first read the ICDRR register first.

SMBS bit (SMBus/IIC-Bus Select)

Setting the SMBS bit to 1 selects the SMBus and enables the HOAE bit in ICSER.

29.2.6 I2C Bus Function Enable Register (ICFER)

Address(es): IIC0.ICFER 4005 3005h, IIC1.ICFER 4005 3105h

	b7	b6	b5	b4	b3	b2	b1	b0
	FMPE	SCLE	NFE	NACKE	SALE	NALE	MALE	TMOE
Value after reset:	0	1	1	1	0	0	1	0

Bit	Symbol	Bit name	Description	R/W
b0	TMOE	Timeout Function Enable	0: Timeout function disabled 1: Timeout function enabled.	R/W
b1	MALE	Master Arbitration-Lost Detection Enable	0: Master arbitration-lost detection disabled. Also disables automatic clearing of the MST and TRS bits in ICCR2 when arbitration is lost. 1: Master arbitration-lost detection enabled. Also enables automatic clearing of the MST and TRS bits in ICCR2 when arbitration is lost.	R/W
b2	NALE	NACK Transmission Arbitration-Lost Detection Enable	0: NACK transmission arbitration-lost detection disabled 1: NACK transmission arbitration-lost detection enabled.	R/W
b3	SALE	Slave Arbitration-Lost Detection Enable	0: Slave arbitration-lost detection disabled 1: Slave arbitration-lost detection enabled.	R/W
b4	NACKE	NACK Reception Transfer Suspension Enable	0: Transfer operation not suspended during NACK reception (transfer suspension disabled) 1: Transfer operation suspended during NACK reception (transfer suspension enabled).	R/W
b5	NFE	Digital Noise Filter Circuit Enable	0: No digital noise filter circuit used 1: A digital noise filter circuit used.	R/W
b6	SCLE	SCL Synchronous Circuit Enable	0: No SCL synchronous circuit used 1: An SCL synchronous circuit used.	R/W
b7	FMPE*1	Fast Mode Plus Enable	0:The Fast mode plus slope control circuit for the SCLn and SDAn pins not used 1: The Fast mode plus slope control circuit for the SCLn and SDAn pins used.	R/W

Note 1. The Fast Mode Plus Enable bit (FMPE) is supported only by IIC0 (SCL0-A, SDA0-A). Bit [7] is reserved in IIC1.

ACKBT bit.

使用此设置接收数据后，SCLn线在发送确认位之前自动保持低电平。这使处理能够根据接收数据发送ACK(ACKBT=0)或NACK(ACKBT=1)。

等待位（等待）

WAIT位控制是否强制将第9个SCL时钟周期和第1个SCL时钟周期之间的周期保持为低电平，直到在接收模式下每次接收到一个单字节数据时，接收数据缓冲区(ICDRR)被完全读取。

当WAIT位为0时，接收操作继续，而不会将第9个和第1个SCL时钟周期之间的周期保持为低电平。当RDRFS和WAIT位都为0时，双缓冲器使能连续接收操作。

当WAIT位为1时，SCLn线从第9个时钟周期的下降沿保持低电平，直到每次接收到一个单字节数据时读取ICDRR值。这启用了以字节为单位的接收操作。

Note: 当要读取WAIT位的值时，一定要先读取ICDRR寄存器。

SMBS位（SMBusIIC-Bus选择）

将SMBS位设置为1可选择SMBus并启用ICSER中的HOAE位。

29.2.6 I2C总线功能使能寄存器(ICFER)

Address(es): IIC0.ICFER 4005 3005h, IIC1.ICFER 4005 3105h

	b7	b6	b5	b4	b3	b2	b1	b0
	FMPE	SCLE	NFE	NACKE	SALE	NALE	MALE	TMOE
重置后的值:	0	1	1	1	0	0	1	0

Bit	Symbol	位名称	Description	R/W
b0	TMOE	超时功能启用	0：禁用超时功能1：启用超时功能。	R/W
b1	MALE	主仲裁-丢失检测Enable	0：禁用主机仲裁丢失检测。 还禁止自动清除MST和TRS位仲裁失败时的ICCR2。1：使能主机仲裁丢失检测。 还可以自动清除MST和TRS位仲裁失败时的ICCR2。	R/W
b2	NALE	NACK传输仲裁丢失检测启用	0：NACK传输仲裁丢失检测禁用1：NACK传输仲裁丢失检测启用。	R/W
b3	SALE	从设备仲裁丢失检测Enable	0：禁止从机仲裁丢失检测1：使能从机仲裁丢失检测。	R/W
b4	NACKE	NACK接收传输暂停启用	0：NACK接收期间传输操作不暂停（传输暂停禁用）1：NACK接收期间传输操作暂停（传输暂停启用）。	R/W
b5	NFE	数字噪声滤波器电路使能	0：不使用数字噪声滤波电路1：使用数字噪声滤波电路。	R/W
b6	SCLE	SCL同步电路使能	0：不使用SCL同步电路1：使用SCL同步电路。	R/W
b7	FMPE*1	快速模式加启用	0：未使用SCLn和SDAn引脚的快速模式加斜率控制电路1：使用SCLn和SDAn引脚的快速模式加斜率控制电路。	R/W

Note 1. 只有IIC0（SCL0-A、SDA0-A）支持快速模式加使能位（FMPE）。位[7]在IIC1中保留。

TMOE bit (Timeout Function Enable)

The TMOE bit enables or disables the timeout function.

For details on this function, see section 29.12.1, Timeout Function.

MALE bit (Master Arbitration-Lost Detection Enable)

The MALE bit specifies whether to use the arbitration-lost detection function in master mode. For normal operation, set this bit to 1.

NALE bit (NACK Transmission Arbitration-Lost Detection Enable)

The NALE bit specifies whether to cause loss of arbitration when ACK is detected during the transmission of NACK in receive mode, for example, when slaves with the same address exist on the bus, or when two or more masters select the same slave device simultaneously with a different number of receive bytes.

SALE bit (Slave Arbitration-Lost Detection Enable)

The SALE bit specifies whether to cause loss of arbitration when a value different from the value being transmitted is detected on the bus in slave transmit mode, for example, when slaves with the same address exist on the bus, or when a mismatch with the transmit data occurs because of noise.

NACKE bit (NACK Reception Transfer Suspension Enable)

The NACKE bit specifies whether to continue or discontinue the transfer operation when NACK is received from the slave device in transmit mode. For normal operation, set this bit to 1.

When NACK is received with the NACKE bit set to 1, the next transfer operation is suspended. When the NACKE bit is 0, the next transfer operation continues regardless of the received acknowledge content.

For details, see section 29.9.2, NACK Reception Transfer Suspension Function.

SCLE bit (SCL Synchronous Circuit Enable)

The SCLE bit specifies whether to synchronize the SCL clock with the SCL input clock. For normal operation, set this bit to 1.

When the SCLE bit is set to 0 (no SCL synchronous circuit used), the IIC does not synchronize the SCL clock with the SCLn input clock. With this setting, the IIC outputs the SCL clock with the transfer rate set in ICBRH and ICBRL, regardless of the SCLn line state. For this reason, if the bus load of the I2C bus line is much larger than the specification value, or if the SCLn clock output overlaps in multiple masters, a short-cycle SCL clock that does not meet the specification might be output. When no SCL synchronous circuit is used, it also affects the issuing of the start, restart, and stop conditions, and the continuous output of extra SCL clock cycles.

Do not set the SCLE bit to 0 except when checking the output of the set transfer rate.

FMPE bit (Fast Mode Plus Enable)

The FMPE bit specifies whether to use a slope control circuit for Fast mode plus (Fm+).

When this bit is set to 1, a slope control circuit conforming to the I2C bus Fast mode plus (Fm+) standard (tof) is selected. When this bit is set to 0, a slope control circuit conforming to the I2C bus Standard mode (Sm) and Fast mode (Fm) standards (tof) is selected.

Set this bit to 1 when using transmission rates up to 1 Mbps (Fast mode plus (Fm+) standard). Set it to 0 when using other transmission rates (up to 100 kbps (Sm) or up to 400 kbps (Fm)) or for SMBus (10 to 100 kbps).

TMOE位（超时功能使能）

TMOE位启用或禁用超时功能。

有关此功能的详细信息，请参阅第29.12.1节，超时功能。

MALE位（主仲裁丢失检测使能）

MALE位指定是否在主机模式下使用仲裁丢失检测功能。对于正常操作，将此位设置为1。

NALE位（NACK传输仲裁丢失检测使能）

NALE位指定在接收模式下发送NACK期间检测到ACK时是否导致仲裁丢失，例如，当总线上存在具有相同地址的从设备时，或者当两个或多个主设备同时选择同一个从设备时不同数量的接收字节。

SALE位（从设备仲裁丢失检测使能）

SALE位指定在从机发送模式下，当在总线上检测到与正在发送的值不同的值时，是否导致仲裁丢失，例如，当总线上存在具有相同地址的从机时，或者当与发送不匹配时数据的出现是因为噪声。

NACKE位（NACK接收传输暂停使能）

NACKE位指定在发送模式下从从设备接收到NACK时是继续还是停止传输操作。对于正常操作，将此位设置为1。

当在NACKE位设置为1的情况下接收到NACK时，暂停下一个传输操作。当NACKE位为0时，无论接收到的确认内容如何，　　下一次传输操作都会继续进行。

有关详细信息，请参阅第29.9.2节，NACK接收传输暂停功能。

SCLE位（SCL同步电路使能）

SCLE位指定是否将SCL时钟与SCL输入时钟同步。对于正常操作，将此位设置为1。

当SCLE位设置为0（不使用SCL同步电路）时，IIC不会将SCL时钟与SCLn输入时钟同步。使用此设置，无论SCLn线路状态如何，IIC都会以ICBRH和ICBRL中设置的传输速率输出SCL时钟。因此，如果I2C总线的总线负载远大于规格值，或者多个主机的SCLn时钟输出重叠，则可能会输出不符合规格的短周期SCL时钟。当不使用SCL同步电路时，也会影响启动、重启和停止条件的发出，以及额外SCL时钟周期的连续输出。

请勿将SCLE位设置为0，除非检查设置传输速率的输出。

FMPE位（快速模式加启用）

FMPE位指定是否对Fastmodeplus(Fm+)使用斜率控制电路。

当该位设置为1时，选择符合I2C总线快速模式加(Fm+)标准(tof)的斜率控制电路。
当该位设置为0时，选择符合I2C总线标准模式(Sm)和快速模式(Fm)标准(tof)的斜率控制电路。

当使用高达1Mbps的传输速率（快速模式加(Fm+)标准）时，将此位设置为1。当使用其他传输速率（最高100kbps(Sm)或最高400kbps(Fm)）或SMBus（10至100kbps）时，将其设置为0。

29.2.7 I²C Bus Status Enable Register (ICSER)

Address(es): IIC0.ICSER 4005 3006h, IIC1.ICSER 4005 3106h

	b7	b6	b5	b4	b3	b2	b1	b0
	HOAE	—	DIDE	—	GCAE	SAR2E	SAR1E	SAR0E
Value after reset:	0	0	0	0	1	0	0	1

Bit	Symbol	Bit name	Description	R/W
b0	SAR0E	Slave Address Register 0 Enable	0: Slave address in SARL0 and SARU0 disabled 1: Slave address in SARL0 and SARU0 enabled.	R/W
b1	SAR1E	Slave Address Register 1 Enable	0: Slave address in SARL1 and SARU1 disabled 1: Slave address in SARL1 and SARU1 enabled.	R/W
b2	SAR2E	Slave Address Register 2 Enable	0: Slave address in SARL2 and SARU2 disabled 1: Slave address in SARL2 and SARU2 enabled.	R/W
b3	GCAE	General Call Address Enable	0: General call address detection disabled 1: General call address detection enabled.	R/W
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b5	DIDE	Device ID Address Detection Enable	0: Device ID address detection disabled 1: Device ID address detection enabled.	R/W
b6	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7	HOAE	Host Address Enable	0: Host address detection disabled 1: Host address detection enabled.	R/W

SARyE bit (Slave Address Register y Enable) (y = 0 to 2)

The SARyE bit enables or disables the received slave address and the slave address set in the SARLy and SARUy registers.

When this bit is set to 1, the slave address set in the SARLy and SARUy registers is enabled and is compared with the received slave address. When this bit is set to 0, the slave address set in SARLy and SARUy is disabled and is ignored even if it matches the received slave address.

GCAE bit (General Call Address Enable)

The GCAE bit specifies whether to ignore the general call address (0000 000b + 0 [W]: All 0) when it is received.

When this bit is set to 1, if the received slave address matches the general call address, the IIC recognizes the received slave address as the general call address independently of the slave addresses set in SARLy and SARUy (y = 0 to 2), and performs the data receive operation. When this bit is set to 0, the received slave address is ignored even if it matches the general call address.

DIDE bit (Device ID Address Detection Enable)

The DIDE bit specifies whether to recognize and execute the device ID address when a device ID (1111 100b) is received in the first frame after a start or restart condition is detected.

When this bit is set to 1, if the received first frame matches the device ID, the IIC recognizes that the device ID address was received. When the next R/W# bit is 0 (W), the IIC recognizes the second and the subsequent frames as slave addresses and continues the receive operation. When this bit is set to 0, the IIC ignores the received first frame even if it matches the device ID address, and recognizes the first frame as a normal slave address.

For details, see section 29.7.3, Device ID Address Detection.

HOAE bit (Host Address Enable)

The HOAE bit specifies whether to ignore the received host address (0001 000b) when the SMBS bit in ICMR3 is 1.

When this bit is set to 1 while the SMBS bit in ICMR3 is 1, if the received slave address matches the host address, the IIC recognizes the received slave address as the host address independently of the slave addresses set in SARLy and

29.2.7 I2C总线状态使能寄存器(ICSER)

Address(es): IIC0.ICSER 4005 3006h, IIC1.ICSER 4005 3106h

	b7	b6	b5	b4	b3	b2	b1	b0
	HOAE	—	DIDE	—	GCAE	SAR2E	SAR1E	SAR0E
重置后的值:	0	0	0	0	1	0	0	1

Bit	Symbol	位名称	Description	R/W
b0	SAR0E	从地址寄存器0使能	0：禁用SARL0和SARU0中的从地址1：启用SARL0和SARU0中的从地址。	R/W
b1	SAR1E	从地址寄存器1使能	0：禁用SARL1和SARU1中的从地址1：启用SARL1和SARU1中的从地址。	R/W
b2	SAR2E	从地址寄存器2使能	0：禁用SARL2和SARU2中的从地址1：启用SARL2和SARU2中的从地址。	R/W
b3	GCAE	广播呼叫地址启用	0：禁止广播呼叫地址检测1：使能广播呼叫地址检测。	R/W
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b5	DIDE	设备ID地址检测 Enable	0：禁用设备ID地址检测1：启用设备ID地址检测。	R/W
b6	—	Reserved	该位读取为0。写入值应为0。	R/W
b7	HOAE	主机地址启用	0：禁止主机地址检测1：使能主机地址检测。	R/W

SARyE位（从地址寄存器y使能）（y=0到2）

SARyE位启用或禁用接收到的从地址以及在SARLy和SARUy寄存器中设置的从地址。

当该位设置为1时，设置在SARLy和SARUy寄存器中的从地址被启用，并与接收到的从地址进行比较。当该位设置为0时，设置在SARLy和SARUy中的从机地址被禁用并被忽略，即使它与接收到的从机地址匹配。

GCAE位（广播呼叫地址使能）

GCAE位指定接收到的广播调用地址（0000000b+0[W]：全0）是否忽略。

当该位设置为1时，如果接收到的从机地址与广播呼叫地址匹配，则IIC将接收到的从机地址识别为广播呼叫地址，独立于SARLy和SARUy中设置的从机地址（y=0到2），并且执行数据接收操作。当该位设置为0时，即使接收到的从机地址与广播呼叫地址匹配，也会忽略它。

DIDE位（设备ID地址检测使能）

DIDE位指定在检测到开始或重新启动条件后的第一帧中接收到设备ID(1111100b)时是否识别和执行设备ID地址。

当该位设置为1时，如果接收到的第一个帧与设备ID匹配，则IIC识别出接收到设备ID地址。当下一个RW#位为0(W)时，IIC将第二个和后续帧识别为从地址并继续接收操作。当该位设置为0时，IIC忽略接收到的第一帧，即使它与设备ID地址匹配，并将第一帧识别为正常的从地址。

有关详细信息，请参阅第29.7.3节，设备ID地址检测。

HOAE位（主机地址使能）

HOAE位指定当ICMR3中的SMBS位为1时是否忽略接收到的主机地址（0001000b）。

当该位设置为1且ICMR3中的SMBS位为1时，如果接收到的从机地址与主机地址匹配，则IIC将接收到的从地址识别为主机地址，与SARLy中设置的从地址无关，并且

SARUy (y = 0 to 2), and performs the receive operation.

When the SMBS bit in ICMR3 or the HOAE bit is set to 0, the received slave address is ignored even if it matches the host address.

29.2.8 I2C Bus Interrupt Enable Register (ICIER)

Address(es): IIC0.ICIER 4005 3007h, IIC1.ICIER 4005 3107h

	b7	b6	b5	b4	b3	b2	b1	b0
	TIE	TEIE	RIE	NAKIE	SPIE	STIE	ALIE	TMOIE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TMOIE	Timeout Interrupt Request Enable	0: Timeout interrupt (TMOIn) request disabled 1: Timeout interrupt (TMOIn) request enabled.	R/W
b1	ALIE	Arbitration-Lost Interrupt Request Enable	0: Arbitration-lost interrupt (ALIn) request disabled 1: Arbitration-lost interrupt (ALIn) request enabled.	R/W
b2	STIE	Start Condition Detection Interrupt Request Enable	0: Start condition detection interrupt (STIn) request disabled 1: Start condition detection interrupt (STIn) request enabled.	R/W
b3	SPIE	Stop Condition Detection Interrupt Request Enable	0: Stop condition detection interrupt (SPIn) request disabled 1: Stop condition detection interrupt (SPIn) request enabled.	R/W
b4	NAKIE	NACK Reception Interrupt Request Enable	0: NACK reception interrupt (NAKIn) request disabled 1: NACK reception interrupt (NAKIn) request enabled.	R/W
b5	RIE	Receive Data Full Interrupt Request Enable	0: Receive data full interrupt (IICn_RXI) request disabled 1: Receive data full interrupt (IICn_RXI) request enabled.	R/W
b6	TEIE	Transmit End Interrupt Request Enable	0: Transmit end interrupt (IICn_TEI) request disabled 1: Transmit end interrupt (IICn_TEI) request enabled.	R/W
b7	TIE	Transmit Data Empty Interrupt Request Enable	0: Transmit data empty interrupt (IICn_TXI) request disabled 1: Transmit data empty interrupt (IICn_TXI) request enabled.	R/W

TMOIE bit (Timeout Interrupt Request Enable)

The TMOIE bit enables or disables timeout interrupt (TMOIn) requests when the TMOF flag in ICSR2 is 1. To cancel a TMOI interrupt request, set the TMOF flag or the TMOIE bit to 0.

ALIE bit (Arbitration-Lost Interrupt Request Enable)

The ALIE bit enables or disables arbitration-lost interrupt (ALIn) requests when the AL flag in ICSR2 is 1. To cancel an ALI interrupt request, set the AL flag or the ALIE bit to 0.

STIE bit (Start Condition Detection Interrupt Request Enable)

The STIE bit enables or disables start condition detection interrupt (STIn) requests when the START flag in ICSR2 is 1. To cancel an STI interrupt request, set the START flag or the STIE bit to 0.

SPIE bit (Stop Condition Detection Interrupt Request Enable)

The SPIE bit enables or disables stop condition detection interrupt (SPIn) requests when the STOP flag in ICSR2 is 1. To cancel an SPI interrupt request, set the STOP flag or the SPIE bit to 0.

NAKIE bit (NACK Reception Interrupt Request Enable)

The NAKIE bit enables or disables NACK reception interrupt (NAKIn) requests when the NACKF flag in ICSR2 is 1. To cancel an NAKI interrupt request, set the NACKF flag or the NAKIE bit to 0.

RIE bit (Receive Data Full Interrupt Request Enable)

The RIE bit enables or disables receive data full interrupt (IICn_RXI) requests when the RDRF flag in ICSR2 is 1.

SARUy(y=0to2)，并执行接收操作。

当ICMR3中的SMBS位或HOAE位设置为0时，即使接收到的从机地址与主机地址匹配，也会忽略它。

29.2.8 I2C总线中断使能寄存器(ICIER)

Address(es): IIC0.ICIER 4005 3007h, IIC1.ICIER 4005 3107h

	b7	b6	b5	b4	b3	b2	b1	b0
	TIE	TEIE	RIE	NAKIE	SPIE	STIE	ALIE	TMOIE
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TMOIE	超时中断请求使能	0：禁止超时中断（TMOIn）请求1：允许超时中断（TMOIn）请求。	R/W
b1	ALIE	仲裁失败中断请求Enable	0：禁用仲裁丢失中断(ALIn)请求1：启用仲裁丢失中断(ALIn)请求。	R/W
b2	STIE	启动条件检测中断请求启用	0：禁止启动条件检测中断（STIn）请求1：允许启动条件检测中断（STIn）请求。	R/W
b3	SPIE	停止条件检测中断请求启用	0：停止条件检测中断（SPIn）请求禁止1：停止条件检测中断（SPIn）请求允许。	R/W
b4	NAKIE	NACK接收中断请求Enable	0：禁止NACK接收中断（NAKIn）请求1：允许NACK接收中断（NAKIn）请求。	R/W
b5	RIE	接收数据完整中断请求Enable	0：禁止接收数据完整中断（IICn_RXI）请求1：使能接收数据完整中断（IICn_RXI）请求。	R/W
b6	TEIE	发送结束中断请求Enable	0：禁止发送结束中断（IICn_TEI）请求1：允许发送结束中断（IICn_TEI）请求。	R/W
b7	TIE	发送数据空中断请求启用	0：禁止发送数据空中断（IICn_TXI）请求1：允许发送数据空中断（IICn_TXI）请求。	R/W

TMOIE位（超时中断请求使能）

当ICSR2中的TMOF标志为1时，TMOIE位启用或禁用超时中断(TMOIn)请求。取消一个TMOI中断请求，设置TMOF标志或TMOIE位为0。

ALIE位（仲裁丢失中断请求使能）

当ICSR2中的AL标志为1时，ALIE位启用或禁用仲裁丢失中断(ALIn)请求。取消ALI中断请求，设置AL标志或ALIE位为0。

STIE位（启动条件检测中断请求使能）

当ICSR2中的START标志为1时，STIE位启用或禁用开始条件检测中断(STIn)请求。要取消STI中断请求，请将START标志或STIE位设置为0。

SPIE位（停止条件检测中断请求使能）

当ICSR2中的STOP标志为1时，SPIE位启用或禁用停止条件检测中断(SPIn)请求。要取消SPI中断请求，请将STOP标志或SPIE位设置为0。

NAKIE位（NACK接收中断请求使能）

当ICSR2中的NACKF标志为1时，NAKIE位启用或禁用NACK接收中断(NAKIn)请求。要取消NAKI中断请求，请将NACKF标志或NAKIE位设置为0。

RIE位（接收数据满中断请求使能）

当ICSR2中的RDRF标志为1时，RIE位启用或禁用接收数据完整中断(IICn_RXI)请求。

TEIE bit (Transmit End Interrupt Request Enable)

The TEIE bit enables or disables transmit end interrupt (IICn_TEI) requests when the TEND flag in ICSR2 is 1. To cancel an IICn_TEI interrupt request, set the TEND flag or the TEIE bit to 0.

TIE bit (Transmit Data Empty Interrupt Request Enable)

The TIE bit enables or disables transmit data empty interrupt (IICn_TXI) requests when the TDRE flag in ICSR2 is 1.

29.2.9 I2C Bus Status Register 1 (ICSR1)

Address(es): IIC0.ICSR1 4005 3008h, IIC1.ICSR1 4005 3108h

	b7	b6	b5	b4	b3	b2	b1	b0
	HOA	—	DID	—	GCA	AAS2	AAS1	AAS0
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	AAS0	Slave Address 0 Detection Flag	0: Slave address 0 not detected 1: Slave address 0 detected.	R/(W) *1
b1	AAS1	Slave Address 1 Detection Flag	0: Slave address 1 not detected 1: Slave address 1 detected.	R/(W) *1
b2	AAS2	Slave Address 2 Detection Flag	0: Slave address 2 not detected 1: Slave address 2 detected.	R/(W) *1
b3	GCA	General Call Address Detection Flag	0: General call address not detected 1: General call address detected.	R/(W) *1
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b5	DID	Device ID Address Detection Flag	0: Device ID command not detected 1: Device ID command detected. This bit is set to 1 when the first frame received immediately after a start condition is detected, matches a value of (device ID (1111 100b) + 0[W]).	R/(W) *1
b6	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7	HOA	Host Address Detection Flag	0: Host address not detected 1: Host address detected. This bit is set to 1 when the received slave address matches the host address (0001 000b).	R/(W) *1

Note 1. Only 0 can be written to clear the flag.

AASy flag (Slave Address y Detection Flag) (y = 0 to 2)

The AASy flag indicates whether slave address y was detected.

[Setting conditions]

For 7-bit address format (SARUy.FS = 0):

- When the received slave address matches the SVA[6:0] value in SARLy, with the SARyE bit in ICSER set to 1 (slave address y detection enabled). The AASy flag is set to 1 on the rising edge of the 9th SCL clock cycle in the frame.

For 10-bit address format: (SARUy.FS = 1):

- When the received slave address matches a value of (11110b + SVA[1:0] in SARUy), and the subsequent address matches the SARLy value, with the SARyE bit in ICSER set to 1 (slave address y detection enabled). The AASy flag is set to 1 on the rising edge of the 9th SCL clock cycle in the frame.

[Clearing conditions]

- When 0 is written to the AASy flag after reading AASy = 1

TEIE位（发送结束中断请求使能）

当ICSR2中的TEND标志为1时，TEIE位启用或禁用发送结束中断(IICn_TEI)请求。要取消IICn_TEI中断请求，请将TEND标志或TEIE位设置为0。

TIE位（发送数据空中断请求使能）

当ICSR2中的TDRE标志为1时，TIE位启用或禁用发送数据空中断（IICn_TXI）请求。

29.2.9 I2C总线状态寄存器1(ICSR1)

Address(es): IIC0.ICSR1 4005 3008h, IIC1.ICSR1 4005 3108h

	b7	b6	b5	b4	b3	b2	b1	b0
	HOA	—	DID	—	GCA	AAS2	AAS1	AAS0
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	AAS0	从地址0检测标志	0：未检测到从地址01：检测到从地址0。	R/(W) *1
b1	AAS1	从地址1检测标志	0：未检测到从地址11：检测到从地址1。	R/(W) *1
b2	AAS2	从地址2检测标志	0：未检测到从地址21：检测到从地址2。	R/(W) *1
b3	GCA	广播呼叫地址检测Flag	0：未检测到广播呼叫地址1：检测到广播呼叫地址。	R/(W) *1
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b5	DID	设备ID地址检测标志	0：未检测到设备ID命令1：检测到设备ID命令。当检测到开始条件后立即接收到的第一个帧与(设备ID(1111100b)+0[W])的值匹配时，该位设置为1。	R/(W) *1
b6	—	Reserved	该位读取为0。写入值应为0。	R/W
b7	HOA	主机地址检测标志	0：未检测到主机地址1：检测到主机地址。当接收到的从机地址与主机地址(0001000b)匹配时，该位设置为1。	R/(W) *1

Note 1. 只能写入0来清除标志。

AASy标志（从机地址y检测标志）（y=0到2）

AASy标志指示是否检测到从地址y。

[Setting conditions]

对于7位地址格式(SARUy.FS=0)：

- 当接收到的从机地址与SARLy中的SVA[6:0]值匹配时，ICSER中的SARyE位设置为1（启用从机地址y检测）。AASy标志在帧中第9个SCL时钟周期的上升沿设置为1。

对于10位地址格式：(SARUy.FS=1)：

- 当接收到的从地址与(SARUy中的11110b+SVA[1:0])值匹配，并且后续地址与SARLy值匹配时，ICSER中的SARyE位设置为1（启用从地址y检测）。AASy标志在帧中第9个SCL时钟周期的上升沿设置为1。

[Clearing conditions]

- 读取AASy=1后将0写入AASy标志时

- When a stop condition is detected
- When 1 is written to the IICRST bit in ICCR1 to apply an IIC reset or an internal reset.

For 7-bit address format (SARUy.FS = 0):

- When the received slave address does not match the SVA[6:0] value in SARLy, with the SARyE bit in ICSER set to 1 (slave address y detection enabled). The AASy flag is set to 0 on the rising edge of the 9th SCL clock cycle in the frame.

For 10-bit address format (SARUy.FS = 1):

- When the received slave address does not match a value of 11110b + SVA[1:0] in SARUy, with the SARyE bit in ICSER set to 1 (slave address y detection enabled). The AASy flag is set to 0 on the rising edge of the 9th SCL clock cycle in the frame.
- When the received slave address matches a value of 11110b + SVA[1:0] in SARUy, and the subsequent address does not match the SARLy value, with the SARyE bit in ICSER set to 1 (slave address y detection enabled). The AASy flag is set to 0 on the rising edge of the 9th SCL clock cycle in the frame.

GCA flag (General Call Address Detection Flag)

The GCA flag indicates whether the general call address was detected.

[Setting condition]

- When the received slave address matches the general call address (0000 000b + 0 [W]), with the GCAE bit in ICSER set to 1 (general call address detection enabled). The GCA flag is set to 1 on the rising edge of the 9th SCL clock cycle in the frame.

[Clearing conditions]

- When 0 is written to the GCA flag after reading GCA = 1
- When a stop condition is detected
- When the received slave address does not match the general call address (0000 000b + 0 [W]), with the GCAE bit in ICSER set to 1 (general call address detection enabled). The GCA flag is set to 0 on the rising edge of the 9th SCL clock cycle in the frame.
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

DID flag (Device ID Address Detection Flag)

The DID flag indicates whether the device ID address was detected.

[Setting condition]

- When the first frame received immediately after a start or restart condition is detected matches a value of (device ID (1111 100b) + 0 [W]), with the DIDE bit in ICSER set to 1 (device ID address detection enabled). The DID flag is set to 1 on the rising edge of the 9th SCL clock cycle in the frame.

[Clearing conditions]

- When 0 is written to the DID flag after reading DID = 1
- When a stop condition is detected
- When the first frame received immediately after a start or restart condition is detected does not match a value of the device ID (1111 100b), with the DIDE bit in ICSER set to 1 (device ID address detection enabled). The DID flag is set to 0 on the rising edge of the 9th SCL clock cycle in the frame.
- When the first frame received immediately after a start or restart condition is detected matches a value of (device ID (1111 100b) + 0 [W]), and the second frame does not match any slave address from 0 to 2, with the DIDE bit in ICSER set to 1 (device ID address detection enabled). The DID flag is set to 0 on the rising edge of the 9th SCL clock cycle in the frame.
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

- 检测到停止条件时
- 当向ICCR1中的IICRST位写入1时，应用IIC复位或内部复位。

对于7位地址格式(SARUy.FS=0)：

- 当接收到的从地址与SARLy中的SVA[6:0]值不匹配时，ICSER中的SARyE位设置为1（从地址y检测使能）。AASy标志在帧中第9个SCL时钟周期的上升沿设置为0。

对于10位地址格式(SARUy.FS=1)：

- 当接收到的从地址与SARUy中的值11110b+SVA[1:0]不匹配时，ICSER中的SARyE位设置为1（启用从地址y检测）。AASy标志在帧中第9个SCL时钟周期的上升沿设置为0。
- 当接收到的从地址与SARUy中的值11110b+SVA[1:0]匹配，并且后续地址与SARLy值不匹配时，ICSER中的SARyE位设置为1（启用从地址y检测）。AASy标志在帧中第9个SCL时钟周期的上升沿设置为0。

GCA标志（广播呼叫地址检测标志）

GCA标志指示是否检测到广播呼叫地址。

[Setting condition]

- 当接收到的从机地址与广播地址（0000000b+0[W]）匹配时，GCAE位在ICSER设置为1（启用广播呼叫地址检测）。GCA标志在帧中第9个SCL时钟周期的上升沿设置为1。

[Clearing conditions]

- 读取GCA=1后将0写入GCA标志时
- 检测到停止条件时
- 当接收到的从地址与广播呼叫地址（0000000b+0[W]）不匹配时，将ICSER中的GCAE位设置为1（启用广播呼叫地址检测）。GCA标志在帧中第9个SCL时钟周期的上升沿设置为0。
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

DID标志（设备ID地址检测标志）

DID标志指示是否检测到设备ID地址。

[Setting condition]

- 当检测到启动或重新启动条件后立即接收到的第一帧与(设备ID(1111100b)+0[W])的值匹配时，ICSER中的DIDE位设置为1（启用设备ID地址检测）。DID标志在帧中第9个SCL时钟周期的上升沿设置为1。

[Clearing conditions]

- 当读取DID=1后将0写入DID标志
- 检测到停止条件时
- 当检测到启动或重启条件后立即接收的第一帧与设备ID(1111100b)的值不匹配时，ICSER中的DIDE位设置为1（启用设备ID地址检测）。DID标志在帧中第9个SCL时钟周期的上升沿设置为0。
- 当检测到启动或重新启动条件后立即接收到的第一帧与(设备ID(1111100b)+0[W])的值匹配，并且第二帧不匹配从0到2的任何从地址时，使用DIDEICSER中的位设置为1（启用设备ID地址检测）。DID标志在帧中第9个SCL时钟周期的上升沿设置为0。
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

HOA flag (Host Address Detection Flag)

The HOA flag indicates whether the host address was detected.

[Setting condition]

- When the received slave address matches the host address (0001 000b), with the HOAE bit in ICSER set to 1 (host address detection enabled). The HOA flag is set to 1 on the rising edge of the 9th SCL clock cycle in the frame.

[Clearing conditions]

- When 0 is written to the HOA flag after reading HOA = 1
- When a stop condition is detected
- When the received slave address does not match the host address (0001 000b), with the HOAE bit in ICSER set to 1 (host address detection enabled). The HOA flag is set to 0 on the rising edge of the 9th SCL clock cycle in the frame.
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

29.2.10 I2C Bus Status Register 2 (ICSR2)

Address(es): IIC0.ICSR2 4005 3009h, IIC1.ICSR2 4005 3109h

	b7	b6	b5	b4	b3	b2	b1	b0
	TDRE	TEND	RDRF	NACKF	STOP	START	AL	TMOF
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TMOF	Timeout Detection Flag	0: Timeout not detected 1: Timeout detected.	R/(W)*1
b1	AL	Arbitration-Lost Flag	0: Arbitration not lost 1: Arbitration lost.	R/(W)*1
b2	START	Start Condition Detection Flag	0: Start condition not detected 1: Start condition detected.	R/(W)*1
b3	STOP	Stop Condition Detection Flag	0: Stop condition not detected 1: Stop condition detected.	R/(W)*1
b4	NACKF	NACK Detection Flag	0: NACK not detected 1: NACK detected.	R/(W)*1
b5	RDRF	Receive Data Full Flag	0: ICDRR contains no receive data 1: ICDRR contains receive data.	R/(W)*1
b6	TEND	Transmit End Flag	0: Data being transmitted 1: Data transmit complete.	R/(W)*1
b7	TDRE	Transmit Data Empty Flag	0: ICDRT contains transmit data 1: ICDRT contains no transmit data.	R

Note 1. Only 0 can be written to clear the flag.

TMOF flag (Timeout Detection Flag)

The TMOF flag is set to 1 when the IIC detects a timeout because the SCLn line state remains unchanged for the set period.

[Setting condition]

- When the SCLn line state remains unchanged for the period specified in the ICMR2.TMOH, TMOL, and TMOS bits while the ICFER.TMOE bit is 1 (timeout function enabled) in master or in slave mode and the received slave address matches.

[Clearing conditions]

- When 0 is written to the TMOF flag after reading TMOF = 1

HOA标志（主机地址检测标志）

HOA标志指示是否检测到主机地址。

[Setting condition]

- 当接收到的从机地址与主机地址（0001000b）匹配时，ICSER中的HOAE位设置为1（主机地址检测使能）。HOA标志在帧中第9个SCL时钟周期的上升沿设置为1。

[Clearing conditions]

- 读取HOA=1后将0写入HOA标志时
- 检测到停止条件时
- 当接收到的从机地址与主机地址（0001000b）不匹配时，ICSER中的HOAE位设置为1（启用主机地址检测）。HOA标志在帧中第9个SCL时钟周期的上升沿设置为0。
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

29.2.10 I2C总线状态寄存器2(ICSR2)

Address(es): IIC0.ICSR2 4005 3009h, IIC1.ICSR2 4005 3109h

	b7	b6	b5	b4	b3	b2	b1	b0
	TDRE	TEND	RDRF	NACKF	STOP	START	AL	TMOF
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TMOF	超时检测标志	0：未检测到超时1：检测到超时。	R/(W)*1
b1	AL	Arbitration-Lost Flag	0：仲裁未失败1：仲裁失败。	R/(W)*1
b2	START	启动条件检测标志	0：未检测到启动条件1：检测到启动条件。	R/(W)*1
b3	STOP	停止条件检测标志	0：未检测到停止条件1：检测到停止条件。	R/(W)*1
b4	NACKF	NACK检测标志	0：未检测到NACK1：检测到NACK。	R/(W)*1
b5	RDRF	接收数据满标志	0：ICDRR不包含接收数据1：ICDRR包含接收数据。	R/(W)*1
b6	TEND	发送结束标志	0：数据传输中1：数据传输完成。	R/(W)*1
b7	TDRE	传输数据空标志	0：ICDRT包含发送数据1：ICDRT不包含发送数据。	R

Note 1. 只能写入0来清除标志。

TMOF标志（超时检测标志）

当IIC检测到超时时，TMOF标志设置为1，因为SCLn线路状态在设置的周期内保持不变。

[Setting condition]

- 当SCLn线状态在ICMR2.TMOH、TMOL和TMOS位指定的时间段内保持不变，而ICFER.TMOE位在主机或从机模式下为1（启用超时功能）并且接收到的从机地址匹配。

[Clearing conditions]

- 读取TMOF=1后向TMOF标志写入0时

- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

AL flag (Arbitration-Lost Flag)

The AL flag indicates that the bus mastership is lost in arbitration because of a bus conflict or because of some other reason, when a start condition was issued, or an address and data was transmitted.

The IIC monitors the level on the SDAn line during transmission. If the level on the line does not match the value of the bit being output, the IIC sets the AL flag to 1 to indicate that the bus is occupied by another device. The IIC can also set the AL flag to indicate the detection of arbitration loss during NACK transmission in master mode or during data transmission in slave mode.

[Setting conditions]

When master arbitration-lost detection is enabled (ICFER.MALE = 1):

- When the internal SDA output state does not match the SDAn line level on the rising edge of the SCL clock, except for the ACK period during data transmission in master transmit mode
- When a start condition is detected while the ST bit in ICCR2 is 1 (start condition requested) or the internal SDA output state does not match the SDAn line level
- When the ST bit in ICCR2 is 1 (start condition requested), with the BBSY flag in ICCR2 set to 1.

When NACK arbitration-lost detection is enabled (ICFER.NALE = 1):

- When the internal SDA output state does not match the SDAn line level on the rising edge of the SCL clock in the ACK period during NACK transmission in receive mode.

When slave arbitration-lost detection is enabled (ICFER.SALE = 1):

- When the internal SDA output state does not match the SDAn line level on the rising edge of the SCL clock, except for the ACK period during data transmission in slave transmit mode.

[Clearing conditions]

- When 0 is written to the AL flag after reading AL = 1
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

Table 29.4 Relationship between arbitration-lost generation sources and arbitration-lost enable functions

ICFER			ICSR2		
MALE	NALE	SALE	AL	Error	Arbitration-lost generation source
1	×	×	1	Start condition issuance error	When internal SDA output state does not match SDAn line level when a start condition is detected while the ST bit in ICCR2 is 1
					When ST in ICCR2 is set to 1 while BBSY in ICCR2 is 1
			1	Transmit data mismatch	When transmit data (including slave address) does not match the bus state in master transmit mode
×	1	×	1	NACK transmission mismatch	When ACK is detected during transmission of NACK in master or slave receive mode
×	×	1	1	Transmit data mismatch	When transmit data does not match the bus state in slave transmit mode

×: Don't care

START flag (Start Condition Detection Flag)

The START flag indicates whether a start or restart condition is detected.

[Setting condition]

- When a start or restart condition is detected.

[Clearing conditions]

- When 0 is written to the START flag after reading START = 1

- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

AL标志（仲裁失败标志）

AL标志表示由于总线冲突或其他原因，当发出启动条件或传输地址和数据时，总线控制权在仲裁中丢失。

IIC在传输过程中监控SDAn线上的电平。如果线路上的电平与正在输出的位的值不匹配，则IIC将AL标志设置为1，以指示总线被另一个设备占用。IIC还可以设置AL标志，以指示在主机模式下的NACK传输期间或从机模式下的数据传输期间检测到仲裁丢失。

[Setting conditions]

当启用主机仲裁丢失检测时(ICFER.MALE=1)：

- 当内部SDA输出状态与SCL时钟上升沿上的SDAn线电平不匹配时，除了主机发送模式下数据传输期间的ACK周期
- 当ICCR2中的ST位为1（请求启动条件）或内部SDA输出状态与SDAn线电平不匹配时检测到启动条件
- ICCR2中的ST位为1（请求启动条件）时，ICCR2中的BBSY标志设置为1。

当启用NACK仲裁丢失检测时(ICFER.NALE=1)：

- 当内部SDA输出状态与SCL时钟上升沿上的SDAn线电平不匹配时
  接收模式下NACK传输期间的ACK周期。

当启用从设备仲裁丢失检测时(ICFER.SALE=1)：

- 当内部SDA输出状态与SCL时钟上升沿上的SDAn线电平不匹配时，除了从机发送模式下数据传输期间的ACK周期。

[Clearing conditions]

- 读取AL=1后向AL标志写入0时
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

Table 29.4 仲裁丢失生成源和仲裁丢失使能函数之间的关系

ICFER			ICSR2		
MALE	NALE	SALE	AL	Error	仲裁失败的生成源
1	×	×	1	开始条件发布错误	当ICCR2中的ST位为1时检测到启动条件时，当内部SDA输出状态与SDAn线电平不匹配时
					ICCR2中的ST设置为1而ICCR2中的BBSY为1时
			1	传输数据不匹配	当发送数据（包括从地址）与主发送模式下的总线状态不匹配时
×	1	×	1	NACK传输不匹配	在主机或从机接收模式下发送NACK期间检测到ACK时
×	×	1	1	传输数据不匹配	当发送数据与从发送模式下的总线状态不匹配时

×: Don't care

START标志（开始条件检测标志）

START标志指示是否检测到启动或重新启动条件。

[Setting condition]

- 当检测到启动或重新启动条件时。

[Clearing conditions]

- 读取START=1后将0写入START标志时

- When a stop condition is detected
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

STOP flag (Stop Condition Detection Flag)

The STOP flag indicates whether a stop condition is detected.

[Setting condition]

- When a stop condition is detected.

[Clearing conditions]

- When 0 is written to the STOP flag after reading STOP = 1
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

NACKF flag (NACK Detection Flag)

The NACKF flag indicates whether a NACK was detected.

[Setting condition]

- When acknowledge is not received (NACK received) from the receive device in transmit mode, with the NACKE bit in ICFER set to 1 (transfer suspension enabled).

[Clearing conditions]

- When 0 is written to the NACKF flag after reading NACKF = 1
- When 1 is written to the IICRST bit in ICCR1 to apply an IIC reset or an internal reset.

Note: When the NACKF flag is set to 1, the IIC suspends data transmission and reception. Writing to ICDRT in transmit mode or reading from ICDRR in receive mode with the NACKF flag set to 1 does not enable data transmit or receive operation. To restart data transmission or reception, set the NACKF flag to 0.

RDRF flag (Receive Data Full Flag)

The RDRF flag indicates whether the IDCRR contains receive data.

[Setting conditions]

- When receive data is transferred from ICDRS to ICDRR. The RDRF flag is set to 1 on the rising edge of the 8th or 9th SCL clock cycle (selected in the RDRFS bit in ICMR3).
- When the received slave address matches after a start (or restart) condition is detected with the TRS bit in ICCR2 set to 0.

[Clearing conditions]

- When 0 is written to the RDRF flag after reading RDRF = 1
- When data is read from ICDRR
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

TEND flag (Transmit End Flag)

The TEND flag indicates whether data transmission is still being transmitted or is complete.

[Setting condition]

- On the rising edge of the 9th SCL clock cycle while the TDRE flag is 1.

[Clearing conditions]

- When 0 is written to the TEND flag after reading TEND = 1
- When data is written to ICDRT
- When a stop condition is detected
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

- 检测到停止条件时
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

停止标志（停止条件检测标志）

STOP标志指示是否检测到停止条件。

[Setting condition]

- 当检测到停止条件时。

[Clearing conditions]

- 在读取STOP=1后将0写入STOP标志时
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

NACKF标志（NACK检测标志）

NACKF标志指示是否检测到NACK。

[Setting condition]

- 当在发送模式下没有从接收设备接收到确认（NACK接收）时，ICFER中的NACKE位设置为1（使能传输暂停）。

[Clearing conditions]

- 读取NACKF=1后将0写入NACKF标志时
- 当向ICCR1中的IICRST位写入1时，应用IIC复位或内部复位。

Note: 当NACKF标志设置为1时，IIC暂停数据发送和接收。在NACKF标志设置为1的情况下，在发送模式下写入ICDRT或在接收模式下从ICDRR读取不会启用数据发送或接收操作。要重新开始数据发送或接收，请将NACKF标志设置为0。

RDRF标志（接收数据满标志）

RDRF标志指示IDCRR是否包含接收数据。

[Setting conditions]

- 当接收数据从ICDRS传输到ICDRR。RDRF标志在第8个或第9个SCL时钟周期的上升沿设置为1（在ICMR3的RDRFS位中选择）。
- 当ICCR2中的TRS位设置为0检测到启动（或重新启动）条件后接收到的从机地址匹配时。

[Clearing conditions]

- 读取RDRF=1后向RDRF标志写入0时
- 从ICDRR读取数据时
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

TEND标志（发送结束标志）

TEND标志指示数据传输是否仍在传输中或已完成。

[Setting condition]

- 在第9个SCL时钟周期的上升沿，同时TDRE标志为1。

[Clearing conditions]

- 读取TEND=1后将0写入TEND标志时
- 数据写入ICDRT时
- 检测到停止条件时
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

TDRE flag (Transmit Data Empty Flag)

The TDRE flag indicates whether the ICDRT contains transmit data.

[Setting conditions]

- When data is transferred from ICDRT to ICDRS and ICDRT becomes empty
- When the TRS bit in ICCR2 is set to 1
- When the received slave address matches while the TRS bit is 1.

[Clearing conditions]

- When data is written to ICDRT
- When the TRS bit in ICCR2 is set to 0
- When 1 is written to the IICRST bit in ICCR1 to initiate an IIC reset or an internal reset.

Note: When the NACKF flag is set to 1 while the NACKE bit in ICFER is 1, the IIC suspends data transmission and reception. In this case, if the TDRE flag is 0 (next transmit data written), data is transferred to the ICDRS register and the ICDRT register becomes empty on the rising edge of the 9th clock cycle, but the TDRE flag is not set to 1.

29.2.11 I2C Bus Wakeup Unit Register (ICWUR)

Address(es): IIC0.ICWUR 4005 3016h

	b7	b6	b5	b4	b3	b2	b1	b0
	WUE	WUIE	WUF	WUACK	—	—	—	WUAFA
Value after reset:	0	0	0	1	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	WUAFA	Wakeup Analog Filter Additional Selection	0: Do not add the wakeup analog filter 1: Add the wakeup analog filter.	R/W
b3 to b1	—	Reserved	These bit are read as 0. The write value should be 0.	R/W
b4	WUACK	ACK Bit for Wakeup Mode	Choice of four response modes in combination with ICCR1.IICRST and WUACK. See Table 29.5.	R/W
b5	WUF	Wakeup Event Occurrence Flag	0: Slave address not matching during wakeup 1: Slave address matching during wakeup.	R/W
b6	WUIE	Wakeup Interrupt Request Enable	0: Wakeup Interrupt Request (IIC0_WUI) disabled 1: Wakeup Interrupt Request (IIC0_WUI) enabled.	R/W
b7	WUE	Wakeup Function Enable	0: Wakeup function disabled 1: Wakeup function enabled.	R/W

Table 29.5 Wakeup mode

IICRST	WUACK	Operation mode	Description
0	0	Normal wakeup mode 1	ACK response on 9th SCL, and SCL low hold after 9th SCL
0	1	Normal wakeup mode 2	No ACK response immediately and SCL low hold between 8th and 9th SCL. SCL low-hold release and ACK response on 9th SCL.
1	0	Command recovery mode	ACK response on 9th SCL and no SCL low hold
1	1	EEP response mode	NACK response on 9th SCL and no SCL low hold

WUF flag (Wakeup Event Occurrence Flag)

The WUF flag indicates whether the slave address is matching during wakeup.

[Setting condition]

TDRE标志（传输数据空标志）

TDRE标志指示ICDRT是否包含发送数据。

[Setting conditions]

- 当数据从ICDRT传输到ICDRS并且ICDRT变为空时
- ICCR2中的TRS位设置为1时
- 当TRS位为1时接收到的从机地址匹配。

[Clearing conditions]

- 数据写入ICDRT时
- ICCR2中的TRS位设置为0时
- 当向ICCR1中的IICRST位写入1以启动IIC复位或内部复位。

Note: 当ICFER的NACKE位为1时NACKF标志设置为1，IIC暂停数据发送和接收。在这种情况下，如果TDRE标志为0（写入下一个发送数据），则数据被传输到ICDRS寄存器，并且ICDRT寄存器在第9个时钟周期的上升沿变为空，但TDRE标志不设置为1.

29.2.11 I2C总线唤醒单元寄存器(ICWUR)

Address(es): IIC0.ICWUR 4005 3016h

	b7	b6	b5	b4	b3	b2	b1	b0
	WUE	WUIE	WUF	WUACK	—	—	—	WUAFA
重置后的值：	0	0	0	1	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	WUAFA	唤醒模拟滤波器附加选择	0：不加唤醒模拟滤波器1：加唤醒模拟滤波器。	R/W
b3 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	WUACK	唤醒模式的ACK位	四种响应模式的选择结合ICCR1.IICRST和WUACK。见表29.5。	R/W
b5	WUF	唤醒事件发生标志	0：唤醒期间从机地址不匹配1：唤醒期间从机地址匹配。	R/W
b6	WUIE	唤醒中断请求使能	0：唤醒中断请求（IIC0_WUI）禁用1：唤醒中断请求（IIC0_WUI）启用。	R/W
b7	WUE	唤醒功能启用	0：禁用唤醒功能1：启用唤醒功能。	R/W

Table 29.5 唤醒模式

IICRST	WUACK	操作模式	Description
0	0	正常唤醒模式1	第9个SCL的ACK响应，以及第9个SCL后的SCL低保持
0	1	正常唤醒模式2	没有ACK立即响应，并且SCL在第8和第9SCL之间保持低电平。SCL低保持释放和ACK响应在9thSCL。
1	0	命令恢复模式	在第9个SCL上的ACK响应并且没有SCL低保持
1	1	EEP响应模式	第9个SCL的NACK响应和无SCL低保持

WUF标志（唤醒事件发生标志）

WUF标志指示在唤醒期间从地址是否匹配。

[Setting condition]

- When PCLKB is supplied after a slave-address match in the first 8th SCL low during wakeup mode.

[Clearing conditions]

- When 0 is written to the WUF flag after reading WUF = 1
- When ICE = 0 and IICRST = 1.

29.2.12 I2C-Bus Wakeup Unit Register 2 (ICWUR2)

Address(es): IIC0.ICWUR2 4005 3017h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	WUSYF	WUASYF	WUSEN
Value after reset:	1	1	1	1	1	1	0	1

Bit	Symbol	Bit name	Description	R/W
b0	WUSEN	Wakeup Function Synchronous Enable	0: IIC asynchronous operation enabled 1: IIC synchronous operation enabled.	R/W
b1	WUASYF	Wakeup Function Asynchronous Operation Status Flag	0: IIC synchronous operation enabled 1: IIC asynchronous operation enabled.	R
b2	WUSYF	Wakeup Function Synchronous Operation Status Flag	0: IIC asynchronous operation enabled 1: IIC synchronous operation enabled.	R
b7 to b3	—	Reserved	These bits are read as1. The write value should be 1.	R/W

WUSEN bit (Wakeup Function Synchronous Enable)

The WUSEN bit is used in combination with the WUASYF flag (or WUSYF flag) to switch between the PCLKB synchronous and asynchronous operation, when the wakeup effective function is enabled (ICWUR.WUE = 1).

The PCLKB operation switches from synchronous to asynchronous operation:

- When the ICCR2.BBSY flag is 0, if 0 is written to the WUSEN bit while the WUASYF flag is 0. The reception occurs independently of the operation of PCLKB (with PCLKB stopped) after it switches to the PCLKB asynchronous operation, on wakeup event detection.

The PCLKB operation switches from asynchronous to synchronous operation:

- When 1 is written to the WUSEN bit, with the WUASYF flag at 1, when a wakeup event is detected. After writing 1, the WUASYF flag immediately becomes 0.
- When the stop condition is detected with a wakeup event undetected.

WUASYF flag (Wakeup Function Asynchronous Operation Status Flag)

The WUASYF flag can place the IIC in PCLKB asynchronous operation when the wakeup effective function is enabled (ICWUR.WUE = 1).

[Setting condition]

- When the ICCR2.BBSY flag is 0, and WUSEN bit is set to 0 with the ICWUR.WUE bit set to 1.

[Clearing conditions]

- When 1 is written to the WUSEN bit after detecting a wakeup event with ICWUR.WUE bit set to 1
- When a stop condition is detected with WUSEN bit set to 1 before detecting the wakeup event with WUASY flag set to 1 with ICWUR.WUE bit set to 1
- When 1 is written to the WUSEN bit with the WUASYF flag set to 1, and a wakeup event is detected with ICWUR.WUE set to 1
- ICCR1.ICE = 0 and ICCRST = 1 (ICC reset)

- 当PCLKB在唤醒模式下的前8个SCL低电平的从地址匹配后提供时。

[Clearing conditions]

- 读取WUF=1后向WUF标志写入0时
- 当ICE=0且IICRST=1时。

29.2.12 I2C-Bus唤醒单元寄存器2(ICWUR2)

Address(es): IIC0.ICWUR2 4005 3017h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	WUSYF	WUASYF	WUSEN
重置后的值:	1	1	1	1	1	1	0	1

Bit	Symbol	位名称	Description	R/W
b0	WUSEN	唤醒功能同步使能	0：IIC异步操作使能1：IIC同步操作使能。	R/W
b1	WUASYF	唤醒功能异步 操作状态标志	0：IIC同步操作使能1：IIC异步操作使能。	R
b2	WUSYF	唤醒功能同步操作 状态标志	0：IIC异步操作使能1：IIC同步操作使能。	R
b7 to b3	—	Reserved	这些位被读取为1。写入值应为1。	R/W

WUSEN位（唤醒功能同步使能）

WUSEN位与WUASYF标志（或WUSYF标志）结合使用，在启用唤醒有效功能（ICWUR.WUE=1）时在PCLKB同步和异步操作之间切换。

PCLKB操作从同步操作切换到异步操作：

- 当ICCR2.BBSY标志为0时，如果在WUASYF标志为0时将0写入WUSEN位。在唤醒事件切换到PCLKB异步操作后，接收发生独立于PCLKB的操作（PCLKB停止）检测。

PCLKB操作从异步操作切换到同步操作：

- 当WUSEN位写入1且WUASYF标志为1时，检测到唤醒事件。写入1后，WUASYF标志立即变为0。
- 当检测到停止条件且未检测到唤醒事件时。

WUASYF标志（唤醒功能异步操作状态标志）

WUASYF标志可以在启用唤醒有效功能（ICWUR.WUE=1）时将IIC置于PCLKB异步操作中。

[Setting condition]

- 当ICCR2.BBSY标志为0且WUSEN位设置为0且ICWUR.WUE位设置为1时。

[Clearing conditions]

- 当检测到唤醒事件后将1写入WUSEN位且ICWUR.WUE位设置为1
- 在检测到WUASY标志设置为1且ICWUR.WUE位设置为1的唤醒事件之前检测到WUSEN位设置为1的停止条件时
- 当WUASYF标志设置为1的情况下将1写入WUSEN位时，检测到唤醒事件
  ICWUR.WUE设置为1
- ICCR1.ICE = 0 and ICCRST = 1 (ICC reset)

- ICWUR.WUE = 0.

WUSYF flag (Wakeup Function Synchronous Operation Status Flag)

The WUSYF flag can place the IIC in PCLKB synchronous operation when the wakeup function is enabled (ICWUR.WUE = 1). When this flag is used, the WUASYF flag is reserved.

[Setting conditions]

- When 1 is written to the WUSEN bit after detecting a wakeup event with ICWUR.WUE bit set to 1 and WUSYF flag set to 0
- When a stop condition is detected with WUSEN bit set to 1, before detecting a wakeup event with the WUSYF flag set to 0 and the ICWUR.WUE bit set to 1
- ICCR1.ICE = 0 and ICCRST = 1 (ICC reset)
- ICWUR.WUE = 0.

[Clearing condition]

- When the ICCR2.BBSY flag is 0 with the ICWUR.WUE bit set to 1, after writing 0 to the WUSEN bit.

29.2.13 Slave Address Register L y (SARLy) (y = 0 to 2)

Address(es): IIC0.SARL0 4005 300Ah, IIC1.SARL0 4005 310Ah, IIC0.SARL1 4005 300Ch, IIC1.SARL1 4005 310Ch, IIC0.SARL2 4005 300Eh, IIC1.SARL2 4005 310Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	SVA[6:0]							SVA0
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SVA0	10-Bit Address LSB	Slave address setting	R/W
b7 to b1	SVA[6:0]	7-Bit Address/10-Bit Address Lower Bits	Slave address setting	R/W

SVA0 bit (10-Bit Address LSB)

When the 10-bit address format is selected (SARUy.FS = 1), the SVA0 bit functions as the LSB of a 10-bit address and is combined with the SVA[6:0] bits to form the lower 8 bits of a 10-bit address.

This bit is valid when the SARyE bit in ICSER is set to 1 (SARLy and SARUy enabled) and the SARUy.FS bit is 1. When the SARUy.FS or SARyE bit is 0, the setting in this bit is ignored.

SVA[6:0] bits (7-Bit Address/10-Bit Address Lower Bits)

When the 7-bit address format is selected (SARUy.FS = 0), the SVA[6:0] bits function as a 7-bit address. When the 10-bit address format is selected (SARUy.FS = 1), these bits combined with the SVA0 bit to form the lower 8 bits of a 10-bit address. When the SARyE bit in ICSER is 0, the setting in these bits is ignored.

- ICWUR.WUE = 0.

WUSYF标志（唤醒功能同步操作状态标志）

WUSYF标志可以在启用唤醒功能（ICWUR.WUE=1）时将IIC置于PCLKB同步操作中。使用此标志时，保留WUASYF标志。

[Setting conditions]

- 当检测到唤醒事件后将1写入WUSEN位时，ICWUR.WUE位设置为1，WUSYF标志位设置为0
- 当WUSEN位设置为1检测到停止条件时，在检测到WUSYF标志设置为0且ICWUR.WUE位设置为1的唤醒事件之前
- ICCR1.ICE = 0 and ICCRST = 1 (ICC reset)
- ICWUR.WUE = 0.

[Clearing condition]

- 当ICCR2.BBSY标志为0且ICWUR.WUE位设置为1时，将0写入WUSEN位。

29.2.13 从地址寄存器Ly(SARLy)(y=0to2)

Address(es): IIC0.SARL0 4005 300Ah, IIC1.SARL0 4005 310Ah, IIC0.SARL1 4005 300Ch, IIC1.SARL1 4005 310Ch, IIC0.SARL2 4005 300Eh, IIC1.SARL2 4005 310Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	SVA[6:0]							SVA0
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SVA0	10-Bit Address LSB	从机地址设置	R/W
b7 to b1	SVA[6:0]	7位地址10位地址低位	从机地址设置	R/W

SVA0位（10位地址LSB）

Whenthe10−bitaddressformatisselected(SARUy.FS=1) theSVA0bitfunctionsastheLSBofa10−bitaddressandiscombinedwiththeSVA[6:0]bitstoformthelower8bitsofa10位地址。

当ICSER中的SARyE位设置为1（启用SARLy和SARUy）且SARUy.FS位为1时，该位有效。当SARUy.FS或SARyE位为0时，忽略该位的设置。

SVA[6:0]位（7位地址10位地址低位）

Whenthe7−bitaddressformatisselected(SARUy.FS=0) theSVA[6:0]bitsfunctionasa7−bitaddress.Whenthe10bitaddressformatisselected(SARUy.FS=1) thesebitscombinedwiththeSVA0bittoformthelower8bitsofa10−bitaddress.当ICSER中的SARyE位为0时，这些位中的设置将被忽略。

29.2.14 Slave Address Register U y (SARUy) (y = 0 to 2)

Address(es): IIC0.SARU0 4005 300Bh, IIC1.SARU0 4005 310Bh, IIC0.SARU1 4005 300Dh, IIC1.SARU1 4005 310Dh, IIC0.SARU2 4005 300Fh, IIC1.SARU2 4005 310Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SVA[1:0]		FS
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	FS	7-Bit/10-Bit Address Format Select	0: Select 7-bit address format 1: Select 10-bit address format.	R/W
b2, b1	SVA[1:0]	10-Bit Address Upper Bits	Slave address setting	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

FS bit (7-Bit/10-Bit Address Format Select)

The FS bit selects the 7-bit or 10-bit address format for the slave address y (in SARLy and SARUy).

When the SARyE bit in ICSER is set to 1 (SARLy and SARUy enabled) and the SARUy.FS bit is 0, the 7-bit address format is selected for slave address y, the SVA[6:0] setting in SARLy is valid, and the SVA[1:0] and SVA0 settings in SARLy are ignored.

When the SARyE bit in ICSER is set to 1 (SARLy and SARUy enabled) and the SARUy.FS bit is 1, the 10-bit address format is selected for slave address y and the SVA[1:0] and SARLy settings are valid.

When the SARyE bit in ICSER is 0 (SARLy and SARUy disabled), the SARUy.FS bit is invalid.

SVA[1:0] bits (10-Bit Address Upper Bits)

When the 10-bit address format is selected (FS = 1), the SVA[1:0] bits function as the upper 2 bits of a 10-bit address.

These bits are valid when the SARyE bit in ICSER is set to 1 (SARLy and SARUy enabled) and the SARUy.FS bit is 1. When the SARUy.FS or SARyE bit is 0, the setting of these bits is ignored.

29.2.15 I2C Bus Bit Rate Low-Level Register (ICBRL)

Address(es): IIC0.ICBRL 4005 3010h, IIC1.ICBRL 4005 3110h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	BRL[4:0]				
Value after reset:	1	1	1	1	1	1	1	1

Bit	Symbol	Bit name	Description	R/W
b4 to b0	BRL[4:0]	Bit Rate Low-Level Period	Low-level period of SCL clock	R/W
b7 to b5	—	Reserved	These bits are read as 1. The write value should be 1.	R/W

ICBRL is a 5-bit register that sets the low-level period of the SCL clock. ICBRL also generates the data setup time for automatic SCL low-hold operation, see section 29.9, Automatic Low-Hold Function for SCL.

BRL[4:0] bits (Bit Rate Low-Level Period)

The BRL[4:0] bits set the low-level period of the SCL clock. ICBRL counts the low-level period with the internal reference clock source (IICϕ) specified in the CKS[2:0] bits in ICMR1. When the IIC is used only in slave mode, the BRL[4:0] bits must be set to a value longer than the data setup time*1.

If the digital noise filter is enabled (NFE bit in ICFER is 1), set the BRL[4:0] bits to a value at least one greater than the

29.2.14 从地址寄存器Uy(SARUy)(y=0to2)

Address(es): IIC0.SARU0 4005 300Bh, IIC1.SARU0 4005 310Bh, IIC0.SARU1 4005 300Dh, IIC1.SARU1 4005 310Dh, IIC0.SARU2 4005 300Fh, IIC1.SARU2 4005 310Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SVA[1:0]		FS
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	FS	7位10位地址格式选择	0：选择7位地址格式1：选择1 0位地址格式。	R/W
b2, b1	SVA[1:0]	10位地址高位	从机地址设置	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

FS位（7位10位地址格式选择）

FS位为从地址y选择7位或10位地址格式（在SARLy和SARUy中）。

当ICSER中的SARyE位设置为1（启用SARLy和SARUy）且SARUy.FS位为0时，从机地址y选择7位地址格式，SARLy中的SVA[6:0]设置有效 并且忽略SARLy中的SVA[1:0]和SVA0设置。

当ICSER中的SARyE位设置为1（启用SARLy和SARUy）且SARUy.FS位为1时，从机地址y选择10位地址格式，并且SVA[1:0]和SARLy设置有效.

当ICSER中的SARyE位为0（SARLy和SARUy禁用）时，SARUy.FS位无效。

SVA[1:0]位（10位地址高位）

Whenthe10-bitaddressformatisselected(FS=1) theSVA[1:0]bitsfunctionastheupper2bitsofa10-bitaddress.

当ICSER中的SARyE位设置为1（启用SARLy和SARUy）且SARUy.FS位为1时，这些位有效。
当SARUy.FS或SARyE位为0时，这些位的设置被忽略。

29.2.15 I2C总线比特率低电平寄存器(ICBRL)

Address(es): IIC0.ICBRL 4005 3010h, IIC1.ICBRL 4005 3110h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	BRL[4:0]				
重置后的值:	1	1	1	1	1	1	1	1

Bit	Symbol	位名称	Description	R/W
b4 to b0	BRL[4:0]	比特率低电平周期	SCL时钟低电平周期	R/W
b7 to b5	—	Reserved	这些位被读取为1。写入值应为1。	R/W

ICBRL是一个5位寄存器，用于设置SCL时钟的低电平周期。ICBRL还为自动SCL低保持操作生成数据建立时间，请参见第29.9节，SCL的自动低保持功能。

BRL[4:0]位（比特率低电平周期）

BRL[4:0]位设置SCL时钟的低电平周期。ICBRL使用ICMR1的CKS[2:0]位中指定的内部参考时钟源(IIC)对低电平周期进行计数。当IIC仅在从机模式下使用时，BRL[4:0]位必须设置为比数据建立时间长*1的值。

如果启用了数字噪声滤波器（ICFER中的NFE位为1），请将BRL[4:0]位设置为至少比

number of stages in the noise filter. For this number, see the description of the ICMR3.NF[1:0] bits.

Note 1. Data setup time ($t_{SU:DAT}$)
250 ns for up to 100 kbps: Standard mode (Sm)
100 ns for up to 400 kbps: Fast mode (Fm)
50 ns for up to 1 Mbps: Fast mode plus (Fm+)

29.2.16 I2C Bus Bit Rate High-Level Register (ICBRH)

Address(es): IIC0.ICBRH 4005 3011h, IIC1.ICBRH 4005 3111h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	BRH[4:0]				
Value after reset:	1	1	1	1	1	1	1	1

Bit	Symbol	Bit name	Description	R/W
b4 to b0	BRH[4:0]	Bit Rate High-Level Period	High-level period of SCL clock	R/W
b7 to b5	—	Reserved	These bits are read as 1. The write value should be 1.	R/W

ICBRH is a 5-bit register that sets the high-level period of the SCL clock. ICBRH is valid in master mode.

BRH[4:0] bits (Bit Rate High-Level Period)

The BRH[4:0] bits set the high-level period of the SCL clock. If the IIC is used only in slave mode, do not set the BRH[4:0] bits.

ICBRH counts the high-level period with the internal reference clock source (IICϕ) specified in the CKS[2:0] bits in ICMR1.

If the digital noise filter is enabled (NFE bit in ICFER is 1), set these bits to a value at least one greater than the number of stages in the noise filter. For this number, see the description of the ICMR3.NF[1:0] bits.

The IIC transfer rate and the SCL clock duty are calculated using the following expressions:

1. ICFER.SCLE = 0
Transfer rate = $1/\{[(BRH + 1) + (BRL + 1)]/IIC\varphi^{*1} + tr^{*2} + tf^{*2}\}$
Duty cycle = $\{tr + [(BRH + 1)/IIC\varphi]\}/\{tr + tf + [(BRH + 1) + (BRL + 1)]/IIC\varphi\}$
2. ICFER.SCLE = 1 and ICFER.NFE = 0 and CKS[2:0] = 000b (IICφ = PCLKB)
Transfer rate = $1/\{[(BRH + 3) + (BRL+ 3)]/IIC\varphi + tr + tf\}$
Duty cycle = $\{tr + [(BRH + 3)/IIC\varphi]\}/\{tr + tf + [(BRH + 3) + (BRL + 3)]/IIC\varphi\}$
3. ICFER.SCLE = 1 and ICFER.NFE = 1 and CKS[2:0] = 000b (IICφ = PCLKB)
Transfer rate = $1/\{[(BRH + 3 + nf^{*3}) + (BRL + 3 + nf)]/IIC\varphi + tr + tf\}$
Duty cycle = $\{tr + [(BRH + 3 + nf)/IIC\varphi]\}/\{tr + tf + [(BRH + 3 + nf) + (BRL + 3 + nf)]/IIC\varphi\}$
4. ICFER.SCLE = 1 and ICFER.NFE = 0 and CKS[2:0] ≠ 000b
Transfer rate = $1/\{[(BRH + 2) + (BRL + 2)]/IIC\varphi + tr + tf\}$
Duty cycle = $\{tr + [(BRH + 2)/IIC\varphi]\}/\{tr + tf + [(BRH + 2) + (BRL + 2)]/IIC\varphi\}$
5. ICFER.SCLE = 1 and ICFER.NFE = 1 and CKS[2:0] ≠ 000b
Transfer rate = $1/\{[(BRH + 2 + nf) + (BRL + 2 + nf)]/IIC\varphi + tr + tf\}$
Duty cycle = $\{tr + [(BRH + 2 + nf)/IIC\varphi]\}/\{tr + tf + [(BRH + 2 + nf) + (BRL + 2 + nf)]/IIC\varphi\}$

Note 1. IICφ = PCLKB × Division ratio.
Note 2. The SCLn line rise time (tr) and SCLn line fall time (tf) depend on the total bus line capacitance (Cb) and the pull-up resistor (Rp). For details, see the I2C bus standard from NXP Semiconductors.
Note 3. nf = Number of digital noise filter stages selected in the ICMR3.NF bit.

噪声滤波器的级数。对于这个数字，请参见ICMR3.NF[1:0]位的描述。

注1.数据建立时间(tSU:DAT)
250ns，最高100kbps：标准模式(Sm)100ns，
最高400kbps：快速模式(Fm)50ns，最高1Mbps
：快速模式加(Fm+)

29.2.16 I2C总线比特率高级寄存器(ICBRH)

Address(es): IIC0.ICBRH 4005 3011h, IIC1.ICBRH 4005 3111h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	BRH[4:0]				
重置后的值：	1	1	1	1	1	1	1	1

Bit	Symbol	位名称	Description	R/W
b4 to b0	BRH[4:0]	比特率高级期	SCL时钟高电平周期	R/W
b7 to b5	—	Reserved	这些位被读取为1。写入值应为1。	R/W

ICBRH是一个5位寄存器，用于设置SCL时钟的高电平周期。ICBRH在主模式下有效。

BRH[4:0]位（比特率高电平周期）

BRH[4:0]位设置SCL时钟的高电平周期。如果IIC仅用于从机模式，则不要设置
BRH[4:0] bits.

ICBRH使用CKS[2:0]位中指定的内部参考时钟源(IIC)计算高电平周期
ICMR1.

如果启用了数字噪声滤波器（ICFER中的NFE位为1），请将这些位设置为至少比噪声滤波器中的级数大1的值。
对于这个数字，请参见ICMR3.NF[1:0]位的描述。

IIC传输速率和SCL时钟占空比使用以下表达式计算：

1. ICFER.SCLE = 0
传输率=$1\{[(BRH+1)+(BRL+1)]IIC\phi*1+tr*2+tf*2$
占空比=$\{tr+[(BRH+1)IIC\phi]\ \{tr+tf+[(BRH+1)+(BRL+1)]IIC\phi$
2. ICFER.SCLE = 1 and ICFER.NFE = 0 and CKS[2:0] = 000b (IICφ = PCLKB)
传输率=$1\{[(BRH+3)+(BRL+3)]IIC\phi+tr+tf$
占空比=$\{tr+[(BRH+3)IIC\phi]\ \{tr+tf+[(BRH+3)+(BRL+3)]IIC\phi$
3. ICFER.SCLE = 1 and ICFER.NFE = 1 and CKS[2:0] = 000b (IICφ = PCLKB)
传输率=$1\{[(BRH+3+nf*3)+(BRL+3+nf)]IIC\phi+tr+tf$
占空比=$\{tr+[(BRH+3+nf)IIC\phi]\ \{tr+tf+[(BRH+3+nf)+(BRL+3+nf)]IIC\phi$
4. ICFER.SCLE = 1 and ICFER.NFE = 0 and CKS[2:0] ≠ 000b
传输率=$1\{[(BRH+2)+(BRL+2)]IIC\phi+tr+tf$
占空比=$\{tr+[(BRH+2)IIC\phi]\ \{tr+tf+[(BRH+2)+(BRL+2)]IIC\phi$
5. ICFER.SCLE = 1 and ICFER.NFE = 1 and CKS[2:0] ≠ 000b
传输率=$1\{[(BRH+2+nf)+(BRL+2+nf)]IIC\phi+tr+tf$
占空比=$\{tr+[(BRH+2+nf)IIC\phi]\ \{tr+tf+[(BRH+2+nf)+(BRL+2+nf)]IIC\phi$

注1.IICφ=PCLKB×分频比。
注2.SCLn线路上升时间(tr)和SCLn线路下降时间(tf)取决于总总线电容(Cb)和上拉电阻(Rp)。有关详细信息，请参阅NXPSemiconductors的I2C总线标准。注3.nf=在ICMR3.NF位中选择的数字噪声滤波器级数。

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Table 29.6 Example of ICBRH/ICBRL settings for transfer rate when SCLE = 0

Transfer rate (kbps)	CKS[2:0]	BRH[4:0] (ICBRH)	BRL[4:0] (ICBRL)	PCLKB (MHz)	NF[1:0]	Computation expression
100	100b	14 (EEh)	17 (F1h)	60	—	(1)
400	010b	8 (E8h)	19 (F3h)	60	—	(1)
1000	000b	15 (EFh)	29 (FDh)	60	—	(1)

Table 29.7 Example of ICBRH/ICBRL settings for transfer rate when SCLE = 1 and NFE = 0

Transfer rate (kbps)	CKS[2:0]	BRH[4:0] (ICBRH)	BRL[4:0] (ICBRL)	PCLKB (MHz)	NF[1:0]	Computation expression
100	100b	13 (EDh)	16 (F0h)	60	—	(4)
400	010b	7 (E7h)	18 (F2h)	60	—	(4)
1000	000b	13 (EDh)	27 (FBh)	60	—	(2)

Table 29.8 Example of ICBRH/ICBRL settings for transfer rate when SCLE = 1 and NFE = 1

Transfer rate (kbps)	CKS[2:0]	BRH[4:0] (ICBRH)	BRL[4:0] (ICBRL)	PCLKB (MHz)	NF[1:0]	Computation expression
100	100b	11 (EBh)	14 (EEh)	60	01b	(5)
400	010b	5 (E5h)	16 (F0h)	60	01b	(5)
1000	000b	11 (EBh)	25 (F9h)	60	01b	(3)

29.2.17 I2C Bus Transmit Data Register (ICDRT)

Address(es): IIC0.ICDRT 4005 3012h, IIC1.ICDRT 4005 3112h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1

When ICDRT detects a space in the I2C Bus Shift Register (ICDRS), it transfers the transmit data that is written to ICDRT to ICDRS and starts transmitting data in transmit mode.

The double-buffer structure of ICDRT and ICDRS allows continuous transmit operation if the next transmit data is written to ICDRT while the ICDRS data is being transmitted.

ICDRT can always be read from and written to. Write transmit data to ICDRT when a transmit data empty interrupt (IICn_TXI) request is generated.

29.2.18 I2C Bus Receive Data Register (ICDRR)

Address(es): IIC0.ICDRR 4005 3013h, IIC1.ICDRR 4005 3113h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0

When 1 byte of data is received, the received data is transferred from the I2C Bus Shift Register (ICDRS) to ICDRR to enable the next data to be received.

The double-buffer structure of ICDRS and ICDRR allows continuous receive operation if the received data is read from ICDRR while ICDRS is receiving data. ICDRR cannot be written to. Read data from ICDRR when a receive data full interrupt (IICn_RXI) request is generated.

Table 29.6 SCLE=0时传输速率的ICBRHICBRL设置示例

传输速率(kbps)	CKS[2:0]	BRH[4:0] (ICBRH)	BRL[4:0] (ICBRL)	PCLKB (MHz)	NF[1:0]	计算表达式
100	100b	14 (EEh)	17 (F1h)	60	—	(1)
400	010b	8 (E8h)	19 (F3h)	60	—	(1)
1000	000b	15 (EFh)	29 (FDh)	60	—	(1)

Table 29.7 SCLE=1和NFE=0时传输速率的ICBRHICBRL设置示例

传输速率(kbps)	CKS[2:0]	BRH[4:0] (ICBRH)	BRL[4:0] (ICBRL)	PCLKB (MHz)	NF[1:0]	计算表达式
100	100b	13 (EDh)	16 (F0h)	60	—	(4)
400	010b	7 (E7h)	18 (F2h)	60	—	(4)
1000	000b	13 (EDh)	27 (FBh)	60	—	(2)

Table 29.8 SCLE=1和NFE=1时传输速率的ICBRHICBRL设置示例

传输速率(kbps)	CKS[2:0]	BRH[4:0] (ICBRH)	BRL[4:0] (ICBRL)	PCLKB (MHz)	NF[1:0]	计算表达式
100	100b	11 (EBh)	14 (EEh)	60	01b	(5)
400	010b	5 (E5h)	16 (F0h)	60	01b	(5)
1000	000b	11 (EBh)	25 (F9h)	60	01b	(3)

29.2.17 I2C总线发送数据寄存器(ICDRT)

Address(es): IIC0.ICDRT 4005 3012h, IIC1.ICDRT 4005 3112h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	1	1	1	1	1	1	1	1

当ICDRT在I2C总线移位寄存器(ICDRS)中检测到一个空间时，它会将写入的发送数据传输到ICDRT到ICDRS并开始在传输模式下传输数据。

ICDRT和ICDRS的双缓冲结构允许在传输ICDRS数据的同时将下一个传输数据写入ICDRT的连续传输操作。

ICDRT始终可以被读取和写入。当产生发送数据空中断(IICn_TXI)请求时，将发送数据写入ICDRT。

29.2.18 I2C总线接收数据寄存器(ICDRR)

Address(es): IIC0.ICDRR 4005 3013h, IIC1.ICDRR 4005 3113h

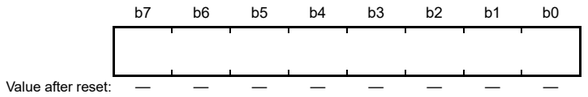
	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0

当接收到1个字节的数据时，接收到的数据会从I2C总线移位寄存器(ICDRS)传输到ICDRR，以便接收下一个数据。

ICDRS和ICDRR的双缓冲结构允许在接收到的数据从ICDRS正在接收数据时的ICDRR。无法写入ICDRR。当产生接收数据完全中断(IICn_RXI)请求时，从ICDRR读取数据。

If ICDRR receives the next receive data before the current data is read from ICDRR while the RDRF flag in ICSR2 is 1, the IIC automatically holds the SCL clock low for 1 clock cycle before the RDRF flag is set to 1 again.

29.2.19 I2C Bus Shift Register (ICDRS)



ICDRS is an 8-bit shift register to transmit and receive data.

During transmission, transmit data is transferred from ICDRT to ICDRS and is sent from the SDAn pin. During reception, data is transferred from ICDRS to ICDRR after 1 byte of data is received. ICDRS cannot be accessed directly.

29.3 Operation

29.3.1 Communication Data Format

The I2C bus format consists of 8-bit data and 1-bit acknowledge. The frame following a start or restart condition is an address frame that specifies a slave device with which the master device communicates. The specified slave is valid until a new slave is specified or a stop condition is issued.

Figure 29.3 shows the I2C bus format, and Figure 29.4 shows the I2C bus timing.

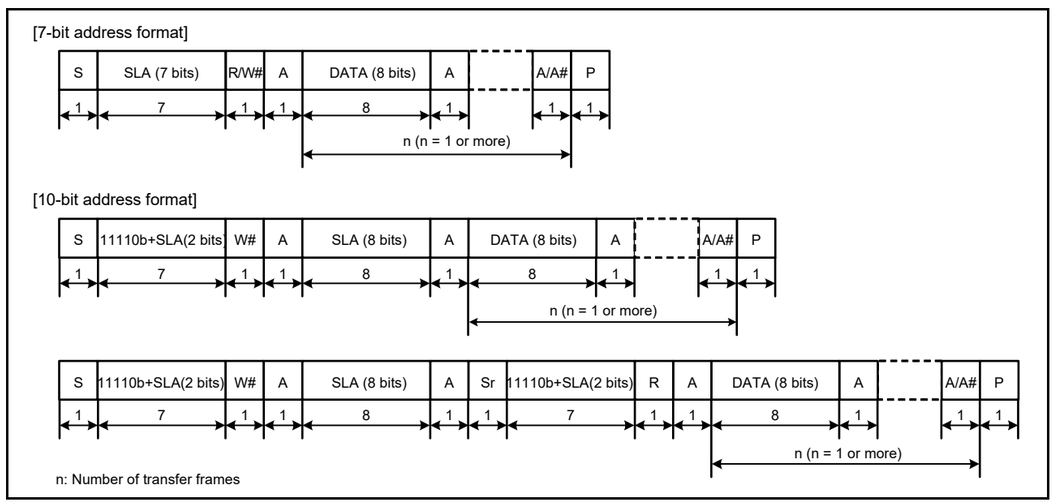


Figure 29.3 I2C bus format

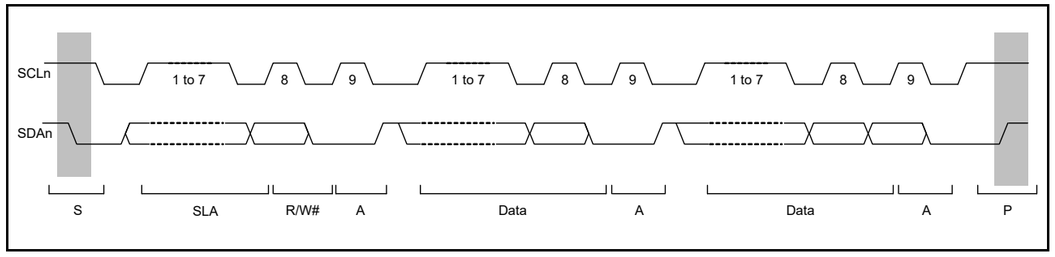
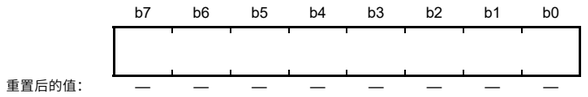


Figure 29.4 I2C bus timing (SLA = 7 bits)

如果ICDRR在从ICDRR读取当前数据之前接收到下一个接收数据，而ICSR2中的RDRF标志为1，则IIC在RDRF标志再次设置为1之前自动将SCL时钟保持低1个时钟周期。

29.2.19 I2C总线移位寄存器(ICDRS)



ICDRS是一个8位移位寄存器，用于发送和接收数据。

在发送期间，发送数据从ICDRT传输到ICDRS，并从SDAn引脚发送。在接收过程中，接收到1个字节的数据后，数据从ICDRS传输到ICDRR。ICDRS不能直接访问。

29.3 Operation

29.3.1 通讯数据格式

I2C总线格式由8位数据和1位确认组成。开始或重启条件之后的帧是地址帧，它指定与主设备通信的从设备。指定的从站有效，直到指定新的从站或发出停止条件。

图29.3显示了I2C总线格式，图29.4显示了I2C总线时序。

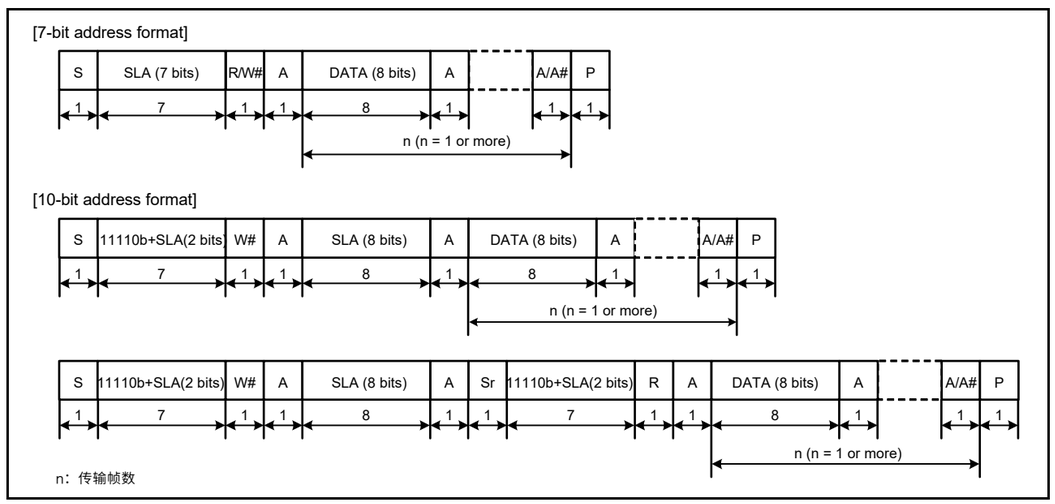


Figure 29.3 I2C总线格式

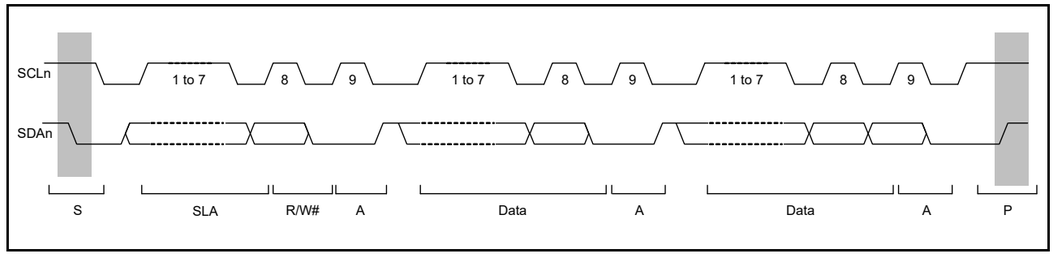


Figure 29.4 I2C总线时序（SLA=7位）

S: Start condition. The master device drives the SDAn line low from high while the SCLn line is high.

SLA: Slave address, by which the master device selects a slave device

R/W#: Indicates the direction of data transfer: from the slave device to the master device when R/W# is 1, or from the master device to the slave device when R/W# is 0

A: Acknowledge. The receive device drives the SDAn line low. In master transmit mode, the slave device returns acknowledge. In master receive mode, the master device returns acknowledge.

A#: Not Acknowledge. The receive device drives the SDAn line high.

Sr: Restart condition. The master device drives the SDAn line low from the high after the setup time elapses with the SCLn line high.

DATA: Transmitted or received data

P: Stop condition. The master device drives the SDAn line high from low when the SCLn line is high.

29.3.2 Initial Settings

Before starting data transmission or reception, initialize the IIC using the procedure shown in Figure 29.5.

1. Set the ICCR1.ICE bit set to 0 to set the SCLn and SDAn pins to the inactive state.
2. Set the ICCR1.IICRST bit to 1 to initiate IIC reset.
3. Set the ICCR1.ICE bit to 1 to initiate internal reset, which initializes the flags and the internal state of the ICSR1 register.
4. Set the SARLy, SARUy, ICSER, ICMR1, ICBRH, and ICBRL registers (y = 0 to 2), and set the other registers as required. For initial IIC settings, see Figure 29.5.
5. When the required register settings are complete, set the ICCR1.IICRST bit to 0 to release the IIC reset.

Note: This procedure is not required if the IIC initialization is already complete.

S: 启动条件。主设备将SDAn线从高电平驱动为低电平，而SCLn线为高电平。

SLA: 从地址，主设备通过该地址选择从设备

R/W#: 指示数据传输的方向：当RW#为1时从从设备到主设备，或者当RW#为0时从主设备到从设备

A: 承认。接收设备将SDAn线驱动为低电平。在主发送模式下，从设备返回确认。
在主接收模式下，主设备返回确认。

A#: 不承认。接收设备将SDAn线驱动为高电平。

Sr: 重启条件。建立时间过后，主器件将SDAn线从高电平驱动为低电平，SCLn线为高电平。

DATA: 传输或接收的数据

P: 停止条件。当SCLn线为高电平时，主设备将SDAn线从低电平驱动为高电平。

29.3.2 初始设置

在开始数据发送或接收之前，使用图29.5所示的过程初始化IIC。

1. 将ICCR1.ICE位设置为0，以将SCLn和SDAn引脚设置为无效状态。
2. 将ICCR1.IICRST位设置为1以启动IIC复位。
3. 将ICCR1.ICE位设置为1以启动内部复位，这会初始化ICSR1寄存器的标志和内部状态。
4. 设置SARLy、SARUy、ICSER、ICMR1、ICBRH和ICBRL寄存器（y=0到2），并根据需要设置其他寄存器。有关初始IIC设置，请参见图29.5。
5. 当所需的寄存器设置完成后，将ICCR1.IICRST位设置为0以释放IIC复位。

Note: 如果IIC初始化已经完成，则不需要此过程。

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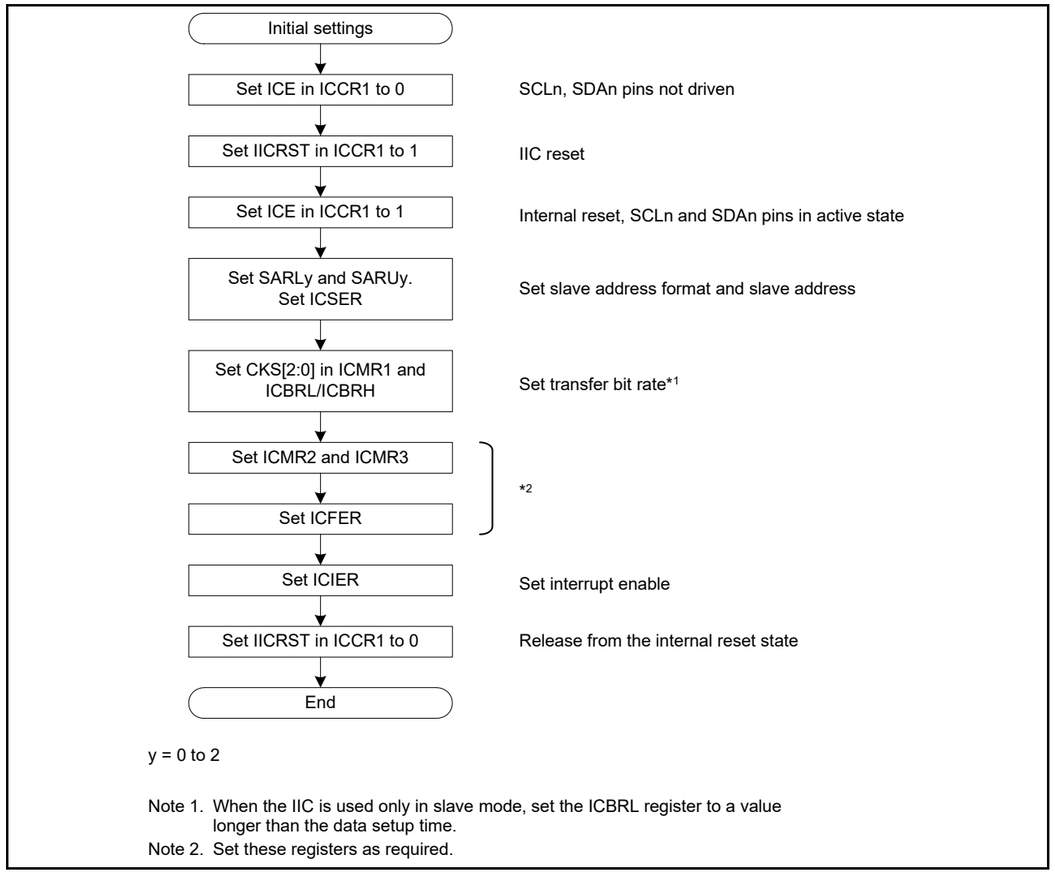

Figure 29.5 Example IIC initialization flow

29.3.3 Master Transmit Operation

In master transmit operation, the IIC outputs the SCL clock and transmit data signals as the master device, and the slave device returns the acknowledgments. Figure 29.6 shows an example of master transmission, and Figure 29.7 to Figure 29.9 show the operation timing in master transmission.

To set up and perform master transmission:

1. Initialize the IIC using the procedure in section 29.3.2, Initial Settings.
2. Read the BBSY flag in ICCR2 to check that the bus is open, then set the ST bit in ICCR2 to 1 (start condition request). On receiving the request, the IIC issues a start condition. At the same time, the BBSY and START flags in ICSR2 automatically set to 1 and the ST bit is automatically set to 0. If the start condition is detected and the internal levels for the SDA output state and the levels on the SDAn line match while the ST bit is 1, the IIC recognizes that the start condition requested by the ST bit has successfully completed, and the MST and TRS bits in ICCR2 automatically set to 1, placing the IIC in master transmit mode. The TDRE flag in ICSR2 is also automatically set to 1 in response to TRS = 1.
3. Check that the TDRE flag in ICSR2 is 1, then write the value for transmission (the slave address and the R/W# bit) to ICDRT. When the transmit data is written to ICDRT, the TDRE flag is automatically set to 0, the data is transferred from ICDRT to ICDRS, and the TDRE flag is again set to 1. After the byte containing the slave address and R/W# bit is transmitted, the value of the TRS bit automatically updates to select master transmit or master receive mode based on the value of the transmitted R/W# bit. If the value of the R/W# bit is 0, the IIC continues in master transmit mode. If the ICSR2.NACKF flag is 1, indicating that no slave device recognized the address or

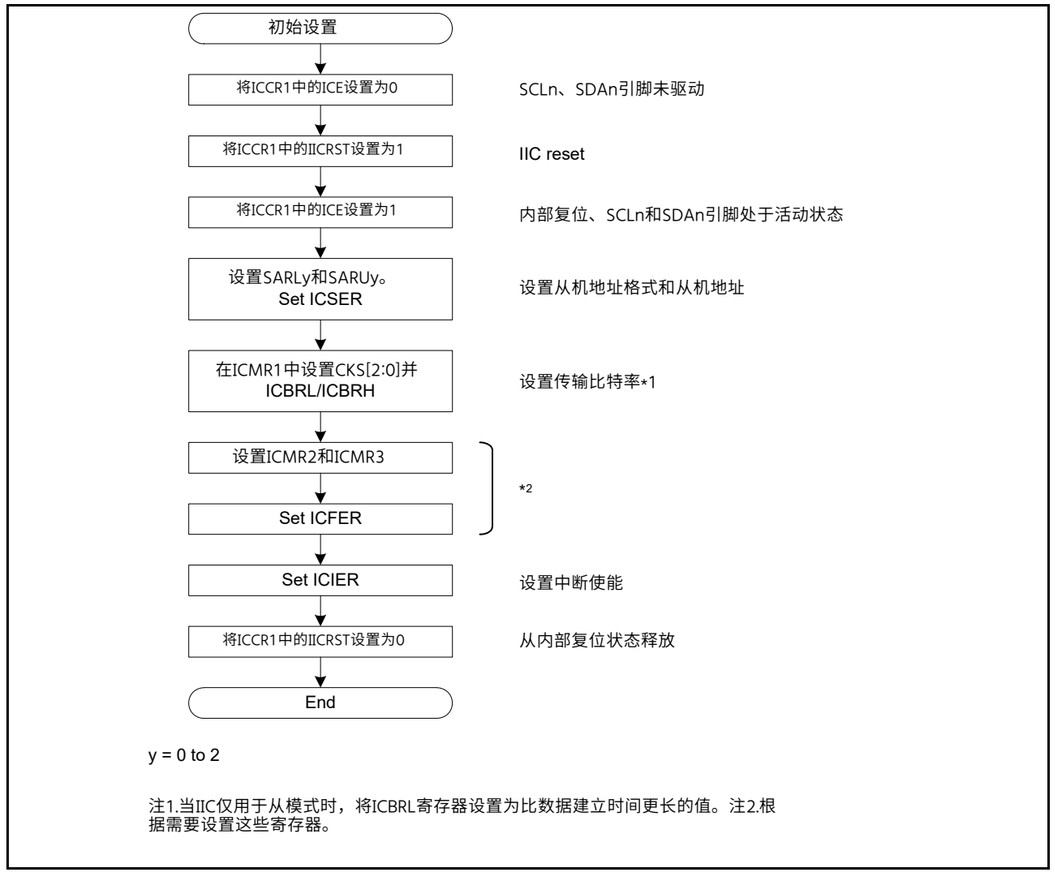

Figure 29.5 示例IIC初始化流程

29.3.3 主发送操作

在主发送操作中，IIC作为主设备输出SCL时钟和发送数据信号，从设备返回确认。图29.6显示了主传输的示例，图29.7至图29.9显示了主传输的操作时序。

设置和执行主传输：

1. 使用第29.3.2节，初始设置中的过程初始化IIC。
2. 读取ICCR2中的BBSY标志以检查总线是否打开，然后将ICCR2中的ST位设置为1（启动条件请求）。收到请求后，IIC发出一个开始条件。同时，ICSR2中的BBSY和START标志自动设置为1，ST位自动设置为0。如果检测到启动条件并且SDA输出状态的内部电平与SDAn线上的电平匹配，则ST位为1，IIC识别到ST位请求的启动条件已成功完成，并且ICCR2中的MST和TRS位自动设置为1，将IIC置于主机发送模式。ICSR2中的TDRE标志也自动设置为1，以响应TRS=1。
3. 检查ICSR2中的TDRE标志是否为1，然后将传输值（从机地址和RW#位）写入ICDRT。当发送数据写入ICDRT时，TDRE标志自动设置为0，数据从ICDRT传输到ICDRS，TDRE标志再次设置为1。在发送包含从机地址和RW#位的字节后，TRS位的值会自动更新，以根据发送的RW#位的值选择主机发送或主机接收模式。如果RW#位的值为0，则IIC继续处于主机发送模式。如果ICSR2.NACKF标志为1，表示没有从设备识别该地址或

there was an error in communications, write 1 to the ICCR2.SP bit to issue a stop condition.
To transmit data with an address in the 10-bit format, start by writing 1111 0b, the two upper bits of the slave address, and W to ICDRT as the first address transmission. For the second address transmission, write the 8 lower bits of the slave address to ICDRT.

4. Check that the TDRE flag in ICSR2 is 1, then write the transmit data to the ICDRT register. The IIC automatically holds the SCLn line low until the transmit data is ready or a stop condition is issued.
5. After all bytes of transmit data are written to the ICDRT register, wait until the value in the TEND flag in ICSR2 returns to 1, then set the SP bit in ICCR2 to 1 (stop condition requested). On receiving a stop condition request, the IIC issues the stop condition. For details, see section 29.11.3, Issuing a Stop Condition.
6. On detecting the stop condition, the IIC automatically sets the MST and TRS bits in ICCR2 to 00b and enters slave receive mode. Additionally, the IIC automatically sets the TDRE and TEND flags to 0, and sets the STOP flag in ICSR2 to 1.
7. Check that the ICSR2.STOP flag is 1, then set the ICSR2.NACKF and STOP flags to 0 for the next transfer operation.

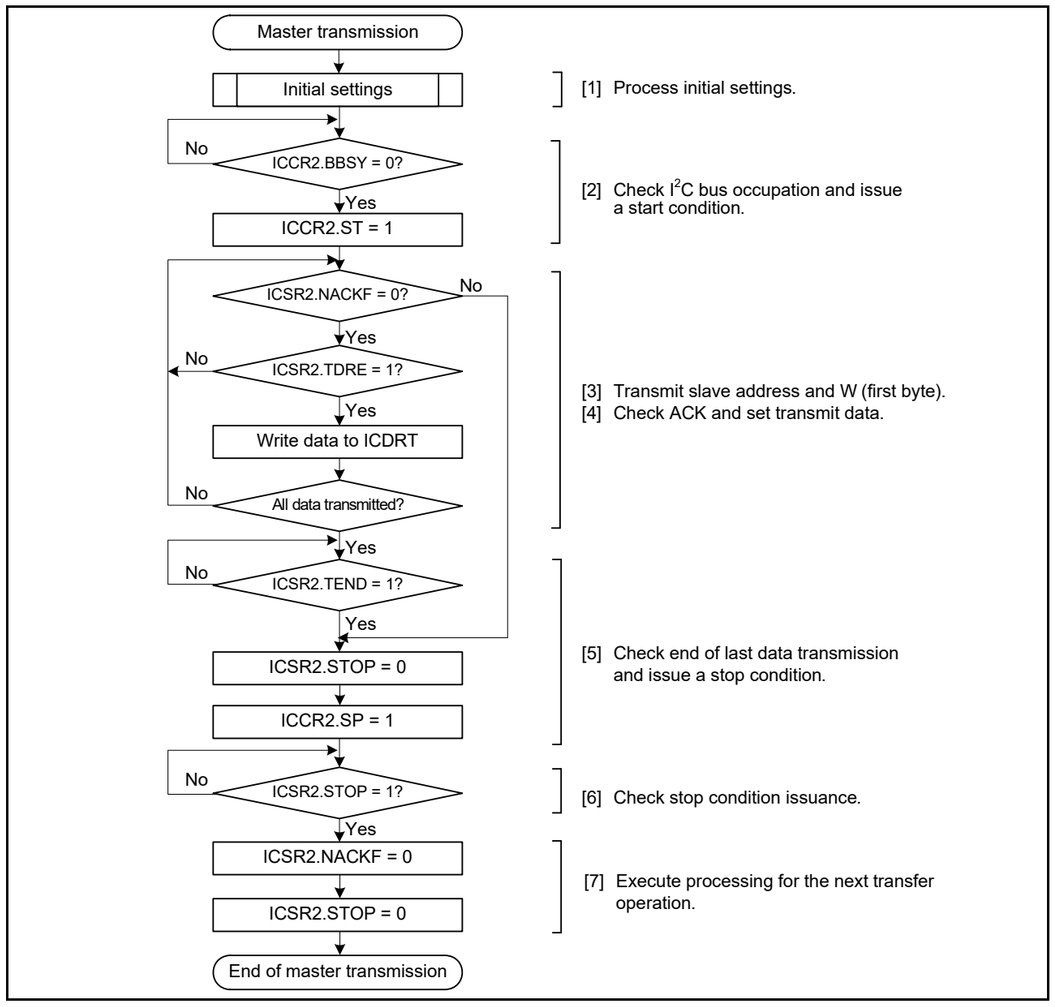

Figure 29.6 Example master transmission flow

通信中出现错误，向ICCR2.SP位写入1以发出停止条件。要使用10位格式的地址传输数据，首先将11110 b、从机地址的高两位和W写入ICDRT作为第一个地址传输。对于第二次地址传输，将从地址的低8位写入ICDRT。

4. 检查ICSR2中的TDRE标志是否为1，然后将发送数据写入ICDRT寄存器。IIC自动将SCLn线保持为低电平，直到发送数据准备好或发出停止条件。
5. 将发送数据的所有字节写入ICDRT寄存器后，等待ICSR2中TEND标志的值返回1，然后将ICCR2中的SP位设置为1（请求停止条件）。在收到停止条件请求时，IIC发出停止条件。有关详细信息，请参阅第29.11.3节，发出停止条件。
6. 在检测到停止条件时，IIC自动将ICCR2中的MST和TRS位设置为00b并进入从机接收模式。此外，IIC自动将TDRE和TEND标志设置为0，并将ICSR2中的STOP标志设置为1。
7. 检查ICSR2.STOP标志是否为1，然后将ICSR2.NACKF和STOP标志设置为0以进行下一次传输操作。

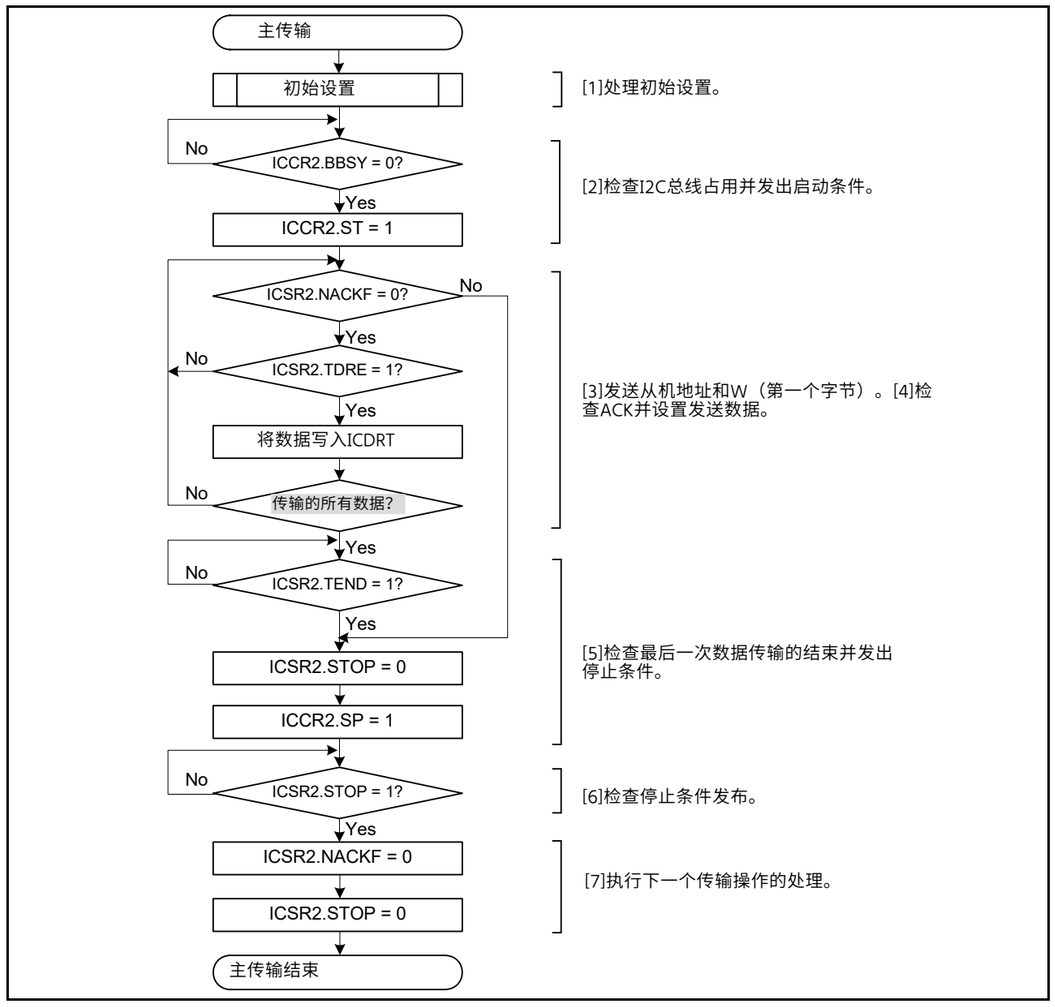

Figure 29.6 示例主传输流程

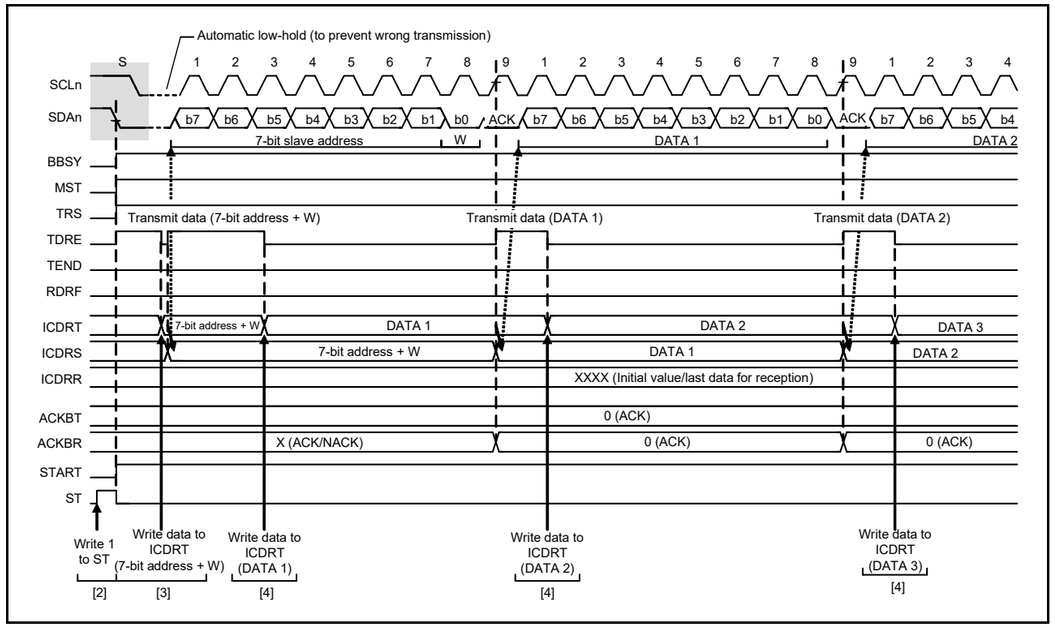

Figure 29.7 Master transmit operation timing (1) with 7-bit address format

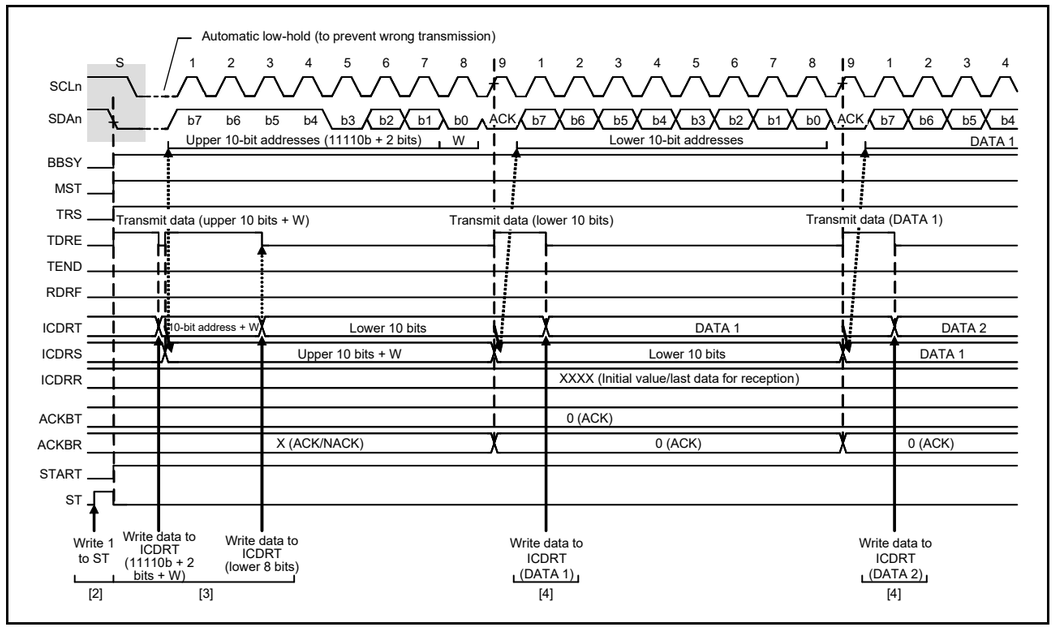

Figure 29.8 Master transmit operation timing (2) with 10-bit address format

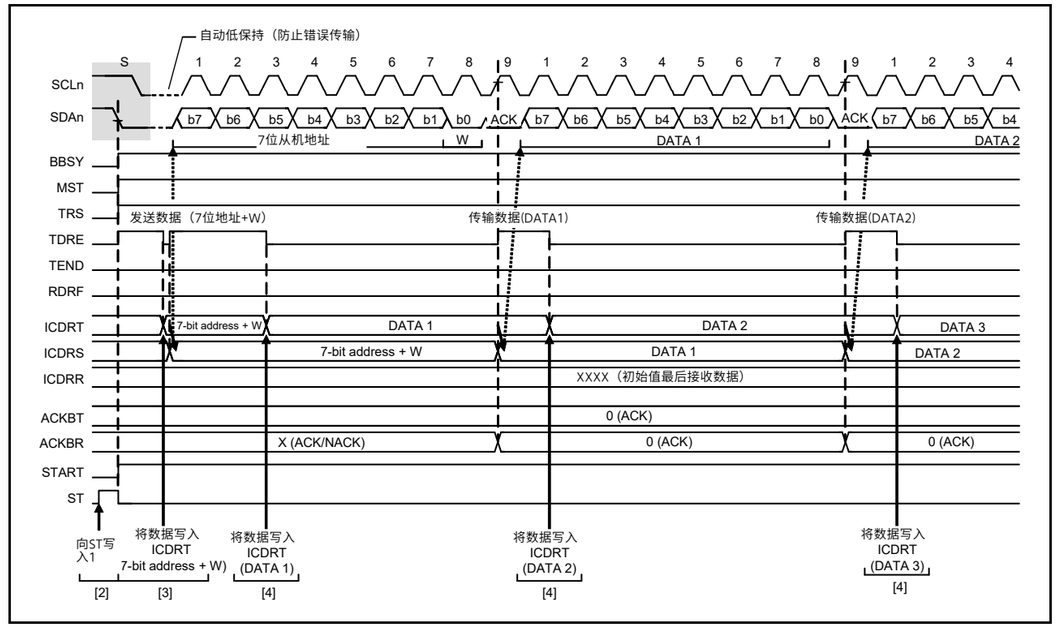

Figure 29.7 7位地址格式的主机发送操作时序(1)

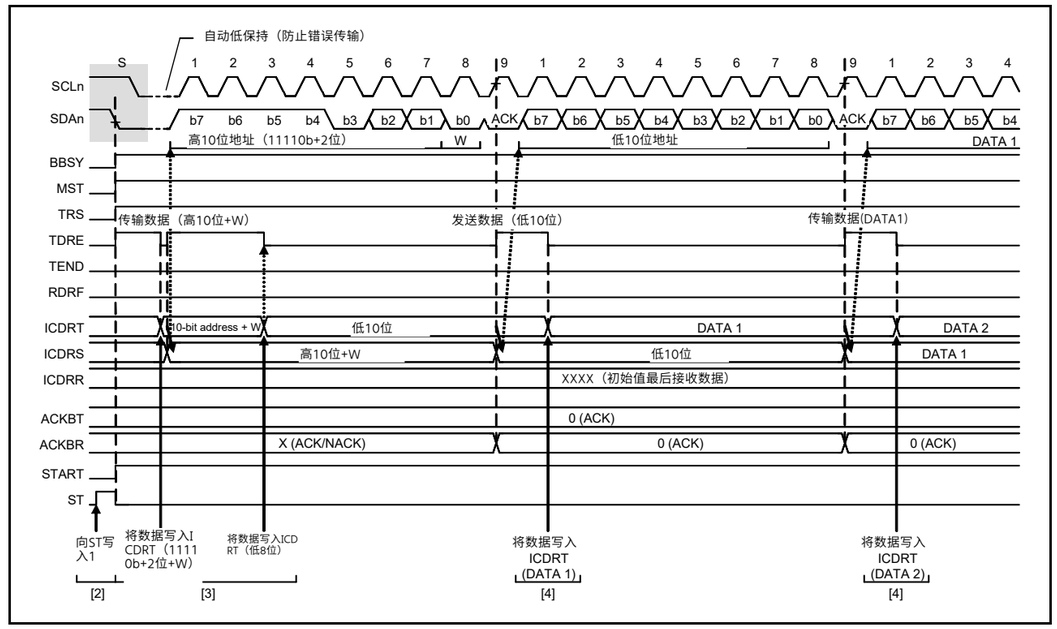

Figure 29.8 10位地址格式的主机发送操作时序(2)

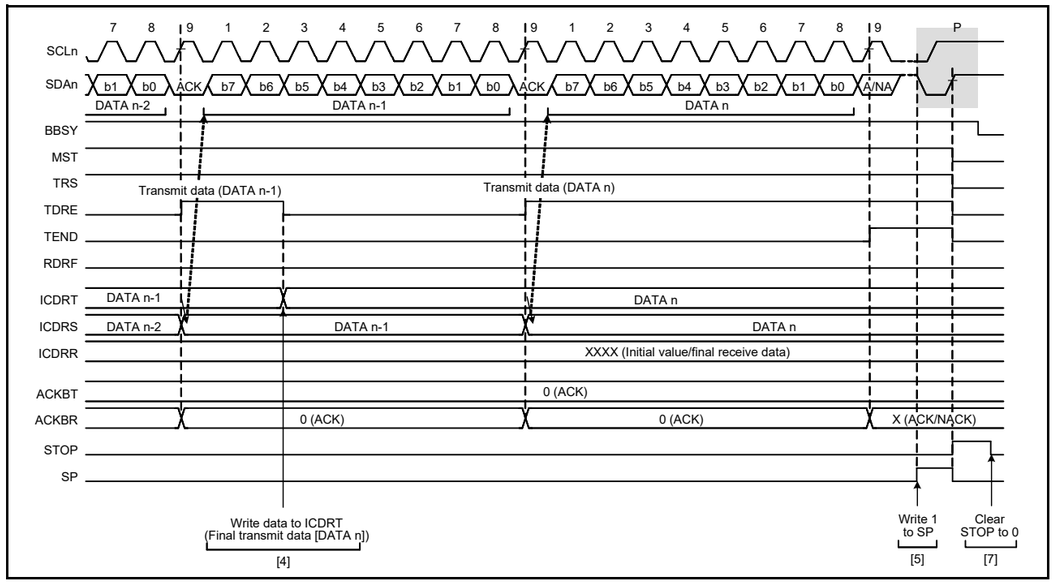

Figure 29.9 Master transmit operation timing (3)

29.3.4 Master Receive Operation

In master receive operation, the IIC as a master device outputs the SCL clock, receives data from the slave device, and returns acknowledgments. Because the IIC must start by sending a slave address to the associated slave device, the slave address part of the procedure is performed in master transmit mode, but the subsequent steps are in master receive mode.

Figure 29.10 and Figure 29.11 show examples of master reception (7-bit address format), and Figure 29.12 to Figure 29.14 show the operation timing in master reception.

To set up and perform master reception:

1. Initialize the IIC using the procedure in section 29.3.2, Initial Settings.
2. Read the BBSY flag in ICCR2 to check that the bus is open, then set the ST bit in ICCR2 to 1 to request the issue of a start condition. On receiving the request, the IIC issues a start condition. When the IIC detects the start condition, the BBSY and START flags in ICSR2 automatically set to 1, and the ST bit automatically sets to 0. If the start condition is detected and the levels for the SDA output and the levels on the SDAn line match while the ST bit is 1, the IIC recognizes that the start condition requested by the ST bit has successfully completed, and the MST and TRS bits in ICCR2 automatically set to 1, placing the IIC in master transmit mode. The TDRE flag in ICSR2 is also automatically set to 1 in response to TRS = 1.
3. Check that the TDRE flag in ICSR2 is 1, then write the value for transmission (the first byte indicates the slave address and value of the R/W# bit) to ICDRT. When the transmit data is written to ICDRT, the TDRE flag is automatically set to 0, the data is transferred from ICDRT to ICDRS, and the TDRE flag is again set to 1. When the byte containing the slave address and R/W# bit is transmitted, the value of the ICCR2.TRS bit automatically updates to select transmit or receive mode based on the value of the transmitted R/W# bit. If the value of the R/W# bit is 1, the TRS bit is set to 0 on the rising edge of the 9th cycle of the SCL clock, placing the IIC in master receive mode. At this time, the TDRE flag is set to 0 and the ICSR2.RDRF flag is automatically set to 1.
   If the ICSR2.NACKF flag is 1, indicating that no slave device recognized the address or there was an error in communications, write 1 to the ICCR2.SP bit to issue a stop condition.
   For master reception from a device with a 10-bit address, start by using master transmission to issue the 10-bit address, and then issue a restart condition. After that, transmit 1111 0b, the two upper bits of the slave address, and the R bit to place the IIC in master receive mode.
4. Dummy read the ICDRR after confirming that the RDRF flag in ICSR2 is 1. Doing so causes the IIC to start output of the SCL clock and start data reception.

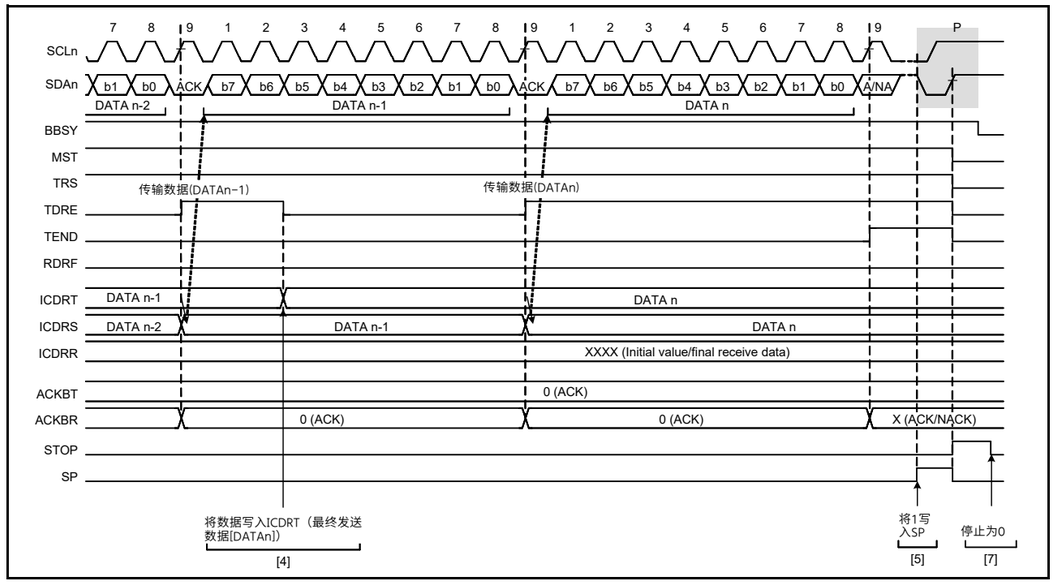

Figure 29.9 主机发送操作时序（3）

29.3.4 主接收操作

在主设备接收操作中，作为主设备的IIC输出SCL时钟，从从设备接收数据，并返回确认。因为IIC必须首先向相关的从设备发送一个从地址，所以该过程的从地址部分在主发送模式下执行，但后续步骤在主接收模式下执行。

图29.10和图29.11显示了主机接收示例（7位地址格式），图29.12至图29.14显示了主机接收中的操作时序。

设置和执行主接收：

1. 使用第29.3.2节，初始设置中的过程初始化IIC。
2. 读取ICCR2中的BBSY标志以检查总线是否打开，然后将ICCR2中的ST位设置为1以请求发出启动条件。收到请求后，IIC发出一个开始条件。当IIC检测到启动条件时，ICSR2中的BBSY和START标志自动设置为1，ST位自动设置为0。如果检测到启动条件并且SDA输出的电平与SDAn线上的电平匹配当ST位为1时，IIC识别到ST位请求的启动条件已成功完成，并且ICCR2中的MST和TRS位自动设置为1，将IIC置于主机发送模式。ICSR2中的TDRE标志也自动设置为1，以响应TRS=1。
3. 检查ICSR2中的TDRE标志是否为1，然后将要发送的值（第一个字节表示从机地址和RW#位的值）写入ICDRT。当发送数据写入ICDRT时，TDRE标志自动设置为0，数据从ICDRT传输到ICDRS，TDRE标志再次设置为1。当发送包含从机地址和RW#位的字节时，ICCR2.TRS位的值自动更新以根据发送的RW#位的值选择发送或接收模式。如果RW#位的值为1，则在SCL时钟的第9个周期的上升沿将TRS位设置为0，将IIC置于主机接收模式。此时TDRE标志置0，ICSR2.RDRF标志自动置1。如果ICSR2.NACKF标志为1，说明没有从设备识别地址或通讯出错，写1ICCR2.SP位发出停止条件。对于来自具有10位地址的设备的主机接收，首先使用主机发送来发出10位地址，然后发出重启条件。之后，发送11110b、从机地址的高两位和R位，将IIC置于主机接收模式。
4. 确认ICSR2中的RDRF标志为1后，虚拟读取ICDRR。这样做会导致IIC开始输出SCL时钟并开始数据接收。

5. After 1 byte of data is received, the RDRF flag in ICSR2 is set to 1 on the rising edge of the 8th or 9th cycle of the SCL clock, as selected in the RDRFS bit in ICMR3. Reading ICDRR produces the received data, and automatically sets the RDRF flag to 0. The value of the acknowledgment field received during the 9th cycle of the SCL clock is returned as the value set in the ICMR3.ACKBT bit. If the next byte to be received is the next to last byte, set the ICMR3.WAIT bit to 1 for wait insertion before reading ICDRR, containing the second byte from the last. In addition to enabling NACK output, even when interrupts or other operations result in delays in setting the ICMR3.ACKBT bit to 1 (NACK) in step (6), this fixes the SCLn line to low on the rising edge of the 9th clock cycle in reception of the last byte, which enables the issue of a stop condition.
6. When the ICMR3.RDRFS bit is 0, and the slave device must be notified that it is to end transfer for data reception after transfer of the next and final byte, set the ICMR3.ACKBT bit to 1 (NACK).
7. After reading the second-to-last byte from the ICDRR register, if the value of the ICSR2.RDRF flag is 1, write 1 to the SP bit in ICCR2 (to request stop condition), then read the last byte from ICDRR. When ICDRR is read, the IIC is released from the wait state and issues the stop condition after low-level output in the 9th clock cycle is complete or the SCLn line is released from the low-hold state.
8. On detecting the stop condition, the IIC automatically sets the MST and TRS bits in ICCR2 to 00b and enters slave receive mode. Additionally, detection of the stop condition sets the ICSR2.STOP flag to 1.
9. Check that the ICSR2.STOP flag is 1, then set the NACKF and STOP flags in ICSR2 to 0 for the next transfer operation.

5. 在接收到1个字节的数据后，ICSR2中的RDRF标志在SCL时钟的第8个或第9个周期的上升沿被设置为1，这在ICMR3中的RDRFS位中选择。读取ICDRR会产生接收到的数据，并自动将RDRF标志设置为0。在SCL时钟的第9个周期内接收到的确认字段的值作为ICMR3.ACKBT位中设置的值返回。如果要接收的下一个字节是倒数第二个字节，则将ICMR3.WAIT位设置为1，以便在读取ICDRR（包含倒数第二个字节）之前等待插入。除了启用NACK输出之外，即使在中断或其他操作导致在步骤(6)中将ICMR3.ACKBT位设置为1(NACK)时出现延迟，这也会在第9个时钟的上升沿将SCLn线固定为低循环接收最后一个字节，这使得发出停止条件。
6. 当ICMR3.RDRFS位为0，并且必须通知从设备在传输下一个和最后一个字节后结束传输以进行数据接收时，将ICMR3.ACKBT位设置为1(NACK)。
7. 从ICDRR寄存器读取倒数第二个字节后，如果ICSR2.RDRF标志的值为1，则将1写入ICCR2中的SP位（请求停止条件），然后从ICDRR读取最后一个字节。当读取ICDRR时，IIC从等待状态中释放，并在第9个时钟周期的低电平输出完成或SCLn线从低保持状态释放后发出停止条件。
8. 在检测到停止条件时，IIC自动将ICCR2中的MST和TRS位设置为00b并进入从机接收模式。此外，检测到停止条件会将ICSR2.STOP标志设置为1。
9. 检查ICSR2.STOP标志是否为1，然后将ICSR2中的NACKF和STOP标志设置为0，以进行下一次传输操作。

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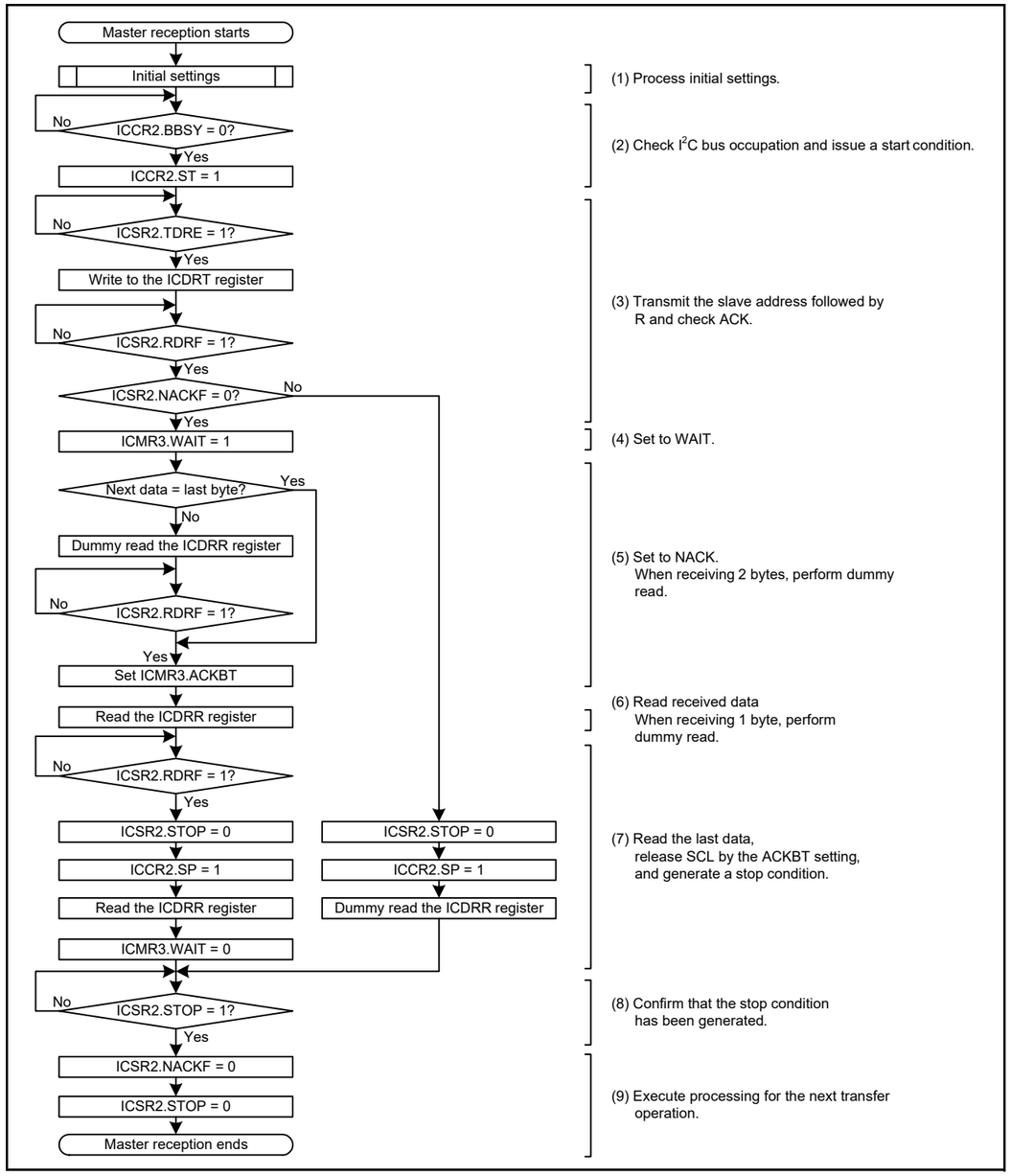


Figure 29.10 Example master reception flow with 7-bit address format, and 1 or 2 bytes

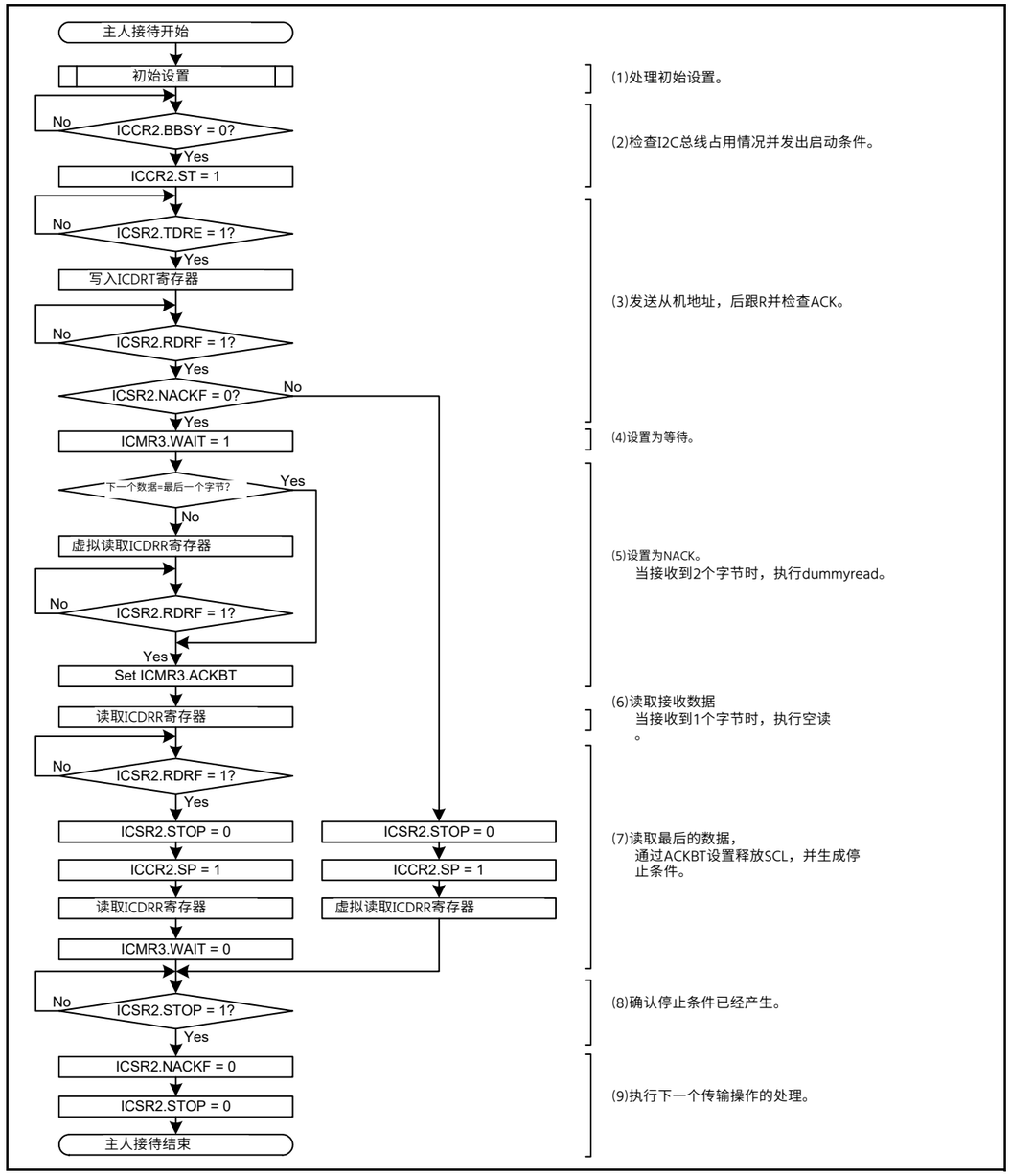


Figure 29.10 具有7位地址格式和1或2个字节的主机接收流程示例

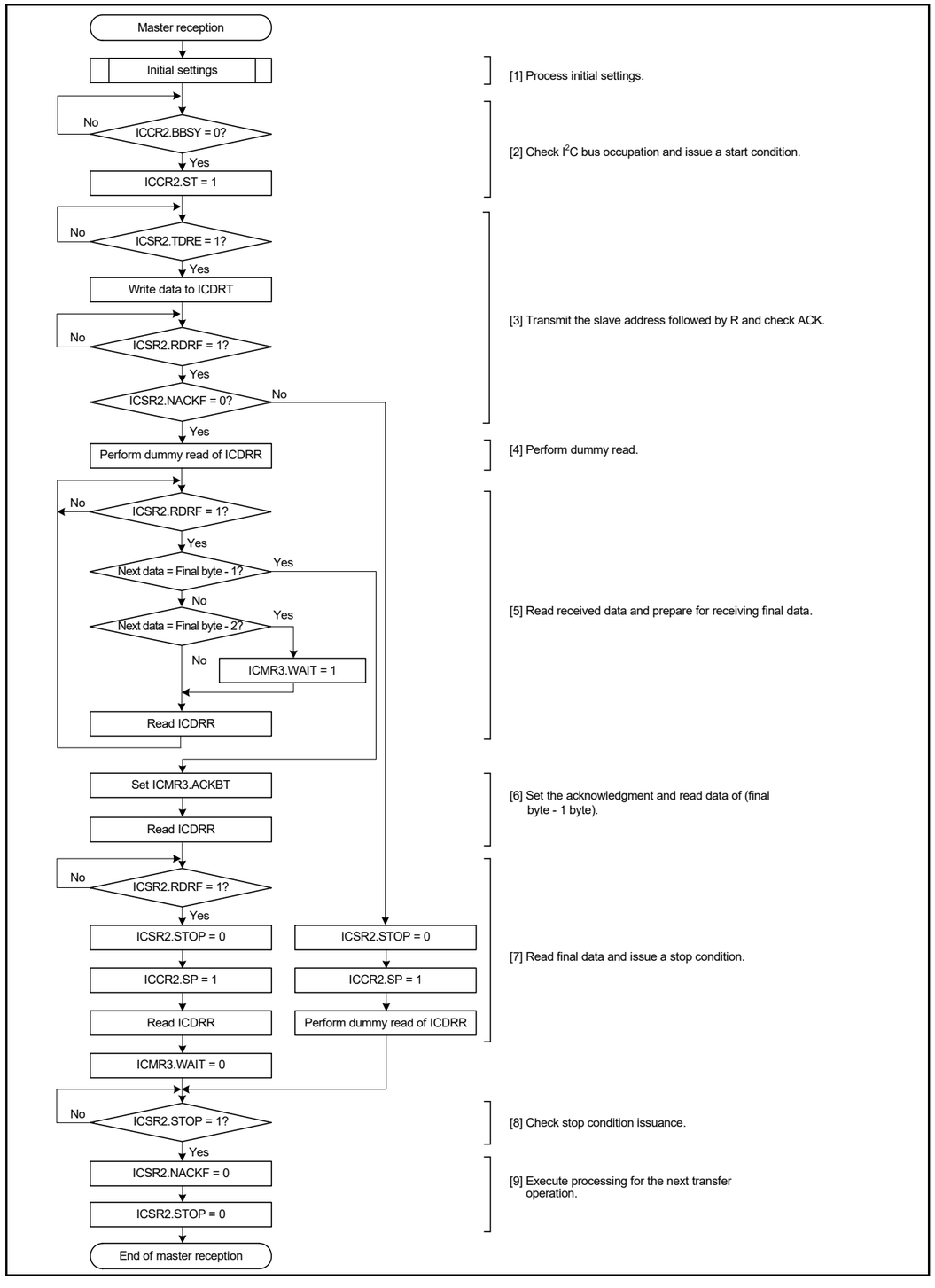


Figure 29.11 Example master reception flow with 7-bit address format and 3 or more bytes

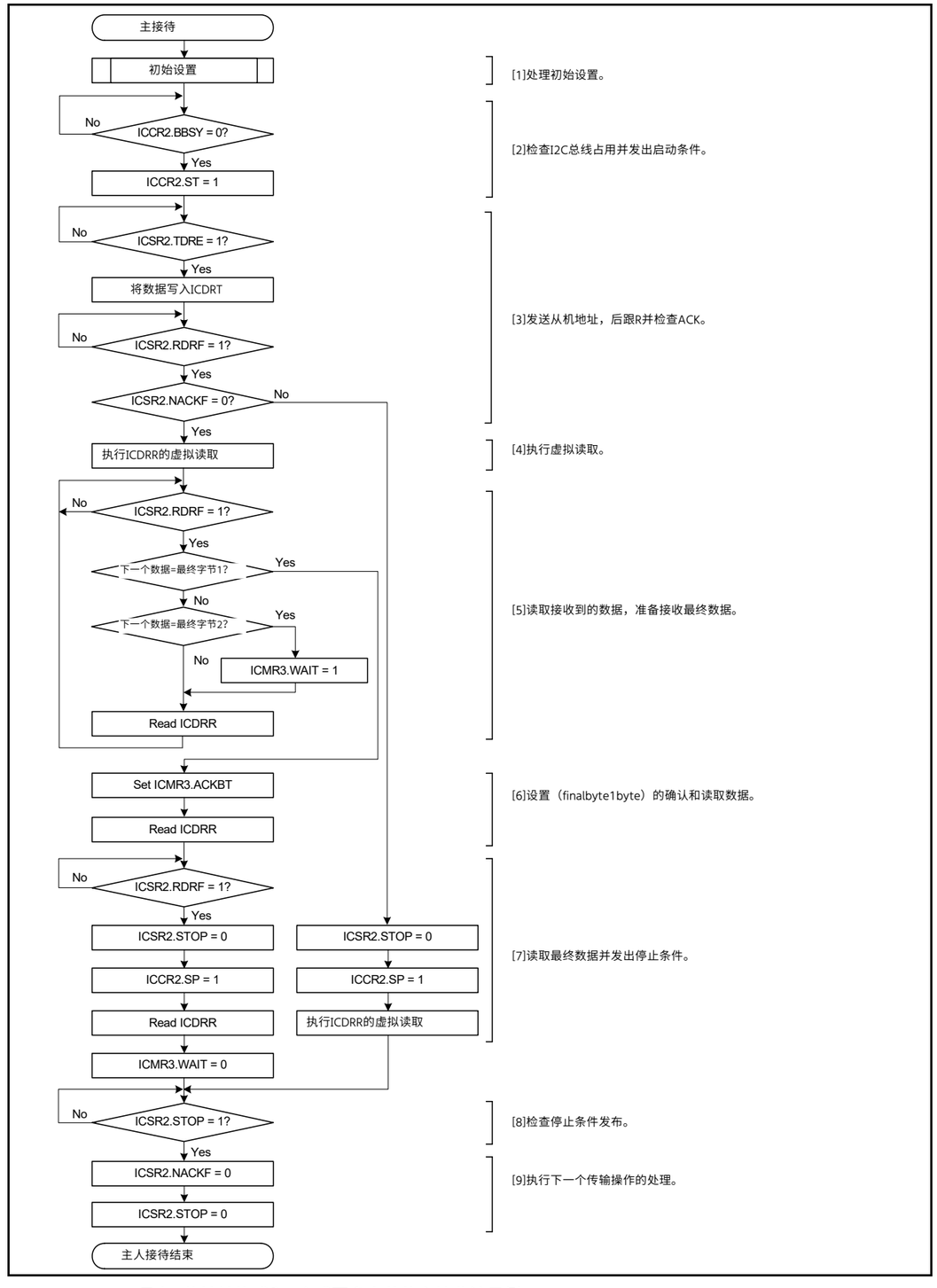


Figure 29.11 具有7位地址格式和3个或更多字节的主接收流示例

RA生态工作室

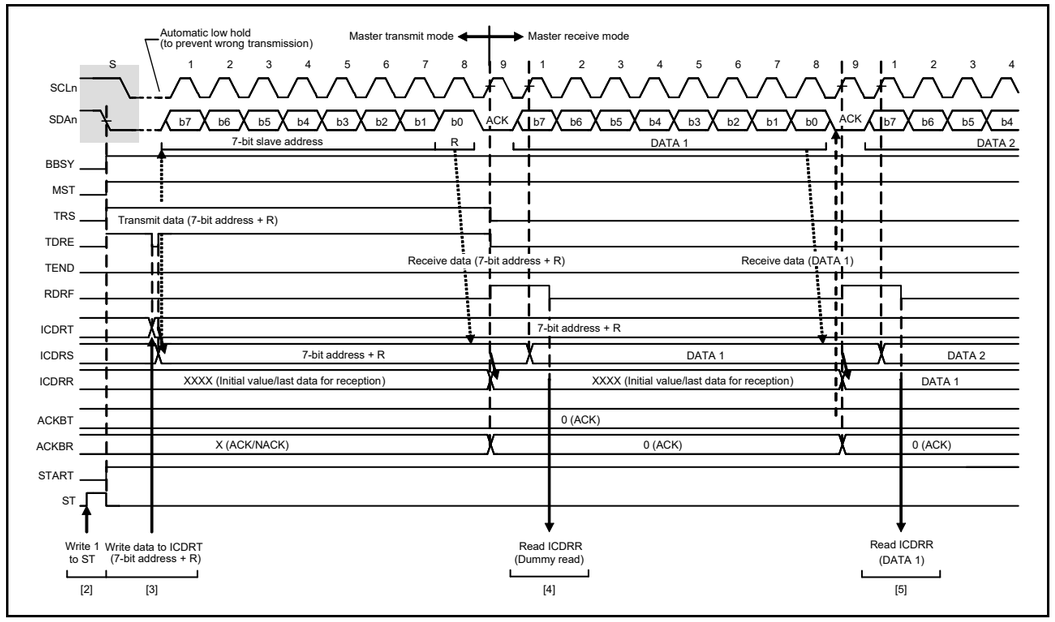


Figure 29.12 Master receive operation timing (1) with 7-bit address format, when RDRFS = 0

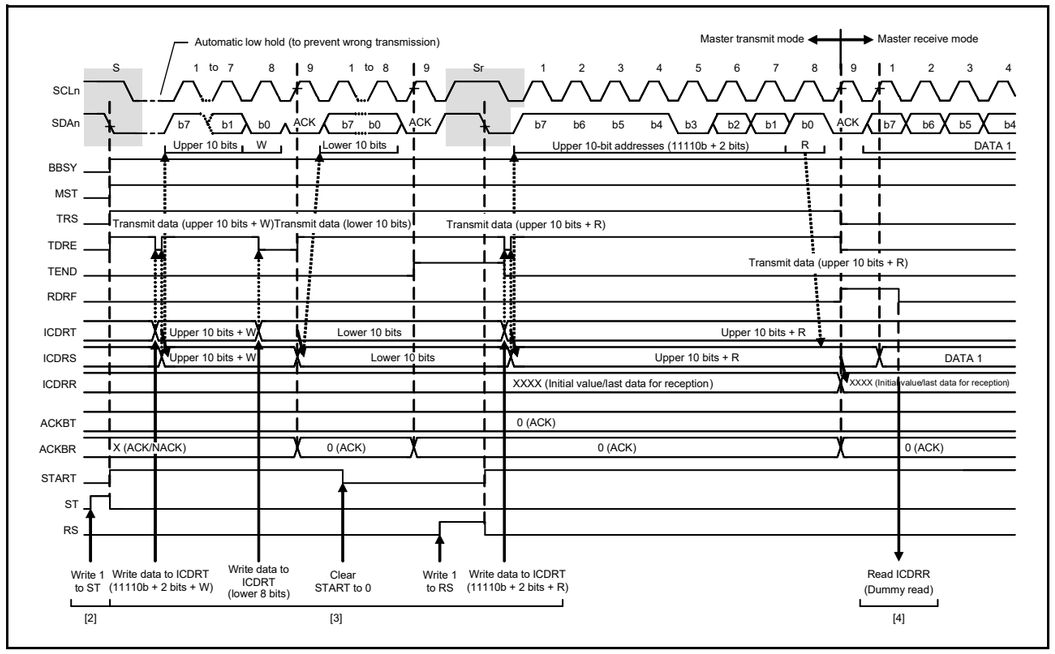


Figure 29.13 Master receive operation timing (2) with 10-bit address format, when RDRFS = 0

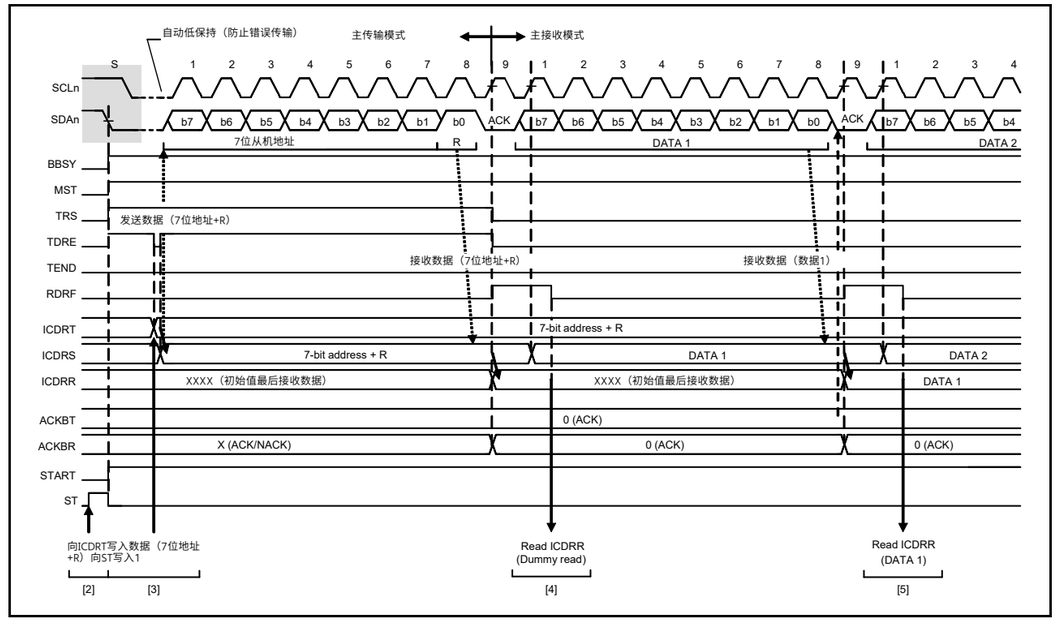


Figure 29.12 当RDRFS=0时，采用7位地址格式的主机接收操作时序(1)

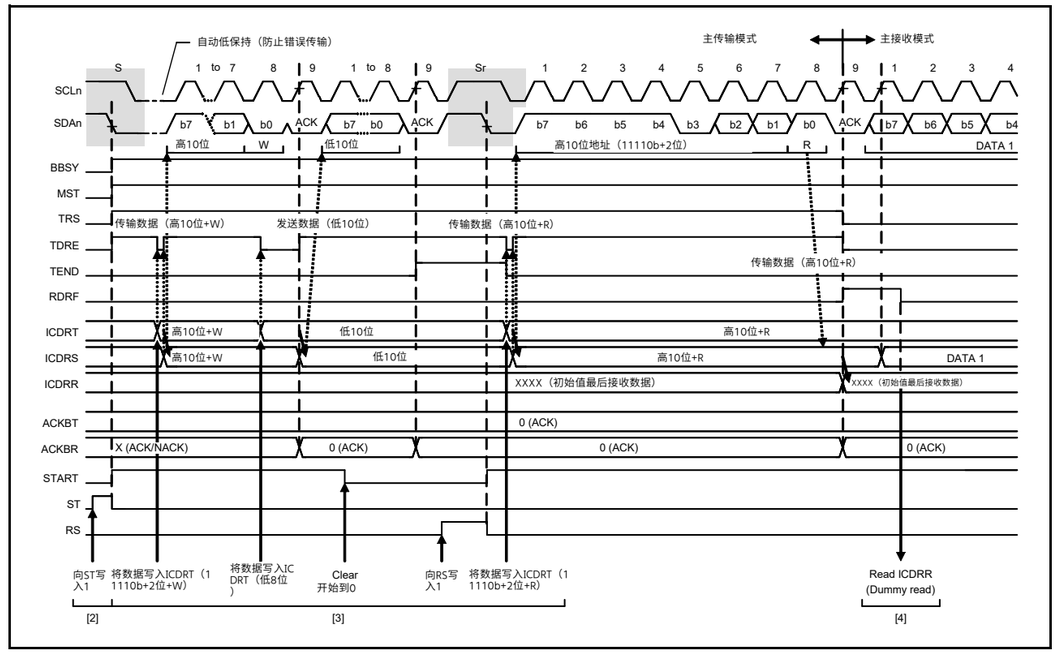


Figure 29.13 10位地址格式的主机接收操作时序（2），当RDRFS=0时

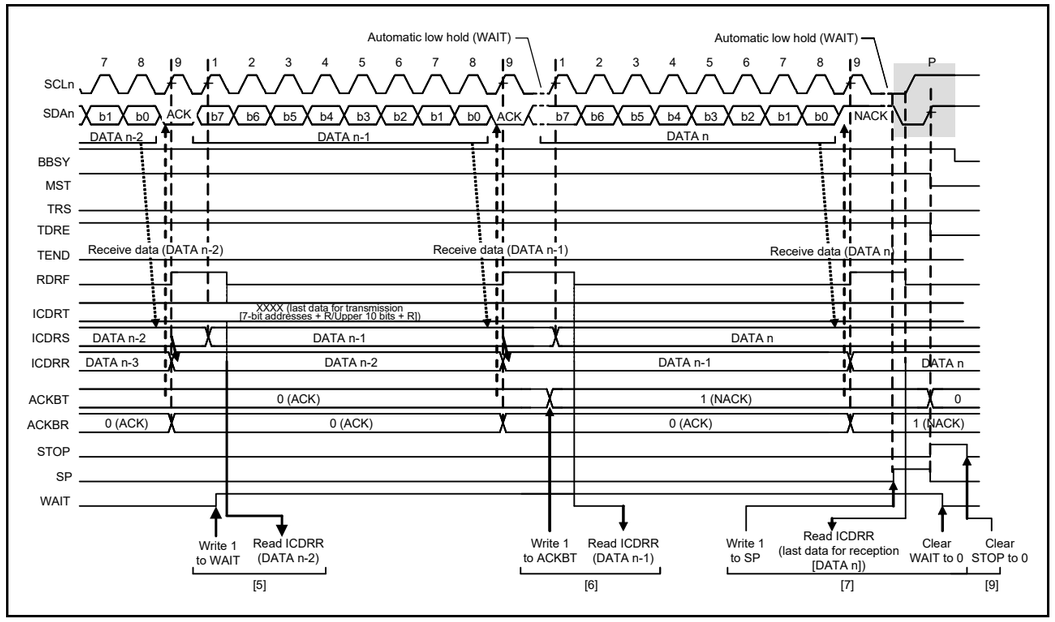


Figure 29.14 Master receive operation timing (3) when RDRFS = 0

29.3.5 Slave Transmit Operation

In slave transmit operation, the master device outputs the SCL clock, the IIC transmits data as a slave device, and the master device returns the acknowledgments.

Figure 29.15 shows an example of slave transmission, and Figure 29.16 and Figure 29.17 show the operation timing in slave transmission.

To set up and perform slave transmission:

1. Initialize the IIC using the procedure in section 29.3.2, Initial Settings.
   After the initialization, the IIC stays in the standby state until it receives a slave address that matches.
2. After receiving a matching slave address, the IIC sets one of the associated ICSR1.HOA, GCA, and AASy (y = 0 to 2) flags to 1 on the rising edge of the 9th cycle of the SCL clock and outputs the value set in the ICMR3.ACKBT bit to the acknowledge bit on the 9th cycle of the SCL clock. If the value of the received R/W# bit is 1, the IIC automatically places itself in slave transmit mode by setting both the ICCR2.TRS bit and the ICSR2.TDRE flag to 1.
3. Check that the ICSR2.TEND flag is 1, then write the transmit data to the ICDRT register. If the IIC receives no acknowledge from the master device (receives an NACK signal) while the ICFER.NACKE bit is 1, the IIC suspends transfer of the next data.
4. Wait until the ICSR2.TEND flag is set to 1 while the ICSR2.TDRE flag is 1, after the ICSR2.NACKF flag is set to 1 or the last byte for transmission is written to the ICDRT register. When the ICSR2.NACKF flag or the TEND flag is 1, the IIC drives the SCLn line low on the 9th falling edge of the SCL clock.
5. When the NACKF or TEND flag in ICSR2 is 1, dummy read ICDRR to complete the processing. This releases the SCLn line.
6. On detecting the stop condition, the IIC automatically sets the ICSR1.HOA, GCA, and AASy (y = 0 to 2) flags, the TDRE and TEND flags in ICSR2, and the ICCR2.TRS bit to 0, and enters slave receive mode.
7. Check that the ICSR2.STOP flag is 1, then set the NACKF and STOP flags in ICSR2 to 0 for the next transfer operation.

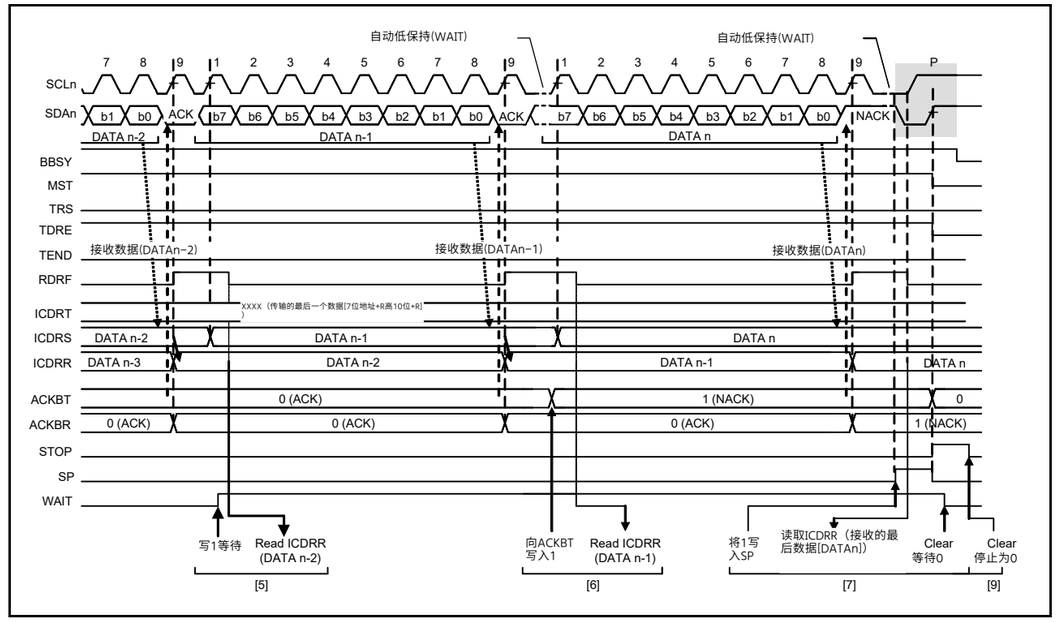


Figure 29.14 RDRFS=0时的主机接收操作时序(3)

29.3.5 从机发送操作

在从发送操作中，主设备输出SCL时钟，IIC作为从设备发送数据，主设备返回确认。

图29.15显示了从机传输的示例，图29.16和图29.17显示了从机传输的操作时序。

设置和执行从属传输：

1. 使用第29.3.2节，初始设置中的过程初始化IIC。
   初始化后，IIC一直处于待机状态，直到收到匹配的从机地址。
2. 接收到匹配的从地址后，IIC设置关联的ICSR1.HOA、GCA和AASy(y=0to2)在SCL时钟的第9个周期的上升沿标记为1，并输出设置在ICMR3.ACKBT位到SCL时钟的第9个周期的确认位。如果接收到的RW#位的值为1，则IIC通过将ICCR2.TRS位和ICSR2.TDRE标志都设置为1自动将自己置于从发送模式。
3. 检查ICSR2.TEND标志是否为1，然后将发送数据写入ICDRT寄存器。如果IIC在ICFER.NACKE位为1时没有收到来自主设备的确认（接收到NACK信号），则IIC暂停下一个数据的传输。
4. 等到ICSR2.TEND标志设置为1，而ICSR2.TDRE标志为1，在ICSR2.NACKF标志设置为1或将要发送的最后一个字节写入ICDRT寄存器之后。当ICSR2.NACKF标志或TEND标志为1时，IIC在SCL时钟的第9个下降沿将SCLn线驱动为低电平。
5. 当ICSR2中的NACKF或TEND标志为1时，假读ICDRR以完成处理。这释放了SCLn line.
6. 在检测到停止条件时，IIC自动设置ICSR1.HOA、GCA和AASy（y=0到2）标志，即ICSR2中的TDRE和TEND标志位，且ICCR2.TRS位为0，进入从机接收模式。
7. 检查ICSR2.STOP标志是否为1，然后将ICSR2中的NACKF和STOP标志设置为0，以进行下一次传输操作。

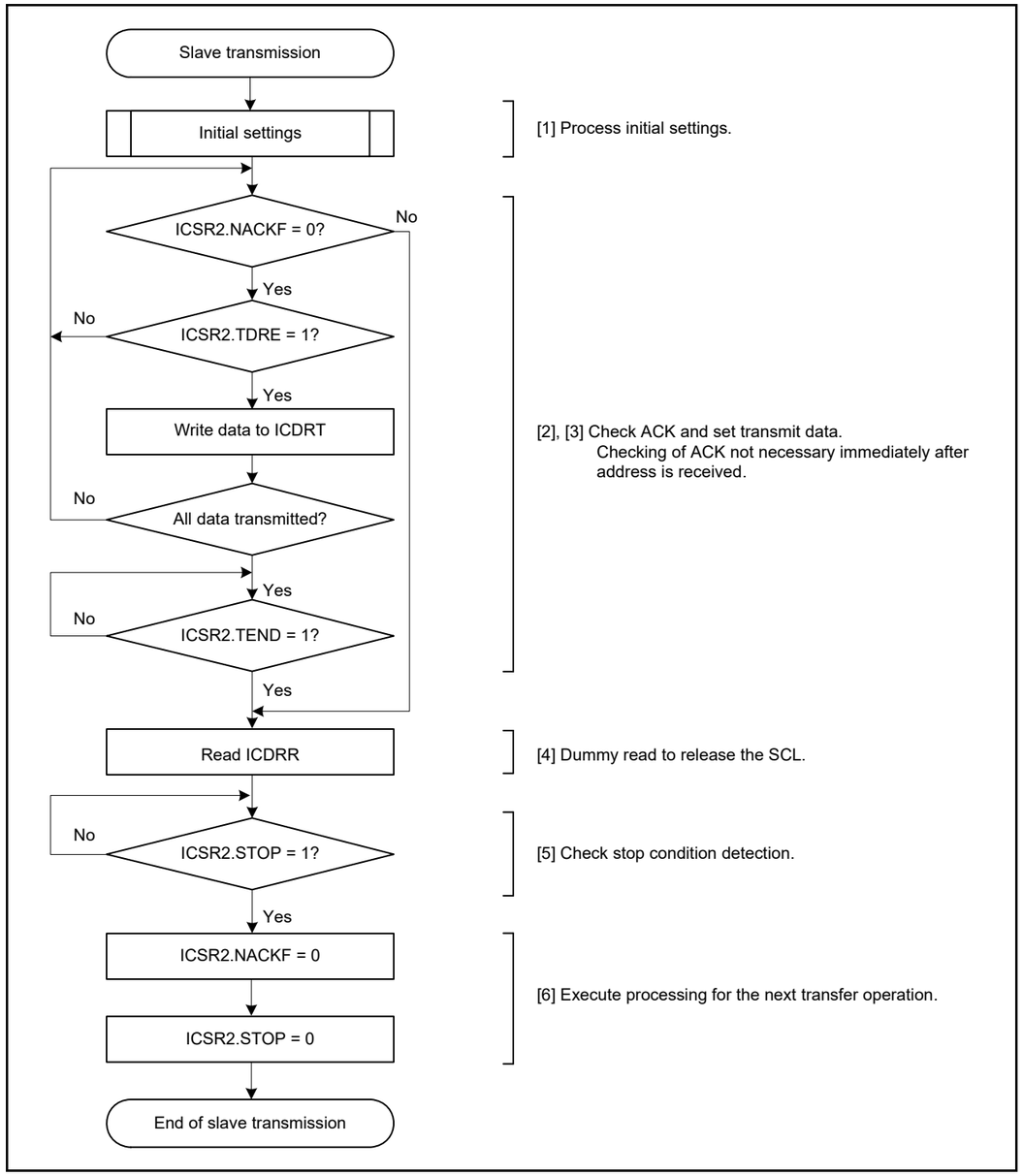


Figure 29.15 Example slave transmission flow

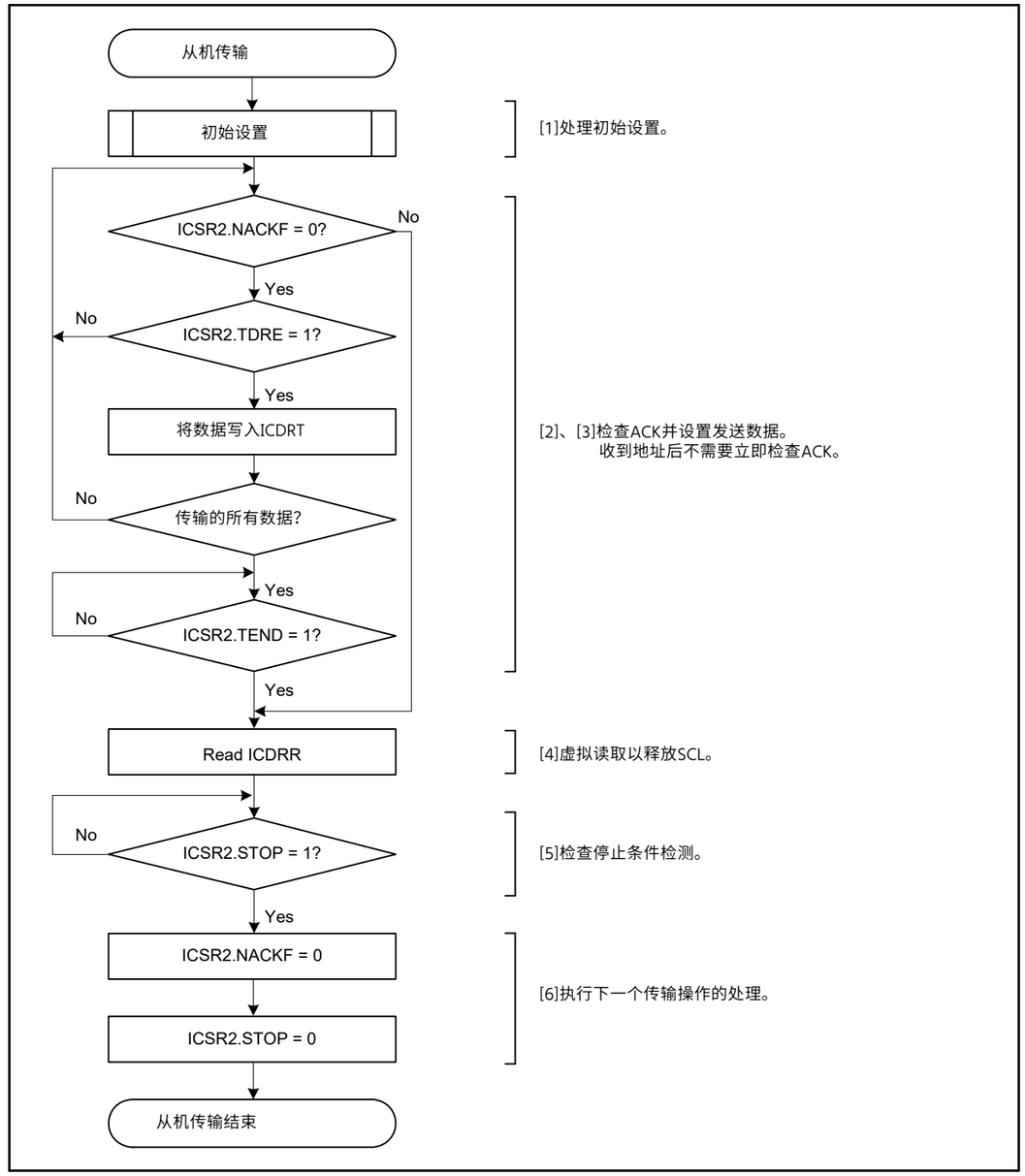


Figure 29.15 从机传输流程示例

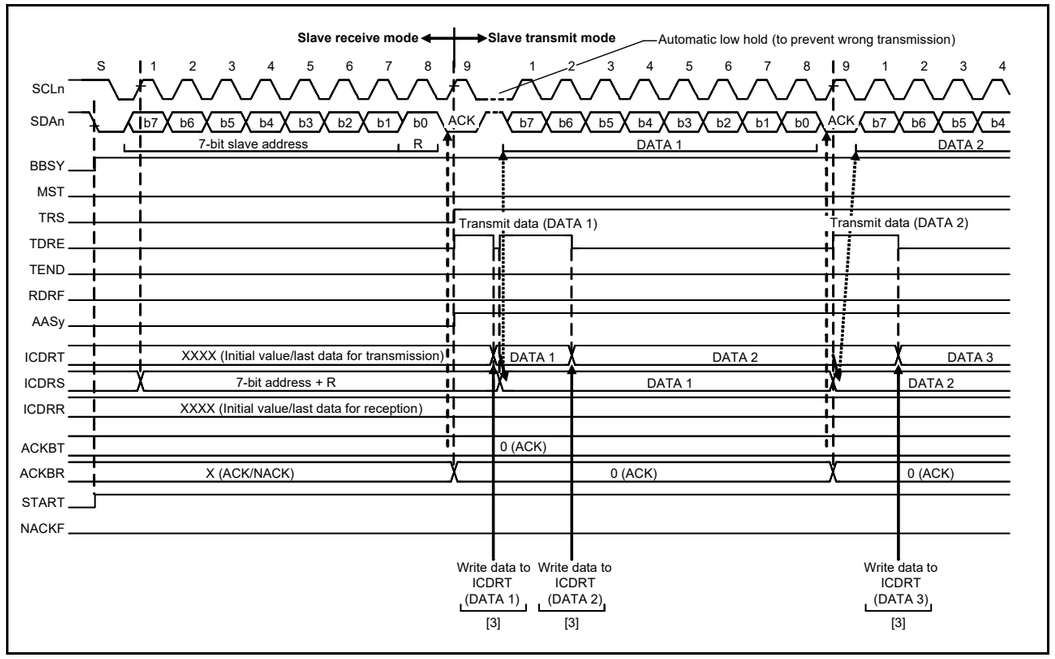


Figure 29.16 Slave transmit operation timing (1) with 7-bit address format

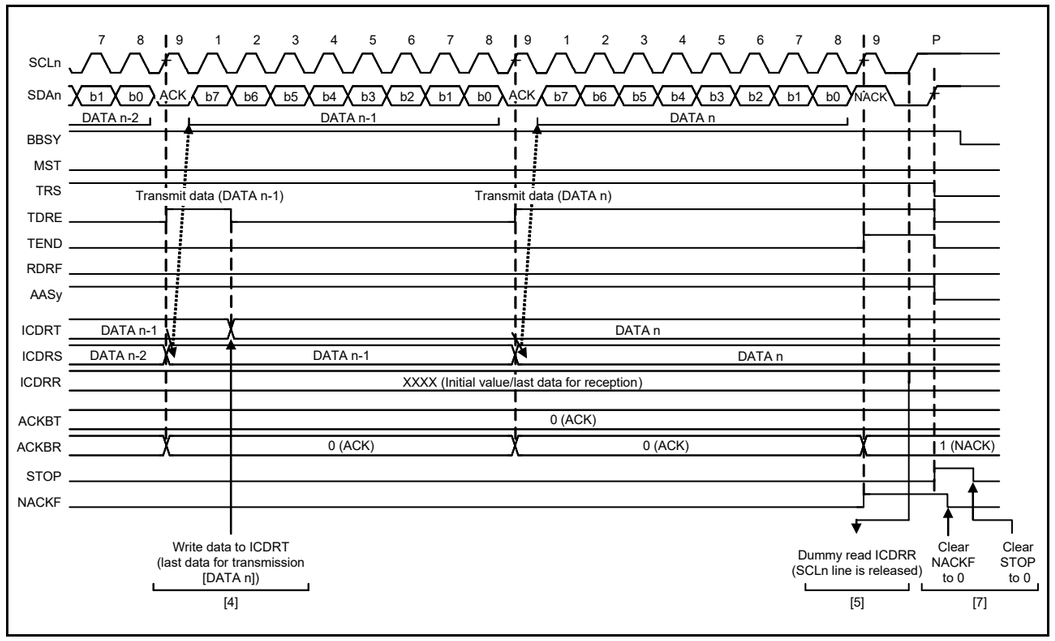


Figure 29.17 Slave transmit operation timing (2)

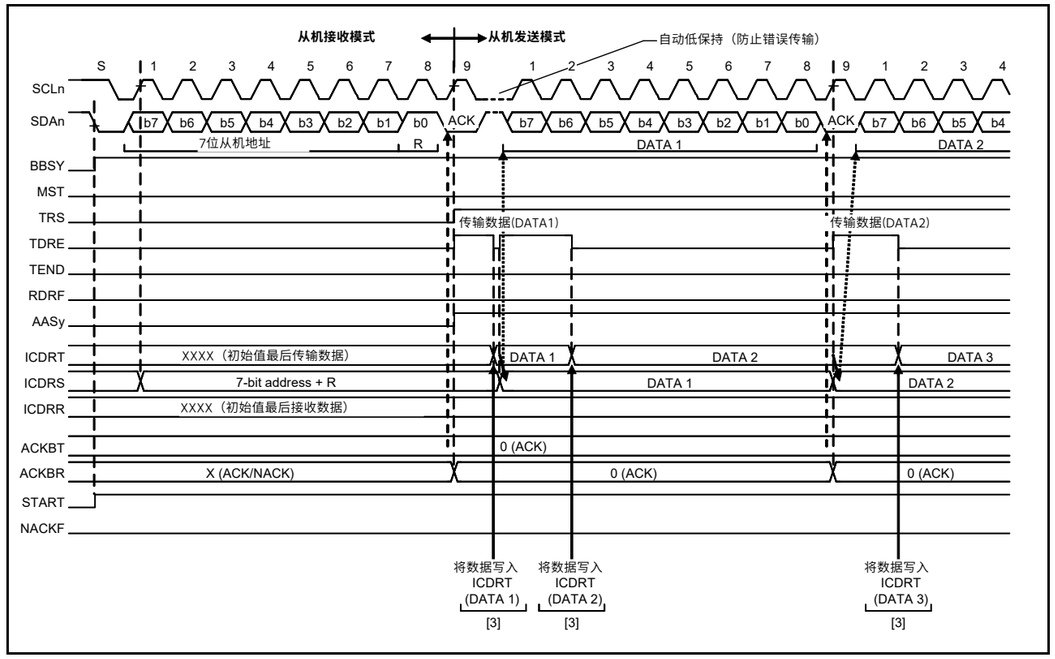


Figure 29.16 7位地址格式的从机发送操作时序(1)

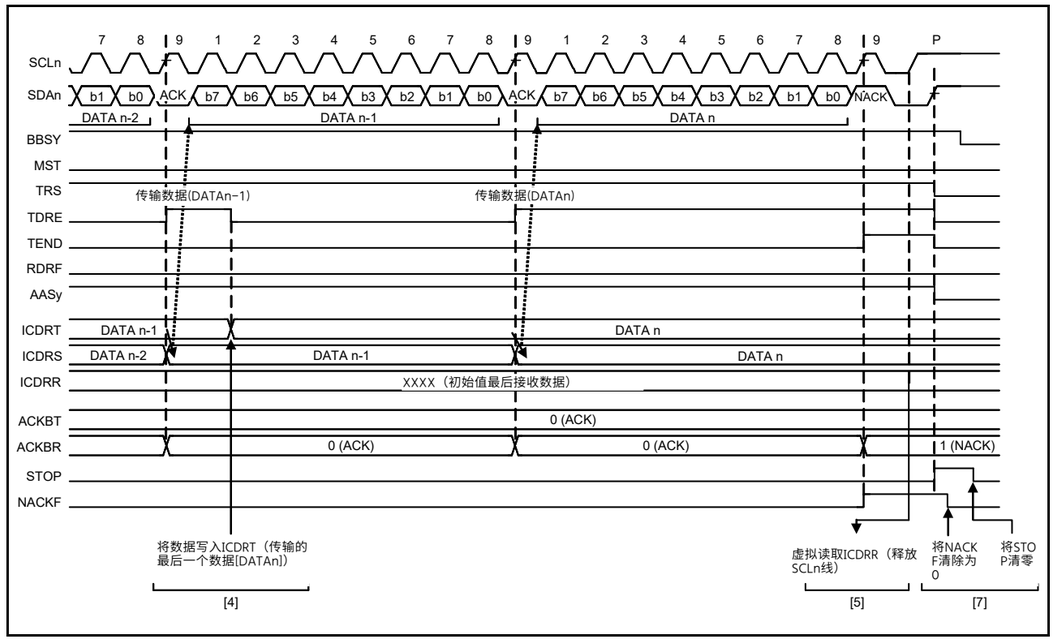


Figure 29.17 从机发送操作时序（2）

29.3.6 Slave Receive Operation

In a slave receive operation, the master device outputs the SCL clock and transmit data, and the IIC returns acknowledgments as a slave device.

Figure 29.18 shows an example of slave reception, and Figure 29.19 and Figure 29.20 show the operation timing in slave reception.

To set up and perform slave reception:

1. Initialize the IIC using the procedure in section 29.3.2, Initial Settings.
   After initialization, the IIC stays in the standby state until it receives a slave address that matches.
2. After receiving a matching slave address, the IIC sets one of the associated ICSR1.HOA, GCA, and AASy (y = 0 to 2) flags to 1 on the rising edge of the 9th cycle of the SCL clock and outputs the value set in the ICMR3.ACKBT bit to the acknowledge bit on the 9th cycle of the SCL clock. If the value of the received R/W# bit is 0, the IIC continues to place itself in slave receive mode and sets the RDRF flag in ICSR2 to 1.
3. Check that the ICSR2.STOP flag is 0 and the ICSR2.RDRF flag is 1, and then dummy read the ICDRR register. The dummy value consists of the slave address and R/W# bit when the 7-bit address format is selected, or the lower 8 bits when the 10-bit address format is selected.
4. When ICDRR is read, the IIC automatically sets the ICSR2.RDRF flag to 0. If reading of ICDRR is delayed and the next byte is received while the RDRF flag is still set to 1, the IIC holds the SCLn line low until 1 SCL cycle before the point where RDRF must be set. In this case, reading ICDRR releases the SCLn line from being held at low. When the ICSR2.STOP flag is 1 and the ICSR2.RDRF flag is also 1, read ICDRR until all the data is completely received.
5. On detecting the stop condition, the IIC automatically set the ICSR1.HOA, GCA, and AASy (y = 0 to 2) flags in ICSR1 to 0.
6. Check that the ICSR2.STOP flag is 1, then set the ICSR2.STOP flag to 0 for the next transfer operation.

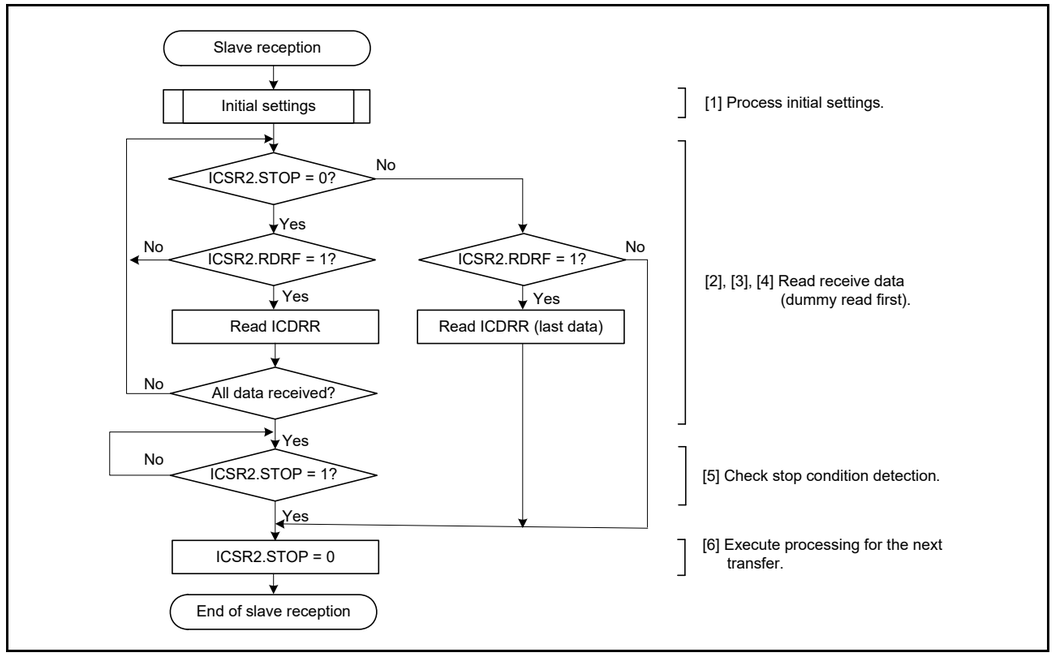


Figure 29.18 Example slave reception flow

29.3.6 从机接收操作

在从机接收操作中，主设备输出SCL时钟并发送数据，IIC作为从设备返回确认。

图29.18显示了从机接收的示例，图29.19和图29.20显示了从机接收的操作时序。

设置和执行从属接收：

1. 使用第29.3.2节，初始设置中的过程初始化IIC。
   初始化后，IIC一直处于待机状态，直到收到匹配的从机地址。
2. 接收到匹配的从地址后，IIC在SCL时钟的第9个周期的上升沿将相关的ICSR1.HOA、GCA和AASy（y=0到2）标志之一设置为1，并输出设置的值在ICMR3.ACKBT位到SCL时钟的第9个周期的确认位。如果接收到的RW#位的值为0，则IIC继续将自身置于从接收模式并将ICSR2中的RDRF标志设置为1。
3. 检查ICSR2.STOP标志为0且ICSR2.RDRF标志为1，然后伪读取ICDRR寄存器。Thedummyvalueconsistsoftheslaveaddressand R/W#bitwhenthe7-bitaddressformatisselected orthelower8bitswhenthe10-bitaddressformatisselected.
4. 读取ICDRR时，IIC自动将ICSR2.RDRF标志设置为0。如果ICDRR的读取延迟并且在RDRF标志仍设置为1时接收到下一个字节，则IIC将SCLn线保持为低电平直到1个SCL周期在必须设置RDRF之前。在这种情况下，读取ICDRR会解除SCLn线保持在低电平的状态。当ICSR2.STOP标志为1且ICSR2.RDRF标志也为1时，读取ICDRR直到完全接收到所有数据。
5. 在检测到停止条件时，IIC自动设置ICSR1.HOA、GCA和AASy（y=0到2）标志
   ICSR1 to 0.
6. 检查ICSR2.STOP标志是否为1，然后将ICSR2.STOP标志设置为0以进行下一次传输操作。

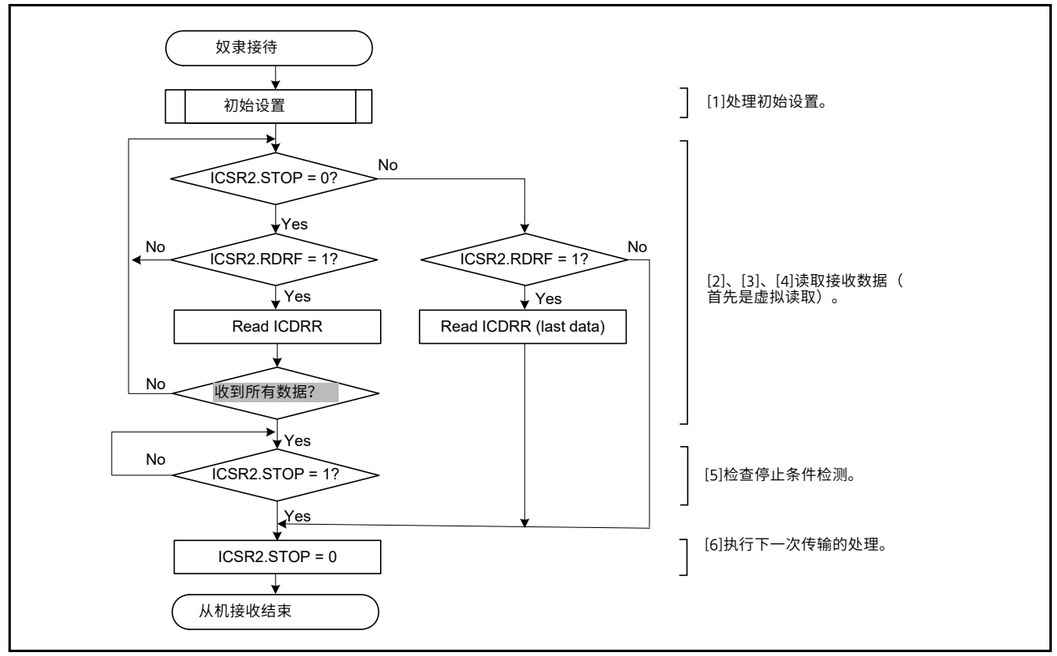


Figure 29.18 从机接收流程示例

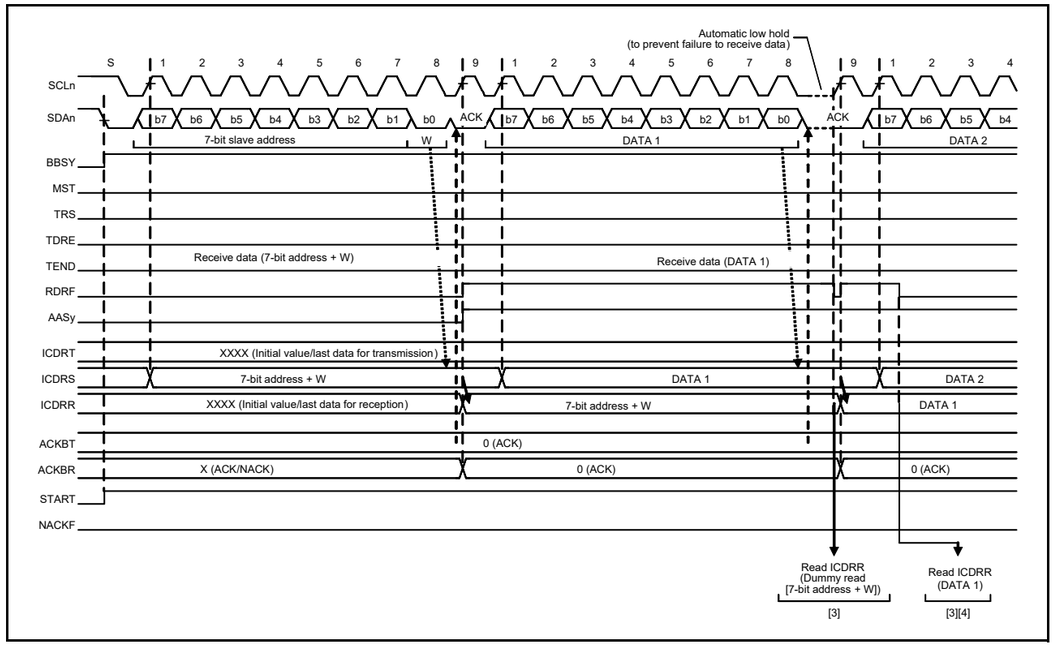


Figure 29.19 Slave receive operation timing (1) with 7-bit address format, when RDRFS = 0

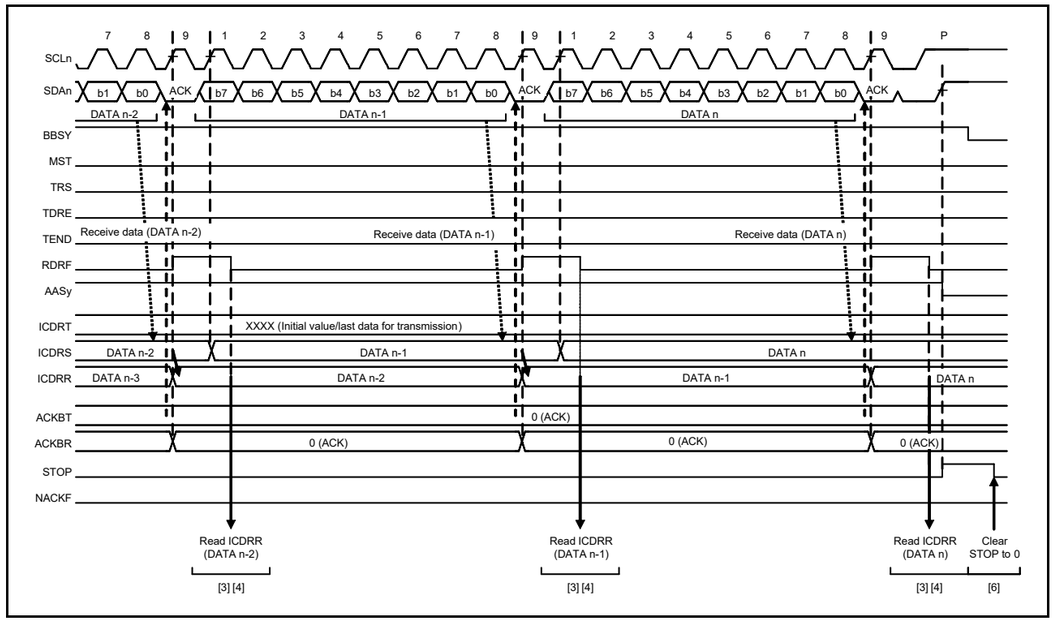


Figure 29.20 Slave receive operation timing (2) when RDRFS = 0

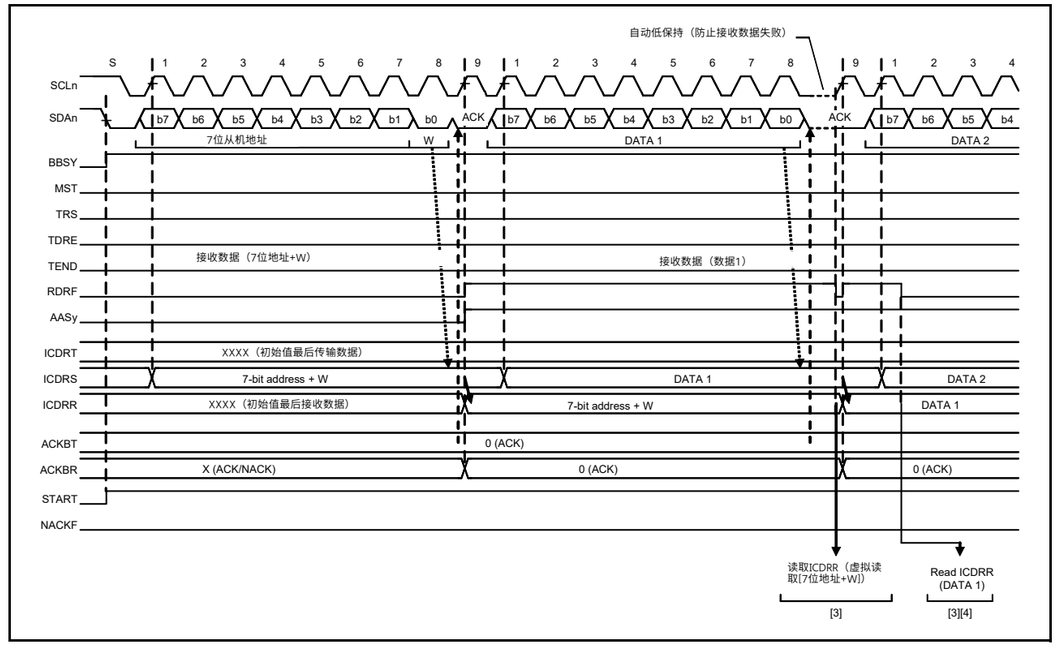


Figure 29.19 当RDRFS=0时，7位地址格式的从机接收操作时序(1)

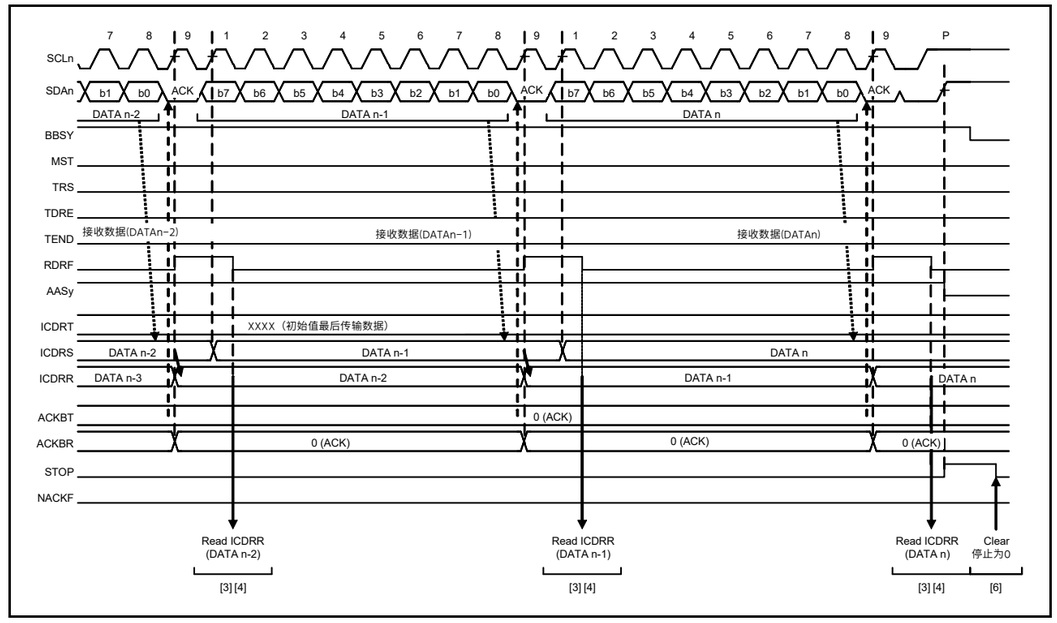


Figure 29.20 RDRFS=0时的从机接收操作时序(2)

29.4 SCL Synchronization Circuit

To generate the SCL clock, the IIC starts counting the value for the high-level period specified in ICBRH when it detects a rising edge on the SCLn line, and drives the SCLn line low when it completes counting. When the IIC detects the falling edge of the SCLn line, it starts counting the value for the low-level period specified in ICBRL, and then stops driving the SCLn line (releases the line) when it completes counting. The IIC repeats this process to generate the SCL clock.

If multiple master devices are connected to the I2C bus, a collision of SCL signals might arise because of contention with another master device. In such cases, the master devices must synchronize their SCL signals. Because this synchronization of SCL signals must be bit-by-bit, IIC includes an SCL synchronization circuit to obtain bit-by-bit synchronization of the SCL clock signals by monitoring the SCLn line while in master mode.

When the IIC detects a rising edge on the SCLn line and starts counting the high-level period specified in ICBRH, and the level on the SCLn line falls because an SCL signal is being generated by another master device, the IIC performs the following:

1. Stops counting when it detects the falling edge.
2. Drives the level on the SCLn line low.
3. Starts counting the low-level period specified in ICBRL.

When the IIC finishes counting the low-level period, it stops driving the SCLn line low to release the line. If the low-level period of the SCL clock signal from the other master device is longer than the low-level period set in the IIC, the low-level period of the SCL signal is extended. When the low-level period for the other master device ends, the SCL signal rises because the SCLn line is released.

When the IIC finishes outputting the low-level period of the SCL clock, the SCLn line is released and the SCL clock rises. That is, when SCL signals from more than one master are contending, the high-level period of the SCL signal is synchronized with that of the clock with the narrower period, and the low-level period of the SCL signal is synchronized with that of the clock with the broader period. However, such synchronization of the SCL signal is only enabled when the SCLE bit in ICFER is set to 1.

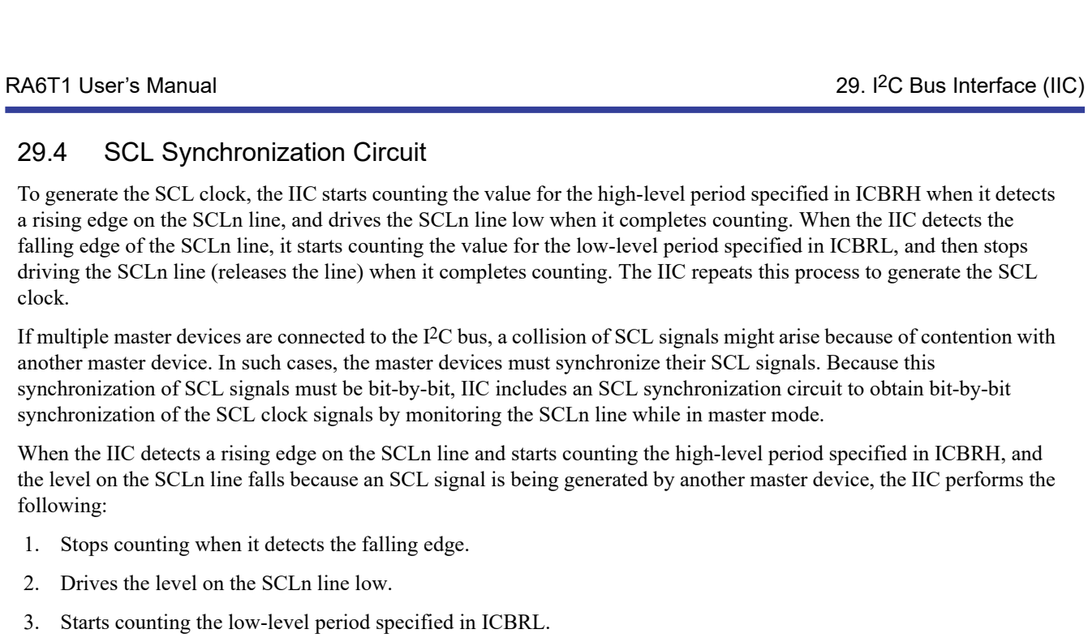


Figure 29.21 Generation and synchronization of SCL signal from the IIC

29.4 SCL同步电路

为了产生SCL时钟，IIC在检测到SCLn线上的上升沿时开始对ICBRH中指定的高电平周期的值进行计数，并在完成计数时将SCLn线驱动为低电平。当IIC检测到SCLn线的下降沿时，它开始对ICBRL中指定的低电平周期的值进行计数，然后在完成计数时停止驱动SCLn线（释放线）。IIC重复此过程以生成SCL时钟。

如果多个主设备连接到I2C总线，由于与另一个主设备争用，可能会出现SCL信号冲突。在这种情况下，主设备必须同步它们的SCL信号。因为SCL信号的这种同步必须是逐位的，所以IIC包括一个SCL同步电路，通过在主机模式下监视SCLn线来获得SCL时钟信号的逐位同步。

当IIC检测到SCLn线上的上升沿并开始计算ICBRH中指定的高电平周期，并且由于另一个主设备正在生成SCL信号而导致SCLn线上的电平下降时，IIC执行以下操作：

1. 检测到下降沿时停止计数。
2. 将SCLn线上的电平驱动为低电平。
3. 开始计算ICBRL中指定的低电平周期。

当IIC完成对低电平周期的计数时，它停止将SCLn线驱动为低电平以释放该线。如果来自其他主设备的SCL时钟信号的低电平周期长于IIC中设置的低电平周期，则延长SCL信号的低电平周期。当另一个主设备的低电平周期结束时，SCL信号上升，因为SCLn线被释放。

当IIC输出完SCL时钟的低电平周期后，SCLn线被释放，SCL时钟上升。即当来自多个主控的SCL信号竞争时，SCL信号的高电平周期与周期较窄的时钟同步，SCL信号的低电平周期与主控的低电平周期同步。具有更广泛周期的时钟。但是，只有当ICFER中的SCLE位设置为1时，才会启用SCL信号的这种同步。

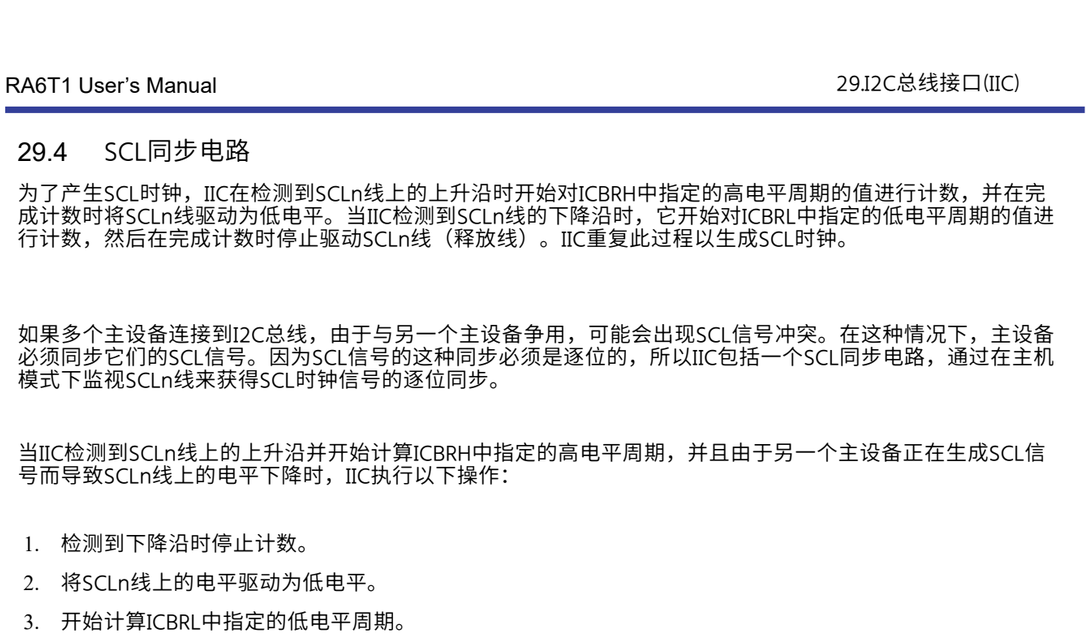


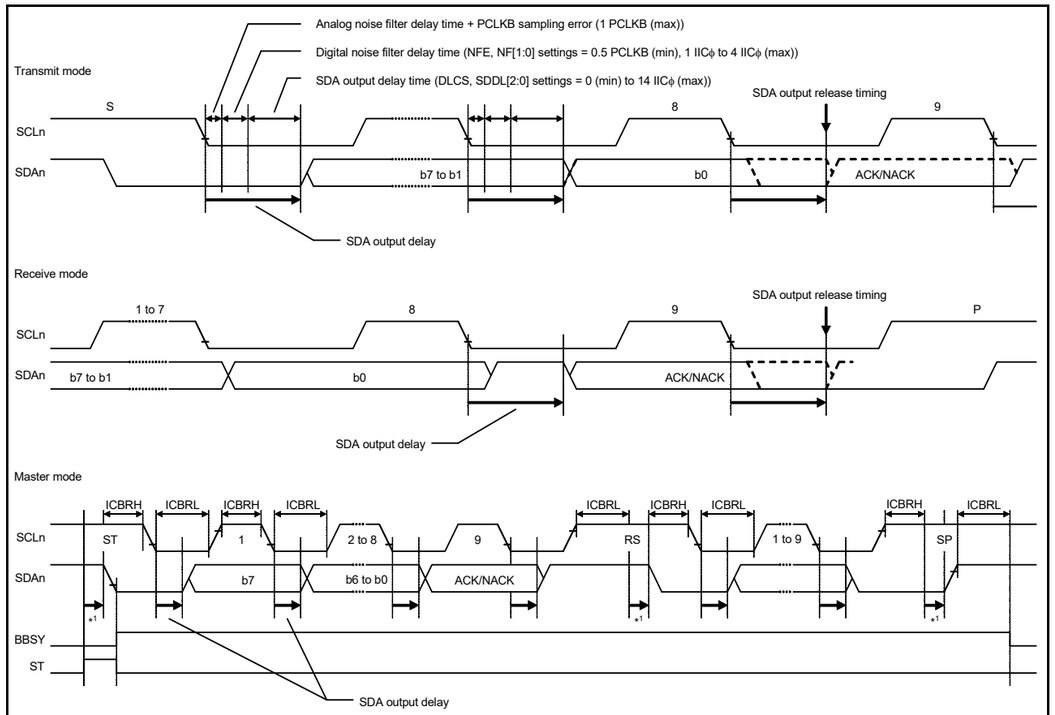
Figure 29.21 从IIC生成和同步SCL信号

29.5 SDA Output Delay Function

The IIC module provides a function for delaying output on the SDA line. The delay can be applied to all outputs on the SDA line, including issuing of start, restart, and stop conditions, data, and the ACK and NACK signals.

With this function, SDA output is delayed from the detection of a falling edge of the SCL signal to ensure that the SDA signal is output within the interval during which the SCL clock is low. This approach helps prevent erroneous operation of communication devices, with the aim of satisfying the 300-ns minimum data-hold time requirement of the SMBus specification. The output delay function is enabled by setting the SDDL[2:0] bits in ICMR2 to any value other than 000b, and disabled by setting the same bits to 000b.

When the SDA output delay function is enabled, for example, the DLCS bit in ICMR2 selects the clock source for the SDA output delay counter, either as the internal base clock (IICϕ) for the IIC module or as the internal base clock divided by two (IICϕ/2). The counter counts the number of cycles set in the SDDL[2:0] bits in ICMR2. When the delay count is reached, the IIC module places the required output (start, restart, or stop condition, data, or an ACK or NACK signal) on the SDA line.



Note 1. The output delay function is set by the DLCS and SDDL[2:0] bits when a start (ST), restart (RS), or stop (SP) condition is issued.

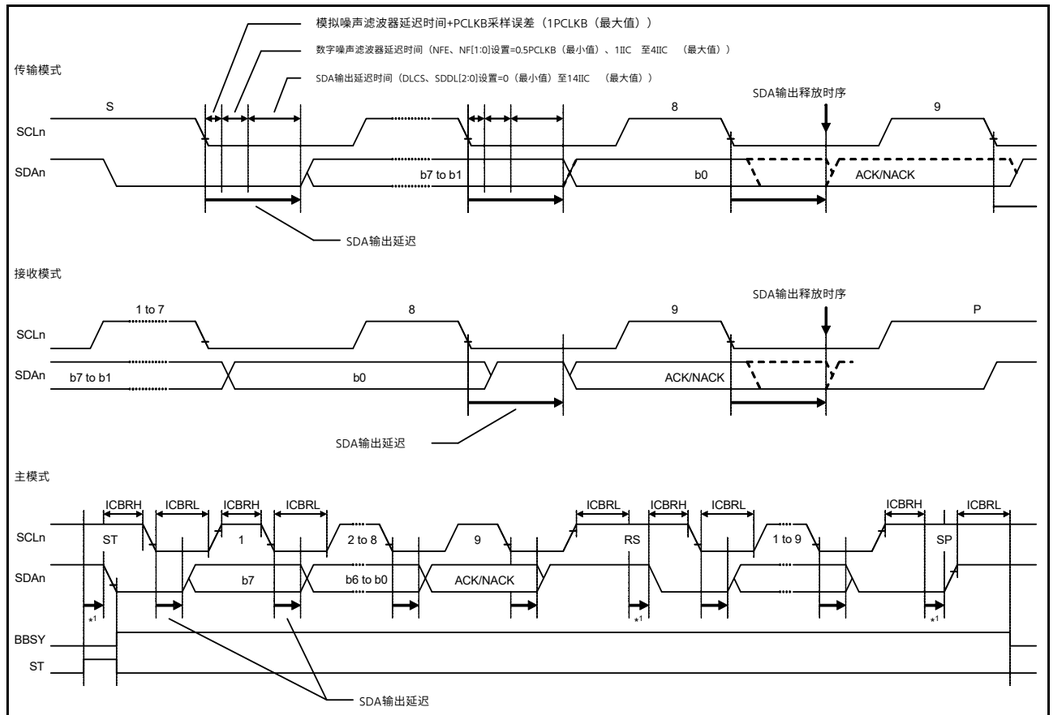
Figure 29.22 SDA output delay function

29.5 SDA输出延迟功能

IIC模块提供了延迟SDA线上输出的功能。延迟可以应用于所有输出
SDA线，包括发出启动、重启和停止条件、数据以及ACK和NACK信号。

使用此功能，SDA输出从检测到SCL信号的下降沿开始延迟，以确保在SCL时钟为低电平的时间间隔内输出SDA信号。这种方法有助于防止通信设备的错误操作，旨在满足SMBus规范的300ns最小数据保持时间要求。通过将ICMR2中的SDDL[2:0]位设置为000b以外的任何值来启用输出延迟功能，并通过将相同位设置为000b来禁用输出延迟功能。

当SDA输出延迟功能使能时，例如ICMR2中的DLCS位选择时钟源
SDA输出延迟计数器，可以作为IIC模块的内部基本时钟(IIC)或作为内部基本时钟除以2(IIC 2)。计数器计算ICMR2中SDDL[2:0]位中设置的周期数。当达到延迟计数时，IIC模块将所需的输出（启动、重启或停止条件、数据或ACK或NACK信号）放在SDA线上。



注1.当发出启动(ST)、重启(RS)或停止(SP)条件时，输出延迟功能由DLCS和SDDL[2:0]位设置。

Figure 29.22 SDA输出延迟功能

29.6 Digital Noise Filter Circuits

The internal circuitry sees the states of the SCLn and SDAn pins through analog and digital noise-filter circuits. Figure 29.23 shows a block diagram of the digital noise-filter circuit.

The on-chip digital noise-filter circuit of the IIC consists of four flip-flop circuit stages connected in series, and a match-detection circuit.

The number of valid stages in the digital noise filter is selected in the NF[1:0] bits in ICMR3. The selected number of valid stages determines the noise-filtering capability as a period from 1 to 4 IICϕ cycles.

The input signal to the SCLn pin (or SDAn pin) is sampled on falling edges of the IICϕ signal. When the input signal level matches the output level of the number of valid flip-flop circuit stages as selected in the NF[1:0] bits in ICMR3, the signal level is seen in the subsequent stage. If the signal levels do not match, the previous value is saved.

If the ratio between the frequency of the internal operating clock (PCLKB) and the transfer rate is small, for example, for a data transfer at 400 kbps with PCLKB at 4 MHz, the digital noise filter might lead to the elimination of the required signals as noise. In such cases, it is possible to disable the digital noise-filter circuit by setting the ICFER.NFE bit to 0, and use only the analog noise-filter circuit.

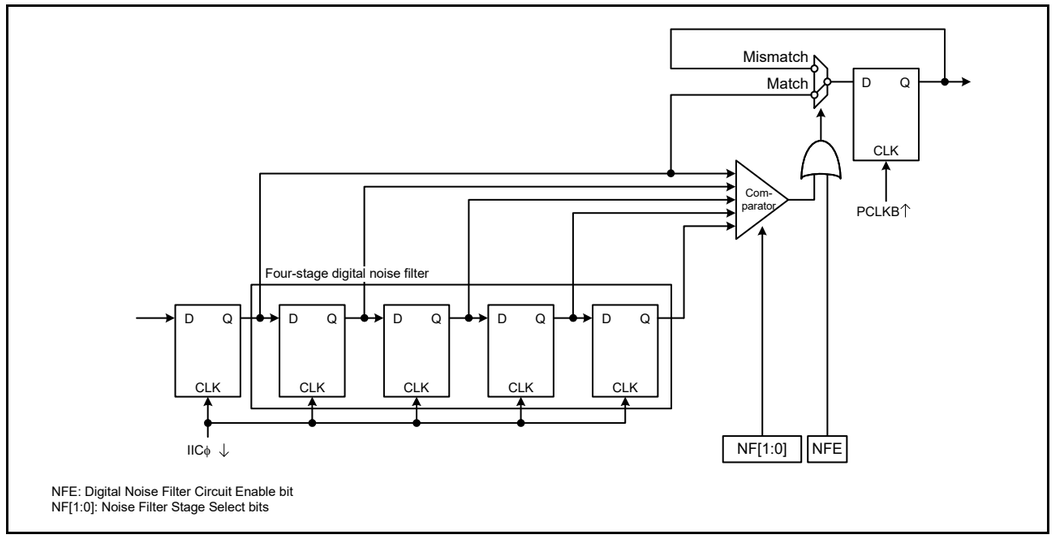


Figure 29.23 Digital noise-filter circuit block diagram

29.7 Address Match Detection

The IIC can set three unique slave addresses in addition to the general call address and host address. The slave addresses can be 7-bit or 10-bit slave addresses.

29.7.1 Slave-Address Match Detection

The IIC can set three unique slave addresses and has a slave address detection function for each unique slave address. When the SARyE bit (y = 0 to 2) in ICSER is set to 1, the slave addresses set in SARUy and SARLy (y = 0 to 2) can be detected.

When the IIC detects a match of the set slave address, the associated AASy (y = 0 to 2) flag in ICSR1 is set to 1 on the rising edge of the 9th SCL clock cycle, and the RDRF flag or TDRE flag in ICSR2 is set to 1 by the subsequent R/W# bit. This causes a receive data full interrupt (IICn_RXI) or transmit data empty interrupt (IICn_TXI) to be generated. The AASy flag identifies which slave address is specified.

29.6 数字噪声滤波器电路

内部电路通过模拟和数字噪声滤波器电路查看SCLn和SDAn引脚的状态。图29.23显示了数字噪声滤波器电路的框图。

IIC的片上数字噪声滤波器电路由四个串联的触发器电路级和一个匹配检测电路组成。

数字噪声滤波器的有效级数在ICMR3的NF[1:0]位中选择。选定的有效级数决定了噪声过滤能力，周期为1到4个IIC 周期。

SCLn引脚（或SDAn引脚）的输入信号在IIC 信号的下降沿采样。当输入信号电平与在ICMR3的NF[1:0]位中选择的有效触发器电路级数的输出电平相匹配时，信号电平将出现在后一级。如果信号电平不匹配，则保存先前的值。

如果内部工作时钟(PCLKB)的频率与传输速率之间的比率很小，例如，对于400kbps的数据传输，PCLKB为4MHz，则数字噪声滤波器可能会导致所需信号的消除作为噪音。在这种情况下，可以通过将ICFER.NFE位设置为0来禁用数字噪声滤波器电路，并仅使用模拟噪声滤波器电路。

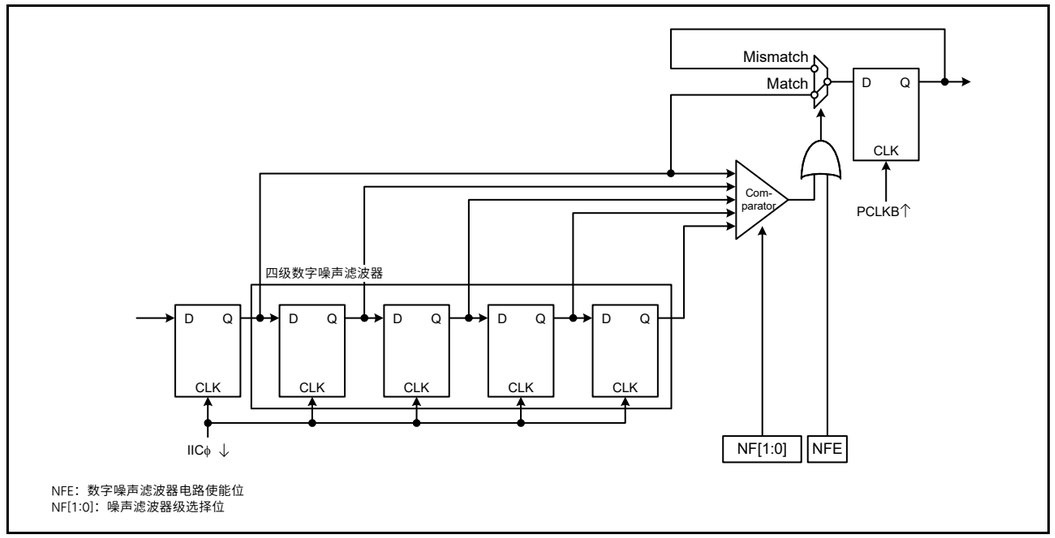


Figure 29.23 数字噪声滤波器电路框图

29.7 地址匹配检测

IIC除了广播地址和主机地址外，还可以设置三个唯一的从机地址。从地址可以是7位或10位从地址。

29.7.1 从地址匹配检测

IIC可以设置三个唯一的从机地址，并对每个唯一的从机地址具有从机地址检测功能。
当ICSER中的SARyE位（y=0到2）设置为1时，可以检测到设置在SARUy和SARLy（y=0到2）中的从机地址。

当IIC检测到设置的从地址匹配时，ICSR1中相关的AASy（y=0到2）标志在第9个SCL时钟周期的上升沿被设置为1，并且ICSR2中的RDRF标志或TDRE标志由随后的RW#位设置为1。这会导致产生接收数据满中断（IICn_RXI）或发送数据空中断（IICn_TXI）。这

AASy标志标识指定了哪个从地址。

Figure 29.24 to Figure 29.26 show the AASy flag set timing in three cases.

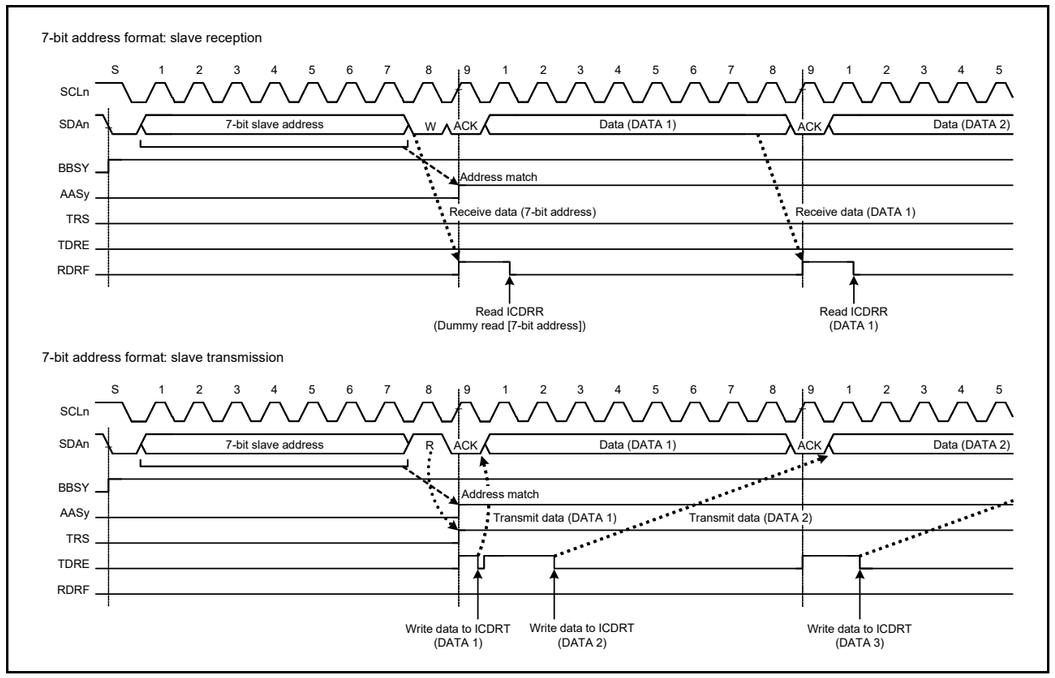


Figure 29.24 AASy flag set timing with 7-bit address format

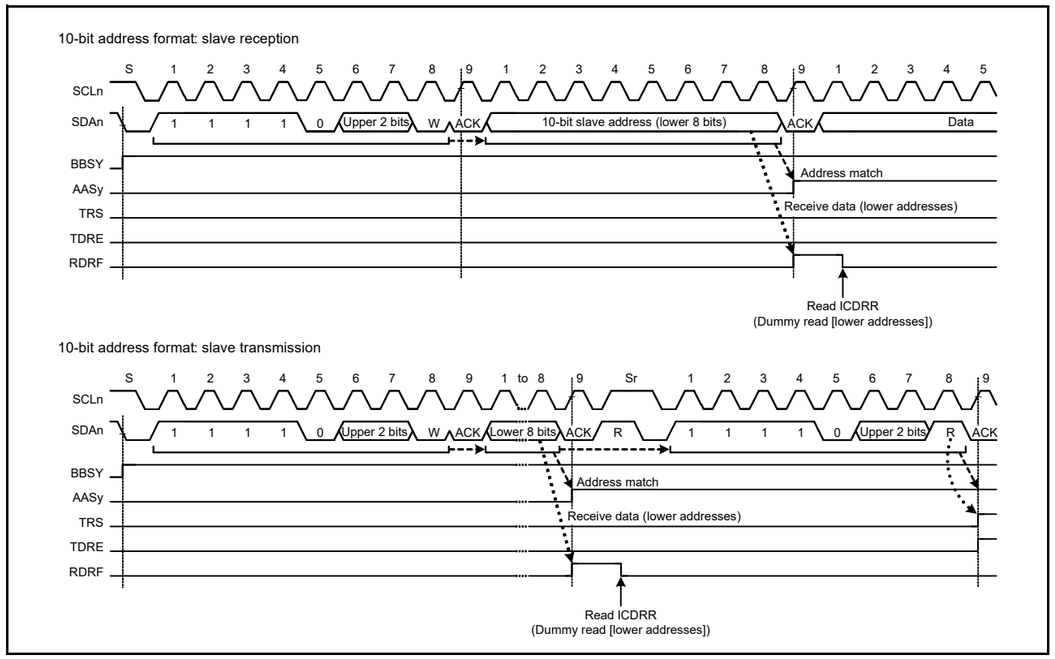


Figure 29.25 AASy flag set timing with 10-bit address format

图29.24至图29.26显示了三种情况下的AASy标志设置时序。

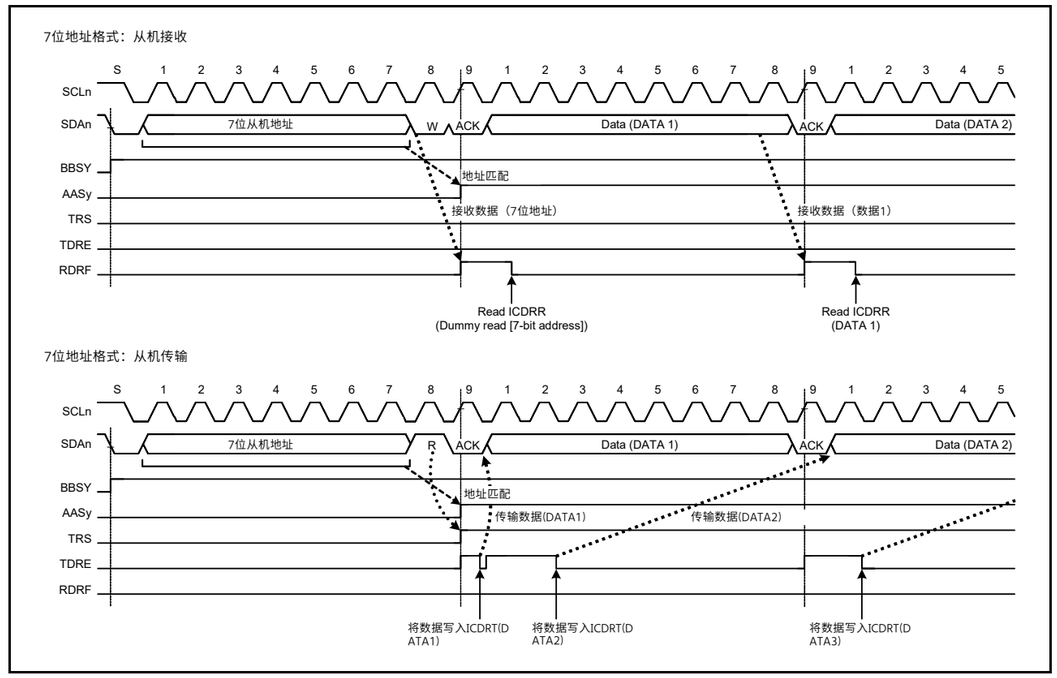


Figure 29.24 7位地址格式的AASy标志设置时序

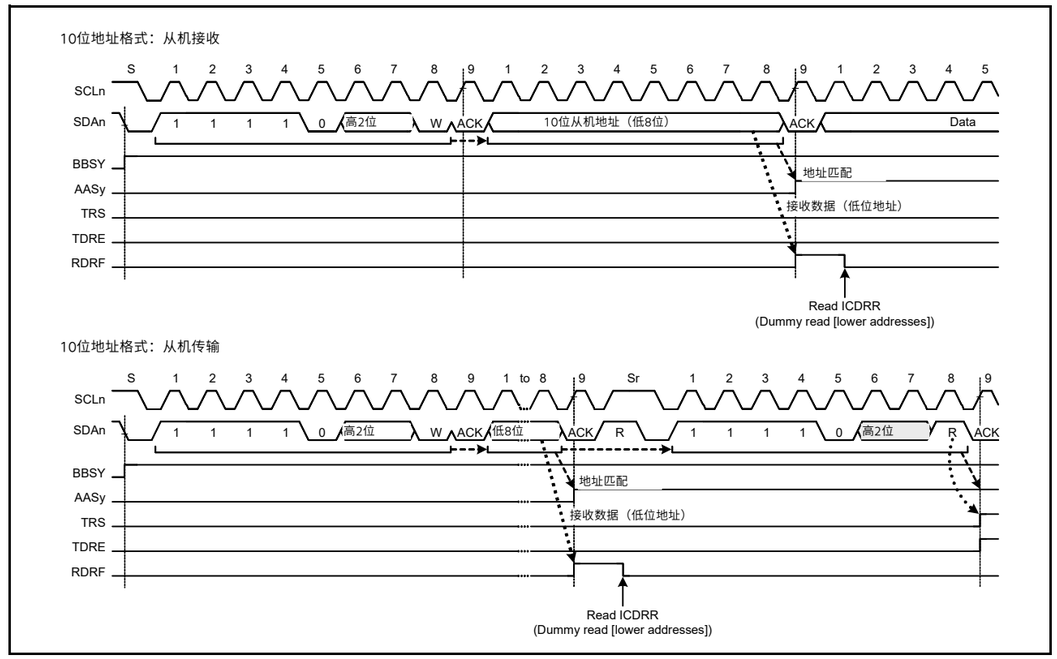


Figure 29.25 10位地址格式的AASy标志设置时序

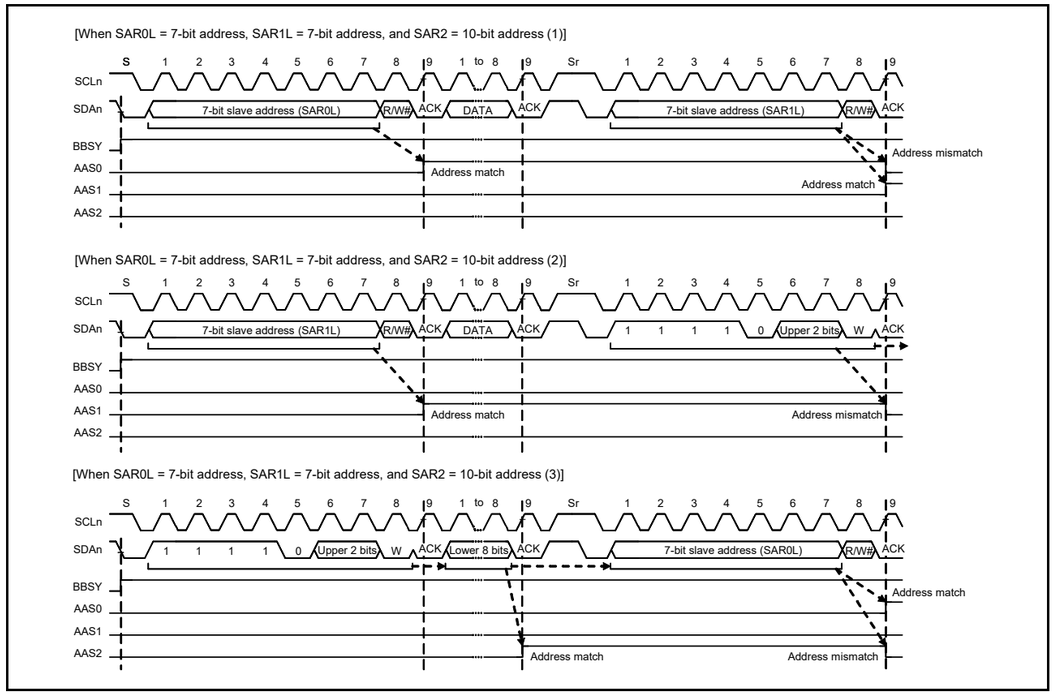


Figure 29.26 AASy flag set and clear timing with 7-bit and 10-bit address formats mixed

29.7.2 Detection of General Call Address

The IIC provides detection of the general call address (0000 000b + 0 [W]). General call address detection is enabled by setting the GCAE bit in ICSER to 1.

If the address received after a start or restart condition is issued is 0000 000b + 1[R] (start byte), the IIC recognizes this as the address of a slave device with an all-zero address, but not as the general call address.

When the IIC detects the general call address, both the GCA flag in ICSR1 and the RDRF flag in ICSR2 are set to 1 on the rising edge of the 9th cycle of the SCL clock. This leads to the generation of a receive data full interrupt (IICn_RXI). The value of the GCA flag can be checked to confirm that the general call address was transmitted.

Operation after detection of the general call address is the same as normal slave receive operation.

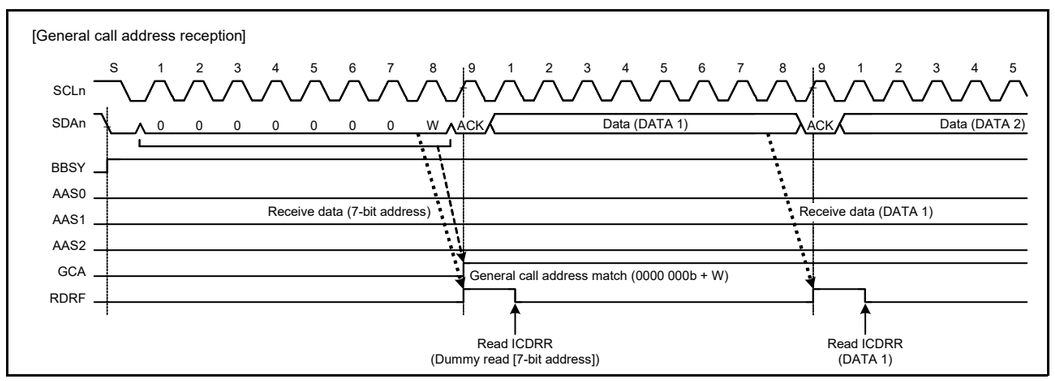


Figure 29.27 Timing of GCA flag setting during reception of general call address

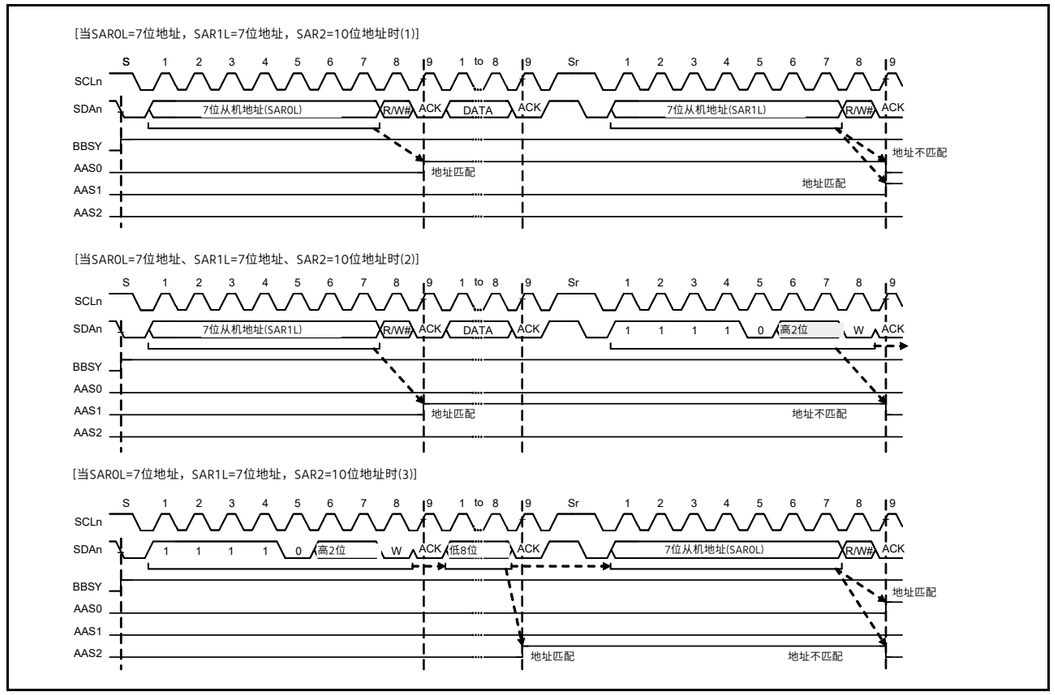


Figure 29.26 混合7位和10位地址格式的AASy标志设置和清除时序

29.7.2 广播呼叫地址检测

IIC提供对广播呼叫地址(0000000b+0[W])的检测。通过将ICSER中的GCAE位设置为1来启用广播呼叫地址检测。

如果在发出启动或重启条件后接收到的地址是0000000b+1[R]（起始字节），则IIC将其识别为具有全零地址的从设备的地址，但不是广播地址.

当IIC检测到广播呼叫地址时，ICSR1中的GCA标志和ICSR2中的RDRF标志都在SCL时钟的第9个周期的上升沿设置为1。这会导致接收数据完全中断(IICn_RXI)的产生。可以检查GCA标志的值以确认广播呼叫地址已被传输。

检测到广播呼叫地址后的操作与正常的从机接收操作相同。

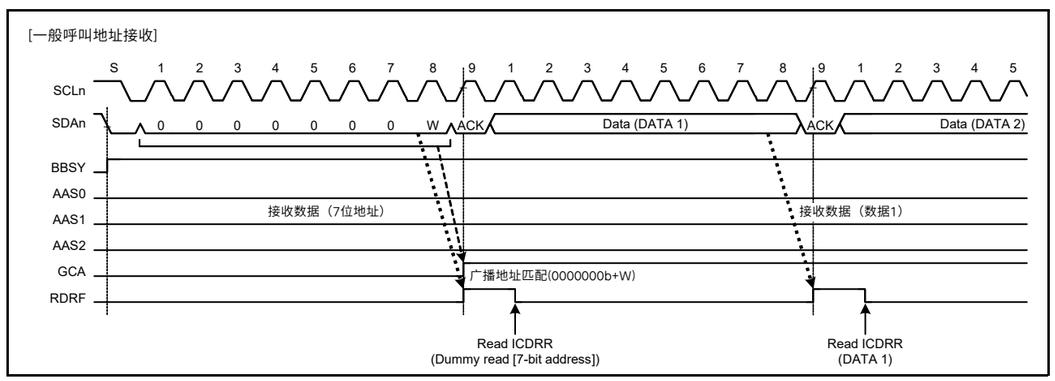


Figure 29.27 在接收广播呼叫地址期间设置GCA标志的时机

29.7.3 Device ID Address Detection

The IIC module provides detection of the device ID address in compliance with the I2C bus specification, revision 03. When the IIC receives 1111 100b as the first byte after a start or restart condition is issued with the DIDE bit in ICSER set to 1, it recognizes the address as a device ID, sets the DID flag in ICSR1 to 1 on the rising edge of the 8th SCL clock cycle when the subsequent R/W# bit is 0, then compares the second and subsequent bytes with its own slave address. If the address matches the value in the slave address register, the IIC sets the associated AASy (y = 0 to 2) flag in ICSR1 to 1.

When the first byte received after the issue of a start or restart condition matches the device ID address (1111 100b) again and the subsequent R/W# bit is 1, the IIC does not compare the second and subsequent bytes, and sets the ICSR2.TDRE flag to 1.

In the device ID address detection function, the IIC sets the DID flag to 0 if a match with the IIC slave address is not obtained, or a match with the device ID address is not obtained after a match with the IIC slave address, and a restart condition is detected. If the first byte after the detection of a start or restart condition matches the device ID address (1111 100b) and the R/W# bit is 0, the IIC sets the DID flag to 1 and compares the second and subsequent bytes with the slave address of IIC. If the R/W# bit is 1, the DID flag holds the previous value and the IIC does not compare the second and subsequent bytes. Therefore, the reception of a device ID address can be checked by reading the DID flag after confirming that TDRE = 1.

Additionally, prepare the device ID fields (3 bytes: 12 bits indicating the manufacturer + 9 bits identifying the part + 3 bits indicating the revision) that must be sent to the host after reception of a continuous device ID field as normal transmit data. For details on the information that must be included in device ID fields, contact NXP Semiconductors.

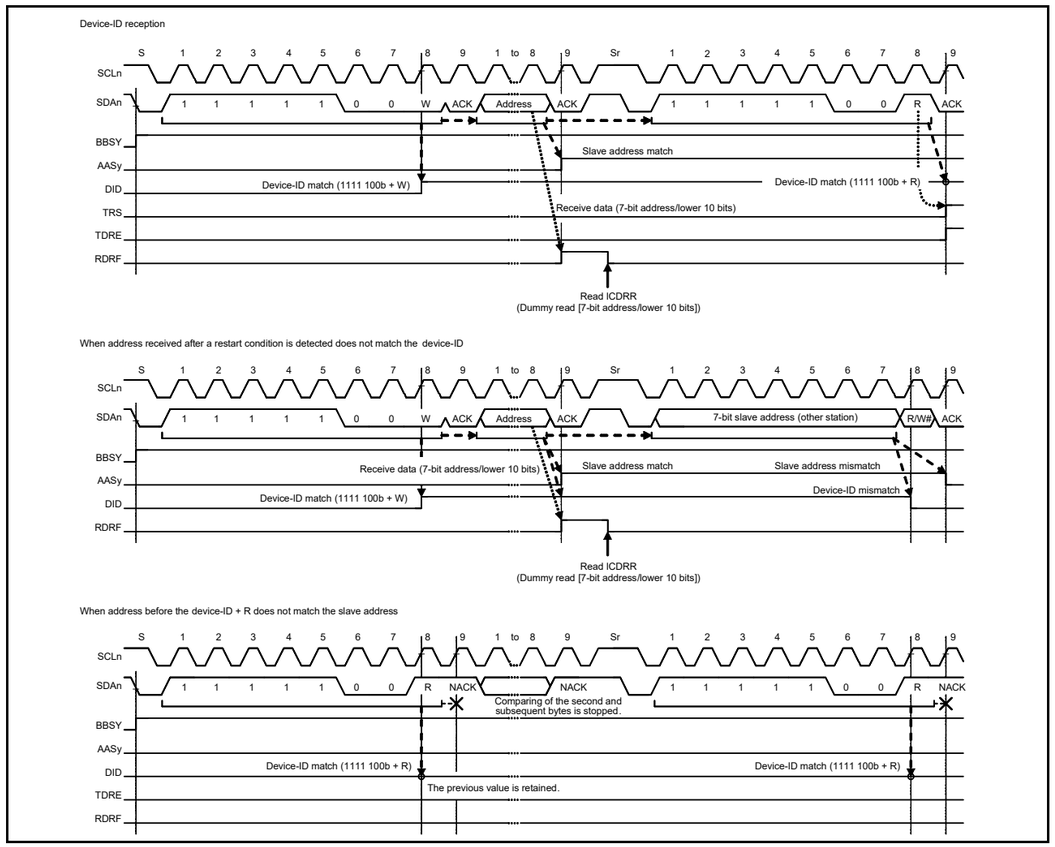


Figure 29.28 AASy and DID flag set and clear timing during reception of device ID

29.7.3 设备ID地址检测

IIC模块提供符合I2C总线规范，修订版03的设备ID地址检测。当IIC在ICSER中的DIDE位设置为1的情况下发出启动或重启条件后收到1111100b作为第一个字节时，它将地址识别为设备ID，当随后的RW#位为0时，在第8个SCL时钟周期的上升沿将ICSR1中的DID标志设置为1，然后将第二个和后续字节与自己的从地址进行比较.如果地址与从地址寄存器中的值匹配，则IIC将ICSR1中相关的AASy（y=0到2）标志设置为1。

当发出启动或重启条件后接收到的第一个字节再次与设备ID地址(1111100b)匹配且后续RW#位为1时，IIC不比较第二个和后续字节，并设置ICSR2.TDRE标志为1。

在设备ID地址检测功能中，如果没有得到与IIC从机地址匹配，或者与IIC从机地址匹配后没有得到与设备ID地址匹配，则IIC将DID标志设置为0，并且检测到重启条件。如果检测到启动或重启条件后的第一个字节与设备ID地址(1111100b)匹配且RW#位为0，则IIC将DID标志设置为1，并将第二个和后续字节与从机地址进行比较国际集成电路。如果RW#位为1，则DID标志保持前一个值，并且IIC不比较第二个和后续字节。因此，在确认TDRE=1后，可以通过读取DID标志来检查设备ID地址的接收。

此外，准备设备ID字段（3个字节：12位表示制造商+9位表示部件+3位表示版本），在接收到连续的设备ID字段作为正常发送数据后必须发送到主机。有关必须包含在设备ID字段中的信息的详细信息，请联系NXPSemiconductors。

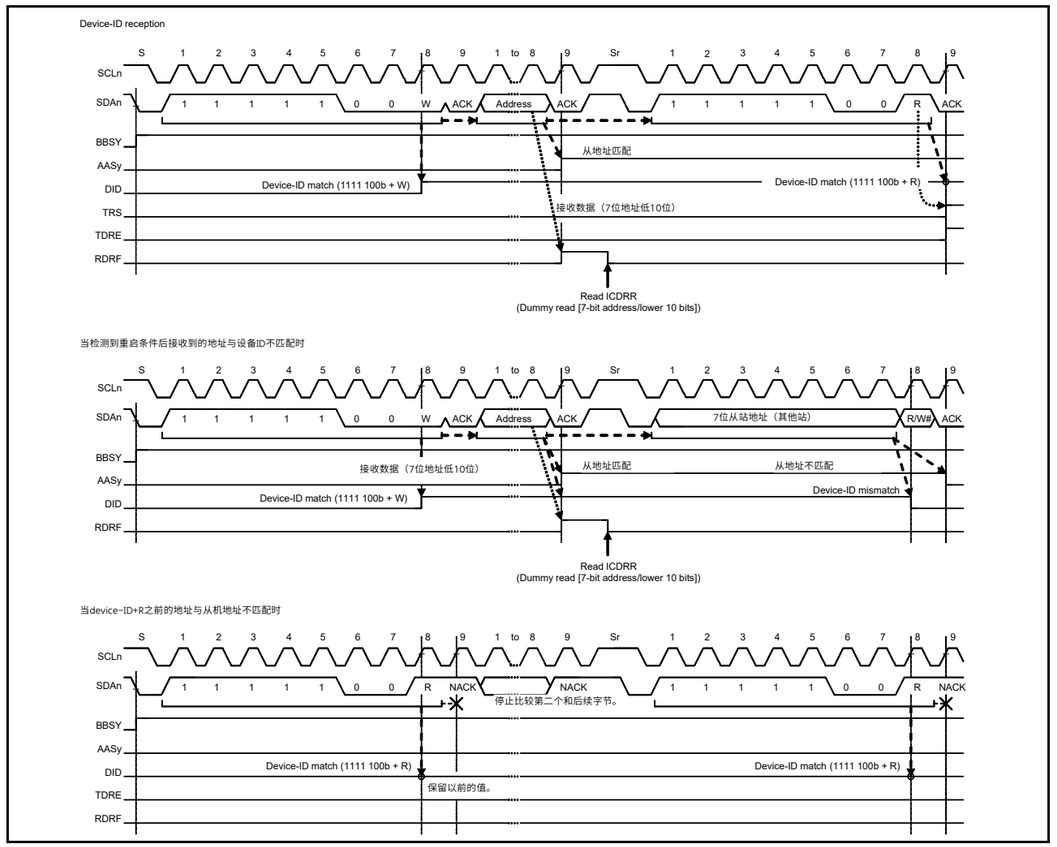


Figure 29.28 在接收设备ID期间设置AASy和DID标志并清除时序

29.7.4 Host Address Detection

The IIC provides host address detection when operating in SMBus mode. When the HOAE bit in ICSER is set to 1 while the SMBS bit in ICMR3 is 1, the IIC can detect the host address (0001 000b) in slave receive mode (MST and TRS bits = 00b in ICCR2).

When the IIC detects the host address, the HOA flag in ICSR1 is set to 1 on the rising edge of the 9th SCL clock cycle. At the same time, the RDRF flag in ICSR2 is set to 1 when the R/W# bit is 0 (Wr bit). This causes a receive data full interrupt (IICn_RXI) to be generated. The HOA flag indicates that the host address was sent from another device.

If the bit following the host address (0001 000b) is a read bit (R/W# bit = 1), the IIC can also detect the host address. After the host address is detected, the IIC operates in the same manner as in normal slave operation.

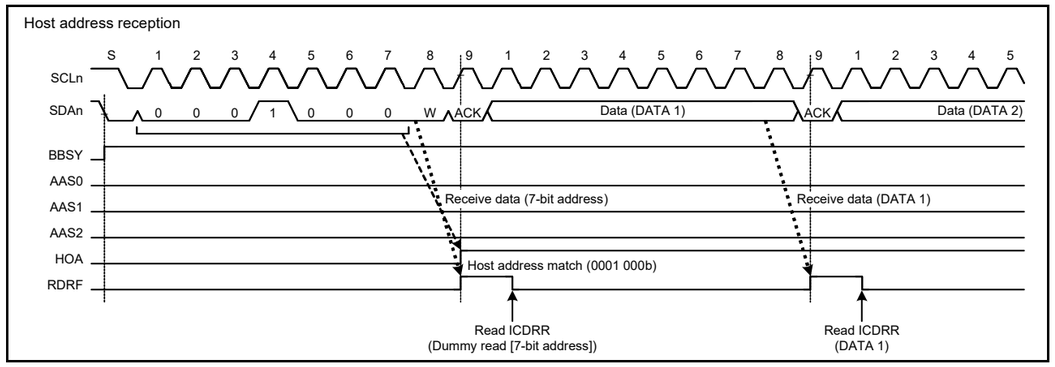


Figure 29.29 HOA flag set timing during reception of host address

29.8 Wakeup Function

The IIC provides a wakeup function that causes the MCU to transition from Software Standby mode to normal operation. The wakeup function enables the reception of data when the system clock is stopped, and generates a wakeup interrupt signal on a match of the slave address of the received data. This wakeup interrupt signal triggers the return to normal operation.

The wakeup function has four operation modes:

- Normal wakeup mode 1
- Normal wakeup mode 2
- Command recovery mode
- EEP response mode.

Table 29.9 describes the behavior in these modes.

Table 29.9 Wakeup operation modes

Operation mode	ACK response timing	ACK response before wakeup	SCL state during wakeup
Normal wakeup mode 1	Before wakeup	ACK	Fixed low
Normal wakeup mode 2	After wakeup	Before wakeup: no response After wakeup: ACK response	Fixed low
Command recovery mode	Before wakeup	ACK	Open
EEP response mode	Before wakeup	NACK	Open

Precautions on the use of the wakeup function

1. Disable the wakeup function (WUE = 0) after a wakeup interrupt triggers the transition from Software Standby mode to normal operation.

29.7.4 主机地址检测

IIC在SMBus模式下工作时提供主机地址检测。当ICSER中的HOAE位设置为1而ICMR3中的SMBS位为1时，IIC可以在从机接收模式下检测主机地址（0001000b）（ICCR2中的MST和TRS位=00b）。

当IIC检测到主机地址时，ICSR1中的HOA标志在第9个SCL时钟周期的上升沿被设置为1。同时，当RW#位为0（Wr位）时，ICSR2中的RDRF标志设置为1。这会导致产生接收数据完全中断（IICn_RXI）。HOA标志表明主机地址是从另一个设备发送的。

如果主机地址（0001000b）后面的位是读取位（RW#位=1），则IIC也可以检测主机地址。
检测到主机地址后，IIC以与正常从机操作相同的方式运行。

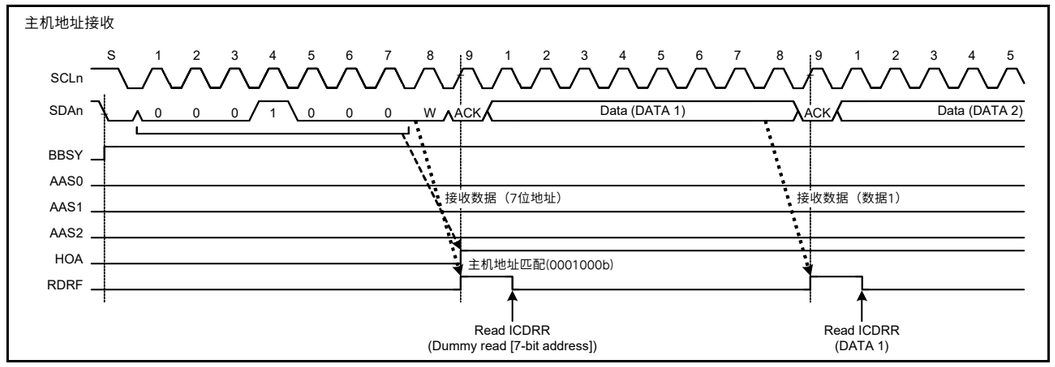


Figure 29.29 接收主机地址期间的HOA标志设置时序

29.8 唤醒功能

IIC提供唤醒功能，使MCU从软件待机模式转换到正常操作。唤醒功能在系统时钟停止时启用数据接收，并在接收到的数据的从地址匹配时产生唤醒中断信号。该唤醒中断信号触发恢复正常操作。

唤醒功能有四种操作模式：

- 正常唤醒模式1
- 正常唤醒模式2
- 命令恢复模式
- EEP响应模式。

表29.9描述了这些模式下的行为。

Table 29.9 唤醒操作模式

操作模式	ACK响应时间	唤醒前的ACK响应	唤醒期间的SCL状态
正常唤醒模式1	醒来前	ACK	固定低
正常唤醒模式2	醒来后	唤醒前：无响应唤醒后：ACK响应	固定低
命令恢复模式	醒来前	ACK	Open
EEP响应模式	醒来前	NACK	Open

唤醒功能使用注意事项

1. 在唤醒中断触发从软件待机模式到正常操作的转换后，禁用唤醒功能(WUE=0)。

2. Do not change the content of the IIC registers while WUF = 0, even if the wakeup interrupt recovers the system clock. Specify the register settings after confirming that WUF = 1.
3. Set WUE = WUIE = 1 and MST = TRS = 0 (slave reception mode) before entering Software Standby mode.
4. Do not transition to Software Standby mode while BBSY = 1.
5. The wakeup function supports the 7-bit slave address of the slave address register SARL0, the general call address, and the host address. 10-bit slave addresses, SARL1 and SARL2, are not supported.
6. When the wakeup function is enabled, disable the interrupts selectable in the TIE, TEIE, RIE, NAKIE, SPIE, STIE, ALIE, and TMOIE bits in the ICIER register.
7. When the wakeup function is enabled, do not use the timeout function.
8. If the transition from Software Standby mode is triggered by an interrupt other than a wakeup interrupt, for example, the IRQn, the WUF flag is not set to 1. Follow the procedures shown in Figure 29.31 and Figure 29.36.

29.8.1 Normal Wakeup Mode 1

This section describes the behavior, timing, and an example operation in normal wakeup mode 1.

In normal wakeup mode 1, a wakeup interrupt triggered by the match of the slave address initiates the transition to normal operation as follows:

Before wakeup: ACK is sent in response to the data received with its own slave address of the IIC.
During wakeup: ACK response is made on the 9th clock cycle of SCL, after which SCL is held low*1.
After wakeup: Normal operation continues.

If the slave address does not match, the SCL line is not held low after the 9th clock cycle of SCL, and the slave operation continues.

Figure 29.30 shows an operation example, and Figure 29.32 shows the detailed timing.

Note 1. Between the 9th clock cycle and the 1st clock cycle during wakeup, WAIT = 1 is invalid.

If the transition from Software Standby mode is triggered by an interrupt other than a wakeup interrupt, for example the IRQn, the WUF flag is not set to 1. Figure 29.31 shows an operation example.

2. 当WUF=0时不要改变IIC寄存器的内容，即使唤醒中断恢复了系统时钟。确认WUF=1后指定寄存器设置。
3. 在进入软件待机模式之前设置WUE=WUIE=1和MST=TRS=0（从接收模式）。
4. 当BBSY=1时不要转换到软件待机模式。
5. 唤醒功能支持从地址寄存器SARL0的7位从地址、广播地址、主机地址。不支持10位从机地址SARL1和SARL2。
6. 启用唤醒功能时，禁用TIE、TEIE、RIE、NAKIE、SPIE、STIE、ICIER寄存器中的ALIE和TMOIE位。
7. 启用唤醒功能时，请勿使用超时功能。
8. 如果从软件待机模式的转换是由唤醒中断以外的中断触发的，例如IRQn，则WUF标志不设置为1。按照图29.31和图29.36中所示的过程。

29.8.1 正常唤醒模式1

本节介绍正常唤醒模式1下的行为、时序和示例操作。

在正常唤醒模式1中，由匹配从机地址触发的唤醒中断启动到正常操作的转换，如下所示：

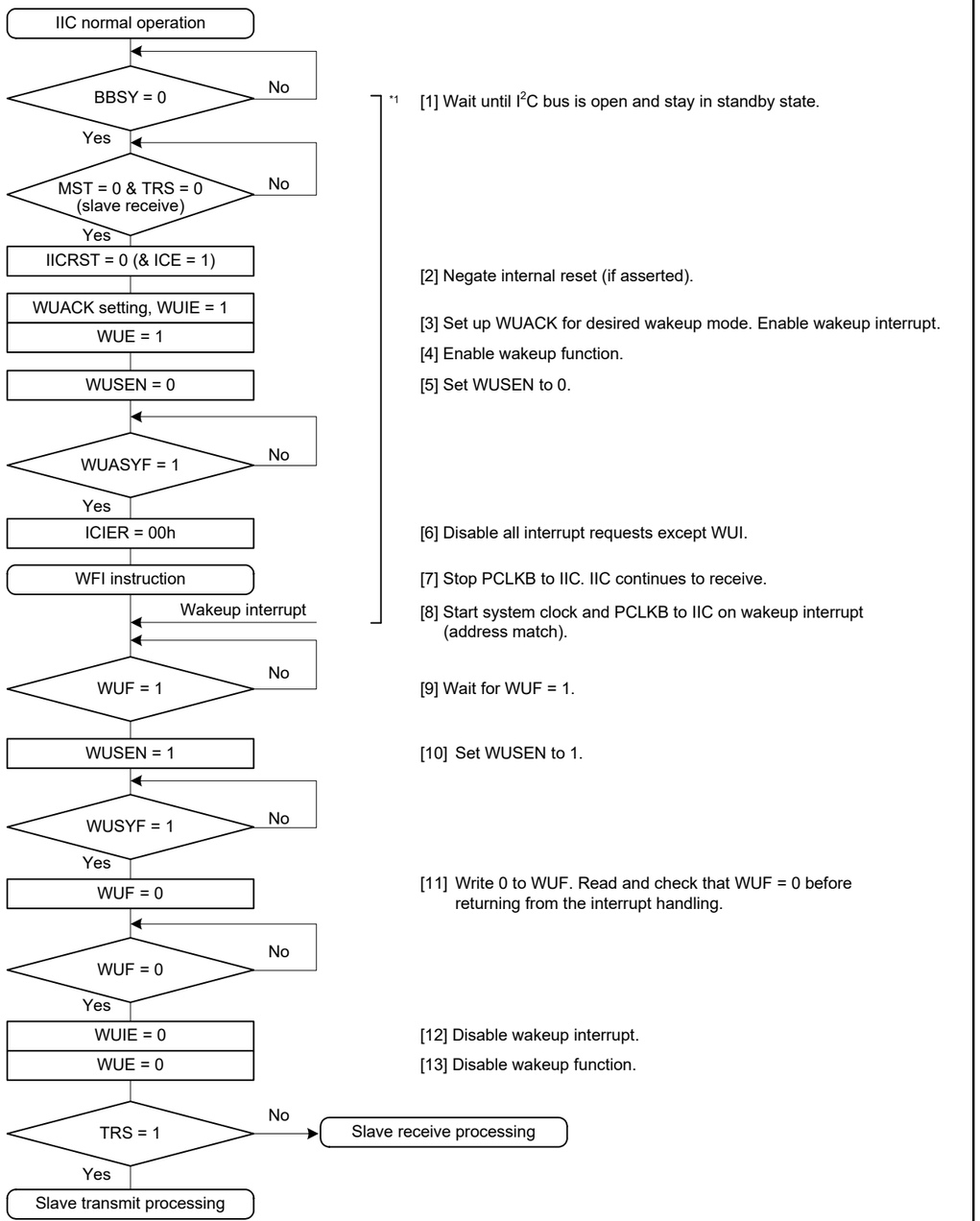
唤醒前：发送ACK以响应接收到的带有IIC从机地址的数据。
唤醒期间：在SCL的第9个时钟周期做出ACK响应，之后SCL保持低电平*1。
唤醒后：继续正常操作。

如果从机地址不匹配，则SCL线在SCL的第9个时钟周期后不保持低电平，从机操作继续。

图29.30显示了一个操作示例，图29.32显示了详细的时序。

注1.在唤醒期间的第9个时钟周期和第1个时钟周期之间，WAIT=1无效。

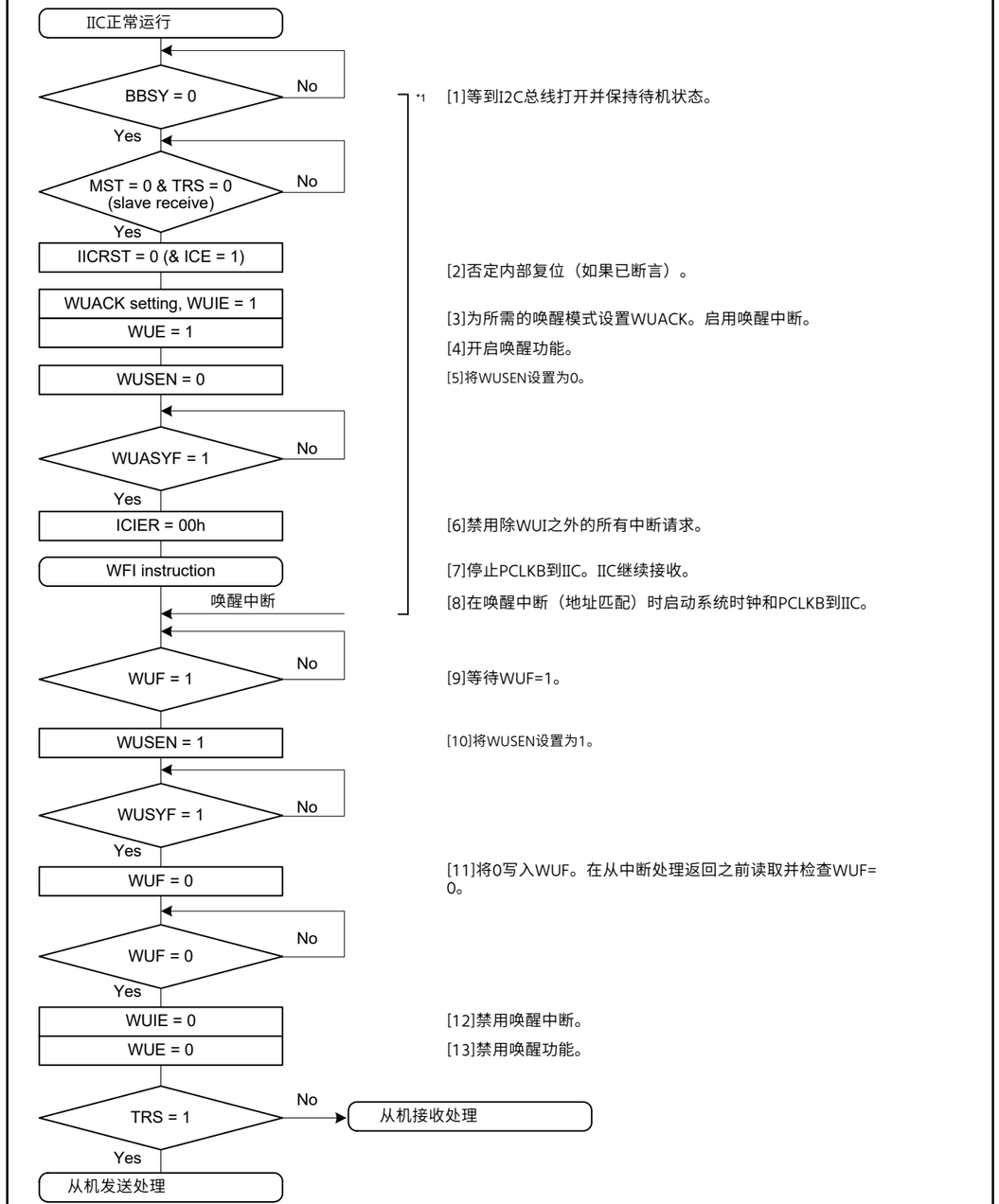
如果从软件待机模式的转换是由唤醒中断以外的中断触发的，例如IRQn，WUF标志未设置为1。图29.31显示了一个操作示例。



Note 1. Do not issue start condition from the setting of BBSY = 0 to the execution of the WFI instruction.

Figure 29.30 Example operation of normal wakeup mode 1 when wakeup is triggered by a wakeup interrupt on match of the slave address

Note: See Precautions on the use of the wakeup function.



Note 1. 不要从设置BBSY=0到执行WFI指令发出启动条件。

Figure 29.30 正常唤醒模式1的示例操作，当唤醒由从地址匹配时的唤醒中断触发时

Note: 请参阅唤醒功能使用注意事项。

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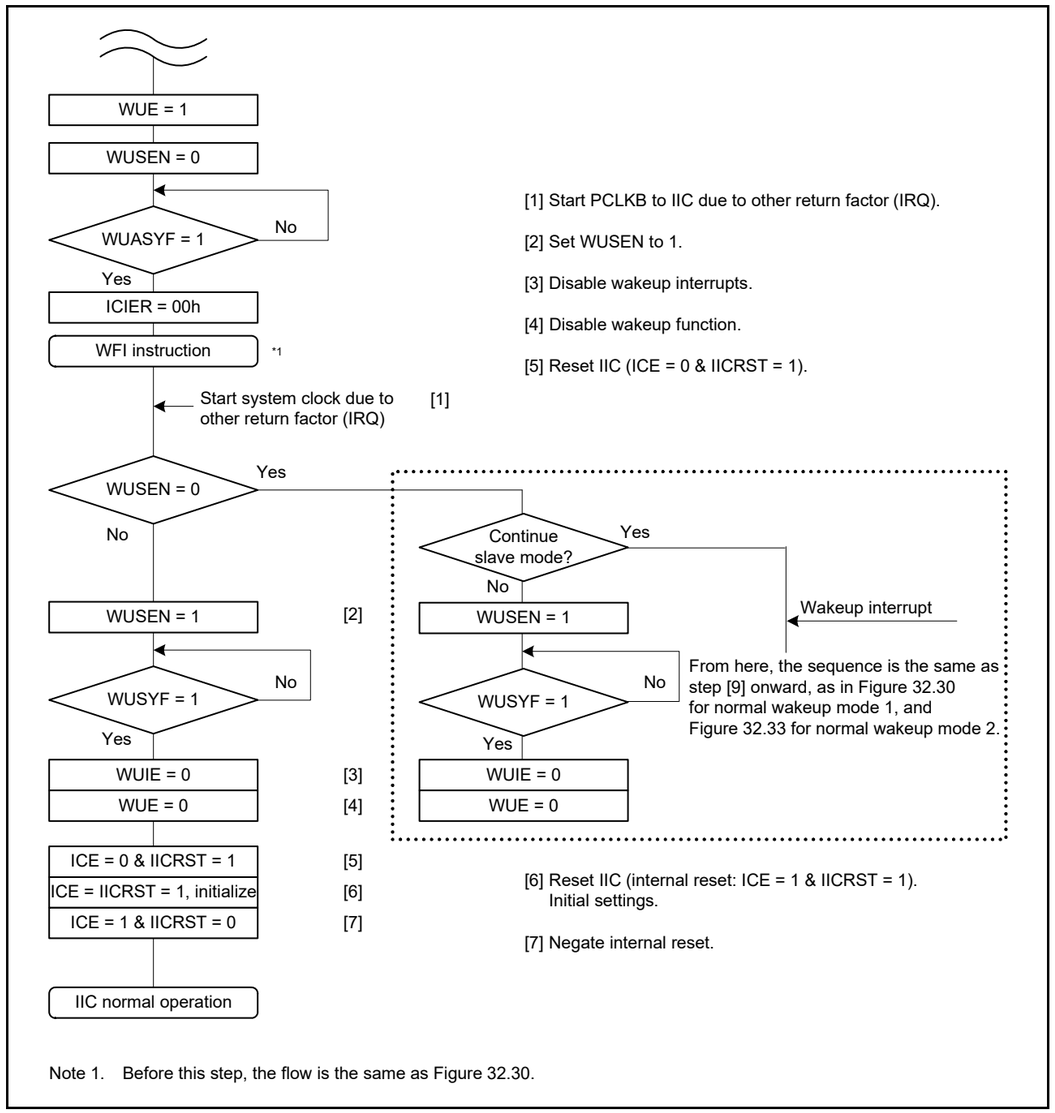


Figure 29.31 Example operation of normal wakeup modes 1 and 2 when wakeup is triggered by an interrupt other than IIC wakeup interrupt, for example, the IRQn

Note: For details on the IIC initial settings, see section 29.3.2, Initial Settings.

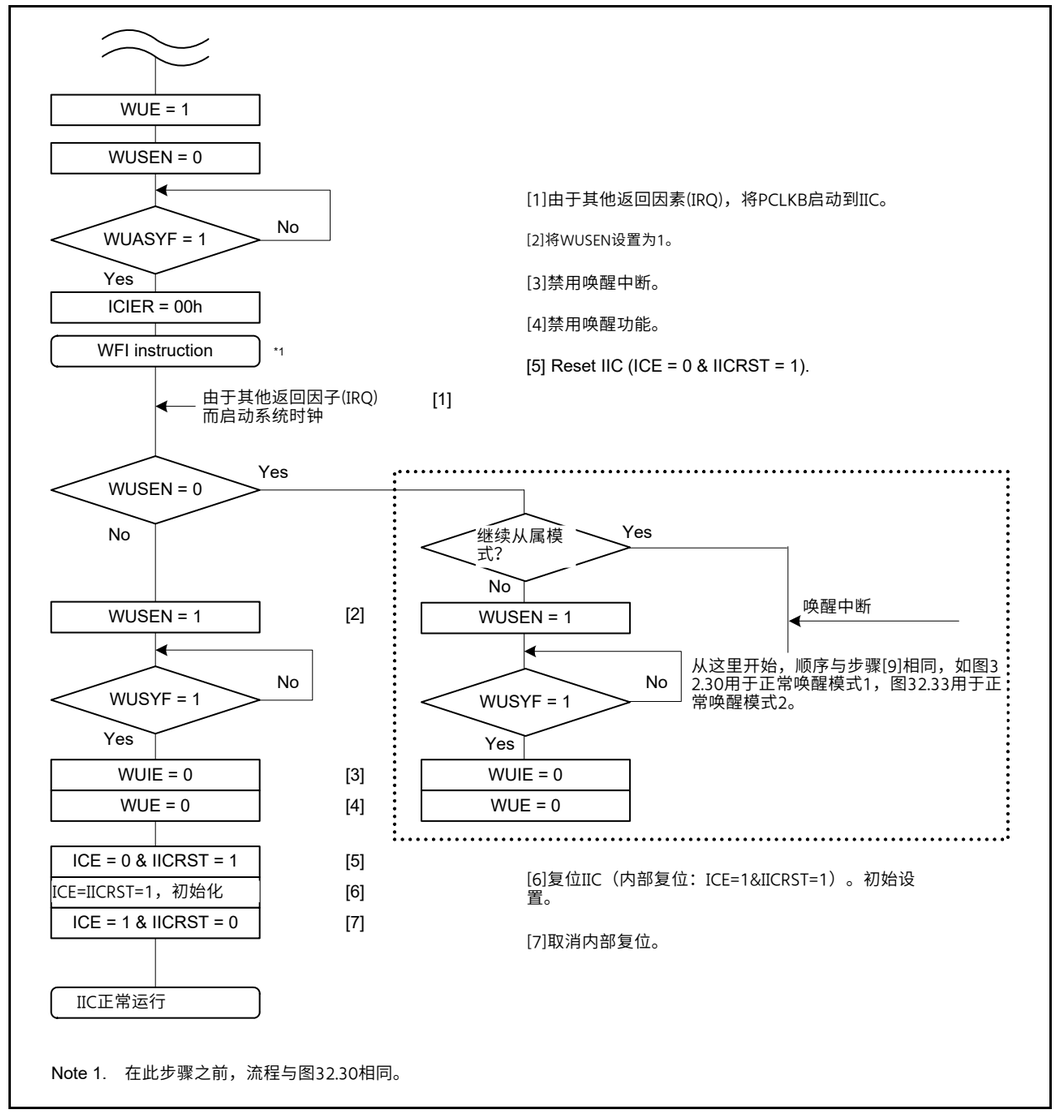


Figure 29.31 当唤醒由IIC唤醒中断以外的中断（例如IRQn）触发时，正常唤醒模式1和2的示例操作

Note: 有关IIC初始设置的详细信息，请参阅第29.3.2节，初始设置。

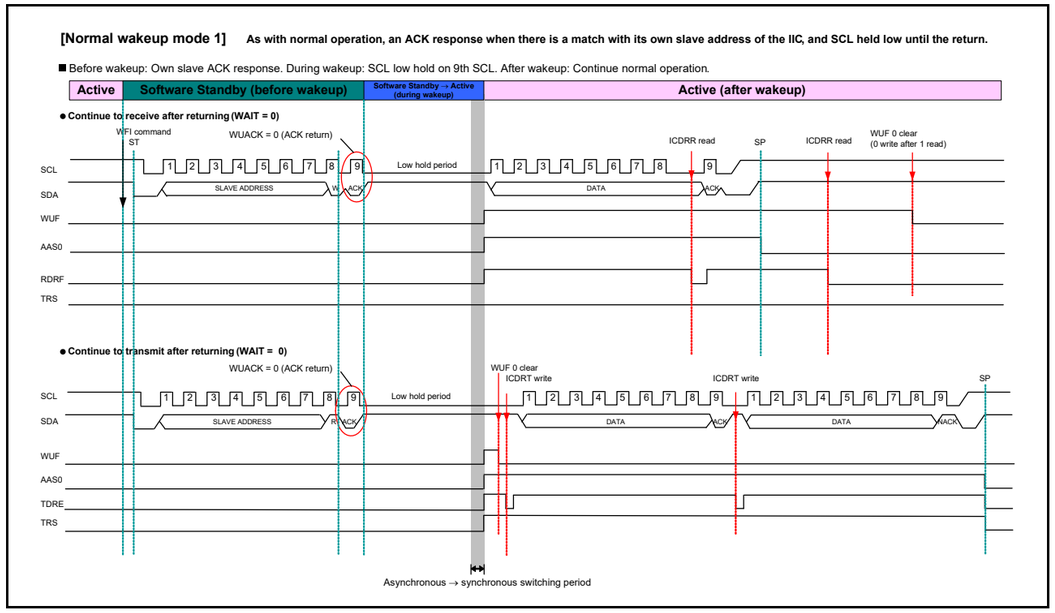


Figure 29.32 Timing of normal wakeup mode 1

29.8.2 Normal Wakeup Mode 2

This section describes the behavior, timing, and an example operation of normal wakeup mode 2.

In normal wakeup mode 2, a wakeup interrupt triggered by a match of the slave address initiates the transition to normal operation as follows:

Before wakeup: No response to data received with its own slave address until the end of the 8th SCL cycle.
During wakeup: SCL line held low during the 8th and 9th clock cycles.
After wakeup: ACK returns on the 9th clock cycle of SCL, and normal operation continues.

If the slave address does not match, the SCL line is not held low after the 8th SCL clock cycle, and the slave operation continues.

Figure 29.33 shows an example operation, and Figure 29.34 shows the detailed timing.

If the transition from Software Standby mode is triggered by an interrupt other than a wakeup interrupt, such as the IRQn for example, the WUF flag is not set to 1. Figure 29.31 shows an operation example.

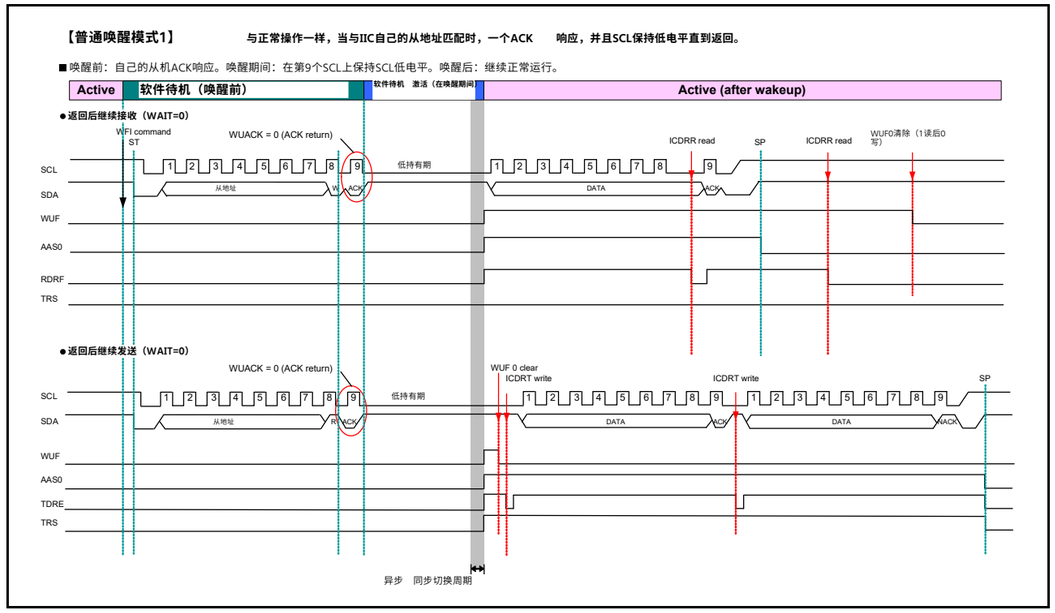


Figure 29.32 正常唤醒模式1的时序

29.8.2 正常唤醒模式2

本节介绍正常唤醒模式2的行为、时序和示例操作。

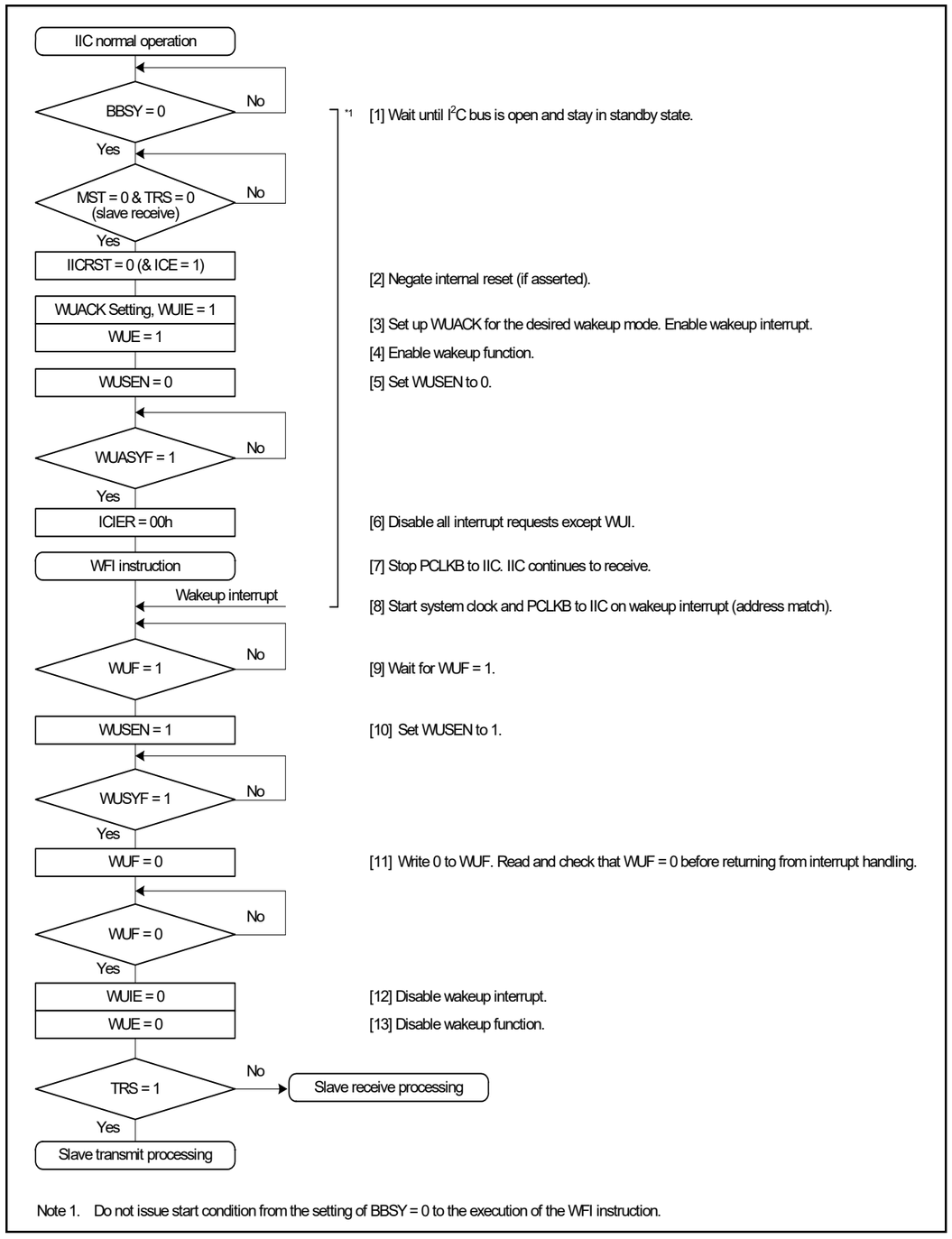
在正常唤醒模式2中，由匹配从机地址触发的唤醒中断会启动到正常操作的转换，如下所示：

唤醒前：在第8个SCL周期结束之前，对接收到的带有自己的从地址的数据没有响应。
唤醒期间：SCL线在第8和第9个时钟周期内保持低电平。
唤醒后：ACK在SCL的第9个时钟周期返回，继续正常运行。

如果从机地址不匹配，则SCL线在第8个SCL时钟周期后不会保持低电平，从机操作继续。

图29.33显示了一个示例操作，图29.34显示了详细的时序。

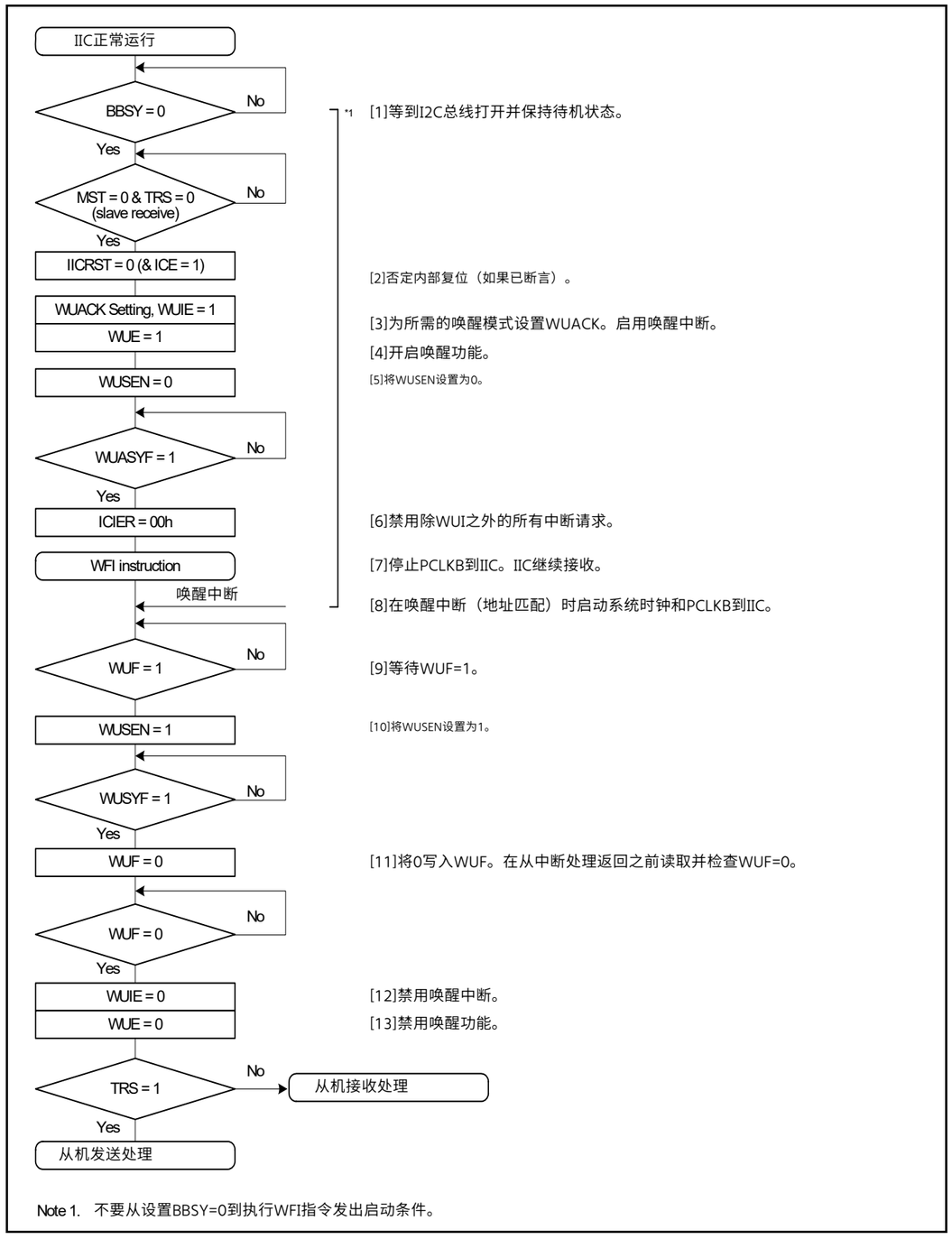
如果从软件待机模式的转换是由唤醒中断以外的中断触发的，例如IRQn，则WUF标志不会设置为1。图29.31显示了一个操作示例。



Note 1. Do not issue start condition from the setting of BBSY = 0 to the execution of the WFI instruction.

Figure 29.33 Example operation of normal wakeup mode 2 when wakeup is triggered by a wakeup interrupt on match of the slave address

Note: See Precautions on the use of the wakeup function.



Note 1. 不要从设置BBSY=0到执行WFI指令发出启动条件。

Figure 29.33 正常唤醒模式2的示例操作，当唤醒由从地址匹配时的唤醒中断触发时

Note: 请参阅唤醒功能使用注意事项。

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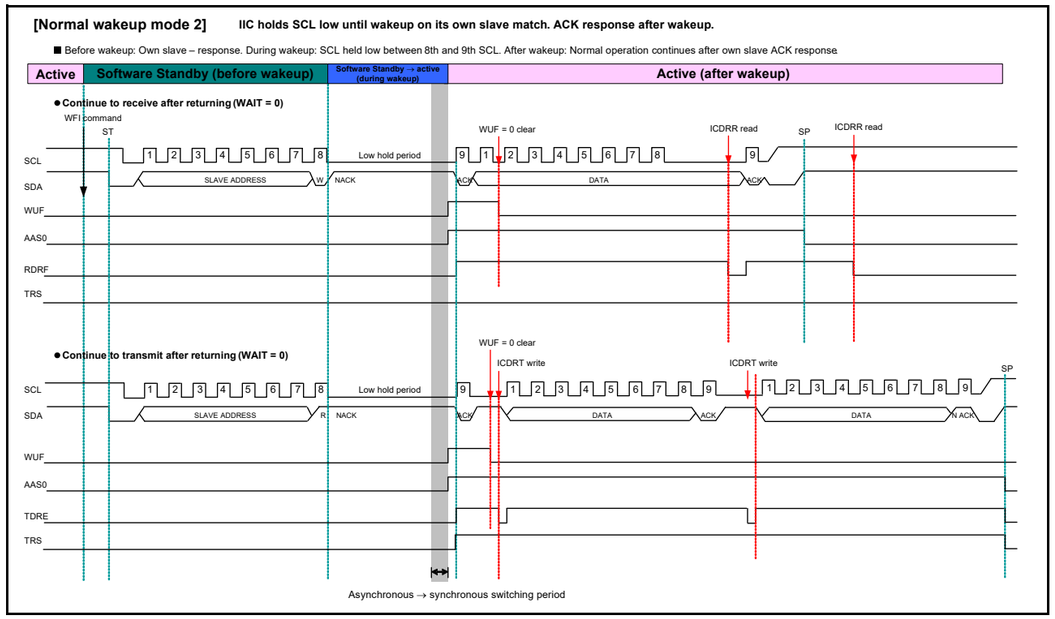


Figure 29.34 Timing of normal wakeup mode 2

29.8.3 Command Recovery Mode and EEP Response Mode (Special Wakeup Modes)

This section describes the behavior, timing, and an example operation in the command recovery and EEP response modes.

In the command recovery and EEP response modes, the SCL line is not held low during the wakeup period (after the rise of the 9th clock cycle of SCL). Therefore, other IIC devices can use the I2C bus during this period.

A wakeup interrupt triggered by a match of the slave address initiates the transition to normal operation as follows:

Before wakeup: In response to data received with its own slave address, the IIC returns ACK (command recovery mode) or NACK (EEP response mode).

During wakeup: The SCL line is not held low.

After wakeup: Normal operation continues after IIC initialization.

If the slave address does not match, the slave operation continues.

Note: Because the SCL line is not held low during wakeup, transmission or reception of the data that follows the slave address is not possible.

Note: The command recovery and EEP response modes are internal reset states (ICE = IICRST = 1). Therefore, the match of the slave address does not set the flags HOA, GCA, ASS0, ASS1, and ASS2 in the ICSR1 register.

Figure 29.35 shows an example of operation in command recovery and EEP response modes. Figure 29.37 shows the detailed timing.

If the transition from Software Standby mode is triggered by an interrupt other than a wakeup interrupt, for example the IRQn, the WUF flag is not set to 1. Figure 29.36 shows an operation example.

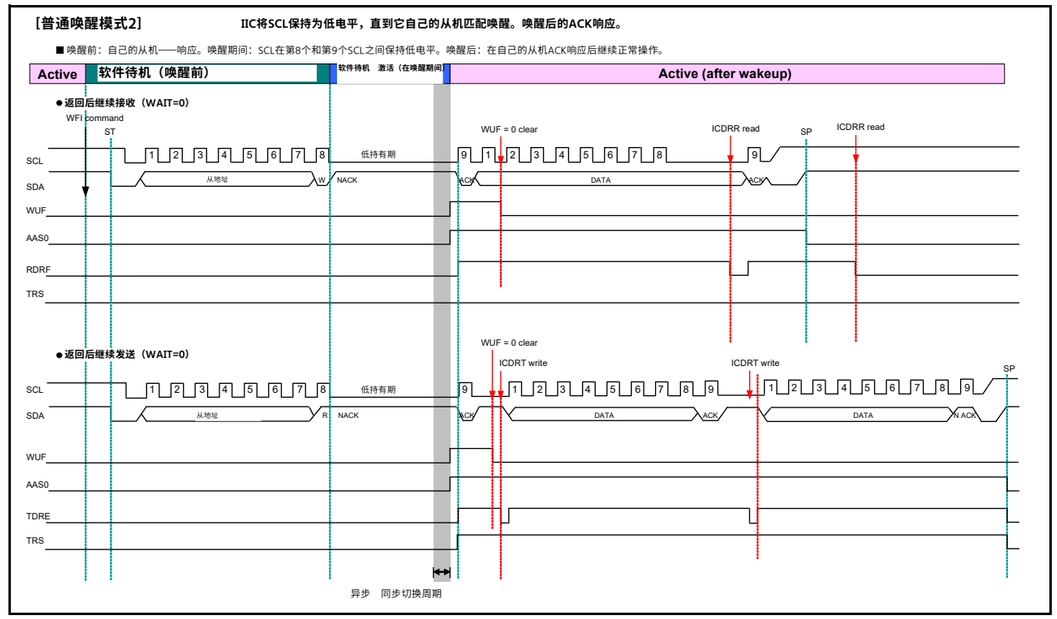


Figure 29.34 正常唤醒模式2的时序

29.8.3 命令恢复模式和EEP响应模式（特殊唤醒模式）

本节介绍命令恢复和EEP响应模式下的行为、时序和示例操作。

在命令恢复和EEP响应模式下，SCL线在唤醒期间（在SCL的第9个时钟周期上升之后）不保持低电平。因此，其他IIC设备在此期间可以使用I2C总线。

由匹配从地址触发的唤醒中断会启动到正常操作的转换，如下所示：

唤醒前：响应接收到带有自己的从机地址的数据，IIC返回ACK（命令恢复模式）或NACK（EEP响应模式）。唤醒期间：SCL线不保持低电平。

唤醒后：IIC初始化后继续正常运行。

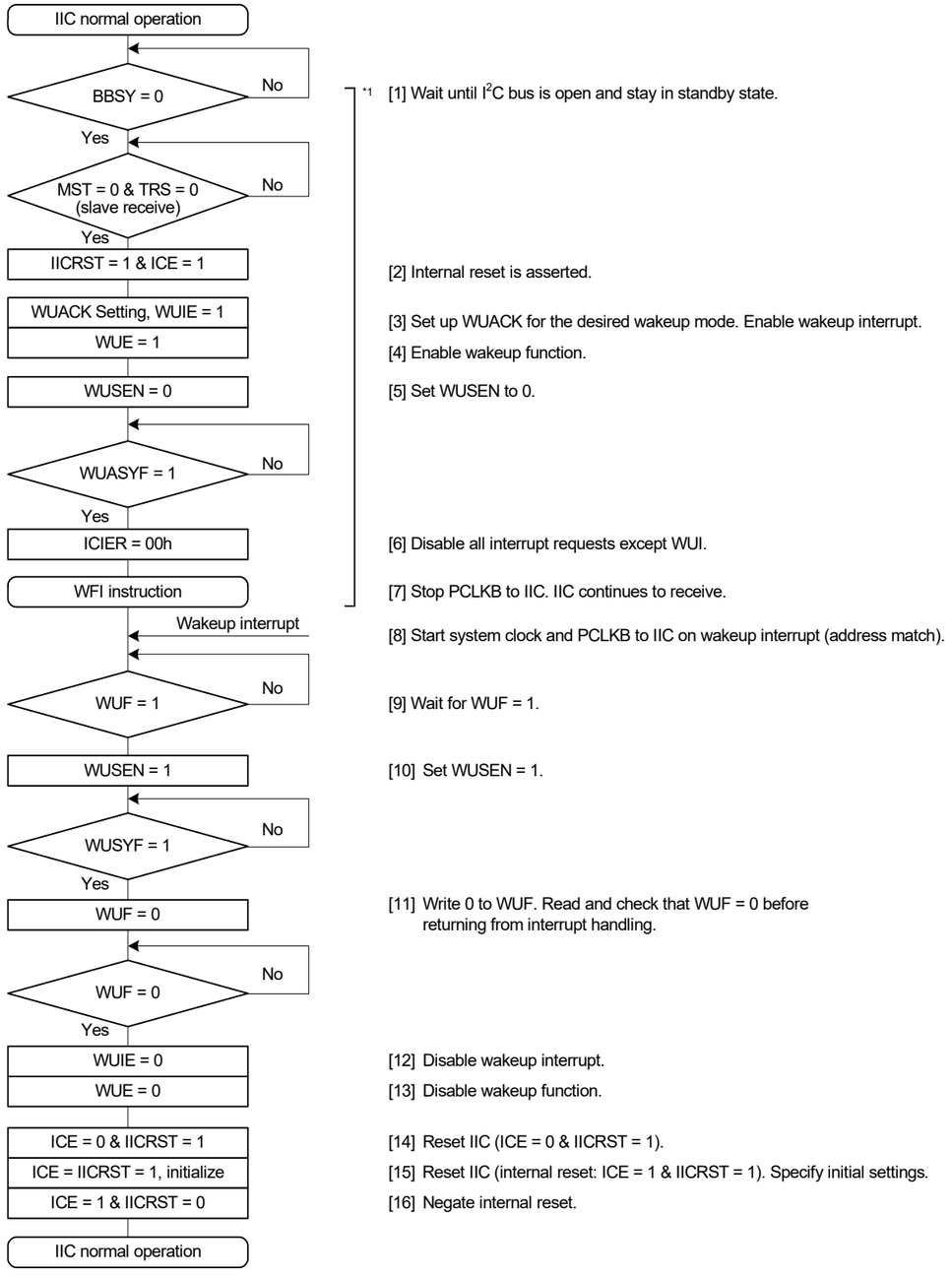
如果从机地址不匹配，从机操作继续。

Note: 因为SCL线在唤醒期间没有保持低电平，所以无法发送或接收跟随从地址的数据。

Note: 命令恢复和EEP响应模式是内部复位状态(ICE=IICRST=1)。因此，从地址的匹配不会设置ICSR1寄存器中的标志HOA、GCA、ASS0、ASS1和ASS2。

图29.35显示了命令恢复和EEP响应模式下的操作示例。图29.37显示了详细的时序。

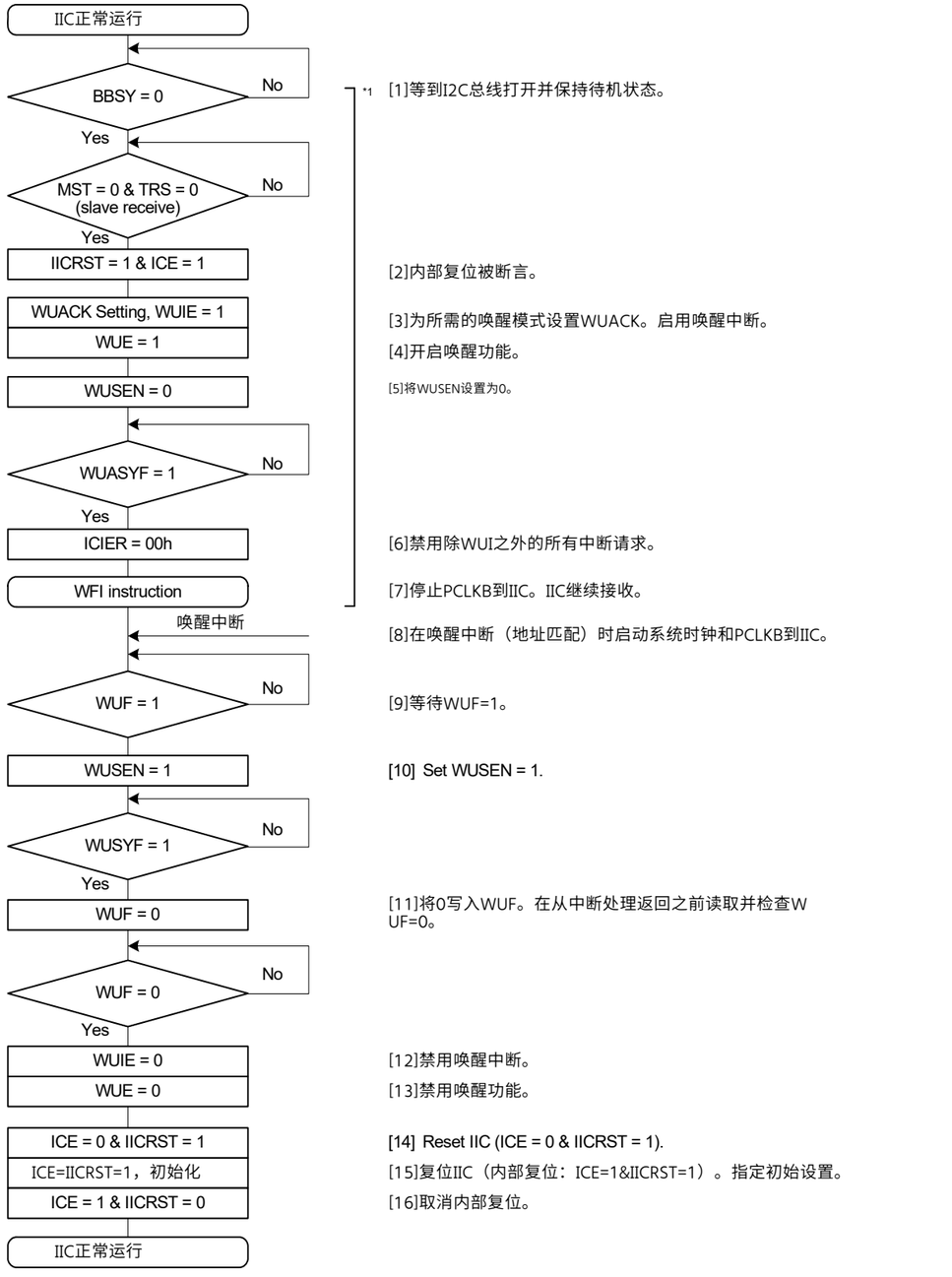
如果从软件待机模式的转换是由唤醒中断以外的中断触发的，例如IRQn，WUF标志未设置为1。图29.36显示了一个操作示例。



Note 1. Do not issue start condition from the setting of BBSY = 0 to the execution of the WFI instruction.

Figure 29.35 Example operation of command recovery and EEP response modes when wakeup is triggered by a wakeup interrupt on match of the slave address

Note: See Precautions on the use of the wakeup function.



Note 1. 不要从设置BBSY=0到执行WFI指令发出启动条件。

Figure 29.35 当从地址匹配时由唤醒中断触发唤醒时命令恢复和EEP响应模式的示例操作

Note: 请参阅唤醒功能使用注意事项。

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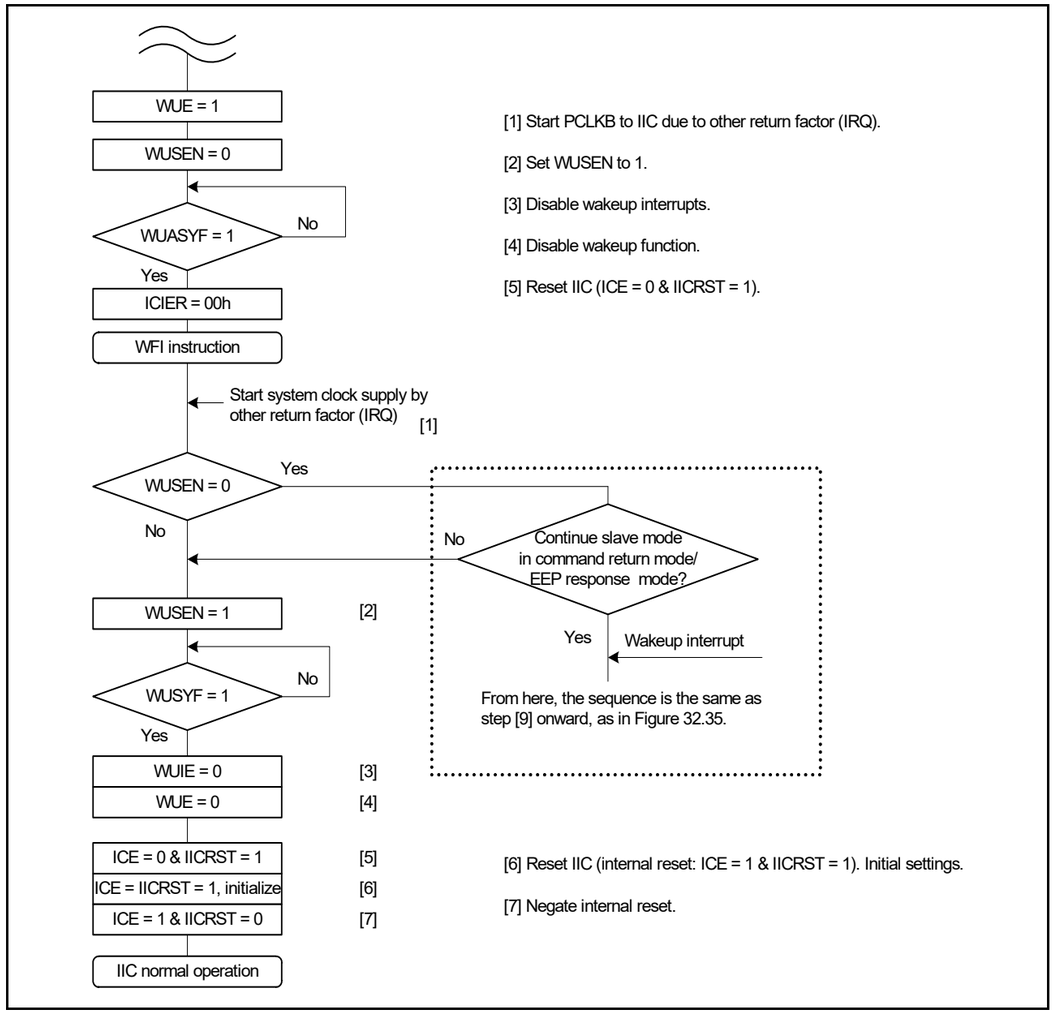

Figure 29.36 Example operation of command recovery mode and EEP response mode when wakeup is triggered by the interrupt other than IIC wakeup interrupt, for example, the IRQn

Note: For details on the IIC initial settings, see section 29.3.2, Initial Settings.

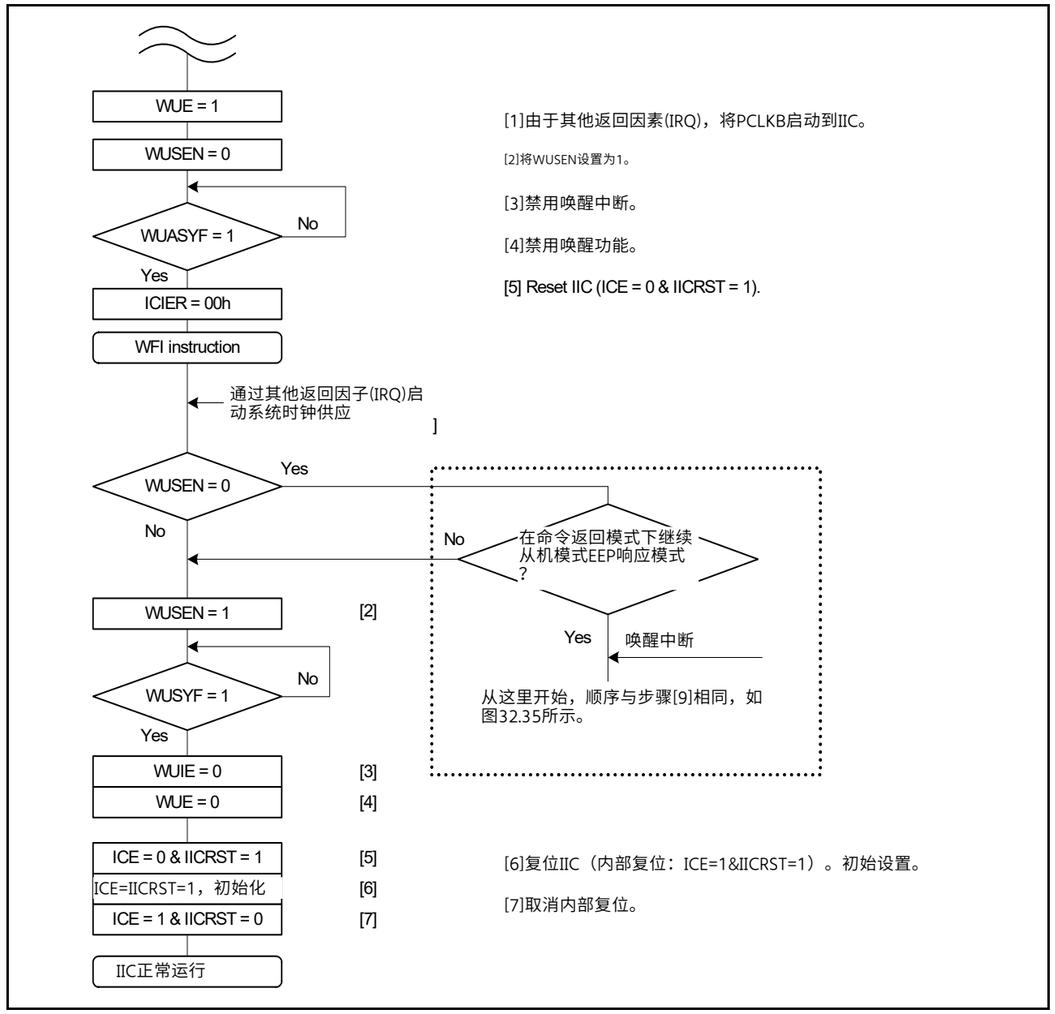

Figure 29.36 由IIC唤醒中断以外的中断（例如IRQn）触发唤醒时的命令恢复模式和EEP响应模式的示例操作

Note: 有关IIC初始设置的详细信息，请参阅第29.3.2节，初始设置。

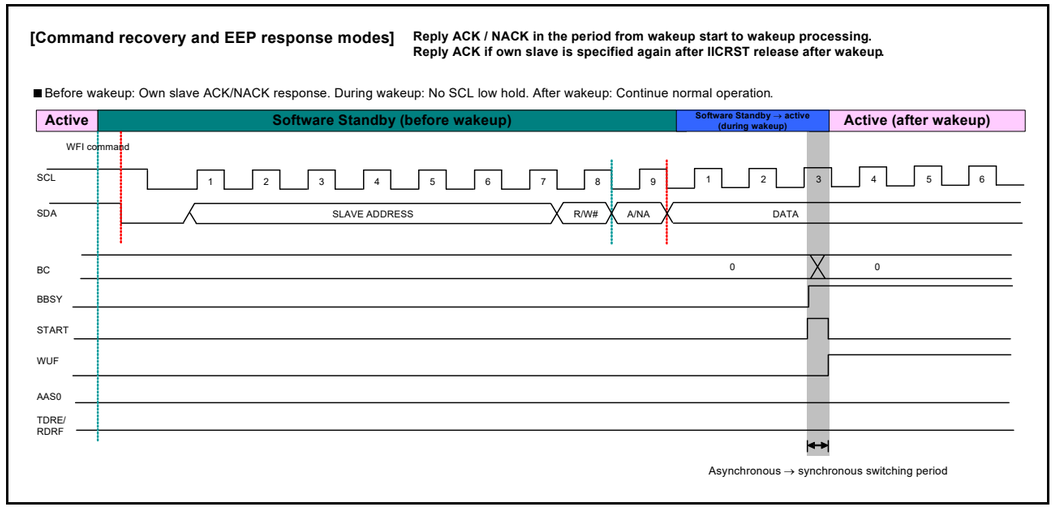

Figure 29.37 Timing of command recovery and EEP response modes

29.8.4 Precautions for WFI Instruction Execution

In the wakeup function examples shown in Figure 29.30, Figure 29.33, and Figure 29.35, make sure that the start condition is not issued during the period from the setting of BBSY = 0 to the execution of the WFI instruction.

When a start condition is issued during this period, NACK is returned after the reception of the first byte of the first data block. Detection of the start or restart condition then enables the wakeup function.

29.9 Automatic Low-Hold Function for SCL

29.9.1 Function to Prevent Wrong Transmission of Transmit Data

If the I2C Bus Shift Register (ICDRS) is empty when data has not been written to the I2C Bus Transmit Data Register (ICDRT) with the IIC in transmission mode (ICCR2.TRS bit = 1), the SCLn line is automatically held at the low level over the subsequent intervals. This low-hold period is extended until the transmit data is written, which prevents the unintended transmission of erroneous data.

Master transmit mode:

- Low-level interval after a start or restart condition is issued
- Low-level interval between the 9th clock cycle of one transfer and the 1st clock cycle of the next.

Slave transmit mode:

- Low-level interval between the 9th clock cycle of one transfer and the 1st clock cycle of the next.

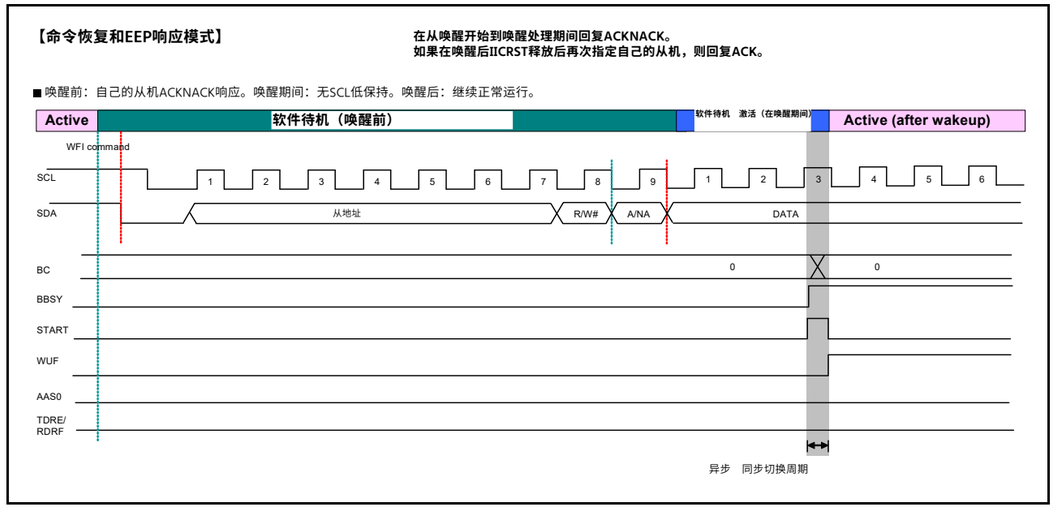

Figure 29.37 命令恢复和EEP响应模式的时序

29.8.4 WFI指令执行注意事项

在图29.30、图29.33和图29.35所示的唤醒功能示例中，请确保在设置BBSY=0到执行WFI指令期间不发出启动条件。

如果在此期间发出启动条件，则在接收到第一个数据块的第一个字节后返回NACK。启动或重启条件的检测然后启用唤醒功能。

29.9 SCL的自动低保持功能

29.9.1 防止传输数据错误传输的功能

如果I2C总线移位寄存器(ICDRS)在IIC处于传输模式（ICCR2.TRS位=1）时尚未将数据写入I2C总线传输数据寄存器(ICDRT)时为空，则SCLn线为在随后的时间间隔内自动保持在低电平。这个低保持期一直延长到发送数据被写入，这样可以防止错误数据的意外传输。

主传输模式：

- 发出启动或重启条件后的低电平间隔
- 一次传输的第9个时钟周期和下一次传输的第1个时钟周期之间的低电平间隔。

从机发送模式：

- 一次传输的第9个时钟周期和下一次传输的第1个时钟周期之间的低电平间隔。

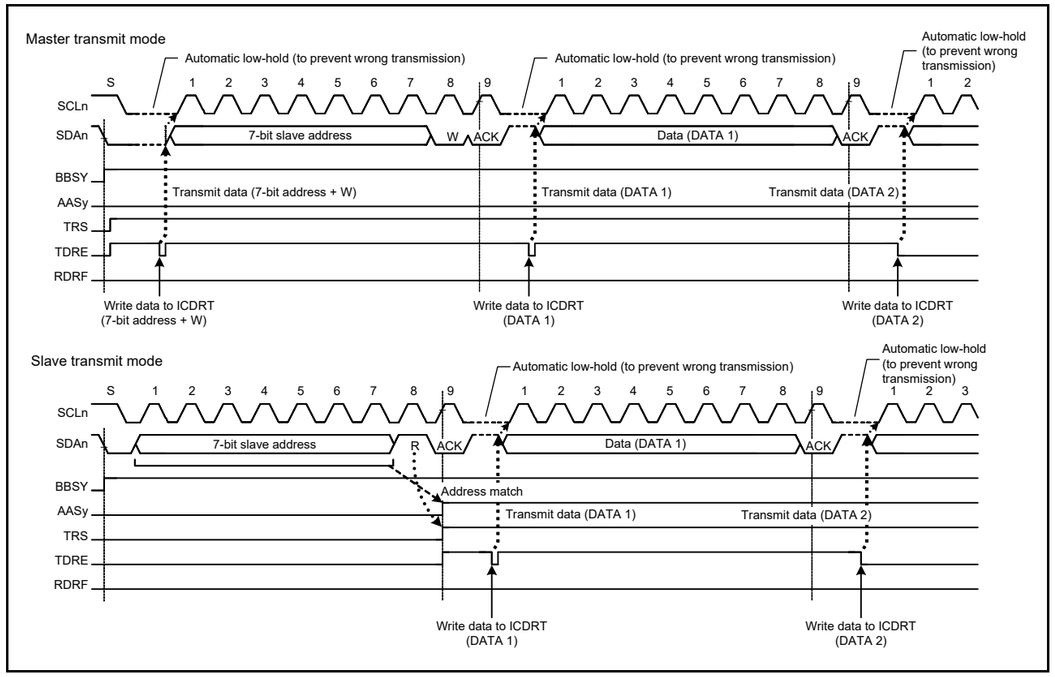

Figure 29.38 Automatic low-hold operation in transmit mode

29.9.2 NACK Reception Transfer Suspension Function

This function suspends transfer operation when NACK is received in transmit mode (ICCR2.TRS bit = 1). This function is enabled when the NACKE bit in ICFER is set to 1 (transfer suspension enabled). If the next transmit data is already written (TDRE flag = 0 in ICSR2) when NACK is received, the next data transmission on the falling edge of the 9th SCL clock cycle is automatically suspended. This prevents the SDAn line output level from being held low when the MSB of the next transmit data is 0.

If the transfer operation is suspended by this function (NACKF = 1 in ICSR2), transmit and receive operations are discontinued. To restore transmit or receive operations, set the NACKF flag to 0. In master transmit mode, after issuing a restart or stop condition, set the NACKF flag to 0, then issue a start condition again.

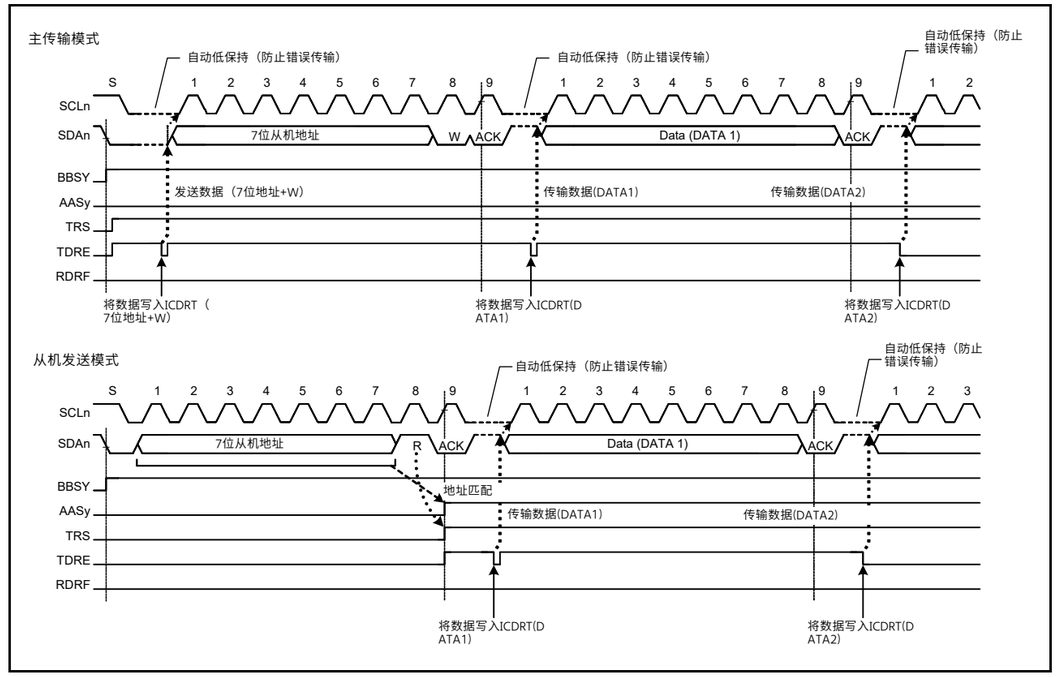

Figure 29.38 发送模式下的自动低保持操作

29.9.2 NACK接收传输暂停功能

当在发送模式下接收到NACK（ICCR2.TRS位=1）时，该函数暂停传输操作。当ICFER中的NACKE位设置为1（传输暂停使能）时，该功能被启用。如果接收到NACK时已经写入下一个发送数据（ICSR2中的TDRE标志=0），则在第9个SCL时钟周期的下降沿自动暂停下一个数据发送。这可以防止SDAn线路输出电平在下一个发送数据的MSB为0时保持低电平。

如果传输操作被此函数挂起（ICSR2中的NACKF=1），发送和接收操作将中断。要恢复发送或接收操作，请将NACKF标志设置为0。在主机发送模式下，发出重启或停止条件后，将NACKF标志设置为0，然后再次发出启动条件。

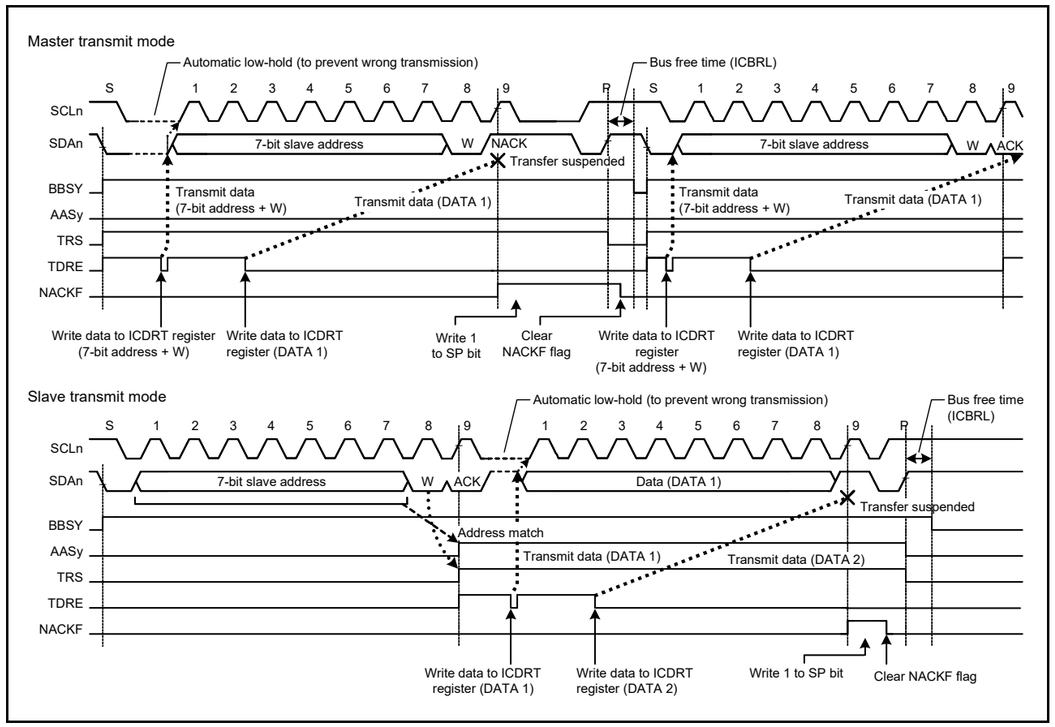

Figure 29.39 Suspension of data transfer when NACK is received (NACKE = 1)

29.9.3 Function to Prevent Failure to Receive Data

If response processing when receive data (ICDRR) read is delayed for a period of one transfer frame or more with receive data full (RDRF flag = 1 in ICSR2) in receive mode (TRS = 0 in ICCR2), the IIC holds the SCLn line low automatically immediately before the next data is received to prevent failure to receive data.

This function is also enabled even if the read processing of the final receive data is delayed and, in the meantime, the IIC slave address is designated after a stop condition is issued. This function does not interfere with other communication because the IIC does not hold the SCLn line low when a mismatch with its own slave address occurs after a stop condition is issued.

Periods in which the SCLn line is held low can be selected with a combination of the WAIT and RDRFS bits in ICMR3.

(1) 1-byte receive operation and automatic low-hold function using the WAIT bit

When the WAIT bit in ICMR3 is set to 1, the IIC performs a 1-byte receive operation using the WAIT bit function. Additionally, when the ICMR3.RDRFS bit is 0, the IIC automatically sends the ACKBT bit value in ICMR3 for the acknowledge bit in the period from the falling edge of the 8th SCL clock cycle to the falling edge of the 9th SCL clock cycle, and automatically holds the SCLn line low on the falling edge of the 9th SCL clock cycle using the WAIT bit function. This low-hold is released by reading data from ICDRR, which enables byte-wise receive operation.

The WAIT bit function is enabled for receive frames after a match with the IIC slave address, including the general call address and host address, is obtained in master receive mode or slave receive mode.

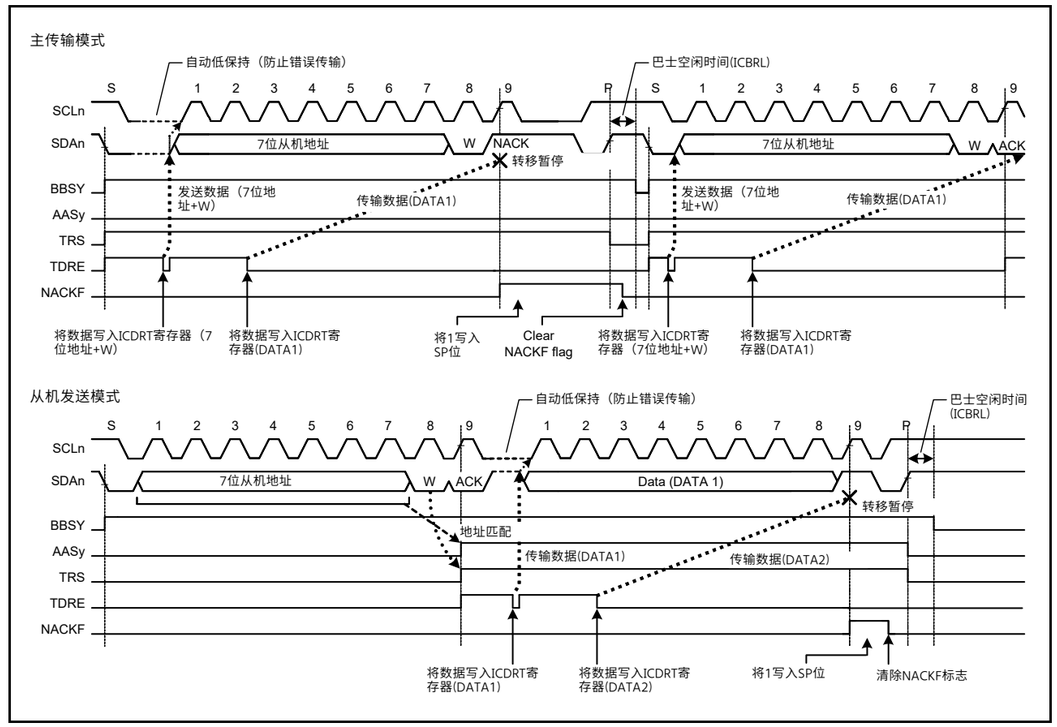

Figure 29.39 接收到NACK时暂停数据传输(NACKE=1)

29.9.3 防止数据接收失败的功能

如果在接收模式（ICCR2中的TRS=0）下接收数据已满（ICSR2中的RDRF标志=1）时，当接收数据（ICDRR）读取延迟一个传输帧或更长时间时的响应处理，则IIC保持SCLn线在接收到下一个数据之前自动拉低，以防止接收数据失败。

即使最终接收数据的读取处理被延迟，该功能也被启用，同时，在发出停止条件后指定IIC从地址。此功能不会干扰其他通信，因为在发出停止条件后发生与其自己的从地址不匹配时，IIC不会将SCLn线保持为低电平。

SCLn线保持低电平的周期可以通过ICMR3中的WAIT和RDRFS位的组合来选择。

(1) 使用WAIT位的1字节接收操作和自动低保持功能

当ICMR3中的WAIT位设置为1时，IIC使用WAIT位功能执行1字节接收操作。此外，当ICMR3.RDRFS位为0时，IIC在第8个SCL时钟周期的下降沿到第9个SCL时钟周期的下降沿期间自动发送ICMR3中的ACKBT位值作为确认位，并使用WAIT位功能在第9个SCL时钟周期的下降沿自动将SCLn线保持为低电平。该低保持通过从ICDRR读取数据来释放，从而启用逐字节接收操作。

在主机接收模式或从机接收模式下获得与IIC从机地址（包括广播地址和主机地址）匹配后的接收帧使能WAIT位功能。

(2) 1-byte receive operation (ACK/NACK transmission control) and automatic low-hold function using the RDRFS bit

When the RDRFS bit in ICMR3 is set to 1, the IIC performs a 1-byte receive operation using the RDRFS bit function. When the RDRFS bit is set to 1, the RDRF (receive data full) flag in ICSR2 is set to 1 on the rising edge of the 8th SCL clock cycle, and the SCLn line is automatically held low on the falling edge of the 8th SCL clock cycle. This low-hold is released by writing a value to the ACKBT bit in ICMR3, but cannot be released by reading data from ICDRR, which enables receive operation through the ACK or NACK transmission control based on the data received in byte units.

The RDRFS bit function is enabled for receive frames after a match with the IIC slave address, including the general call address and host address, is obtained in master receive mode or slave receive mode.

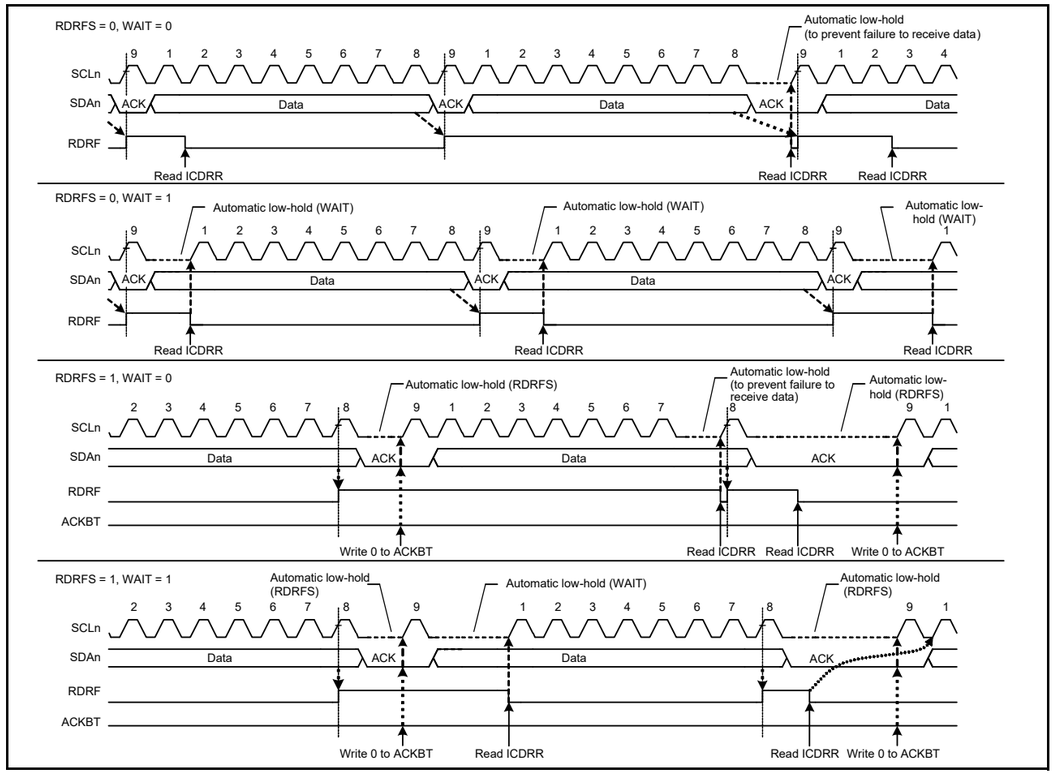

Figure 29.40 Automatic low-hold operation in receive mode using the RDRFS and WAIT bits

29.10 Arbitration-Lost Detection Functions

In addition to the normal arbitration-lost detection function defined by the I2C bus standard, the IIC provides functions to prevent double-issue of a start condition, detect arbitration-lost during the transmission of NACK, and detect arbitration-lost in slave transmit mode.

29.10.1 Master Arbitration-Lost Detection (MALE Bit)

The IIC drives the SDAn line low to issue a start condition. However, if the SDAn line was already driven low by another master device issuing a start condition, the IIC regards its own start condition as an error and considers this a loss in arbitration. Priority is given to transfer by the other master device. Similarly, if a request to issue a start condition is made by setting the ST bit in ICCR2 to 1 while the bus is busy (BBSY = 1 in ICCR2), the IIC regards this as a double-issuing-of-start-condition error and considers itself to have lost the arbitration. This prevents a failure of transfer resulting from a start condition issued while transfer is in progress.

When a start condition is issued successfully, if the transmit data including the address bits (internal SDA output level)

(2) 1字节接收操作（ACKNACK传输控制）和使用RDRFS位的自动低保持功能

当ICMR3中的RDRFS位设置为1时，IIC使用RDRFS位功能执行1字节接收操作。
当RDRFS位设置为1时，ICSR2中的RDRF（接收数据满）标志在第8个SCL时钟周期的上升沿设置为1，并且SCLn线在第8个下降沿自动保持为低第SCL时钟周期。该低保持通过向ICMR3中的ACKBT位写入值来释放，但不能通过从ICDRR读取数据来释放，ICDRR可以根据以字节为单位接收的数据通过ACK或NACK传输控制进行接收操作。

在主接收模式或从接收模式下获得与IIC从地址匹配的接收帧（包括广播地址和主机地址）后，使能RDRFS位功能。

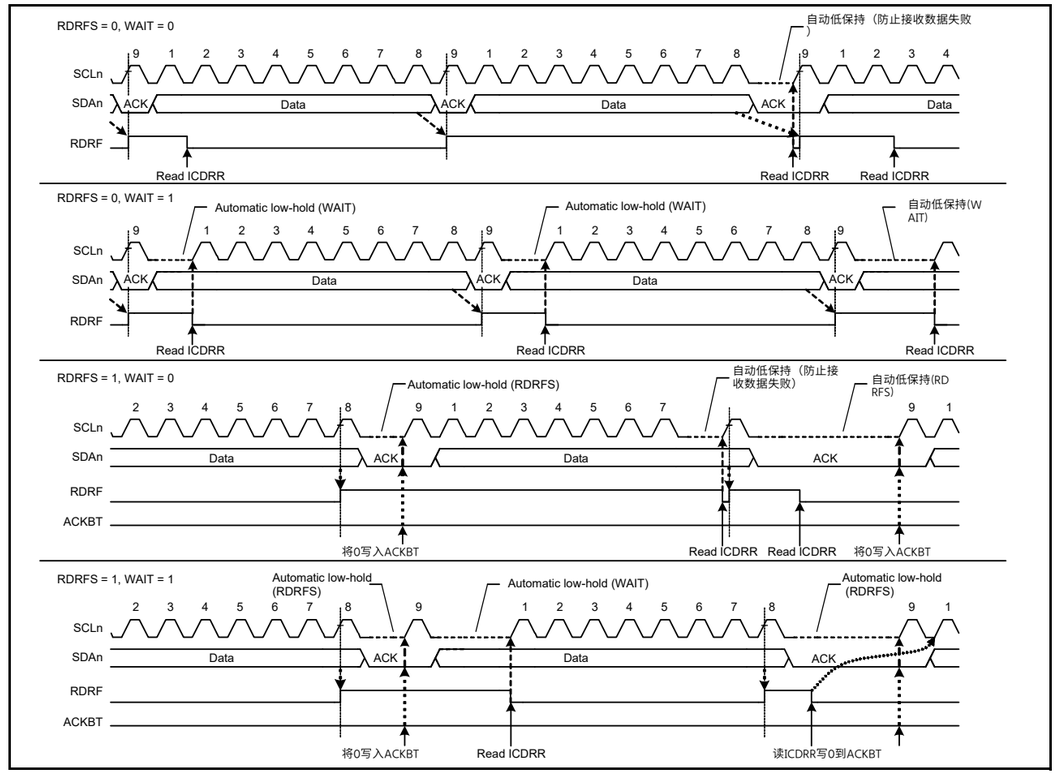

Figure 29.40 使用RDRFS和WAIT位在接收模式下自动保持低电平操作

29.10 仲裁丢失检测功能

除了I2C总线标准定义的正常仲裁丢失检测功能外，IIC还提供防止重复发出启动条件、在NACK传输期间检测仲裁丢失以及在从发送模式下检测仲裁丢失的功能.

29.10.1 主仲裁丢失检测（MALE位）

IIC将SDAn线驱动为低电平以发出启动条件。但是，如果SDAn线已经被另一个发出启动条件的主设备驱动为低电平，则IIC将其自己的启动条件视为错误，并认为这是仲裁失败。其他主设备优先传输。类似地，如果在总线忙时（ICCR2中的BBSY=1）通过将ICCR2中的ST位设置为1来请求发出启动条件，则IIC将此视为双重发出启动条件错误并考虑本身已经失去了仲裁。这可以防止传输过程中发出的开始条件导致传输失败。

成功发出启动条件时，如果发送数据包括地址位（内部SDA输出电平）

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and the level on the SDAn line do not match (high output as the internal SDA output, meaning the SDAn pin is in the high-impedance state) and a low level is detected on the SDAn line, IIC loses the arbitration.

After a loss in arbitration of mastership, the IIC immediately enters slave receive mode. If a slave address, including the general call address, matches its own address at this time, the IIC continues in slave operation.

A loss in arbitration of mastership is detected when the following conditions are met while the MALE bit in ICFER is 1 (master arbitration-lost detection enabled).

[Master arbitration-lost conditions]

- Mismatching of the internal level for output on SDA and the level on the SDAn line after a start condition was issued by setting the ICCR2.ST bit to 1 while the BBSY flag in ICCR2 is set to 0 (erroneous issuing of a start condition)
- Setting of the ICCR2.ST bit to 1 (start condition double-issue error) while the BBSY flag is 1
- When the transmit data excluding acknowledge (internal SDA output level) does not match the level on the SDAn line in master transmit mode (MST and TRS bits = 11b in ICCR2).

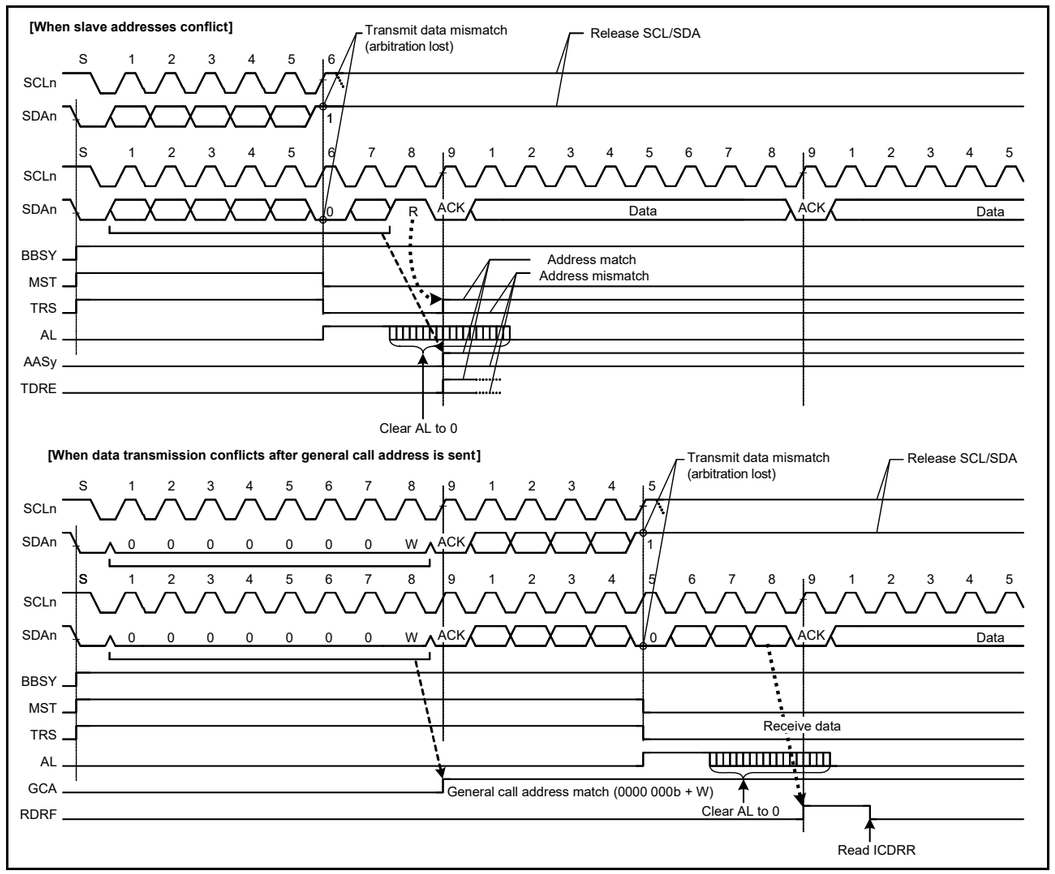

Figure 29.41 Examples of master arbitration-lost detection (MALE = 1)

和SDAn线上的电平不匹配（高输出作为内部SDA输出，意味着SDAn引脚处于高阻状态）并且在SDAn线上检测到低电平，IIC失去仲裁。

在主控权仲裁失败后，IIC立即进入从机接收模式。如果此时从机地址（包括广播地址）与自己的地址匹配，则IIC继续从机操作。

当ICFER中的MALE位为1（启用主仲裁丢失检测）时满足以下条件时，检测到主控仲裁丢失。

[Master arbitration-lost conditions]

- 通过将ICCR2.ST位设置为1而ICCR2中的BBSY标志设置为0发出启动条件后，SDA输出的内部电平与SDAn线上的电平不匹配（错误发出启动条件）
- 当BBSY标志为1时，将ICCR2.ST位设置为1（启动条件双发错误）
- 当发送数据不包括确认（内部SDA输出电平）与主发送模式下SDAn线上的电平不匹配时（ICCR2中的MST和TRS位=11b）。

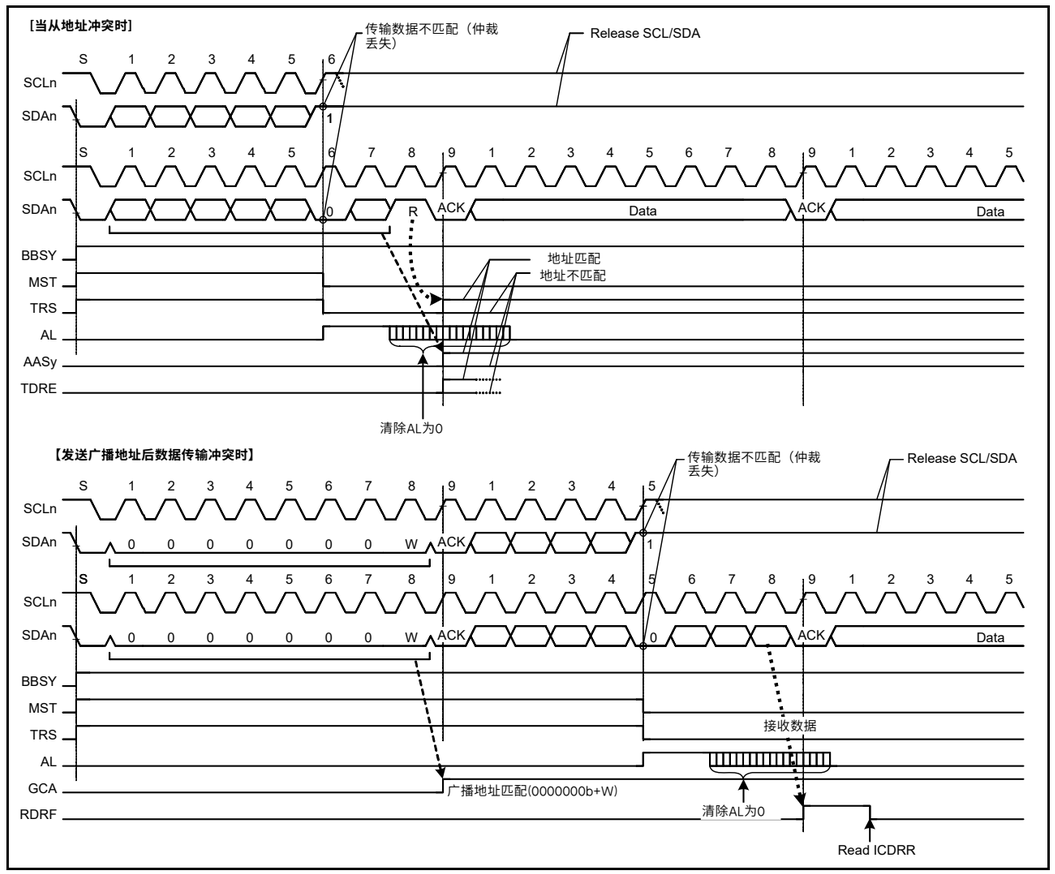

Figure 29.41 主仲裁丢失检测示例(MALE=1)

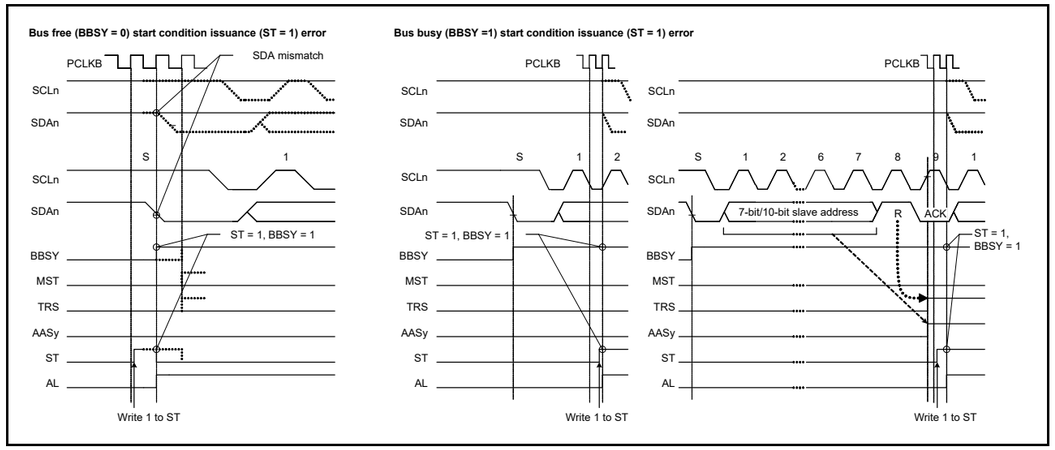

Figure 29.42 Arbitration-lost when start condition is issued (MALE = 1)

29.10.2 Function to Detect Loss of Arbitration during NACK Transmission (NALE Bit)

This function causes arbitration to be lost if the internal SDA output level does not match the level on the SDAn line during transmission of NACK in receive mode. Arbitration is lost because of a conflict between NACK and ACK transmissions when two or more master devices receive data from the same slave device simultaneously in a multi-master system. Such conflict occurs when multiple master devices send or receive the same information through a single slave device. Figure 29.43 shows an example of arbitration-lost detection during the transmission of NACK.

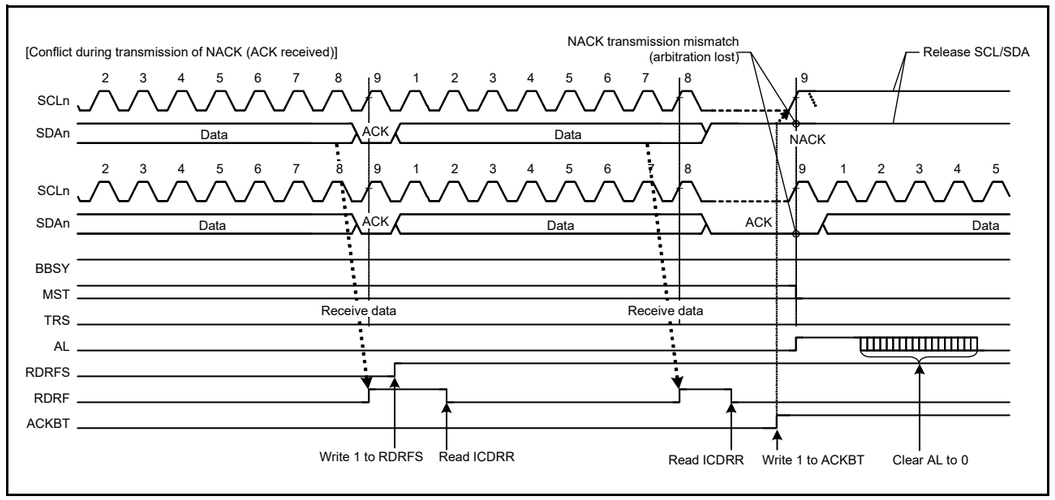

Figure 29.43 Example of arbitration-lost detection during transmission of NACK (NALE = 1)

The following description explains arbitration-lost detection using an example in which two master devices (master A and master B) and a single slave device are connected through the bus. In this example, master A receives 2 bytes of data from the slave device, and master B receives 4 bytes of data from the slave device.

If master A and master B access the slave device simultaneously, because the slave address is identical, arbitration is not lost in either master A or B during access to the slave device. Therefore, both master A and master B recognize that they have obtained the bus mastership and operate as such. Master A sends NACK when it has received the 2 final bytes of data from the slave device. Meanwhile, master B sends ACK because it has not received the required 4 bytes of data.

The NACK transmission from master A and the ACK transmission from master B conflict. In general, if a conflict like

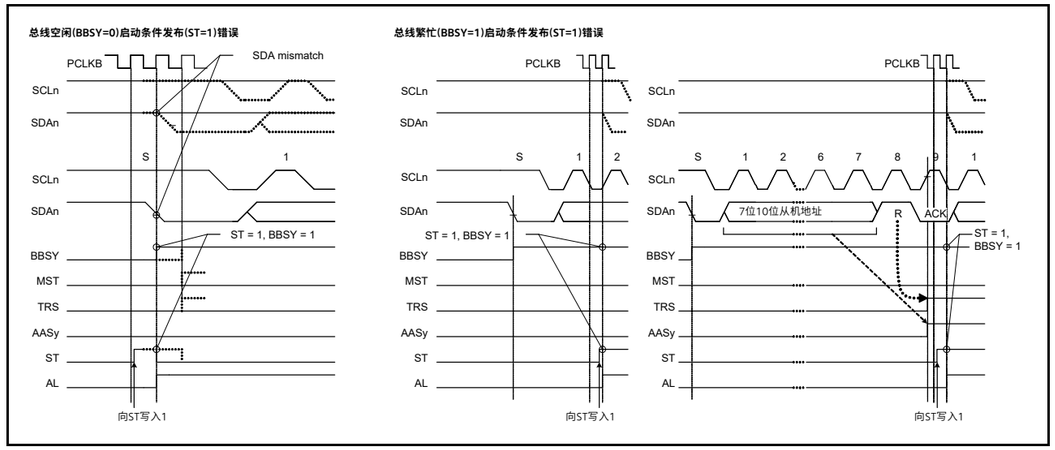

Figure 29.42 发出启动条件时仲裁失败(MALE=1)

29.10.2 在NACK传输期间检测仲裁丢失的功能（NALE位）

如果在接收模式下发送NACK期间内部SDA输出电平与SDAn线上的电平不匹配，此功能会导致仲裁丢失。当多主控系统中两个或多个主控设备同时从同一从属设备接收数据时，由于NACK和ACK传输之间的冲突，仲裁会丢失。当多个主设备通过单个从设备发送或接收相同的信息时，就会发生这种冲突。图29.43显示了在NACK传输期间检测仲裁丢失的示例。

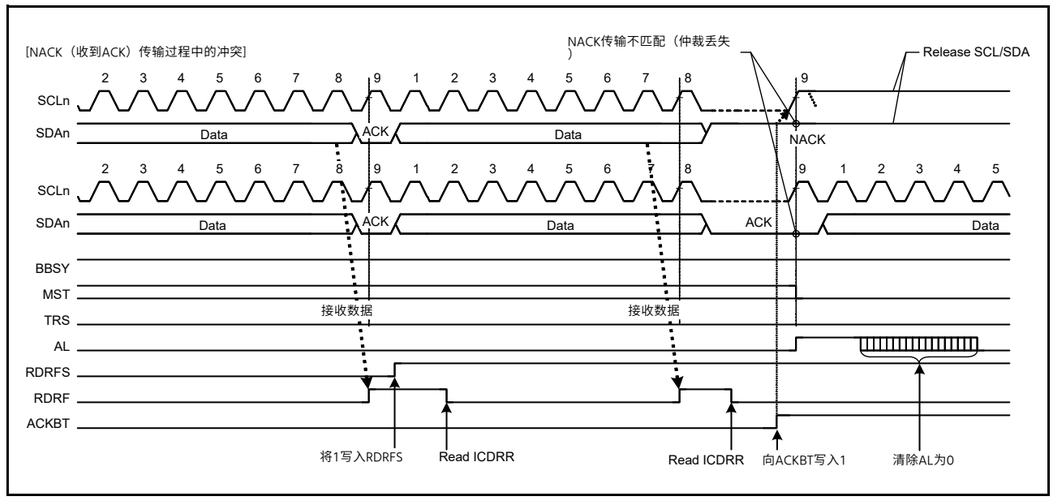

Figure 29.43 NACK(NALE=1)传输期间的仲裁丢失检测示例

以下描述使用通过总线连接两个主设备（主设备A和主设备B）和单个从设备的示例来说明仲裁丢失检测。在本例中，主设备A从从设备接收2个字节的数据，主设备B从从设备接收4个字节的数据。

如果主设备A和主设备B同时访问从设备，因为从设备地址相同，在访问从设备期间，主设备A或B都不会丢失仲裁。因此，主机A和主机B都承认他们已经获得了总线控制权并照此运行。主设备A在从从设备接收到最后2个字节的数据时发送NACK。同时，masterB发送ACK，因为它没有收到所需的4字节数据。

来自主机A的NACK传输和来自主机B的ACK传输冲突。一般来说，如果像这样的冲突

this occurs, master A cannot detect the ACK transmitted by master B and issues a stop condition. The stop condition issue conflicts with the SCL clock output of master B, which disrupts communication.

When the IIC receives ACK during transmission of NACK, it detects a defeat in conflict with other master devices and causes arbitration to be lost. If arbitration is lost during transmission of NACK, the IIC immediately cancels the slave match condition and enters slave receive mode. This prevents a stop condition from being issued, preventing a communication failure on the bus.

Similarly, in the ARP command processing of SMBus, the function to detect loss of arbitration during transmission of NACK is also available for eliminating the extra clock cycle processing, such as FFh transmission processing, which is required if the UDID (Unique Device Identifier) of the assigned address does not match in the Get UDID general processing after the Assign Address command.

The IIC detects arbitration-lost during transmission of NACK when the following condition is met with the NALE bit in ICFER set to 1 (arbitration-lost detection during NACK transmission enabled).

[Condition for arbitration-lost during NACK transmission]

- When the internal SDA output level does not match the SDAn line (ACK is received) during transmission of NACK (ACKBT bit = 1 in ICMR3).

29.10.3 Slave Arbitration-Lost Detection (SALE Bit)

This function causes arbitration to be lost if the transmit data (internal SDA output level) and the level on the SDAn line do not match in slave transmit mode. This arbitration-lost detection function is mainly used when transmitting a UDID (Unique Device Identifier) over an SMBus.

When the IIC loses slave arbitration, the IIC is immediately released from the slave-matched state and enters slave receive mode. This function can detect conflicts of data during transmission of UDIDs over an SMBus and eliminates subsequent redundant processing for the transmission of FFh.

The IIC detects slave arbitration-lost when the following condition is met with the SALE bit in ICFER set to 1 (slave arbitration-lost detection enabled).

[Condition for slave arbitration-lost]

- When transmit data excluding acknowledge (internal SDA output level) does not match the SDAn line in slave transmit mode (MST and TRS bits = 01b in ICCR2).

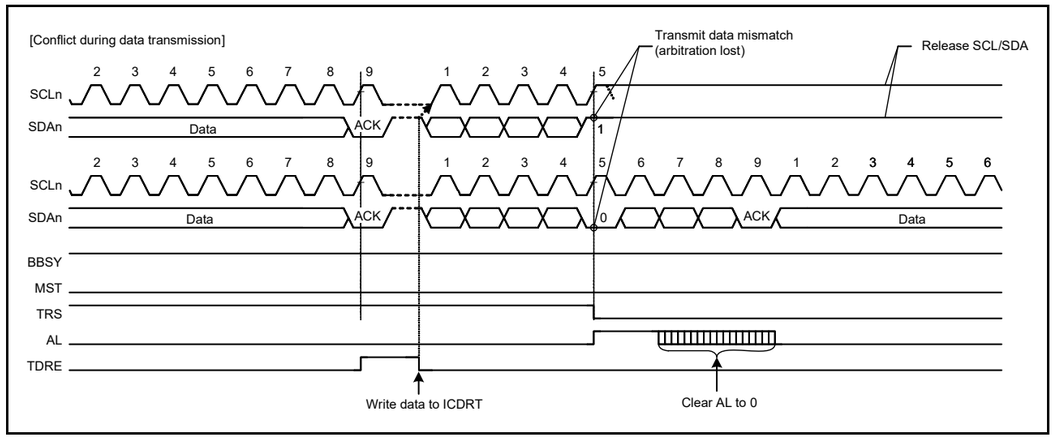

Figure 29.44 Example of slave arbitration-lost detection (SALE = 1)

发生这种情况时，主机A无法检测到主机B发送的ACK并发出停止条件。停止条件问题与主B的SCL时钟输出冲突，从而中断通信。

当IIC在NACK传输过程中收到ACK时，它会检测到与其他主设备冲突的失败并导致仲裁丢失。如果在NACK传输过程中仲裁丢失，IIC立即取消从机匹配条件并进入从机接收模式。这可以防止发出停止条件，从而防止总线上的通信故障。

同样，在SMBus的ARP命令处理中，检测传输过程中仲裁丢失的功能
NACK也可用于消除额外的时钟周期处理，例如FFh传输处理，如果分配地址的UDID（唯一设备标识符）在分配地址命令后的获取UDID常规处理中不匹配，则需要此处理。

IIC在NACK传输期间检测到仲裁丢失，当满足以下条件时
ICFER设置为1（启用NACK传输期间的仲裁丢失检测）。

[在NACK传输期间仲裁丢失的条件]

- 在NACK传输期间内部SDA输出电平与SDAn线不匹配（接收到ACK）时（ICMR3中的ACKBT位=1）。

29.10.3 从设备仲裁丢失检测（SALE位）

如果发送数据（内部SDA输出电平）和SDAn线上的电平在从发送模式下不匹配，此功能会导致仲裁丢失。这种仲裁丢失检测功能主要用于通过SMBus传输UDID（唯一设备标识符）时。

当IIC失去从机仲裁时，IIC立即从从机匹配状态中释放并进入从机接收模式。此功能可以检测在SMBus上传输UDID期间的数据冲突，并消除后续传输FFh的冗余处理。

当ICFER中的SALE位设置为1（启用从设备仲裁丢失检测）满足以下条件时，IIC检测从设备仲裁丢失。

[从机仲裁失败的条件]

- 当发送数据不包括确认（内部SDA输出电平）与从发送模式下的SDAn线不匹配时（MST和TRS位=ICCR2中的01b）。

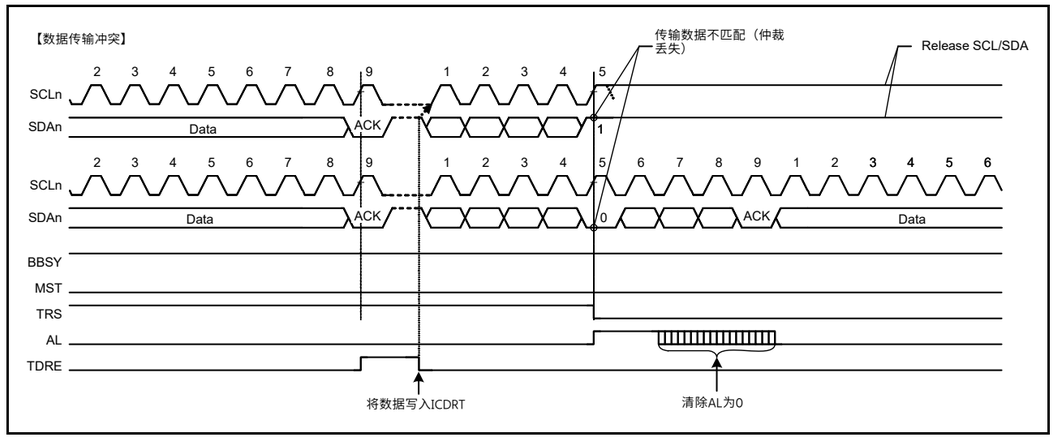

Figure 29.44 从机仲裁丢失检测示例(SALE=1)

29.11 Start, Restart, and Stop Condition Issuing Function

29.11.1 Issuing a Start Condition

The IIC issues a start condition when the ST bit in ICCR2 is set to 1.

When the ST bit is set to 1, a start condition request is made, and the IIC issues a start condition when the BBSY flag in ICCR2 is 0 (bus free state). When a start condition is issued normally, the IIC automatically shifts to the master transmit mode.

To issue a start condition:

1. Drive the SDAn line low (high level to low level).
2. Ensure that the time set in ICBRH and the start condition hold time elapse.
3. Drive the SCLn line low (high level to low level).
4. Detect low level on the SCLn line and ensure the low-level period of the SCLn line set in ICBRL elapses.

29.11.2 Issuing a Restart Condition

The IIC issues a restart condition when the RS bit in ICCR2 is set to 1.

When the RS bit is set to 1, a restart condition request is made. The IIC issues a restart condition when the BBSY flag in ICCR2 is 1 (bus busy state) and the MST bit in ICCR2 is 1 (master mode).

To issue a restart condition:

1. Release the SDAn line.
2. Ensure the low-level period of the SCLn line set in ICBRL elapses.
3. Release the SCLn line (low level to high level).
4. Detect a high level on the SCLn line and ensure the time set in ICBRL and the restart condition setup time elapse.
5. Drive the SDAn line low (high level to low level).
6. Ensure the time set in ICBRH and the restart condition hold time elapse.
7. Drive the SCLn line low (high level to low level).
8. Detect a low level on the SCLn line and ensure the low-level period of the SCLn line set in ICBRL elapses.

Note: When issuing restart condition requests, write the slave address to ICDRT after confirming that ICCR2.RS = 0. Data written while ICCR2.RS = 1 is not forwarded because of the retransmission condition before the occurrence.

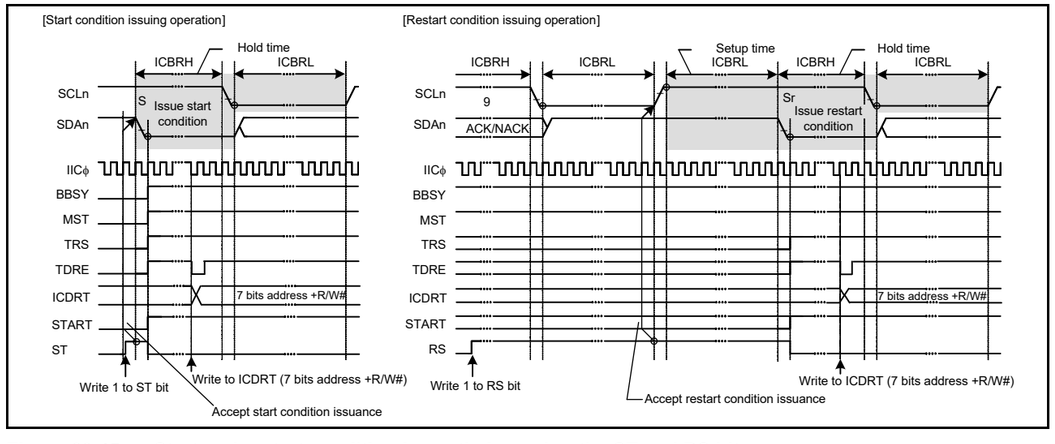

Figure 29.45 Start and restart condition issue timing using the ST and RS bits

29.11 启动、重启和停止条件发布功能

29.11.1 发出开始条件

当ICCR2中的ST位设置为1时，IIC发出启动条件。

当ST位设置为1时，发出启动条件请求，当ICCR2中的BBSY标志为0（总线空闲状态）时，IIC发出启动条件。当启动条件正常发出时，IIC自动切换到主机发送模式。

发出开始条件：

1. 将SDAn线驱动为低电平（高电平到低电平）。
2. 确保ICBRH中设置的时间和启动条件保持时间已过。
3. 将SCLn线驱动为低电平（高电平到低电平）。
4. 检测SCLn线上的低电平，确保经过ICBRL中设置的SCLn线的低电平周期。

29.11.2 发出重启条件

当ICCR2中的RS位设置为1时，IIC发出重启条件。

当RS位设置为1时，发出重启条件请求。当BBSY标志在IIC发出重启条件
ICCR2为1（总线繁忙状态），ICCR2中的MST位为1（主机模式）。

发出重启条件：

1. 释放SDAn线。
2. 确保ICBRL中设置的SCLn线的低电平周期已过。
3. 释放SCLn线（低电平到高电平）。
4. 检测SCLn线上的高电平并确保ICBRL中设置的时间和重启条件设置时间已过。
5. 将SDAn线驱动为低电平（高电平到低电平）。
6. 确保ICBRH中设置的时间和重启条件保持时间已过。
7. 将SCLn线驱动为低电平（高电平到低电平）。
8. 检测SCLn线上的低电平，确保经过ICBRL中设置的SCLn线的低电平周期。

Note: 发出重启条件请求时，确认ICCR2.RS=0后，将从机地址写入ICDRT。
ICCR2.RS=1时写入的数据由于发生前的重发条件而不会转发。

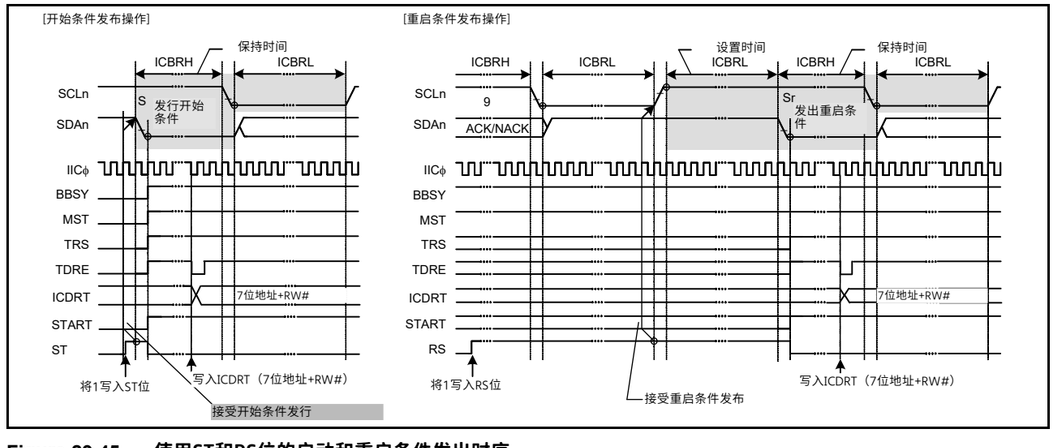

Figure 29.45 使用ST和RS位的启动和重启条件发出时序

Figure 29.46 shows the operation timing when a restart condition is issued after the master transmission.

To issue a restart condition after the master transmission:

1. Initialize the IIC using the procedure in section 29.3.2, Initial Settings.
2. Read the BBSY flag in IICR2 to check that the bus is open, and then set the ICCR2.ST bit to 1 (start condition request). On receiving the request, the IIC issues a start condition. At the same time, the BBSY and the START flags in ICSR2 are automatically set to 1 and the ST bit automatically sets to 0. If the start condition is detected and the internal levels for the SDA output state and the levels on the SDAn line match while the ST bit is 1, the IIC recognizes that a start condition is successfully issued as requested by the ST bit. The MST and TRS bits in ICCR2 automatically set to 1, placing the IIC in master transmit mode. The TDRE flag in ICSR2 is also automatically set to 1 when the TRS bit is set to 1.
3. Check that the TDRE flag in ICSR2 is 1, then write the value for transmission (the slave address and the R/W# bit) to the ICDRT register. After the transmit data is written to ICDRT, the TDRE flag is automatically set to 0, the data is transferred from ICDRT to ICDRS, and the TDRE flag again sets to 1. After the byte containing the slave address and R/W# bit has been transmitted, the value of the TRS bit is automatically updated to select master transmit or master receive mode according to the value of the transmitted R/W# bit. If the value of the R/W# bit is 0, the IIC continues in master transmit mode. If the ICSR2.NACKF flag is 1 at this time, indicating that no slave device recognized the address or there was an error in communications, write 1 to ICCR2.SP bit to issue a stop condition.

   To transmit data with an address in the 10-bit format, start by writing 1111 0b, the 2 upper bits of the slave address, and W to ICDRT as the first address transmission. Then, as the second address transmission, write the 8 lower bits of the slave address to the ICDRT register.
4. After confirming that the TDRE flag in ICSR2 is 1, write the data for transmission to the ICDRT register. The IIC automatically holds the SCLn line low until data for transmission is ready, and a restart or stop condition is issued.
5. After all bytes of data for transmission are written to the ICDRT register, wait until the value of the TEND flag in ICSR2 returns to 1. Then, after checking that the START flag in ICSR2 is 1, set the START flag in ICSR2 to 0.
6. Set the RS bit in ICCR2 to 1 (restart condition request). On receiving the request, the IIC issues a restart condition.
7. After checking that the START flag in ICSR2 is 1, write the value for transmission (the slave address and the R/W# bit) to the ICDRT register.

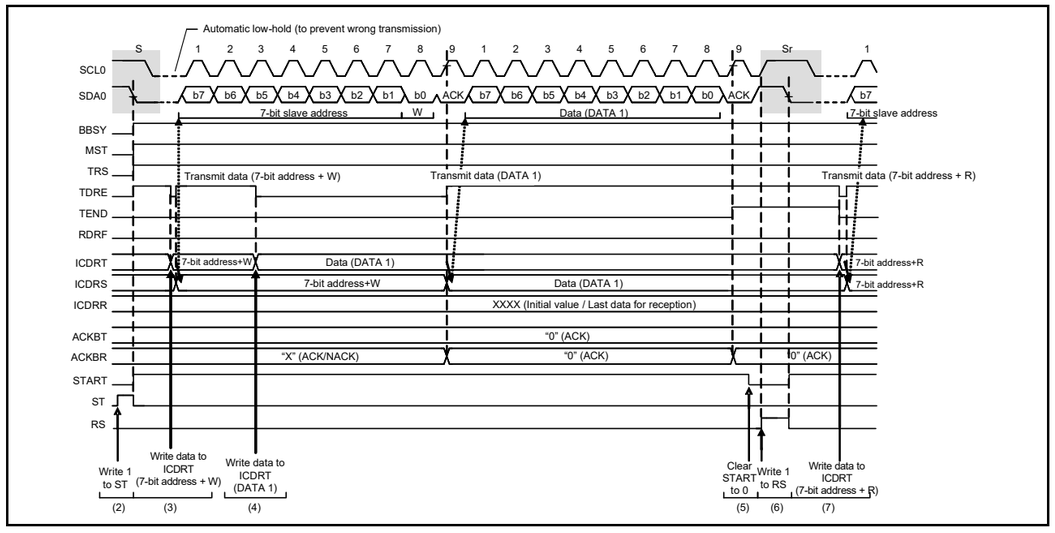

Figure 29.46 Restart condition issue timing after master transmission.

图29.46显示了在主机发送后发出重新启动条件时的操作时序。

在主传输后发出重启条件：

1. 使用第29.3.2节，初始设置中的过程初始化IIC。
2. 读取IICR2中的BBSY标志以检查总线是否打开，然后将ICCR2.ST位设置为1（启动条件请求）。收到请求后，IIC发出一个开始条件。同时，ICSR2中的BBSY和START标志自动设置为1，ST位自动设置为0。如果检测到启动条件并且SDA输出状态的内部电平与SDAn线上的电平匹配当ST位为1时，IIC识别出启动条件已按照ST位的请求成功发出。ICCR2中的MST和TRS位自动设置为1，将IIC置于主机发送模式。当TRS位设置为1时，ICSR2中的TDRE标志也自动设置为1。
3. 检查ICSR2中的TDRE标志是否为1，然后将要发送的值（从机地址和RW#位）写入ICDRT寄存器。发送数据写入ICDRT后，TDRE标志自动设置为0，数据从ICDRT传输到ICDRS，TDRE标志再次设置为1。在发送包含从机地址和RW#位的字节后，TRS位的值会根据发送的RW#位的值自动更新以选择主机发送或主机接收模式。如果RW#位的值为0，则IIC继续处于主机发送模式。如果此时ICSR2.NACKF标志位为1，表示没有从设备识别该地址或通信出现错误，向ICCR2.SP位写入1发出停止条件。

   要使用10位格式的地址传输数据，首先将11110b、从机地址的高2位和W写入ICDRT作为第一个地址传输。然后，作为第二次地址传输，将从地址的低8位写入ICDRT寄存器。
4. 确认ICSR2中的TDRE标志为1后，将要发送的数据写入ICDRT寄存器。IIC自动将SCLn线保持在低电平，直到传输数据准备好，并发出重新启动或停止条件。
5. 待传输数据的所有字节写入ICDRT寄存器后，等待直到TEND标志的值ICSR2恢复为1。然后，在检查ICSR2中的START标志为1后，将ICSR2中的START标志设置为0。
6. 将ICCR2中的RS位设置为1（重新启动条件请求）。收到请求后，IIC发出重启条件。
7. 检查ICSR2中的START标志为1后，将要发送的值（从机地址和RW#位）写入ICDRT寄存器。

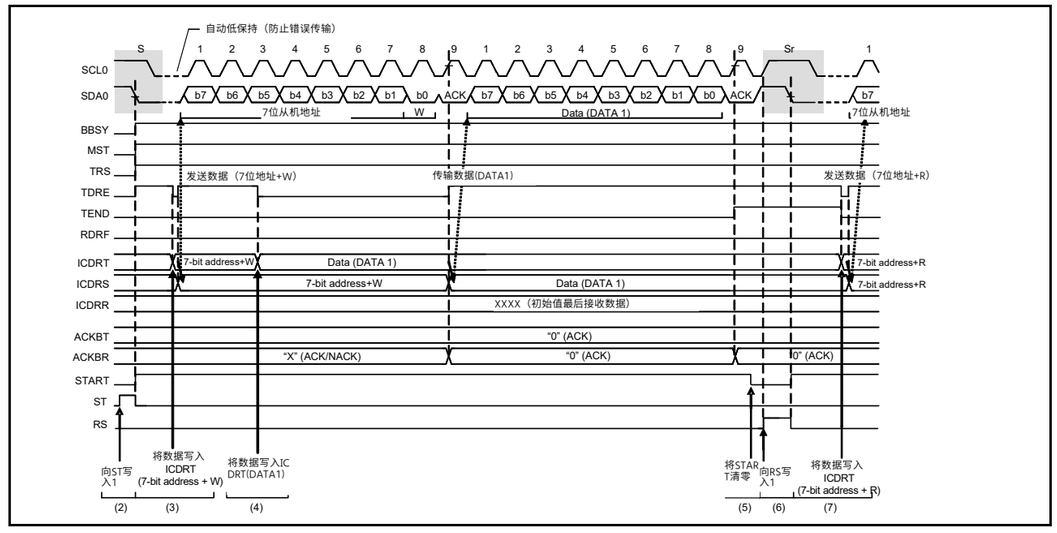

Figure 29.46 主传输后重启条件发出时序。

29.11.3 Issuing a Stop Condition

The IIC issues a stop condition when the SP bit in ICCR2 is set to 1.

When the SP bit is set to 1, a stop condition request is made. The IIC issues a stop condition when the BBSY flag in ICCR2 is 1 (bus busy state) and the MST bit in ICCR2 is 1 (master mode).

To issue a stop condition:

1. Drive the SDAn line low (high level to low level).
2. Ensure that the low-level period of the SCLn line set in ICBRL elapses.
3. Release the SCLn line (low level to high level).
4. Detect a high level on the SCLn line and ensure that the time set in ICBRH and the stop condition setup time elapse.
5. Release the SDAn line (low level to high level).
6. Ensure the time set in ICBRL and the bus free time elapse.
7. Clear the BBSY flag to 0 to release the bus mastership.

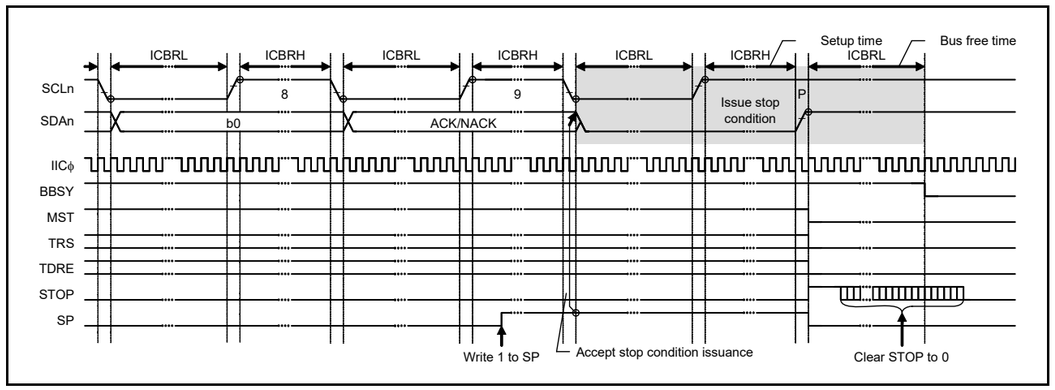

Figure 29.47 Stop condition issue timing using the SP bit

29.12 Bus Hanging

If the clock signals from the master and slave devices are out of synchronization because of noise or other factors, the I2C bus might hang with a fixed level on the SCLn line or SDAn line.

To manage bus hanging, the IIC has:

- A timeout function to detect hanging by monitoring the SCLn line
- A function for the output of an extra SCL clock cycle to release the bus from a hung state because of clock signals being out of synchronization
- An IIC reset function
- An internal reset function.

By checking the SCLO, SDAO, SCLI, and SDAI bits in ICCR1, it is possible to see whether the IIC or its communicating partner is placing the low level on the SCLn or SDAn lines.

29.12.1 Timeout Function

The timeout function can detect when the SCLn line is stuck longer than the predetermined time. The IIC can detect an abnormal bus state by monitoring that the SCLn line is stuck low or high for a predetermined time.

The timeout function monitors the SCLn line state and counts the low-level or high-level period using the internal counter. The timeout function resets the internal counter each time the SCLn line changes (rising or falling), but continues to count unless the SCLn line changes. If the internal counter overflows because no SCLn line changes, the IIC

29.11.3 发出停止条件

当ICCR2中的SP位设置为1时，IIC发出停止条件。

当SP位设置为1时，发出停止条件请求。IIC发出停止条件，当BBSY标志在ICCR2为1（总线繁忙状态），ICCR2中的MST位为1（主机模式）。

发出停止条件：

1. 将SDAn线驱动为低电平（高电平到低电平）。
2. 确保ICBRL中设置的SCLn线的低电平周期已过。
3. 释放SCLn线（低电平到高电平）。
4. 检测SCLn线上的高电平并确保ICBRH中设置的时间和停止条件设置时间已过。
5. 释放SDAn线（低电平到高电平）。
6. 确保ICBRL中设置的时间和巴士空闲时间已过。
7. 将BBSY标志清除为0以释放总线主控权。

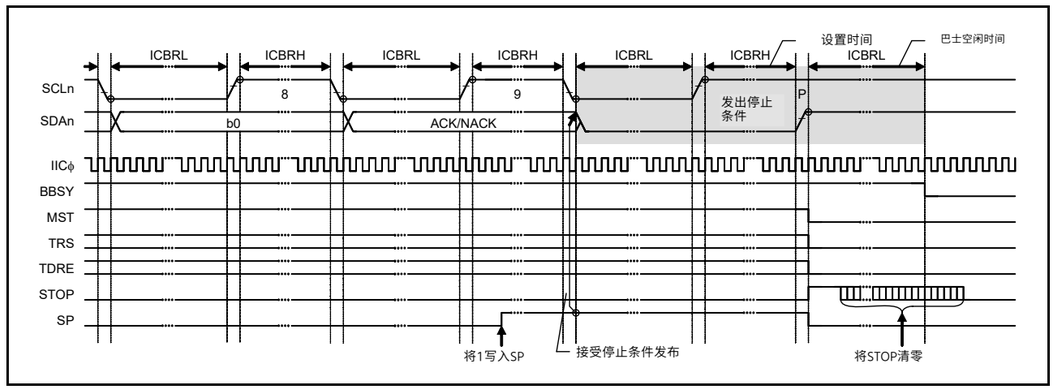

Figure 29.47 使用SP位的停止条件发出时序

29.12 巴士挂

如果来自主从设备的时钟信号由于噪声或其他因素不同步，则I2C总线可能会在SCLn线或SDAn线上以固定电平挂起。

为了管理总线挂起，IIC具有：

- 通过监控SCLn线路来检测挂起的超时功能
- 由于时钟信号不同步而输出额外SCL时钟周期以将总线从挂起状态中释放的功能
- 一个IIC复位功能
- 内部复位功能。

通过检查ICCR1中的SCLO、SDAO、SCLI和SDAI位，可以查看IIC或其通信伙伴是否在SCLn或SDAn线上设置了低电平。

29.12.1 超时功能

超时功能可以检测SCLn线路何时卡住超过预定时间。IIC可以通过监视SCLn线在预定时间内保持低电平或高电平来检测异常总线状态。

超时功能监视SCLn线路状态并使用内部计数器计算低电平或高电平周期。每次SCLn线改变（上升或下降）时，超时功能都会复位内部计数器，但除非SCLn线改变，否则会继续计数。如果内部计数器因SCLn线没有变化而溢出，则IIC

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can detect the timeout and report the bus hung state.

This timeout function is enabled when the ICFER.TMOE bit is 1. It detects a hung state when the SCLn line is stuck low or high during the following conditions:

- The bus is busy (ICCR2.BBSY flag is 1) in master mode (ICCR2.MST bit is 1)
- The IIC slave address is detected (ICSR1 register is not 00h) and the bus is busy (ICCR2.BBSY flag is 1) in slave mode (ICCR2.MST bit is 0)
- The bus is open (ICCR2.BBSY flag is 0) while a start condition is requested (ICCR2.ST bit is 1).

The internal counter of the timeout function uses the internal reference clock (IICϕ) set in the CKS[2:0] bits in ICMR1 as a count source. It functions as a 16-bit counter when long mode is selected (TMOS bit = 0 in ICMR2) or a 14-bit counter when short mode is selected (TMOS bit = 1).

The SCLn line level (low, high, or both levels) during which this counter is activated can be selected in the TMOH and TMOL bits in ICMR2. If both TMOL and TMOH bits are set to 0, the internal counter is disabled.

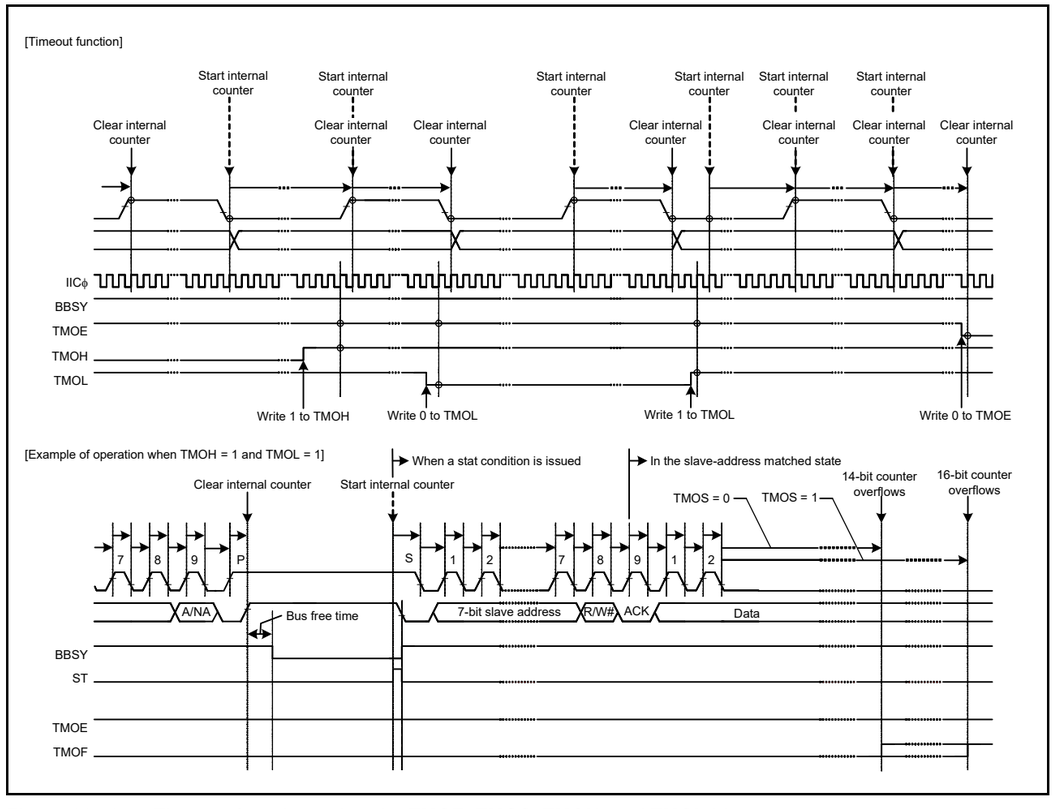

Figure 29.48 Timeout function using the TMOE, TMOS, TMOH, and TMOL bits

29.12.2 Extra SCL Clock Cycle Output Function

In master mode, this function outputs extra SCL clock cycles to release the SDAn line of the slave device from being held low because the master is out of synchronization with the slave device.

This function is mainly used in master mode to release the SDAn line of the slave device from being fixed low by including extra cycles of SCL output from the IIC. It uses single cycles of the SCL clock for a bus error where the IIC cannot issue a stop condition because the slave device is holding the SDAn line at the low level. Do not use this function in normal situations. Using it when communications are proceeding correctly leads to malfunctioning.

可以检测到超时并报告总线挂起状态。

此超时功能在ICFER.TMOE位为1时启用。在以下情况下，当SCLn线卡在低电平或高电平时，它会检测到挂起状态：

- 总线繁忙（ICCR2.BBSY标志为1）处于主模式（ICCR2.MST位为1）
- 检测到IIC从机地址（ICSR1寄存器不是00h）并且在从机模式下总线忙（ICCR2.BBSY标志为1）（ICCR2.MST位为0）
- 请求启动条件（ICCR2.ST位为1）时，总线打开（ICCR2.BBSY标志为0）。

超时功能的内部计数器使用ICMR1的CKS[2:0]位中设置的内部参考时钟(IIC)作为计数源。Itfunctionsasa16-bitcounterwhenlongmodeisselected(TMOSbit=0inICMR2)ora14-bitcounterwhenshortmodeisselected(TMOSbit=1).

可以在TMOH和
ICMR2中的TMOL位。如果TMOL和TMOH位都设置为0，则内部计数器被禁用。

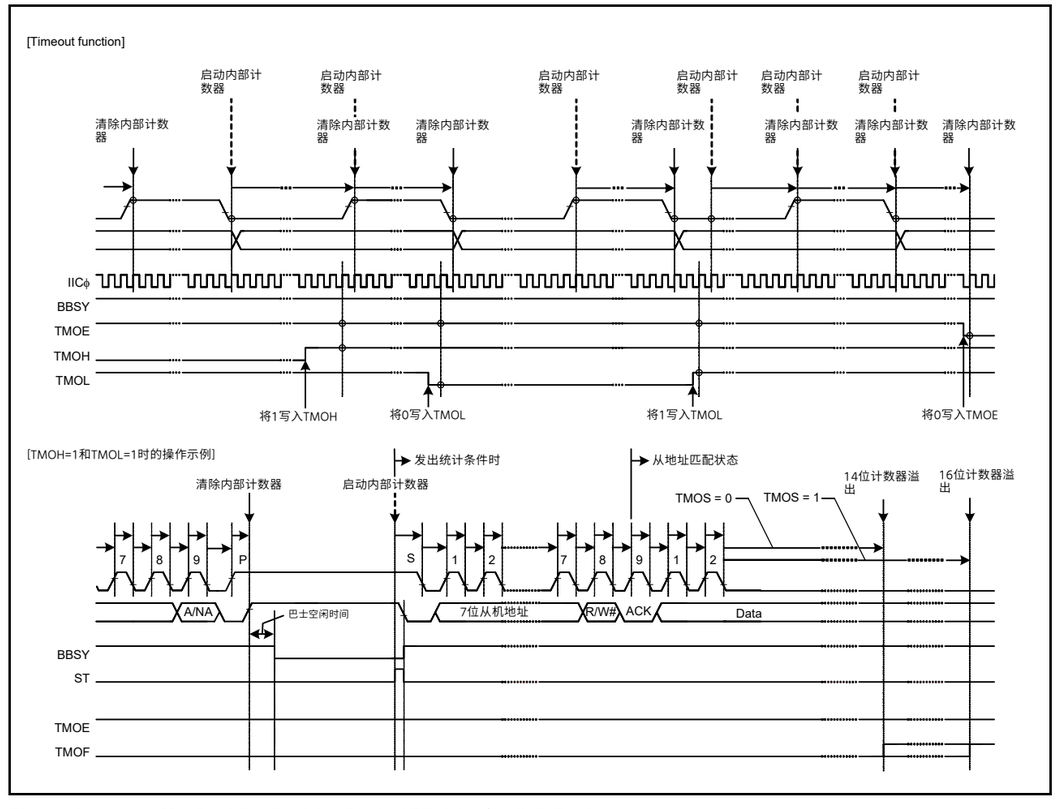

Figure 29.48 使用TMOE、TMOS、TMOH和TMOL位的超时功能

29.12.2 额外的SCL时钟周期输出功能

在主模式下，该函数输出额外的SCL时钟周期，以释放从设备的SDAn线保持低电平，因为主设备与从设备不同步。

该功能主要用于主机模式，通过包含IIC的额外SCL输出周期来释放从机设备的SDAn线固定为低电平。它使用SCL时钟的单个周期来处理IIC无法发出停止条件的总线错误，因为从设备将SDAn线保持在低电平。在正常情况下不要使用此功能。在通信正常进行时使用它会导致故障。

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When the CLO bit in ICCR1 is set to 1 in master mode, a single cycle of the SCL clock at the transfer rate specified in the CKS[2:0] bits in ICMR1, the ICBRH, and ICBRL registers, is output as an extra clock cycle. After output of this single cycle of the SCL clock, the CLO bit is automatically set to 0. Therefore, more extra clock cycles can be output consecutively by writing 1 to the CLO bit after having read CLO = 0.

When the IIC module is in master mode and the slave device is holding the SDAn line low because synchronization with the slave device is lost due to the effects of noise, the output of a stop condition is not possible. This function can be used to output extra cycles of SCL one by one to make the slave device release the SDAn line from being held low, and recover the bus from an unusable state. Release of the SDAn line by the slave device can be monitored by reading the SDAI bit in ICCR1. After confirming the release of the SDAn line by the slave device, complete the communication by reissuing the stop condition.

Use this function with the MALE bit in ICFER set to 0 (master arbitration-lost detection disabled). If the MALE bit is set to 1 (enabled), arbitration is lost when the value of the SDAO bit in ICCR1 does not match the state of the SDAn line.

[Output conditions for using the CLO bit in ICCR1]

- When the bus is free (BBSY flag in ICCR2 = 0) or in master mode (MST bit = 1 and BBSY flag = 1 in ICCR2)
- When the communication device does not hold the SCLn line low.

Figure 29.49 shows the operation timing of the extra SCL clock cycle output function (CLO bit).

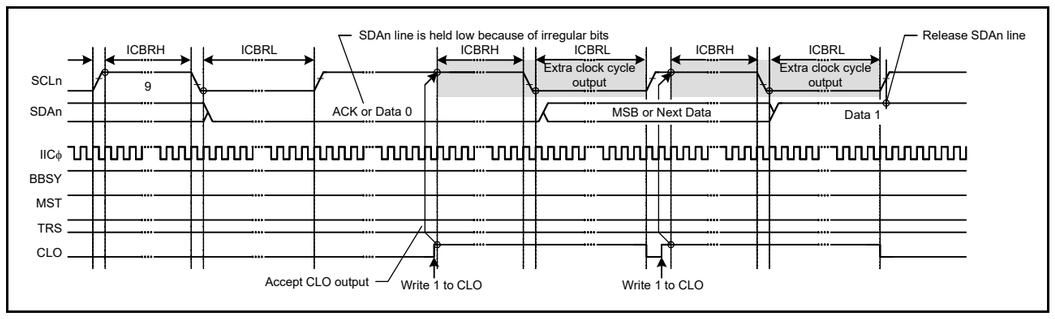


Figure 29.49 Extra SCL clock cycle output function using the CLO bit

29.12.3 IIC Reset and Internal Reset

The IIC module has two types of resets:

- IIC reset, which initializes all registers, including the BBSY flag in ICCR2
- Internal reset, which releases the IIC from the slave-address matched state and initializes the internal counter while saving other settings.

After issuing a reset, be sure to set the IICRST bit in ICCR1 to 0. Both types of resets are valid for release from bus-hung states, because both restore the output state of the SCLn and SDAn pins to the high-impedance state.

Issuing a reset during slave operation might lead to a loss of synchronization between the master device clock and the slave device clock, so avoid this when possible. In addition, monitoring of the bus state, such as for the presence of a start condition, is not possible during an IIC reset (ICE and IICRST bits = 01b in ICCR1).

For a detailed description of the IIC and internal resets, see section 29.15, State of Registers when Issuing each Condition.

29.13 SMBus Operation

The IIC supports data communication conforming to the SMBus Specification, version 2.0. To perform SMBus communication, set the SMBS bit in ICMR3 to 1. To use the transfer rate within a range of 10 kbps to 100 kbps of the SMBus standard, set the CKS[2:0] bits in ICMR1, the ICBRH, and ICBRL registers. In addition, specify the values in the DLCS bit in ICMR2 and the SDDL[2:0] bits in ICMR2 to meet the data hold time specification of 300 ns or more. When the IIC is used only as a slave device, the transfer rate setting is not required, but ICBRL must be set to a value longer than the data setup time (250 ns).

当ICCR1中的CLO位在主机模式下设置为1时，以ICMR1中的CKS[2:0]位、ICBRH和ICBRL寄存器中指定的传输速率输出一个SCL时钟周期作为额外的输出。时钟周期。在SCL时钟的这个单周期输出后，CLO位自动设置为0。因此，在读取CLO=0后，通过向CLO位写入1可以连续输出更多的额外时钟周期。

当IIC模块处于主模式且从设备保持SDAn线为低电平时，因为与从设备的同步由于噪声的影响而丢失，停止条件的输出是不可能的。该功能可用于逐个输出额外的SCL周期，使从设备解除SDAn线的低电平状态，使总线从不可用状态恢复。从设备释放SDAn线可以通过读取ICCR1中的SDAI位来监控。从设备确认SDAn线的释放后，通过重新发出停止条件完成通信。

在ICFER中的MALE位设置为0（禁用主机仲裁丢失检测）时使用此功能。如果MALE位设置为1（启用），当ICCR1中SDAO位的值与SDAn线的状态不匹配时，仲裁将丢失。

[使用ICCR1中CLO位的输出条件]

- 当总线空闲（ICCR2中的BBSY标志=0）或处于主机模式（ICCR2中的MST位=1且BBSY标志=1）时
- 当通信设备不保持SCLn线为低电平时。

图29.49显示了额外SCL时钟周期输出功能（CLO位）的操作时序。

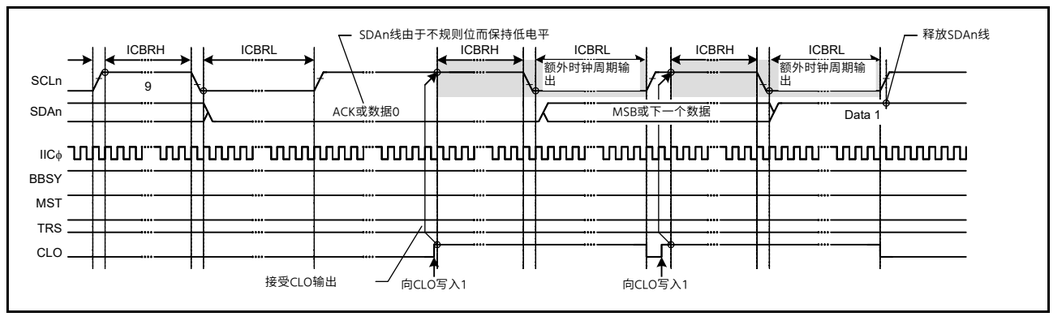


Figure 29.49 使用CLO位的额外SCL时钟周期输出功能

29.12.3 IIC复位和内部复位

IIC模块有两种类型的复位：

- IIC复位，初始化所有寄存器，包括ICCR2中的BBSY标志
- 内部复位，将IIC从从地址匹配状态释放并初始化内部计数器，同时保存其他设置。

发出复位后，务必将ICCR1中的IICRST位设置为0。这两种复位都对从总线挂起状态释放有效，因为两者都将SCLn和SDAn引脚的输出状态恢复为高阻抗状态。

在从机操作期间发出复位可能会导致主设备时钟和从设备时钟之间失去同步，因此请尽可能避免这种情况。此外，在IIC复位（ICE和IICRST位=ICCR1中的01b）期间无法监控总线状态，例如是否存在启动条件。

有关IIC和内部复位的详细说明，请参阅第29.15节，发出每个寄存器时的寄存器状态
Condition.

29.13 SMBus Operation

IIC支持符合SMBus规范2.0版的数据通信。要执行SMBus通信，请将ICMR3中的SMBS位设置为1。要使用SMBus标准的10kbps至100kbps范围内的传输速率，请设置ICMR1、ICBRH和ICBRL中的CKS[2:0]位寄存器。此外，请指定ICMR2中的DLCS位和ICMR2中的SDDL[2:0]位中的值，以满足300ns或更长的数据保持时间规范。当IIC仅用作从设备时，不需要设置传输速率，但必须将ICBRL设置为比数据建立时间（250ns）更长的值。

RA生态工作室

For the SMBus device default address (1100 001b), use one of the slave address registers L0 to L2 (SARL0, SARL1, and SARL2), and set the associated FS bit (7- or 10-bit address format select) in SARUy (y = 0 to 2) to 0 (7-bit address format).

When transmitting the UDID (Unique Device Identifier), set the SALE bit in ICFER to 1 to enable the slave arbitration-lost detection function.

29.13.1 SMBus Timeout Measurement

(1) Measuring slave device timeout

The following period (timeout interval: $T_{LOW: SEXT}$) must be measured for slave devices in SMBus communication:

- From start condition to stop condition.

To measure timeout for slave devices, measure the period from start condition detection to stop condition detection with the GPT using the IIC start condition detection interrupt (STIn) and stop condition detection interrupt (SPIn). The measured timeout period must be within the total clock low-level period [slave device] $T_{LOW: SEXT}$: 25 ms (maximum) of the SMBus standard.

If the time measured with the GPT exceeds the clock low-level detection timeout $T_{TIMEOUT}$: 25 ms (minimum) of the SMBus standard, the slave device must release the bus by writing 1 to the IICRST bit in ICCR1 to issue an internal reset of the IIC. When an internal reset is issued, the IIC stops driving the bus for the SCLn and SDAn pins and makes the SCLn/SDAn pin output high-impedance, which releases the bus.

(2) Measuring master device timeout

The following periods (timeout interval: $T_{LOW: MEXT}$) must be measured for master devices in SMBus communication:

- From start condition to acknowledge bit
- Between acknowledge bits
- From acknowledge bit to stop condition.

To measure timeout for master devices, measure these periods with the GPT using the IIC start condition detection interrupt (STIn), stop condition detection interrupt (SPIn), transmit end interrupt (IICn_TEI), or receive data full interrupt (IICn_RXI). The measured timeout period must be within the total clock low-level extended period (master device) $T_{LOW: MEXT}$: 10 ms (maximum) of the SMBus standard, and the total of all $T_{LOW: MEXT}$ values from the start condition to stop condition must be within $T_{LOW: SEXT}$: 25 ms (maximum).

For the ACK receive timing (rising edge of the 9th SCL clock cycle), monitor the TEND flag in ICSR2 in master transmit mode (master transmitter) and the RDRF flag in ICSR2 in master receive mode (master receiver). Perform byte-wise transmit operations in master transmit mode, and hold the RDRFS bit in ICMR3 at 0 until the byte immediately before the reception of the final byte in master receive mode. While the RDRFS bit is 0, the RDRF flag is set to 1 on the rising edge of the 9th SCL clock cycle.

If the period measured with GPT exceeds the total clock low-level extended period (master device), $T_{LOW: MEXT}$: 10 ms (maximum) of the SMBus standard or the total of measured periods exceeds the clock low-level detection timeout, $T_{TIMEOUT}$: 25 ms (minimum) of the SMBus standard, the master device must stop the transaction by issuing a stop condition. In master transmit mode, immediately stop the transmit operation (stop writing data to ICDRT).

对于SMBus器件默认地址(1100001b)，使用从地址寄存器L0到L2之一（SARL0、SARL1和SARL2），并将SARUy(y=0to2)中相关的FS位（7位或10位地址格式选择）设置为0（7位地址格式）。

发送UDID（UniqueDeviceIdentifier）时，将ICFER中的SALE位设置为1，以使能从机仲裁丢失检测功能。

29.13.1 SMBus超时测量

(1) 测量从设备超时

对于SMBus通信中的从设备，必须测量以下周期（超时间隔：TLOW:SEXT）：

- 从开始条件到停止条件。

要测量从设备的超时，请使用GPT使用IIC启动条件检测中断(STIn)和停止条件检测中断(SPIn)测量从启动条件检测到停止条件检测的周期。测得的超时周期必须在总时钟低电平周期[从设备]TLOW:SEXT:SMBus标准的25ms（最大值）内。

如果使用GPT测量的时间超过时钟低电平检测超时TTIMEOUT:SMBus标准的25ms（最小值），从设备必须通过向ICCR1中的IICRST位写入1来释放总线，以发出内部复位IIC。当内部复位发出时，IIC停止驱动SCLn和SDAn引脚的总线，并使SCLnSDAn引脚输出高阻态，从而释放总线。

(2) 测量主设备超时

对于SMBus通信中的主设备，必须测量以下周期（超时间隔：TLOW:MEXT）：

- 从开始条件到确认位
- 确认位之间
- 从确认位到停止条件。

要测量主设备的超时，请使用GPT使用IIC开始条件检测中断(STIn)、停止条件检测中断(SPIn)、发送结束中断(ICn_TEI)或接收数据完整中断(IICn_RXI)来测量这些周期。测得的超时周期必须在总时钟低电平扩展周期（主设备）TLOW:MEXT:SMBus标准的10ms（最大值）内，以及从启动条件到停止的所有TLOW:MEXT值的总和条件必须在TLOW内：SEXT：25ms（最大值）。

对于ACK接收时序（第9个SCL时钟周期的上升沿），在主机发送模式（主机发送器）监视ICSR2中的TEND标志，在主机接收模式（主机接收器）监视ICSR2中的RDRF标志。在主机发送模式下执行逐字节发送操作，并将ICMR3中的RDRFS位保持为0，直到在主机接收模式下接收到最后一个字节之前的字节。当RDRFS位为0时，RDRF标志在第9个SCL时钟周期的上升沿设置为1。

如果用GPT测量的周期超过总时钟低电平扩展周期（主设备），TLOW:MEXT:SMBus标准的10ms（最大值）或总测量周期超过时钟低电平检测超时，TTIMEOUT：SMBus标准的25ms（最小值），主设备必须通过发出停止条件来停止事务。在主机发送模式下，立即停止发送操作（停止向ICDRT写入数据）。

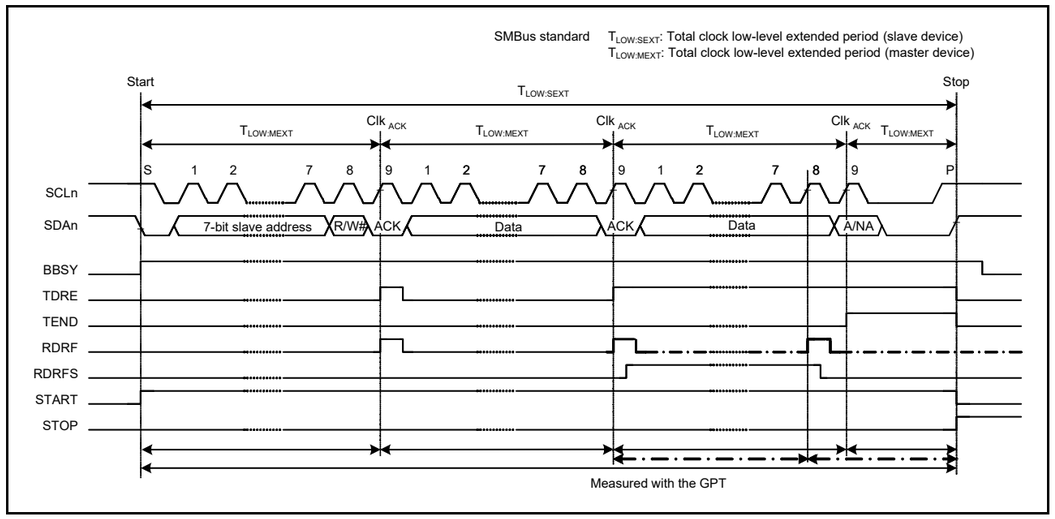


Figure 29.50 SMBus timeout measurement

29.13.2 Packet Error Code (PEC)

The MCU provides a CRC calculator that enables transmission of a Packet Error Code (PEC) or allows checking the received data in SMBus data communication. For the CRC-generating polynomials of the CRC calculator, see section 32, Cyclic Redundancy Check (CRC) Calculator.

In master transmit mode, the PEC data can be generated by writing all transmit data to the CRC Data Input Register (CRCDIR) in the CRC calculator.

In master receive mode, the PEC data can be checked by writing all receive data to CRCDIR in the CRC calculator and comparing the obtained value in the CRC Data Output Register (CRCDOR) with the received PEC data.

To send ACK or NACK based on the match or mismatch result when the final byte is received as a result of the PEC code check, set the RDRFS bit in ICMR3 to 1 before the rising edge of the 8th SCL clock cycle during reception of the final byte, and hold the SCLn line low on the falling edge of the 8th clock cycle.

29.13.3 SMBus Host Notification Protocol (Notify ARP Master Command)

In communications over an SMBus, a slave device can temporarily act as a master device to notify the SMBus host (or ARP master) of its own slave address, or to request its own slave address from the SMBus host.

For a product using the MCU to operate as an SMBus host or ARP master, the host address (0001 000b) sent from the slave device must be detected as a slave address, and so the IIC has a function for detecting the host address. To detect the host address as a slave address, set the SMBS bit in ICMR3 and the HOAE bit in ICSER to 1. Operation after the host address is detected is the same as normal slave operation.

29.14 Interrupt Sources

The IIC issues four types of interrupt requests:

- Transfer error or event generation (arbitration-lost, NACK detection, timeout detection, start or restart condition detection, and stop condition detection)
- Receive data full
- Transmit data empty
- Transmit end.

Table 29.10 lists details of the interrupt requests. The receive data full and transmit data empty interrupts can activate data transfer by the DTC or DMAC.

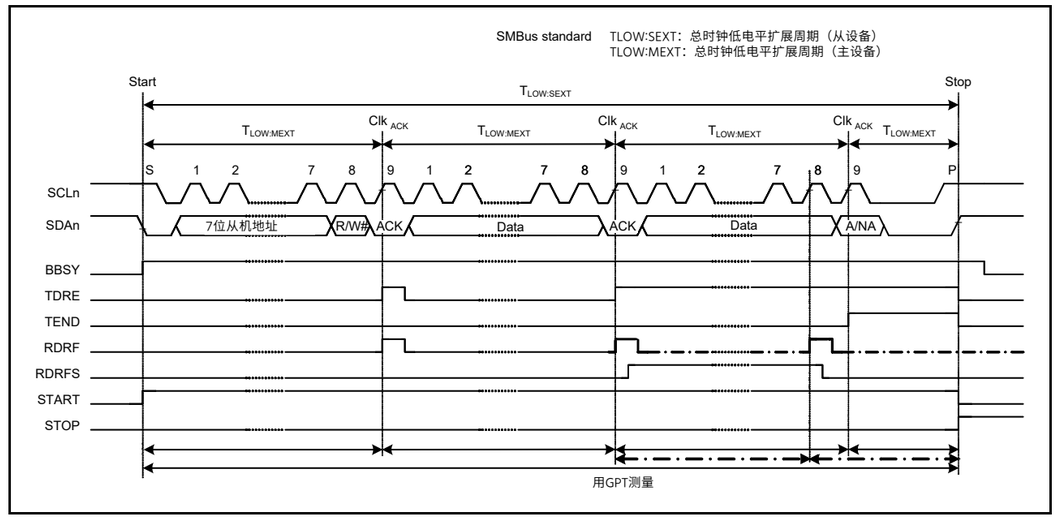


Figure 29.50 SMBus超时测量

29.13.2 数据包错误代码(PEC)

MCU提供了一个CRC计算器，可以传输数据包错误代码(PEC)或检查SMBus数据通信中接收到的数据。有关CRC计算器的CRC生成多项式，请参阅第32节，循环冗余校验(CRC)计算器。

在主机发送模式下，可以通过将所有发送数据写入CRC计算器中的CRC数据输入寄存器(CRCDIR)来生成PEC数据。

在主机接收模式下，可以通过将所有接收数据写入CRC计算器中的CRCDIR并将CRC数据输出寄存器(CRCDOR)中获得的值与接收到的PEC数据进行比较来检查PEC数据。

在接收到作为PEC代码检查的结果的最后一个字节时，要根据匹配或不匹配结果发送ACK或NACK，请在接收到第8个SCL时钟周期的上升沿之前将ICMR3中的RDRFS位设置为1最后一个字节，并在第8个时钟周期的下降沿保持SCLn线为低电平。

29.13.3 SMBus主机通知协议（通知ARP主机命令）

在通过SMBus进行通信时，从设备可以临时充当主设备来通知SMBus主机（或ARP主机）自己的从地址，或从SMBus主机请求自己的从地址。

对于使用MCU作为SMBus主机或ARP主机的产品，从机发送的主机地址（0001000b）必须被检测为从机地址，因此IIC具有主机地址检测功能。要将主机地址检测为从机地址，请将ICMR3中的SMBS位和ICSER中的HOAE位设置为1。检测到主机地址后的操作与正常从机操作相同。

29.14 中断源

IIC发出四种类型的中断请求：

- 传输错误或事件生成（仲裁丢失、NACK检测、超时检测、启动或重启条件检测和停止条件检测）
- 接收数据已满
- 传输数据为空
- 传送结束。

表29.10列出了中断请求的详细信息。接收数据满和发送数据空中断可以通过DTC或DMAC激活数据传输。

Table 29.10 Interrupt sources

Symbol	Interrupt source	Interrupt flag	DMAC/DTC activation	Interrupt condition
IICn_EEI*5	Transfer error or event generation	AL	Not possible	AL = 1, ALIE = 1
		NACKF		NACKF = 1, NAKIE = 1
		TMOF		TMOF = 1, TMOIE = 1
		START		START = 1, STIE = 1
		STOP		STOP = 1, SPIE = 1
IICn_RXI*2, *5	Receive data full	RDRF	Possible	RDRF = 1, RIE = 1
IICn_TXI*1, *5	Transmit data empty	TDRE	Possible	TDRE = 1, TIE = 1
IICn_TEI*3, *5	Transmit end	TEND	Not possible	TEND = 1, TEIE = 1
IIC0_WUI*4	Slave address match during wakeup function	WUF	Not possible	Slave address match Slave receive complete RWAK operation ASY0 = 1 WUIE = 1

Note: There is a delay between the execution of a write instruction for a peripheral module by the CPU and actual writing to the module. When an interrupt flag is cleared or masked, read the relevant flag again to check whether clearing or masking is complete, and then return from interrupt handling. Not doing so creates the possibility of repeated processing of the same interrupt.
Note 1. Because IICn_TXI is an edge-detected interrupt, it does not require clearing. Additionally, the TDRE flag in ICSR2 (condition for IICn_TXI) is automatically set to 0 when transmit data is written to ICDRT or a stop condition is detected (STOP flag = 1 in ICSR2).
Note 2. Because IICn_RXI is an edge-detected interrupt, it does not require clearing. Additionally, the RDRF flag in ICSR2 (condition for IICn_RXI) automatically is set to 0 when data is read from ICDRR.
Note 3. When using the IICn_TEI interrupt, clear the TEND flag in ICSR2 in the IICn_TEI interrupt handling. The TEND flag in ICSR2 automatically is set to 0 when transmit data is written to ICDRT or a stop condition is detected (STOP flag = 1 in ICSR2).
Note 4. Only channel 0 has a wakeup function, therefore IIC0_WUI is for channel 0 only.
Note 5. Channel number (n = 0, 1).

Clear or mask each flag during interrupt handling.

29.14.1 Buffer Operation for IICn_TXI and IICn_RXI Interrupts

If the conditions for generating an IICn_TXI or IICn_RXI interrupt are satisfied while the associated IR flag is 1, the interrupt request is not output for the ICU but is saved internally. One request per source can be saved internally.

An interrupt request that is saved within the ICU is output when the ICU.IELSRn.IR flag becomes 0. Internally saved interrupt requests are automatically cleared under normal conditions. They can also be cleared by writing 0 to the interrupt enable bit within the associated peripheral module.

29.15 State of Registers when Issuing each Condition

The IIC has two dedicated resets, IIC reset and internal reset. Table 29.11 lists the registers states when issuing each condition.

Table 29.11 Register states when issuing each condition (1 of 2)

Registers		Reset	IIC reset (ICE = 0, IICRST = 1)	Internal reset (ICE = 1, IICRST = 1)	Start or restart condition detection	Stop condition detection
ICCR1	ICE, IICRST	Reset	Saved	Saved	Saved	Saved
	SCLO, SDAO		Reset	Reset		
	Others			Saved		
ICCR2	BBSY	Reset	Reset	Saved	Set	Saved
	ST			Reset	Saved	Saved
	TRS,MST				Set or saved	Reset
	Others				Reset	Reset or saved

Table 29.10 中断源

Symbol	中断源	中断标志	DMAC/DTC activation	中断条件
IICn_EEI*5	传输错误或事件生成	AL	不可能	AL = 1, ALIE = 1
		NACKF		NACKF = 1, NAKIE = 1
		TMOF		TMOF = 1, TMOIE = 1
		START		START = 1, STIE = 1
		STOP		STOP = 1, SPIE = 1
IICn_RXI*2, *5	接收数据已满	RDRF	Possible	RDRF = 1, RIE = 1
IICn_TXI*1, *5	传输数据为空	TDRE	Possible	TDRE = 1, TIE = 1
IICn_TEI*3, *5	发射端	TEND	不可能	TEND = 1, TEIE = 1
IIC0_WUI*4	唤醒功能期间的从机地址匹配	WUF	不可能	从地址匹配 从机接收完成 RWAK operation ASY0 = 1 WUIE = 1

Note: CPU执行外围模块的写指令与实际写入模块之间存在延迟。当一个中断标志被清除或屏蔽时，再次读取相关标志，检查清除或屏蔽是否完成，然后从中断处理返回。不这样做会产生重复处理同一中断的可能性。

Note 1. 因为IICn_TXI是边沿检测中断，所以不需要清除。此外，ICSR2中的TDRE标志（条件为IICn_TXI)在发送数据写入ICDRT或检测到停止条件时自动设置为0(STOPflag=1in ICSR2).
Note 2. 因为IICn_RXI是边沿检测中断，所以不需要清除。此外，从ICDRR读取数据时，ICSR2中的RDRF标志（IICn_RXI的条件）自动设置为0。
Note 3. 使用IICn_TEI中断时，在IICn_TEI中断处理中清除ICSR2中的TEND标志。当发送数据写入ICDRT或检测到停止条件（ICSR2中的STOP标志=1）时，ICSR2中的TEND标志自动设置为0。
Note 4. 只有通道0具有唤醒功能，因此IIC0_WUI仅适用于通道0。
Note 5. 通道号(n=0 1)。

在中断处理期间清除或屏蔽每个标志。

29.14.1 IICn_TXI和IICn_RXI中断的缓冲区操作

如果在相关的IR标志为1时满足产生IICn_TXI或IICn_RXI中断的条件，则中断请求不会输出给ICU，而是在内部保存。每个源的一个请求可以在内部保存。

当ICU.IELSRn.IR标志变为0时，输出ICU中保存的中断请求。在正常情况下，内部保存的中断请求会自动清除。它们也可以通过向相关外围模块中的中断使能位写入0来清除。

29.15 发布每个条件时的注册状态

IIC有两个专用复位，IIC复位和内部复位。表29.11列出了发出每个条件时的寄存器状态。

Table 29.11 发出每个条件时注册状态（2个中的1个）

Registers		Reset	IIC reset (ICE = 0, IICRST = 1)	内部复位（ICE=1，IICRST=1）	启动或重启条件检测	停止条件检测
ICCR1	ICE, IICRST	Reset	Saved	Saved	Saved	Saved
	SCLO, SDAO		Reset	Reset		
	Others			Saved		
ICCR2	BBSY	Reset	Reset	Saved	Set	Saved
	ST			Reset	Saved	Saved
	TRS,MST				设置或保存	Reset
	Others				Reset	重置或保存

Table 29.11 Register states when issuing each condition (2 of 2)

Registers		Reset	IIC reset (ICE = 0, IICRST = 1)	Internal reset (ICE = 1, IICRST = 1)	Start or restart condition detection	Stop condition detection
ICMR1	BC[2:0]	Reset	Reset	Reset	Reset	Saved
	Others			Saved	Saved	
ICMR2		Reset	Reset	Saved	Saved	Saved
ICMR3		Reset	Reset	Saved	Saved	Saved
ICFER		Reset	Reset	Saved	Saved	Saved
ICSER		Reset	Reset	Saved	Saved	Saved
ICIER		Reset	Reset	Saved	Saved	Saved
ICSR1		Reset	Reset	Reset	Saved	Reset
ICSR2	TDRE, TEND	Reset	Reset	Reset	Saved	Reset
	START				Set	
	STOP				Saved	Set
	Others				Saved	Saved
ICWUR		Reset	Reset	Saved	Saved	Saved
SARL0, SARL1, SARL2 SARU0, SARU1, SARU2		Reset	Reset	Saved	Saved	Saved
ICBRH, ICBRL		Reset	Reset	Saved	Saved	Saved
ICDRT		Reset	Reset	Saved	Saved	Saved
ICDRR		Reset	Reset	Saved	Saved	Saved
ICDRS		Reset	Reset	Reset	Saved	Saved
Timeout function		Reset	Reset	Operating	Operating	Operating
Bus free time measurement		Reset	Reset	Operating	Operating	Operating
ICWUR2	WUSEN	Reset	Reset	Saved	Saved	Saved
	Others					Saved, set, or reset

29.16 Event Link Output

IIC0 and IIC1 modules handle the event output for the Event Link Controller (ELC) for the following sources:

(1) Transfer error event

When a transfer error event occurs, the associated event signal can be output to another module by the ELC.

(2) Receive data full

When a receive data register becomes full, the associated event signal can be output to another module by the ELC.

(3) Transmit data empty

When a transmit data register becomes empty, the associated event signal can be output to another module by the ELC.

(4) Transmit end

On completion of the transfer, the associated event signal can be output to another module by the ELC.

29.16.1 Interrupt Handling and Event Linking

Each of the IIC interrupt types (see Table 29.10) has an enable bit to control enabling and disabling of the associated interrupt signal. An interrupt request signal is output to the CPU when an interrupt source condition is satisfied while the associated enable bit is set.

The associated event link output signals are sent to other modules as event signals by the ELC when the interrupt source conditions are satisfied, regardless of the interrupt enable bit settings. For details on interrupt sources, see Table 29.10.

Table 29.11 发布每个条件时注册状态（2个中的2个）

Registers		Reset	IIC reset (ICE = 0, IICRST = 1)	内部复位（ICE=1，IICRST=1）	启动或重启条件检测	停止条件检测
ICMR1	BC[2:0]	Reset	Reset	Reset	Reset	Saved
	Others			Saved	Saved	
ICMR2		Reset	Reset	Saved	Saved	Saved
ICMR3		Reset	Reset	Saved	Saved	Saved
ICFER		Reset	Reset	Saved	Saved	Saved
ICSER		Reset	Reset	Saved	Saved	Saved
ICIER		Reset	Reset	Saved	Saved	Saved
ICSR1		Reset	Reset	Reset	Saved	Reset
ICSR2	TDRE, TEND	Reset	Reset	Reset	Saved	Reset
	START				Set	
	STOP				Saved	Set
	Others				Saved	Saved
ICWUR		Reset	Reset	Saved	Saved	Saved
SARL0, SARL1, SARL2 SARU0, SARU1, SARU2		Reset	Reset	Saved	Saved	Saved
ICBRH, ICBRL		Reset	Reset	Saved	Saved	Saved
ICDRT		Reset	Reset	Saved	Saved	Saved
ICDRR		Reset	Reset	Saved	Saved	Saved
ICDRS		Reset	Reset	Reset	Saved	Saved
超时功能		Reset	Reset	Operating	Operating	Operating
公交车空闲时间测量		Reset	Reset	Operating	Operating	Operating
ICWUR2	WUSEN	Reset	Reset	Saved	Saved	Saved
	Others					保存、设置或重置

29.16 事件链接输出

IIC0和IIC1模块为以下源处理事件链接控制器(ELC)的事件输出：

(1) 传输错误事件

当发生传输错误事件时，ELC可以将相关事件信号输出到另一个模块。

(2) 接收数据已满

当接收数据寄存器变满时，ELC可以将相关的事件信号输出到另一个模块。

(3) 传输数据为空

当发送数据寄存器变为空时，ELC可以将相关的事件信号输出到另一个模块。

(4) 发射端

传输完成后，ELC可以将相关的事件信号输出到另一个模块。

29.16.1 中断处理和事件链接

每种IIC中断类型（见表29.10）都有一个启用位来控制相关中断信号的启用和禁用。当相关的使能位设置时，中断源条件成立时，将向CPU输出中断请求信号。

当满足中断源条件时，ELC将关联的事件链接输出信号作为事件信号发送到其他模块，而不管中断使能位设置如何。有关中断源的详细信息，请参见表29.10。

RA生态工作室

29.17 Usage Notes

29.17.1 Settings for the Module-Stop State

The Module Stop Control Register B (MSTPCRB) can enable or disable IIC operation. The IIC module is initially stopped after a reset. Releasing the module-stop state enables access to the registers.

For details on Module Stop Control Register B, see section 11, Low Power Modes.

29.17.2 Notes on Starting Transfer

If the IR flag associated with the IIC interrupt is 1 when the transfer is started (ICCR1.ICE bit = 1), follow the procedure in this section to clear the interrupts before enabling operations. Starting transfer with the IR flag set to 1 while the ICCR1.ICE bit is 1 leads to an interrupt request being internally saved after transfer starts, and this can lead to unexpected behavior of the IR flag.

To clear interrupts before starting transfer operation:

1. Confirm that the ICCR1.ICE bit is 0.
2. Set the relevant interrupt enable bits, such as ICIER.TIE to 0.
3. Read the relevant interrupt enable bits, such as ICIER.TIE, and confirm that the value is 0.
4. Set the IR flag to 0.

29.17 使用说明

29.17.1 模块停止状态的设置

模块停止控制寄存器B(MSTPCRB)可以启用或禁用IIC操作。IIC模块在复位后最初停止。释放模块停止状态可以访问寄存器。

有关模块停止控制寄存器B的详细信息，请参见第11节，低功耗模式。

29.17.2 开始转移注意事项

如果在传输开始时与IIC中断相关的IR标志为1（ICCR1.ICE位=1），请按照本节中的步骤在使能操作之前清除中断。在ICCR1.ICE位为1时将IR标志设置为1开始传输会导致在传输开始后内部保存中断请求，这可能导致IR标志的意外行为。

在开始传输操作之前清除中断：

1.确认ICCR1.ICE位为0。

2.设置相关的中断使能位，如ICIER.TIE为0。

3、读取相关的中断使能位，如ICIER.TIE，确认值为0。

4.将IR标志设置为0。

RA生态工作室

30. Controller Area Network (CAN) Module

30.1 Overview

The CAN module uses a message-based protocol to receive and transmit data between multiple slaves and masters in electromagnetically noisy applications. The module complies with the ISO 11898-1 (CAN 2.0A/CAN 2.0B) standard and supports up to 32 mailboxes, which can be configured for transmission or reception in normal mailbox and FIFO modes. Both standard (11-bit) and extended (29-bit) messaging formats are supported. The CAN module requires an additional external CAN transceiver.

Table 30.1 lists the CAN specifications, and Figure 30.1 shows a block diagram.

Table 30.1 CAN specifications (1 of 2)

Parameter	Specifications
Data transfer rate	ISO11898-1-compliant for standard and extended frames
Bit rate	Programmable up to 1 Mbps (fCAN ≥ 8 MHz) fCAN: CAN clock source
Message box	32 mailboxes, with two selectable mailbox modes • Normal mode: 32 mailboxes independently configurable for transmission or reception • FIFO mode: 24 mailboxes independently configurable for either transmission or reception, with remaining mailboxes used for receive (RX) and transmit (TX) 4-stage FIFOs.
Reception	• Support for data frame and remote frame reception • Reception ID format selectable to only standard ID, only extended ID, or mixed IDs • Programmable one-shot reception function • Selectable between overwrite mode (unread message overwritten) and overrun mode (unread message saved) • Reception complete interrupt independently enabled or disabled for each mailbox.
Acceptance filter	• Eight acceptance masks (one for every four mailboxes) • Masks independently enabled or disabled for each mailbox.
Transmission	• Support for data frame and remote frame transmission • Transmission ID format selectable to only standard ID, only extended ID, or mixed IDs • Programmable one-shot transmission function • Broadcast messaging function • Priority mode selectable based on message ID or mailbox number • Support for transmission request abort, with abort completion confirmable in status flag • Transmission complete interrupt independently enabled or disabled for each mailbox.
Mode transition for bus-off recovery	Mode transition for the recovery from the bus-off state selectable to: • ISO11898-1 specification-compliant • Automatic invoking of CAN halt mode on bus-off entry • Automatic invoking of CAN halt mode on bus-off end • Transition to CAN halt mode through software • Transition to error-active state through software.
Error status monitoring	• Monitoring of CAN bus errors, including stuff error, form error, ACK error, 15-bit CRC error, bit error, and ACK delimiter error • Detection of transition to error states, including error-warning, error-passive, bus-off entry, and bus-off recovery • Support for reading of error counters.
Time stamping	• Time stamp function using a 16-bit counter • Reference clock selectable to 1-bit, 2-bit, 4-bit, and 8-bit time periods.
Interrupt function	Support for five interrupt sources: • Reception complete • Transmission complete • Receive FIFO • Transmit FIFO • Error interrupts.
CAN sleep mode	CAN clock stopped to reduce power consumption

30. 控制器局域网(CAN)模块

30.1 Overview

CAN模块使用基于消息的协议在电磁噪声应用中的多个从机和主机之间接收和传输数据。该模块符合ISO11898-1(CAN2.0ACAN2.0B)标准，最多支持32个邮箱，可配置为普通邮箱和FIFO模式下的发送或接收。支持标准（11位）和扩展（29位）消息格式。CAN模块需要额外的外部CAN收发器。

表30.1列出了CAN规格，图30.1显示了框图。

Table 30.1 CAN规格(1of2)

Parameter	Specifications
数据传输率	标准和扩展框架符合ISO11898-1
比特率	可编程高达1Mbps(fCAN 8MHz)fCAN：CAN 时钟源
消息框	32个邮箱，有两种可选邮箱模式 普通模式：32个邮箱可独立配置用于发送或接收 FIFO模式：24个邮箱可独立配置用于发送或接收，其余邮箱用于接收(RX)和发送(TX)4-阶段FIFO。
Reception	支持数据帧和远程帧接收 接收ID格式可选择仅标准ID、仅扩展ID或混合ID 可编程一次性接收功能可选择覆盖模式（未读消息覆盖）和溢出模式（保存未读消息） 为每个邮箱独立启用或禁用接收完成中断。
验收过滤器	八个接受掩码（每四个邮箱一个） 为每个邮箱独立启用或禁用掩码。
Transmission	支持数据帧和远程帧传输 传输ID格式可选择仅标准ID、仅扩展ID或混合ID 可编程一次性传输功能 广播消息功能 基于消息ID或邮箱号选择优先模式 支持对于传输请求中止，在状态标志中可确认中止完成 为每个邮箱独立启用或禁用传输完成中断。
总线关闭恢复的模式转换	从总线关闭状态恢复的模式转换可选择： 符合ISO11898-1规范 在总线关闭进入时自动调用CAN暂停模式 在总线关闭结束时自动调用CAN暂停模式 转换到CAN暂停通过软件模式 通过软件转换到错误激活状态。
错误状态监控	监控CAN总线错误，包括填充错误、格式错误、ACK错误、15位CRC错误、位错误和ACK分隔符错误 检测到错误状态的转换，包括错误警告、错误被动、总线关闭入口和总线关闭恢复 支持读取错误计数器。
时间戳	使用16位计数器的时间戳功能 可选择1位、2位、4位和8位时间周期的参考时钟。
中断功能	支持五个中断源： 接收完成 发送完成 接收FIFO 发送FIFO 错误中断。
CAN睡眠模式	CAN时钟停止以降低功耗

Table 30.1 CAN specifications (2 of 2)

Parameter	Specifications
Software support unit	Three software support units: • Acceptance filter support • Mailbox search support, including receive mailbox search, transmit mailbox search, and message lost search • Channel search support.
CAN clock source	PCLKB or CANMCLK
Test mode	Three test modes available for evaluation purposes: • Listen-only mode • Self-test mode 0 (external loopback) • Self-test mode 1 (internal loopback).
Module-stop function	Module-stop state can be set to reduce power consumption

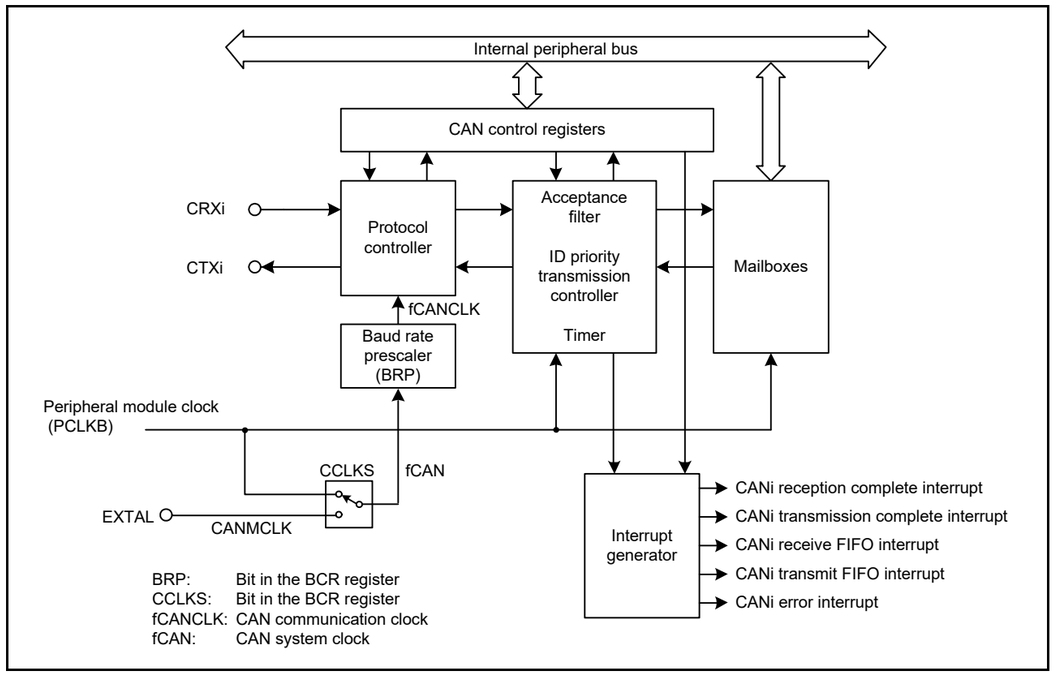


Figure 30.1 CAN module block diagram (i = 0)

The CAN module constitutes the following blocks:

- CAN input and output pins
  CRXi and CTXi, where i = 0
- Protocol controller
  Handles CAN protocol processing such as bus arbitration, bit timing at transmission and reception, stuffing, and error handling
- Mailboxes
  Consists of 32 mailboxes, which can be configured as either transmit or receive. Each mailbox has an individual ID, data length code (DLC), data field (8 bytes), and a time stamp.
- Acceptance filter
  Performs filtering of received messages using MKR0 to MKR7 registers for the filtering process
- Timer
  Used for the time stamp function. The timer value when a message is stored in the mailbox is written as the time stamp value.

Table 30.1 CAN规格（2个中的2个）

Parameter	Specifications
软件支持单位	三个软件支持单元： 接受过滤器支持 邮箱搜索支持，包括接收邮箱搜索、发送邮箱搜索和邮件丢失搜索渠道搜索支持。
CAN时钟源	PCLKB or CANMCLK
测试模式	三种测试模式可用于评估目的： 只听模式 自测模式0（外部环回） 自测模式1（内部环回）。
Module-stop function	可设置模块停止状态以降低功耗

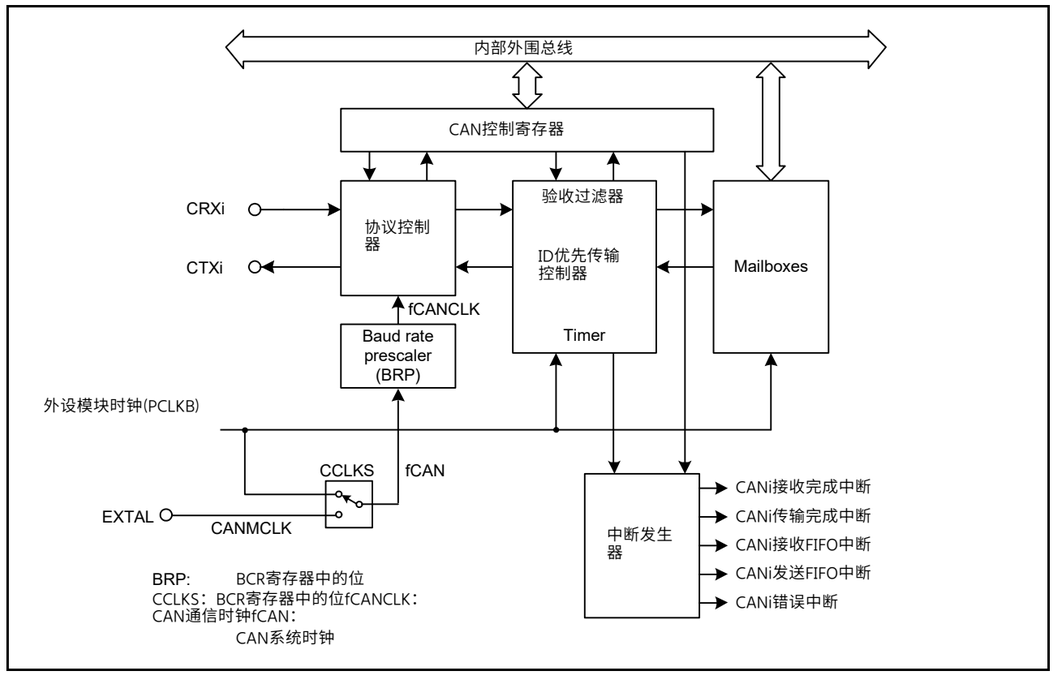


Figure 30.1 CAN模块框图(i=0)

CAN模块由以下模块组成：

- CAN输入和输出引脚
  CRXi和CTXi，其中i=0
- 协议控制器
  处理CAN协议处理，例如总线仲裁、发送和接收时的位时序、填充和错误处理
- Mailboxes
  包含32个邮箱，可配置为发送或接收。每个邮箱都有一个单独的ID、数据长度代码(DLC)、数据字段（8个字节）和一个时间戳。
- 验收过滤器
  使用用于过滤过程的MKR0到MKR7寄存器对接收到的消息进行过滤
- Timer
  用于时间戳功能。将消息存储在邮箱中时的计时器值作为时间戳值写入。

- Interrupt generator for five types of interrupts:
  - CANi reception complete interrupt
  - CANi transmission complete interrupt
  - CANi receive FIFO interrupt
  - CANi transmit FIFO interrupt
  - CANi error interrupt.

Table 30.2 lists the CAN module pins. These pins are multiplexed with other signals on the MCU. For details, see section 19, I/O Ports.

Table 30.2 CAN module I/O pins

Pin name	I/O	Function
CRX0	Input	Data receive pin
CTX0	Output	Data transmit pin

30.2 Register Descriptions

30.2.1 Control Register (CTLR)

Address(es): CAN0.CTLR 4005 0840h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	RBOC	BOM[1:0]		SLPM	CANM[1:0]		TSPS[1:0]		TSRC	TPM	MLM	IDFM[1:0]		MBM
Value after reset:	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	MBM	CAN Mailbox Mode Select*1	0: Normal mailbox mode 1: FIFO mailbox mode.	R/W
b2, b1	IDFM[1:0]	ID Format Mode Select *1	b2 b1 0 0: Standard ID mode All mailboxes, including FIFO mailboxes, handle only standard IDs 0 1: Extended ID mode All mailboxes, including FIFO mailboxes, handle only extended IDs 1 0: Mixed ID mode All mailboxes, including FIFO mailboxes, handle both standard and extended IDs. In normal mailbox mode, use the associated IDE bit to differentiate between standard and extended IDs. In FIFO mailbox mode, the associated IDE bits are used for mailboxes 0 to 23, the IDE bits in FIDCR0 and FIDCR1 are used for the receive FIFO, and the IDE bit associated with mailbox 24 is used for the transmit FIFO. 1 1: Setting prohibited.	R/W
b3	MLM	Message Lost Mode Select*1	0: Overwrite mode 1: Overrun mode.	R/W
b4	TPM	Transmission Priority Mode Select*1	0: ID priority transmit mode 1: Mailbox number priority transmit mode.	R/W
b5	TSRC	Time Stamp Counter Reset Command*4	0: Do not reset time stamp counter 1: Reset time stamp counter.*3	R/W
b7, b6	TSPS[1:0]	Time Stamp Prescaler Select*1	b7 b6 0 0: Every 1-bit time 0 1: Every 2-bit time 1 0: Every 4-bit time 1 1: Every 8-bit time.	R/W

- 用于五种类型中断的中断发生器：
  - CANi接收完成中断
  - CANi传输完成中断
  - CANi接收FIFO中断
  - CANi发送FIFO中断
  - CANi错误中断。

表30.2列出了CAN模块引脚。这些引脚与MCU上的其他信号复用。有关详细信息，请参阅第19节，IO端口。

Table 30.2 CAN模块IO引脚

引脚名称	I/O	Function
CRX0	Input	数据接收引脚
CTX0	Output	数据传输引脚

30.2 注册说明

30.2.1 控制寄存器(CTLR)

Address(es): CAN0.CTLR 4005 0840h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	RBOC	BOM[1:0]		SLPM	CANM[1:0]		TSPS[1:0]		TSRC	TPM	MLM	IDFM[1:0]		MBM
重置后的值:	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	MBM	CAN邮箱模式 Select*1	0：普通邮箱模式1：FIFO邮箱模式。	R/W
b2, b1	IDFM[1:0]	ID格式模式选择*1	b2b100：标准ID模式 所有邮箱，包括FIFO邮箱，只处理标准ID01：扩展ID模式 所有邮箱，包括FIFO邮箱，只处理扩展ID10：混合ID模式 所有邮箱，包括FIFO邮箱，都处理标准ID和扩展ID。在普通邮箱模式下，使用相关的IDE位来区分标准ID和扩展ID。在FIFO邮箱模式下，相关的IDE位用于邮箱0到23，FIDCR0和FIDCR1中的IDE位用于接收FIFO，与邮箱24相关的IDE位用于发送FIFO。11：禁止设置。	R/W
b3	MLM	消息丢失模式 Select*1	0：覆盖模式1：溢出模式。	R/W
b4	TPM	传输优先级 Mode Select*1	0：ID优先发送模式1：邮箱号码优先发送模式。	R/W
b5	TSRC	时间戳计数器 Reset Command*4	0：不重置时间戳计数器1：重置时间戳计数器。*3	R/W
b7, b6	TSPS[1:0]	时间戳预分频器 Select*1	b7b600：每1位时间01：每2位时间10：每4位时间11：每8位时间。	R/W

Bit	Symbol	Bit name	Description	R/W
b9, b8	CANM[1:0]	CAN Operating Mode Select*5	b9 b8 0 0: CAN operation mode 0 1: CAN reset mode 1 0: CAN halt mode 1 1: CAN reset mode (forced transition).	R/W
b10	SLPM	CAN Sleep Mode*5,*6	0: Exit CAN sleep mode 1: Enter CAN sleep mode.	R/W
b12, b11	BOM[1:0]	Bus-Off Recovery Mode*1	b12 b11 0 0: Normal mode (ISO11898-1 specification compliant) 0 1: Enter CAN halt mode automatically on entering bus-off state 1 0: Enter CAN halt mode automatically at the end of bus-off state 1 1: Enter CAN halt mode during bus-off recovery period through a software request.	R/W
b13	RBOC	Forcible Return from Bus-Off*2	0: No return occurred 1: Forced return from bus-off state.*3	R/W
b15, b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. Write to the BOM[1:0], TSPS[1:0], TPM, MLM, IDFM[1:0], and MBM bits in CAN reset mode.
Note 2. Set the RBOC bit to 1 in the bus-off state.
Note 3. This bit automatically sets to 0 after being set to 1. It should be read as 0.
Note 4. Set the TSRC bit to 1 in CAN operation mode.
Note 5. When the CANM[1:0] and SLPM bits are changed, check STR to ensure that the mode is switched. Do not change the CANM[1:0] bits or SLPM bit until the mode is switched.
Note 6. Write to the SLPM bit in CAN reset mode or CAN halt mode. When changing the SLPM bit, write 0 or 1 only to the SLPM bit.

MBM bit (CAN Mailbox Mode Select)

When the MBM bit is 0 (normal mailbox mode), mailboxes 0 to 31 are configured as transmit or receive mailboxes.

When the MBM bit is 1 (FIFO mailbox mode):

- Mailboxes 0 to 23 are configured as transmit or receive mailboxes
- Mailboxes 24 to 27 are configured as transmit FIFO
- Mailboxes 28 to 31 are configured as receive FIFO.

Transmit data is written into mailbox 24, a window mailbox for the transmit FIFO. Receive data is read from mailbox 28, a window mailbox for the receive FIFO.

Table 30.3 lists the mailbox configuration.

IDFM[1:0] bits (ID Format Mode Select)

The IDFM[1:0] bits specify the ID format.

MLM bit (Message Lost Mode Select*1)

The MLM bit specifies the operation when a new message is captured in an unread mailbox. Overwrite mode or overrun mode can be selected. All mailboxes, including the receive FIFO are set to either overwrite mode or overrun mode.

When the MLM bit is 0, all mailboxes are set to overwrite mode. Any new message received overwrites the pre-existing message.

When the MLM bit is 1, all mailboxes are set to overrun mode. Any new message received does not overwrite the pre-existing message, and the new message is discarded.

TPM bit (Transmission Priority Mode Select*1)

The TPM bit specifies the priority when transmitting messages.

The ID priority transmit mode or mailbox number transmit mode can be selected. All mailboxes are set for either ID priority transmission or mailbox number priority transmission.

When TPM is 0, ID priority transmit mode is selected and transmission priority is arbitrated, as defined in the CAN specification (ISO11898-1). In ID priority transmit mode, mailboxes 0 to 31 (in normal mailbox mode), and mailboxes 0 to 23 (in FIFO mailbox mode), and the transmit FIFO are compared for the IDs of mailboxes configured for transmission. If two or more mailbox IDs are the same, the mailbox with the smaller number has higher priority.

Bit	Symbol	位名称	Description	R/W
b9, b8	CANM[1:0]	CAN操作模式 Select*5	b9b800：CAN操作模式01：CAN复位模式10：CAN暂停模式11：CAN复位模式（强制转换）。	R/W
b10	SLPM	CAN睡眠模式*5 *6	0：退出CAN睡眠模式1：进入CAN睡眠模式。	R/W
b12, b11	BOM[1:0]	Bus-Off Recovery Mode*1	b12b1100：正常模式（符合ISO11898-1规范）01：进入总线关闭状态时自动进入CAN停止模式10：在总线关闭状态结束时自动进入CAN停止模式11：进入CAN停止在总线关闭恢复期间通过软件请求模式。	R/W
b13	RBOC	强行返回 Bus-Off*2	0：未发生返回1：从总线关闭状态强制返回。*3	R/W
b15, b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 在CAN复位模式下写入BOM[1:0]、TSPS[1:0]、TPM、MLM、IDFM[1:0]和MBM位。
Note 2. 在总线关闭状态下将RBOC位设置为1。
Note 3. 该位设置为1后自动设置为0，应读为0。
Note 4. 在CAN操作模式下将TSRC位设置为1。
Note 5. 当CANM[1:0]和SLPM位改变时，检查STR以确保模式切换。不要改变CANM[1:0]位或SLPM位，直到模式切换。
Note 6. 在CAN复位模式或CAN暂停模式下写入SLPM位。更改SLPM位时，仅向SLPM位写入0或1。

MBM位（CAN邮箱模式选择）

当MBM位为0（正常邮箱模式）时，邮箱0到31被配置为发送或接收邮箱。

当MBM位为1（FIFO邮箱模式）时：

- 邮箱0到23被配置为发送或接收邮箱
- 邮箱24到27被配置为发送FIFO
- 邮箱28到31配置为接收FIFO。

发送数据写入邮箱24，这是发送FIFO的窗口邮箱。接收数据从邮箱28中读取，该邮箱是接收FIFO的窗口邮箱。

表30.3列出了邮箱配置。

IDFM[1:0]位（ID格式模式选择）

IDFM[1:0]位指定ID格式。

MLM位（消息丢失模式选择*1）

MLM位指定在未读邮箱中捕获新消息时的操作。可以选择覆盖模式或溢出模式。所有邮箱，包括接收FIFO都设置为覆盖模式或溢出模式。

当MLM位为0时，所有邮箱都设置为覆盖模式。收到的任何新消息都会覆盖先前存在的消息。

当MLM位为1时，所有邮箱都设置为溢出模式。收到的任何新消息都不会覆盖先前存在的消息，并且新消息将被丢弃。

TPM位（传输优先模式选择*1）

TPM位指定传输消息时的优先级。

可选择ID优先传送模式或信箱号码传送模式。所有信箱都设置为ID优先传输或信箱号码优先传输。

当TPM为0时，选择ID优先传输模式并仲裁传输优先级，如CAN规范(ISO11898-1)中所定义。在ID优先传输模式下，邮箱0到31（在普通邮箱模式下）和邮箱0到23（在FIFO邮箱模式下）和传输FIFO会针对配置为传输的邮箱ID进行比较。如果两个或多个邮箱ID相同，则编号较小的邮箱优先级较高。

Only the next message to be transmitted from the transmit FIFO is included in the transmission arbitration. If a FIFO message is currently being transmitted, the next pending message within the transmit FIFO is included in the transmission arbitration.

When TPM is 1, mailbox number transmit mode is selected and the transmit mailbox with the smallest mailbox number has the highest priority. In FIFO mailbox mode, the transmit FIFO has lower priority than normal mailboxes (0 to 23).

TSRC bit (Time Stamp Counter Reset Command*4)

The TSRC bit resets the time stamp counter. When this bit is set to 1, TSR is set to 0000h. This bit is automatically set to 0.

TSPS[1:0] bits (Time Stamp Prescaler Select*1)

The TSPS[1:0] bits select the prescaler for the time stamp. The reference clock for the time stamp can be selected to either 1-bit, 2-bit, 4-bit, or 8-bit time periods.

CANM[1:0] bits (CAN Operating Mode Select*5)

The CANM[1:0] bits select one of the following modes for the CAN module:

- CAN operation mode
- CAN reset mode
- CAN halt mode.

The CAN sleep mode is set in the SLPM bit. For details, see section 30.3, Operation Modes. When the CAN module enters CAN halt mode based on the BOM[1:0] setting, the CANM[1:0] bits are automatically set to 10b.

SLPM bit (CAN Sleep Mode)

When the SLPM bit is set to 1, the CAN module enters CAN sleep mode. When the SLPM bit is set to 0, the CAN module exits CAN sleep mode. For details, see section 30.3, Operation Modes.

BOM[1:0] bits (Bus-Off Recovery Mode*1)

The BOM[1:0] bits select bus-off recovery mode for the CAN module.

When the BOM[1:0] bits are 00b, the recovery from bus-off is compliant with the ISO11898-1 CAN specification. The CAN module recovers CAN communication (error-active state) after detecting 11 consecutive recessive bits 128 times. A bus-off recovery interrupt request occurs when recovering from bus-off.

When the BOM[1:0] bits are 01b and the CAN module reaches the bus-off state, the CANM[1:0] bits in CTLR are set to 10b to enter CAN halt mode. No bus-off recovery interrupt request occurs when recovering from bus-off, and TECR and RECR are set to 00h.

When the BOM[1:0] bits are 10b, the CANM[1:0] bits are set to 10b as soon as the CAN module reaches the bus-off state. The CAN module enters CAN halt mode after recovery from the bus-off state, and after detecting 11 consecutive recessive bits 128 times. A bus-off recovery interrupt request occurs when recovering from bus-off, and TECR and RECR are set to 00h.

When the BOM[1:0] bits are 11b, the CAN module enters CAN halt mode by setting the CANM[1:0] bits to 10b while the CAN module is still in the bus-off state. No bus-off recovery interrupt request is generated when recovering from bus-off, and TECR and RECR are set to 00h. However, if the CAN module recovers from bus-off after detecting 11 consecutive recessive bits 128 times before the CANM[1:0] bits are set to 10b, a bus-off recovery interrupt request is generated.

If the CPU requests an entry to the CAN reset mode at the same time as the CAN module attempts to enter CAN halt mode (at bus-off entry when the BOM[1:0] bits are 01b, or at bus-off end when the BOM[1:0] bits are 10b), then the CPU request has higher priority.

RBOC bit (Forcible Return from Bus-Off*2)

When the RBOC bit is set to 1 in the bus-off state, the CAN module forcibly exits the bus-off state. This bit is automatically set to 0, and the error state changes from bus-off to error-active. When the RBOC bit is set to 1, RECR and TECR are set to 00h and the BOST bit in STR is set to 0, indicating that the CAN module is not in bus-off state. The other registers remain unchanged when RBOC is set to 1. No bus-off recovery interrupt request is generated by this

只有从发送FIFO发送的下一条消息包含在发送仲裁中。如果当前正在发送FIFO消息，则发送FIFO中的下一个未决消息将包含在发送仲裁中。

当TPM为1时，选择邮箱号发送模式，邮箱号最小的发送邮箱优先级最高。在FIFO邮箱模式下，发送FIFO的优先级低于普通邮箱（0到23）。

TSRC位（时间戳计数器复位命令*4）

TSRC位复位时间戳计数器。当该位设置为1时，TSR设置为0000h。该位自动设置为0。

TSPS[1:0]位（时间戳预分频器选择*1）

TSPS[1:0]位选择时间戳的预分频器。时间戳的参考时钟可以选择为1位、2位、4位或8位时间段。

CANM[1:0]位（CAN操作模式选择*5）

CANM[1:0]位为CAN模块选择以下模式之一：

- CAN操作模式
- CAN复位模式
- CAN暂停模式。

CAN睡眠模式在SLPM位中设置。有关详细信息，请参阅第30.3节，操作模式。当CAN模块根据BOM[1:0]设置进入CAN暂停模式时，CANM[1:0]位自动设置为10b。

SLPM位（CAN休眠模式）

当SLPM位设置为1时，CAN模块进入CAN睡眠模式。当SLPM位设置为0时，CAN模块退出CAN睡眠模式。有关详细信息，请参阅第30.3节，操作模式。

BOM[1:0]位（总线关闭恢复模式*1）

BOM[1:0]位选择CAN模块的总线关闭恢复模式。

当BOM[1:0]位为00b时，总线关闭恢复符合ISO11898-1CAN规范。CAN模块在检测到11个连续隐性位128次后恢复CAN通信（错误激活状态）。
从总线关闭中恢复时会出现总线关闭恢复中断请求。

当BOM[1:0]位为01b且CAN模块达到总线关闭状态时，CTLR中的CANM[1:0]位设置为10b以进入CAN停止模式。总线关闭恢复时不产生总线关闭恢复中断请求，TECR和RECR设置为00h。

当BOM[1:0]位为10b时，CAN模块一到达总线关闭状态，CANM[1:0]位就会设置为10b。CAN模块从总线关闭状态恢复后，并在检测到11个连续的隐性位128次后进入CAN停止模式。总线关闭恢复时产生总线关闭恢复中断请求，TECR和RECR设置为00h。

当BOM[1:0]位为11b时，CAN模块通过将CANM[1:0]位设置为10b进入CAN停止模式，同时CAN模块仍处于总线关闭状态。总线关闭恢复时不产生总线关闭恢复中断请求，TECR和RECR设置为00h。但是，如果CAN模块在CANM[1:0]位设置为10b之前128次检测到11个连续隐性位后从总线关闭中恢复，则会产生总线关闭恢复中断请求。

如果CPU在CAN模块尝试进入CAN暂停模式的同时请求进入CAN复位模式（当BOM[1:0]位为01b时在总线关闭进入，或在总线关闭结束时BOM[1:0]位为10b），则CPU请求具有更高的优先级。

RBOC位（从总线关闭强制返回*2）

当RBOC位在总线关闭状态下设置为1时，CAN模块强制退出总线关闭状态。该位自动设置为0，错误状态从总线关闭变为错误激活。当RBOC位设置为1时，RECR和TECR设置为00h，STR中的BOST位设置为0，表示CAN模块不处于总线关闭状态。当RBOC设置为1时，其他寄存器保持不变。不产生总线关闭恢复中断请求

recovery from the bus-off state. Use the RBOC bit only when the BOM[1:0] bits are 00b (normal mode).

Table 30.3 Mailbox configuration

Mailbox	MBM bit = 0 (normal mailbox mode)	MBM bit = 1 (FIFO mailbox mode)*1 to *5
Mailboxes 0 to 23	Normal mailbox	Normal mailbox
Mailboxes 24 to 27		Transmit FIFO
Mailboxes 28 to 31		Receive FIFO

Note 1. The transmit FIFO is controlled by TFCR. The MCTL_TXj registers associated with mailboxes 24 to 27 are disabled. MCTL_TX24 to MCTL_TX27 cannot be used by the transmit FIFO.
Note 2. The receive FIFO is controlled by RFCR. The MCTL_RXj registers associated with mailboxes 28 to 31 are disabled. MCTL_RX28 to MCTL_RX31 cannot be used by the receive FIFO.
Note 3. See the MIER_FIFO register for information on the FIFO interrupts.
Note 4. The bits in MKIVLR associated with mailboxes 24 to 31 are disabled. Set these bits to 0.
Note 5. The transmit and receive FIFOs can be used for both data frames and remote frames.

30.2.2 Bit Configuration Register (BCR)

Address(es): CAN0.BCR 4005 0844h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	TSEG1[3:0]				—	—	BRP[9:0]									
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	SJW[1:0]		—	TSEG2[2:0]			—	—	—	—	—	—	—	CCLKS
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CCLKS	CAN Clock Source Selection	0: PCLKB (generated by the PLL clock) 1: CANMCLK (generated by the main clock oscillator).	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b10 to b8	TSEG2[2:0]	Time Segment 2 Control	b10 b8 0 0 0: Setting prohibited 0 0 1: 2 Tq 0 1 0: 3 Tq 0 1 1: 4 Tq 1 0 0: 5 Tq 1 0 1: 6 Tq 1 1 0: 7 Tq 1 1 1: 8 Tq.	R/W
b11	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b13, b12	SJW[1:0]	Synchronization Jump Width Control	b13 b12 0 0: 1 Tq 0 1: 2 Tq 1 0: 3 Tq 1 1: 4 Tq.	R/W
b15, b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b25 to b16	BRP[9:0]	Baud Rate Prescaler Select*1	These bits set the frequency of the CAN communication clock (fCANCLK)	R/W
b27, b26	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

从总线关闭状态恢复。仅当BOM[1:0]位为00b（正常模式）时才使用RBOC位。

Table 30.3 邮箱配置

Mailbox	MBM位=0（正常邮箱模式）	MBM位=1（FIFO邮箱模式）*1到*5
邮箱0到23	普通邮箱	普通邮箱
邮箱24至27		Transmit FIFO
邮箱28至31		Receive FIFO

Note 1. 发送FIFO由TFCR控制。与邮箱24到27关联的MCTL_TXj寄存器被禁用。发送FIFO不能使用MCTL_TX24到MCTL_TX27。
Note 2. 接收FIFO由RFCR控制。与邮箱28到31关联的MCTL_RXj寄存器被禁用。MCTL_RX28到MCTL_RX31不能被接收FIFO使用。
Note 3. 有关FIFO中断的信息，请参见MIER_FIFO寄存器。
Note 4. MKIVLR中与邮箱24到31关联的位被禁用。将这些位设置为0。
Note 5. 发送和接收FIFO可用于数据帧和远程帧。

30.2.2 位配置寄存器(BCR)

Address(es): CAN0.BCR 4005 0844h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	TSEG1[3:0]				—	—	BRP[9:0]									
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	SJW[1:0]		—	TSEG2[2:0]			—	—	—	—	—	—	—	CCLKS
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CCLKS	CAN时钟源 Selection	0：PCLKB（由PLL时钟产生）1：CANMCLK（由主时钟振荡器产生）。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b10 to b8	TSEG2[2:0]	时间段2控制	b10b8000：禁止设置001：2Tq010：3Tq011：4Tq100：5Tq101：6Tq110：7Tq111：8Tq.	R/W
b11	—	Reserved	该位读取为0。写入值应为0。	R/W
b13, b12	SJW[1:0]	同步跳转宽度控制	b13 b12 0 0: 1 Tq 0 1: 2 Tq 1 0: 3 Tq 1 1: 4 Tq.	R/W
b15, b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b25 to b16	BRP[9:0]	Baud Rate Prescaler Select*1	这些位设置CAN通信时钟(fCANCLK)的频率	R/W
b27, b26	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Bit	Symbol	Bit name	Description	R/W
b31 to b28	TSEG1[3:0]	Time Segment 1 Control	b31 b28 0 0 0 0: Setting prohibited 0 0 0 1: Setting prohibited 0 0 1 0: Setting prohibited 0 0 1 1: 4 Tq 0 1 0 0: 5 Tq 0 1 0 1: 6 Tq 0 1 1 0: 7 Tq 0 1 1 1: 8 Tq 1 0 0 0: 9 Tq 1 0 0 1: 10 Tq 1 0 1 0: 11 Tq 1 0 1 1: 12 Tq 1 1 0 0: 13 Tq 1 1 0 1: 14 Tq 1 1 1 0: 15 Tq 1 1 1 1: 16 Tq.	R/W

Tq: Time Quantum

Note 1. Do not select a value less than or equal to 1 while the SCKSCR.CKSEL[2:0] bits are 011b (selecting the main clock oscillator).

For details about setting the bit timing, see section 30.4, Data Transfer Rate Configuration. Set BCR before entering CAN halt mode or CAN operation mode from CAN reset mode. After the setting is made once, this register can be written to in CAN reset mode or CAN halt mode. A 32-bit read/write access must be performed carefully so as not to change bits [7:0].

CCLKS bit (CAN Clock Source Selection)

When the CCLKS bit is 0, the peripheral module clock (PCLKB) produced by the PLL frequency synthesizer is used as the CAN clock source (fCAN). When the CCLKS bit is 1, CANMCLK produced externally by the EXTAL pins is used as the CAN clock source (fCAN).

TSEG2[2:0] bits (Time Segment 2 Control)

The TSEG2[2:0] bits specify the length of the phase buffer segment 2 (PHASE_SEG2) with a Tq value. A value from 2 to 8 Tq can be set. Set a value smaller than that in the TSEG1[3:0] bits.

SJW[1:0] bits (Synchronization Jump Width Control)

The SJW[1:0] bits specify the synchronization jump width with a Tq value. A value from 1 to 4 Tq can be set. Set a value smaller than or equal to that in the TSEG2[2:0] bits.

BRP[9:0] bits (Baud Rate Prescaler Select*1)

The BRP[9:0] bits set the frequency of the CAN communication clock (fCANCLK). The fCANCLK cycle is 1 Tq. If the setting is P (0 to 1023), the baud rate prescaler divides fCAN by P + 1.

TSEG1[3:0] bits (Time Segment 1 Control)

The TSEG1[3:0] bits specify the total length of the propagation time segment (PROP_SEG) and phase buffer segment 1 (PHASE_SEG1) with a time quantum (Tq) value. A value from 4 to 16 Tq can be set.

Bit	Symbol	位名称	Description	R/W
b31 to b28	TSEG1[3:0]	时间段1控制	b31b280000：禁止设置0001：禁止设置0010：禁止设置0011：4Tq0100：5Tq0101：6Tq0110：7Tq0111：8Tq1000：9Tq1001：10Tq1010：11Tq1011：12Tq1100：13Tq1101：14Tq1110：15Tq1111：16Tq。	R/W

Tq：时间量子

Note 1. 当SCKSCR.CKSEL[2:0]位为011b（选择主时钟振荡器）时，请勿选择小于或等于1的值。

有关设置位时序的详细信息，请参见第30.4节，数据传输速率配置。在从CAN复位模式进入CAN停止模式或CAN操作模式之前设置BCR。设置一次后，可在CAN复位模式或CAN暂停模式下写入该寄存器。必须小心执行32位读写访问，以免更改位[7:0]。

CCLKS位（CAN时钟源选择）

当CCLKS位为0时，PLL频率合成器产生的外设模块时钟（PCLKB）用作CAN时钟源（fCAN）。当CCLKS位为1时，由EXTAL引脚从外部产生的CANMCLK用作CAN时钟源(fCAN)。

TSEG2[2:0]位（时间段2控制）

TSEG2[2:0]位用Tq值指定相位缓冲段2(PHASE_SEG2)的长度。可以设置2到8Tq的值。设置一个小于TSEG1[3:0]位的值。

SJW[1:0]位（同步跳转宽度控制）

SJW[1:0]位用Tq值指定同步跳转宽度。可以设置1到4Tq的值。设置一个小于或等于TSEG2[2:0]位的值。

BRP[9:0]位（波特率预分频器选择*1）

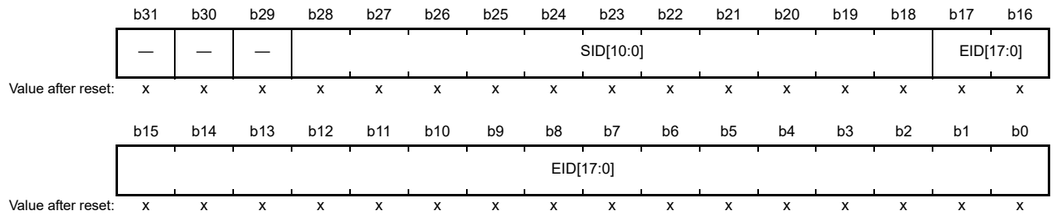
BRP[9:0]位设置CAN通信时钟(fCANCLK)的频率。fCANCLK周期为1Tq。如果设置为P（0到1023），则波特率预分频器将fCAN除以P+1。

TSEG1[3:0]位（时间段1控制）

TSEG1[3:0]位用时间量(Tq)值指定传播时间段(PROP_SEG)和相位缓冲段1(PHASE_SEG1)的总长度。可以设置4到16Tq的值。

30.2.3 Mask Register k (MKRk) (k = 0 to 7)

Address(es): CAN0.MKR[0] 4005 0400h to CAN0.MKR[7] 4005 041Ch



x: Undefined

Bit	Symbol	Bit name	Description	R/W
b17 to b0	EID[17:0]	Extended ID	0: Do not compare associated EID[17:0] bits 1: Compare associated EID[17:0] bits.	R/W
b28 to b18	SID[10:0]	Standard ID	0: Do not compare associated SID[10:0] bits 1: Compare associated SID[10:0] bits.	R/W
b31 to b29	—	Reserved	The read value is undefined. The write value should be 0.	R/W

For the mask function in FIFO mailbox mode, see section 30.6, Acceptance Filtering and Masking Functions. Write to MKR0 to MKR7 in CAN reset mode or CAN halt mode.

EID[17:0] bits (Extended ID)

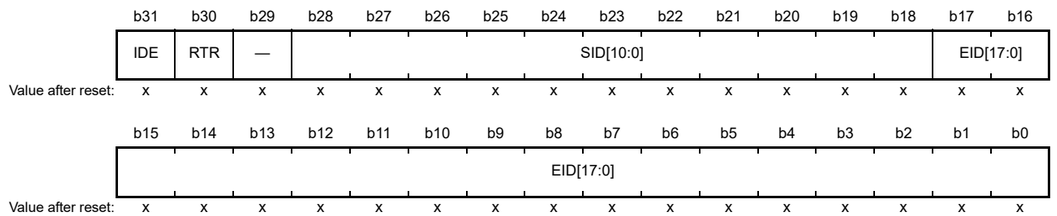
The EID[17:0] bits are the filter mask bits associated with the CAN extended ID bits. They are used to receive extended ID messages. When an EID[17:0] bit is set to 0, the received ID is not compared with the associated mailbox ID. When an EID[17:0] bit is set to 1, the received ID is compared with the associated mailbox ID.

SID[10:0] bits (Standard ID)

The SID[10:0] bits are the filter mask bits associated with the CAN standard ID bits. They are used to receive both standard ID and extended ID messages. When an SID[10:0] bit is set to 0, the received ID is not compared with the associated mailbox ID. When an SID[10:0] bit is set to 1, the received ID is compared with the associated mailbox ID.

30.2.4 FIFO Received ID Compare Registers 0 and 1 (FIDCR0 and FIDCR1)

Address(es): CAN0.FIDCR0 4005 0420h, CAN0.FIDCR1 4005 0424h

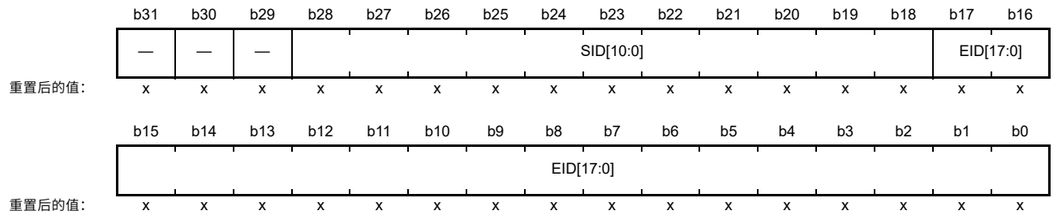


x: Undefined

Bit	Symbol	Bit name	Description	R/W
b17 to b0	EID[17:0]	Extended ID	Extended ID of data and remote frames	R/W
b28 to b18	SID[10:0]	Standard ID	Standard ID of data and remote frames	R/W
b29	—	Reserved	The read value is undefined. The write value should be 0.	R/W
b30	RTR	Remote Transmission Request	0: Data frame 1: Remote frame.	R/W

30.2.3 屏蔽寄存器k(MKRk)(k=0到7)

Address(es): CAN0.MKR[0] 4005 0400h to CAN0.MKR[7] 4005 041Ch



x: Undefined

Bit	Symbol	位名称	Description	R/W
b17 to b0	EID[17:0]	扩展ID	0：不比较关联的EID[17:0]位1：比较关联的EID[17:0]位。	R/W
b28 to b18	SID[10:0]	标准标识	0：不比较关联的SID[10:0]位1：比较关联的SID[10:0]位。	R/W
b31 to b29	—	Reserved	读取值未定义。写入值应为0。	R/W

对于FIFO邮箱模式下的屏蔽功能，请参见第30.6节，接受过滤和屏蔽功能。写给MKR0至MKR7处于CAN复位模式或CAN暂停模式。

EID[17:0]位（扩展ID）

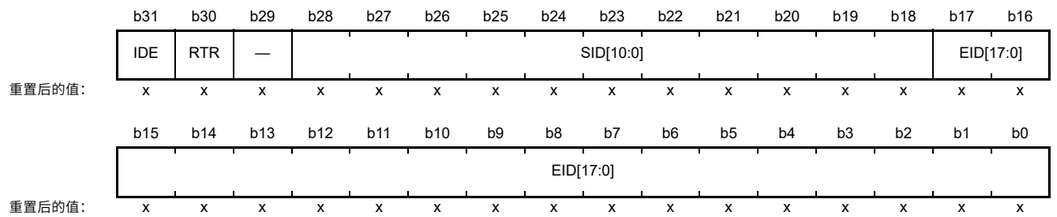
EID[17:0]位是与CAN扩展ID位相关的过滤器掩码位。它们用于接收扩展ID消息。当EID[17:0]位设置为0时，接收到的ID不会与关联的邮箱ID进行比较。当EID[17:0]位设置为1时，接收的ID将与关联的邮箱ID进行比较。

SID[10:0]位（标准ID）

SID[10:0]位是与CAN标准ID位相关的过滤器掩码位。它们用于接收标准ID和扩展ID消息。当SID[10:0]位设置为0时，接收到的ID不会与关联的邮箱ID进行比较。当SID[10:0]位设置为1时，接收的ID将与关联的邮箱ID进行比较。

30.2.4 FIFO接收ID比较寄存器0和1（FIDCR0和FIDCR1）

Address(es): CAN0.FIDCR0 4005 0420h, CAN0.FIDCR1 4005 0424h



x: Undefined

Bit	Symbol	位名称	Description	R/W
b17 to b0	EID[17:0]	扩展ID	数据和远程帧的扩展ID	R/W
b28 to b18	SID[10:0]	标准标识	数据和远程帧的标准ID	R/W
b29	—	Reserved	读取值未定义。写入值应为0。	R/W
b30	RTR	远程传输 Request	0：数据帧1：远程帧。	R/W

Bit	Symbol	Bit name	Description	R/W
b31	IDE	ID Extension*1	0: Standard ID 1: Extended ID.	R/W

Note 1. When the CTLR.IDFM[1:0] bits are any value other than 10b (mixed ID mode), the IDE bit should be written with 0 and read as 0.

FIDCR0 and FIDCR1 are enabled when the MBM bit in CTLR is set to 1 (FIFO mailbox mode). In this mode, the EID[17:0], SID[10:0], RTR, and IDE bits in mailbox 28 to mailbox 31 are disabled. Write to FIDCR0 and FIDCR1 in CAN reset mode or CAN halt mode. For information on using FIDCR0 and FIDCR1, see section 30.6, Acceptance Filtering and Masking Functions.

EID[17:0] bits (Extended ID)

The EID[17:0] bits set the extended ID of data and remote frames. These bits are used to receive extended ID messages.

SID[10:0] bits (Standard ID)

The SID[10:0] bits set the standard ID of data frames and remote frames. These bits are used to receive both standard ID and extended ID messages.

RTR bit (Remote Transmission Request)

The RTR bit sets the frame format to data frames or remote frames:

- When the RTR bits in both FIDCR0 and FIDCR1 registers are set to 0, only data frames are received
- When the RTR bits in both FIDCR0 and FIDCR1 registers are set to 1, only remote frames are received
- When the RTR bits in both FIDCR0 and FIDCR1 registers are set to different values, both data frames and remote frames are received.

IDE bit (ID Extension*1)

The IDE bit sets the ID format to standard ID or extended ID. The IDE bit is enabled when the IDFM[1:0] bits in CTLR are 10b (mixed ID mode):

- When IDE bits in both FIDCR0 and FIDCR1 are set to 0, only standard ID frames are received
- When IDE bits in both FIDCR0 and FIDCR1 are set to 1, only extended ID frames are received
- When IDE bits in FIDCR0 and FIDCR1 are set to different values, both standard and extended ID frames are received.

30.2.5 Mask Invalid Register (MKIVLR)

Address(es): CAN0.MKIVLR 4005 0428h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MB31	MB30	MB29	MB28	MB27	MB26	MB25	MB24	MB23	MB22	MB21	MB20	MB19	MB18	MB17	MB16
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MB15	MB14	MB13	MB12	MB11	MB10	MB9	MB8	MB7	MB6	MB5	MB4	MB3	MB2	MB1	MB0
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	MB31 to MB0	Mask Invalid	0: Mask valid 1: Mask invalid.	R/W

Each bit in MKIVLR is associated with a mailbox of the same number. Bit [0] in MKIVLR corresponds to mailbox 0 (MB0), and bit [31] corresponds to mailbox 31 (MB31).

Bit	Symbol	位名称	Description	R/W
b31	IDE	ID Extension*1	0：标准ID1： 扩展ID。	R/W

Note 1. 当CTLR.IDFM[1:0]位为10b以外的任何值（混合ID模式）时，IDE位应写入0，读取为0。

当CTLR中的MBM位设置为1（FIFO邮箱模式）时，FIDCR0和FIDCR1被使能。在此模式下，邮箱28到邮箱31中的EID[17:0]、SID[10:0]、RTR和IDE位被禁用。写入FIDCR0和FIDCR1中
CAN复位模式或CAN暂停模式。有关使用FIDCR0和FIDCR1的信息，请参阅第30.6节，验收
过滤和屏蔽功能。

EID[17:0]位（扩展ID）

EID[17:0]位设置数据和远程帧的扩展ID。这些位用于接收扩展ID消息。

SID[10:0]位（标准ID）

SID[10:0]位设置数据帧和远程帧的标准ID。这些位用于接收标准ID和扩展ID消息。

RTR位（远程传输请求）

RTR位将帧格式设置为数据帧或远程帧：

- 当FIDCR0和FIDCR1寄存器中的RTR位都设置为0时，只接收数据帧
- 当FIDCR0和FIDCR1寄存器中的RTR位都设置为1时，只接收远程帧
- 当FIDCR0和FIDCR1寄存器中的RTR位设置为不同的值时，数据帧和远程帧都会被接收。

IDE位（ID扩展*1）

IDE位将ID格式设置为标准ID或扩展ID。当CTLR中的IDFM[1:0]位为10b（混合ID模式）时，IDE位被使能：

- 当FIDCR0和FIDCR1中的IDE位都设置为0时，只接收标准ID帧
- 当FIDCR0和FIDCR1中的IDE位都设置为1时，只接收扩展ID帧
- 当FIDCR0和FIDCR1中的IDE位设置为不同的值时，标准和扩展ID帧都会被接收。

30.2.5 屏蔽无效寄存器(MKIVLR)

Address(es): CAN0.MKIVLR 4005 0428h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MB31	MB30	MB29	MB28	MB27	MB26	MB25	MB24	MB23	MB22	MB21	MB20	MB19	MB18	MB17	MB16
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MB15	MB14	MB13	MB12	MB11	MB10	MB9	MB8	MB7	MB6	MB5	MB4	MB3	MB2	MB1	MB0
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	MB31 to MB0	掩码无效	0：屏蔽有效1 ：屏蔽无效。	R/W

MKIVLR中的每个位都与一个相同号码的邮箱相关联。MKIVLR中的位[0]对应邮箱0(MB0)，位[31]对应邮箱31(MB31)。

Note: Set bits [31:24] to 0 in FIFO mailbox mode.

When a bit is set to 1, the associated acceptance mask register becomes invalid for the associated mailbox. When a mask invalid bit is set to 1, a message is received by the associated mailbox only if the receive message ID matches the mailbox ID exactly. Write to MKIVLR in CAN reset or halt mode.

30.2.6 Mailbox Register j (MBj_ID, MBj_DL, MBj_Dm, MBj_TS) (j = 0 to 31; m = 0 to 7)

Table 30.4 lists the CANi mailbox memory mapping, and Table 30.5 lists the CAN data frame configuration. The value of the CANi mailbox after reset is undefined.

Write to MBj_ID, MBj_DL, MBj_Dm, and MBj_TS registers only when the related MCTL_TXj or MCTL_RXj register (j = 0 to 31) is 00h and the associated mailbox does not process an abort request. See Table 30.4 for details on register addresses.

Table 30.4 CAN mailbox memory mapping

Address	Message content
CAN0	Memory mapping
4005 0200h + 16 × j + 0	IDE, RTR, SID10 to SID6
4005 0200h + 16 × j + 1	SID5 to SID0, EID17, EID16
4005 0200h + 16 × j + 2	EID15 to EID8
4005 0200h + 16 × j + 3	EID7 to EID0
4005 0200h + 16 × j + 4	-
4005 0200h + 16 × j + 5	Data length code (DLC[3:0])
4005 0200h + 16 × j + 6	Data byte 0
4005 0200h + 16 × j + 7	Data byte 1
4005 0200h + 16 × j + 8	Data byte 2
4005 0200h + 16 × j + 9	Data byte 3
4005 0200h + 16 × j + 10	Data byte 4
4005 0200h + 16 × j + 11	Data byte 5
4005 0200h + 16 × j + 12	Data byte 6
4005 0200h + 16 × j + 13	Data byte 7
4005 0200h + 16 × j + 14	Time stamp upper byte
4005 0200h + 16 × j + 15	Time stamp lower byte

Table 30.5 CAN data frame configuration

SID10 to SID6	SID5 to SID0	EID17 to EID16	EID15 to EID8	EID7 to EID0	DLC3 to DLC1	DATA0	DATA1	…	DATA7

The previous value of each mailbox is saved unless a new message is received.

Address(es): CAN0.MB0_ID 4005 0200h to CAN0.MB31_ID 4005 03F0h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	IDE	RTR	—	SID[10:0]											EID[17:0]	
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	EID[17:0]															
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Note: 在FIFO邮箱模式下将位[31:24]设置为0。

当某个位设置为1时，相关联的接受屏蔽寄存器对于相关联的邮箱变得无效。当掩码无效位设置为1时，只有当接收消息ID与邮箱ID完全匹配时，相关邮箱才会接收消息。在CAN复位或暂停模式下写入MKIVLR。

30.2.6 邮箱寄存器j（MBj_ID、MBj_DL、MBj_Dm、MBj_TS）（j=0到31；m=0到7）

表30.4列出了CANi邮箱内存映射，表30.5列出了CAN数据帧配置。复位后CANi邮箱的值未定义。

仅当相关的MCTL_TXj或MCTL_RXj寄存器（j=0到31）为00h且相关邮箱不处理中止请求时才写入MBj_ID、MBj_DL、MBj_Dm和MBj_TS寄存器。有关寄存器地址的详细信息，请参见表30.4。

Table 30.4 CAN邮箱内存映射

Address	留言内容
CAN0	内存映射
4005 0200h + 16 × j + 0	IDE、RTR、SID10到SID6
4005 0200h + 16 × j + 1	SID5 to SID0, EID17, EID16
4005 0200h + 16 × j + 2	EID15 to EID8
4005 0200h + 16 × j + 3	EID7 to EID0
4005 0200h + 16 × j + 4	-
4005 0200h + 16 × j + 5	数据长度码（DLC[3:0]）
4005 0200h + 16 × j + 6	数据字节0
4005 0200h + 16 × j + 7	数据字节1
4005 0200h + 16 × j + 8	数据字节2
4005 0200h + 16 × j + 9	数据字节3
4005 0200h + 16 × j + 10	数据字节4
4005 0200h + 16 × j + 11	数据字节5
4005 0200h + 16 × j + 12	数据字节6
4005 0200h + 16 × j + 13	数据字节7
4005 0200h + 16 × j + 14	时间戳高字节
4005 0200h + 16 × j + 15	时间戳低字节

Table 30.5 CAN数据帧配置

SID10 to SID6	SID5 to SID0	EID17 to EID16	EID15 to EID8	EID7 to EID0	DLC3 to DLC1	DATA0	DATA1	…	DATA7

除非收到新邮件，否则会保存每个邮箱的先前值。

Address(es): CAN0.MB0_ID 4005 0200h to CAN0.MB31_ID 4005 03F0h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	IDE	RTR	—	SID[10:0]											EID[17:0]	
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	EID[17:0]															
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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x: Undefined

Bit	Symbol	Bit name	Description	R/W
b17 to b0	EID[17:0]	Extended ID*1	Extended ID of data and remote frames	R/W
b28 to b18	SID[10:0]	Standard ID	Standard ID of data and remote frames	R/W
b29	—	Reserved	The read value is undefined. The write value should be 0.	R/W
b30	RTR	Remote Transmission Request	0: Data frame 1: Remote frame.	R/W
b31	IDE	ID Extension*2	0: Standard ID 1: Extended ID.	R/W

Note 1. If the mailbox receives a standard ID message, the EID bits in the mailbox are undefined.
Note 2. The IDE bit is enabled when the CTLR.IDFM[1:0] bits are 10b (mixed ID mode). When the IDFM[1:0] bits are any value other than 10b, the IDE bit should be written with 0 and read as 0.

Address(es): CAN0.MB0_DL 4005 0204h to CAN0.MB31_DL 4005 03F4h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	DLC[3:0]			
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b3 to b0	DLC[3:0]	Data Length Code*1	b3 b0 0 0 0 0: Data length = 0 byte 0 0 0 1: Data length = 1 byte 0 0 1 0: Data length = 2 bytes 0 0 1 1: Data length = 3 bytes 0 1 0 0: Data length = 4 bytes 0 1 0 1: Data length = 5 bytes 0 1 1 0: Data length = 6 bytes 0 1 1 1: Data length = 7 bytes 1 x x x: Data length = 8 bytes.	R/W
b15 to b4	—	Reserved	The read value is undefined. The write value should be 0.	R/W

x: Don't care
Note 1. If the mailbox receives a message with data length (set in DLC[3:0]) of n bytes, where n is less than 8, the data in the DATAn to DATA7 registers in the mailbox is undefined. DATA0 to DATA7 are data registers for this mailbox. For example, if data length is 6 bytes (DLC[3:0] = 6h), the data in DATA6 and DATA7 registers is undefined.

Address(es): CAN0.MB0_D0 4005 0206h to CAN0.MB31_D0 4005 03F6h

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA0							
Value after reset:	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D1 4005 0207h to CAN0.MB31_D1 4005 03F7h

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA1							
Value after reset:	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b17 to b0	EID[17:0]	Extended ID*1	数据和远程帧的扩展ID	R/W
b28 to b18	SID[10:0]	标准标识	数据和远程帧的标准ID	R/W
b29	—	Reserved	读取值未定义。写入值应为0。	R/W
b30	RTR	远程传输请求	0：数据帧1：远 程帧。	R/W
b31	IDE	ID Extension*2	0：标准ID1： 扩展ID。	R/W

Note 1. 如果邮箱收到标准ID消息，则邮箱中的EID位未定义。
Note 2. 当CTLR.IDFM[1:0]位为10b（混合ID模式）时，IDE位被使能。当IDFM[1:0]位为10b以外的任何值时，IDE位应写为0，读为0。

Address(es): CAN0.MB0_DL 4005 0204h to CAN0.MB31_DL 4005 03F4h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	DLC[3:0]			
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b3 to b0	DLC[3:0]	数据长度代码*1	b3b00000：数据长度=0字节0 001：数据长度=1字节0010： 数据长度=2字节0011：数据长 度=3字节0100：数据长度=4 字节0101：数据长度=5字节0 110：数据长度=6字节0111： 数据长度=7字节1xxx：数据长 度=8字节。	R/W
b15 to b4	—	Reserved	读取值未定义。写入值应为0。	R/W

x：不关心注
1。 如果邮箱接收到数据长度（在DLC[3:0]中设置）为n字节的消息，其中n小于8，则邮箱中DATAn到DATA7寄存器中的数据未定义。DATA0到DATA7是该邮箱的数据寄存器。例如，如果数据长度为6字节（DLC[3:0]=6h），则DATA6和DATA7寄存器中的数据未定义。

Address(es): CAN0.MB0_D0 4005 0206h to CAN0.MB31_D0 4005 03F6h

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA0							
重置后的值：	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D1 4005 0207h to CAN0.MB31_D1 4005 03F7h

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA1							
重置后的值：	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D2 4005 0208h to CAN0.MB31_D2 4005 03F8h

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA2							
Value after reset:	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D3 4005 0209h to CAN0.MB31_D3 4005 03F9h

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA3							
Value after reset:	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D4 4005 020Ah to CAN0.MB31_D4 4005 03FAh

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA4							
Value after reset:	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D5 4005 020Bh to CAN0.MB31_D5 4005 03FBh

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA5							
Value after reset:	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D6 4005 020Ch to CAN0.MB31_D6 4005 03FCh

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA6							
Value after reset:	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D7 4005 020Dh to CAN0.MB31_D7 4005 03FDh

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA7							
Value after reset:	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b7 to b0	DATA0 to DATA7	Data Bytes 0 to 7*1,*2	DATA0 to DATA7 store the transmitted or received CAN message data. Transmission or reception starts from DATA0. The bit order on the CAN bus is MSB-first, and transmission or reception starts from bit [7].	R/W

Note 1. If the mailbox receives a message with n bytes, where n is less than 8 bytes, the DATAn to DATA7 values in the mailbox are undefined.

Note 2. If the mailbox receives a remote frame, the previous values of DATA0 to DATA7 in the mailbox are saved.

Address(es): CAN0.MB0_TS 4005 020Eh to CAN0.MB31_TS 4005 03FEh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	TSH[7:0]								TSL[7:0]							
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Address(es): CAN0.MB0_D2 4005 0208h to CAN0.MB31_D2 4005 03F8h

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA2							
重置后的值：	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D3 4005 0209h to CAN0.MB31_D3 4005 03F9h

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA3							
重置后的值：	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D4 4005 020Ah to CAN0.MB31_D4 4005 03FAh

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA4							
重置后的值：	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D5 4005 020Bh to CAN0.MB31_D5 4005 03FBh

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA5							
重置后的值：	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D6 4005 020Ch to CAN0.MB31_D6 4005 03FCh

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA6							
重置后的值：	x	x	x	x	x	x	x	x

Address(es): CAN0.MB0_D7 4005 020Dh to CAN0.MB31_D7 4005 03FDh

	b7	b6	b5	b4	b3	b2	b1	b0
	DATA7							
重置后的值：	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b7 to b0	DATA0 to DATA7	数据字节0到7*1 *2	DATA0到DATA7存储发送或接收的CAN报文数据。发送或接收从DATA0开始。CAN总线上的位顺序是MSB优先，发送或接收从位[7]开始。	R/W

Note 1. 如果邮箱收到n字节的消息，其中n小于8字节，则邮箱中的DATAn到DATA7值未定义。

Note 2. 如果邮箱接收到远程帧，则邮箱中DATA0到DATA7的先前值被保存。

Address(es): CAN0.MB0_TS 4005 020Eh to CAN0.MB31_TS 4005 03FEh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	TSH[7:0]								TSL[7:0]							
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b7 to b0	TSL[7:0]	Time Stamp Lower Byte	The TSH[7:0] and TSL[7:0] bits store the counter value of the time stamp when received messages are stored in the mailbox.	R/W
b15 to b8	TSH[7:0]	Time Stamp Higher Byte		R/W

EID[17:0] bits (Extended ID*1)

The EID[17:0] bits set the extended ID of data frames and remote frames. These bits transmit or receive extended ID messages.

SID[10:0] bits (Standard ID)

The SID[10:0] bits set the standard ID of data frames and remote frames. These bits transmit or receive both standard ID and extended ID messages.

RTR bit (Remote Transmission Request)

The RTR bit sets the frame format to data frames or remote frames:

- The receive mailbox only receives frames with the format specified in the RTR bit
- The transmit mailbox transmits frames with the frame format specified in the RTR bit
- The receive FIFO mailbox receives the data frame, remote frame, or both frames as specified in the RTR bit in FIDCR0 and FIDCR1
- The transmit FIFO mailbox transmits the data frame or remote frame as specified in the RTR bit in the relevant transmit message.

IDE bit (ID Extension*2)

The IDE bit sets the ID format to standard ID or extended ID. The IDE bit is enabled when the IDFM[1:0] bits in CTLR are 10b (mixed ID mode):

- The receive mailbox receives only the ID format specified in the IDE bit
- The transmit mailbox transmits with the ID format specified in the IDE bit
- The receive FIFO mailbox receives messages with the standard ID and extended ID settings specified in the IDE bit in FIDCR0 and FIDCR1
- The transmit FIFO mailbox transmits messages with the standard ID or extended ID settings specified in the IDE bit in the transmit message.

DLC[3:0] bits (Data Length Code*1)

The DLC[3:0] bits specify the data length to be transmitted in data frames. When a remote frame is used to request data, this field specifies the requested data length.

When a data frame is received, the received data length is stored in this field. When a remote frame is received, this field stores the requested data length.

Bit	Symbol	位名称	Description	R/W
b7 to b0	TSL[7:0]	时间戳低字节	当收到的消息存储在邮箱中时，TSH[7:0]和TSL[7:0]位存储时间戳的计数器值。	R/W
b15 to b8	TSH[7:0]	时间戳高字节		R/W

EID[17:0]位（扩展ID*1）

EID[17:0]位设置数据帧和远程帧的扩展ID。这些位发送或接收扩展ID消息。

SID[10:0]位（标准ID）

SID[10:0]位设置数据帧和远程帧的标准ID。这些位发送或接收标准ID和扩展ID消息。

RTR位（远程传输请求）

RTR位将帧格式设置为数据帧或远程帧：

- 接收邮箱只接收RTR位指定格式的帧
- 发送邮箱以RTR位中指定的帧格式发送帧
- 接收FIFO邮箱接收数据帧、远程帧或两个帧，如 FIDCR0 and FIDCR1
- 发送FIFO邮箱发送相关发送消息中RTR位中指定的数据帧或远程帧。

IDE位（ID扩展*2）

IDE位将ID格式设置为标准ID或扩展ID。当CTLR中的IDFM[1:0]位为10b（混合ID模式）时，IDE位被使能：

- 接收邮箱只接收IDE位指定的ID格式
- 发送邮箱以IDE位中指定的ID格式发送
- 接收FIFO邮箱接收具有FIDCR0和FIDCR1中的IDE位指定的标准ID和扩展ID设置的消息
- 发送FIFO邮箱使用发送消息的IDE位中指定的标准ID或扩展ID设置发送消息。

DLC[3:0]位（数据长度代码*1）

DLC[3:0]位指定要在数据帧中传输的数据长度。当使用远程帧请求数据时，该字段指定请求的数据长度。

当接收到一个数据帧时，接收到的数据长度存储在该字段中。当接收到远程帧时，该字段存储请求的数据长度。

30.2.7 Mailbox Interrupt Enable Register (MIER)

Address(es): CAN0.MIER 4005 042Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MB31	MB30	MB29	MB28	MB27	MB26	MB25	MB24	MB23	MB22	MB21	MB20	MB19	MB18	MB17	MB16
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MB15	MB14	MB13	MB12	MB11	MB10	MB9	MB8	MB7	MB6	MB5	MB4	MB3	MB2	MB1	MB0
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b31 to b0	MB31 to MB0	Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled. Bit [31] is associated with mailbox 31 (MB31), and bit [0] with mailbox 0 (MB0).	R/W

The MIER register can enable interrupts for each mailbox independently. This register is available in normal mailbox mode. Do not access this register in FIFO mailbox mode.

Each bit is associated with a mailbox having the same number. These bits enable or disable transmission and reception complete interrupts for the associated mailboxes as follows:

- Bit [0] in MIER is associated with mailbox 0 (MB0)
- Bit [31] in MIER is associated with mailbox 31 (MB31).

Write to MIER only when the associated MCTL_TXj or MCTL_RXj register (j = 0 to 31) is 00h and the associated mailbox does not process a transmission or reception abort request.

30.2.8 Mailbox Interrupt Enable Register for FIFO Mailbox Mode (MIER_FIFO)

Address(es): CAN0.MIER_FIFO 4005 042Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	MB29	MB28	—	—	MB25	MB24	MB23	MB22	MB21	MB20	MB19	MB18	MB17	MB16
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MB15	MB14	MB13	MB12	MB11	MB10	MB9	MB8	MB7	MB6	MB5	MB4	MB3	MB2	MB1	MB0
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	Bit name	Description	R/W
b23 to b0	MB23 to MB0	Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled. Bit [23] corresponds to mailbox 23 (MB23), and bit [0] corresponds to mailbox 0 (MB0).	R/W
b24	MB24	Transmit FIFO Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b25	MB25	Transmit FIFO Interrupt Generation Timing Control	0: Generated every time transmission completes 1: Generated when the transmit FIFO empties on transmission completion.	R/W

30.2.7 邮箱中断使能寄存器(MIER)

Address(es): CAN0.MIER 4005 042Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	MB31	MB30	MB29	MB28	MB27	MB26	MB25	MB24	MB23	MB22	MB21	MB20	MB19	MB18	MB17	MB16
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MB15	MB14	MB13	MB12	MB11	MB10	MB9	MB8	MB7	MB6	MB5	MB4	MB3	MB2	MB1	MB0
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b31 to b0	MB31 to MB0	中断使能	0：中断禁止1：中断允许。位[31]与邮箱31(MB31)相关联，位[0]与邮箱0(MB0)相关联。	R/W

MIER寄存器可以独立启用每个邮箱的中断。该寄存器在正常邮箱模式下可用。不要在FIFO邮箱模式下访问该寄存器。

每个位与具有相同编号的邮箱相关联。这些位启用或禁用相关邮箱的发送和接收完成中断，如下所示：

- MIER中的位[0]与邮箱0(MB0)相关联
- MIER中的位[31]与邮箱31(MB31)相关联。

仅当相关的MCTL_TXj或MCTL_RXj寄存器（j=0到31）为00h且相关邮箱不处理发送或接收中止请求时才写入MIER。

30.2.8 FIFO邮箱模式的邮箱中断使能寄存器(MIER_FIFO)

Address(es): CAN0.MIER_FIFO 4005 042Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	MB29	MB28	—	—	MB25	MB24	MB23	MB22	MB21	MB20	MB19	MB18	MB17	MB16
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	MB15	MB14	MB13	MB12	MB11	MB10	MB9	MB8	MB7	MB6	MB5	MB4	MB3	MB2	MB1	MB0
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Symbol	位名称	Description	R/W
b23 to b0	MB23 to MB0	中断使能	0：中断禁止1：中断允许。位[23]对应邮箱23(MB23)，位[0]对应邮箱0(MB0)。	R/W
b24	MB24	发送FIFO中断Enable	0：中断禁止1：中断允许。	R/W
b25	MB25	发送FIFO中断发电时序控制	0：每次发送完成时产生1：发送完成时发送FIFO清空时产生。	R/W

Bit	Symbol	Bit name	Description	R/W
b27, b26	—	Reserved	The read value is undefined. The write value should be 0.	R/W
b28	MB28	Receive FIFO Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b29	MB29	Receive FIFO Interrupt Generation Timing Control*1	0: Generated every time reception completes 1: Generated when the receive FIFO becomes a buffer warning*2 on reception completion.	R/W
b31, b30	—	Reserved	The read value is undefined. The write value should be 0.	R/W

Note 1. No interrupt request occurs when the receive FIFO becomes a buffer warning because it is full.
Note 2. Buffer warning indicates a state in which the third message is stored in the receive FIFO.

The MIER_FIFO register can independently enable interrupts for each mailbox and FIFO. This register is available in FIFO mailbox mode. Do not access this register in normal mailbox mode.

The MB0 to MB23 bits are associated with the mailbox of the same number. These bits enable or disable transmission and reception complete interrupts for the associated mailboxes:

- Bit [0] in MIER_FIFO is associated with mailbox 0 (MB0)
- Bit [23] in MIER_FIFO is associated with mailbox 23 (MB23).

MB24, MB25, MB28, and MB29 specify whether the transmit and receive FIFO interrupts are enabled or disabled, and the timing when interrupt requests are generated.

Write to the MIER_FIFO register only when the associated MCTL_TXj or MCTL_RXj register (j = 0 to 31) is 00h and the associated mailbox does not process a transmission or reception abort request. In addition, change the bits in MIER_FIFO for the associated FIFO only when all the following conditions are true:

- The TFE bit in TFCR is 0 and the TFEST bit is 1
- The RFE bit in RFCR is 0 and the RFEST flag in RFCR is 1.

30.2.9 Message Control Register for Transmit (MCTL_TXj) (j = 0 to 31)

- Transmit mode (when the TRMREQ bit is 1 and the RECREQ bit is 0)

Address(es): CAN0.MCTL_TX[0] 4005 0820h to CAN0.MCTL_TX[31] 4005 083Fh,

	b7	b6	b5	b4	b3	b2	b1	b0
	TRMREQ	RECREQ	—	ONESHOT	—	TRMABT	TRMACTIVE	SENTDATA
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SENTDATA	Transmission Complete Flag*1,*2	0: Transmission not complete 1: Transmission complete.	R/W
b1	TRMACTIVE	Transmission-in-Progress Status Flag	0: Transmission pending or not requested 1: Transmission in progress.	R
b2	TRMABT	Transmission Abort Complete Flag*1,*2	0: Transmission started, transmission abort failed because transmission completed, or transmission abort not requested 1: Transmission abort complete.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	ONESHOT	One-Shot Enable*2,*3	0: Disable one-shot transmission 1: Enable one-shot transmission.	R/W
b5	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6	RECREQ	Receive Mailbox Request *2,*3,*4,*5	0: Do not configure for reception 1: Configure for reception.	R/W
b7	TRMREQ	Transmit Mailbox Request *2,*4	0: Do not configure for transmission 1: Configure for transmission.	R/W

Bit	Symbol	位名称	Description	R/W
b27, b26	—	Reserved	读取值未定义。写入值应为0。	R/W
b28	MB28	接收FIFO中断 Enable	0：中断禁止1：中断允许。	R/W
b29	MB29	接收FIFO中断发电时序控制*1	0：每次接收完成时产生1：当接收FIFO变为缓冲区警告*2接收完成时产生。	R/W
b31, b30	—	Reserved	读取值未定义。写入值应为0。	R/W

Note 1. 当接收FIFO因已满而变为缓冲区警告时，不会发生中断请求。
Note 2. 缓冲区警告表示第三个消息存储在接收FIFO中的状态。

MIER_FIFO寄存器可以独立启用每个邮箱和FIFO的中断。该寄存器可在FIFO邮箱模式。不要在普通邮箱模式下访问该寄存器。

MB0到MB23位与相同编号的邮箱相关联。这些位启用或禁用相关邮箱的发送和接收完成中断：

- MIER_FIFO中的位[0]与邮箱0(MB0)相关联
- MIER_FIFO中的位[23]与邮箱23(MB23)相关联。

MB24、MB25、MB28和MB29指定是启用还是禁用发送和接收FIFO中断，以及产生中断请求的时序。

仅当相关的MCTL_TXj或MCTL_RXj寄存器（j=0到31）为00h且相关邮箱不处理发送或接收中止请求时才写入MIER_FIFO寄存器。此外，仅当以下所有条件都为真时，才更改关联FIFO的MIER_FIFO中的位：

- TFCR中的TFE位为0，TFEST位为1
- RFCR中的RFE位为0，RFCR中的RFEST标志为1。

30.2.9 用于发送的消息控制寄存器(MCTL_TXj)(j=0到31)

发送模式（当TRMREQ位为1且RECREQ位为0时）

Address(es): CAN0.MCTL_TX[0] 4005 0820h to CAN0.MCTL_TX[31] 4005 083Fh,

	b7	b6	b5	b4	b3	b2	b1	b0
	TRMREQ	RECREQ	—	ONESHOT	—	TRMABT	TRMACTIVE	SENTDATA
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SENTDATA	传输完成 Flag*1,*2	0：传输未完成1：传输完成。	R/W
b1	TRMACTIVE	Transmission-in-Progress 状态标志	0：传输未决或未请求1：传输中。	R
b2	TRMABT	传输中止完成 Flag*1,*2	0：传输开始，传输中止失败，因为传输完成，或未请求传输中止1：传输中止完成。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	ONESHOT	One-Shot Enable*2,*3	0：禁止一次性发送1：允许一次性发送。	R/W
b5	—	Reserved	该位读取为0。写入值应为0。	R/W
b6	RECREQ	接收邮箱请求*2 *3 *4 *5	0：不配置接收1：配置接收。	R/W
b7	TRMREQ	发送邮箱请求*2 *4	0：不配置传输1：配置传输。	R/W

Note 1. Write 0 only. Writing 1 has no effect.
Note 2. When writing to bits in this register, write 1 to SENTDATA and TRMABT flags if these bits are not the write target.
Note 3. To enter one-shot transmit mode, write 1 to the ONESHOT bit at the same time as setting the TRMREQ bit to 1. To exit one-shot transmit mode, write 0 to the ONESHOT bit after the message is transmitted or aborted.
Note 4. Do not set both the RECREQ and TRMREQ bits to 1.
Note 5. When setting the RECREQ bit to 0, set the SENTDATA, TRMACTIVE, and TRMABT flags to 0 simultaneously.

MCTL_TXj sets mailbox j to transmit mode or receive mode. In transmit mode, MCTL_TXj also controls and indicates the transmission status. Do not access MCTL_TXj if mailbox j is in receive mode. Only write to MCTL_TXj in CAN operation or halt mode. Do not use MCTL_TX24 to MCTL_TX31 in FIFO mailbox mode.

SENTDATA flag (Transmission Complete Flag*1,*2)

The SENTDATA flag is set to 1 when data transmission from the associated mailbox is complete. This flag is set to 0 through a software write. To set this flag to 0, first set the TRMREQ bit to 0. The SENTDATA and TRMREQ flags cannot be set to 0 simultaneously. To transmit a new message from the associated mailbox, set the SENTDATA flag to 0.

TRMACTIVE flag (Transmission-in-Progress Status Flag)

The TRMACTIVE flag is set to 1 when the associated mailbox of the CAN module begins to transmit a message. It is set to 0 when the CAN module loses the CAN bus arbitration, when a CAN bus error occurs, or when data transmission completes.

TRMABT flag (Transmission Abort Complete Flag*1,*2)

The TRMABT flag is set to 1 in the following cases:

- Following a transmission abort request, when the transmission abort is complete before starting transmission
- Following a transmission abort request, when the CAN module detects CAN bus arbitration-lost or a CAN bus error
- In one-shot transmission mode (RECREQ = 0, TRMREQ = 1, and ONESHOT = 1), when the CAN module detects a CAN bus arbitration-lost or a CAN bus error.

The TRMABT flag is not set to 1 when data transmission is complete. The SENTDATA flag is set to 1 and the TRMABT flag is set to 0 through a software write.

ONESHOT bit (One-Shot Enable*2,*3)

When the ONESHOT bit is set to 1 in transmit mode (RECREQ = 0 and TRMREQ = 1), the CAN module transmits a message only one time. The CAN module does not transmit the message again if a CAN bus error or CAN bus arbitration-lost occurs. When transmission is complete, the SENTDATA flag is set to 1. If transmission does not complete because of a CAN bus error or CAN bus arbitration-lost error, the TRMABT flag is set to 1. Set the ONESHOT bit to 0 after the SENTDATA or TRMABT flag is set to 1.

RECREQ bit (Receive Mailbox Request)

The RECREQ bit selects the receive modes listed in Table 30.10.

When the RECREQ bit is set to 1, the associated mailbox is configured for reception of a data frame or remote frame.

When the RECREQ bit is set to 0, the associated mailbox is not configured for reception of a data frame or remote frame.

Due to hardware protection, the RECREQ bit cannot be set to 0 through a software write during the following period:

- Hardware protection is started from the acceptance filter processing (the beginning of the CRC field)
- Hardware protection is released:
  - For the mailbox that is specified to receive the incoming message, after the received data is stored in the mailbox or a CAN bus error occurs. This means that the maximum period of hardware protection is from the beginning of CRC field to the end of the 7th bit of EOF.
  - For the other mailboxes, after acceptance filter processing
  - If no mailbox is specified to receive the message, after acceptance filter processing.

When setting the RECREQ bit to 1, do not set the TRMREQ bit to 1. To change the configuration of a mailbox from transmission to reception, first abort the transmission, then set the SENTDATA and TRMABT flags to 0 before changing to reception.

Note 1. 只写0。写1无效。
Note 2. 写入该寄存器中的位时，如果这些位不是写入目标，则将1写入SENTDATA和TRMABT标志。
Note 3. 要进入一次性发送模式，请在将TRMREQ位设置为1的同时将1写入ONESHOT位。要退出一次性发送模式，请在发送或中止消息后向ONESHOT位写入0。
Note 4. 不要将RECREQ和TRMREQ位都设置为1。
Note 5. 将RECREQ位设置为0时，同时将SENTDATA、TRMACTIVE和TRMABT标志设置为0。

MCTL_TXj将邮箱j设置为发送模式或接收模式。在传输模式下，MCTL_TXj还控制和指示传输状态。如果邮箱j处于接收模式，则不要访问MCTL_TXj。仅在CAN操作或暂停模式下写入MCTL_TXj。不要在FIFO邮箱模式下使用MCTL_TX24到MCTL_TX31。

SENTDATA标志（传输完成标志*1 *2）

当来自相关邮箱的数据传输完成时，SENTDATA标志设置为1。该标志通过软件写入设置为0。要将此标志设置为0，首先将TRMREQ位设置为0。SENTDATA和TRMREQ标志不能同时设置为0。要从关联邮箱发送新消息，请将SENTDATA标志设置为0。

TRMACTIVE标志（传输中状态标志）

当CAN模块的相关邮箱开始发送消息时，TRMACTIVE标志设置为1。当CAN模块失去CAN总线仲裁、发生CAN总线错误或数据传输完成时，它设置为0。

TRMABT标志（传输中止完成标志*1 *2）

在以下情况下，TRMABT标志设置为1：

- 在传输中止请求之后，当传输中止在开始传输之前完成时
- 在发送中止请求之后，当CAN模块检测到CAN总线仲裁丢失或CAN总线错误时
- 在一次性传输模式下（RECREQ=0、TRMREQ=1和ONESHOT=1），当CAN模块检测到CAN总线仲裁丢失或CAN总线错误时。

当数据传输完成时，TRMABT标志不设置为1。SENTDATA标志设置为1，TRMABT标志通过软件写入设置为0。

ONESHOT bit (One-Shot Enable*2,*3)

在发送模式下（RECREQ=0且TRMREQ=1）将ONESHOT位设置为1时，CAN模块仅发送一次报文。如果发生CAN总线错误或CAN总线仲裁失败，CAN模块不会再次发送消息。传输完成后，SENTDATA标志设置为1。如果由于CAN总线错误或CAN总线仲裁丢失错误导致传输未完成，则TRMABT标志设置为1。在SENTDATA或TRMABT标志设置为1。

RECREQ位（接收邮箱请求）

RECREQ位选择表30.10中列出的接收模式。

当RECREQ位设置为1时，相关邮箱配置为接收数据帧或远程帧。

当RECREQ位设置为0时，相关邮箱未配置为接收数据帧或远程帧。

由于硬件保护，RECREQ位在以下期间不能通过软件写入设置为0：

- 硬件保护从验收过滤器处理开始（CRC字段的开始）
- 硬件保护发布：
  - 对于指定接收传入报文的邮箱，在接收到的数据存入邮箱后或出现CAN总线错误。这意味着硬件保护的最大周期是从CRC字段的开始到EOF的第7位结束。
  - 对于其他邮箱，接受过滤处理后
  - 如果没有指定邮箱接收邮件，则经过接受过滤处理。

将RECREQ位设置为1时，不要将TRMREQ位设置为1。要将邮箱配置从发送更改为接收，首先中止发送，然后在更改为接收之前将SENTDATA和TRMABT标志设置为0。

Note: MCTL_TXj.RECREQ is the mirror bit of MCTL_RXj.RECREQ.

TRMREQ bit (Transmit Mailbox Request)

The TRMREQ bit selects the transmit modes listed in Table 30.10.

When the TRMREQ bit is set to 1, the associated mailbox is configured for transmission of a data frame or remote frame.

When the TRMREQ bit is set to 0, the associated mailbox is not configured for transmission of a data frame or remote frame.

If the TRMREQ bit is changed from 1 to 0 to cancel the associated transmission request, either the TRMABT or SENTDATA flag is set to 1. When setting the TRMREQ bit to 1, do not set the RECREQ bit to 1. To change the configuration of a mailbox from reception to transmission, first abort the reception, then set the NEWDATA and MSGLOST flags to 0 before changing to transmission.

Note: MCTL_TXj.TRMREQ is the mirror bit of MCTL_RXj.TRMREQ.

30.2.10 Message Control Register for Receive (MCTL_RXj) (j = 0 to 31)

- Receive mode (when the TRMREQ bit is 0 and the RECREQ bit is 1)

Address(es): CAN0.MCTL_RX[0] 4005 0820h to CAN0.MCTL_RX[31] 4005 083Fh,

	b7	b6	b5	b4	b3	b2	b1	b0
	TRMREQ	RECREQ	—	ONESHOT	—	MSGLOST	INVALDATA	NEWDATA
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	NEWDATA	Reception Complete Flag*1,*2	0: No data received, or 0 was written to the flag 1: New message is being stored or was stored in the mailbox.	R/W
b1	INVALDATA	Reception-in-Progress Status Flag	0: Message valid 1: Message being updated.	R
b2	MSGLOST	Message Lost Flag*1,*2	0: Message not overwritten or overrun 1: Message overwritten or overrun.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	ONESHOT	One-Shot Enable*2,*3	0: Disable one-shot reception 1: Enable one-shot reception.	R/W
b5	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6	RECREQ	Receive Mailbox Request *2,*3,*4,*5	0: Do not configure for reception 1: Configure for reception.	R/W
b7	TRMREQ	Transmit Mailbox Request *2,*4	0: Do not configure for transmission 1: Configure for transmission.	R/W

Note 1. Write 0 only. Writing 1 has no effect.
Note 2. When writing to bits in this register, write 1 to the NEWDATA and MSGLOST flags if they are not the write target.
Note 3. To enter one-shot receive mode, write 1 to the ONESHOT bit at the same time as setting the RECREQ bit to 1. To exit one-shot receive mode, write 0 to the ONESHOT bit after writing 0 to the RECREQ bit and confirming that it is 0.
Note 4. Do not set both the RECREQ and TRMREQ bits to 1.
Note 5. When setting the RECREQ bit to 0, set MSGLOST, NEWDATA, and RECREQ to 0 simultaneously.

MCTL_RXj sets mailbox j to transmit or receive mode. In receive mode, MCTL_RXj also controls and indicates the reception status.

Do not access MCTL_RXj if mailbox j is in transmit mode. Only write to the MCTL_RXj in CAN operation or halt mode. Do not use MCTL_RX24 to MCTL_RX31 registers in FIFO mailbox mode.

NEWDATA flag (Reception Complete Flag*1,*2)

The NEWDATA flag is set to 1 when a new message is being stored or was stored in the mailbox. Always set this bit to 1 simultaneously with the INVALDATA flag. The NEWDATA flag is set to 0 through a software write. The NEWDATA

Note: MCTL_TXj.RECREQ是MCTL_RXj.RECREQ的镜像位。

TRMREQ位（发送邮箱请求）

TRMREQ位选择表30.10中列出的发送模式。

当TRMREQ位设置为1时，相关邮箱配置为传输数据帧或远程帧。

当TRMREQ位设置为0时，相关邮箱未配置为传输数据帧或远程帧。

如果TRMREQ位从1更改为0以取消相关的发送请求，则TRMABT或SENTDATA标志设置为1。将TRMREQ位设置为1时，不要将RECREQ位设置为1。要更改邮箱从接收到发送，首先中止接收，然后将NEWDATA和MSGLOST标志设置为0，然后再更改为发送。

Note: MCTL_TXj.TRMREQ是MCTL_RXj.TRMREQ的镜像位。

30.2.10 接收消息控制寄存器(MCTL_RXj)(j=0to31)

接收模式（当TRMREQ位为0且RECREQ位为1时）

Address(es): CAN0.MCTL_RX[0] 4005 0820h to CAN0.MCTL_RX[31] 4005 083Fh,

	b7	b6	b5	b4	b3	b2	b1	b0
	TRMREQ	RECREQ	—	ONESHOT	—	MSGLOST	INVALDATA	NEWDATA
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	NEWDATA	接收完成标志*1 *2	0：未接收到数据，或标志位已写入01：新消息正在存储或已存储在邮箱中。	R/W
b1	INVALDATA	Reception-in-Progress Status Flag	0：消息有效1：消息正在更新。	R
b2	MSGLOST	消息丢失标志*1 *2	0：信息未被覆盖或溢出1：信息被覆盖或溢出。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	ONESHOT	One-Shot Enable*2,*3	0：关闭一键接收1：打开一键接收。	R/W
b5	—	Reserved	该位读取为0。写入值应为0。	R/W
b6	RECREQ	接收邮箱请求*2 *3 *4 *5	0：不配置接收1：配置接收。	R/W
b7	TRMREQ	发送邮箱请求*2 *4	0：不配置传输1：配置传输。	R/W

Note 1. 只写0。写1无效。
Note 2. 写入此寄存器中的位时，如果NEWDATA和MSGLOST标志不是写入目标，则将它们写入1。
Note 3. 要进入一次性接收模式，请在将RECREQ位设置为1的同时向ONESHOT位写入1。要退出一次性接收模式，请在向RECREQ位写入0并确认后向ONESHOT位写入0它是0。
Note 4. 不要将RECREQ和TRMREQ位都设置为1。
Note 5. 将RECREQ位设置为0时，同时将MSGLOST、NEWDATA和RECREQ设置为0。

MCTL_RXj将邮箱j设置为发送或接收模式。在接收模式下，MCTL_RXj还控制和指示接收状态。

如果邮箱j处于传输模式，则不要访问MCTL_RXj。仅在CAN操作或暂停模式下写入MCTL_RXj。不要在FIFO邮箱模式下使用MCTL_RX24到MCTL_RX31寄存器。

NEWDATA标志（接收完成标志*1 *2）

当新消息正在存储或已存储在邮箱中时，NEWDATA标志设置为1。始终将此位与INVALDATA标志同时设置为1。NEWDATA标志通过软件写入设置为0。新数据

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flag cannot be set to 0 through a software write when the associated INVALDATA flag is 1.

INVALDATA flag (Reception-in-Progress Status Flag)

After the completion of a message reception, the INVALDATA flag is set to 1 while the received message is updated in the associated mailbox. The INVALDATA flag is set to 0 immediately after the message is stored. If the mailbox is read when the INVALDATA flag is 1, the data is undefined.

MSGLOST flag (Message Lost Flag*1,*2)

The MSGLOST flag is set to 1 when the mailbox is overwritten or overrun by a new received message while the NEWDATA flag is 1. The MSGLOST flag is set to 1 at the end of the 6th bit of EOF. The MSGLOST flag is set to 0 through a software write.

In both overwrite and overrun modes, the MSGLOST flag cannot be set to 0 through a software write during the 5 PCLKB cycles following the 6th bit of EOF.

ONESHOT bit (One-Shot Enable*2,*3)

When the ONESHOT bit is set to 1 in receive mode (RECREQ = 1 and TRMREQ = 0), the mailbox receives a message only one time. The mailbox does not behave as a receive mailbox after having received the message one time. The behavior of the NEWDATA and INVALDATA flags is the same as in normal receive mode. In one-shot receive mode, the MSGLOST flag is not set to 1. To set the ONESHOT bit to 0, first write 0 to the RECREQ bit and ensure that it is 0.

RECREQ bit (Receive Mailbox Request)

The RECREQ bit selects the receive modes listed in Table 30.10.

When the RECREQ bit is set to 1, the associated mailbox is configured for reception of a data frame or remote frame.

When the RECREQ bit is set to 0, the associated mailbox is not configured for reception of a data frame or remote frame.

Due to hardware protection, the RECREQ bit cannot be set to 0 through a software write during the following period:

- Hardware protection is started from the acceptance filter processing (the beginning of the CRC field)
- Hardware protection is released:
  - For the mailbox that is specified to receive the incoming message, after the received data is stored in the mailbox or a CAN bus error occurs. The maximum period of hardware protection is from the beginning of the CRC field to the end of the 7th bit of EOF.
  - For the other mailboxes, after the acceptance filter processing
  - If no mailbox is specified to receive the message, after acceptance filter processing.

When setting the RECREQ bit to 1, do not set the TRMREQ bit to 1. To change the configuration of a mailbox from transmission to reception, first abort the transmission, then set the SENTDATA and TRMABT flags to 0 before changing to reception.

Note: MCTL_RXj.RECREQ is the mirror bit of MCTL_TXj.RECREQ.

TRMREQ bit (Transmit Mailbox Request)

The TRMREQ bit selects the transmit modes listed in Table 30.10.

When the TRMREQ bit is set to 1, the associated mailbox is configured for transmission of a data frame or remote frame. When the TRMREQ bit is set to 0, the associated mailbox is not configured for transmission of a data frame or remote frame.

If the TRMREQ bit is changed from 1 to 0 to cancel the associated transmission request, either the TRMABT or the SENTDATA flag is set to 1. When setting the TRMREQ bit to 1, do not set the RECREQ bit to 1. To change the configuration of a mailbox from reception to transmission, first abort the reception, and then set the NEWDATA and MSGLOST flags to 0 before changing to transmission.

Note: MCTL_RXj.TRMREQ is the mirror bit of MCTL_TXj.TRMREQ.

当关联的INVALDATA标志为1时，不能通过软件写入将标志设置为0。

INVALDATA标志（接收进行中状态标志）

消息接收完成后，INVALDATA标志设置为1，同时在相关邮箱中更新接收到的消息。INVALDATA标志在消息存储后立即设置为0。如果在INVALDATA标志为1时读取邮箱，则数据未定义。

MSGLOST标志（消息丢失标志*1 *2）

当邮箱被新收到的消息覆盖或溢出时，MSGLOST标志设置为1，而
NEWDATA标志为1。MSGLOST标志在EOF的第6位末尾设置为1。MSGLOST标志通过软件写入设置为0。

在覆盖和溢出模式下，MSGLOST标志不能在5期间通过软件写入设置为0
在EOF的第6位之后的PCLKB周期。

ONESHOT bit (One-Shot Enable*2,*3)

在接收模式下（RECREQ=1和TRMREQ=0）将ONESHOT位设置为1时，邮箱只接收一次消息。邮箱在收到一次消息后不再充当接收邮箱。NEWDATA和INVALDATA标志的行为与正常接收模式相同。在单次接收模式下，MSGLOST标志不设置为1。要将ONESHOT位设置为0，首先将0写入RECREQ位并确保其为0。

RECREQ位（接收邮箱请求）

RECREQ位选择表30.10中列出的接收模式。

当RECREQ位设置为1时，相关邮箱配置为接收数据帧或远程帧。

当RECREQ位设置为0时，相关邮箱未配置为接收数据帧或远程帧。

由于硬件保护，RECREQ位在以下期间不能通过软件写入设置为0：

- 硬件保护从验收过滤器处理开始（CRC字段的开始）
- 硬件保护发布：
  - 对于指定接收传入报文的邮箱，在接收到的数据存入邮箱后或出现CAN总线错误。硬件保护的最大周期是从CRC域开始到EOF第7位结束。
  - 对于其他邮箱，接受过滤处理后
  - 如果没有指定邮箱接收邮件，则经过接受过滤处理。

将RECREQ位设置为1时，不要将TRMREQ位设置为1。要将邮箱配置从发送更改为接收，首先中止发送，然后在更改为接收之前将SENTDATA和TRMABT标志设置为0。

Note: MCTL_RXj.RECREQ是MCTL_TXj.RECREQ的镜像位。

TRMREQ位（发送邮箱请求）

TRMREQ位选择表30.10中列出的发送模式。

当TRMREQ位设置为1时，相关邮箱配置为传输数据帧或远程帧。
当TRMREQ位设置为0时，相关邮箱未配置为传输数据帧或远程帧。

如果TRMREQ位从1更改为0以取消相关的传输请求，则TRMABT或SENTDATA标志设置为1。将TRMREQ位设置为1时，不要将RECREQ位设置为1。要更改配置邮箱从接收到发送，首先中止接收，然后在更改为发送之前将NEWDATA和MSGLOST标志设置为0。

Note: MCTL_RXj.TRMREQ是MCTL_TXj.TRMREQ的镜像位。

30.2.11 Receive FIFO Control Register (RFCR)

Address(es): CAN0.RFCR 4005 0848h

	b7	b6	b5	b4	b3	b2	b1	b0
	RFEST	RFWST	RFFST	RFMLF	RFUST[2:0]			RFE
Value after reset:	1	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	RFE	Receive FIFO Enable	0: Receive FIFO disabled 1: Receive FIFO enabled.	R/W
b3 to b1	RFUST[2:0]	Receive FIFO Unread Message Number Status	b3 b1 0 0 0: No unread message 0 0 1: 1 unread message 0 1 0: 2 unread messages 0 1 1: 3 unread messages 1 0 0: 4 unread messages 1 0 1: Reserved 1 1 0: Reserved 1 1 1: Reserved.	R
b4	RFMLF	Receive FIFO Message Lost Flag	0: Receive FIFO message not lost 1: Receive FIFO message lost.	R/W
b5	RFFST	Receive FIFO Full Status Flag	0: Receive FIFO not full 1: Receive FIFO full (4 unread messages).	R
b6	RFWST	Receive FIFO Buffer Warning Status Flag	0: Receive FIFO has no buffer warning 1: Receive FIFO has buffer warning (3 unread messages).	R
b7	RFEST	Receive FIFO Empty Status Flag	0: Unread message in receive FIFO 1: No unread message in receive FIFO.	R

Write to the RFCR register in CAN operation mode or halt mode.

RFE bit (Receive FIFO Enable)

When the RFE bit is set to 1, the receive FIFO is enabled.

When the RFE bit is set to 0, the receive FIFO is disabled for reception and becomes empty (RFEST = 1). Write 0 to the RFE bit simultaneously with the RFMLF flag setting.

Do not set this bit to 1 in normal mailbox mode (MBM bit in CTLR = 0). Due to hardware protection, the RFE bit cannot be set to 0 through a software write during the following period:

- Hardware protection is started from acceptance filter processing (the beginning of the CRC field)
- Hardware protection is released:
  - If the receive FIFO is specified to receive the incoming message, after the received data is stored in the receive FIFO or a CAN bus error occurs. The maximum period of hardware protection is from the beginning of the CRC field to the end of the 7th bit of EOF.
  - If the receive FIFO is not specified to receive the message, after acceptance filter processing.

RFUST[2:0] bits (Receive FIFO Unread Message Number Status)

The RFUST[2:0] bits indicate the number of unread messages in the receive FIFO. The value of the RFUST[2:0] bits is initialized to 000b when the RFE bit is set to 0.

RFMLF flag (Receive FIFO Message Lost Flag)

The RFMLF flag is set to 1 (receive FIFO message lost) when the receive FIFO receives a new message and is full. It is set to 1 at the end of the 6th bit of EOF.

The RFMLF flag is set to 0 through a software write (writing 1 has no effect). In both overwrite and overrun modes, if the receive FIFO is full and determined to have received a message, the RFMLF flag cannot be set to 0 (no receive FIFO

30.2.11 接收FIFO控制寄存器(RFCR)

Address(es): CAN0.RFCR 4005 0848h

	b7	b6	b5	b4	b3	b2	b1	b0
	RFEST	RFWST	RFFST	RFMLF	RFUST[2:0]			RFE
重置后的值：	1	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	RFE	接收FIFO使能	0：接收FIFO禁用1：接收FIFO启用。	R/W
b3 to b1	RFUST[2:0]	接收FIFO未读消息号码状态	b3b1000：没有未读消息001：1条未读消息010：2条未读消息011：3条未读消息100：4条未读消息101：保留110：保留111：预订的。	R
b4	RFMLF	接收FIFO消息丢失标志	0：接收FIFO报文不丢失1：接收FIFO报文丢失。	R/W
b5	RFFST	接收FIFO满状态标志	0：接收FIFO未满1：接收FIFO已满（4个未读消息）。	R
b6	RFWST	接收FIFO缓冲区警告状态标志	0：接收FIFO没有缓冲区警告1：接收FIFO有缓冲区警告（3个未读消息）。	R
b7	RFEST	接收FIFO空状态标志	0：接收FIFO中未读消息1：接收FIFO中没有未读消息。	R

在CAN操作模式或暂停模式下写入RFCR寄存器。

RFE位（接收FIFO使能）

当RFE位设置为1时，启用接收FIFO。

当RFE位设置为0时，接收FIFO禁止接收并变为空(RFEST=1)。将0写入RFE位与RFMLF标志设置同时进行。

在正常邮箱模式下不要将此位设置为1（CTLR中的MBM位=0）。由于硬件保护，RFE位在以下期间不能通过软件写入设置为0：

- 硬件保护从验收过滤器处理开始（CRC字段的开始）
- 硬件保护发布：
  - 如果指定接收FIFO接收传入报文，则在接收到的数据存储在接收FIFO中或发生CAN总线错误后。硬件保护的最大周期是从CRC域开始到EOF第7位结束。
  - 如果接收FIFO没有指定接收报文，接受过滤后处理。

RFUST[2:0]位（接收FIFO未读消息编号状态）

RFUST[2:0]位指示接收FIFO中未读消息的数量。当RFE位设置为0时，RFUST[2:0]位的值初始化为000b。

RFMLF标志（接收FIFO消息丢失标志）

当接收FIFO接收到新消息并已满时，RFMLF标志设置为1（接收FIFO消息丢失）。它在EOF的第6位末尾设置为1。

RFMLF标志通过软件写入设置为0（写入1无效）。在覆盖和溢出模式下，如果接收FIFO已满并确定已接收到消息，则RFMLF标志不能设置为0（无接收FIFO

message lost) through a software write during 5 PCLKB cycles following the 6th bit of EOF, due to hardware protection.

RFFST flag (Receive FIFO Full Status Flag)

The RFFST flag is set to 1 (receive FIFO is full) when the number of unread messages in the receive FIFO is 4. The RFFST flag is 0 (receive FIFO is not full) when the number of unread messages in the receive FIFO is less than 4. The flag is set to 0 when the RFE bit is 0.

RFWST flag (Receive FIFO Buffer Warning Status Flag)

The RFWST flag is set to 1 (receive FIFO buffer warning) when the number of unread messages in the receive FIFO is 3. The RFWST flag is 0 (no receive FIFO buffer warning) when the number of unread messages in the receive FIFO is less than 3 or equal to 4. The RFWST flag is set to 0 when the RFE bit is 0.

RFEST flag (Receive FIFO Empty Status Flag)

The RFEST flag is set to 1 (no unread message in receive FIFO) when the number of unread messages in the receive FIFO is 0. The RFEST flag is set to 1 when the RFE bit is set to 0. The RFEST flag is set to 0 (unread message in receive FIFO) when the number of unread messages in the receive FIFO is one or more.

Figure 30.2 shows the receive FIFO mailbox operation.

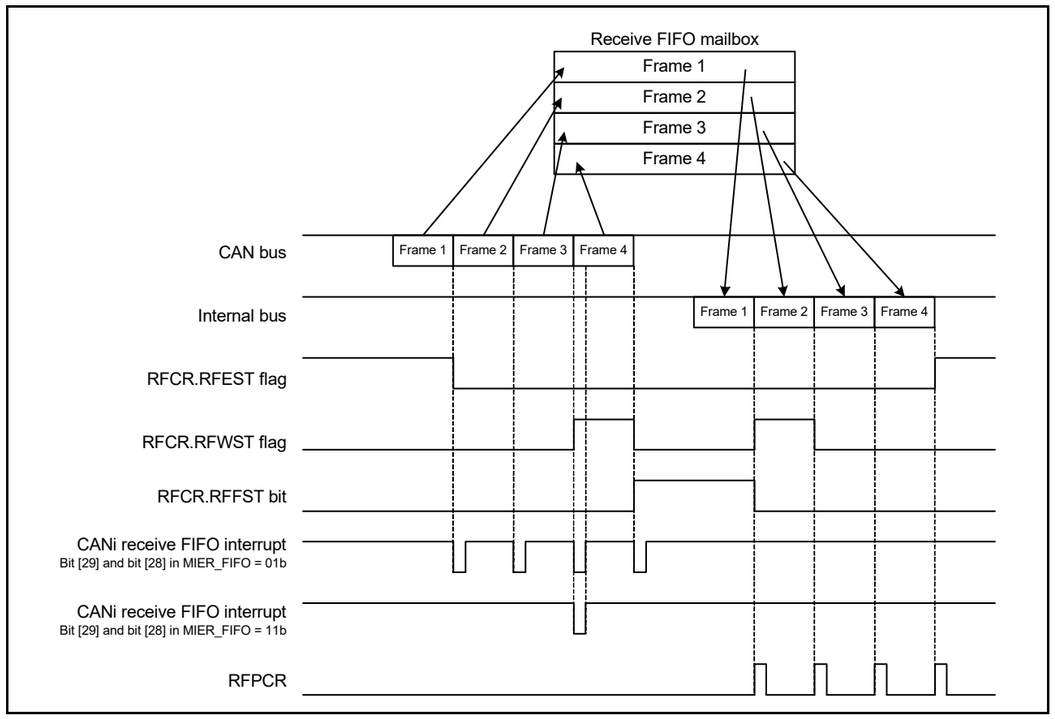


Figure 30.2 Receive FIFO mailbox operation with bits [29:28] in MIER_FIFO = 01b or 11b

由于硬件保护，在EOF第6位之后的5个PCLKB周期内通过软件写入。

RFFST标志（接收FIFO满状态标志）

当接收FIFO中的未读消息数为4时，RFFST标志设置为1（接收FIFO已满）。
当接收FIFO中未读消息的数量小于4时，RFFST标志为0（接收FIFO未满）。当RFE位为0时，该标志设置为0。

RFWST标志（接收FIFO缓冲区警告状态标志）

当接收FIFO中的未读消息数为3时，RFWST标志设置为1（接收FIFO缓冲区警告）。当接收FIFO中的未读消息数较少时，RFWST标志为0（无接收FIFO缓冲区警告）大于3或等于4。当RFE位为0时，RFWST标志设置为0。

RFEST标志（接收FIFO空状态标志）

RFEST标志设置为1（接收FIFO中没有未读消息），当接收中的未读消息数
FIFO为0。当RFE位设置为0时，RFEST标志设置为1。RFEST标志设置为0（接收中的未读消息
FIFO)当接收FIFO中的未读消息数为1或更多时。

图30.2显示了接收FIFO邮箱操作。

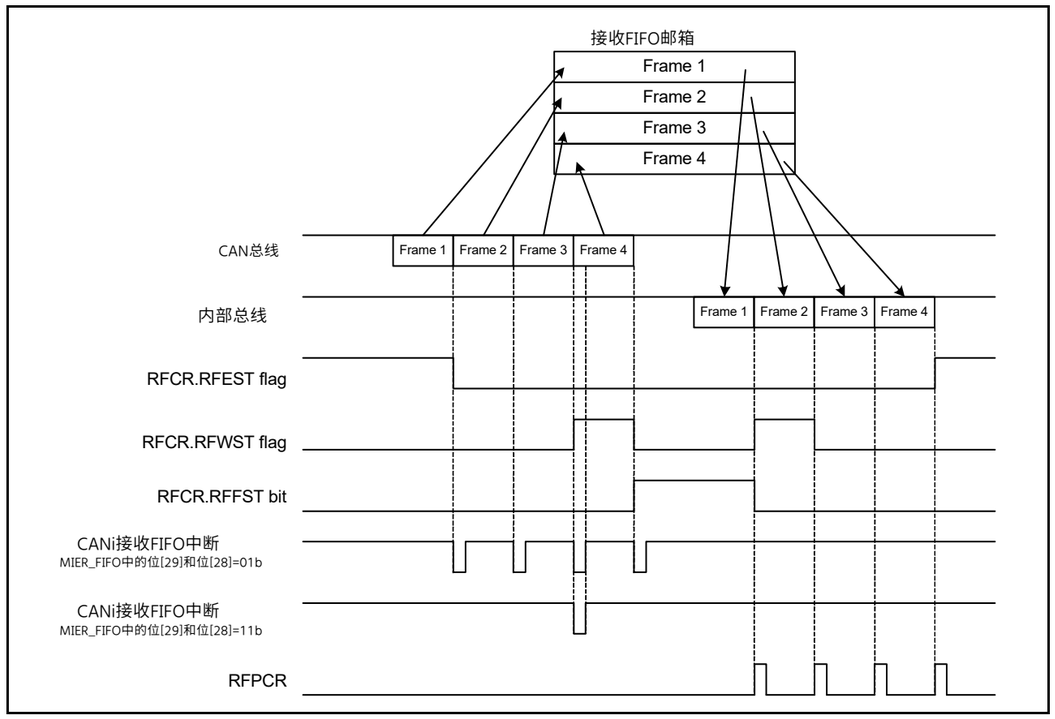


Figure 30.2 使用MIER_FIFO=01b或11b中的位[29:28]接收FIFO邮箱操作

30.2.12 Receive FIFO Pointer Control Register (RFPCR)

Address(es): CAN0.RFPCR 4005 0849h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	x	x	x	x	x	x	x	x

x: Undefined

Bit	Description	R/W
b7 to b0	The CPU pointer for the receive FIFO is incremented by writing FFh to RFPCR	W

When the receive FIFO is not empty, write FFh to RFPCR through software to increment the CPU pointer to the next mailbox location. Do not write to RFPCR when the RFE bit in RFCR is 0 (receive FIFO disabled).

Both the CAN and CPU pointers are incremented when a new message is received and the RFFST flag is 1 (receive FIFO is full) in overwrite mode. When the RFMLF flag is 1 in this condition, the CPU pointer does not increment on a software write to RFPCR.

30.2.13 Transmit FIFO Control Register (TFCR)

Address(es): CAN0.TFCR 4005 084Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	TFEST	TFFST	—	—	TFUST[2:0]			TFE
Value after reset:	1	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TFE	Transmit FIFO Enable	0: Transmit FIFO disabled 1: Transmit FIFO enabled.	R/W
b3 to b1	TFUST[2:0]	Transmit FIFO Unsent Message Number Status	b3 b1 0 0 0: 0 unsent messages 0 0 1: 1 unsent message 0 1 0: 2 unsent messages 0 1 1: 3 unsent messages 1 0 0: 4 unsent messages 1 0 1: Reserved 1 1 0: Reserved 1 1 1: Reserved.	R
b5, b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	TFFST	Transmit FIFO Full Status	0: Transmit FIFO is not full 1: Transmit FIFO is full (4 unsent messages).	R
b7	TFEST	Transmit FIFO Empty Status	0: Unsent message in transmit FIFO 1: No unsent message in transmit FIFO.	R

Write to the TFCR register in CAN operation mode or halt mode.

TFE bit (Transmit FIFO Enable)

When the TFE bit is set to 1, the transmit FIFO is enabled.

When the TFE bit is set to 0, the transmit FIFO becomes empty (TFEST = 1), and unsent messages in the transmit FIFO are lost in the following ways:

- Immediately if a message from the transmit FIFO is not scheduled for the next transmission or is already in transmission

30.2.12 接收FIFO指针控制寄存器(RFPCR)

Address(es): CAN0.RFPCR 4005 0849h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	x	x	x	x	x	x	x	x

x: Undefined

Bit	Description	R/W
b7 to b0	通过将FFh写入RFPCR，接收FIFO的CPU指针递增	W

当接收FIFO不为空时，通过软件将FFh写入RFPCR，使CPU指针递增到下一个邮箱位置。当RFCR中的RFE位为0（禁用接收FIFO）时，不要写入RFPCR。

CAN和CPU指针都在收到新消息并且RFFST标志为1时递增（接收FIFO已满）处于覆盖模式。在这种情况下，当RFMLF标志为1时，CPU指针不会在软件写入RFPCR时递增。

30.2.13 发送FIFO控制寄存器(TFCR)

Address(es): CAN0.TFCR 4005 084Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	TFEST	TFFST	—	—	TFUST[2:0]			TFE
重置后的值：	1	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TFE	发送FIFO使能	0：发送FIFO禁用1：发送FIFO使能。	R/W
b3 to b1	TFUST[2:0]	发送FIFO未发送消息号码状态	b3b1000：0条未发送消息001：1条未发送消息010：2条未发送消息011：3条未发送消息100：4条未发送消息101：保留110：保留111：预订的。	R
b5, b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	TFFST	发送FIFO满状态	0：发送FIFO未满1：发送FIFO已满（4条未发送消息）。	R
b7	TFEST	发送FIFO空状态	0：发送FIFO中未发送消息1：发送FIFO中没有未发送消息。	R

在CAN操作模式或暂停模式下写入TFCR寄存器。

TFE位（发送FIFO使能）

当TFE位设置为1时，使能发送FIFO。

当TFE位设置为0时，发送FIFO变为空（TFEST=1），发送FIFO中未发送的消息会以下列方式丢失：

- 如果来自发送FIFO的消息未安排下一次发送或已在发送中，则立即

- On completion of transmission, on a CAN bus error, a CAN bus arbitration-lost, or an entry to CAN halt mode, if a message from the transmit FIFO is scheduled for the next transmission or is already in transmission.

Before setting the TFE bit to 1 again, ensure that the TFEST bit is set to 1. After setting the TFE bit to 1, write transmit data to mailbox 24.

Do not set the TFE bit to 1 in normal mailbox mode (MBM bit in CTLR = 0).

TFUST[2:0] bits (Transmit FIFO Unsent Message Number Status)

The TFUST[2:0] bits indicate the number of unsent messages in the transmit FIFO. These bits are set to 000b after the TFE bit is set to 0 and transmission aborts or completes.

TFFST bit (Transmit FIFO Full Status)

The TFFST bit is set to 1 (transmit FIFO is full) when the number of unsent messages in the transmit FIFO is 4. The TFFST bit is set to 0 (transmit FIFO is not full) when the number of unsent messages in the transmit FIFO is less than 4. The TFFST bit is set to 0 when transmission from the transmit FIFO is aborted.

TFEST bit (Transmit FIFO Empty Status)

The TFEST bit is set to 1 (no message in transmit FIFO) when the number of unsent messages in the transmit FIFO is 0. The TFEST bit is set to 1 when transmission from the transmit FIFO is aborted. The TFEST bit is set to 0 (message in transmit FIFO) when the number of unsent messages in the transmit FIFO is not 0.

Figure 30.3 shows the transmit FIFO mailbox operation.

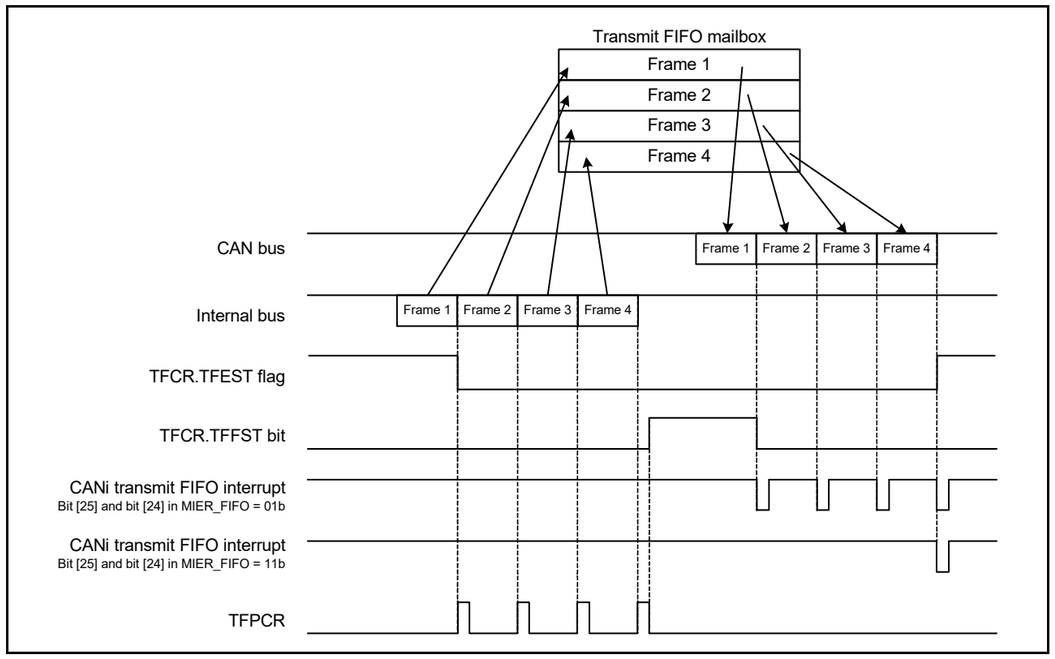


Figure 30.3 Transmit FIFO mailbox operation when bits [25:24] in MIER_FIFO = 01b or 11b

- 在传输完成、CAN总线错误、CAN总线仲裁丢失或进入CAN暂停模式时，如果来自传输FIFO的消息被安排用于下一次传输或已经在传输中。

再次将TFE位设置为1之前，请确保TFEST位设置为1。将TFE位设置为1后，将发送数据写入邮箱24。

不要在正常邮箱模式下将TFE位设置为1（CTLR中的MBM位=0）。

TFUST[2:0]位（发送FIFO未发送消息编号状态）

TFUST[2:0]位指示发送FIFO中未发送消息的数量。这些位被设置为000b后TFE位设置为0，传输中止或完成。

TFFST位（发送FIFO满状态）

当发送FIFO中未发送的消息数为4时，TFFST位设置为1（发送FIFO已满）。
当发送FIFO中未发送消息的数量小于4时，TFFST位设置为0（发送FIFO未满）。
当来自发送FIFO的发送被中止时，TFFST位设置为0。

TFEST位（发送FIFO空状态）

当发送FIFO中未发送消息的数量为0时，TFEST位设置为1（发送FIFO中没有消息）。
当来自发送FIFO的发送被中止时，TFEST位设置为1。当发送FIFO中未发送消息的数量不为0时，TFEST位设置为0（发送FIFO中的消息）。

图30.3显示了发送FIFO邮箱操作。

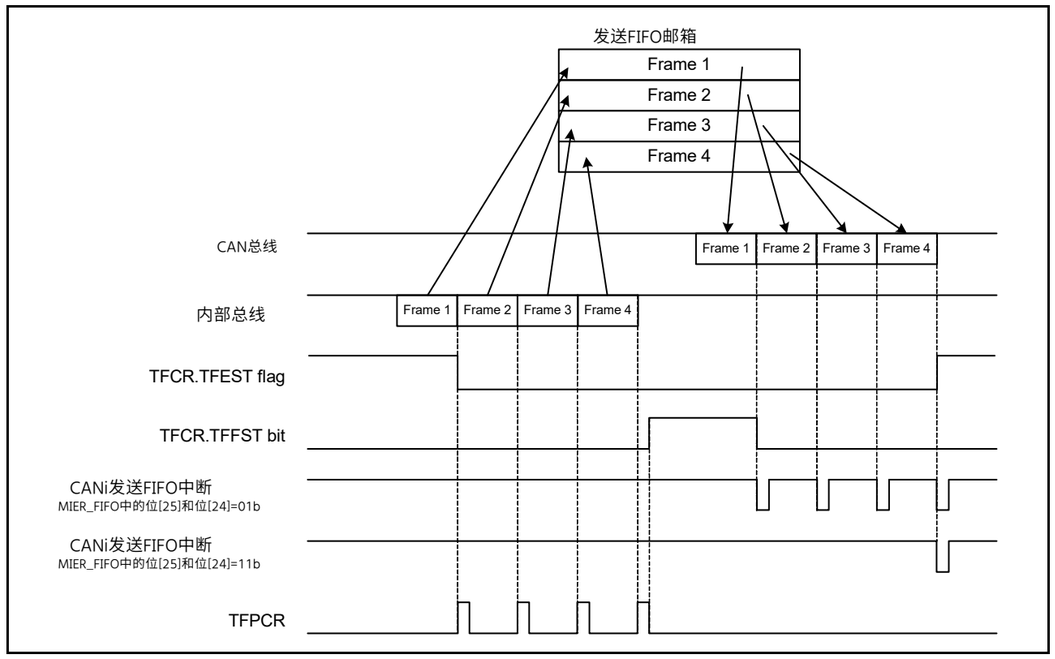


Figure 30.3 当MIER_FIFO中的位[25:24]=01b或11b时发送FIFO邮箱操作

30.2.14 Transmit FIFO Pointer Control Register (TFPCR)

Address(es): CAN0.TFPCR 4005 084Bh

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	x	x	x	x	x	x	x	x

x: Undefined

Bit	Description	R/W
b7 to b0	The CPU pointer for the transmit FIFO is incremented by writing FFh to TFPCR	W

When the transmit FIFO is not full, write FFh to the TFPCR register through software to increment the CPU pointer for the transmit FIFO to the next mailbox location.

Do not write to TFPCR when the TFE bit in TFCR is 0 (transmit FIFO disabled).

30.2.15 Status Register (STR)

Address(es): CAN0.STR 4005 0842h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	RECST	TRMST	BOST	EPST	SLPST	HLTST	RSTST	EST	TABST	FMLST	NMLST	TFST	RFST	SDST	NDST
Value after reset:	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	NDST	NEWDATA Status Flag	0: No mailbox with NEWDATA = 1 1: One or more mailboxes with NEWDATA = 1.	R
b1	SDST	SENTDATA Status Flag	0: No mailbox with SENTDATA = 1 1: One or more mailboxes with SENTDATA = 1.	R
b2	RFST	Receive FIFO Status Flag	0: Receive FIFO empty 1: Message in receive FIFO.	R
b3	TFST	Transmit FIFO Status Flag	0: Transmit FIFO full 1: Transmit FIFO not full.	R
b4	NMLST	Normal Mailbox Message Lost Status Flag	0: No mailbox with MSGLOST = 1 1: One or more mailboxes with MSGLOST = 1.	R
b5	FMLST	FIFO Mailbox Message Lost Status Flag	0: RFMLF = 0 1: RFMLF = 1.	R
b6	TABST	Transmission Abort Status Flag	0: No mailbox with TRMABT = 1 1: One or more mailboxes with TRMABT = 1.	R
b7	EST	Error Status Flag	0: No error occurred 1: Error occurred.	R
b8	RSTST	CAN Reset Status Flag	0: Not in CAN reset mode 1: In CAN reset mode.	R
b9	HLTST	CAN Halt Status Flag	0: Not in CAN halt mode 1: In CAN halt mode.	R
b10	SLPST	CAN Sleep Status Flag	0: Not in CAN sleep mode 1: In CAN sleep mode.	R
b11	EPST	Error-Passive Status Flag	0: Not in error-passive state 1: In error-passive state.	R
b12	BOST	Bus-Off Status Flag	0: Not in bus-off state 1: In bus-off state.	R

30.2.14 发送FIFO指针控制寄存器(TFPCR)

Address(es): CAN0.TFPCR 4005 084Bh

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	x	x	x	x	x	x	x	x

x: Undefined

Bit	Description	R/W
b7 to b0	通过将FFh写入TFPCR，发送FIFO的CPU指针递增	W

当发送FIFO未满时，通过软件将FFh写入TFPCR寄存器，以将发送FIFO的CPU指针递增到下一个邮箱位置。

当TFCR中的TFE位为0（禁用发送FIFO）时，不要写入TFPCR。

30.2.15 状态寄存器(STR)

Address(es): CAN0.STR 4005 0842h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	RECST	TRMST	BOST	EPST	SLPST	HLTST	RSTST	EST	TABST	FMLST	NMLST	TFST	RFST	SDST	NDST
重置后的值:	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	NDST	NEWDATA状态标志	0：没有NEWDATA=1的邮箱1：一个或多个NEWDATA=1的邮箱。	R
b1	SDST	SENTDATA状态标志	0：没有SENTDATA=1的邮箱1：一个或多个SENTDATA=1的邮箱。	R
b2	RFST	接收FIFO状态标志	0：接收FIFO空1：接收FIFO中的消息。	R
b3	TFST	发送FIFO状态标志	0：发送FIFO已满1：发送FIFO未满。	R
b4	NMLST	普通邮箱消息丢失状态标志	0：没有MSGLOST=1的邮箱1：一个或多个MSGLOST=1的邮箱。	R
b5	FMLST	FIFO邮箱消息丢失状态Flag	0: RFMLF = 0 1: RFMLF = 1.	R
b6	TABST	传输中止状态标志	0：没有TRMABT=1的邮箱1：一个或多个TRMABT=1的邮箱。	R
b7	EST	错误状态标志	0：未发生错误1：发生错误。	R
b8	RSTST	CAN复位状态标志	0：不处于CAN复位模式1：处于CAN复位模式。	R
b9	HLTST	CAN停止状态标志	0：不处于CAN停止模式1：处于CAN停止模式。	R
b10	SLPST	CAN睡眠状态标志	0：不处于CAN睡眠模式1：处于CAN睡眠模式。	R
b11	EPST	错误被动状态标志	0：不处于被动错误状态1：处于被动错误状态。	R
b12	BOST	总线关闭状态标志	0：不处于总线关闭状态 1：处于总线关闭状态。	R

Bit	Symbol	Bit name	Description	R/W
b13	TRMST	Transmit Status Flag	0: Bus idle or reception in progress 1: Transmission in progress or in bus-off state.	R
b14	RECST	Receive Status Flag	0: Bus idle or transmission in progress 1: Reception in progress.	R
b15	—	Reserved	This bit is read as 0	R

NDST flag (NEWDATA Status Flag)

The NDST flag is set to 1 when at least one NEWDATA flag in MCTL_RXj (j = 0 to 31) registers is 1, regardless of the value of MIER or MIER_FIFO. The NDST flag is set to 0 when all NEWDATA flags are 0.

SDST flag (SENTDATA Status Flag)

The SDST flag is set to 1 when at least one SENTDATA flag in MCTL_TXj (j = 0 to 31) registers is 1, regardless of the value of MIER or MIER_FIFO. The SDST flag is set to 0 when all SENTDATA flags are 0.

RFST flag (Receive FIFO Status Flag)

The RFST flag is set to 1 when the receive FIFO is not empty. The RFST flag is set to 0 when the receive FIFO is empty or normal mailbox mode is selected.

TFST flag (Transmit FIFO Status Flag)

The TFST flag is set to 1 when the transmit FIFO is not full. The TFST flag is set to 0 when the transmit FIFO is full or normal mailbox mode is selected.

NMLST flag (Normal Mailbox Message Lost Status Flag)

The NMLST flag is set to 1 when at least one MSGLOST flag in MCTL_RXj (j = 0 to 31) registers is 1, regardless of the value of MIER or MIER_FIFO. The NMLST is set to 0 when all MSGLOST flags are 0.

FMLST flag (FIFO Mailbox Message Lost Status Flag)

The FMLST flag is set to 1 when the RFMLF flag in RFCR is 1, regardless of the value of MIER_FIFO. The FMLST flag is set to 0 when the RFMLF flag is 0.

TABST flag (Transmission Abort Status Flag)

The TABST flag is set to 1 when at least one TRMABT flag in MCTL_TXj (j = 0 to 31) registers is 1, regardless of the value of MIER or MIER_FIFO. The TABST flag is set to 0 when all TRMABT flags are 0.

EST flag (Error Status Flag)

The EST flag is set to 1 when at least one error is detected by EIFR, regardless of the value of EIER. The EST flag is set to 0 when no error is detected by EIFR.

RSTST flag (CAN Reset Status Flag)

The RSTST flag is set to 1 when the CAN module is in CAN reset mode. The RSTST flag is 0 when the CAN module is not in CAN reset mode. Even when the state changes from CAN reset mode to CAN sleep mode, the flag remains 1.

HLTST flag (CAN Halt Status Flag)

The HLTST flag is set to 1 when the CAN module is in CAN halt mode. The HLTST flag is set to 0 when the CAN module is not in CAN halt mode. Even when the state changes from CAN halt mode to CAN sleep mode, the flag remains 1.

SLPST flag (CAN Sleep Status Flag)

The SLPST flag is set to 1 when the CAN module is in CAN sleep mode. The SLPST flag is set to 0 when the CAN module is not in CAN sleep mode.

EPST flag (Error-Passive Status Flag)

The EPST flag is set to 1 when the value of TECR or RECR exceeds 127 and the CAN module is in an error-passive state (128 ≤ TEC < 256 or 128 ≤ REC < 256). The EPST flag is set to 0 when the CAN module is not in the error-passive state.

Bit	Symbol	位名称	Description	R/W
b13	TRMST	发送状态标志	0：总线空闲或接收中1：传输中或总线关闭状态。	R
b14	RECST	接收状态标志	0：总线空闲或传输中1：接收中。	R
b15	—	Reserved	该位读为0	R

NDST标志（NEWDATA状态标志）

无论MIER或MIER_FIFO的值如何，当MCTL_RXj（j=0到31）寄存器中的至少一个NEWDATA标志为1时，NDST标志设置为1。当所有NEWDATA标志为0时，NDST标志设置为0。

SDST标志（SENTDATA状态标志）

无论MIER或MIER_FIFO的值如何，当MCTL_TXj（j=0到31）寄存器中的至少一个SENTDATA标志为1时，SDST标志设置为1。当所有SENTDATA标志为0时，SDST标志设置为0。

RFST标志（接收FIFO状态标志）

当接收FIFO不为空时，RFST标志设置为1。当接收FIFO为空或选择正常邮箱模式时，RFST标志设置为0。

TFST标志（发送FIFO状态标志）

当发送FIFO未满时，TFST标志设置为1。当发送FIFO已满或选择正常邮箱模式时，TFST标志设置为0。

NMLST标志（正常邮箱消息丢失状态标志）

无论MIER或MIER_FIFO的值如何，当MCTL_RXj（j=0到31）寄存器中的至少一个MSGLOST标志为1时，NMLST标志设置为1。当所有MSGLOST标志为0时，NMLST设置为0。

FMLST标志（FIFO邮箱消息丢失状态标志）

当RFCR中的RFMLF标志为1时，无论MIER_FIFO的值如何，FMLST标志都设置为1。当RFMLF标志为0时，FMLST标志设置为0。

TABST标志（传输中止状态标志）

无论MIER或MIER_FIFO的值如何，当MCTL_TXj（j=0到31）寄存器中的至少一个TRMABT标志为1时，TABST标志设置为1。当所有TRMABT标志为0时，TABST标志设置为0。

EST标志（错误状态标志）

当EIFR检测到至少一个错误时，无论EIER的值如何，EST标志设置为1。当EIFR未检测到错误时，EST标志设置为0。

RSTST标志（CAN复位状态标志）

当CAN模块处于CAN复位模式时，RSTST标志设置为1。当CAN模块未处于CAN复位模式时，RSTST标志为0。即使状态从CAN复位模式更改为CAN睡眠模式，该标志仍　　保持为1。

HLTST标志（CAN停止状态标志）

当CAN模块处于CAN暂停模式时，HLTST标志设置为1。当CAN模块未处于CAN暂停模式时，HLTST标志设置为0。即使状态从CAN停止模式更改为CAN睡眠模式，该标志仍　　保持为1。

SLPST标志（CAN睡眠状态标志）

当CAN模块处于CAN睡眠模式时，SLPST标志设置为1。当CAN模块未处于CAN睡眠模式时，SLPST标志设置为0。

EPST标志（错误被动状态标志）

当TECR或RECR的值超过127并且CAN模块处于错误被动状态（128≤TEC<256或128≤REC<256）时，EPST标志设置为1。当CAN模块不处于被动错误状态时，EPST标志设置为0。

BOST flag (Bus-Off Status Flag)

The BOST flag is set to 1 when the value in TECR exceeds 255 and the CAN module is in the bus-off state (TEC ≥ 256). The BOST flag is set to 0 when the CAN module is not in the bus-off state.

TRMST flag (Transmit Status Flag)

The TRMST flag is set to 1 when the CAN module performs as a transmitter node or is in the bus-off state. The TRMST flag is set to 0 when the CAN module performs as a receiver node or is in the bus-idle state.

RECST flag (Receive Status Flag)

The RECST flag is set to 1 when the CAN module performs as a receiver node. The RECST flag is set to 0 when the CAN module performs as a transmitter node or is in the bus-idle state.

30.2.16 Mailbox Search Mode Register (MSMR)

Address(es): CAN0.MSMR 4005 0853h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	MBSM[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	MBSM[1:0]	Mailbox Search Mode Select	b1 b0 0 0: Receive mailbox search mode 0 1: Transmit mailbox search mode 1 0: Message lost search mode 1 1: Channel search mode.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Write to the MSMR register in CAN operation mode or halt mode.

MBSM[1:0] bits (Mailbox Search Mode Select)

The MBSM[1:0] bits select the search mode for the mailbox search function.

When the MBSM[1:0] bits are 00b, receive mailbox search mode is selected. In this mode, the search targets are the NEWDATA flag in MCTL_RXj (j = 0 to 31) registers for the normal mailbox, and the RFEST flag in RFCR.

When the MBSM[1:0] bits are 01b, transmit mailbox search mode is selected. In this mode, the search target is the SENTDATA flag in MCTL_TXj.

When the MBSM[1:0] bits are 10b, message lost search mode is selected. In this mode, the search targets are the MSGLOST flag in MCTL_RXj for the normal mailbox, and the RFMLF flag in RFCR.

When the MBSM[1:0] bits are 11b, channel search mode is selected. In this mode, the search target is CSSR. See section 30.2.18, Channel Search Support Register (CSSR).

BOST标志（总线关闭状态标志）

当TECR中的值超过255并且CAN模块处于总线关闭状态(TEC≥256)时，BOST标志设置为1。
当CAN模块不处于总线关闭状态时，BOST标志设置为0。

TRMST标志（发送状态标志）

当CAN模块作为发送器节点运行或处于总线关闭状态时，TRMST标志设置为1。当CAN模块作为接收器节点运行或处于总线空闲状态时，TRMST标志设置为0。

RECST标志（接收状态标志）

当CAN模块作为接收器节点运行时，RECST标志设置为1。RECST标志设置为0，当CAN模块作为发送器节点运行或处于总线空闲状态。

30.2.16 邮箱搜索模式寄存器(MSMR)

Address(es): CAN0.MSMR 4005 0853h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	MBSM[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	MBSM[1:0]	邮箱搜索模式选择	b1b000：接收邮箱搜索模式01：发送邮箱搜索模式10：消息丢失搜索模式11：频道搜索模式。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

在CAN操作模式或暂停模式下写入MSMR寄存器。

MBSM[1:0]位（邮箱搜索模式选择）

MBSM[1:0]位选择邮箱搜索功能的搜索模式。

当MBSM[1:0]位为00b时，选择接收邮箱搜索模式。在这种模式下，搜索目标是MCTL_RXj(j=0到31)中的NEWDATA标志为普通邮箱注册，RFCR中的RFEST标志。

当MBSM[1:0]位为01b时，选择发送邮箱搜索模式。在这种模式下，搜索目标是MCTL_TXj中的SENTDATA标志。

当MBSM[1:0]位为10b时，选择消息丢失搜索模式。在这种模式下，搜索目标是正常邮箱的MCTL_RXj中的MSGLOST标志，以及RFCR中的RFMLF标志。

当MBSM[1:0]位为11b时，选择频道搜索模式。在这种模式下，搜索目标是CSSR。请参阅第30.2.18节，频道搜索支持寄存器(CSSR)。

30.2.17 Mailbox Search Status Register (MSSR)

Address(es): CAN0.MSSR 4005 0852h

	b7	b6	b5	b4	b3	b2	b1	b0
	SEST	—	—	MBNST[4:0]				
Value after reset:	1	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	MBNST[4:0]	Search Result Mailbox Number Status	These bits output the smallest mailbox number that is found in each search mode selected in the MSMR register	R
b6, b5	—	Reserved	These bits are read as 0	R
b7	SEST	Search Result Status	0: Search result found 1: No search result.	R

MBNST[4:0] bits (Search Result Mailbox Number Status)

In all mailbox search modes, the MBNST[4:0] bits output the smallest mailbox number. In receive mailbox search mode, transmit mailbox search mode, and message lost search mode, the value of the mailbox (the search result to be output) is updated under the following conditions:

- When the associated NEWDATA, SENTDATA, or MSGLOST flag is set to 0 for a mailbox output by MBNST[4:0]
- When the associated NEWDATA, SENTDATA, or MSGLOST flag is set to 1 for a mailbox with a smaller number than that in MBNST[4:0].

If the MBSM[1:0] bits are set to 00b (receive mailbox search mode) or 10b (message lost search mode), the receive FIFO (mailbox 28) is output when it is not empty and there are no unread received messages and no lost messages in any of the normal mailboxes 0 to 23. If the MBSM[1:0] bits are set to 01b (transmit mailbox search mode), the transmit FIFO (mailbox 24) is not output. Table 30.6 lists the behavior of the MBNST[4:0] bits in FIFO mailbox mode.

In channel search mode, the MBNST[4:0] bits output the associated channel number. After MSSR is read by software, the next target channel number is output.

SEST bit (Search Result Status)

The SEST bit is set to 1 (no search result) when no associated mailbox is found after searching all mailboxes. For example, in transmit mailbox search mode, the SEST bit is set to 1 when no SENTDATA flag is 1 for any mailbox. The SEST bit is set to 0 when at least one SENTDATA flag is 1. When the SEST bit is 1, the value of the MBNST[4:0] bits is undefined.

Table 30.6 Behavior of MBNST[4:0] bits in FIFO mailbox mode

MBSM[1:0] bits	Mailbox 24 (transmit FIFO)	Mailbox 28 (receive FIFO)
00b	Mailbox 24 is not output	Mailbox 28 is output when no MCTL_RXj.NEWDATA flag for the normal mailboxes is set to 1 (new message is being stored or was stored in the mailbox) and the receive FIFO is not empty
01b		Mailbox 28 is not output
10b		Mailbox 28 is output when no MCTL_RXj.MSGLOST flag for the normal mailboxes is set to 1 (message is overwritten or overrun) and the RFCR.RFMLF flag is set to 1 (receive FIFO message lost) in the receive FIFO
11b		Mailbox 28 is not output

30.2.17 邮箱搜索状态寄存器(MSSR)

Address(es): CAN0.MSSR 4005 0852h

	b7	b6	b5	b4	b3	b2	b1	b0
	SEST	—	—	MBNST[4:0]				
重置后的值：	1	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	MBNST[4:0]	搜索结果邮箱号码状态	这些位输出在MSMR寄存器中选择的每个搜索模式中找到的最小邮箱号	R
b6, b5	—	Reserved	这些位被读为0	R
b7	SEST	搜索结果状态	0：找到搜索结果1： 没有搜索结果。	R

MBNST[4:0]位（搜索结果邮箱号码状态）

在所有邮箱搜索模式中，MBNST[4:0]位输出最小的邮箱号。在接收邮箱搜索模式、发送邮箱搜索模式和消息丢失搜索模式下，邮箱的值（要输出的搜索结果）在以下条件下更新：

- 当邮箱输出的相关NEWDATA、SENTDATA或MSGLOST标志设置为0时MBNST[4:0]
- 当邮箱的相关NEWDATA、SENTDATA或MSGLOST标志设置为1时，邮箱的编号小于MBNST[4:0]中的编号。

如果MBSM[1:0]位设置为00b（接收邮箱搜索模式）或10b（邮件丢失搜索模式），则在接收FIFO（邮箱28）不为空且没有未读接收到的消息时输出在任何正常邮箱0到23中都没有丢失消息。如果MBSM[1:0]位设置为01b（发送邮箱搜索模式），则不输出发送FIFO（邮箱24）。表30.6列出了MBNST[4:0]位在FIFO邮箱模式下的行为。

在频道搜索模式下，MBNST[4:0]位输出相关的频道号。软件读取MSSR后，输出下一个目标通道号。

SEST位（搜索结果状态）

当搜索所有邮箱后未找到相关邮箱时，SEST位设置为1（无搜索结果）。例如，在发送邮箱搜索模式中，当没有任何邮箱的SENTDATA标志为1时，SEST位设置为1。当至少一个SENTDATA标志为1时，SEST位设置为0。当SEST位为1时，MBNST[4:0]位的值未定义。

Table 30.6 FIFO邮箱模式下MBNST[4:0]位的行为

MBSM[1:0] bits	Mailbox 24 (transmit FIFO)	Mailbox 28 (receive FIFO)
00b	邮箱24不输出	当正常邮箱的MCTL_RXj.NEWDATA标志未设置为1（新消息正在存储或已存储在邮箱中）且接收FIFO不为空时，输出邮箱28
01b		28号邮箱不输出
10b		当正常邮箱的MCTL_RXj.MSGLOST标志未设置为1（消息被覆盖或溢出）且接收FIFO中的RFCR.RFMLF标志设置为1（接收FIFO消息丢失）时，输出邮箱28
11b		28号邮箱不输出

30.2.18 Channel Search Support Register (CSSR)

Address(es): CAN0.CSSR 4005 0851h

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	x	x	x	x	x	x	x	x

x: Undefined

Bit	Description	R/W
b7 to b0	When the value for the channel search is input, the channel number is output to MSSR	R/W

The bits that are set to 1 in the CSSR are encoded by an 8/3 encoder (the LSB position has the higher priority) and output to the MBNST[4:0] bits in MSSR. The MSSR register outputs the updated value whenever it is read by software.

Write to CSSR only when the MSMR.MBSM[1:0] bits are 11b (channel search mode). Write to CSSR in CAN operation mode or CAN halt mode.

Figure 30.4 shows the write and read operations of the CSSR and MSSR registers.

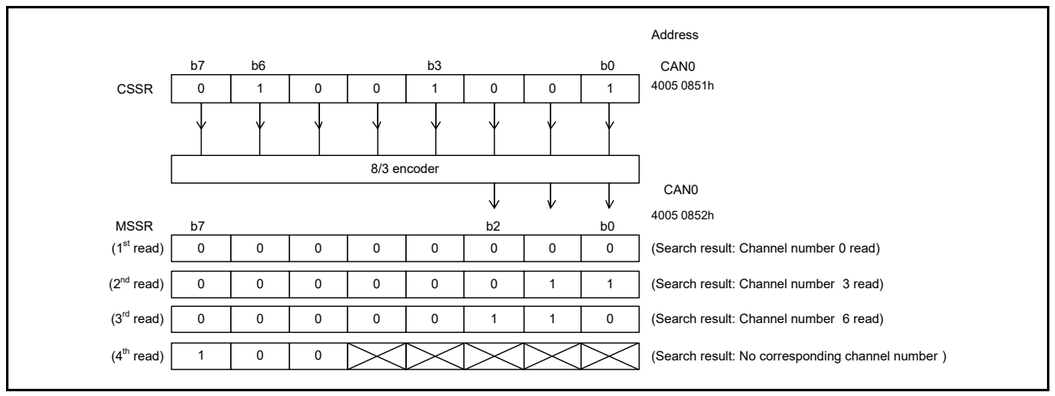


Figure 30.4 Write and read operations of the CSSR and MSSR registers

The value of CSSR is also updated whenever MSSR is read. On this read, the value prior to conversion by the 8/3 encoder can be read.

30.2.19 Acceptance Filter Support Register (AFSR)

Address(es): CAN0.AFSR 4005 0856h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Description	R/W
b15 to b0	After the standard ID of a received message is written, the value converted for data table search can be read	R/W

Note: Write to AFSR in CAN operation mode or halt mode.

30.2.18 频道搜索支持寄存器(CSSR)

Address(es): CAN0.CSSR 4005 0851h

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	x	x	x	x	x	x	x	x

x: Undefined

Bit	Description	R/W
b7 to b0	输入通道搜索值时，通道号输出到MSSR	R/W

CSSR中设置为1的位由83编码器（LSB位置具有较高优先级）编码并输出到MSSR中的MBNST[4:0]位。每当软件读取时，MSSR寄存器就会输出更新的值。

仅当MSMR.MBSM[1:0]位为11b（通道搜索模式）时才写入CSSR。在CAN操作模式或CAN暂停模式下写入CSSR。

图30.4显示了CSSR和MSSR寄存器的写和读操作。

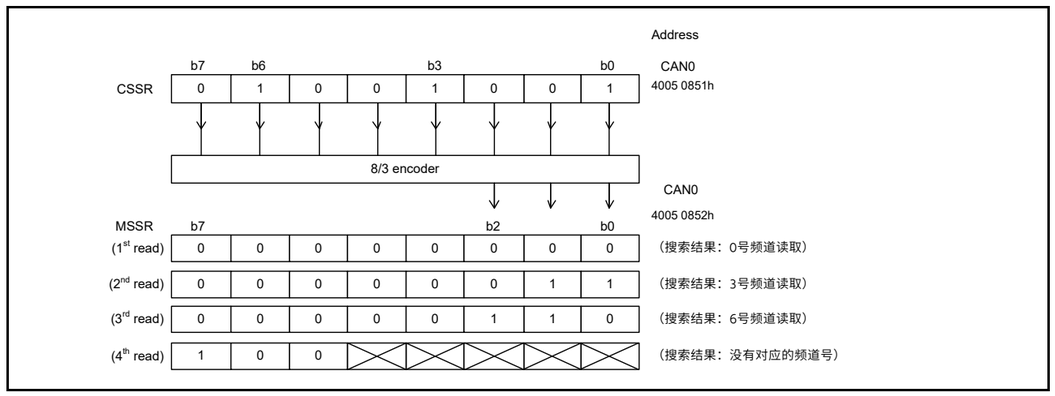


Figure 30.4 CSSR和MSSR寄存器的写和读操作

每当读取MSSR时，CSSR的值也会更新。在此读取中，可以读取83编码器转换之前的值。

30.2.19 接受过滤器支持寄存器(AFSR)

Address(es): CAN0.AFSR 4005 0856h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x: Undefined

Bit	Description	R/W
b15 to b0	接收报文的标准ID写入后，即可读取数据查表转换后的值	R/W

Note: 在CAN操作模式或暂停模式下写入AFSR。

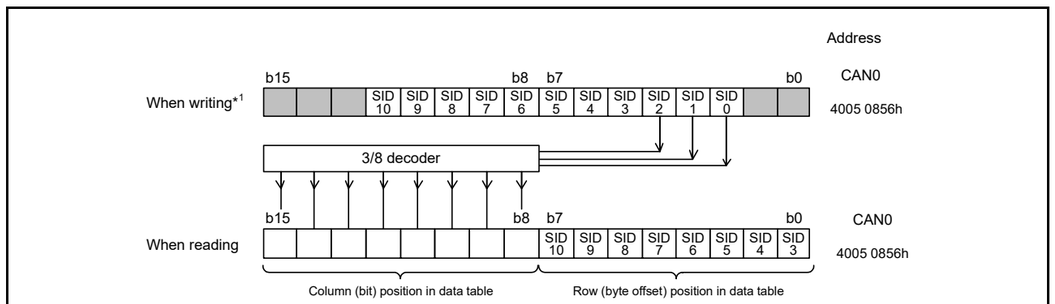
The acceptance filter support unit (ASU) can be used for data table (8 bits × 256) searches. In the data table, all standard IDs that are created are set as valid or invalid in bit units. When AFSR is written with data in 16-bit units including the SID[10:0] bits in MBj_ID (j = 0 to 31), in which a received standard ID is stored, a decoded row (byte offset) position and column (bit) position for data table search can be read. The ASU can be used for standard (11-bit) IDs only.

The ASU is enabled in the following cases:

- When the ID to be received cannot be masked by the acceptance filter.
  For example, if the IDs to be received are 078h, 087h, and 111h.
- When there are too many IDs to receive, and the software filtering time is expected to be shortened.

Note: The AFSR register cannot be set in CAN reset mode.

Figure 30.5 shows the write and read operations in the AFSR register.



Note 1. Write the same value as the 16-bit unit data, including the SID[10:0] bits in MBj_ID (j = 0 to 31).

Figure 30.5 Write and read operations in the AFSR register

30.2.20 Error Interrupt Enable Register (EIER)

Address(es): CAN0.EIER 4005 084Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	BLIE	OLIE	ORIE	BORIE	BOEIE	EPIE	EWIE	BEIE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	BEIE	Bus Error Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b1	EWIE	Error-Warning Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b2	EPIE	Error-Passive Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b3	BOEIE	Bus-Off Entry Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b4	BORIE	Bus-Off Recovery Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b5	ORIE	Overrun Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b6	OLIE	Overload Frame Transmit Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W
b7	BLIE	Bus Lock Interrupt Enable	0: Interrupt disabled 1: Interrupt enabled.	R/W

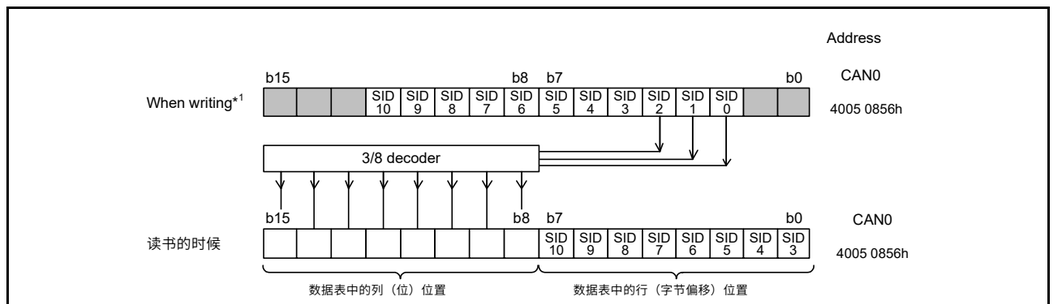
验收滤波器支持单元(ASU)可用于数据表（8位×256）搜索。在数据表中，所有创建的标准ID都以位为单位设置为有效或无效。当AFSR以16位单元写入数据时，包括MBj_ID(j=0到31)中的SID[10:0]位，其中存储了接收到的标准ID，解码的行（字节偏移）位置和列（位）数据表搜索的位置可以被读取。ASU只能用于标准（11位）ID。

ASU在以下情况下启用：

- 当接受过滤器不能屏蔽要接收的ID时。
  例如，如果要接收的ID是078h、087h和111h。
- 当接收的ID太多时，预计软件过滤时间会缩短。

Note: 在CAN复位模式下不能设置AFSR寄存器。

图30.5显示了AFSR寄存器中的写和读操作。



Note 1. 写入与16位单元数据相同的值，包括MBj_ID中的SID[10:0]位（j=0到31）。

Figure 30.5 AFSR寄存器中的写和读操作

30.2.20 错误中断使能寄存器(EIER)

Address(es): CAN0.EIER 4005 084Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	BLIE	OLIE	ORIE	BORIE	BOEIE	EPIE	EWIE	BEIE
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	BEIE	总线错误中断使能	0：中断禁止1：中断允许。	R/W
b1	EWIE	错误警告中断使能	0：中断禁止1：中断允许。	R/W
b2	EPIE	错误被动中断使能	0：中断禁止1：中断允许。	R/W
b3	BOEIE	总线关闭进入中断使能	0：中断禁止1：中断允许。	R/W
b4	BORIE	总线关闭恢复中断使能	0：中断禁止1：中断允许。	R/W
b5	ORIE	溢出中断使能	0：中断禁止1：中断允许。	R/W
b6	OLIE	过载帧发送中断 Enable	0：中断禁止1：中断允许。	R/W
b7	BLIE	总线锁定中断使能	0：中断禁止1：中断允许。	R/W

The EIER register independently enables or disables the error interrupt for each error interrupt source. Write to EIER in CAN reset mode.

BEIE bit (Bus Error Interrupt Enable)

When the BEIE bit is 0, no error interrupt request occurs even if the BEIF flag in EIFR is 1. When the BEIE bit is 1, an error interrupt request occurs if the BEIF flag is set to 1.

EWIE bit (Error-Warning Interrupt Enable)

When the EWIE bit is 0, no error interrupt request occurs even if the EWIF flag in EIFR is 1. When the EWIE bit is 1, an error interrupt request is generated if the EWIF flag is set to 1.

EPIE bit (Error-Passive Interrupt Enable)

When the EPIE bit is 0, no error interrupt request occurs even if the EPIF flag in EIFR is 1. When the EPIE bit is 1, an error interrupt request occurs if the EPIF flag is set to 1.

BOEIE bit (Bus-Off Entry Interrupt Enable)

When the BOEIE bit is 0, no error interrupt request occurs even if the BOEIF flag in EIFR is 1. When the BOEIE bit is 1, an error interrupt request occurs if the BOEIF flag is set to 1.

BORIE bit (Bus-Off Recovery Interrupt Enable)

When the BORIE bit is 0, no error interrupt request occurs even if the BORIF flag in EIFR is 1. When the BORIE bit is 1, an error interrupt request occurs if the BORIF flag is set to 1.

ORIE bit (Overrun Interrupt Enable)

When the ORIE bit is 0, no error interrupt request occurs even if the ORIF flag in EIFR is 1. When the ORIE bit is 1, an error interrupt request occurs if the ORIF flag is set to 1.

OLIE bit (Overload Frame Transmit Interrupt Enable)

When the OLIE bit is 0, no error interrupt request occurs even if the OLIF flag in EIFR is 1. When the OLIE bit is 1, an error interrupt request occurs if the OLIF flag is set to 1.

BLIE bit (Bus Lock Interrupt Enable)

When the BLIE bit is 0, no error interrupt request occurs even if the BLIF flag in EIFR is 1. When the BLIE bit is 1, an error interrupt request occurs if the BLIF flag is set to 1.

30.2.21 Error Interrupt Factor Judge Register (EIFR)

Address(es): CAN0.EIFR 4005 084Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	BLIF	OLIF	ORIF	BORIF	BOEIF	EPIF	EWIF	BEIF
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	BEIF	Bus Error Detect Flag	0: No bus error detected 1: Bus error detected.	R/W
b1	EWIF	Error-Warning Detect Flag	0: No error-warning detected 1: Error-warning detected.	R/W
b2	EPIF	Error-Passive Detect Flag	0: No error-passive detected 1: Error-passive detected.	R/W
b3	BOEIF	Bus-Off Entry Detect Flag	0: No bus-off entry detected 1: Bus-off entry detected.	R/W
b4	BORIF	Bus-Off Recovery Detect Flag	0: No bus-off recovery detected 1: Bus-off recovery detected.	R/W

EIER寄存器独立启用或禁用每个错误中断源的错误中断。写信给EIER
CAN复位模式。

BEIE位（总线错误中断使能）

当BEIE位为0时，即使EIFR中的BEIF标志为1，也不会发生错误中断请求。当BEIE位为1时，如果BEIF标志位设置为1，则发生错误中断请求。

EWIE位（错误警告中断使能）

当EWIE位为0时，即使EIFR中的EWIF标志为1，也不会产生错误中断请求。当EWIE位为1时，如果EWIF标志位设置为1，则产生错误中断请求。

EPIE位（错误被动中断使能）

当EPIE位为0时，即使EIFR中的EPIF标志为1，也不会发生错误中断请求。当EPIE位为1时，如果EPIF标志位设置为1，则会发生错误中断请求。

BOEIE位（总线关闭进入中断使能）

当BOEIE位为0时，即使EIFR中的BOEIF标志为1，也不会产生错误中断请求。当BOEIE位为1时，如果将BOEIF标志设置为1，则会产生错误中断请求。

BORIE位（总线关闭恢复中断使能）

当BORIE位为0时，即使EIFR中的BORIF标志为1，也不会产生错误中断请求。当BORIE位为1时，如果将BORIF标志设置为1，则会产生错误中断请求。

ORIE位（溢出中断使能）

当ORIE位为0时，即使EIFR中的ORIF标志为1，也不会发生错误中断请求。当ORIE位为1时，如果将ORIF标志设置为1，则会发生错误中断请求。

OLIE位（过载帧发送中断使能）

当OLIE位为0时，即使EIFR中的OLIF标志为1，也不会产生错误中断请求。当OLIE位为1时，如果OLIF标志被设置为1，则产生错误中断请求。

BLIE位（总线锁定中断使能）

当BLIE位为0时，即使EIFR中的BLIF标志为1，也不会发生错误中断请求。当BLIE位为1时，如果BLIF标志位设置为1，则会发生错误中断请求。

30.2.21 错误中断因素判断寄存器（EIFR）

Address(es): CAN0.EIFR 4005 084Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	BLIF	OLIF	ORIF	BORIF	BOEIF	EPIF	EWIF	BEIF
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	BEIF	总线错误检测标志	0：未检测到总线错误1 ：检测到总线错误。	R/W
b1	EWIF	错误警告检测标志	0：未检测到错误警告1：检测到错误警告。	R/W
b2	EPIF	错误被动检测标志	0：未检测到被动错误1：检测到被动错误。	R/W
b3	BOEIF	总线关闭进入检测标志	0：未检测到总线关闭条目1 ：检测到总线关闭条目。	R/W
b4	BORIF	总线关闭恢复检测标志	0：未检测到总线关闭恢复1： 检测到总线关闭恢复。	R/W

Bit	Symbol	Bit name	Description	R/W
b5	ORIF	Receive Overrun Detect Flag	0: No receive overrun detected 1: Receive overrun detected.	R/W
b6	OLIF	Overload Frame Transmission Detect Flag	0: No overload frame transmission detected 1: Overload frame transmission detected.	R/W
b7	BLIF	Bus Lock Detect Flag	0: No bus lock detected 1: Bus lock detected.	R/W

If an event associated with an EIFR flag occurs, the associated bit in EIFR is set to 1, regardless of the setting of EIER.

Clear the bits to 0 through a software write. If a bit is set to 1 at the same time that software clears it, the bit becomes 1. When setting a single bit to 0 in software, use the transfer instruction (MOV) to ensure that only the specified bit is set to 0 and the other bits are set to 1. Writing 1 has no effect to these bit values.

BEIF flag (Bus Error Detect Flag)

The BEIF flag is set to 1 when a bus error is detected.

EWIF flag (Error-Warning Detect Flag)

The EWIF flag is set to 1 when the value of the receive error counter (REC) or transmit error counter (TEC) exceeds 95. This flag is set to 1 only when the REC or TEC value initially exceeds 95. If software writes 0 to this flag while the REC or TEC value remains greater than 95, the EWIF flag is not set to 1 until the REC or TEC value goes below 95, and then exceeds 95 again.

EPIF flag (Error-Passive Detect Flag)

The EPIF flag is set to 1 when the CAN error state becomes error-passive, while the REC or TEC value exceeds 127. This flag is set to 1 only when the REC or TEC value initially exceeds 127. If software writes 0 to this flag while REC or TEC remains greater than 127, the EPIF flag is not set to 1 until REC or TEC goes below 127, and then exceeds 127 again.

BOEIF flag (Bus-Off Entry Detect Flag)

The BOEIF flag is set to 1 when the CAN error state becomes bus-off, while the TEC value exceeds 255. This flag is also set to 1 when the BOM[1:0] bits in CTLR are 01b (automatic entry to CAN halt mode on bus-off entry) and the CAN module enters the bus-off state.

BORIF flag (Bus-Off Recovery Detect Flag)

The BORIF flag is set to 1 when the CAN module recovers from the bus-off state normally by detecting 11 consecutive recessive bits 128 times in the following conditions:

- When the BOM[1:0] bits in CTLR are 00b
- When the BOM[1:0] bits in CTLR are 10b
- When the BOM[1:0] bits in CTLR are 11b.

The BORIF flag is not set to 1 if the CAN module recovers from the bus-off state in the following conditions:

- When the CANM[1:0] bits in CTLR are set to 01b or 11b (CAN reset mode)
- When the RBOC bit in CTLR is set to 1 (forced return from bus-off)
- When the BOM[1:0] bits in CTLR are set to 01b
- When the BOM[1:0] bits in CTLR are set to 11b and the CANM[1:0] bits in CTLR are set to 10b (CAN halt mode) before normal recovery occurs.

Table 30.7 lists the behavior of the BOEIF and BORIF flags for each CTLR.BOM[1:0] bit setting.

Bit	Symbol	位名称	Description	R/W
b5	ORIF	接收溢出检测标志	0：未检测到接收溢出1：检测到接收溢出。	R/W
b6	OLIF	过载帧传输检测标志	0：未检测到过载帧传输1：检测到过载帧传输。	R/W
b7	BLIF	总线锁定检测标志	0：未检测到总线锁定1：检测到总线锁定。	R/W

如果发生与EIFR标志相关的事件，则EIFR中的相关位设置为1，而与EIER的设置无关。

通过软件写入将这些位清除为0。如果在软件清零的同时将某个位设置为1，则该位变为1。在软件中将单个位设置为0时，使用传输指令(MOV)确保只有指定的位设置为0，并且其他位设置为1。写入1对这些位值没有影响。

BEIF标志（总线错误检测标志）

当检测到总线错误时，BEIF标志设置为1。

EWIF标志（错误警告检测标志）

当接收错误计数器(REC)或发送错误计数器(TEC)的值超过95时，EWIF标志设置为1。仅当REC或TEC值最初超过95时，该标志才设置为1。如果软件将0写入当REC或TEC值保持大于95时，EWIF标志不会设置为1，直到REC或TEC值低于95，然后再次超过95。

EPIF标志（错误被动检测标志）

当CAN错误状态变为被动错误，而REC或TEC值超过127时，EPIF标志设置为1。仅当REC或TEC值最初超过127时，此标志设置为1。如果软件将0写入此标志而REC或
TEC保持大于127，EPIF标志不会设置为1，直到REC或TEC低于127，然后再次超过127。

BOEIF标志（总线关闭进入检测标志）

当CAN错误状态变为总线关闭时，BOEIF标志设置为1，而TEC值超过255。当CTLR中的BOM[1:0]位为01b时，该标志也设置为1（自动进入CAN停止进入总线关闭模式）和CAN模块进入总线关闭状态。

BORIF标志（总线关闭恢复检测标志）

当CAN模块在以下情况下通过检测11个连续的隐性位128次从总线关闭状态正常恢复时，BORIF标志设置为1：

- CTLR的BOM[1:0]位为00b时
- CTLR中BOM[1:0]位为10b时
- 当CTLR的BOM[1:0]位为11b时。

如果CAN模块在以下情况下从总线关闭状态恢复，则BORIF标志不设置为1：

- 当CTLR中的CANM[1:0]位设置为01b或11b时（CAN复位模式）
- 当CTLR的RBOC位设置为1时（从总线关闭强制返回）
- 当CTLR中的BOM[1:0]位设置为01b
- 当CTLR中的BOM[1:0]位设置为11b且CTLR中的CANM[1:0]位设置为10b（CAN停止模式）时，才会发生正常恢复。

表30.7列出了每个CTLR.BOM[1:0]位设置的BOEIF和BORIF标志的行为。

Table 30.7 Behavior of BOEIF and BORIF flags for each CTLR.BOM[1:0] setting

BOM[1:0] bits	BOEIF flag	BORIF flag
00b	Set to 1 on entry to the bus-off state	Set to 1 on exit from the bus-off state
01b		Do not set to 1
10b		Set to 1 on exit from the bus-off state
11b		Set to 1 if normal bus-off recovery occurs before the CANM[1:0] bits are set to 10b (CAN halt mode)

ORIF flag (Receive Overrun Detect Flag)

The ORIF flag is set to 1 when a receive overrun occurs. This flag is not set to 1 in overwrite mode. In overwrite mode, a reception complete interrupt request occurs if an overwrite condition occurs and the ORIF flag is not set to 1.

In overrun mode with normal mailbox mode, if an overrun occurs in any of mailboxes 0 to 31, the ORIF flag is set to 1. In overrun mode with FIFO mailbox mode, if an overrun occurs in any of mailboxes 0 to 23 or the receive FIFO, this flag is set to 1.

OLIF flag (Overload Frame Transmission Detect Flag)

The OLIF flag is set to 1 if the transmitting condition of an overload frame is detected when the CAN module is transmitting or receiving.

BLIF flag (Bus Lock Detect Flag)

The BLIF flag is set to 1 if 32 consecutive dominant bits are detected on the CAN bus while the CAN module is in CAN operation mode.

After the BLIF flag is set to 1, 32 consecutive dominant bits are detected again in either of the following conditions:

- Recessive bits are detected after the BLIF flag changes to 0 from 1
- The CAN module enters CAN reset or halt mode and then enters CAN operation mode again, after the BLIF flag changes to 0 from 1.

30.2.22 Receive Error Count Register (RECR)

Address(es): CAN0.RECR 4005 084Eh

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0

Bit	Description	R/W
b7 to b0	Receive error count function. RECR increments or decrements the counter value based on the error status of the CAN module during reception.	R

The RECR register indicates the value of the receive error counter. See the CAN specification (ISO11898-1) for the increment and decrement conditions of the receive error counter. The value of RECR in the bus-off state is undefined.

Table 30.7 每个CTLR.BOM[1:0]设置的BOEIF和BORIF标志的行为

BOM[1:0] bits	BOEIF flag	BORIF flag
00b	进入总线关闭状态时设置为1	退出总线关闭状态时设置为1
01b		不要设置为1
10b		退出总线关闭状态时设置为1
11b		如果在CANM[1:0]位设置为10b（CAN停止模式）之前发生正常的总线关闭恢复，则设置为1

ORIF标志（接收溢出检测标志）

当发生接收溢出时，ORIF标志设置为1。此标志在覆盖模式下不设置为1。在覆盖模式下，如果出现覆盖条件且ORIF标志未设置为1，则会产生接收完成中断请求。

在具有正常邮箱模式的溢出模式中，如果在任何邮箱0到31中发生溢出，则ORIF标志设置为1。在具有FIFO邮箱模式的溢出模式中，如果在任何邮箱0到23或接收中发生溢出FIFO，此标志设置为1。

OLIF标志（过载帧传输检测标志）

如果在CAN模块发送或接收时检测到过载帧的发送条件，则OLIF标志设置为1。

BLIF标志（总线锁定检测标志）

如果在CAN模块处于CAN操作模式时在CAN总线上检测到32个连续显性位，则BLIF标志设置为1。

将BLIF标志设置为1后，在以下任一条件下再次检测到32个连续的显性位：

- BLIF标志从1变为0后检测到隐性位
- CAN模块进入CAN复位或停止模式，然后在BLIF标志从1变为0后再次进入CAN操作模式。

30.2.22 接收错误计数寄存器(RECR)

Address(es): CAN0.RECR 4005 084Eh

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0

Bit	Description	R/W
b7 to b0	接收错误计数功能。RECR根据错误状态递增或递减计数器值 接收期间的CAN模块。	R

RECR寄存器指示接收错误计数器的值。有关接收错误计数器的递增和递减条件，请参见CAN规范(ISO11898-1)。总线关闭状态下RECR的值未定义。

30.2.23 Transmit Error Count Register (TECR)

Address(es): CAN0.TECR 4005 084Fh

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0

Bit	Description	R/W
b7 to b0	Transmit error count function. TECR increments or decrements the counter value based on the error status of the CAN module during transmission.	R

The TECR register indicates the value of the transmit error counter. See the CAN specification (ISO11898-1) for the increment and decrement conditions of the transmit error counter. The value of TECR in the bus-off state is undefined.

30.2.24 Error Code Store Register (ECSR)

Address(es): CAN0.ECSR 4005 0850h

	b7	b6	b5	b4	b3	b2	b1	b0
	EDPM	ADEF	BE0F	BE1F	CEF	AEF	FEF	SEF
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SEF	Stuff Error Flag*1,*2	0: No stuff error detected 1: Stuff error detected.	R/W
b1	FEF	Form Error Flag*1,*2	0: No form error detected 1: Form error detected.	R/W
b2	AEF	ACK Error Flag*1,*2	0: No ACK error detected 1: ACK error detected.	R/W
b3	CEF	CRC Error Flag*1,*2	0: No CRC error detected 1: CRC error detected.	R/W
b4	BE1F	Bit Error (recessive) Flag*1,*2	0: No bit error (recessive) detected 1: Bit error (recessive) detected.	R/W
b5	BE0F	Bit Error (dominant) Flag*1,*2	0: No bit error (dominant) detected 1: Bit error (dominant) detected.	R/W
b6	ADEF	ACK Delimiter Error Flag*1,*2	0: No ACK delimiter error detected 1: ACK delimiter error detected.	R/W
b7	EDPM	Error Display Mode Select*3,*4	0: Output first detected error code 1: Output accumulated error code.	R/W

Note 1. Writing 1 has no effect on these bit values.
Note 2. To write 0 to the SEF, FEF, AEF, CEF, BE1F, BE0F, and ADEF bits, use the transfer (MOV) instruction to ensure that only the specified bit is set to 0 and the other bits are set to 1.
Note 3. Write to the EDPM bit in CAN reset mode or halt mode.
Note 4. If more than one error condition is detected simultaneously, all the related bits are set to 1.

ECSR indicates whether an error occurred on the CAN bus. See the CAN specification (ISO11898-1) for the conditions when each error occurs.

Clear all of the bits, except for EDPM, to 0 through a software write. If the ECSR bit is set to 1 by the CAN module at that same time that software writes 0 to it, the bit is set to 1.

30.2.23 发送错误计数寄存器(TECR)

Address(es): CAN0.TECR 4005 084Fh

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0

Bit	Description	R/W
b7 to b0	发送错误计数功能。TECR根据错误状态递增或递减计数器值 CAN模块在传输过程中。	R

TECR寄存器指示发送错误计数器的值。有关发送错误计数器的递增和递减条件，请参见CAN规范(ISO11898-1)。总线关闭状态下的TECR值未定义。

30.2.24 错误代码存储寄存器(ECSR)

Address(es): CAN0.ECSR 4005 0850h

	b7	b6	b5	b4	b3	b2	b1	b0
	EDPM	ADEF	BE0F	BE1F	CEF	AEF	FEF	SEF
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SEF	填充错误标志*1 *2	0：未检测到填充错误1 ：检测到填充错误。	R/W
b1	FEF	表格错误标志*1 *2	0：未检测到表单错误1 ：检测到表单错误。	R/W
b2	AEF	ACK错误标志*1 *2	0：未检测到ACK错误1： 检测到ACK错误。	R/W
b3	CEF	CRC Error Flag*1,*2	0：未检测到CRC错误1： 检测到CRC错误。	R/W
b4	BE1F	位错误（隐性）标志*1 *2	0：未检测到位错误（隐性）1：检 测到位错误（隐性）。	R/W
b5	BE0F	误码（显性）标志*1 *2	0：未检测到位错误（显性）1：检 测到位错误（显性）。	R/W
b6	ADEF	ACK分隔符错误标志*1 *2	0：未检测到ACK分隔符错误1：检 测到ACK分隔符错误。	R/W
b7	EDPM	错误显示模式选择*3 *4	0：输出第一个检测到的错误代码 1：输出累积错误代码。	R/W

Note 1. 写1对这些位值没有影响。
Note 2. 要将0写入SEF、FEF、AEF、CEF、BE1F、BE0F和ADEF位，请使用传输(MOV)指令确保只有指定位设置为0，其他位设置为1。

Note 3. 在CAN复位模式或暂停模式下写入EDPM位。
Note 4. 如果同时检测到多个错误条件，则所有相关位都设置为1。

ECSR指示CAN总线上是否发生错误。有关每个错误发生的条件，请参见CAN规范(ISO11898-1)。

通过软件写入将除EDPM之外的所有位清零。如果在软件向其写入0的同时CAN模块将ECSR位设置为1，则该位设置为1。

SEF flag (Stuff Error Flag*1,*2)

The SEF flag is set to 1 when a stuff error is detected.

FEF flag (Form Error Flag*1,*2)

The FEF flag is set to 1 when a form error is detected.

AEF flag (ACK Error Flag*1,*2)

The AEF flag is set to 1 when an ACK error is detected.

CEF flag (CRC Error Flag*1,*2)

The CEF flag is set to 1 when a CRC error is detected.

BE1F flag (Bit Error (recessive) Flag*1,*2)

The BE1F flag is set to 1 when a recessive bit error is detected.

BE0F flag (Bit Error (dominant) Flag*1,*2)

The BE0F flag is set to 1 when a dominant bit error is detected.

ADEF flag (ACK Delimiter Error Flag*1,*2)

The ADEF flag is set to 1 when a form error is detected with the ACK delimiter during transmission.

EDPM bit (Error Display Mode Select*3,*4)

The EDPM bit selects the output mode of ECSR. When the EDPM bit is set to 0, ECSR outputs the first error code. When the EDPM bit is set to 1, ECSR outputs the accumulated error code.

30.2.25 Time Stamp Register (TSR)

Address(es): CAN0.TSR 4005 0854h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	R/W
b15 to b0	Free-running counter value for the time stamp function	R

Note: Read TSR in 16-bit units.

Reading the TSR register returns the current value of the 16-bit free-running time stamp counter. The time stamp counter reference clock is configured in the TSPS[1:0] bits in CTLR. The counter stops in CAN sleep mode and CAN halt mode, and is initialized in CAN reset mode. The time stamp counter value is stored in the TSL[7:0] and TSH[7:0] bits in the MBj_TS register when a received message is stored in a receive mailbox.

SEF标志（StuffErrorFlag*1 *2）

当检测到填充错误时，SEF标志设置为1。

FEF标志（表格错误标志*1 *2）

当检测到表单错误时，FEF标志设置为1。

AEF标志（ACK错误标志*1 *2）

当检测到ACK错误时，AEF标志设置为1。

CEF标志（CRC错误标志*1 *2）

当检测到CRC错误时，CEF标志设置为1。

BE1F标志（误码（隐性）标志*1 *2）

当检测到隐性位错误时，BE1F标志设置为1。

BE0F标志（位错误（显性）标志*1 *2）

当检测到显性位错误时，BE0F标志设置为1。

ADEF标志（ACK分隔符错误标志*1 *2）

当在传输过程中使用ACK定界符检测到格式错误时，ADEF标志设置为1。

EDP M位（错误显示模式选择*3 *4）

EDP M位选择ECSR的输出模式。当EDPM位设置为0时，ECSR输出第一个错误代码。当EDPM位设置为1时，ECSR输出累积的错误代码。

30.2.25 时间戳寄存器(TSR)

Address(es): CAN0.TSR 4005 0854h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Description	R/W
b15 to b0	时间戳功能的自由运行计数器值	R

Note: 以16位为单位读取TSR。

读取TSR寄存器返回16位自由运行时间戳计数器的当前值。时间戳计数器参考时钟在CTLR的TSPS[1:0]位中配置。计数器在CAN睡眠模式和CAN暂停模式下停止，并在CAN复位模式下初始化。当接收到的消息存储在接收邮箱中时，时间戳计数器值存储在MBj_TS寄存器的TSL[7:0]和TSH[7:0]位中。

30.2.26 Test Control Register (TCR)

Address(es): CAN0.TCR 4005 0858h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	TSTM[1:0]		TSTE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TSTE	CAN Test Mode Enable	0: CAN test mode disabled 1: CAN test mode enabled.	R/W
b2, b1	TSTM[1:0]	CAN Test Mode Select	b2 b1 0 0: Not CAN test mode 0 1: Listen-only mode 1 0: Self-test mode 0 (external loopback) 1 1: Self-test mode 1 (internal loopback).	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

TCR controls the CAN test mode. Write to TCR in CAN halt mode only.

(1) Listen-only mode

The CAN specification (ISO11898-1) recommends an optional bus monitoring mode. In listen-only mode, valid data frames and valid remote frames can be received. However, only recessive bits can be sent on the CAN bus. The ACK bit, overload flag, and active error flag cannot be sent. Listen-only mode can be used for baud rate detection. Do not request transmission from any mailboxes in listen-only mode.

Figure 30.6 shows the connection when listen-only mode is selected.

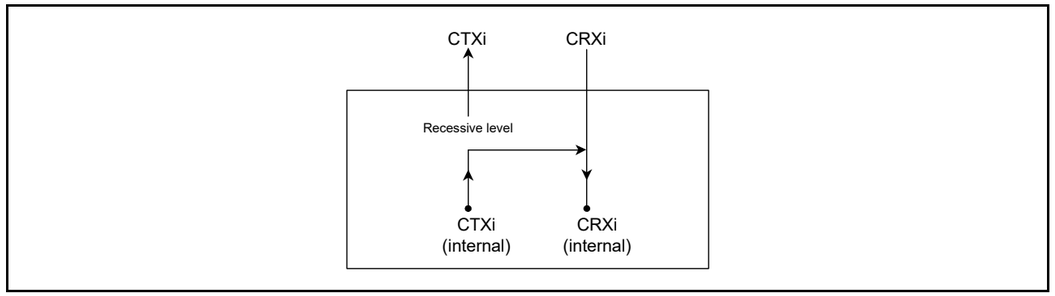


Figure 30.6 Connection when listen-only mode is selected (i = 0)

(2) Self-test mode 0 (external loopback)

Self-test mode 0 is provided for CAN transceiver tests. In this mode, the protocol module treats its own transmitted messages as those received by the CAN transceiver and stores them into the receive mailbox. To be independent from external stimulation, the protocol module generates the ACK bit. Connect the CTXi and CRXi pins to the transceiver.

Figure 30.7 shows the connection when self-test mode 0 is selected.

30.2.26 测试控制寄存器(TCR)

Address(es): CAN0.TCR 4005 0858h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	TSTM[1:0]		TSTE
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TSTE	CAN测试模式启用	0：禁用CAN测试模式1： 启用CAN测试模式。	R/W
b2, b1	TSTM[1:0]	CAN测试模式选择	b2b100：非CAN测试模式01：只听模式1 0：自测模式0（外部环回）11：自测模式 1（内部环回）。	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

TCR控制CAN测试模式。仅在CAN停止模式下写入TCR。

(1) Listen-only mode

CAN规范(ISO11898-1)推荐一种可选的总线监控模式。在只听模式下，可以接收到有效的数据帧和有效的远程帧。但是，只能在CAN总线上发送隐性位。不能发送ACK位、过载标志和活动错误标志。只听模式可用于波特率检测。不要在只听模式下从任何邮箱请求传输。

图30.6显示了选择只听模式时的连接。

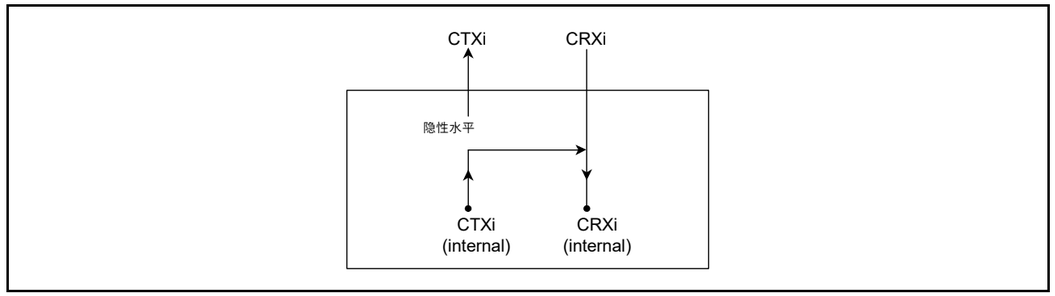


Figure 30.6 选择只听模式时的连接(i=0)

(2) Self-test mode 0 (external loopback)

自测模式0用于CAN收发器测试。在该模式下，协议模块将自己发送的报文视为CAN收发器接收到的报文，并将其存储到接收邮箱中。为独立于外部刺激，协议模块生成ACK位。将CTXi和CRXi引脚连接到收发器。

图30.7显示了选择自检模式0时的连接。

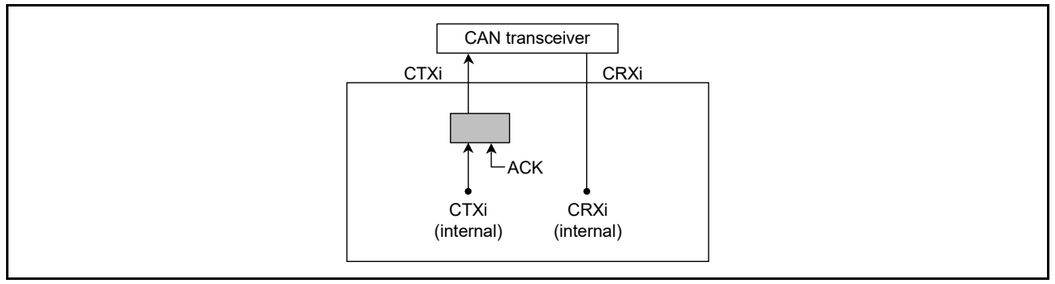


Figure 30.7 Connection when self-test mode 0 is selected (i = 0)

(3) Self-test mode 1 (internal loopback)

Self-test mode 1 is provided for self-test functions. In this mode, the protocol controller treats its transmitted messages as received messages and stores them into the receive mailbox. To be independent from external stimulation, the protocol controller generates the ACK bit.

In self-test mode 1, the protocol controller performs an internal feedback from the internal CTXi pin to the internal CRXi pin. The input value of the external CRXi pin is ignored. The external CTXi pin outputs only recessive bits. The CTXi and CRXi pins are not required to be connected to the CAN bus or any external device.

Figure 30.8 shows the connection when self-test mode 1 is selected.

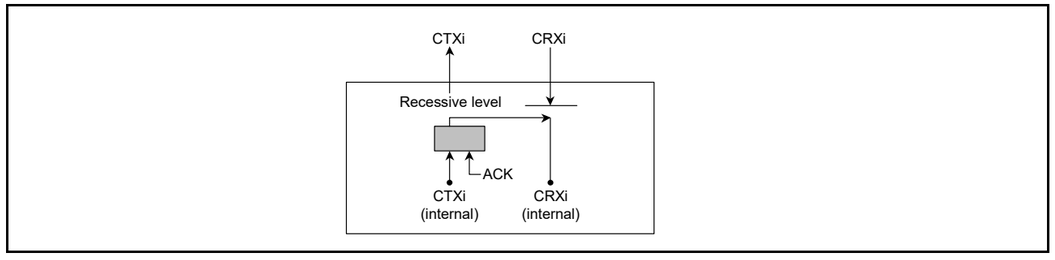


Figure 30.8 Connection when self-test mode 1 is selected (i = 0)

30.3 Operation Modes

The CAN module operation includes the following modes:

- CAN reset mode
- CAN halt mode
- CAN operation mode
- CAN sleep mode.

Figure 30.9 shows the transitions between different operation modes.

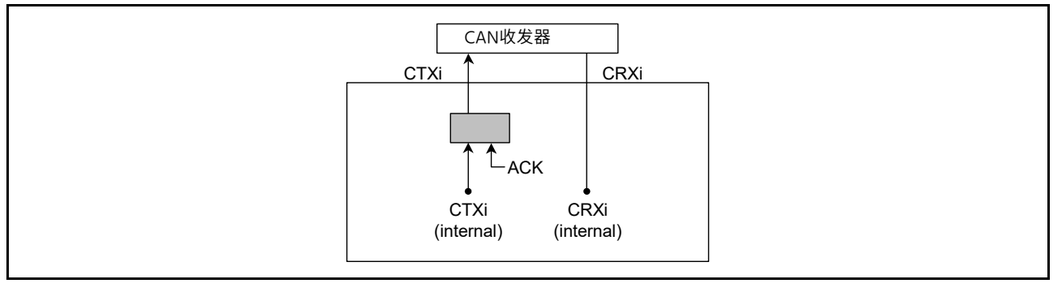


Figure 30.7 选择自检模式0时的连接(i=0)

(3) Self-test mode 1 (internal loopback)

自检模式1用于自检功能。在这种模式下，协议控制器将其发送的消息视为接收的消息，并将它们存储到接收邮箱中。为了独立于外部刺激，协议控制器生成ACK位。

在自检模式1中，协议控制器执行从内部CTXi引脚到内部CRXi引脚的内部反馈。外部CRXi引脚的输入值被忽略。外部CTXI引脚仅输出隐性位。CTXi和CRXi引脚不需要连接到CAN总线或任何外部设备。

图30.8显示了选择自检模式1时的连接。

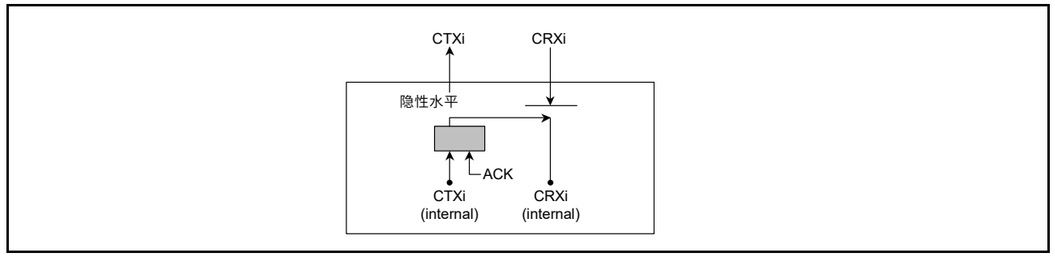


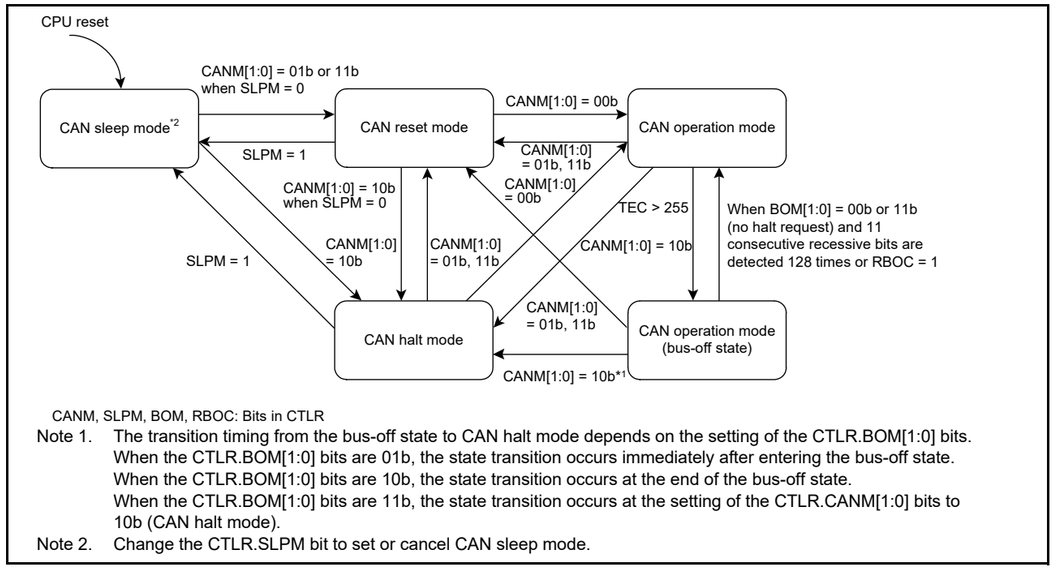
Figure 30.8 选择自检模式1时的连接(i=0)

30.3 操作模式

CAN模块操作包括以下模式：

- CAN复位模式
- CAN暂停模式
- CAN操作模式
- CAN睡眠模式。

图30.9显示了不同操作模式之间的转换。



Note 1. The transition timing from the bus-off state to CAN halt mode depends on the setting of the CTLR.BOM[1:0] bits.
When the CTLR.BOM[1:0] bits are 01b, the state transition occurs immediately after entering the bus-off state.
When the CTLR.BOM[1:0] bits are 10b, the state transition occurs at the end of the bus-off state.
When the CTLR.BOM[1:0] bits are 11b, the state transition occurs at the setting of the CTLR.CANM[1:0] bits to 10b (CAN halt mode).
Note 2. Change the CTLR.SLPM bit to set or cancel CAN sleep mode.

Figure 30.9 Transition between different operation modes

30.3.1 CAN Reset Mode

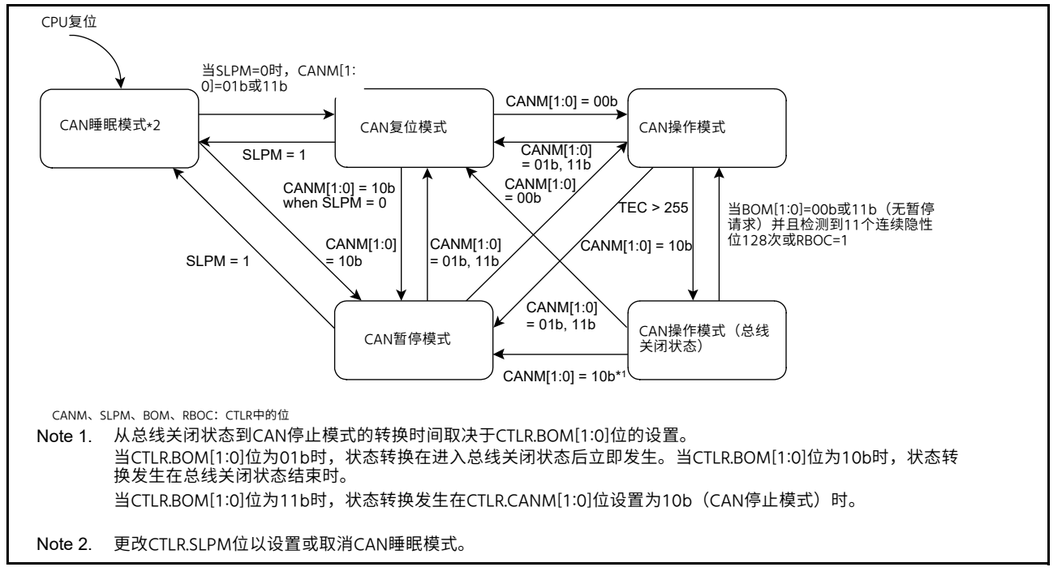
CAN reset mode is provided for CAN communication configuration. When the CTLR.CANM[1:0] bits are set to 01b or 11b, the CAN module enters CAN reset mode. The STR.RSTST flag is then set to 1. Do not change the CTLR.CANM[1:0] bits until the RSTST flag is 1. Set the BCR register before exiting CAN reset mode to enter any other modes.

The following registers are initialized to their reset values after entering CAN reset mode, and their initial values are saved during CAN reset mode:

- MCTL_TXj and MCTL_RXj
- STR (except for the SLPST and TFST bits)
- EIFR
- RECR
- TECR
- TSR
- MSSR
- MSMR
- RFCR
- TFCR
- TCR
- ECSR (except for the EDPM bit).

The following registers retain their previous values even after entering CAN reset mode:

- CTLR
- STR (only the SLPST and TFST bits)
- MIER and MIER_FIFO



Note 1. 从总线关闭状态到CAN停止模式的转换时间取决于CTLR.BOM[1:0]位的设置。
当CTLR.BOM[1:0]位为01b时，状态转换在进入总线关闭状态后立即发生。当CTLR.BOM[1:0]位为10b时，状态转换发生在总线关闭状态结束时。
当CTLR.BOM[1:0]位为11b时，状态转换发生在CTLR.CANM[1:0]位设置为10b（CAN停止模式）时。
Note 2. 更改CTLR.SLPM位以设置或取消CAN睡眠模式。

Figure 30.9 不同操作模式之间的转换

30.3.1 CAN复位模式

CAN复位模式用于CAN通信配置。当CTLR.CANM[1:0]位设置为01b或11b时，CAN模块进入CAN复位模式。然后将STR.RSTST标志设置为1。在RSTST标志为1之前不要更改CTLR.CANM[1:0]位。在退出CAN复位模式以进入任何其他模式之前设置BCR寄存器。

以下寄存器在进入CAN复位模式后初始化为其复位值，并在CAN复位模式期间保存其初始值：

- MCTL_TXj and MCTL_RXj
- STR（SLPST和TFST位除外）
- EIFR
- RECR
- TECR
- TSR
- MSSR
- MSMR
- RFCR
- TFCR
- TCR
- ECSR（EDPM位除外）。

即使在进入CAN复位模式后，以下寄存器仍保留其先前的值：

- CTLR
- STR（仅SLPST和TFST位）
- MIER and MIER_FIFO

- EIER
- BCR
- CSSR
- ECSR (only the EDPM bit)
- MBj_ID, MBj_DL, MBj_Dm and MBj_TS
- MKRk
- FIDCR0 and FIDCR1
- MKIVLR
- AFSR
- RFPCR
- TFPCR.

30.3.2 CAN Halt Mode

CAN halt mode is used for mailbox configuration and test mode setting. When the CTLR.CANM[1:0] bits are set to 10b, CAN halt mode is selected and the STR.HLTST bit is set to 1. Do not change the CTLR.CANM[1:0] bits until the HLTST bit is 1. See Table 30.8 for the state transition conditions when transmitting or receiving.

All registers except for the RSTST, HLTST, and SLPST bits in STR remain unchanged when the CAN enters CAN halt mode. Do not change CTLR (except for the CANM[1:0] and SLPM bits) and EIER in CAN halt mode. The BCR register can be changed in CAN halt mode only when listen-only mode is selected for automatic baud rate detection.

Table 30.8 Operation in CAN reset mode and CAN halt mode

Operation mode	Receiver	Transmitter	Bus-off
CAN reset mode (forced transition) CANM[1:0] = 11b	CAN module enters CAN reset mode without waiting for the end of message reception	CAN module enters CAN reset mode without waiting for the end of message transmission	CAN module enters CAN reset mode without waiting for the end of bus-off recovery
CAN reset mode CANM[1:0] = 01b	CAN module enters CAN reset mode without waiting for the end of message reception	CAN module enters CAN reset mode after waiting for the end of message transmission*1,*4	CAN module enters CAN reset mode without waiting for the end of bus-off recovery
CAN halt mode	CAN module enters CAN halt mode after waiting for the end of message reception*2,*3	CAN module enters CAN halt mode after waiting for the end of message transmission*1,*4	• When the BOM[1:0] bits are 00b: A halt request from software is accepted only after bus-off recovery • When the BOM[1:0] bits are 01b: CAN module automatically enters CAN halt mode without waiting for the end of bus-off recovery, regardless of a halt request from software • When the BOM[1:0] bits are 10b: CAN module automatically enters CAN halt mode after waiting for the end of bus-off recovery, regardless of a halt request from software • When the BOM[1:0] bits are 11b: CAN module enters CAN halt mode without waiting for the end of bus-off recovery, if a halt is requested by software during bus-off.

BOM[1:0] bits: Bits in CTLR.

Note 1. If transmission of multiple messages is requested, a mode transition occurs on completion of the first transmission. If the CAN reset mode is being requested during suspend transmission, mode transition occurs when the bus is idle, the next transmission ends, or the CAN module becomes a receiver.

Note 2. If the CAN bus is locked at the dominant level, the program can detect this state by monitoring the BLIF flag in EIFR.

Note 3. If a CAN bus error occurs during reception after CAN halt mode is requested, the CAN module transitions to CAN halt mode.

Note 4. If a CAN bus error or arbitration-lost occurs during transmission after CAN reset mode or CAN halt mode is requested, the CAN module transitions to the requested CAN mode.

- EIER
- BCR
- CSSR
- ECSR (only the EDPM bit)
- MBj_ID, MBj_DL, MBj_Dm and MBj_TS
- MKRk
- FIDCR0 and FIDCR1
- MKIVLR
- AFSR
- RFPCR
- TFPCR.

30.3.2 CAN暂停模式

CAN暂停模式用于邮箱配置和测试模式设置。当CTLR.CANM[1:0]位设置为10b时，选择CAN暂停模式且STR.HLTST位设置为1。请勿更改CTLR.CANM[1:0]位，直到HLTST位为1。发送或接收时的状态转换条件见表30.8。

当CAN进入CAN暂停模式时，除STR中的RSTST、HLTST和SLPST位之外的所有寄存器都保持不变。不要在CAN暂停模式下更改CTLR（CANM[1:0]和SLPM位除外）和EIER。只有在为自动波特率检测选择只听模式时，才能在CAN暂停模式下更改BCR寄存器。

Table 30.8 CAN复位模式和CAN暂停模式下的操作

操作模式	Receiver	Transmitter	Bus-off
CAN复位模式（强制转换）CANM[1:0]=11b	CAN模块无需等待报文接收结束即可进入CAN复位模式	CAN模块无需等待报文传输结束即可进入CAN复位模式	CAN模块无需等待总线关闭恢复结束即可进入CAN复位模式
CAN复位模式CANM[1:0]=01b	CAN模块无需等待报文接收结束即可进入CAN复位模式	CAN模块等待报文传输结束后进入CAN复位模式*1、*4	CAN模块无需等待总线关闭恢复结束即可进入CAN复位模式
CAN暂停模式	CAN模块等待报文接收结束后进入CAN停机模式*2 *3	CAN模块等待报文传输结束后进入CAN停机模式*1、*4	当BOM[1:0]位为00b时：仅在总线关闭恢复后才接受来自软件的暂停请求 当BOM[1:0]位为01b时：CAN模块自动进入CAN暂停模式，无需等待总线关闭恢复结束，无论软件是否有停止请求 当BOM[1:0]位为10b时：CAN模块在等待总线关闭恢复结束后自动进入CAN停止模式，无论是否有停止请求来自软件 当BOM[1:0]位为11b时：如果在总线关闭期间软件请求停止，CAN模块无需等待总线关闭恢复结束即可进入CAN停止模式。

BOM[1:0] bits: CTLR中的位。

Note 1. 如果请求传输多个消息，则在第一次传输完成时发生模式转换。如果在暂停传输期间请求CAN复位模式，则在总线空闲、下一次传输结束或CAN模块成为接收器时发生模式转换。

Note 2. 如果CAN总线被锁定在显性电平，程序可以通过监控EIFR中的BLIF标志来检测该状态。

Note 3. 如果在请求CAN暂停模式后接收期间发生CAN总线错误，则CAN模块将转换到CAN暂停模式。

Note 4. 如果在请求CAN复位模式或CAN暂停模式后的传输过程中发生CAN总线错误或仲裁丢失，则CAN模块将转换到请求的CAN模式。

30.3.3 CAN Sleep Mode

CAN sleep mode reduces power consumption by stopping the clock supply to the CAN module. After a reset from an MCU pin or a software reset, the CAN module starts from CAN sleep mode.

When the SLPM bit in CTLR is set to 1, the CAN module enters CAN sleep mode and the SLPST bit in STR is set to 1. Do not change the value of the SLPM bit until the SLPST bit is 1. The other registers remain unchanged when the CAN module enters CAN sleep mode.

Write to the SLPM bit in CAN reset mode and CAN halt mode. Do not change any registers (except for the SLPM bit) during CAN sleep mode. Read operation is still allowed.

When the SLPM bit is set to 0, the CAN module is released from CAN sleep mode. When the CAN module exits CAN sleep mode, the other registers remain unchanged.

30.3.4 CAN Operation Mode (Excluding Bus-Off State)

CAN operation mode is used for CAN communication. When the CANM[1:0] bits in CTLR are set to 00b, the CAN module enters CAN operation mode. The RSTST and HLTST bits in STR are set to 0. Do not change the value of the CANM[1:0] bits until the RSTST and HLTST bits are 0.

If 11 consecutive recessive bits are detected after entering CAN operation mode:

- The CAN module becomes an active node on the network, which enables transmission and reception of CAN messages
- Error monitoring of the CAN bus, such as receive and transmit error counters, is performed.

During CAN operation mode, the CAN module may be in one of the following three sub-modes, depending on the status of the CAN bus:

- Idle mode: No transmission or reception occurs
- Receive mode: A CAN message sent by another node is being received
- Transmit mode: A CAN message is being transmitted. The CAN module receives a message transmitted by the local node simultaneously when self-test mode 0 (TSTM[1:0] bits in TCR = 10b) or self-test mode 1 (TSTM[1:0] bits = 11b) is selected.

Figure 30.10 shows the sub-modes of CAN operation mode.

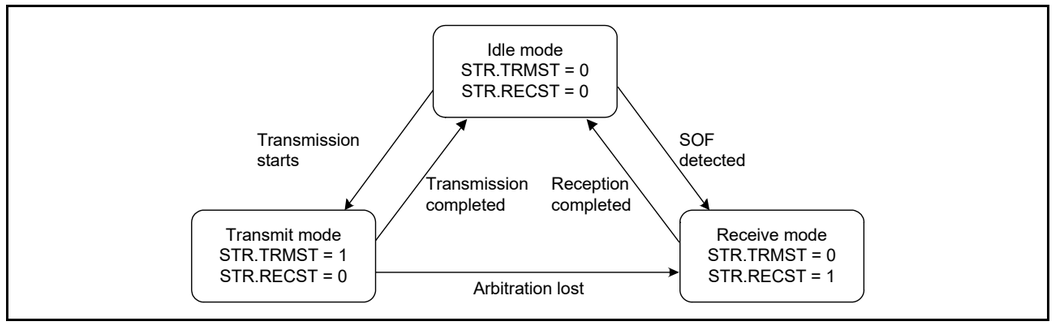


Figure 30.10 Sub-modes of CAN operation mode

30.3.5 CAN Operation Mode (Bus-Off State)

The CAN module enters the bus-off state based on the increment or decrement rules for the transmit or receive error counters, as defined in the CAN specifications.

The following cases apply when the CAN module is recovering from the bus-off state. When the CAN module is in the bus-off state, the values of the CAN module registers remain unchanged, except for those in STR, EIFR, RECR, TECR, and TSR.

30.3.3 CAN睡眠模式

CAN睡眠模式通过停止向CAN模块提供时钟来降低功耗。从一个复位后MCU引脚或软件复位，CAN模块从CAN睡眠模式启动。

CTLR中的SLPM位为1时，CAN模块进入CAN休眠模式，STR中的SLPST位为1。在SLPST位为1之前不要改变SLPM位的值。其他寄存器保持不变当CAN模块进入CAN睡眠模式时。

在CAN复位模式和CAN暂停模式下写入SLPM位。在CAN睡眠模式期间不要更改任何寄存器（SLPM位除外）。仍然允许读取操作。

当SLPM位设置为0时，CAN模块从CAN睡眠模式中释放。当CAN模块退出CAN休眠模式时，其他寄存器保持不变。

30.3.4 CAN操作模式（不包括总线关闭状态）

CAN操作模式用于CAN通信。当CTLR中的CANM[1:0]位设置为00b时，CAN模块进入CAN操作模式。STR中的RSTST和HLTST位设置为0。在RSTST和HLTST位为0之前，不要更改CANM[1:0]位的值。

如果进入CAN操作模式后检测到11个连续的隐性位：

- CAN模块成为网络上的一个活动节点，可以传输和接收CAN报文
- 执行CAN总线的错误监控，例如接收和发送错误计数器。

在CAN操作模式下，CAN模块可能处于以下三种子模式之一，具体取决于CAN总线的状态：

- 空闲模式：没有发送或接收发生
- 接收模式：正在接收另一个节点发送的CAN报文
- 传输模式：正在传输CAN消息。选择自测模式0（TCR中的TSTM[1:0]位=10b）或自测模式1（TSTM[1:0]位=11b）时，CAN模块同时接收本地节点发送的消息.

图30.10显示了CAN操作模式的子模式。

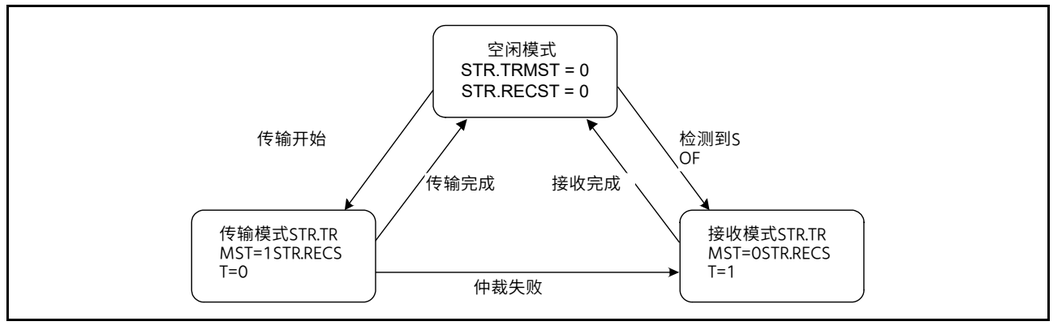


Figure 30.10 CAN操作模式的子模式

30.3.5 CAN操作模式（总线关闭状态）

CAN模块根据CAN规范中定义的发送或接收错误计数器的递增或递减规则进入总线关闭状态。

以下情况适用于CAN模块从总线关闭状态恢复时。当CAN模块处于总线关闭状态时，CAN模块寄存器的值保持不变，除了STR、EIFR、RECR、TECR和TSR中的值。

(1) When CTLR.BOM[1:0] bits = 00b (normal mode)

The CAN module enters the error-active state after it completes recovery from the bus-off state and CAN communication is enabled. The BORIF flag in EIFR is set to 1 (bus-off recovery detected).

(2) When CTLR.RBOC bit = 1 (forced return from bus-off)

The CAN module enters the error-active state when it is in the bus-off state and the RBOC bit is 1. CAN communication is enabled again after 11b consecutive recessive bits are detected. The BORIF flag is not set to 1.

(3) When CTLR.BOM[1:0] bits = 01b (automatic transition to CAN halt mode on bus-off entry)

The CAN module enters CAN halt mode when it reaches the bus-off state. The BORIF flag is not set to 1.

(4) When CTLR.BOM[1:0] bits = 10b (automatic transition to CAN halt mode on bus-off end)

The CAN module enters CAN halt mode when it completes recovery from bus-off. The BORIF flag is set to 1.

(5) When CTLR.BOM[1:0] bits = 11b (automatic transition to CAN halt mode through software) and CTLR.CANM[1:0] bits = 10b (CAN halt mode) during bus-off state

The CAN module enters CAN halt mode when it is in the bus-off state and the CANM[1:0] bits are set to 10b (CAN halt mode). The BORIF flag is not set to 1. If the CANM[1:0] bits are not set to 10b during bus-off, the same behavior as (1) applies.

30.4 Data Transfer Rate Configuration

This section describes how to configure the data transfer rate.

30.4.1 Clock Setting

The CAN module has a CAN clock generator that can be set by the CCLKS and the BRP[9:0] bits in the BCR register.

Figure 30.11 shows a block diagram of the CAN clock generator.

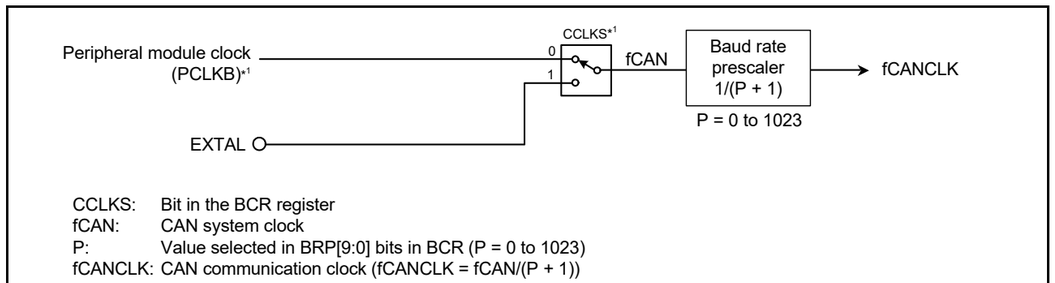


Figure 30.11 Block diagram of CAN clock generator

30.4.2 Bit Timing Setting

The bit timing consists of three segments as shown in Figure 30.12.

(1) 当CTLR.BOM[1:0]位=00b时（正常模式）

CAN模块在完成从总线关闭状态恢复并启用CAN通信后进入错误激活状态。EIFR中的BORIF标志设置为1（检测到总线关闭恢复）。

(2) 当CTLR.RBOC位=1时（从总线关闭强制返回）

当CAN模块处于总线关闭状态且RBOC位为1时，进入错误激活状态。在检测到11b个连续的隐性位后再次启用CAN通信。BORIF标志未设置为1。

(3) 当CTLR.BOM[1:0]位=01b时（进入总线关闭时自动转换到CAN暂停模式）

CAN模块在达到总线关闭状态时进入CAN停止模式。BORIF标志未设置为1。

(4) 当CTLR.BOM[1:0]位=10b时（在总线关闭结束时自动转换到CAN暂停模式）

CAN模块在完成总线关闭恢复后进入CAN暂停模式。BORIF标志设置为1。

(5) 当CTLR.BOM[1:0]位=11b（通过软件自动转换到CAN暂停模式）且CTLR.CANM[1:0]位=10b（CAN暂停模式）时在总线关闭状态

CAN模块在总线关闭状态且CANM[1:0]位设置为10b（CAN停止模式）时进入CAN停止模式。BORIF标志未设置为1。如果在总线关闭期间CANM[1:0]位未设置为10b，则适用与(1)相同的行为。

30.4 数据传输率配置

本节介绍如何配置数据传输速率。

30.4.1 时钟设置

CAN模块有一个CAN时钟发生器，可以通过BCR寄存器中的CCLKS和BRP[9:0]位进行设置。

图30.11显示了CAN时钟发生器的框图。

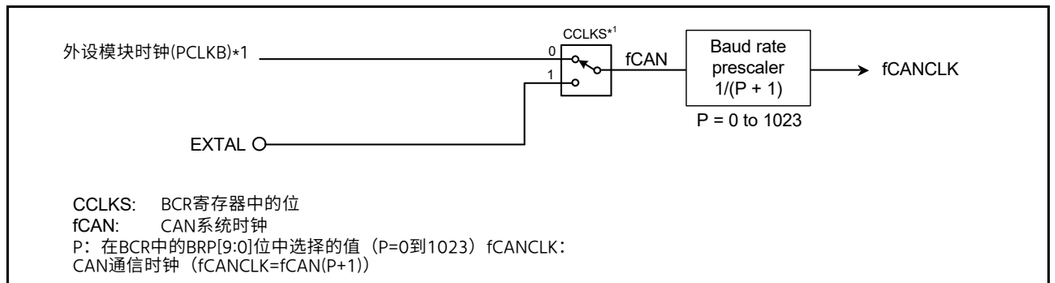


Figure 30.11 CAN时钟发生器框图

30.4.2 位时序设置

位时序由三个部分组成，如图30.12所示。

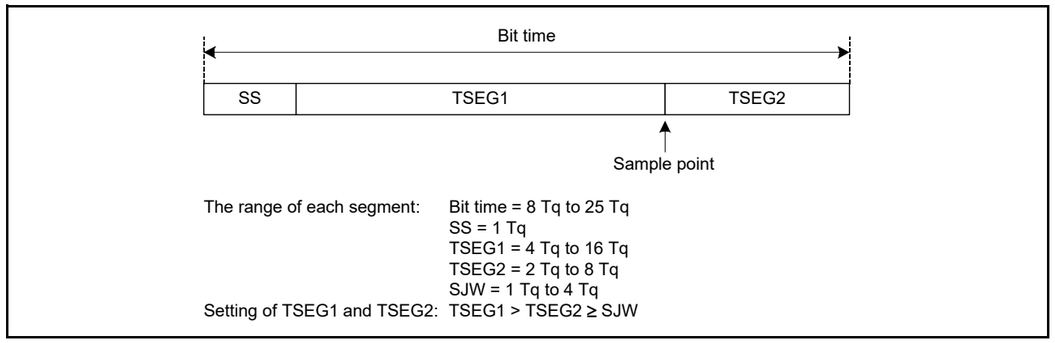


Figure 30.12 Bit timing

30.4.3 Data Transfer Rate

The data transfer rate depends on the division value of fCAN (CAN system clock), the division value of the baud rate prescaler, and the Tq count for 1 bit time.

$$\text{Data transfer rate (bps)} = \frac{\text{fCAN}}{\text{Baud rate prescaler division value*1 x Tq count for 1 bit time}} = \frac{\text{fCANCLK}}{\text{Tq count for 1 bit time}}$$

Note 1. Division value of baud rate prescaler = P + 1 (P: 0 to 1023), where P is the BRP[9:0] setting in BCR.

Table 30.9 lists data transfer rate examples.

Table 30.9 Data transfer rate examples

fCAN	50 MHz		48 MHz		40 MHz		32 MHz	
Data transfer rate	Tq count	P + 1	Tq count	P + 1	Tq count	P + 1	Tq count	P + 1
1 Mbps	10 Tq 25 Tq	5 2	8 Tq 12 Tq 16 Tq	6 4 3	10 Tq 20 Tq	4 2	8 Tq 16 Tq	4 2
500 kbps	10 Tq 25 Tq	10 4	8 Tq 12 Tq 16 Tq	12 8 6	10 Tq 20 Tq	8 4	8 Tq 16 Tq	8 4
250 kbps	10 Tq 25 Tq	20 8	8 Tq 12 Tq 16 Tq	24 16 12	10 Tq 20 Tq	16 8	8 Tq 16 Tq	16 8
125 kbps	10 Tq 25 Tq	40 16	8 Tq 12 Tq 16 Tq	48 32 24	10 Tq 20 Tq	32 16	8 Tq 16 Tq	32 16
83.3 kbps	10 Tq 25 Tq	60 24	8 Tq 12 Tq 16 Tq	72 48 36	8 Tq 10 Tq 16 Tq 20 Tq	60 48 30 24	8 Tq 16 Tq	48 24
33.3 kbps	10 Tq 25 Tq	150 60	8 Tq 12 Tq 16 Tq	180 120 90	8 Tq 10 Tq 20 Tq	150 120 60	8 Tq 10 Tq 16 Tq 20 Tq	120 96 60 48

30.5 Mailbox and Mask Register Structure

Figure 30.13 shows the structure of the 32 mailbox registers MBj_ID, MBj_DL, MBj_Dm, and MBj_TS.

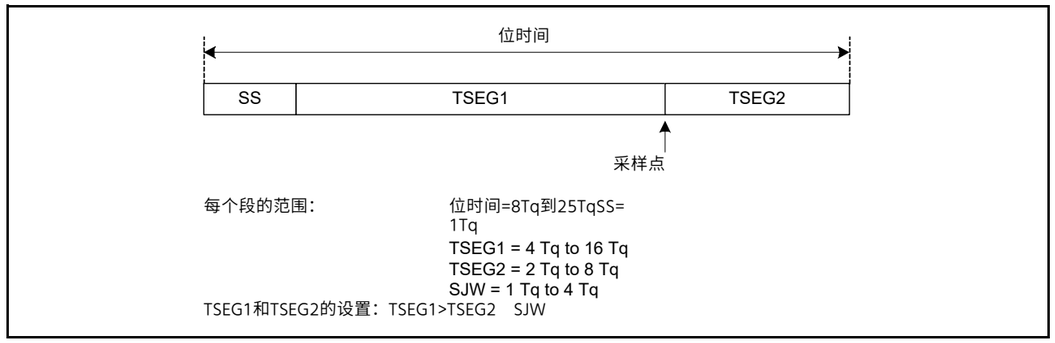


Figure 30.12 位时序

30.4.3 数据传输率

数据传输速率取决于fCAN（CAN系统时钟）的分频值、波特率预分频器的分频值和1位时间的Tq计数。

$$\text{数据传输率(bps)} = \frac{\text{fCAN}}{\text{波特率预分频器分频值*1xTq计数1位时间}} = \frac{\text{fCANCLK}}{\text{1位时间的Tq计数}}$$

注1.波特率预分频器的分频值=P+1(P:0to1023)，其中P是BCR中的BRP[9:0]设置。

表30.9列出了数据传输率示例。

Table 30.9 数据传输率示例

fCAN	50 MHz		48 MHz		40 MHz		32 MHz	
数据传输率	Tq count	P + 1	Tq count	P + 1	Tq count	P + 1	Tq count	P + 1
1 Mbps	10 Tq 25 Tq	5 2	8 Tq 12 Tq 16 Tq	6 4 3	10 Tq 20 Tq	4 2	8 Tq 16 Tq	4 2
500 kbps	10 Tq 25 Tq	10 4	8 Tq 12 Tq 16 Tq	12 8 6	10 Tq 20 Tq	8 4	8 Tq 16 Tq	8 4
250 kbps	10 Tq 25 Tq	20 8	8 Tq 12 Tq 16 Tq	24 16 12	10 Tq 20 Tq	16 8	8 Tq 16 Tq	16 8
125 kbps	10 Tq 25 Tq	40 16	8 Tq 12 Tq 16 Tq	48 32 24	10 Tq 20 Tq	32 16	8 Tq 16 Tq	32 16
83.3 kbps	10 Tq 25 Tq	60 24	8 Tq 12 Tq 16 Tq	72 48 36	8 Tq 10 Tq 16 Tq 20 Tq	60 48 30 24	8 Tq 16 Tq	48 24
33.3 kbps	10 Tq 25 Tq	150 60	8 Tq 12 Tq 16 Tq	180 120 90	8 Tq 10 Tq 20 Tq	150 120 60	8 Tq 10 Tq 16 Tq 20 Tq	120 96 60 48

30.5 邮箱和掩码寄存器结构

图30.13显示了32个邮箱寄存器MBj_ID、MBj_DL、MBj_Dm和MBj_TS的结构。

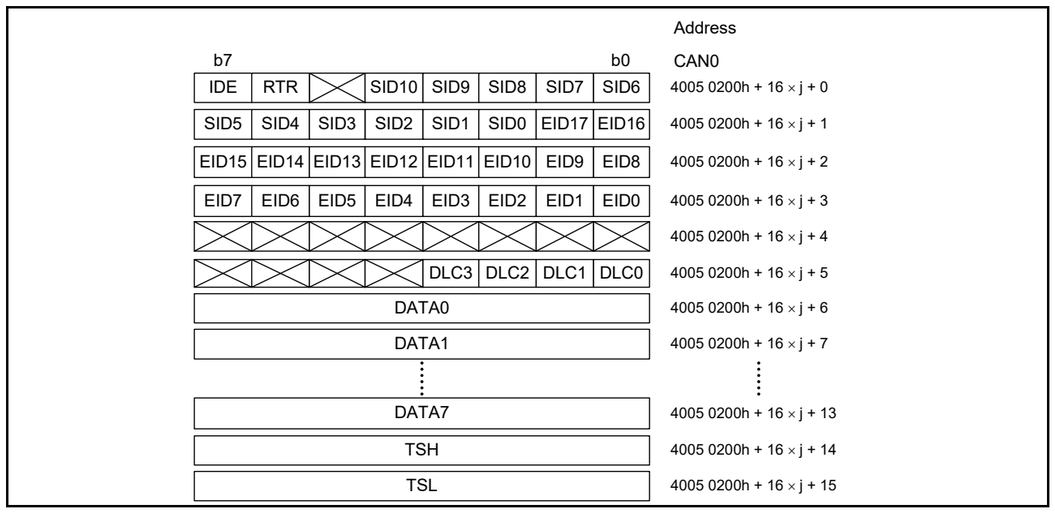


Figure 30.13 Structure of the mailbox registers (j = 0 to 31)

Figure 30.14 shows the structure of the eight mask registers MKRk.

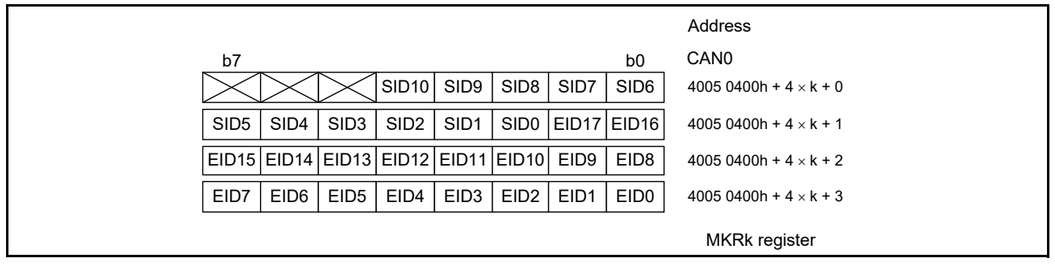


Figure 30.14 Structure of the MKRk registers (k = 0 to 7)

Figure 30.15 shows the structure of the two FIFO received ID compare registers, FIDCR0 and FIDCR1.

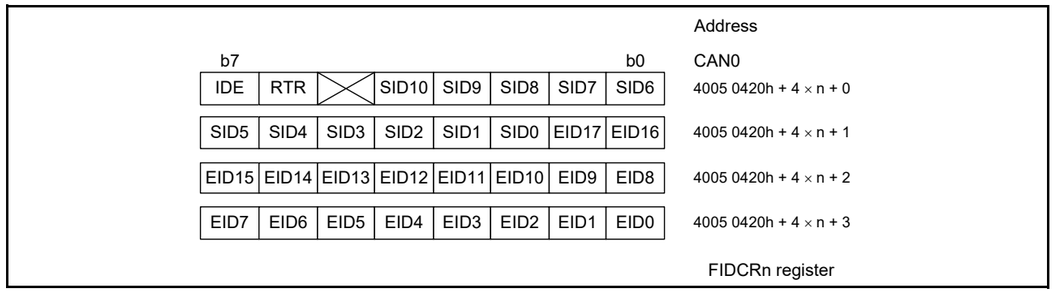


Figure 30.15 Structure of the FIDCRn registers (n = 0, 1)

30.6 Acceptance Filtering and Masking Functions

The acceptance filtering and masking functions allow you to select and receive messages with multiple IDs for mailboxes within a specified range.

The MKRk registers can mask the standard ID and the extended ID of 29 bits:

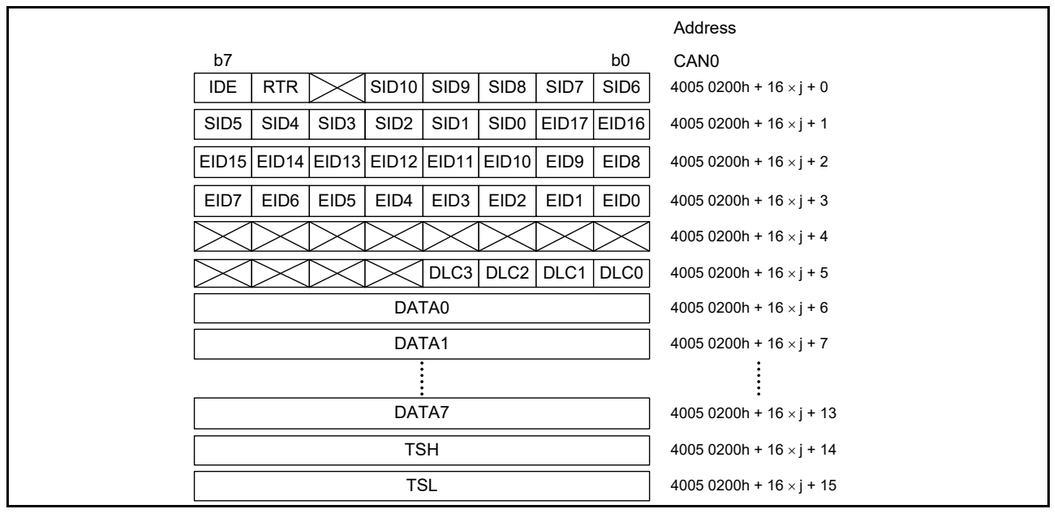


Figure 30.13 邮箱寄存器的结构（j=0到31）

图30.14显示了8个屏蔽寄存器MKRk的结构。

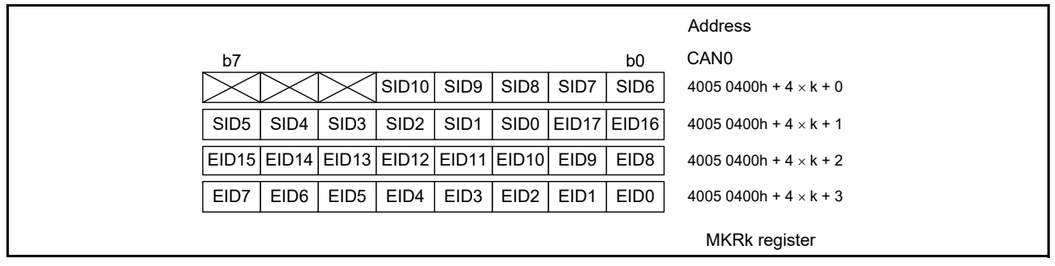


Figure 30.14 MKRk寄存器的结构（k=0到7）

图30.15显示了两个FIFO接收ID比较寄存器FIDCR0和FIDCR1的结构。

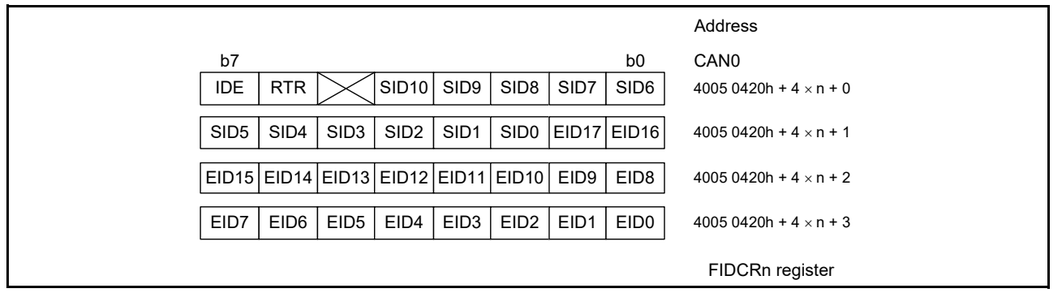


Figure 30.15 FIDCRn寄存器的结构(n=0 1)

30.6 接受过滤和屏蔽功能

接受过滤和屏蔽功能允许您为指定范围内的邮箱选择和接收具有多个ID的消息。

MKRk寄存器可以屏蔽标准ID和29位扩展ID：

- MKR0 is the mask register for mailboxes 0 to 3
- MKR1 is the mask register for mailboxes 4 to 7
- MKR2 is the mask register for mailboxes 8 to 11
- MKR3 is the mask register for mailboxes 12 to 15
- MKR4 is the mask register for mailboxes 16 to 19
- MKR5 is the mask register for mailboxes 20 to 23
- MKR6 is the mask register for mailboxes 24 to 27 in normal mailbox mode and receive FIFO mailboxes 28 to 31 in FIFO mailbox mode
- MKR7 is the mask register for mailboxes 28 to 31 in normal mailbox mode and receive FIFO mailboxes 28 to 31 in FIFO mailbox mode.

MKIVLR disables acceptance filtering independently for each mailbox.

The IDE bit in MBj_ID register is valid when the IDFM[1:0] bits in CTLR are 10b (mixed ID mode).

The RTR bit in MBj_ID register selects a data frame or remote frame.

In FIFO mailbox mode, normal mailboxes 0 to 23 use the associated register (MKR0 to MKR5) for acceptance filtering. The receive FIFO mailboxes 28 to 31 use two registers, MKR6 and MKR7, for acceptance filtering.

The receive FIFO uses two registers, FIDCR0 and FIDCR1, for ID comparison. The EID[17:0], SID[10:0], RTR, and IDE bits in mailbox 28 to mailbox 31 for the receive FIFO are disabled. As acceptance filtering depends on the result of two logic OR operations, two ranges of IDs can be received into the receive FIFO. The MKIVLR is disabled for the receive FIFO.

If different standard ID and extended ID values are set in the IDE bits in FIDCR0 and FIDCR1, both ID formats are received. If different data frame and remote frame values are set in the RTR bits in FIDCR0 and FIDCR1, both data and remote frames are received.

When a combination of two ranges of IDs is not required, set the same mask value and the same ID in both the FIFO ID and mask registers.

Figure 30.16 shows the associations between the mask registers and mailboxes. Figure 30.17 shows acceptance filtering.

- MKR0是邮箱0到3的掩码寄存器
- MKR1是邮箱4到7的掩码寄存器
- MKR2是邮箱8到11的掩码寄存器
- MKR3是邮箱12到15的掩码寄存器
- MKR4是邮箱16到19的掩码寄存器
- MKR5是邮箱20到23的掩码寄存器
- MKR6是普通邮箱模式下邮箱24到27的掩码寄存器，在正常邮箱模式下接收FIFO邮箱28到31 FIFO邮箱模式
- MKR7是普通邮箱模式下邮箱28到31的掩码寄存器，在正常邮箱模式下接收FIFO邮箱28到31 FIFO邮箱模式。

MKIVLR为每个邮箱单独禁用接受过滤。

当CTLR中的IDFM[1:0]位为10b（混合ID模式）时，MBj_ID寄存器中的IDE位有效。

MBj_ID寄存器中的RTR位选择数据帧或远程帧。

在FIFO邮箱模式下，普通邮箱0到23使用相关寄存器（MKR0到MKR5）进行接受过滤。
接收FIFO邮箱28到31使用两个寄存器，MKR6和MKR7，用于接受过滤。

接收FIFO使用两个寄存器FIDCR0和FIDCR1进行ID比较。EID[17:0]、SID[10:0]、RTR和邮箱28到邮箱31中用于接收FIFO的IDE位被禁用。由于接受过滤取决于两个逻辑或运算的结果，因此可以将两个范围的ID接收到接收FIFO中。MKIVLR为接收FIFO禁用。

如果在FIDCR0和FIDCR1的IDE位中设置了不同的标准ID和扩展ID值，则会接收两种ID格式。如果在FIDCR0和FIDCR1的RTR位中设置了不同的数据帧和远程帧值，则数据帧和远程帧都被接收。

当不需要两个ID范围的组合时，在FIFOID和掩码寄存器中设置相同的掩码值和相同的ID。

图30.16显示了掩码寄存器和邮箱之间的关联。图30.17显示了接受过滤。

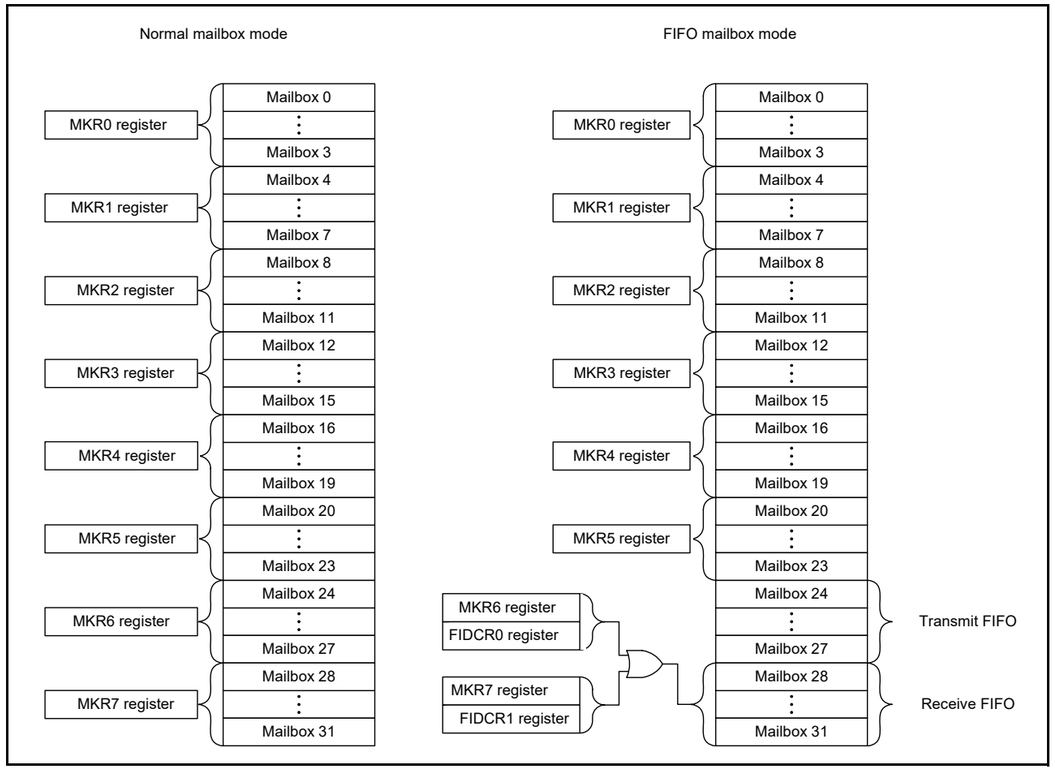
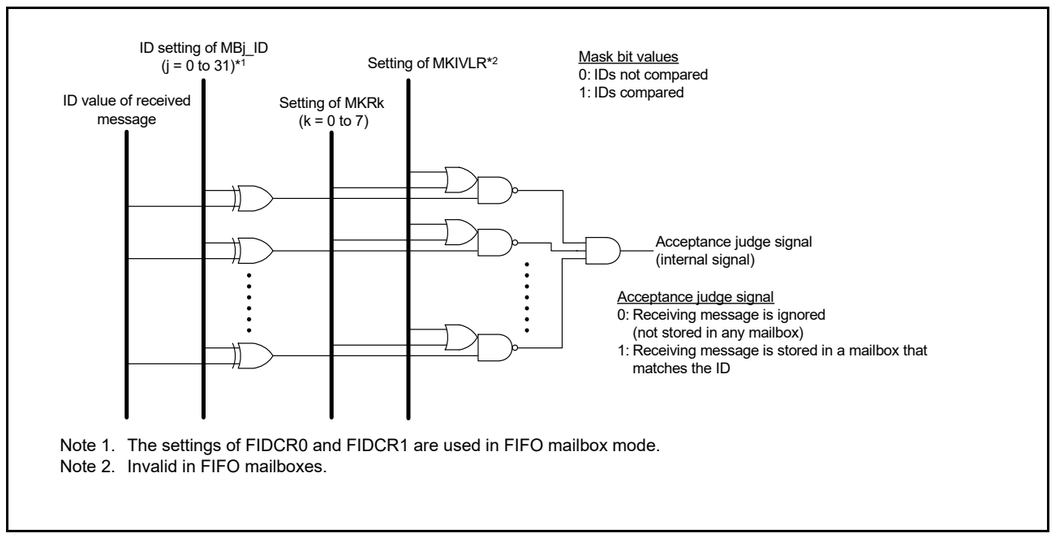


Figure 30.16 Associations between mask registers and mailboxes



Note 1. The settings of FIDCR0 and FIDCR1 are used in FIFO mailbox mode.
Note 2. Invalid in FIFO mailboxes.

Figure 30.17 Acceptance filtering

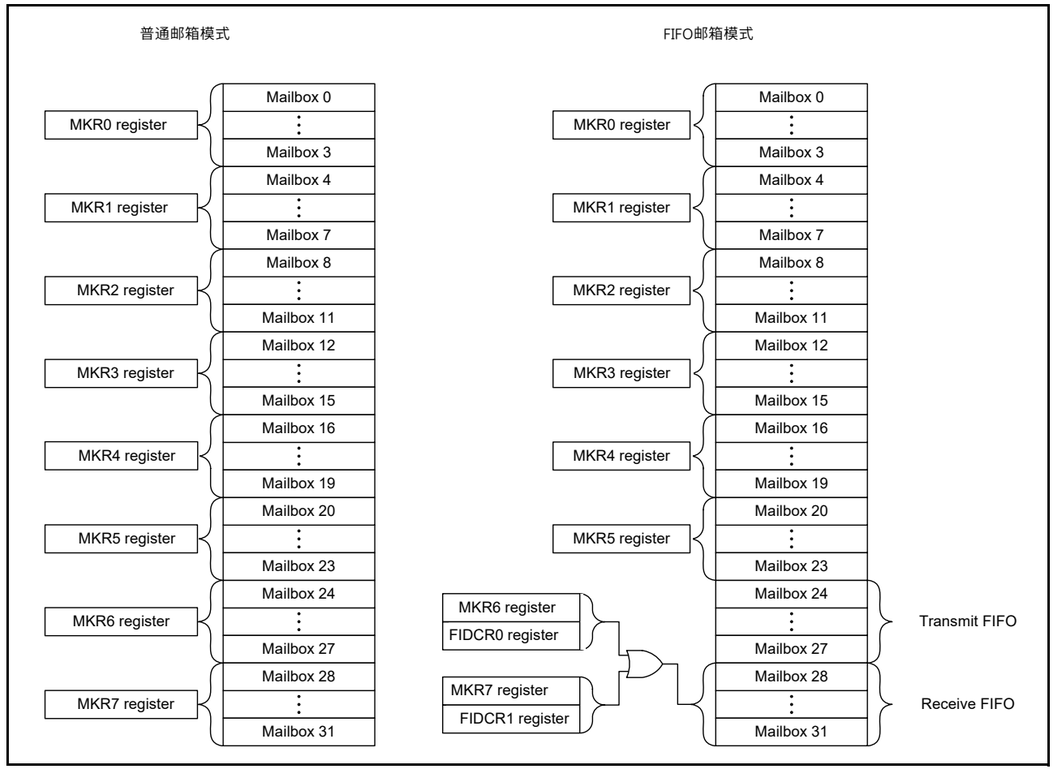
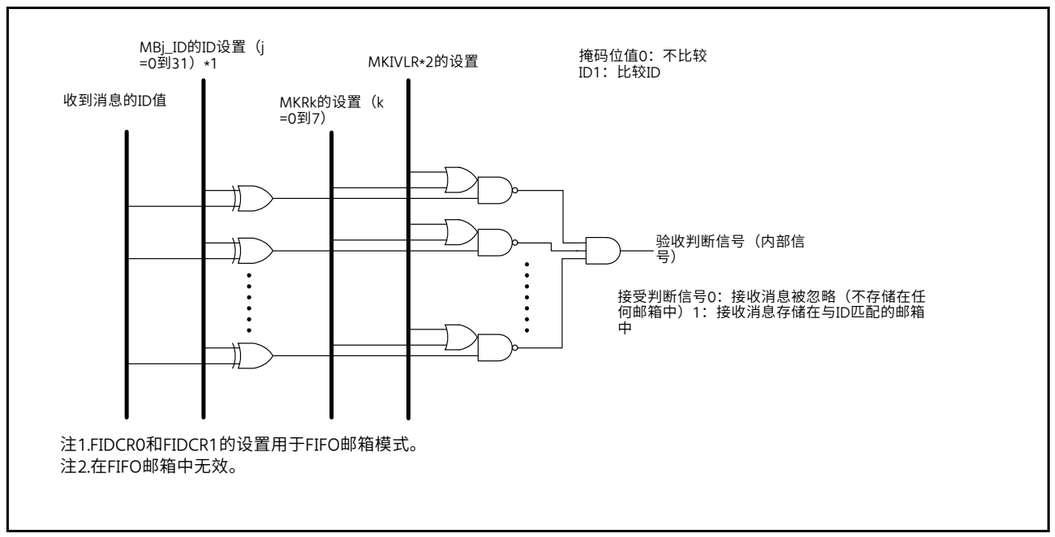


Figure 30.16 掩码寄存器和邮箱之间的关联



注1.FIDCR0和FIDCR1的设置用于FIFO邮箱模式。
注2.在FIFO邮箱中无效。

Figure 30.17 验收过滤

30.7 Reception and Transmission

Table 30.10 lists the CAN communication mode settings.

Table 30.10 Settings for CAN receive and transmit modes

MCTL_TXj.TRMREQ and MCTL_RXj.TRMREQ	MCTL_TXj.RECREQ and MCTL_RXj.RECREQ	MCTL_TXj.ONESHOT and MCTL_RXj.ONESHOT	Mailbox communication mode
0	0	0	Mailbox disabled or transmission aborted
0	0	1	Can be configured only when transmission or reception from a mailbox programmed in one-shot mode is aborted
0	1	0	Configured as a receive mailbox for a data frame or remote frame
0	1	1	Configured as a one-shot receive mailbox for a data frame or remote frame
1	0	0	Configured as a transmit mailbox for a data frame or remote frame
1	0	1	Configured as a one-shot transmit mailbox for a data frame or remote frame
1	1	0	Do not set
1	1	1	Do not set

j = 0 to 31

When a mailbox is configured as a receive mailbox or a one-shot receive mailbox:

- Before configuring a mailbox, set MCTL_RXj to 00h
- A received message is stored in the first mailbox that matches the condition resulting from the receive mode settings and acceptance filtering. The matching mailbox with the smallest number takes priority for storing the received message.
- In CAN operation mode, the CAN module does not receive its own transmitted data even when the ID is a match. In self-test mode, however, the CAN module receives its own transmitted data and returns ACK.

When configuring a mailbox as a transmit mailbox or a one-shot transmit mailbox:

- Before configuring a mailbox, ensure that MCTL_TXj is 00h and that there is no pending abort process.

30.7.1 Reception

Figure 30.18 shows an operation example of data frame reception in overwrite mode.

The example shows the overwriting of the first message when the CAN module receives two consecutive CAN messages that match the receiving conditions in MCTL_RXj (j = 0 to 31).

30.7 接收和传输

表30.10列出了CAN通信模式设置。

Table 30.10 CAN接收和发送模式的设置

MCTL_TXj.TRMREQ and MCTL_RXj.TRMREQ	MCTL_TXj.RECREQ and MCTL_RXj.RECREQ	MCTL_TXj.ONESHOT and MCTL_RXj.ONESHOT	邮箱通讯方式
0	0	0	邮箱禁用或传输中止
0	0	1	只有在一次性模式中编程的邮箱的发送或接收被中止时才可以配置
0	1	0	配置为数据帧或远程帧的接收邮箱
0	1	1	配置为数据帧或远程帧的一次性接收邮箱
1	0	0	配置为数据帧或远程帧的发送邮箱
1	0	1	配置为数据帧或远程帧的一次性发送邮箱
1	1	0	不要设置
1	1	1	不要设置

j = 0 to 31

当邮箱配置为接收邮箱或一次性接收邮箱时：

- 在配置邮箱之前，将MCTL_RXj设置为00h
- 收到的消息存储在与接收模式设置和接受过滤产生的条件匹配的第一个邮箱中。编号最小的匹配邮箱优先存储收到的消息。
- 在CAN操作模式下，即使ID匹配，CAN模块也不会接收到自己发送的数据。然而，在自检模式下，CAN模块接收自己发送的数据并返回ACK。

将邮箱配置为发送邮箱或一次性发送邮箱时：

- 在配置邮箱之前，请确保MCTL_TXj为00h并且没有挂起的中止进程。

30.7.1 Reception

图30.18显示了覆盖模式下数据帧接收的操作示例。

该示例显示当CAN模块接收到与MCTL_RXj（j=0到31）中的接收条件匹配的两个连续CAN报文时，第一条报文的覆盖。

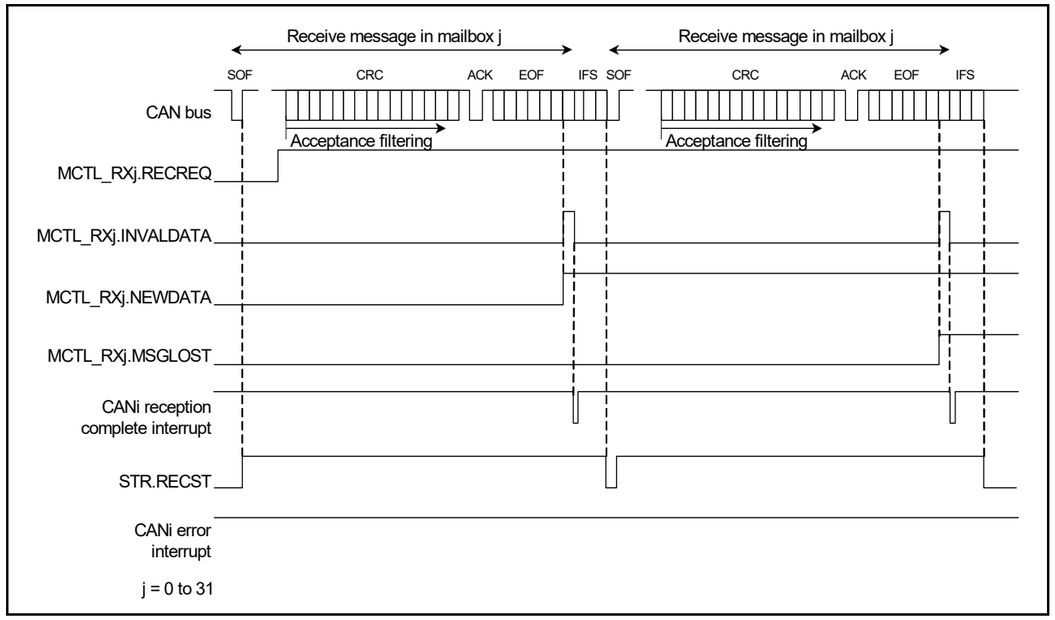


Figure 30.18 Operation example of data frame reception in overwrite mode

1. When an SOF is detected on the CAN bus, the RECST bit in STR is set to 1 (reception in progress) if the CAN module has no message ready to start transmission.
2. Acceptance filtering starts at the beginning of the CRC field to select the receive mailbox.
3. After a message is received, the NEWDATA flag in MCTL_RXj for the receive mailbox is set to 1 (new message is being stored or was stored to the mailbox). The INVALDATA flag in MCTL_RXj is set to 1 (message is updated) at the same time. The INVALDATA flag is set to 0 (message valid) again after the complete message is transferred to the mailbox.
4. When the interrupt enable bit in MIER for the receive mailbox is 1 (interrupt enabled), the INVALDATA flag is set to 0, triggering a CAN0 reception complete interrupt request.
5. After reading the message from the mailbox, the NEWDATA flag must be set to 0 by software.
6. In overwrite mode, if the next CAN message is received while the NEWDATA flag in MCTL_RXj is set to 1, the MSGLOST flag in MCTL_RXj is set to 1 (message was overwritten). The new received message is transferred to the mailbox. The CAN0 reception complete interrupt request is generated in the same as in step 4.

Figure 30.19 shows an operation example of data frame reception in overrun mode. The example shows the overrunning of the second message when the CAN module receives two consecutive CAN messages that match the receiving conditions in MCTL_RXj (j = 0 to 31).

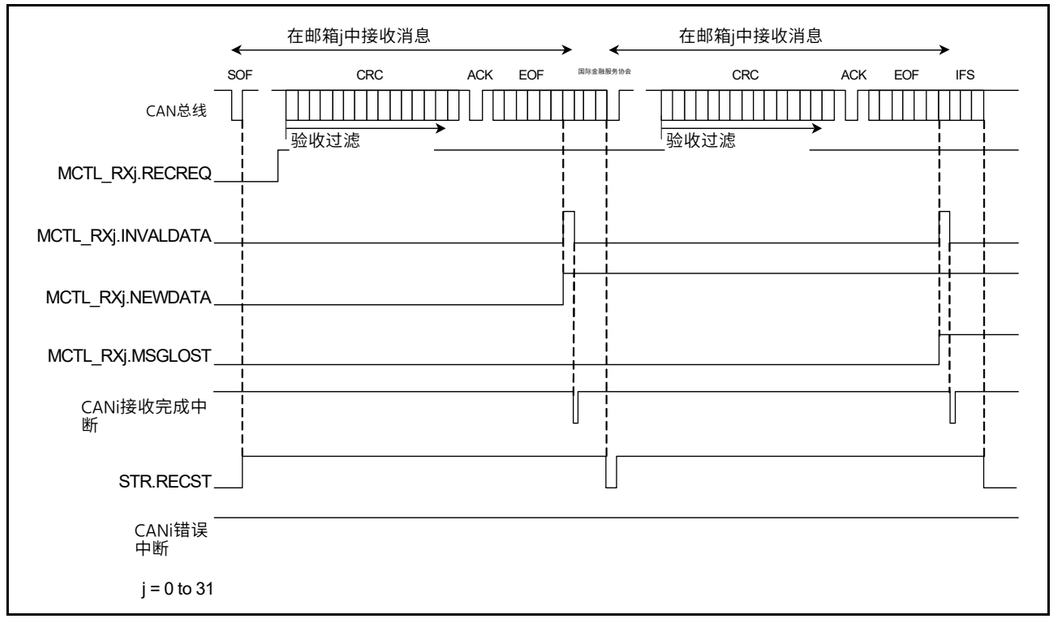


Figure 30.18 覆盖模式下数据帧接收的操作示例

1. 当在CAN总线上检测到SOF时，如果CAN模块没有准备好开始发送的消息，则STR中的RECST位设置为1（正在接收）。
2. 接受过滤从CRC字段的开头开始，以选择接收邮箱。
3. 收到消息后，接收邮箱的MCTL_RXj中的NEWDATA标志设置为1（新消息正在存储或已存储到邮箱中）。MCTL_RXj中的INVALDATA标志同时设置为1（消息已更新）。在完整的消息传送到邮箱后，INVALDATA标志再次设置为0（消息有效）。
4. 当接收邮箱的MIER中的中断允许位为1（允许中断）时，INVALDATA标志设置为0，触发CAN0接收完成中断请求。
5. 从邮箱读取消息后，NEWDATA标志必须由软件设置为0。
6. 在覆盖模式下，如果在MCTL_RXj中的NEWDATA标志设置为1时接收到下一条CAN消息，则MCTL_RXj中的MSGLOST标志设置为1（消息被覆盖）。新收到的消息被传送到邮箱。CAN0接收完成中断请求的产生与步骤4相同。

图30.19显示了溢出模式下数据帧接收的操作示例。该示例显示当CAN模块接收到与MCTL_RXj（j=0到31）中的接收条件匹配的两个连续CAN报文时，第二条报文的溢出。

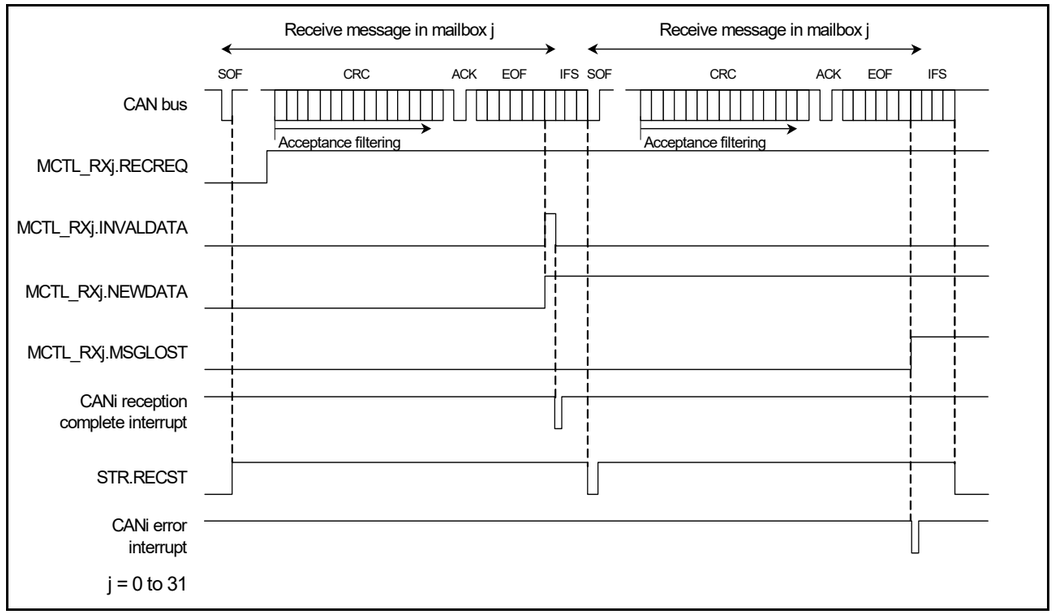


Figure 30.19 Operation example of data frame reception in overrun mode

Steps 1. to 5. are the same as in overwrite mode.

6. In overrun mode, if the next CAN message is received before the NEWDATA flag in MCTL_RXj is set to 0, the MSGLOST flag in MCTL_RXj is set to 1 (message overrun). The new received message is discarded and a CANi error interrupt request occurs if the associated interrupt enable bit in EIER is set to 1 (interrupt enabled).

30.7.2 Transmission

Figure 30.20 shows an example operation of data frame transmission.

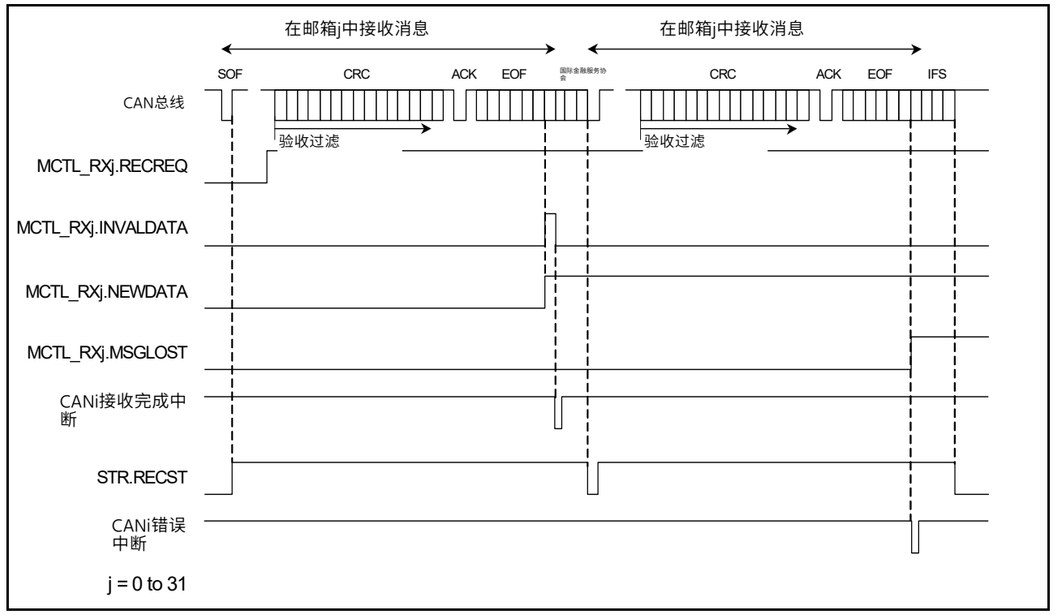


Figure 30.19 溢出模式下数据帧接收的操作示例

步骤1.至5.与覆盖模式相同。

6. 在溢出模式下，如果在MCTL_RXj中的NEWDATA标志设置为0之前接收到下一个CAN报文，则MCTL_RXj中的MSGLOST标志设置为1（消息溢出）。如果EIER中的相关中断使能位设置为1（中断使能），则丢弃新接收到的消息并产生CANi错误中断请求。

30.7.2 Transmission

图30.20显示了数据帧传输的示例操作。

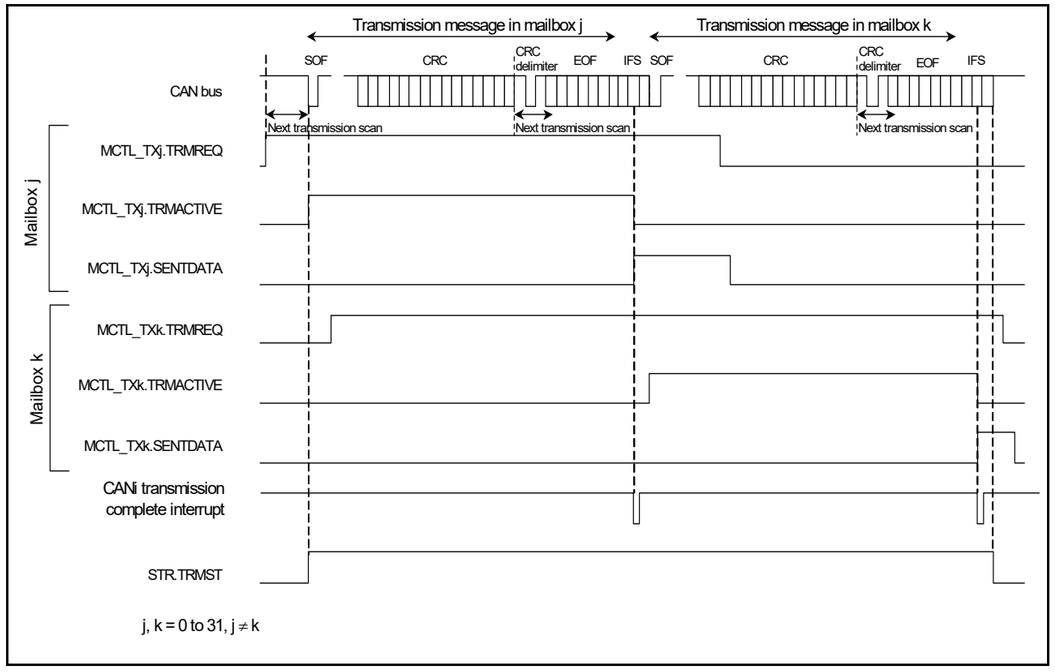


Figure 30.20 Operation example of data frame transmission

1. When a TRMREQ bit in MCTL_TXj (j = 0 to 31) is set to 1 (transmit mailbox) in the bus-idle state, mailbox scanning determines the highest-priority mailbox for transmission. When the transmit mailbox is determined, the TRMACTIVE flag in MCTL_TXj is set to 1 (from acceptance of transmission request to completion of transmission, or error/arbitration-lost), the TRMST bit in STR is set to 1 (transmission in progress), and the CAN module starts transmission.*1
2. If other TRMREQ bits are set, the transmission scanning starts with the CRC delimiter for the next transmission.
3. If transmission is complete without losing arbitration, the SENTDATA flag in MCTL_TXj is set to 1 (transmission complete) and the TRMACTIVE flag is set to 0 (transmission is pending or transmission is not requested). If the interrupt enable bit in MIER is 1 (interrupt enabled), the CANi transmission complete interrupt request is generated.
4. When requesting the next transmission from the same mailbox, set the SENTDATA flag and TRMREQ bit to 0, and then set the TRMREQ bit to 1 after checking that the SENTDATA flag and TRMREQ bit are set to 0.

Note 1. If arbitration is lost after the CAN module starts transmission, the TRMACTIVE flag is set to 0. Transmission scanning is performed again to search for the highest-priority transmit mailbox from the beginning of the CRC delimiter. If an error occurs either during transmission or following arbitration-lost, transmission scanning is performed again to search for the highest-priority transmit mailbox from the start of the CRC delimiter.

30.8 Interrupts

The CAN module provides the following interrupts for each channel:

- CANi reception complete interrupt for mailboxes 0 to 31 (CANi_RXM)
- CANi transmission complete interrupt for mailboxes 0 to 31 (CANi_TXM)
- CANi receive FIFO interrupt (CANi_RXF)
- CANi transmit FIFO interrupt (CANi_TXF)
- CANi error interrupt (CANi_ERS).

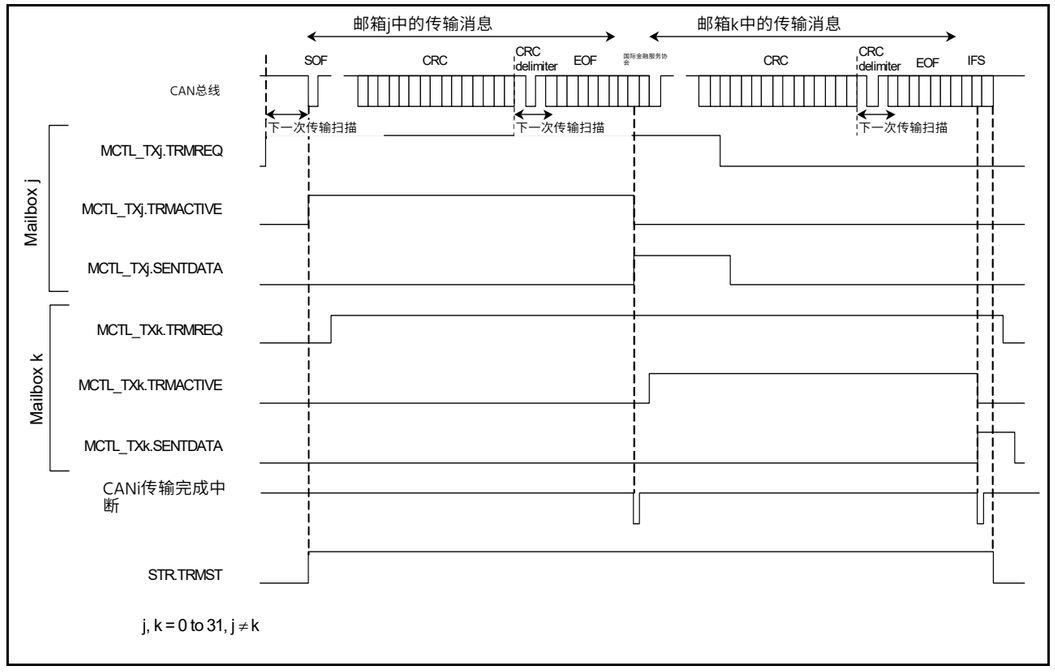


Figure 30.20 数据帧传输的操作示例

1. 当MCTL_TXj（j=0到31）中的TRMREQ位在总线空闲状态下设置为1（发送邮箱）时，邮箱扫描确定发送的最高优先级邮箱。当确定发送邮箱时，MCTL_TXj中的TRMACTIVE标志设置为1（从接受发送请求到发送完成，或错误仲裁丢失），STR中的TRMST位设置为1（正在发送），并且CAN模块开始传输。*1
2. 如果设置了其他TRMREQ位，则传输扫描以CRC定界符开始，以进行下一次传输。
3. 如果传输完成且没有丢失仲裁，则MCTL_TXj中的SENTDATA标志设置为1（传输完成），TRMACTIVE标志设置为0（传输未决或未请求传输）。如果MIER中的中断使能位为1（中断使能），则产生CANi传输完成中断请求。
4. 从同一邮箱请求下一次发送时，将SENTDATA标志和TRMREQ位设置为0，然后在检查SENTDATA标志和TRMREQ位设置为0后将TRMREQ位设置为1。

注1.如果CAN模块开始发送后仲裁丢失，则TRMACTIVE标志设置为0。再次执行发送扫描以从CRC分隔符的开头搜索优先级最高的发送邮箱。如果在传输过程中或仲裁丢失后发生错误，则再次执行传输扫描以从CRC分隔符的开头搜索最高优先级的传输邮箱。

30.8 Interrupts

CAN模块为每个通道提供以下中断：

- 邮箱0到31(CANi_RXM)的CANi接收完成中断
- 邮箱0到31(CANi_TXM)的CANi传输完成中断
- CANi接收FIFO中断(CANi_RXF)
- CANi发送FIFO中断(CANi_TXF)
- CANi错误中断(CANi_ERS)。

Eight interrupt sources are available for the CANi error interrupts. Check the EIFR register to determine the interrupt sources:

- Bus error
- Error-warning
- Error-passive
- Bus-off entry
- Bus-off recovery
- Receive overrun
- Overload frame transmission
- Bus lock.

Table 30.11 lists the CAN interrupts.

Table 30.11 CAN interrupts

Module	Interrupt symbol	Interrupt source	Source flag
CANi i = 0	CANi_ERS	Bus lock detected	EIFR.BLIF
		Overload frame transmission detected	EIFR.OLIF
		Overrun detected	EIFR.ORIF
		Bus-off recovery detected	EIFR.BORIF
		Bus-off entry detected	EIFR.BOEIF
		Error-passive detected	EIFR.EPIF
		Error-warning detected	EIFR.EWIF
		Bus error detected	EIFR.BEIF
	CANi_RXF	Receive FIFO message received (MIER_FIFO.MB29 = 0)	RFCR.RFUST[2:0]
		Receive FIFO warning (MIER_FIFO.MB29 = 1)	
	CANi_TXF	Transmit FIFO message transmission completed (MIER_FIFO.MB25 = 0)	TFCR.TFUST[2:0]
		FIFO last message transmission completed (MIER_FIFO.MB25 = 1)	
	CANi_RXM	Mailbox 0 to 31 message received	MCTL_RX0.NEWDATA to MCTL_RX31.NEWDATA
	CANi_TXM	Mailbox 0 to 31 message transmission completed	MCTL_TX0.SENTDATA to MCTL_TX31.SENTDATA

30.9 Usage Notes

30.9.1 Settings for the Module-Stop State

The Module Stop Control Register B (MSTPCRB) can enable or disable CAN operation. The CAN module is initially stopped after a reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

30.9.2 Settings for the Operating Clock

The settings for the operating clock can be made as follows:

- The following clock constraint must be satisfied for the CAN module when the CCLKS bit is 1:

  $f_{PCLKB} \geq f_{CANMCLK}$

- The source of the peripheral module clock must be PLL for the CAN module when the CCLKS bit is 0.

八个中断源可用于CANi错误中断。检查EIFR寄存器以确定中断源：

- 总线错误
- Error-warning
- Error-passive
- Bus-off entry
- Bus-off recovery
- 接收溢出
- 过载帧传输
- 巴士锁。

表30.11列出了CAN中断。

Table 30.11 CAN中断

Module	中断符号	中断源	源标志
CANi i = 0	CANi_ERS	检测到总线锁	EIFR.BLIF
		检测到过载帧传输	EIFR.OLIF
		检测到溢出	EIFR.ORIF
		检测到总线关闭恢复	EIFR.BORIF
		检测到总线关闭条目	EIFR.BOEIF
		Error-passive detected	EIFR.EPIF
		Error-warning detected	EIFR.EWIF
		检测到总线错误	EIFR.BEIF
	CANi_RXF	接收接收到的FIFO消息(MIER_FIFO.MB29=0)	RFCR.RFUST[2:0]
		接收FIFO警告(MIER_FIFO.MB29=1)	
	CANi_TXF	传输FIFO消息传输完成(MIER_FIFO.MB25=0)	TFCR.TFUST[2:0]
		FIFO最后一条消息传输完成(MIER_FIFO.MB25=1)	
	CANi_RXM	邮箱0到31收到消息	MCTL_RX0.NEWDATA to MCTL_RX31.NEWDATA
	CANi_TXM	邮箱0到31消息传输完成	MCTL_TX0.SENTDATA to MCTL_TX31.SENTDATA

30.9 使用说明

30.9.1 模块停止状态的设置

模块停止控制寄存器B(MSTPCRB)可以启用或禁用CAN操作。CAN模块在复位后最初停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

30.9.2 工作时钟设置

工作时钟的设置可按如下方式进行：

- 当CCLKS位为1时，CAN模块必须满足以下时钟约束：

  $f_{PCLKB} \geq f_{CANMCLK}$

- 当CCLKS位为0时，外设模块时钟源必须是CAN模块的PLL。

31. Serial Peripheral Interface (SPI)

31.1 Overview

The MCU provides two independent channels of the Serial Peripheral Interface (SPI). The SPI channels are capable of high-speed, full-duplex, synchronous serial communications with multiple processors and peripheral devices.

Table 31.1 lists the SPI specifications, and Figure 31.1 shows a block diagram.

In this section, *n* indicates A or B, and *i* indicates 0 or 1. A lower-case letter *i* in pin and signal names indicates a value from 0 to 3, and a lower-case letter *m* in SPI Command Register m (SPCMDm) indicates a value from 0 to 7.

Table 31.1 SPI specifications (1 of 2)

Parameter	Specifications
Number of channels	Two channels
SPI transfer functions	• Use of MOSI (master out/slave in), MISO (master in/slave out), SSL (slave select), and RSPCK (SPI clock) signals allows serial communications through SPI operation (4-wire method) or clock synchronous operation (3-wire method) • Transmit-only operation available • Communication mode selectable to full-duplex or transmit-only • RSPCK polarity switching • RSPCK phase switching.
Data format	• MSB-first or LSB-first selectable • Transfer bit length selectable to 8, 9, 10, 11, 12, 13, 14, 15, 16, 20, 24, or 32 bits • 128-bit transmit and receive buffers • Up to four frames transferrable in one round of transmission or reception (each frame consisting of up to 32 bits) • Byte swap operating function.
Bit rate	• In master mode, the on-chip baud rate generator generates RSPCK by frequency-dividing PCLKA (the division ratio ranges from divided by 2 to divided by 4096) • In slave mode, the minimum PCLKA clock divided by 4 can be input as RSPCK (the maximum RSPCK frequency is that of PCLKA divided by 4) Width at high level: 2 PCLKA cycles Width at low level: 2 PCLKA cycles.
Buffer configuration	• Double buffer configuration for the transmit and receive buffers • 128 bits for the transmit and receive buffers.
Error detection	• Mode fault error detection • Underrun error detection • Overrun error detection*1 • Parity error detection.
SSL control function	• Four SSL pins (SSLn0 to SSLn3) for each channel • In single-master mode, SSLn0 to SSLn3 pins are output • In multi-master mode, SSLn0 pin for input and SSLn1 to SSLn3 pins for either for output or unused • In slave mode, SSLn0 pin for input and SSLn1 to SSLn3 pins for unused • Controllable delay from SSL output assertion to RSPCK operation (RSPCK delay) Range: 1 to 8 RSPCK cycles (set in RSPCK-cycle units) • Controllable delay from RSPCK stop to SSL output negation (SSL negation delay) Range: 1 to 8 RSPCK cycles (set in RSPCK-cycle units) • Controllable wait for next-access SSL output assertion (next-access delay) Range: 1 to 8 RSPCK cycles (set in RSPCK-cycle units) • Function for changing SSL polarity.
Control in master transfer	• Transfers of up to eight commands, each can be executed sequentially in looped execution • For each command, the following can be set: SSL signal value, bit rate, RSPCK polarity and phase, transfer data length, MSB- or LSB-first, burst, RSPCK delay, SSL negation delay, and next-access delay • Transfers can be initiated by writing to the transmit buffer • MOSI signal value specifiable in SSL negation • RSPCK auto-stop function.

31. 串行外设接口(SPI)

31.1 Overview

MCU提供两个独立的串行外设接口(SPI)通道。SPI通道能够与多个处理器和外围设备进行高速、全双工、同步串行通信。

表31.1列出了SPI规范，图31.1显示了框图。

在本节中，n表示A或B，i表示0或1。引脚和信号名称中的小写字母i表示从0到3的值，SPI命令寄存器m(SPCMDm)中的小写字母m)表示从0到7的值。

Table 31.1 SPI规格（2个中的1个）

Parameter	Specifications
通道数	两个通道
SPI传输函数	使用MOSI（主输出从输入）、MISO（主输入从输出）、SSL（从选择）和RSPCK（SPI时钟）信号允许通过SPI操作（4线方法）或时钟同步操作（3线法） 仅传输操作可用 可选择全双工或仅传输的通信模式 RSPCK极性切换 RSPCK相位切换。
数据格式	可选择MSB优先或LSB优先 传输位长度可选择为8、9、10、11、12、13、14、15、16、20、24或32位 128位发送和接收缓冲区 向上在一轮发送或接收中可传输到四帧（每帧最多由32位组成）•字节交换操作功能。
比特率	在主机模式下，片内波特率发生器通过对PCLKA分频产生RSPCK（分频比范围从2分频到4096分频） 在从机模式下，可以输入最小PCLKA时钟4分频作为RSPCK（最大RSPCK频率为PCLKA除以4）高电平宽度：2个PCLKA周期低电平宽度：2个PCLKA周期。
缓冲区配置	发送和接收缓冲区的双缓冲区配置 发送和接收缓冲区为128位。
错误检测	模式故障错误检测 欠载错误检测 溢出错误检测*1 奇偶校验错误检测。
SSL控制功能	每个通道有四个SSL引脚（SSLn0到SSLn3） 在单主模式下，SSLn0到SSLn3引脚是输出 在多主模式下，SSLn0引脚用于输入，SSLn1到SSLn3引脚用于输出或未使用 在从机中模式，SSLn0引脚用于输入，SSLn1到SSLn3引脚用于未使用 从SSL输出断言到RSPCK操作的可控延迟（RSPCK延迟）范围：1到8个RSPCK周期（以RSPCK周期为单位设置） 从RSPCK停止到SSL的可控延迟输出否定（SSL否定延迟）范围：1到8个RSPCK周期（以RSPCK周期为单位设置） 可控制等待下一次访问SSL输出断言（下一次访问延迟）范围：1到8个RSPCK周期（以RSPCK-周期为单位设置）周期单位） 改变SSL极性的功能。
主传输中的控制	最多传输8个命令，每个命令可以循环执行 对于每个命令，可以设置以下内容： SSL信号值、比特率、RSPCK极性和相位、传输数据长度、MSB或LSB优先、突发、RSPCK延迟、SSL否定延迟和下一次访问延迟 可以通过写入传输缓冲区来启动传输 在SSL否定中指定的MOSI信号值 RSPCK自动停止功能。

Table 31.1 SPI specifications (2 of 2)

Parameter	Specifications
Interrupt sources	• Receive buffer full interrupt • Transmit buffer empty interrupt • SPI error interrupt (mode-fault, overrun, parity error) • SPI idle interrupt (SPI idle) • Transmission-complete interrupt.
Event link function (output)	The following events can be output to the Event Link Controller (ELC): • Receive buffer full signal • Transmit buffer empty signal • Mode-fault, underrun, overrun, or parity error signal • SPI idle signal • Transmission-completed signal.
Other functions	• Switching between CMOS output and open-drain output • SPI initialization function • Loopback mode.
Module-stop function	Module-stop state can be set to reduce power consumption

Note 1. In master reception, when the RSPCK auto-stop function is enabled, an overrun error does not occur because the transfer clock is stopped on overrun error detection.

Table 31.1 SPI规范（2个中的2个）

Parameter	Specifications
中断源	接收缓冲区满中断 发送缓冲区空中断 SPI错误中断（模式错误、溢出、奇偶校验错误） SPI空闲中断（SPI空闲） 传输完成中断。
事件链接功能（输出）	以下事件可以输出到事件链接控制器(ELC)： 接收缓冲区满信号 发送缓冲区空信号 模式故障、欠载、溢出或奇偶校验错误信号 SPI空闲信号 传输完成信号。
其他功能	在CMOS输出和开漏输出之间切换 SPI初始化功能 环回模式。
Module-stop function	可设置模块停止状态以降低功耗

Note 1. 在主机接收中，当启用RSPCK自动停止功能时，不会发生溢出错误，因为在检测到溢出错误时会停止传输时钟。

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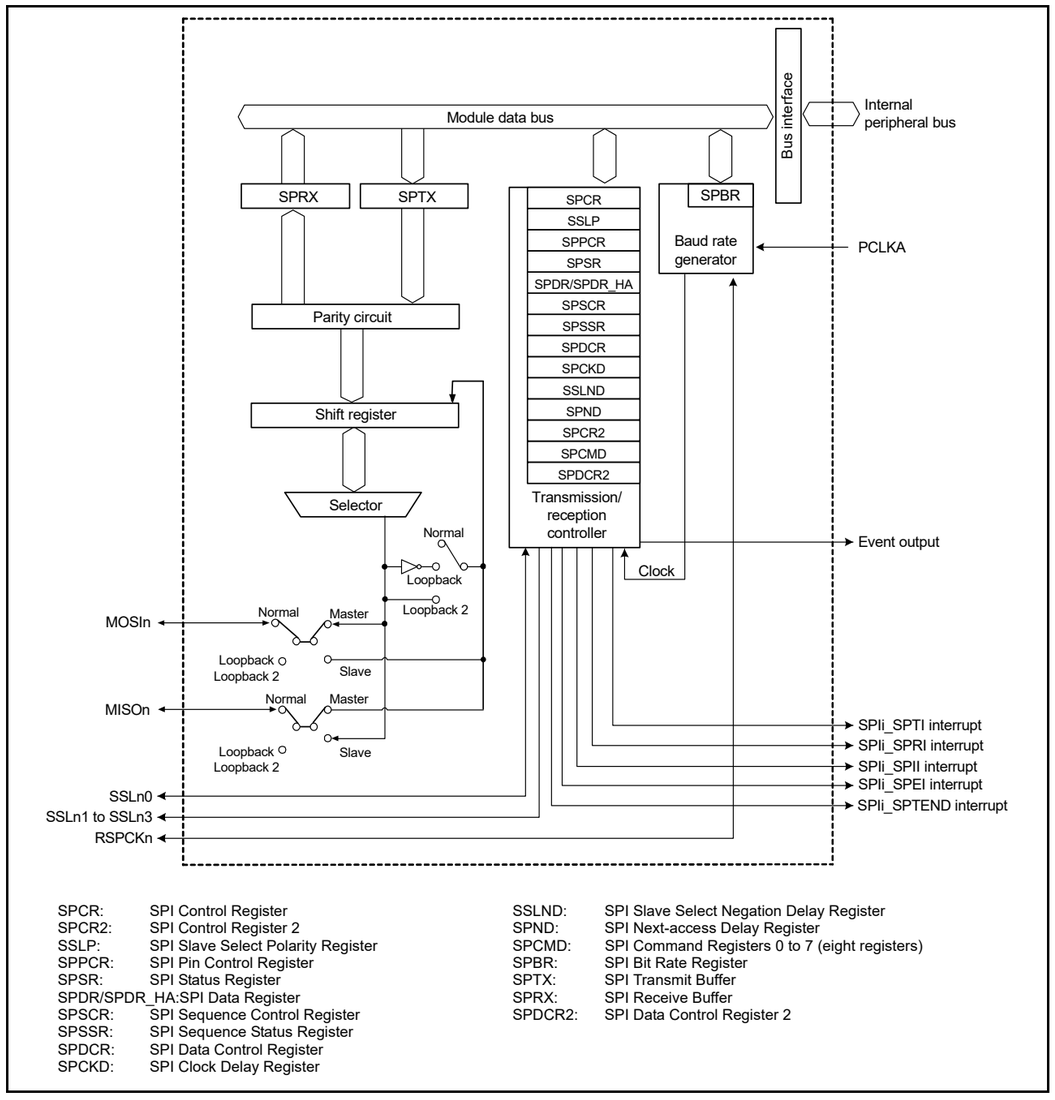
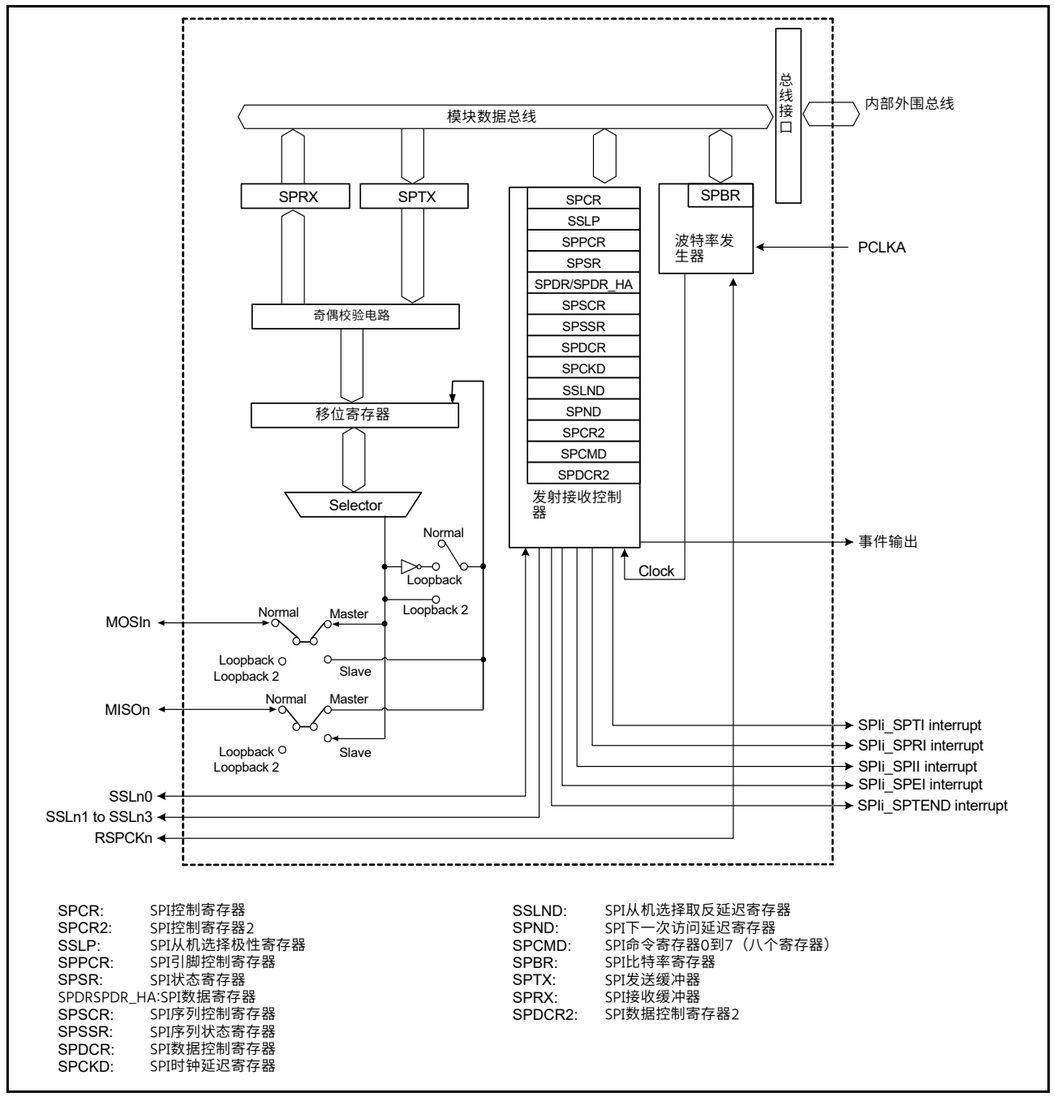


SPCR: SPI Control Register
SPCR2: SPI Control Register 2
SSLP: SPI Slave Select Polarity Register
SPPCR: SPI Pin Control Register
SPSR: SPI Status Register
SPDR/SPDR_HA:SPI Data Register
SPSCR: SPI Sequence Control Register
SPSSR: SPI Sequence Status Register
SPDCR: SPI Data Control Register
SPCKD: SPI Clock Delay Register
SSLND: SPI Slave Select Negation Delay Register
SPND: SPI Next-access Delay Register
SPCMD: SPI Command Registers 0 to 7 (eight registers)
SPBR: SPI Bit Rate Register
SPTX: SPI Transmit Buffer
SPRX: SPI Receive Buffer
SPDCR2: SPI Data Control Register 2

Figure 31.1 SPI block diagram

Table 31.2 lists the I/O pins used in the SPI. The SPI automatically switches the I/O direction of the SSLn0 pin. SSLn0 is an output when the SPI is a single master and an input when the SPI is a multi-master or a slave. The RSPCKn, MOSIn, and MISOn pins are automatically set as inputs or outputs based on the master or slave setting and the level input on the SSLn0 pin. For details, see section 31.3.2, Controlling the SPI Pins.



SPCR: SPI控制寄存器
SPCR2: SPI控制寄存器2
SSLP: SPI从机选择极性寄存器
SPPCR: SPI引脚控制寄存器
SPSR: SPI状态寄存器
SPDRSPDR_HA:SPI数据寄存器
SPSCR: SPI序列控制寄存器
SPSSR: SPI序列状态寄存器
SPDCR: SPI数据控制寄存器
SPCKD: SPI时钟延迟寄存器
SSLND: SPI从机选择取反延迟寄存器
SPND: SPI下一次访问延迟寄存器
SPCMD: SPI命令寄存器0到7（八个寄存器）
SPBR: SPI比特率寄存器
SPTX: SPI发送缓冲器
SPRX: SPI接收缓冲器
SPDCR2: SPI数据控制寄存器2

Figure 31.1 SPI框图

表31.2列出了SPI中使用的IO引脚。SPI自动切换SSLn0引脚的IO方向。SSLn0在SPI为单主机时为输出，在SPI为多主机或从机时为输入。RSPCKn、MOSIn和MISOn引脚会根据主机或从机设置以及SSLn0引脚上的电平输入自动设置为输入或输出。有关详细信息，请参见第31.3.2节，控制SPI引脚。

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Table 31.2 SPI I/O pins

Channel	Pin name	I/O	Function
SPI0	RSPCKA	I/O	Clock input/output
	MOSIA	I/O	Master transmit data input/output
	MISOA	I/O	Slave transmit data input/output
	SSLA0	I/O	Slave selection input/output
	SSLA1	Output	Slave selection output
	SSLA2	Output	Slave selection output
	SSLA3	Output	Slave selection output
SPI1	RSPCKB	I/O	Clock input/output
	MOSIB	I/O	Master transmit data input/output
	MISOB	I/O	Slave transmit data input/output
	SSLB0	I/O	Slave selection input/output
	SSLB1	Output	Slave selection output
	SSLB2	Output	Slave selection output
	SSLB3	Output	Slave selection output

31.2 Register Descriptions

31.2.1 SPI Control Register (SPCR)

Address(es): SPI0.SPCR 4007 2000h, SPI1.SPCR 4007 2100h

	b7	b6	b5	b4	b3	b2	b1	b0
	SPRIE	SPE	SPTIE	SPEIE	MSTR	MODF EN	TXMD	SPMS
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SPMS	SPI Mode Select	0: Select SPI operation (4-wire method) 1: Select clock synchronous operation (3-wire method).	R/W
b1	TXMD	Communications Operating Mode Select	0: Select full-duplex synchronous serial communications 1: Select serial communications with transmit-only.	R/W
b2	MODFEN	Mode Fault Error Detection Enable	0: Disable detection of mode fault errors 1: Enable detection of mode fault errors.	R/W
b3	MSTR	SPI Master/Slave Mode Select	0: Select slave mode 1: Select master mode.	R/W
b4	SPEIE	SPI Error Interrupt Enable	0: Disable SPI error interrupt requests 1: Enable SPI error interrupt requests.	R/W
b5	SPTIE	Transmit Buffer Empty Interrupt Enable	0: Disable transmit buffer empty interrupt requests 1: Enable transmit buffer empty interrupt requests.	R/W
b6	SPE	SPI Function Enable	0: Disable SPI function 1: Enable SPI function.	R/W
b7	SPRIE	SPI Receive Buffer Full Interrupt Enable	0: Disable SPI receive buffer full interrupt requests 1: Enable SPI receive buffer full interrupt requests.	R/W

If the SPCR.MSTR, SPCR.MODFEN, or SPCR.TXMD bit is changed while the SPCR.SPE bit is 1, do not perform subsequent operations.

SPMS bit (SPI Mode Select)

The SPMS bit selects SPI operation (4-wire method) or clock synchronous operation (3-wire method).

Table 31.2 SPIIO引脚

Channel	引脚名称	I/O	Function
SPI0	RSPCKA	I/O	Clock input/output
	MOSIA	I/O	主机发送数据输入输出
	MISOA	I/O	从机发送数据输入输出
	SSLA0	I/O	从机选择输入输出
	SSLA1	Output	从机选择输出
	SSLA2	Output	从机选择输出
	SSLA3	Output	从机选择输出
SPI1	RSPCKB	I/O	Clock input/output
	MOSIB	I/O	主机发送数据输入输出
	MISOB	I/O	从机发送数据输入输出
	SSLB0	I/O	从机选择输入输出
	SSLB1	Output	从机选择输出
	SSLB2	Output	从机选择输出
	SSLB3	Output	从机选择输出

31.2 注册说明

31.2.1 SPI控制寄存器(SPCR)

Address(es): SPI0.SPCR 4007 2000h, SPI1.SPCR 4007 2100h

	b7	b6	b5	b4	b3	b2	b1	b0
	SPRIE	SPE	SPTIE	SPEIE	MSTR	MODF EN	TXMD	SPMS
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SPMS	SPI模式选择	0：选择SPI操作（4线方式）1：选择时钟同步操作（3线方式）。	R/W
b1	TXMD	通讯操作模式 Select	0：选择全双工同步串行通信1：选择仅发送的串行通信。	R/W
b2	MODFEN	模式故障错误检测启用	0：禁用模式故障错误检测1：启用模式故障错误检测。	R/W
b3	MSTR	SPI主从模式选择	0：选择从模式1：选择主模式。	R/W
b4	SPEIE	SPI错误中断使能	0：禁用SPI错误中断请求1：启用SPI错误中断请求。	R/W
b5	SPTIE	发送缓冲区空中断 Enable	0：禁止发送缓冲区空中断请求1：使能发送缓冲区空中断请求。	R/W
b6	SPE	SPI功能使能	0：禁用SPI功能1：启用SPI功能。	R/W
b7	SPRIE	SPI接收缓冲器满中断 Enable	0：禁止SPI接收缓冲区满中断请求1：使能SPI接收缓冲区满中断请求。	R/W

如果在SPCR.SPE位为1时更改了SPCR.MSTR、SPCR.MODFEN或SPCR.TXMD位，则不要执行后续操作。

SPMS位（SPI模式选择）

SPMS位选择SPI操作（4线方法）或时钟同步操作（3线方法）。

The SSLn0 to SSLn3 pins are not used in clock synchronous operation. The RSPCKn, MOSIn, and MISOn pins handle communications. For clock synchronous operation in master mode (SPCR.MSTR = 1), the SPCMDm.CPHA bit can be set to either 0 or 1. For clock synchronous operation in slave mode (SPCR.MSTR = 0), set the CPHA bit to 1. Do not perform the operations if the CPHA bit is set to 0 when clock synchronous operation is in slave mode.

TXMD bit (Communications Operating Mode Select)

The TXMD bit selects full-duplex synchronous serial communications or transmit-only operations. When this bit is set to 1, the SPI only performs transmit operations and not receive operations (see section 31.3.6, Data Transfer Modes), and the receive buffer full interrupt requests cannot be used.

MODFEN bit (Mode Fault Error Detection Enable)

The MODFEN bit enables or disables the detection of mode fault errors (see section 31.3.8, Error Detection). In addition, the SPI determines the I/O direction of the SSLn0 to SSLn3 pins based on combinations of the MODFEN and MSTR bit settings (see section 31.3.2, Controlling the SPI Pins).

MSTR bit (SPI Master/Slave Mode Select)

The MSTR bit selects master or slave mode for the SPI. Based on the MSTR bit settings, the SPI determines the direction of the RSPCKn, MOSIn, MISOn, and SSLn0 to SSLn3 pins.

SPEIE bit (SPI Error Interrupt Enable)

The SPEIE bit enables or disables the generation of SPI error interrupt requests when one of the following occurs:

- The SPI detects a mode fault error or underrun error and sets the SPSR.MODF flag to 1
- The SPI detects an overrun error and sets the SPSR.OVRF flag to 1
- The SPI detects a parity error and sets the SPSR.PERF flag to 1.

For details, see section 31.3.8, Error Detection.

SPTIE bit (Transmit Buffer Empty Interrupt Enable)

The SPTIE bit enables or disables the generation of transmit buffer empty interrupt requests when the SPI detects that the transmit buffer is empty. To generate a transmit buffer empty interrupt request when transmission starts, set the SPE and SPTIE bits to 1 at the same time or set the SPE bit to 1 after setting the SPTIE bit to 1.

When the SPTIE bit is 1, transmit buffer interrupts are generated even when the SPI function is disabled (when the SPE bit is changed to 0).

SPE bit (SPI Function Enable)

The SPE bit enables or disables the SPI function. The SPE bit cannot be set to 1 when the SPSR.MODF flag is 1. For details, see section 31.3.8, Error Detection.

Setting the SPE bit to 0 disables the SPI function and initializes a part of the module function. For details, see section 31.3.9, Initializing the SPI. In addition, a transmit buffer empty interrupt request is generated when the SPE bit is changed from 0 to 1 or 1 to 0.

SPRIE bit (SPI Receive Buffer Full Interrupt Enable)

The SPRIE bit enables or disables the generation of an SPI receive buffer full interrupt request when the SPI detects a receive buffer full write after completion of a serial transfer.

SSLn0到SSLn3引脚不用于时钟同步操作。RSPCKn、MOSIn和MIOn引脚处理通信。对于主机模式下的时钟同步操作(SPCR.MSTR=1)，SPCMDm.CPHA位可以设置为0或1。对于从机模式下的时钟同步操作(SPCR.MSTR=0)，将CPHA位设置为1.如果时钟同步操作处于从机模式时CPHA位设置为0，则不要执行这些操作。

TXMD位（通信操作模式选择）

TXMD位选择全双工同步串行通信或仅发送操作。当该位设置为1时，SPI仅执行发送操作而不执行接收操作（参见第31.3.6节，数据传输模式），并且无法使用接收缓冲区满中断请求。

MODFEN位（模式故障错误检测使能）

MODFEN位启用或禁用模式故障错误检测（参见第31.3.8节，错误检测）。此外，SPI根据MODFEN和MSTR位设置的组合确定SSLn0到SSLn3引脚的IO方向（请参见第31.3.2节，控制SPI引脚）。

MSTR位（SPI主从模式选择）

MSTR位选择SPI的主模式或从模式。根据MSTR位设置，SPI确定RSPCKn、MOSIn、MISOn和SSLn0到SSLn3引脚的方向。

SPEIE位（SPI错误中断使能）

当发生以下情况之一时，SPEIE位启用或禁用SPI错误中断请求的生成：

- SPI检测到模式故障错误或欠载错误并将SPSR.MODF标志设置为1
- SPI检测到溢出错误并将SPSR.OVRF标志设置为1
- SPI检测到奇偶校验错误并将SPSR.PERF标志设置为1。

有关详细信息，请参阅第31.3.8节，错误检测。

SPTIE位（发送缓冲区空中断使能）

当SPI检测到发送缓冲区为空时，SPTIE位使能或禁止生成发送缓冲区空中断请求。要在发送开始时产生发送缓冲区空中断请求，请将SPE和SPTIE位同时设置为1，或在将SPTIE位设置为1后将SPE位设置为1。

当SPTIE位为1时，即使禁用SPI功能（当SPE位变为0时）也会产生发送缓冲区中断。

SPE位（SPI功能使能）

SPE位启用或禁用SPI功能。当SPSR.MODF标志为1时，SPE位不能设置为1。有关详细信息，请参阅第31.3.8节，错误检测。

将SPE位设置为0将禁用SPI功能并初始化部分模块功能。有关详细信息，请参阅第31.3.9节，初始化SPI。此外，当SPE位从0变为1或1变为0时，会产生发送缓冲区空中断请求。

SPRIE位（SPI接收缓冲区满中断使能）

当SPI在串行传输完成后检测到接收缓冲区已满写入时，SPRIE位启用或禁用SPI接收缓冲区已满中断请求的生成。

31.2.2 SPI Slave Select Polarity Register (SSLP)

Address(es): SPI0.SSLP 4007 2001h, SPI1.SSLP 4007 2101h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	SSL3P	SSL2P	SSL1P	SSL0P
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SSL0P	SSL0 Signal Polarity Setting	0: Set SSL0 signal to active-low 1: Set SSL0 signal to active-high.	R/W
b1	SSL1P	SSL1 Signal Polarity Setting	0: Set SSL1 signal to active-low 1: Set SSL1 signal to active-high.	R/W
b2	SSL2P	SSL2 Signal Polarity Setting	0: Set SSL2 signal to active-low 1: Set SSL2 signal to active-high.	R/W
b3	SSL3P	SSL3 Signal Polarity Setting	0: Set SSL3 signal to active-low 1: Set SSL3 signal to active-high.	R/W
b7 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

If the contents of SSLP are changed when the SPCR.SPE bit is 1, do not perform subsequent operations.

31.2.3 SPI Pin Control Register (SPPCR)

Address(es): SPI0.SPPCR 4007 2002h, SPI1.SPPCR 4007 2102h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	MOIFE	MOIFV	—	—	SPLP2	SPLP
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SPLP	SPI Loopback	0: Normal mode 1: Loopback mode, with data inverted for transmission.	R/W
b1	SPLP2	SPI Loopback 2	0: Normal mode 1: Loopback mode, with data not inverted for transmission.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	MOIFV	MOSI Idle Fixed Value	0: Set level output on the MOSIn pin during MOSI idling to low 1: Set level output on the MOSIn pin during MOSI idling to high.	R/W
b5	MOIFE	MOSI Idle Value Fixing Enable	0: Set MOSI output value to equal the final data from previous transfer 1: Set MOSI output value to equal value set in the MOIFV bit.	R/W
b7, b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

If the contents of SPPCR are changed when the SPCR.SPE bit is 1, do not perform subsequent operations.

SPLP bit (SPI Loopback)

The SPLP bit selects the mode of the SPI pins. When this bit is set to 1, SPI shuts off the path between the MISOn pin and the shift register if the SPCR.MSTR bit is 1, and between the MOSIn pin and the shift register if the SPCR.MSTR bit is 0. The SPI then connects the input path and output path for the shift register, establishing loopback mode.

SPLP2 bit (SPI Loopback 2)

The SPLP2 bit selects the mode of the SPI pins. When this bit is set to 1, SPI shuts off the path between the MISOn pin and the shift register if the SPCR.MSTR bit is 1, and between the MOSIn pin and the shift register if the SPCR.MSTR bit is 0. The SPI then connects the input path and the output path for the shift register, establishing loopback mode 2.

31.2.2 SPI从机选择极性寄存器(SSLP)

Address(es): SPI0.SSLP 4007 2001h, SPI1.SSLP 4007 2101h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	SSL3P	SSL2P	SSL1P	SSL0P
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SSL0P	SSL0信号极性设置	0：将SSL0信号设置为低电平有效1： 将SSL0信号设置为高电平有效。	R/W
b1	SSL1P	SSL1信号极性设置	0：设置SSL1信号为低电平有效1 ：设置SSL1信号为高电平有效。	R/W
b2	SSL2P	SSL2信号极性设置	0：将SSL2信号设置为低电平有效1： 将SSL2信号设置为高电平有效。	R/W
b3	SSL3P	SSL3信号极性设置	0：将SSL3信号设置为低电平有效1： 将SSL3信号设置为高电平有效。	R/W
b7 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W

如果SPCR.SPE位为1时SSLP的内容发生变化，则不要进行后续操作。

31.2.3 SPI引脚控制寄存器(SPPCR)

Address(es): SPI0.SPPCR 4007 2002h, SPI1.SPPCR 4007 2102h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	MOIFE	MOIFV	—	—	SPLP2	SPLP
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SPLP	SPI Loopback	0：正常模式1：环回模式，数据反转传输。	R/W
b1	SPLP2	SPI Loopback 2	0：正常模式1：环回模式，数据不反相传输。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	MOIFV	MOSI空闲固定值	0：在MOSI空闲期间将MOSIn引脚上的电平输出设置为低1：在MOSI空闲期间将MOSIn引脚上的电平输出设置为高。	R/W
b5	MOIFE	MOSI空闲值修复 Enable	0：设置MOSI输出值等于上次传输的最终数据1：设置MOSI输出值等于MOIFV位中设置的值。	R/W
b7, b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W

如果SPCR.SPE位为1时SPPCR的内容发生了变化，则不要进行后续操作。

SPLP位（SPI环回）

SPLP位选择SPI引脚的模式。当该位设置为1时，如果SPCR.MSTR位为1，则SPI关闭MIOn引脚和移位寄存器之间的路径，如果SPCR.MSTR位为0，则关闭MOSIn引脚和移位寄存器之间的路径。SPI然后连接移位寄存器的输入路径和输出路径，建立环回模式。

SPLP2位（SPI环回2）

SPLP2位选择SPI引脚的模式。当该位设置为1时，如果SPCR.MSTR位为1，则SPI关闭MIOn引脚和移位寄存器之间的路径，如果SPCR.MSTR位为0，则关闭MOSIn引脚和移位寄存器之间的路径。SPI然后连接移位寄存器的输入路径和输出路径，建立环回模式2。

MOIFV bit (MOSI Idle Fixed Value)

If the MOIFE bit is 1 in master mode, the MOIFV bit determines the MOSIn pin output value during the SSL negation period, including the SSL retention period during a burst transfer.

MOIFE bit (MOSI Idle Value Fixing Enable)

The MOIFE bit fixes the MOSIn output value when the SPI in master mode is in an SSL negation period, including the SSL retention period during a burst transfer. When the MOIFE bit is 0, the SPI outputs the last data from the previous serial transfer during the SSL negation period to the MOSIn pin. When the MOIFE bit is 1, the SPI outputs the fixed value set in the MOIFV bit to the MOSIn pin.

31.2.4 SPI Status Register (SPSR)

Address(es): SPI0.SPSR 4007 2003h, SPI1.SPSR 4007 2103h

	b7	b6	b5	b4	b3	b2	b1	b0
	SPRF	—	SPTEF	UDRF	PERF	MODF	IDLNF	OVRF
Value after reset:	0	0	1	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	OVRF	Overrun Error Flag	0: No overrun error occurred 1: Overrun error occurred.	R/(W)*1
b1	IDLNF	SPI Idle Flag	0: SPI is in idle state 1: SPI is in transfer state.	R
b2	MODF	Mode Fault Error Flag	0: No mode fault or underrun error occurred 1: Mode fault error or underrun error occurred.	R/(W)*1
b3	PERF	Parity Error Flag	0: No parity error occurred 1: Parity error occurred.	R/(W)*1
b4	UDRF	Underrun Error Flag	0: A mode fault error occurred (MODF = 1) 1: An underrun error occurred (MODF = 1). This bit is invalid when MODF is 0.	R/W*1,*2
b5	SPTEF	SPI Transmit Buffer Empty Flag	0: Data is in the transmit buffer 1: No data is in the transmit buffer.	R/(W)*3
b6	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7	SPRF	SPI Receive Buffer Full Flag	0: No valid data is in SPDR/SPDR_HA 1: Valid data is in SPDR/SPDR_HA.	R/(W)*3

Note 1. Only 0 can be written to clear the flag after reading 1.
Note 2. Clear the UDRF flag at the same time as the MODF flag.
Note 3. The write value should be 1.

OVRF flag (Overrun Error Flag)

The OVRF flag indicates the occurrence of an overrun error. In master mode (SPCR.MSTR = 1) and when the RSPCK clock auto-stop function is enabled (SPCR2.SCKASE = 1), an overrun error does not occur, and this flag is not set to 1. For details, see section 31.3.8.1, Overrun errors.

[Setting condition]

- When the next serial transfer ends while the SPCR.TXMD bit is 0 and the receive buffer is full.

[Clearing condition]

- When SPSR is read while this flag is 1, and then 0 is written to this flag.

IDLNF flag (SPI Idle Flag)

The IDLNF flag indicates the transfer status of the SPI.

[Setting conditions]

MOIFV位（MOSI空闲固定值）

如果MOIFE位在主模式下为1，则MOIFV位确定SSL否定期间的MOSIn引脚输出值，包括突发传输期间的SSL保持期间。

MOIFE位（MOSI空闲值固定使能）

MOIFE位固定SPI在主模式下处于SSL否定周期时的MOSIn输出值，包括
突发传输期间的SSL保留期。当MOIFE位为0时，SPI将SSL否定期间上次串行传输的最后一个数据输出到MOSIn引脚。当MOIFE位为1时，SPI将MOIFV位中设置的固定值输出到MOSIn引脚。

31.2.4 SPI状态寄存器(SPSR)

Address(es): SPI0.SPSR 4007 2003h, SPI1.SPSR 4007 2103h

	b7	b6	b5	b4	b3	b2	b1	b0
	SPRF	—	SPTEF	UDRF	PERF	MODF	IDLNF	OVRF
重置后的值：	0	0	1	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	OVRF	溢出错误标志	0：未发生溢出错误1：发生溢出错误。	R/(W)*1
b1	IDLNF	SPI空闲标志	0：SPI处于空闲状态1：SPI处于传输状态。	R
b2	MODF	模式故障错误标志	0：未发生模式故障或欠载错误1：发生模式故障错误或欠载错误。	R/(W)*1
b3	PERF	奇偶校验错误标志	0：未发生奇偶校验错误1：发生奇偶校验错误。	R/(W)*1
b4	UDRF	欠载错误标志	0：发生模式故障错误(MODF=1)1：发生欠载错误(MODF=1)。当MODF为0时该位无效。	R/W*1,*2
b5	SPTEF	SPI发送缓冲区空标志	0：发送缓冲区中有数据1：发送缓冲区中没有数据。	R/(W)*3
b6	—	Reserved	该位读取为0。写入值应为0。	R/W
b7	SPRF	SPI接收缓冲区满标志	0：SPDRSPDR_HA中没有有效数据1：SPDRSPDR_HA中有有效数据。	R/(W)*3

Note 1. 读1后只能写0清除标志。
Note 2. 在清除MODF标志的同时清除UDRF标志。
Note 3. 写入值应为1。

OVRF标志（溢出错误标志）

OVRF标志指示发生溢出错误。在主机模式（SPCR.MSTR=1）和启用RSPCK时钟自动停止功能（SPCR2.SCKASE=1）时，不会发生溢出错误，并且该标志不设置为1。详细信息见章节31.3.8.1，溢出错误。

[Setting condition]

- 当SPCR.TXMD位为0且接收缓冲区已满时，下一次串行传输结束。

[Clearing condition]

- 当此标志为1时读取SPSR，然后将0写入此标志。

IDLNF标志（SPI空闲标志）

IDLNF标志指示SPI的传输状态。

[Setting conditions]

Master mode

- When conditions 1. and 2. in the master mode, in the clearing conditions, are not satisfied.

Slave mode

- When the SPCR.SPE bit is 1, enabling the SPI function.

[Clearing conditions]

Master mode

- When condition 1. or conditions 2., 3., and 4. are satisfied.

1. The SPCR.SPE bit is 0, indicating that the SPI is initialized.
2. The transmit buffer (SPTX) is empty, indicating that data for the next transfer is not set.
3. The SPSSR.SPCP[2:0] bits are 000b, indicating the beginning of sequence control.
4. The SPI internal sequencer is in the idle state, indicating that operations up to the next-access delay are complete.

Slave mode

- When condition 1. is satisfied.

MODF flag (Mode Fault Error Flag)

The MODF flag indicates the occurrence of a mode fault error or an underrun error. The UDRF flag indicates which error occurred.

[Setting conditions]

Multi-master mode

- When the input level of the SSLni pin changes to an active level while the SPCR.MSTR bit is 1 (master mode) and the SPCR.MODFEN bit is 1 (mode fault error detection is enabled), triggering a mode fault error.

Slave mode

- When condition 1. or 2. is satisfied.

  1. The SSLni pin is negated before the RSPCK cycle required for data transfer ends while the SPCR.MSTR bit is 0 (slave mode) and the SPCR.MODFEN bit is 1 (mode fault error detection is enabled), triggering a mode fault error.
  2. The serial transfer begins with the SPCR.MSTR bit set to 0 (slave mode), the SPCR.SPE bit set to 1, and the transmission data not prepared, triggering an underrun error.

The active level of the SSLni signal is determined by the SSLP.SSLiP bit (SSLi signal polarity setting).

[Clearing condition]

- When SPSR is read while this flag is 1, and then 0 is written to this flag.

PERF flag (Parity Error Flag)

The PERF flag indicates the occurrence of a parity error.

[Setting condition]

- When a serial transfer ends while the SPCR.TXMD bit is 0 and the SPCR2.SPPE bit is 1, triggering a parity error.

[Clearing condition]

- When SPSR is read while this flag is 1, and then 0 is written to this flag.

UDRF flag (Underrun Error Flag)

The UDRF flag indicates the occurrence of an underrun error.

[Setting condition]

- When the serial transfer begins with the SPCR.MSTR bit set to 0 (slave mode), the SPCR.SPE bit set to 1, and the

主模式

- 当条件1.和2.在主模式中，在清除条件中，不满足。

从机模式

- 当SPCR.SPE位为1时，使能SPI功能。

[Clearing conditions]

主模式

- 当条件1.或条件2.、3.和4.满足时。

1. SPCR.SPE位为0，表示SPI已初始化。
2. 发送缓冲区(SPTX)为空，表示未设置下一次传输的数据。
3. SPSSR.SPCP[2:0]位为000b，表示序列控制的开始。
4. SPI内部定序器处于空闲状态，表示直到下一次访问延迟的操作已完成。

从机模式

- 当条件1.满足时。

MODF标志（模式故障错误标志）

MODF标志指示发生模式故障错误或欠载错误。UDRF标志指示发生了哪个错误。

[Setting conditions]

Multi-master mode

- 当SPCR.MSTR位为1（主模式）且SPCR.MODFEN位为1（启用模式故障错误检测）时，当SSLni引脚的输入电平变为有效电平时，触发模式故障错误。

从机模式

- 当满足条件1.或2.时。

  1.在SPCR.MSTR位为0（从模式）且SPCR.MODFEN位为1（使能模式故障错误检测）时，SSLni引脚在数据传输所需的RSPCK周期结束前被取反，触发模式故障错误.

  2.串行传输开始时SPCR.MSTR位设置为0（从模式），SPCR.SPE位设置为1，传输数据未准备好，触发欠载错误。

SSLni信号的有效电平由SSLP.SSLiP位（SSLi信号极性设置）决定。

[Clearing condition]

- 当此标志为1时读取SPSR，然后将0写入此标志。

PERF标志（奇偶校验错误标志）

PERF标志指示奇偶校验错误的发生。

[Setting condition]

- 当SPCR.TXMD位为0且SPCR2.SPPE位为1时串行传输结束，触发奇偶校验错误。

[Clearing condition]

- 当此标志为1时读取SPSR，然后将0写入此标志。

UDRF标志（欠载错误标志）

UDRF标志指示发生了欠载错误。

[Setting condition]

- 当串行传输开始时SPCR.MSTR位设置为0（从模式），SPCR.SPE位设置为1，并且

transmission data not prepared, triggering an underrun error.

[Clearing condition]

- When SPSR is read while this flag is 1, and then 0 is written to this flag.

SPTEF flag (SPI Transmit Buffer Empty Flag)

The SPTEF flag indicates the status of the transmit buffer for the SPI Data Register (SPDR/SPDR_HA).

[Setting conditions]

- When condition 1. or 2. is satisfied.

  1. The SPCR.SPE bit is 0, indicating that the SPI is initialized.

  2. Transmit data is transferred from the transmit buffer to the shift register.

[Clearing condition]

- When data written to SPDR/SPDR_HA equals the number of frames set in the SPFC[1:0] bits in the SPI Data Control Register (SPDCR).

Data can only be written to SPDR/SPDR_HA when the SPTEF flag is 1. If data is written to the transmit buffer of SPDR/SPDR_HA when the SPTEF flag is 0, data in the transmit buffer is not updated.

SPRF flag (SPI Receive Buffer Full Flag)

The SPRF flag indicates the status of the receive buffer for the SPI Data Register (SPDR/SPDR_HA).

[Setting condition]

- When a serial transfer ends while the Communication Operating Mode Select bit (TXMD) in the SPI Control Register (SPCR) is 0, the SPRF flag is 0, and the SPI transfers the receive data from the shift register to SPDR/SPDR_HA. However, when the OVRF flag is 1, the SPRF flag does not change from 0 to 1.

[Clearing condition]

- When received data is read from SPDR/SPDR_HA.

31.2.5 SPI Data Register (SPDR/SPDR_HA)

Address(es): SPI0.SPDR 4007 2004h, SPI1.SPDR 4007 2104h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Address(es): SPI0.SPDR_HA 4007 2004h, SPI1.SPDR_HA 4007 2104h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPDR/SPDR_HA is the interface with the buffers that hold data for transmission and reception by the SPI.

When accessing this register in words (SPLW = 1), access the SPDR register. When accessing it in halfwords (SPLW = 0), access the SPDR_HA register.

The transmit buffer (SPTX) and receive buffer (SPRX) are independent but are both mapped to SPDR/SPDR_HA. Figure 31.2 shows the configuration of the SPDR/SPDR_HA register.

传输数据未准备好，触发欠载错误。

[Clearing condition]

- 当此标志为1时读取SPSR，然后将0写入此标志。

SPTEF标志（SPI发送缓冲区空标志）

SPTEF标志指示SPI数据寄存器(SPDRSPDR_HA)的发送缓冲区的状态。

[Setting conditions]

- 当满足条件1.或2.时。

  1.SPCR.SPE位为0，表示SPI初始化。

  2.发送数据从发送缓冲器传送到移位寄存器。

[Clearing condition]

- 当写入SPDR的数据SPDR_HA等于SPI数据中SPFC[1:0]位中设置的帧数时控制寄存器(SPDCR)。

只有当SPTEF标志为1时，才能将数据写入SPDRSPDR_HA。如果将数据写入SPDRSPDR_HA当SPTEF标志为0时，发送缓冲区中的数据不更新。

SPRF标志（SPI接收缓冲区满标志）

SPRF标志指示SPI数据寄存器(SPDRSPDR_HA)的接收缓冲区的状态。

[Setting condition]

- 当串行传输结束而SPI控制中的通信操作模式选择位(TXMD)寄存器（SPCR）为0，SPRF标志为0，SPI将接收到的数据从移位寄存器传送到SPDRSPDR_HA。但是，当OVRF标志为1时，SPRF标志不会从0变为1。

[Clearing condition]

- 当从SPDRSPDR_HA读取接收到的数据时。

31.2.5 SPI数据寄存器(SPDRSPDR_HA)

Address(es): SPI0.SPDR 4007 2004h, SPI1.SPDR 4007 2104h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

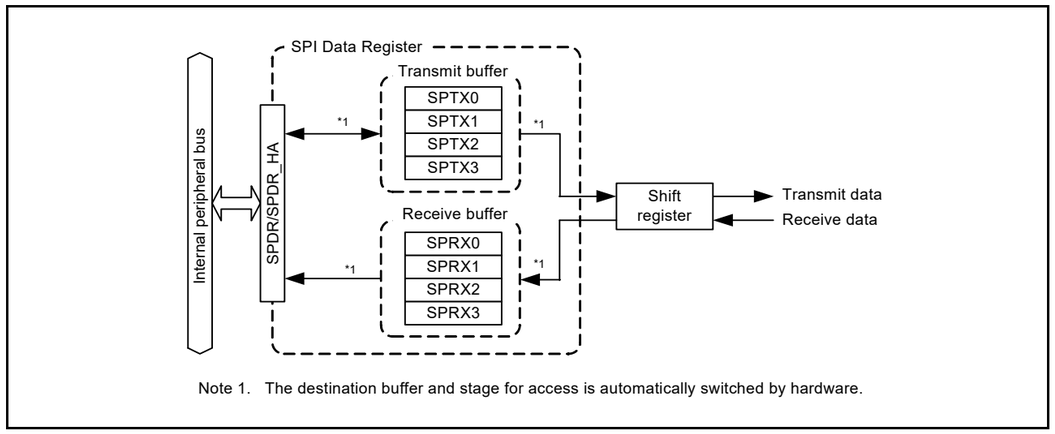
Address(es): SPI0.SPDR_HA 4007 2004h, SPI1.SPDR_HA 4007 2104h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPDRSPDR_HA是与保存数据以供SPI发送和接收的缓冲区的接口。

当以字（SPLW=1）访问该寄存器时，访问SPDR寄存器。以半字(SPLW=0)访问时，访问SPDR_HA寄存器。

发送缓冲区(SPTX)和接收缓冲区(SPRX)是独立的，但都映射到SPDRSPDR_HA。
图31.2显示了SPDRSPDR_HA寄存器的配置。



Note 1. The destination buffer and stage for access is automatically switched by hardware.

Figure 31.2 Configuration of SPDR/SPDR_HA

The transmit and receive buffers each have four stages. The number of stages to be used is selectable by the number of frames specification bits in the SPI Data Control Register (SPDCR.SPFC[1:0]). The eight stages of the buffer are all mapped to the single address of the SPDR/SPDR_HA register.

Data written to SPDR/SPDR_HA is written to a transmit-buffer stage (SPTXn) (n = 0 to 3) and then transmitted from the buffer. The receive buffer holds the received data on completion of reception. The receive buffer is not updated if an overrun is generated.

If the data length is not 32 bits, the bits not referred to in SPTXn (n = 0 to 3) are stored in the associated bits in SPRXn (n = 0 to 3). For example, if the data length is 9 bits, the received data is stored in the SPRXn[8:0] bits, and the SPTXn[31:9] bits are stored in the SPRXn[31:9] bits.

(1) Bus interface

SPDR/SPDR_HA is an interface with 32-bit wide transmit and receive buffers, each of which has four stages, for a total of 32 bytes. The 32 bytes are mapped to the 4-byte address space for SPDR/SPDR_HA. The unit of access for SPDR/SPDR_HA is selected by the SPI Word Access/Halfword Access Specification bit in the SPI Data Control Register (SPDCR.SPLW). SPDR can also be accessed with the access size specified by the SPI Byte Access bit in the SPI Data Control Register (SPDCR.SPBYT).

Flush the transmission data at the LSB end of the register, and store the received data at the LSB end.

The following sections describe the operations involved in writing to and reading from SPDR/SPDR_HA.

(a) Writing

Data written to SPDR/SPDR_HA is written to a transmit buffer (SPTXn). This is not affected by the value of the SPDCR.SPRDTD bit, unlike when reading from SPDR/SPDR_HA. The transmit buffer includes a transmit buffer write pointer that is automatically updated to reference the next stage each time data is written to SPDR/SPDR_HA.

Figure 31.3 shows the configuration of the bus interface with the transmit buffer when writing to SPDR/SPDR_HA.

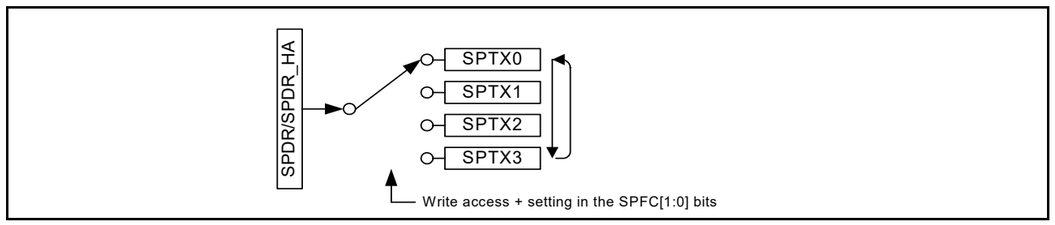
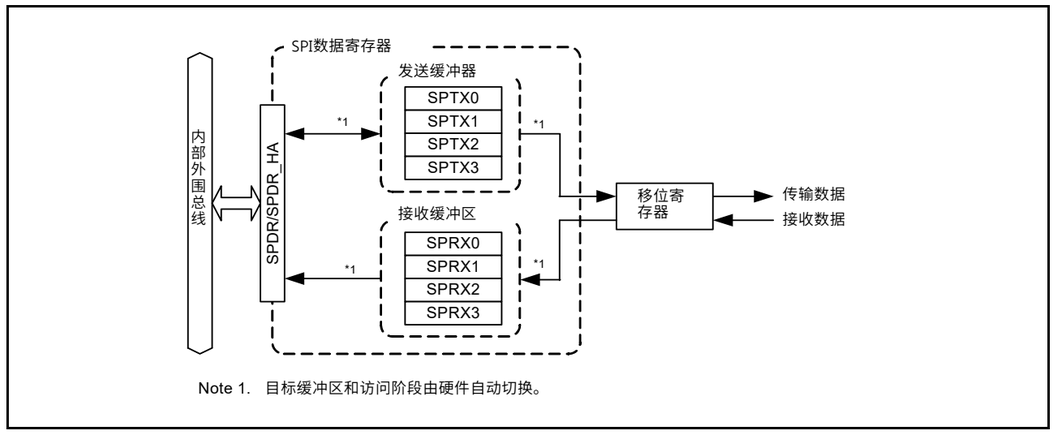


Figure 31.3 Configuration of SPDR/SPDR_HA for write access



Note 1. 目标缓冲区和访问阶段由硬件自动切换。

Figure 31.2 SPDRSPDR_HA的配置

发送和接收缓冲器各有四个阶段。要使用的级数可通过SPI数据控制寄存器(SPDCR.SPFC[1:0])中的帧数规范位来选择。缓冲区的八个阶段都映射到SPDRSPDR_HA寄存器的单个地址。

写入SPDRSPDR_HA的数据被写入发送缓冲器级(SPTXn)（n=0到3），然后从缓冲器发送。接收缓冲器在接收完成时保存接收到的数据。如果产生溢出，接收缓冲区不会更新。

如果数据长度不是32位，则SPTXn(n=0到3)中未引用的位将存储在SPRXn(n=0到3)的相关位中。例如，如果数据长度为9位，则接收到的数据存储在SPRXn[8:0]位中，SPTXn[31:9]位存储在SPRXn[31:9]位中。

(1) 总线接口

SPDRSPDR_HA是一个具有32位宽的发送和接收缓冲区的接口，每个缓冲区有四个阶段，总共32个字节。32个字节映射到SPDRSPDR_HA的4字节地址空间。SPDRSPDR_HA的访问单元由SPI数据控制中的SPI字访问半字访问规范位选择

寄存器(SPDCR.SPLW)。SPDR也可以通过SPI字节访问位指定的访问大小访问
SPI数据控制寄存器(SPDCR.SPBYT)。

在寄存器的LSB端刷新发送数据，在LSB端存储接收到的数据。

以下部分描述了写入和读取SPDRSPDR_HA所涉及的操作。

(a) Writing

写入SPDRSPDR_HA的数据被写入发送缓冲器(SPTXn)。这不受价值的影响
SPDCR.SPRDTD位，与从SPDRSPDR_HA读取时不同。发送缓冲区包括一个发送缓冲区写指针，每次将数据写入SPDRSPDR_HA时，该写指针会自动更新以引用下一阶段。

图31.3显示了写入SPDRSPDR_HA时带有发送缓冲区的总线接口的配置。

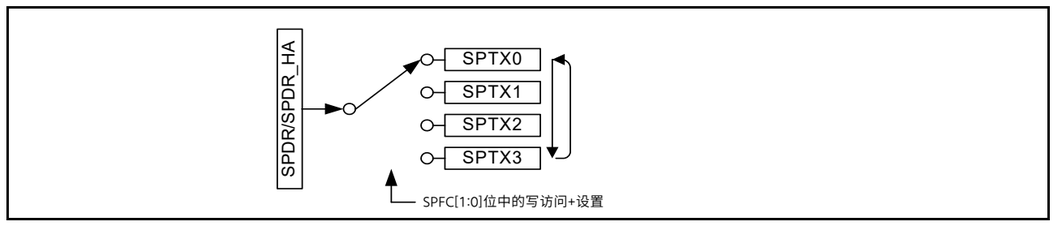


Figure 31.3 为写访问配置SPDRSPDR_HA

The sequence for switching the transmit buffer write pointer changes with the setting of the number of frames specification bits in the SPI Data Control Register (SPDCR.SPFC[1:0]).

The relationship of the SPFC[1:0] setting and the sequence of pointer switching from SPTX0 to SPTX3 is as follows:

- When the SPFC[1:0] bits are 00b: SPTX0 → SPTX0 → SPTX0 → …
- When the SPFC[1:0] bits are 01b: SPTX0 → SPTX1 → SPTX0 → SPTX1 → …
- When the SPFC[1:0] bits are 10b: SPTX0 → SPTX1 → SPTX2 → SPTX0 → SPTX1 → …
- When the SPFC[1:0] bits are 11b: SPTX0 → SPTX1 → SPTX2 → SPTX3 → SPTX0 → SPTX1 → …

When 1 is written to the SPI Function Enable bit in the SPI Control Register (SPCR.SPE) while the bit is 0, SPTX0 is the destination for the next write.

When writing to the transmit buffer (SPTXn) after generation of the transmit buffer empty interrupt (when SPSR.SPTEF is 1), write the number of frames set in the SPI Data Control Register (SPDCR.SPFC[1:0]). Even when the specified number of frames is written to the transmit buffer (SPTXn), the value of the buffer is not updated after completion of the writing and before generation of the next transmit buffer empty interrupt (when SPTEF is 0).

(b) Reading

SPDR/SPDR_HA can be accessed to read the value of a receive buffer (SPRXn) or a transmit buffer (SPTXn). The setting in the SPI Receive/Transmit Data Select bit in the SPI Data Control Register (SPDCR.SPRDTD) selects whether reading is from the receive or transmit buffer.

The sequence of reading the SPDR/SPDR_HA register is controlled by the independent receive buffer and transmit buffer read pointers.

Figure 31.4 shows the configuration of a bus interface with the receive and transmit buffers for reading from SPDR/SPDR_HA.

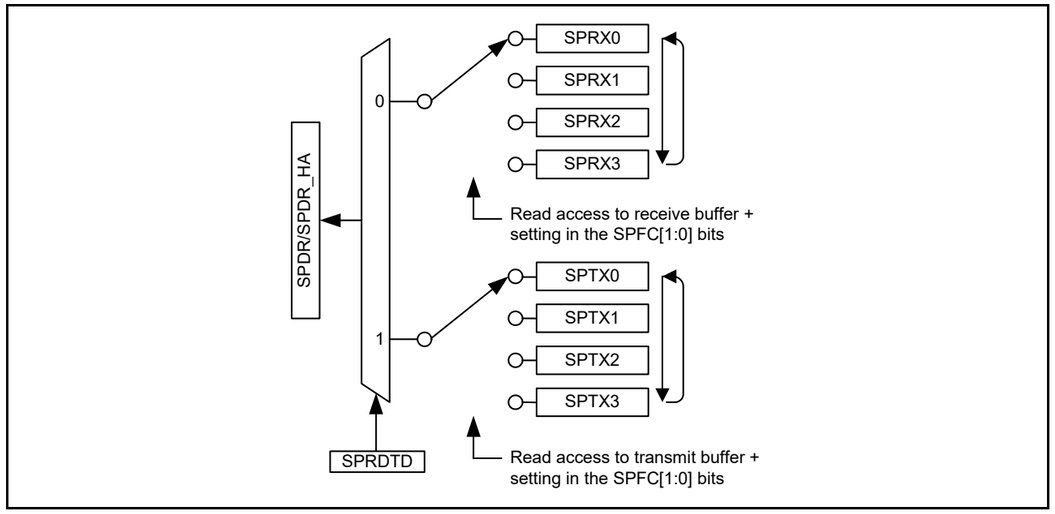


Figure 31.4 Configuration of SPDR/SPDR_HA for read access

Reading the receive buffer switches the receive buffer read pointer to the next buffer automatically. The switching sequence for the receive buffer read pointer is the same as that for the transmit buffer write pointer. However, when 1 is written to the SPI Function Enable bit in the SPI Control Register (SPCR.SPE) when the bit is 1, SPRX0 is referenced by the buffer read pointer for the next read.

The transmit buffer read pointer is updated when writing to SPDR/SPDR_HA, but is not updated when reading from the transmit buffer. When reading from the transmit buffer, the value most recently written to SPDR/SPDR_HA is read.

However, after a transmit buffer empty interrupt is generated, and the transmit buffer becomes full again, reading from

发送缓冲区写指针的切换顺序随SPI数据控制寄存器(SPDCR.SPFC[1:0])中帧数规范位的设置而变化。

SPFC[1:0]设置与指针从SPTX0切换到SPTX3的顺序关系如下：

- 当SPFC[1:0]位为00b时：SPTX0→SPTX0→SPTX0→…
- SPFC[1:0]位为01b时：SPTX0→SPTX1→SPTX0→SPTX1→…
- SPFC[1:0]位为10b时：SPTX0→SPTX1→SPTX2→SPTX0→SPTX1→…
- SPFC[1:0]位为11b时：SPTX0→SPTX1→SPTX2→SPTX3→SPTX0→SPTX1→…

当1写入SPI控制寄存器(SPCR.SPE)中的SPI功能使能位且该位为0时，SPTX0是下一次写入的目标。

在产生发送缓冲区空中断后（当SPSR.SPTEF为1时）写入发送缓冲区(SPTXn)时，写入SPI数据控制寄存器(SPDCR.SPFC[1:0])中设置的帧数。即使指定的帧数被写入发送缓冲区(SPTXn)，缓冲区的值在写入完成后和下一个发送缓冲区空中断发生之前（SPTEF为0时）也不会更新。

(b) Reading

SPDR可以访问SPDR_HA以读取接收缓冲区(SPRXn)或发送缓冲区(SPTXn)的值。SPI数据控制寄存器(SPDCR.SPRDTD)中SPI接收发送数据选择位的设置选择是从接收缓冲区还是从发送缓冲区读取。

读取SPDRSPDR_HA寄存器的顺序由独立的接收缓冲区和发送缓冲区读取指针控制。

图31.4显示了带有接收和发送缓冲区的总线接口配置，用于从
SPDR/SPDR_HA.

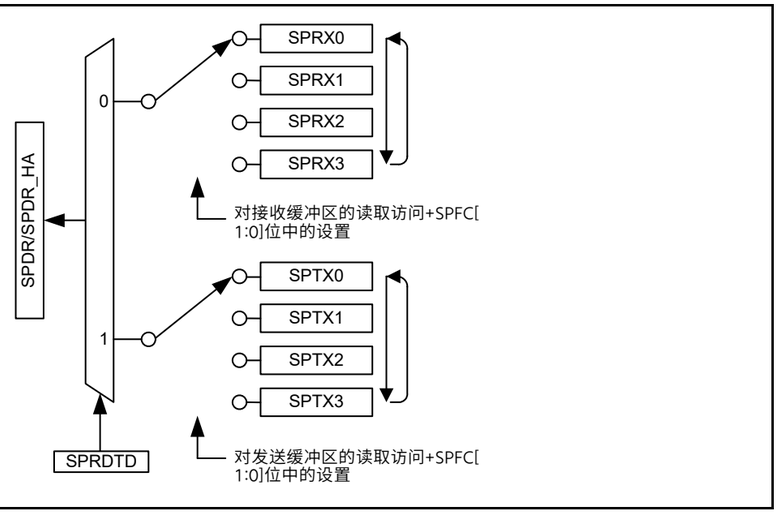


Figure 31.4 为读取访问配置SPDRSPDR_HA

读取接收缓冲区会自动将接收缓冲区读取指针切换到下一个缓冲区。接收缓冲区读指针的切换顺序与发送缓冲区写指针的切换顺序相同。但是，当SPI控制寄存器(SPCR.SPE)中的SPI功能使能位为1时，当该位为1时，SPRX0将被缓冲区读取指针引用以进行下一次读取。

发送缓冲区读指针在写入SPDRSPDR_HA时更新，但在从发送缓冲区读取时不更新。从发送缓冲区读取时，会读取最近写入SPDRSPDR_HA的值。

但是，在产生发送缓冲区空中断后，发送缓冲区再次变满，从

the transmit buffer returns all 0s after the completion of writing the number of frames of data specified in the SPDCR.SPFC[1:0] bits, until the next buffer empty interrupt is generated (when SPTEF is 0).

31.2.6 SPI Sequence Control Register (SPSCR)

Address(es): SPI0.SPSCR 4007 2008h, SPI1.SPSCR 4007 2108h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SPSLN[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	SPSLN[2:0]	SPI Sequence Length Specification	b2 b0 Sequence Length — Referenced SPCMD0 to SPCMD7 (Number) 0 0 0: 1 — 0→0→… 0 0 1: 2 — 0→1→0→… 0 1 0: 3 — 0→1→2→0→… 0 1 1: 4 — 0→1→2→3→0→… 1 0 0: 5 — 0→1→2→3→4→0→… 1 0 1: 6 — 0→1→2→3→4→5→0→… 1 1 0: 7 — 0→1→2→3→4→5→6→0→… 1 1 1: 8 — 0→1→2→3→4→5→6→7→0→… The sequence length that is set in these bits determines the order in which the SPCMD0 to SPCMD07 registers are referenced. The setting defines the relationship between the sequence length and the SPCMD0 to SPCMD7 registers referenced by the SPI. In slave mode, the SPI references SPCMD0.	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

SPSCR specifies the sequence length when the SPI operates in master mode. When changing the SPSCR.SPSLN[2:0] bits while both the SPCR.MSTR and SPCR.SPE bits are 1, always check that the SPSR.IDLNF flag is 0.

SPSLN[2:0] bits (SPI Sequence Length Specification)

The SPSLN[2:0] bits specify the sequence length when the SPI in master mode performs sequential operations. The SPI in master mode changes the SPCMD0 to SPCMD7 registers to be referenced, and the order in which they are referenced is based on this sequence length setting. In slave mode, SPCMD0 is referenced.

31.2.7 SPI Sequence Status Register (SPSSR)

Address(es): SPI0.SPSSR 4007 2009h, SPI1.SPSSR 4007 2109h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	SPECM[2:0]			—	SPCP[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	SPCP[2:0]	SPI Command Pointer	b2 b0 0 0 0: SPCMD0 0 0 1: SPCMD1 0 1 0: SPCMD2 0 1 1: SPCMD3 1 0 0: SPCMD4 1 0 1: SPCMD5 1 1 0: SPCMD6 1 1 1: SPCMD7.	R
b3	—	Reserved	This bit is read as 0	R

在完成写入SPDCR.SPFC[1:0]位中指定的数据帧数后，发送缓冲区返回全0，直到产生下一个缓冲区空中断（当SPTEF为0时）。

31.2.6 SPI序列控制寄存器(SPSCR)

Address(es): SPI0.SPSCR 4007 2008h, SPI1.SPSCR 4007 2108h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SPSLN[2:0]		
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	SPSLN[2:0]	SPI序列长度 Specification	b2b0参考SPCMD0到SPCMD7的序列长度（编号）000：10→0→…001：20→1→0→…010：30→1→2→0→…011:40→1→2→3→0→…100:50→1→2→3→4→0→…101:60→1→2→3→4→5→0→…110:70→1→2→3→4→5→6→0→…111:80→1→2→3→4→5→6→7→0→… 序列长度在这些位中设置的值决定了引用SPCMD0到SPCMD7寄存器的顺序。该设置定义了序列长度与SPI引用的SPCMD0到SPCMD7寄存器之间的关系。在从机模式下，SPI参考SPCMD0。	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SPSCR指定SPI在主模式下工作时的序列长度。在SPCR.MSTR和SPCR.SPE位均为1时更改SPSCR.SPSLN[2:0]位时，请始终检查SPSR.IDLNF标志是否为0。

SPSLN[2:0]位（SPI序列长度规范）

SPSLN[2:0]位指定SPI在主模式下执行顺序操作时的序列长度。主机模式下的SPI将SPCMD0到SPCMD7寄存器更改为被引用，它们被引用的顺序基于此序列长度设置。在从模式下，以SPMD0为参考。

31.2.7 SPI序列状态寄存器(SPSSR)

Address(es): SPI0.SPSSR 4007 2009h, SPI1.SPSSR 4007 2109h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	SPECM[2:0]			—	SPCP[2:0]		
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	SPCP[2:0]	SPI命令指针	b2 b0 0 0 0: SPCMD0 0 0 1: SPCMD1 0 1 0: SPCMD2 0 1 1: SPCMD3 1 0 0: SPCMD4 1 0 1: SPCMD5 1 1 0: SPCMD6 1 1 1: SPCMD7.	R
b3	—	Reserved	该位读为0	R

Bit	Symbol	Bit name	Description	R/W
b6 to b4	SPECM[2:0]	SPI Error Command	b6 b4 0 0 0: SPCMD0 0 0 1: SPCMD1 0 1 0: SPCMD2 0 1 1: SPCMD3 1 0 0: SPCMD4 1 0 1: SPCMD5 1 1 0: SPCMD6 1 1 1: SPCMD7.	R
b7	—	Reserved	This bit is read as 0	R

SPSSR indicates the sequence control status when the SPI operates in master mode. Any writes to SPSSR are ignored.

SPCP[2:0] bits (SPI Command Pointer)

The SPCP[2:0] bits indicate the SPCMDm register that is referenced to by the pointer during sequence control by the SPI. For the SPI sequence control, see section 31.3.10.1, Master mode operation.

SPECM[2:0] bits (SPI Error Command)

The SPECM[2:0] bits indicate the SPCMDm register that is specified in the SPCP[2:0] bits when an error is detected during sequence control by the SPI. The SPI updates the SPECM[2:0] bits only when an error is detected. If both the SPSR.OVRF and SPSR.MODF flags are 0 and there is no error, the values of the SPECM[2:0] bits have no meaning.

For the SPI error detection function, see section 31.3.8, Error Detection. For the SPI sequence control, see section 31.3.10.1, Master mode operation.

31.2.8 SPI Bit Rate Register (SPBR)

Address(es): SPI0.SPBR 4007 200Ah, SPI1.SPBR 4007 210Ah

	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	1	1	1	1	1	1	1	1

SPBR sets the bit rate in master mode. If the contents of SPBR are changed while both the SPCR.MSTR and SPCR.SPE bits are 1, do not perform subsequent operations.

When the SPI is in slave mode, the bit rate depends on the bit rate of the input clock, regardless of the settings in SPBR and the SPCMDm.BRDV[1:0] bits (bit rate division setting). Use bit rates that satisfy the electrical characteristics of the device.

The bit rate is determined by combination of the SPBR and SPCMDm.BRDV[1:0] settings in the SPI Command Register. The equation for calculating the bit rate is as follows:

$$\text{Bit rate} = \frac{f(\text{PCLKA})}{2 \times (n + 1) \times 2^N}$$

In the equation, n denotes an SPBR setting (0, 1, 2, …, 255), and N denotes a BRDV[1:0] setting (0, 1, 2, 3).

Table 31.3 lists examples of the relationship between the SPBR settings, BRDV[1:0] settings, and bit rates.

Table 31.3 Relationship between SPBR settings, BRDV[1:0] settings, and bit rates (1 of 2)

SPBR (n)	BRDV[1:0] bits (N)	Division ratio	Bit rate							
			PCLKA = 32 MHz	PCLKA = 36 MHz	PCLKA = 40 MHz	PCLKA = 50 MHz	PCLKA = 60 MHz	PCLKA = 80 MHz	PCLKA = 100 MHz	PCLKA = 120 MHz
0	0	2	16.0 Mbps	18.0 Mbps	20.0 Mbps	25.0 Mbps	30.0 Mbps	Not supported		
1	0	4	8.00 Mbps	9.00 Mbps	10.0 Mbps	12.5 Mbps	15.0 Mbps	20.0 Mbps	25.0 Mbps	30.0 Mbps

Bit	Symbol	位名称	Description	R/W
b6 to b4	SPECM[2:0]	SPI错误命令	b6 b4 0 0 0: SPCMD0 0 0 1: SPCMD1 0 1 0: SPCMD2 0 1 1: SPCMD3 1 0 0: SPCMD4 1 0 1: SPCMD5 1 1 0: SPCMD6 1 1 1: SPCMD7.	R
b7	—	Reserved	该位读为0	R

SPSSR指示SPI在主模式下工作时的序列控制状态。对SPSSR的任何写入都将被忽略。

SPCP[2:0]位（SPI命令指针）

SPCP[2:0]位指示在序列控制期间由指针引用的SPCMDm寄存器
SPI。对于SPI序列控制，请参见第31.3.10.1节，主模式操作。

SPECM[2:0]位（SPI错误命令）

SPECM[2:0]位指示在SPI序列控制期间检测到错误时在SPCP[2:0]位中指定的SPCMDm寄存器。SPI仅在检测到错误时更新SPECM[2:0]位。如果SPSR.OVRF和SPSR.MODF标志均为0且没有错误，则SPECM[2:0]位的值没有意义。

关于SPI错误检测功能，请参见第31.3.8节，错误检测。对于SPI序列控制，请参见第31.3.10.1节，主模式操作。

31.2.8 SPI比特率寄存器（SPBR）

Address(es): SPI0.SPBR 4007 200Ah, SPI1.SPBR 4007 210Ah

	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	1	1	1	1	1	1	1	1

SPBR在主模式下设置比特率。如果在SPCR.MSTR和SPCR.SPE位都为1时SPBR的内容发生了变化，则不要执行后续操作。

当SPI处于从机模式时，比特率取决于输入时钟的比特率，与SPBR和SPMDm.BRDV[1:0]位（比特率分频设置）的设置无关。使用满足设备电气特性的比特率。

比特率由SPI命令中的SPBR和SPMDm.BRDV[1:0]设置组合确定
登记。比特率的计算公式如下：

$$\text{比特率} = \frac{f(\text{PCLKA})}{2 \times (n + 1) \times 2^N}$$

在等式中，n表示SPBR设置(0 1 2 … 255)，N表示BRDV[1:0]设置(0 1 2 3)。

表31.3列出了SPBR设置、BRDV[1:0]设置和比特率之间的关系示例。

Table 31.3 SPBR设置、BRDV[1:0]设置和比特率之间的关系（1of2）

SPBR (n)	BRDV[1:0] bits (N)	分工比	比特率							
			PCLKA = 32 MHz	PCLKA = 36 MHz	PCLKA = 40 MHz	PCLKA = 50 MHz	PCLKA = 60 MHz	PCLKA = 80 MHz	PCLKA = 100 MHz	PCLKA = 120 MHz
0	0	2	16.0 Mbps	18.0 Mbps	20.0 Mbps	25.0 Mbps	30.0 Mbps	不支持		
1	0	4	8.00 Mbps	9.00 Mbps	10.0 Mbps	12.5 Mbps	15.0 Mbps	20.0 Mbps	25.0 Mbps	30.0 Mbps

Table 31.3 Relationship between SPBR settings, BRDV[1:0] settings, and bit rates (2 of 2)

SPBR (n)	BRDV[1:0] bits (N)	Division ratio	Bit rate							
			PCLKA = 32 MHz	PCLKA = 36 MHz	PCLKA = 40 MHz	PCLKA = 50 MHz	PCLKA = 60 MHz	PCLKA = 80 MHz	PCLKA = 100 MHz	PCLKA = 120 MHz
2	0	6	5.33 Mbps	6.00 Mbps	6.67 Mbps	8.33 Mbps	10.0 Mbps	13.3 Mbps	16.7 Mbps	20.0 Mbps
3	0	8	4.00 Mbps	4.50 Mbps	5.00 Mbps	6.25 Mbps	7.50Mbps	10.0 Mbps	12.5 Mbps	15.0 Mbps
4	0	10	3.20 Mbps	3.60 Mbps	4.00 Mbps	5.00 Mbps	6.00 Mbps	8.00 Mbps	10.0 Mbps	12.0 Mbps
5	0	12	2.67 Mbps	3.00 Mbps	3.33 Mbps	4.16 Mbps	5.00 Mbps	6.67 Mbps	8.33 Mbps	10.0 Mbps
5	1	24	1.33 Mbps	1.50 Mbps	1.67 Mbps	2.08 Mbps	2.50 Mbps	3.33 Mbps	4.17 Mbps	5.00 Mbps
5	2	48	667 kbps	750 kbps	833 kbps	1.04 Mbps	1.25 Mbps	1.67 Mbps	2.08 Mbps	2.50 Mbps
5	3	96	333 kbps	375 kbps	417 kbps	521 kbps	625 kbps	833 kbps	1.04 Mbps	1.25 Mbps
255	3	4096	7.81 kbps	8.80 kbps	9.78 kbps	12.2 kbps	14.6 kbps	19.5 kbps	24.4 kbps	29.3 kbps

31.2.9 SPI Data Control Register (SPDCR)

Address(es): SPI0.SPDCR 4007 200Bh, SPI1.SPDCR 4007 210Bh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	SPBYT	SPLW	SPRDTD	—	—	SPFC[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	SPFC[1:0]	Number of Frames Specification	b1 b0 0 0: 1 frame 0 1: 2 frames 1 0: 3 frames 1 1: 4 frames.	R/W
b3, b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	SPRDTD	SPI Receive/Transmit Data Select	0: Read SPDR/SPDR_HA values from the receive buffer 1: Read SPDR/SPDR_HA values from the transmit buffer, but only if the transmit buffer is empty.	R/W
b5	SPLW	SPI Word Access/Halfword Access Specification	0: Set SPDR_HA to valid for halfword access 1: Set SPDR to valid for word access.	R/W
b6	SPBYT	SPI Byte Access Specification	0: SPDR is accessed in halfword or word (SPLW is valid) 1: SPDR is accessed in byte (SPLW is invalid).	R/W
b7	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

Up to four frames can be transmitted or received in one round of transmission or reception. The amount of data in each transfer is controlled by the combination of the SPCMDm.SPB[3:0] bits, SPSCR.SPSLN[2:0] bits, and SPDCR.SPFC[1:0] bits.

When changing the SPDCR.SPFC[1:0] bits while the SPCR.SPE bit is 1, always check that the SPSR.IDLNF flag is 0.

SPFC[1:0] bits (Number of Frames Specification)

The SPFC[1:0] bits specify the number of frames that can be stored in SPDR/SPDR_HA per transfer activation. Up to four frames can be transmitted or received in one round of transmission or reception.

When the number of transmission data frames specified in the SPFC[1:0] bits is written to the SPDR/SPDR_HA register, the SPI clears the SPSR.SPTEF flag to 0 and begins transmitting. After that, when the number of transmission data frames specified in the SPFC[1:0] bits is transmitted to the shift register, the SPI generates the transmit buffer empty interrupt (SPSR.SPTEF is set to 1).

When the number of data frames specified in the SPFC[1:0] bits is received, the SPI generates a receive buffer full interrupt (SPSR.SPRF is set to 1).

Table 31.3 SPBR设置、BRDV[1:0]设置和比特率之间的关系(2of2)

SPBR (n)	BRDV[1:0] bits (N)	分工比	比特率							
			PCLKA = 32 MHz	PCLKA = 36 MHz	PCLKA = 40 MHz	PCLKA = 50 MHz	PCLKA = 60 MHz	PCLKA = 80 MHz	PCLKA = 100 MHz	PCLKA = 120 MHz
2	0	6	5.33 Mbps	6.00 Mbps	6.67 Mbps	8.33 Mbps	10.0 Mbps	13.3 Mbps	16.7 Mbps	20.0 Mbps
3	0	8	4.00 Mbps	4.50 Mbps	5.00 Mbps	6.25 Mbps	7.50Mbps	10.0 Mbps	12.5 Mbps	15.0 Mbps
4	0	10	3.20 Mbps	3.60 Mbps	4.00 Mbps	5.00 Mbps	6.00 Mbps	8.00 Mbps	10.0 Mbps	12.0 Mbps
5	0	12	2.67 Mbps	3.00 Mbps	3.33 Mbps	4.16 Mbps	5.00 Mbps	6.67 Mbps	8.33 Mbps	10.0 Mbps
5	1	24	1.33 Mbps	1.50 Mbps	1.67 Mbps	2.08 Mbps	2.50 Mbps	3.33 Mbps	4.17 Mbps	5.00 Mbps
5	2	48	667 kbps	750 kbps	833 kbps	1.04 Mbps	1.25 Mbps	1.67 Mbps	2.08 Mbps	2.50 Mbps
5	3	96	333 kbps	375 kbps	417 kbps	521 kbps	625 kbps	833 kbps	1.04 Mbps	1.25 Mbps
255	3	4096	7.81 kbps	8.80 kbps	9.78 kbps	12.2 kbps	14.6 kbps	19.5 kbps	24.4 kbps	29.3 kbps

31.2.9 SPI数据控制寄存器(SPDCR)

Address(es): SPI0.SPDCR 4007 200Bh, SPI1.SPDCR 4007 210Bh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	SPBYT	SPLW	SPRDTD	—	—	SPFC[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	SPFC[1:0]	帧数 Specification	b1b000：1帧0 1：2帧10：3 帧11：4帧。	R/W
b3, b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	SPRDTD	SPI接收发送数据 Select	0：从接收缓冲区读取SPDRSPDR_HA值1：从发送缓冲区读取SPDRSPDR_HA值，但前提是发送缓冲区为空。	R/W
b5	SPLW	SPI字访问半字 访问规范	0：将SPDR_HA设置为对半字访问有效1：将SPDR设置为对字访问有效。	R/W
b6	SPBYT	SPI字节访问规范	0：SPDR按半字或字访问（SPLW有效）1：SPDR按字节访问（SPLW无效）。	R/W
b7	—	Reserved	该位读取为0。写入值应为0。	R/W

在一轮发送或接收中最多可以发送或接收四帧。每次传输中的数据量由SPCMDm.SPB[3:0]位、SPSCR.SPSLN[2:0]位和SPDCR.SPFC[1:0]位的组合控制。

在SPCR.SPE位为1时更改SPDCR.SPFC[1:0]位时，请始终检查SPSR.IDLNF标志是否为0。

SPFC[1:0]位（帧数规范）

SPFC[1:0]位指定每次传输激活时可以存储在SPDRSPDR_HA中的帧数。在一轮发送或接收中最多可以发送或接收四帧。

当SPFC[1:0]位中指定的传输数据帧数写入SPDRSPDR_HA寄存器时，SPI将SPSR.SPTEF标志清零并开始传输。之后，当SPFC[1:0]位中指定的发送数据帧数被发送到移位寄存器时，SPI产生发送缓冲区空中断（SPSR.SPTEF设置为1）。

当接收到SPFC[1:0]位中指定的数据帧数时，SPI产生接收缓冲区满中断（SPSR.SPRF设置为1）。

Table 31.4 Settable combinations of the SPSLN[2:0] and SPFC[1:0] bits

Setting	SPSLN[2:0]	SPFC[1:0]	Number of frames in a single sequence	Number of frames at which transmit or receive buffer is filled
1-1	000b	00b	1	1
1-2	000b	01b	2	2
1-3	000b	10b	3	3
1-4	000b	11b	4	4
2-1	001b	01b	2	2
2-2	001b	11b	4	4
3	010b	10b	3	3
4	011b	11b	4	4
5	100b	00b	5	1
6	101b	00b	6	1
7	110b	00b	7	1
8	111b	00b	8	1

SPRDTD bit (SPI Receive/Transmit Data Select)

The SPRDTD bit selects whether the SPDR/SPDR_HA reads values from the receive buffer or from the transmit buffer.

If reading is from the transmit buffer, the last value written to the SPDR/SPDR_HA register is read. Read the transmit buffer before the writing of the number of frames set in the SPFC[1:0] bits is finished and after the generation of the transmit buffer empty interrupt (when SPSR.SPTEF is 1).

For details, see section 31.2.5, SPI Data Register (SPDR/SPDR_HA).

SPLW bit (SPI Word Access/Halfword Access Specification)

The SPLW bit specifies the access width for SPDR. Access to SPDR_HA in halfwords is valid when the SPLW bit is 0 and access to SPDR in words is valid when the SPLW bit is 1. Also, when the SPLW bit is 0, set the SPI data length setting bits, SPCMDm.SPB[3:0]), from 8 to 16 bits. Do not perform any operations when a data length of 20, 24, or 32 bits is specified.

SPBYT bit (SPI Byte Access Specification)

The SPBYT bit is used to set the data width of access to the SPI Data Register (SPDR). When SPBYT is 0, use word or half word access to SPDR. When SPBYT is 1 (SPLW is invalid), use byte access to SPDR.

When SPBYT is 1, set the SPI Data Length Setting (SPB[3:0]) bits in the SPI Command Register n (SPCMDn) to 0 bits. If SPB[3:0] are set to 9 to 16, 20, 24, or 32 bits, subsequent operation is not guaranteed.

Table 31.4 SPSLN[2:0]和SPFC[1:0]位的可设置组合

Setting	SPSLN[2:0]	SPFC[1:0]	单个序列中的帧数	填充发送或接收缓冲区的帧数
1-1	000b	00b	1	1
1-2	000b	01b	2	2
1-3	000b	10b	3	3
1-4	000b	11b	4	4
2-1	001b	01b	2	2
2-2	001b	11b	4	4
3	010b	10b	3	3
4	011b	11b	4	4
5	100b	00b	5	1
6	101b	00b	6	1
7	110b	00b	7	1
8	111b	00b	8	1

SPRDTD位（SPI接收发送数据选择）

SPRDTD位选择SPDRSPDR_HA是从接收缓冲区还是从发送缓冲区读取值。

如果从发送缓冲区读取，则读取写入SPDRSPDR_HA寄存器的最后一个值。在SPFC[1:0]位中设置的帧数写入完成之前以及在发送缓冲区空中断产生之后（当SPSR.SPTEF为1时）读取发送缓冲区。

有关详细信息，请参阅第31.2.5节，SPI数据寄存器(SPDRSPDR_HA)。

SPLW位（SPI字访问半字访问规范）

SPLW位指定SPDR的访问宽度。当SPLW位为0时，以半字访问SPDR_HA有效，当SPLW位为1时，以字访问SPDR有效。另外，当SPLW位为0时，设置SPI数据长度设置位，SPCMDm.SPB[3:0])，从8位到16位。当指定数据长度为20、24或32位时，请勿执行任何操作。

SPBYT位（SPI字节访问规范）

SPBYT位用于设置访问SPI数据寄存器(SPDR)的数据宽度。当SPBYT为0时，使用字或半字访问SPDR。当SPBYT为1（SPLW无效）时，使用字节访问SPDR。

当SPBYT为1时，将SPI命令寄存器n(SPCMDn)中的SPI数据长度设置(SPB[3:0])位设置为0位。
如果SPB[3:0]设置为9至16、20、24或32位，则无法保证后续操作。

31.2.10 SPI Clock Delay Register (SPCKD)

Address(es): SPI0.SPCKD 4007 200Ch, SPI1.SPCKD 4007 210Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SCKDL[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	SCKDL[2:0]	RSPCK Delay Setting	b2 b0 0 0 0: 1 RSPCK 0 0 1: 2 RSPCK 0 1 0: 3 RSPCK 0 1 1: 4 RSPCK 1 0 0: 5 RSPCK 1 0 1: 6 RSPCK 1 1 0: 7 RSPCK 1 1 1: 8 RSPCK.	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

SPCKD specifies the RSPCK delay, the period from the beginning of SSLni signal assertion to RSPCK oscillation, when the SPCMDm.SCKDEN bit is 1. If the contents of SPCKD are changed while both the SPCR.MSTR and SPCR.SPE bits are 1, do not perform subsequent operations.

SCKDL[2:0] bits (RSPCK Delay Setting)

The SCKDL[2:0] bits specify an RSPCK delay value when the SPCMDm.SCKDEN bit is 1. When using the SPI in slave mode, set the SCKDL[2:0] bits to 000b.

31.2.11 SPI Slave Select Negation Delay Register (SSLND)

Address(es): SPI0.SSLND 4007 200Dh, SPI1.SSLND 4007 210Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SLNDL[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	SLNDL[2:0]	SSL Negation Delay Setting	b2 b0 0 0 0: 1 RSPCK 0 0 1: 2 RSPCK 0 1 0: 3 RSPCK 0 1 1: 4 RSPCK 1 0 0: 5 RSPCK 1 0 1: 6 RSPCK 1 1 0: 7 RSPCK 1 1 1: 8 RSPCK.	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

SSLND specifies the SSL negation delay, the period from the transmission of a final RSPCK edge to the negation of the SSLni signal during a serial transfer by the SPI in master mode. If the contents of SSLND are changed while both the SPCR.MSTR and SPCR.SPE bits are 1, do not perform subsequent operations.

SLNDL[2:0] bits (SSL Negation Delay Setting)

The SLNDL[2:0] bits specify an SSL negation delay value when the SPI is in master mode. When using the SPI in slave mode, set the SLNDL[2:0] bits to 000b.

31.2.10 SPI时钟延迟寄存器(SPCKD)

Address(es): SPI0.SPCKD 4007 200Ch, SPI1.SPCKD 4007 210Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SCKDL[2:0]		
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	SCKDL[2:0]	RSPCK延迟设置	b2 b0 0 0 0: 1 RSPCK 0 0 1: 2 RSPCK 0 1 0: 3 RSPCK 0 1 1: 4 RSPCK 1 0 0: 5 RSPCK 1 0 1: 6 RSPCK 1 1 0: 7 RSPCK 1 1 1: 8 RSPCK.	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SPCKD指定RSPCK延迟，即从SSLni信号断言开始到RSPCK振荡的周期，当SPCMDm.SCKDEN位为1时。如果SPCKD的内容在SPCR.MSTR和SPCR.SPE位都为1时改变，请不进行后续操作。

SCKDL[2:0]位（RSPCK延迟设置）

当SPCMDm.SCKDEN位为1时，SCKDL[2:0]位指定RSPCK延迟值。在从机模式下使用SPI时，将SCKDL[2:0]位设置为000b。

31.2.11 SPI从机选择否定延迟寄存器(SSLND)

Address(es): SPI0.SSLND 4007 200Dh, SPI1.SSLND 4007 210Dh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SLNDL[2:0]		
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	SLNDL[2:0]	SSL否定延迟设置	b2 b0 0 0 0: 1 RSPCK 0 0 1: 2 RSPCK 0 1 0: 3 RSPCK 0 1 1: 4 RSPCK 1 0 0: 5 RSPCK 1 0 1: 6 RSPCK 1 1 0: 7 RSPCK 1 1 1: 8 RSPCK.	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SSLND指定SSL否定延迟，从传输最终RSPCK边缘到否定SPI在主模式下进行串行传输期间的SSLni信号。如果SSLND的内容发生更改，而SPCR.MSTR和SPCR.SPE位为1，不执行后续操作。

SLNDL[2:0]位（SSL否定延迟设置）

当SPI处于主模式时，SLNDL[2:0]位指定SSL否定延迟值。在从机模式下使用SPI时，将SLNDL[2:0]位设置为000b。

31.2.12 SPI Next-Access Delay Register (SPND)

Address(es): SPI0.SPND 4007 200Eh, SPI1.SPND 4007 210Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SPNDL[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	SPNDL[2:0]	SPI Next-Access Delay Setting	b2 b0 0 0 0: 1 RSPCK + 2 PCLKA 0 0 1: 2 RSPCK + 2 PCLKA 0 1 0: 3 RSPCK + 2 PCLKA 0 1 1: 4 RSPCK + 2 PCLKA 1 0 0: 5 RSPCK + 2 PCLKA 1 0 1: 6 RSPCK + 2 PCLKA 1 1 0: 7 RSPCK + 2 PCLKA 1 1 1: 8 RSPCK + 2 PCLKA.	R/W
b7 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

SPND specifies the next-access delay, the non-active period of the SSLni signal after termination of a serial transfer, when the SPCMDm.SPNDEN bit is 1. If the contents of SPND are changed while both the SPCR.MSTR and SPCR.SPE bits are 1, do not perform subsequent operations.

SPNDL[2:0] bits (SPI Next-Access Delay Setting)

The SPNDL[2:0] bits specify a next-access delay when the SPCMDm.SPNDEN bit is 1. When using the SPI in slave mode, set the SPNDL[2:0] bits to 000b.

31.2.13 SPI Control Register 2 (SPCR2)

Address(es): SPI0.SPCR2 4007 200Fh, SPI1.SPCR2 4007 210Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SCKASE	PTE	SPIIE	SPOE	SPPE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SPPE	Parity Enable	0: No parity bit added to transmit data and parity bit of receive data not checked 1: When SPCR.TXMD = 0, parity bit added to transmit data and parity bit of receive data checked When SPCR.TXMD = 1, parity bit added to transmit data but parity bit of receive data not checked.	R/W
b1	SPOE	Parity Mode	0: Even parity selected for transmission and reception 1: Odd parity selected for transmission and reception.	R/W
b2	SPIIE	SPI Idle Interrupt Enable	0: Idle interrupt requests disabled 1: Idle interrupt requests enabled.	R/W
b3	PTE	Parity Self-Testing	0: Self-diagnosis function of the parity circuit disabled 1: Self-diagnosis function of the parity circuit enabled.	R/W
b4	SCKASE	RSPCK Auto-Stop Function Enable	0: RSPCK auto-stop function disabled 1: RSPCK auto-stop function enabled.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

If the SPPE, SPOE, or SCKASE bit in SPCR2 is changed while the SPCR.SPE bit is 1, do not perform subsequent operations.

31.2.12 SPI下一次访问延迟寄存器(SPND)

Address(es): SPI0.SPND 4007 200Eh, SPI1.SPND 4007 210Eh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SPNDL[2:0]		
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	SPNDL[2:0]	SPI下一次访问延迟设置	b2 b0 0 0 0: 1 RSPCK + 2 PCLKA 0 0 1: 2 RSPCK + 2 PCLKA 0 1 0: 3 RSPCK + 2 PCLKA 0 1 1: 4 RSPCK + 2 PCLKA 1 0 0: 5 RSPCK + 2 PCLKA 1 0 1: 6 RSPCK + 2 PCLKA 1 1 0: 7 RSPCK + 2 PCLKA 1 1 1: 8 RSPCK + 2 PCLKA.	R/W
b7 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W

当SPCMDm.SPNDEN位为1时，SPND指定下一次访问延迟，即串行传输终止后SSLni信号的非活动周期。如果在SPCR.MSTR和SPCR.SPE都更改了SPND的内容位为1，不执行后续操作。

SPNDL[2:0]位（SPI下一次访问延迟设置）

当SPMDm.SPNDEN位为1时，SPNDL[2:0]位指定下一次访问延迟。在从机模式下使用SPI时，将SPNDL[2:0]位设置为000b。

31.2.13 SPI控制寄存器2(SPCR2)

Address(es): SPI0.SPCR2 4007 200Fh, SPI1.SPCR2 4007 210Fh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	SCKASE	PTE	SPIIE	SPOE	SPPE
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SPPE	奇偶校验使能	0：发送数据不添加奇偶校验位，接收数据不检查奇偶校验位1：当SPCR.TXMD=0时，发送数据添加奇偶校验位，接收数据检查奇偶校验位当SPCR.TXMD=1时，奇偶校验位添加到发送数据但未检查接收数据的奇偶校验位。	R/W
b1	SPOE	奇偶校验模式	0：发送和接收选择偶校验1：发送和接收选择奇校验。	R/W
b2	SPIIE	SPI空闲中断使能	0：禁止空闲中断请求1：允许空闲中断请求。	R/W
b3	PTE	Parity Self-Testing	0：奇偶电路自诊断功能无效1：奇偶电路自诊断功能有效。	R/W
b4	SCKASE	RSPCK Auto-Stop Function Enable	0：RSPCK自动停机功能无效1：RSPCK自动停机功能有效。	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

如果SPCR.SPE位为1时SPCR2中的SPPE、SPOE或SCKASE位发生变化，则不要执行后续操作。

SPPE bit (Parity Enable)

The SPPE bit enables or disables the parity function.

When the SPCR.TXMD bit is 0 and this bit is 1, the parity bit is added to transmit data and parity checking is performed for receive data.

When the SPCR.TXMD bit is 1 and this bit is 1, the parity bit is added to transmit data but parity checking is not performed for receive data.

SPOE bit (Parity Mode)

The SPOE bit specifies odd or even parity.

When even parity is set, parity bit addition is performed so that the total number of bits whose value is 1 in the transmit or receive character plus the parity bit is even. Similarly, when odd parity is set, parity bit addition is performed so that the total number of bits whose value is 1 in the transmit or receive character plus the parity bit is odd.

The SPOE bit is only valid when the SPPE bit is 1.

SPIIE bit (SPI Idle Interrupt Enable)

The SPIIE bit enables or disables the generation of SPI idle interrupt requests when an idle state is detected in the SPI and the SPSR.IDLNF flag is set to 0.

PTE bit (Parity Self-Testing)

The PTE bit enables self-diagnosis of the parity circuit to check whether the parity function is operating correctly.

SCKASE bit (RSPCK Auto-Stop Function Enable)

The SCKASE bit enables or disables the RSPCK auto-stop function. When this function is enabled, the RSPCK clock is stopped before an overrun error occurs, when data is received in master mode. For details, see section 31.3.8.1, Overrun errors.

31.2.14 SPI Command Registers 0 to 7 (SPCMD0 to SPCMD7)

Address(es): SPI0.SPCMD0 4007 2010h, SPI0.SPCMD1 4007 2012h, SPI0.SPCMD2 4007 2014h, SPI0.SPCMD3 4007 2016h, SPI0.SPCMD4 4007 2018h, SPI0.SPCMD5 4007 201Ah, SPI0.SPCMD6 4007 201Ch, SPI0.SPCMD7 4007 201Eh, SPI1.SPCMD0 4007 2110h, SPI1.SPCMD1 4007 2112h, SPI1.SPCMD2 4007 2114h, SPI1.SPCMD3 4007 2116h, SPI1.SPCMD4 4007 2118h, SPI1.SPCMD5 4007 211Ah, SPI1.SPCMD6 4007 211Ch, SPI1.SPCMD7 4007 211Eh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SCKDEN	SLNDEN	SPNDEN	LSBF	SPB[3:0]				SSLKP	SSLA[2:0]			BRDV[1:0]		CPOL	CPHA
Value after reset:	0	0	0	0	0	1	1	1	0	0	0	0	1	1	0	1

Bit	Symbol	Bit name	Description	R/W
b0	CPHA	RSPCK Phase Setting	0: Select data sampling on leading edge, data change on trailing edge 1: Select data change on leading edge, data sampling on trailing edge.	R/W
b1	CPOL	RSPCK Polarity Setting	0: Set RSPCK low when idle 1: Set RSPCK high when idle.	R/W
b3, b2	BRDV[1:0]	Bit Rate Division Setting	b3 b2 0 0: Select the base bit rate 0 1: Select the base bit rate divided by 2 1 0: Select the base bit rate divided by 4 1 1: Select the base bit rate divided by 8.	R/W
b6 to b4	SSLA[2:0]	SSL Signal Assertion Setting	b6 b4 0 0 0: SSL0 0 0 1: SSL1 0 1 0: SSL2 0 1 1: SSL3 1 x x: Setting prohibited x: Don't care.	R/W

SPPE位（奇偶校验使能）

SPPE位启用或禁用奇偶校验功能。

当SPCR.TXMD位为0且该位为1时，发送数据添加奇偶校验位，接收数据执行奇偶校验。

当SPCR.TXMD位为1且该位为1时，发送数据添加奇偶校验位，但接收数据不执行奇偶校验。

SPOE位（奇偶校验模式）

SPOE位指定奇校验或偶校验。

当设置了偶校验时，执行奇偶校验位相加，以使发送或接收字符中值为1的总位数加上奇偶校验位为偶数。类似地，当设置奇校验时，执行校验位相加，使得发送或接收字符中值为1的位加上奇偶校验位的总数为奇数。

SPOE位仅在SPPE位为1时有效。

SPIIE位（SPI空闲中断使能）

当在SPI中检测到空闲状态并且SPSR.IDLNF标志设置为0时，SPIIE位启用或禁用SPI空闲中断请求的生成。

PTE位（奇偶自检）

PTE位启用奇偶校验电路的自诊断，以检查奇偶校验功能是否正常运行。

SCKASE位（RSPCK自动停止功能使能）

SCKASE位启用或禁用RSPCK自动停止功能。启用此功能后，在主机模式下接收数据时，RSPCK时钟会在发生溢出错误之前停止。有关详细信息，请参阅第31.3.8.1节，溢出错误。

31.2.14 SPI命令寄存器0到7(SPCMD0到SPCMD7)

Address(es): SPI0.SPCMD0 4007 2010h, SPI0.SPCMD1 4007 2012h, SPI0.SPCMD2 4007 2014h, SPI0.SPCMD3 4007 2016h, SPI0.SPCMD4 4007 2018h, SPI0.SPCMD5 4007 201Ah, SPI0.SPCMD6 4007 201Ch, SPI0.SPCMD7 4007 201Eh, SPI1.SPCMD0 4007 2110h, SPI1.SPCMD1 4007 2112h, SPI1.SPCMD2 4007 2114h, SPI1.SPCMD3 4007 2116h, SPI1.SPCMD4 4007 2118h, SPI1.SPCMD5 4007 211Ah, SPI1.SPCMD6 4007 211Ch, SPI1.SPCMD7 4007 211Eh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	SCKDEN	SLNDEN	SPNDEN	LSBF	SPB[3:0]				SSLKP	SSLA[2:0]			BRDV[1:0]		CPOL	CPHA
重置后的值:	0	0	0	0	0	1	1	1	0	0	0	0	1	1	0	1

Bit	Symbol	位名称	Description	R/W
b0	CPHA	RSPCK相位设置	0：选择前沿数据采样，后沿数据变化1：选择前沿数据变化，后沿数据采样。	R/W
b1	CPOL	RSPCK极性设置	0：空闲时将RSPCK设置为低1 ：空闲时将RSPCK设置为高。	R/W
b3, b2	BRDV[1:0]	比特率划分设置	b3b200：选择基本比特率01：选择基本比特率除以210：选择基本比特率除以411：选择基本比特率除以8。	R/W
b6 to b4	SSLA[2:0]	SSL信号断言设置	b6b4000：SSL0001：SSL1010：SSL2011：SSL31xx：设置禁止x：无关。	R/W

Bit	Symbol	Bit name	Description	R/W
b7	SSLKP	SSL Signal Level Keeping	0: Negate all SSL signals on completion of transfer 1: Keep the SSL signal level from the end of transfer until the beginning of the next access.	R/W
b11 to b8	SPB[3:0]	SPI Data Length Setting	b11 b8 0100 to 0111: 8 bits 1 0 0 0: 9 bits 1 0 0 1: 10 bits 1 0 1 0: 11 bits 1 0 1 1: 12 bits 1 1 0 0: 13 bits 1 1 0 1: 14 bits 1 1 1 0: 15 bits 1 1 1 1: 16 bits 0 0 0 0: 20 bits 0 0 0 1: 24 bits 0010, 0011: 32 bits.	R/W
b12	LSBF	SPI LSB First	0: MSB-first 1: LSB-first.	R/W
b13	SPNDEN	SPI Next-Access Delay Enable	0: Select next-access delay of 1 RSPCK + 2 PCLKA 1: Select next-access delay equal to the setting in the SPI Next-Access Delay Register (SPND).	R/W
b14	SLNDEN	SSL Negation Delay Setting Enable	0: Select SSL negation delay of 1 RSPCK 1: Select SSL negation delay equal to the setting in the SPI Slave Select Negation Delay register (SSLND).	R/W
b15	SCKDEN	RSPCK Delay Setting Enable	0: Select RSPCK delay of 1 RSPCK 1: Select RSPCK delay equal to the setting in the SPI Clock Delay register (SPCKD).	R/W

The SPCMDm registers specify the transfer format for the SPI in master mode. Each SPI channel has eight SPI Command registers (SPCMD0 to SPCMD7). Some of the bits in the SPCMD0 register are used to set the transfer mode for the SPI in slave mode. The SPI in master mode sequentially references the SPCMDm registers based on the settings in the SPSCR.SPSLN[2:0] bits and executes the serial transfer that is set in the referenced SPCMDm register.

Set the SPCMDm registers while the transmit buffer is empty (SPSR.SPTEF is 1 and the data for the next transfer is not set), and before the setting of the data to be transmitted when that SPCMDm register is referenced.

The SPCMDm register referenced by the SPI in master mode can be checked with the SPSSR.SPCP[2:0] bits. If the contents of SPCMDm are changed while the SPCR.MSTR bit is 0 and the SPCR.SPE bit is 1, do not perform subsequent operations.

CPHA bit (RSPCK Phase Setting)

The CPHA bit selects the RSPCK phase of the SPI in master or slave mode. Data communications between SPI modules require the same RSPCK phase setting between the modules.

CPOL bit (RSPCK Polarity Setting)

The CPOL bit selects the RSPCK polarity of the SPI in master or slave mode. Data communications between SPI modules require the same RSPCK polarity setting between the modules.

BRDV[1:0] bits (Bit Rate Division Setting)

The BRDV[1:0] bits determine the bit rate by combination of the settings in the BRDV[1:0] bits and the SPBR register (see section 31.2.8, SPI Bit Rate Register (SPBR)). The SPBR settings determine the base bit rate. The BRDV[1:0] settings select a bit rate obtained by dividing the base bit rate by 1, 2, 4, or 8. Different BRDV[1:0] bit settings can be specified in the SPCMDm registers, enabling the execution of serial transfers at a different bit rate for each command.

SSLA[2:0] bits (SSL Signal Assertion Setting)

The SSLA[2:0] bits control the SSLni signal assertion when the SPI performs serial transfers in master mode. When an SSLni signal is asserted, its polarity is determined by the value set in the associated SSLP. When the SSLA[2:0] bits are set to 000b in multi-master mode, serial transfers are performed with all the SSL signals in the negated state, as the SSLn0 pin acts as input. When using the SPI in slave mode, set the SSLA[2:0] bits to 000b.

Bit	Symbol	位名称	Description	R/W
b7	SSLKP	SSL信号电平保持	0：在传输完成时否定所有SSL信号1：从传输结束到下一次访问开始时保持SSL信号电平。	R/W
b11 to b8	SPB[3:0]	SPI数据长度设置	b11b80100到0111：8位1000：9位1001：10位1010：11位1011：12位1100：13位1101：14位1110：15位1111：16位0000：20位0001：24位0010、0011：32位。	R/W
b12	LSBF	SPILSB优先	0: MSB-first 1: LSB-first.	R/W
b13	SPNDEN	SPI下一次访问延迟Enable	0：选择下一次访问延迟1RSPCK+2PCLKA1：选择下一次访问延迟等于SPI下一次访问延迟寄存器(SPND)中的设置。	R/W
b14	SLNDEN	SSL否定延迟设置Enable	0：选择SSL否定延迟为1RSPCK1：选择SSL否定延迟等于SPI从器件选择否定延迟寄存器(SSLND)中的设置。	R/W
b15	SCKDEN	RSPCK延迟设置启用	0：选择RSPCK延迟为1RSPCK1：选择RSPCK延迟等于SPI时钟延迟寄存器(SPCKD)中的设置。	R/W

SPCMDm寄存器指定主模式下SPI的传输格式。每个SPI通道有8个SPI命令寄存器（SPCMD0到SPCMD7）。SPCMD0寄存器中的一些位用于设置SPI在从机模式下的传输模式。主模式下的SPI根据SPSCR.SPSLN[2:0]位中的设置顺序引用SPCMDm寄存器，并执行在引用的SPCMDm寄存器中设置的串行传输。

在发送缓冲区为空时（SPSR.SPTEF为1，未设置下一次传输的数据）设置SPCMDm寄存器，并且在设置要发送的数据之前，当引用该SPCMDm寄存器时。

SPI在主模式下引用的SPCMDm寄存器可以通过SPSSR.SPCP[2:0]位进行检查。如果在SPCR.MSTR位为0且SPCR.SPE位为1时改变了SPCMDm的内容，则不要执行后续操作。

CPHA位（RSPCK相位设置）

CPHA位在主模式或从模式下选择SPI的RSPCK相位。SPI模块之间的数据通信需要模块之间相同的RSPCK相位设置。

CPOL位（RSPCK极性设置）

CPOL位在主模式或从模式下选择SPI的RSPCK极性。SPI模块之间的数据通信要求模块之间的RSPCK极性设置相同。

BRDV[1:0]位（比特率划分设置）

BRDV[1:0]位通过组合BRDV[1:0]位和SPBR寄存器中的设置来确定比特率（参见第31.2.8节，SPI比特率寄存器(SPBR)）。SPBR设置决定了基本比特率。BRDV[1:0]设置选择通过将基本比特率除以1、2、4或8获得的比特率。可以在SPCMDm寄存器中指定不同的BRDV[1:0]位设置，从而可以执行每个命令以不同的比特率进行串行传输。

SSLA[2:0]位（SSL信号断言设置）

当SPI在主模式下执行串行传输时，SSLA[2:0]位控制SSLni信号断言。当SSLni信号被置位时，其极性由相关SSLP中设置的值确定。当SSLA[2:0]位在多主机模式下设置为000b时，所有SSL信号都在否定状态下执行串行传输，因为SSLn0引脚用作输入。在从机模式下使用SPI时，将SSLA[2:0]位设置为000b。

SSLKP bit (SSL Signal Level Keeping)

When the SPI in master mode performs a serial transfer, the SSLKP bit specifies whether the SSLni signal level for the current command is to be kept or negated between the SSL negation associated with the current command and the SSL assertion timing associated with the next command.

Setting the SSLKP bit to 1 enables a burst transfer. For details, see (4) Burst transfers in section 31.3.10.1, Master mode operation. When using the SPI in slave mode, set the SSLKP bit to 0.

SPB[3:0] bits (SPI Data Length Setting)

The SPB[3:0] bits specify the transfer data length for the SPI in master or slave mode. When the SPLW bit is 0, set these bits from 8 to 16 bits.

LSBF bit (SPI LSB First)

The LSBF bit specifies the data format of the SPI in master or slave mode to MSB-first or LSB-first.

SPNDEN bit (SPI Next-Access Delay Enable)

The SPNDEN bit specifies the next-access delay, the period from the time the SPI in master mode terminates a serial transfer and sets the SSLni signal inactive until the SPI enables the SSLni signal assertion for the next access. If the SPNDEN bit is 0, the SPI sets the next-access delay to 1 RSPCK + 2 PCLKA. If the SPNDEN bit is 1, the SPI inserts a next-access delay in accordance with the SPND setting.

When using the SPI in slave mode, set the SPNDEN bit to 0.

SLNDEN bit (SSL Negation Delay Setting Enable)

The SLNDEN bit specifies the SSL negation delay, the period from the time the SPI in master mode stops RSPCK oscillation until the SPI sets the SSLni signal to inactive. If the SLNDEN bit is 0, the SPI sets the SSL negation delay to 1 RSPCK. If the SLNDEN bit is 1, the SPI negates the SSL signal at an SSL negation delay according to the SSLND setting.

When using the SPI in slave mode, set the SLNDEN bit to 0.

SCKDEN bit (RSPCK Delay Setting Enable)

The SCKDEN bit specifies the SPI clock delay, the period from the point when the SPI in master mode asserts the SSLni signal until the RSPCK starts oscillation (SPI clock delay). If the SCKDEN bit is 0, the SPI sets the RSPCK delay to 1 RSPCK. If the SCKDEN bit is 1, the SPI starts the oscillation of RSPCK at an RSPCK delay according to the SPCKD setting.

When using the SPI in slave mode, set the SCKDEN bit to 0.

31.2.15 SPI Data Control Register 2 (SPDCR2)

Address(es): SPI0.SPDCR2 4007 2020h, SPI1.SPDCR2 4007 2120h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	BYSW
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	BYSW	Byte Swap Operating Mode Select	0: Byte swap off 1: Byte swap on.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

SPI Data Control Register 2 (SPDCR2) swaps the transmit or receive data in byte units. When transmit buffer data is copied to a shift register, it is swapped in byte units. When shift register data is copied to a receive buffer, it is swapped in byte units.

SSLKP位（SSL信号电平保持）

当主模式的SPI执行串行传输时，SSLKP位指定当前命令的SSLni信号电平是在与当前命令关联的SSL否定和与下一个命令关联的SSL断言时序之间保持还是否定。

将SSLKP位设置为1可启用突发传输。有关详细信息，请参阅第31.3.10.1节，主模式操作中的(4)突发传输。在从机模式下使用SPI时，将SSLKP位设置为0。

SPB[3:0]位（SPI数据长度设置）

SPB[3:0]位指定SPI在主模式或从模式下的传输数据长度。当SPLW位为0时，将这些位设置为8至16位。

LSBF位（SPILSB优先）

LSBF位指定SPI在主模式或从模式下的数据格式为MSB优先或LSB优先。

SPNDEN位（SPI下一次访问延迟使能）

SPNDEN位指定下一次访问延迟，即从主模式下的SPI终止串行传输并将SSLni信号设置为无效到SPI为下一次访问启用SSLni信号断言的时间段。如果SPNDEN位为0，则SPI将下一次访问延迟设置为1RSPCK+2PCLKA。如果SPNDEN位为1，则SPI根据SPND设置插入下一次访问延迟。

在从机模式下使用SPI时，将SPNDEN位设置为0。

SLNDEN位（SSL否定延迟设置启用）

SLNDEN位指定SSL否定延迟，即从主模式下的SPI停止RSPCK振荡到SPI将SSLni信号设置为无效的时间段。如果SLNDEN位为0，则SPI将SSL否定延迟设置为1RSPCK。如果SLNDEN位为1，则SPI根据SSLND设置以SSL否定延迟否定SSL信号。

在从机模式下使用SPI时，将SLNDEN位设置为0。

SCKDEN位（RSPCK延迟设置使能）

SCKDEN位指定SPI时钟延迟，即从主模式下的SPI断言SSLni信号到RSPCK开始振荡的时间段（SPI时钟延迟）。如果SCKDEN位为0，则SPI将RSPCK延迟设置为1RSPCK。如果SCKDEN位为1，则SPI根据SPCKD设置以RSPCK延迟启动RSPCK的振荡。

在从机模式下使用SPI时，将SCKDEN位设置为0。

31.2.15 SPI数据控制寄存器2(SPDCR2)

Address(es): SPI0.SPDCR2 4007 2020h, SPI1.SPDCR2 4007 2120h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	BYSW
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	BYSW	字节交换操作模式选择	0：字节交换关闭1 ：字节交换打开。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SPI数据控制寄存器2(SPDCR2)以字节为单位交换发送或接收数据。当发送缓冲区数据被复制到移位寄存器时，它以字节为单位进行交换。当移位寄存器数据被复制到接收缓冲区时，它以字节为单位进行交换。

BYSW bit (Byte Swap Operating Mode Select)

The BYSW bit swaps the transmit or receive data in byte units. When byte access is valid (SPDCR.SPBYT = 1), byte swap is invalid. When byte swap is valid, parity function is invalid (SPCR2.SPPE bit = 0). The BYSW bit can only be changed when the SPCR.SPE bit is 0.

Data after byte swap is different depending on the data length (setting of SPCMD.SPB[3:0]).

At byte swap, the data length must be set to 32 bits or 16 bits. If data length is set to other values such as 8 to 15, 20, 24 bit length, byte swap is not guaranteed. Before swap and after swap (data length is 32 bits or 16 bits), the values are as shown:

- For data length of 32 bits (SPB[3:0] = 0010 or 0011)

  Before swap: [31:24] [23:16] [15:8] [7:0]

  After swap: [7:0] [15:8] [23:16] [31:24]
- For data length data of 16 bits (SPB[3:0] = 1111)

  Before swap: [31:24] [23:16]

  After swap: [23:16] [31:24].

In byte access mode (SPDCR.SPBT = 1), byte swap setting is invalid.

When byte swap is valid, set the parity function to invalid (SPCR2.SPPE = 0). When the parity function is set to valid, the behavior is not guaranteed.

31.3 Operation

In this section, the *serial transfer period* refers to the period from the beginning of driving valid data to the fetching of the final valid data.

31.3.1 Overview of SPI Operation

The SPI is capable of synchronous serial transfers in the following modes:

- Slave mode (SPI operation)
- Single-master mode (SPI operation)
- Multi-master mode (SPI operation)
- Slave mode (clock synchronous operation)
- Master mode (clock synchronous operation).

The SPI mode can be selected with the MSTR, MODFEN, and SPMS bits in SPCR. Table 31.5 lists the relationship between the SPI modes and SPCR settings, and a description of each mode.

Table 31.5 Relationship between SPCR settings and SPI modes (1 of 2)

Mode	Slave (SPI operation)	Single-master (SPI operation)	Multi-master (SPI operation)	Slave (clock synchronous operation)	Master (clock synchronous operation)
MSTR bit setting	0	1	1	0	1
MODFEN bit setting	0 or 1	0	1	0	0
SPMS bit setting	0	0	0	1	1
RSPCKn signal	Input	Output	Output/Hi-Z	Input	Output
MOSIn signal	Input	Output	Output/Hi-Z	Input	Output
MISOn signal	Output/Hi-Z	Input	Input	Output	Input
SSLn0 signal	Input	Output	Input	Hi-Z*1	Hi-Z*1
SSLn1 to SSLn3 signals	Hi-Z*1	Output	Output/Hi-Z	Hi-Z*1	Hi-Z*1

BYSW位（字节交换操作模式选择）

BYSW位以字节为单位交换发送或接收数据。当字节访问有效时（SPDCR.SPBYT=1），字节交换无效。当字节交换有效时，奇偶校验功能无效（SPCR2.SPPE位=0）。BYSW位只能在SPCR.SPE位为0时更改。

字节交换后的数据因数据长度而异（SPCMD.SPB[3:0]的设置）。

在字节交换时，数据长度必须设置为32位或16位。如果数据长度设置为其他值，例如8到15、20、24位长度，则不保证字节交换。交换前和交换后（数据长度为32位或16位），取值如下：

- 对于32位的数据长度（SPB[3:0]=0010或0011）

  Before swap: [31:24] [23:16] [15:8] [7:0]

  After swap: [7:0] [15:8] [23:16] [31:24]
- 对于16位数据长度数据(SPB[3:0]=1111)

  Before swap: [31:24] [23:16]

  After swap: [23:16] [31:24].

在字节访问模式下（SPDCR.SPBT=1），字节交换设置无效。

当字节交换有效时，将奇偶校验功能设置为无效（SPCR2.SPPE=0）。当奇偶校验函数设置为有效时，不能保证行为。

31.3 Operation

在本节中，串行传输周期是指从开始驱动有效数据到获取最终有效数据的周期。

31.3.1 SPI操作概述

SPI能够在以下模式下进行同步串行传输：

- 从机模式（SPI操作）
- Single-master mode (SPI operation)
- Multi-master mode (SPI operation)
- 从机模式（时钟同步操作）
- 主模式（时钟同步操作）。

SPI模式可以通过SPCR中的MSTR、MODFEN和SPMS位进行选择。表31.5列出了SPI模式和SPCR设置之间的关系，以及每种模式的说明。

Table 31.5 SPCR设置和SPI模式之间的关系(1of2)

Mode	Slave (SPI operation)	Single-master (SPI operation)	Multi-master (SPI operation)	从机（时钟同步操作）	主控（时钟同步操作）
MSTR位设置	0	1	1	0	1
MODFEN位设置	0 or 1	0	1	0	0
SPMS位设置	0	0	0	1	1
RSPCKn signal	Input	Output	Output/Hi-Z	Input	Output
MOSIn signal	Input	Output	Output/Hi-Z	Input	Output
MISOn signal	Output/Hi-Z	Input	Input	Output	Input
SSLn0 signal	Input	Output	Input	Hi-Z*1	Hi-Z*1
SSLn1到SSLn3信号	Hi-Z*1	Output	Output/Hi-Z	Hi-Z*1	Hi-Z*1

Table 31.5 Relationship between SPCR settings and SPI modes (2 of 2)

Mode	Slave (SPI operation)	Single-master (SPI operation)	Multi-master (SPI operation)	Slave (clock synchronous operation)	Master (clock synchronous operation)
SSL polarity change function	Supported	Supported	Supported	-	-
Max transfer rate	PCLKA/4	PCLKA/2	PCLKA/2	PCLKA/4	PCLKA/2
Clock source	RSPCKn input	On-chip baud rate generator	On-chip baud rate generator	RSPCKn input	On-chip baud rate generator
Clock polarity	Two				
Clock phase	Two	Two	Two	One (CPHA = 1)	Two
First transfer bit	MSB/LSB				
Transfer data length	8 to 16, 20, 24, 32 bits				
Burst transfer	Possible (CPHA = 1)	Possible (CPHA = 0,1)	Possible (CPHA = 0,1)	-	-
RSPCK delay control	Not supported	Supported	Supported	Not supported	Supported
SSL negation delay control	Not supported	Supported	Supported	Not supported	Supported
Next-access delay control	Not supported	Supported	Supported	Not supported	Supported
Transfer trigger	SSL input active or RSPCK oscillation	Write to transmit buffer on generation of a transmit buffer empty interrupt request (SPTEF = 1)	Write to transmit buffer on generation of a transmit buffer empty interrupt request (SPTEF = 1)	RSPCK oscillation	Write to transmit buffer on generation of a transmit buffer empty interrupt request (SPTEF = 1)
Sequence control	Not supported	Supported	Supported	Not supported	Supported
Transmit buffer empty detection	Supported				
Receive buffer full detection	Supported*2				
Overrun error detection	Supported*2	Supported*2, *4	Supported*2, *4	Supported*2	Supported*2
Parity error detection	Supported*2,*3				
Mode fault error detection	Supported (MODFEN = 1)	Not supported	Supported	Not supported	Not supported
Underrun error detection	Supported	Not supported	Not supported	Supported	Not supported

Note 1. This function is not supported in this mode.
Note 2. When the SPCR.TXMD bit is 1, detection of receiver buffer full, overrun error, and parity error is not performed.
Note 3. When the SPCR2.SPPE bit is 0, parity error detection is not performed.
Note 4. When the SPCR2.SCKASE bit is 1, overrun error detection does not proceed.

31.3.2 Controlling the SPI Pins

The SPI can switch pin states based on the MSTR, MODFEN, and SPMS bit settings in SPCR and the PmnPFS.NCODR bit for the I/O ports. Table 31.6 lists the relationship between the pin states and bit settings. Setting the PmnPFS.NCODR bit for an I/O port to 0 selects the CMOS output. Setting it to 1 selects the open-drain output. The I/O port settings must follow this relationship.

Table 31.5 SPCR设置和SPI模式之间的关系(2of2)

Mode	Slave (SPI operation)	Single-master (SPI operation)	Multi-master (SPI operation)	从机（时钟同步操作）	主控（时钟同步操作）
SSL极性改变功能	Supported	Supported	Supported	-	-
最大传输率	PCLKA/4	PCLKA/2	PCLKA/2	PCLKA/4	PCLKA/2
时钟源	RSPCKn input	片上波特率发生器	片上波特率发生器	RSPCKn input	片上波特率发生器
时钟极性	Two				
时钟相位	Two	Two	Two	One (CPHA = 1)	Two
第一个传输位	MSB/LSB				
传输数据长度	8至16、20、24、32位				
突发传输	Possible (CPHA = 1)	Possible (CPHA = 0,1)	Possible (CPHA = 0,1)	-	-
RSPCK延迟控制	不支持	Supported	Supported	不支持	Supported
SSL否定延迟控制	不支持	Supported	Supported	不支持	Supported
下一次访问延迟控制	不支持	Supported	Supported	不支持	Supported
转移触发	SSL输入有效或RSPCK振荡	在产生发送缓冲区空中断请求时写入发送缓冲区(SPTEF=1)	在产生发送缓冲区空中断请求时写入发送缓冲区(SPTEF=1)	RSPCK oscillation	在产生发送缓冲区空中断请求时写入发送缓冲区(SPTEF=1)
顺序控制	不支持	Supported	Supported	不支持	Supported
发送缓冲区空检测	Supported				
接收缓冲区满检测	Supported*2				
溢出错误检测	Supported*2	Supported*2, *4	Supported*2, *4	Supported*2	Supported*2
奇偶校验错误检测	Supported*2,*3				
模式故障错误检测	Supported (MODFEN = 1)	不支持	Supported	不支持	不支持
欠载错误检测	Supported	不支持	不支持	Supported	不支持

Note 1. 此模式不支持此功能。
Note 2. 当SPCR.TXMD位为1时，不执行接收缓冲器满、溢出错误和奇偶校验错误的检测。
Note 3. 当SPCR2.SPPE位为0时，不执行奇偶校验错误检测。
Note 4. 当SPCR2.SCKASE位为1时，不进行溢出错误检测。

31.3.2 控制SPI引脚

SPI可以根据SPCR中的MSTR、MODFEN和SPMS位设置以及IO端口的PmnPFS.NCODR位来切换引脚状态。表31.6列出了引脚状态和位设置之间的关系。将IO端口的PmnPFS.NCODR位设置为0可选择CMOS输出。将其设置为1选择开漏输出。IO端口设置必须遵循这种关系。

Table 31.6 Relationship between pin states and bit settings

Mode	Pin	Pin state*2	
		PmnPFS.NCODR bit for I/O ports = 0	PmnPFS.NCODR bit for I/O ports = 1
Single-master mode (SPI operation) (MSTR = 1, MODFEN = 0, SPMS = 0)	RSPCKn	CMOS output	Open-drain output
	SSLn0 to SSLn3	CMOS output	Open-drain output
	MOSIn	CMOS output	Open-drain output
	MISOn	Input	Input
Multi-master mode (SPI operation) (MSTR = 1, MODFEN = 1, SPMS = 0)	RSPCKn*3	CMOS output/Hi-Z	Open-drain output/Hi-Z
	SSLn0	Input	Input
	SSLn1 to SSLn3*3	CMOS output/Hi-Z	Open-drain output/Hi-Z
	MOSIn*3	CMOS output/Hi-Z	Open-drain output/Hi-Z
	MISOn	Input	Input
Slave mode (SPI operation) (MSTR = 0, SPMS = 0)	RSPCKn	Input	Input
	SSLn0	Input	Input
	SSLn1 to SSLn3*5	Hi-Z*1	Hi-Z*1
	MOSIn	Input	Input
	MISOn*4	CMOS output/Hi-Z	Open-drain output/Hi-Z
Master mode (clock synchronous operation) (MSTR = 1, MODFEN = 0, SPMS = 1)	RSPCKn	CMOS output	Open-drain output
	SSLn0 to SSLn3*5	Hi-Z*1	Hi-Z*1
	MOSIn	CMOS output	Open-drain output
	MISOn	Input	Input
Slave mode (clock synchronous operation) (MSTR = 0, SPMS = 1)	RSPCKn	Input	Input
	SSLn0 to SSLn3*5	Hi-Z*1	Hi-Z*1
	MOSIn	Input	Input
	MISOn	CMOS output	Open-drain output

Note 1. This function is not supported in this mode.
Note 2. SPI settings are not reflected in multiplexed pins for which the SPI function is not selected.
Note 3. When SSLn0 is at the active level, the pin state is Hi-Z.
Note 4. When SSLn0 is at the non-active level or the SPCR.SPE bit is 0, the pin state is Hi-Z.
Note 5. These pins are available for use as I/O port pins.

The SPI in single-master (SPI operation) or multi-master mode (SPI operation) determines the MOSI signal values during the SSL negation period (including the SSL retention period during a burst transfer) based on the MOIFE and MOIFV bit settings in SPPCR, as listed in Table 31.7.

Table 31.7 MOSI signal value determination during SSL negation period

MOIFE bit	MOIFV bit	MOSIn signal value during SSL negation period
0	0, 1	Final data from previous transfer
1	0	Low
1	1	High

31.3.3 SPI System Configuration Examples

31.3.3.1 Single master and single slave with the MCU as a master

Figure 31.5 shows a single-master and single-slave SPI system configuration example where the MCU is a master. In the single-master/single-slave configuration, the SSLn0 to SSLn3 outputs of the MCU (master) are not used. The SSL input of the SPI slave is fixed to the low level, and the SPI slave stays selected.*1

The MCU (master) drives the RSPCKn and MOSIn signals. The SPI slave drives the MISO signal.

Table 31.6 引脚状态和位设置之间的关系

Mode	Pin	Pin state*2	
		IO端口的PmnPFS.NCODR位=0	IO端口的PmnPFS.NCODR位=1
Single-master mode (SPI operation) (MSTR = 1, MODFEN = 0, SPMS = 0)	RSPCKn	CMOS output	Open-drain output
	SSLn0 to SSLn3	CMOS output	Open-drain output
	MOSIn	CMOS output	Open-drain output
	MISOn	Input	Input
Multi-master mode (SPI operation) (MSTR = 1, MODFEN = 1, SPMS = 0)	RSPCKn*3	CMOS output/Hi-Z	Open-drain output/Hi-Z
	SSLn0	Input	Input
	SSLn1 to SSLn3*3	CMOS output/Hi-Z	Open-drain output/Hi-Z
	MOSIn*3	CMOS output/Hi-Z	Open-drain output/Hi-Z
	MISOn	Input	Input
从机模式（SPI操作）（MSTR=0，SPMS=0）	RSPCKn	Input	Input
	SSLn0	Input	Input
	SSLn1 to SSLn3*5	Hi-Z*1	Hi-Z*1
	MOSIn	Input	Input
	MISOn*4	CMOS output/Hi-Z	Open-drain output/Hi-Z
主模式（时钟同步操作）（MSTR=1，MODFEN=0，SPMS=1）	RSPCKn	CMOS output	Open-drain output
	SSLn0 to SSLn3*5	Hi-Z*1	Hi-Z*1
	MOSIn	CMOS output	Open-drain output
	MISOn	Input	Input
从机模式（时钟同步操作）（MSTR=0，SPMS=1）	RSPCKn	Input	Input
	SSLn0 to SSLn3*5	Hi-Z*1	Hi-Z*1
	MOSIn	Input	Input
	MISOn	CMOS output	Open-drain output

Note 1. 此模式不支持此功能。
Note 2. SPI设置不会反映在未选择SPI功能的复用引脚中。
Note 3. 当SSLn0处于有效电平时，引脚状态为Hi-Z。
Note 4. 当SSLn0处于非活动电平或SPCR.SPE位为0时，引脚状态为Hi-Z。
Note 5. 这些引脚可用作IO端口引脚。

单主机（SPI操作）或多主机模式（SPI操作）的SPI根据SPPCR中的MOIFE和MOIFV位设置确定SSL否定期间（包括突发传输期间的SSL保留期间）的MOSI信号值，如表31.7所列。

Table 31.7 SSL否定期间的MOSI信号值确定

MOIFE bit	MOIFV bit	SSL否定期间的MOSIn信号值
0	0, 1	上次传输的最终数据
1	0	Low
1	1	High

31.3.3 SPI系统配置示例

31.3.3.1 单主单从，单片机为主

图31.5显示了单主单从SPI系统配置示例，其中MCU为主。在单主单从配置中，不使用MCU（主）的SSLn0到SSLn3输出。SPI从机的SSL输入固定为低电平，SPI从机保持选中状态。*1

MCU（主控）驱动RSPCKn和MOSIn信号。SPI从机驱动MISO信号。

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Note 1. In the transfer format used when the SPCMDm.CPHA bit is 0, the SSL signal for some slave devices cannot be fixed to an active level. In this case, always connect the SSLni output of the MCU to the SSL input of the slave device.

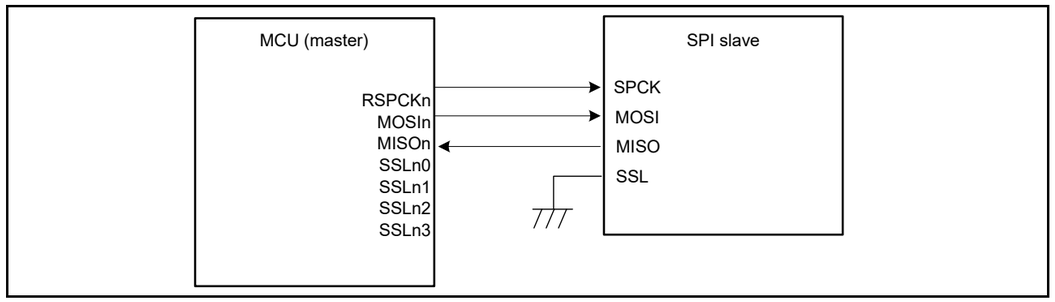

Figure 31.5 Single-master/single-slave configuration example with the MCU as a master

31.3.3.2 Single master and single slave with the MCU as a slave

Figure 31.6 shows a single-master and single-slave SPI system configuration example where the MCU is a slave. When the MCU operates as a slave, the SSLn0 pin is used as SSL input. The SPI master drives the RSPCK and MOSI signals. The MCU (slave) drives the MISOn signal.*1

In the single-slave configuration when the SPCMDm.CPHA bit is set to 1, the SSLn0 input of the MCU (slave) is fixed to the low level and the MCU (slave) stays selected. This enables serial transfer execution (Figure 31.7).

Note 1. When SSLn0 is at a non-active level, the pin state is Hi-Z.

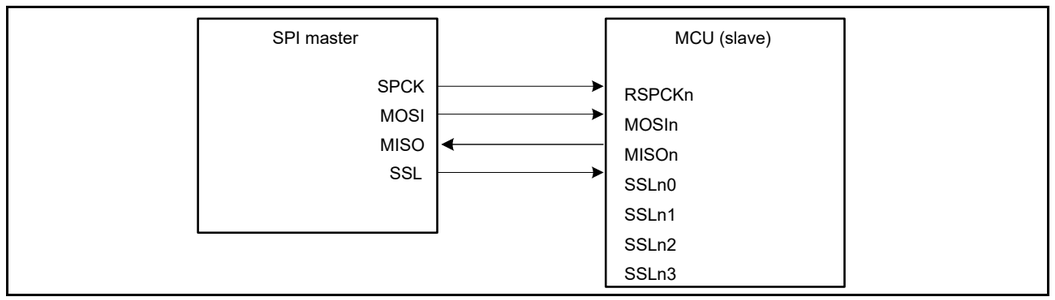

Figure 31.6 Single-master/single-slave configuration example with the MCU as a slave and CPHA = 0

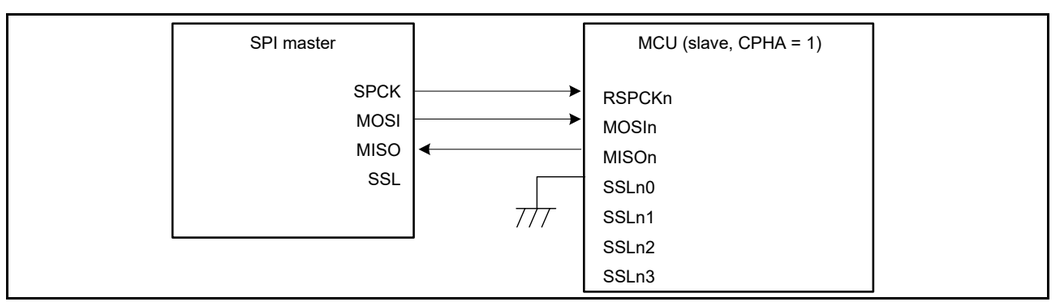

Figure 31.7 Single-master/single-slave configuration example with the MCU as a slave and CPHA = 1

注1.在SPCMDm.CPHA位为0时使用的传输格式中，某些从设备的SSL信号不能固定为有效电平。在这种情况下，请始终将MCU的SSLni输出连接到从设备的SSL输入。

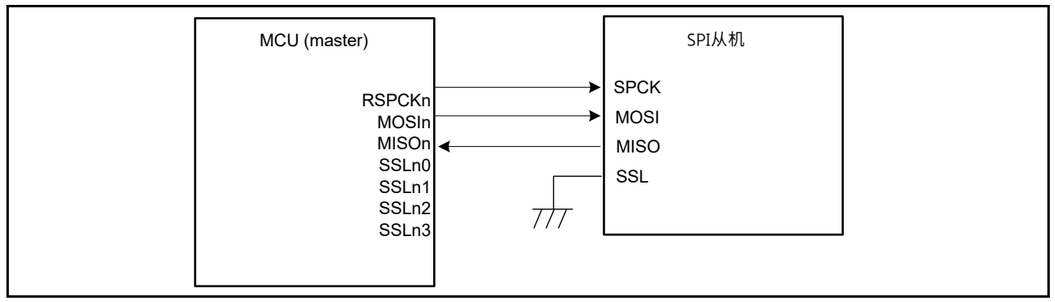

Figure 31.5 MCU为主的单主单从配置示例

31.3.3.2 单主单从单片机作为从机

图31.6显示了单主单从SPI系统配置示例，其中MCU是从设备。当MCU作为从机运行时，SSLn0引脚用作SSL输入。SPI主机驱动RSPCK和MOSI信号。MCU（从机）驱动MIOn信号。*1

在单从配置中，当SPCMDm.CPHA位设置为1时，MCU（从）的SSLn0输入固定为低电平，MCU（从）保持选择状态。这将启用串行传输执行（图31.7）。

注1.当SSLn0处于非活动电平时，引脚状态为Hi-Z。

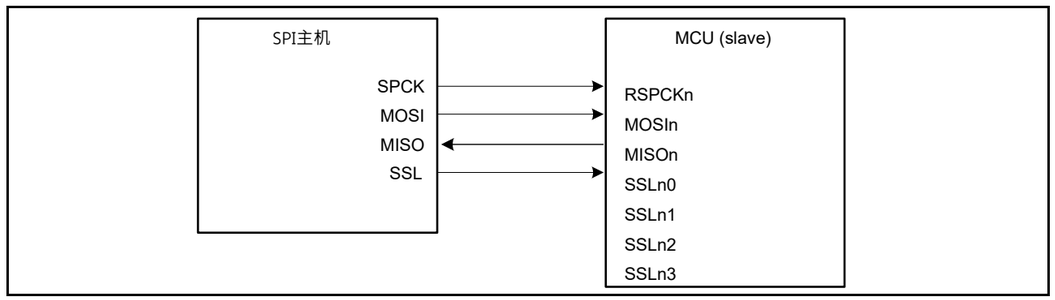

Figure 31.6 单主单从配置示例，单片机作为从机，CPHA=0

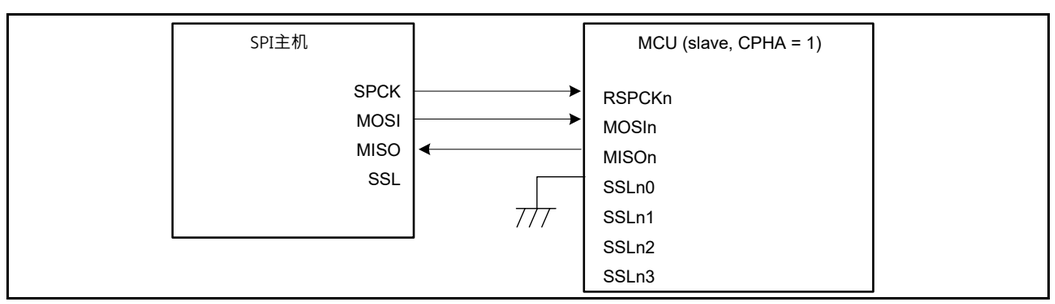

Figure 31.7 MCU作为从机且CPHA=1的单主单从配置示例

31.3.3.3 Single master and multi slave with the MCU as a master

Figure 31.8 shows a single-master and multi-slave SPI system configuration example where the MCU is a master. In the example, the SPI system includes the MCU (master) and four slaves (SPI slave 0 to SPI slave 3).

The RSPCKn and MOSIn outputs of the MCU (master) are connected to the RSPCK and MOSI inputs of SPI slave 0 to SPI slave 3. The MISO outputs of SPI slave 0 to SPI slave 3 are all connected to the MISOn input of the MCU (master). The SSLn0 to SSLn3 outputs of the MCU (master) are connected to the SSL inputs of SPI slave 0 to SPI slave 3, respectively.

The MCU (master) drives the RSPCKn, MOSIn, and SSLn0 to SSLn3 pins. Of the SPI slave 0 to SPI slave 3, the slave that receives low-level input into the SSL input drives the MISO signal.

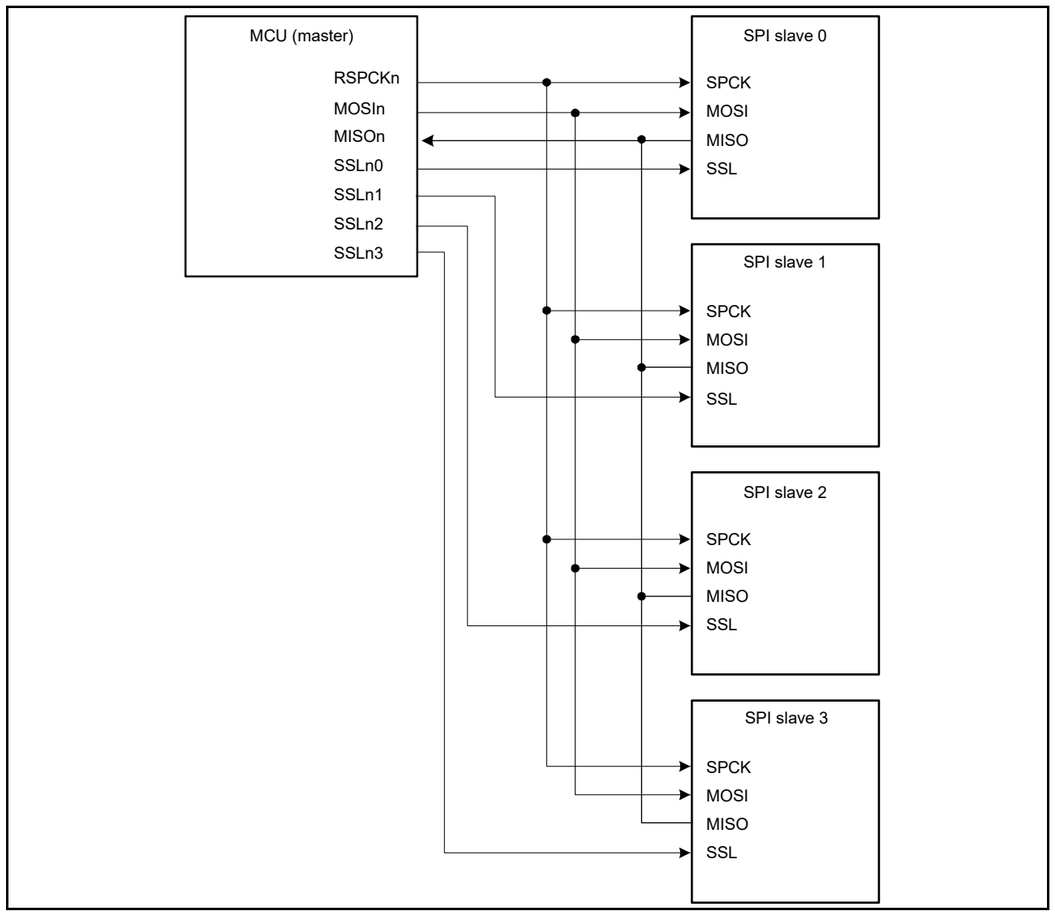

Figure 31.8 Single-master/multi-slave configuration example with the MCU as a a master

31.3.3.4 Single master and multi slave with the MCU as a slave

Figure 31.9 shows a single-master and multi-slave SPI system configuration example where the MCU is a slave. In this example, the SPI system includes an SPI master and two MCUs (slave X and slave Y).

The SPCK and MOSI outputs of the SPI master are connected to the RSPCKn and MOSIn inputs of the MCUs (slaves X and Y). The MISOn outputs of the MCUs (slave X and slave Y) are all connected to the MISO input of the SPI master. The SSLX and SSLY outputs of the SPI master are connected to the SSLn0 inputs of the MCUs (slave X and slave Y), respectively.

31.3.3.3 单主多从，单片机为主

图31.8显示了单主和多从SPI系统配置示例，其中MCU为主。在示例中，SPI系统包括MCU（主机）和四个从机（SPI从机0到SPI从机3）。

MCU（主机）的RSPCKn和MOSIn输出连接到SPI从机0到SPI从机3的RSPCK和MOSI输入。SPI从机0到SPI从机3的MISO输出都连接到MCU的MISOn输入（掌握）。

MCU（主机）的SSLn0到SSLn3输出分别连接到SPI从机0到SPI从机3的SSL输入。

MCU（主控）驱动RSPCKn、MOSIn和SSLn0至SSLn3引脚。在SPI从机0到SPI从机3中，接收到SSL输入的低电平输入的从机驱动MISO信号。

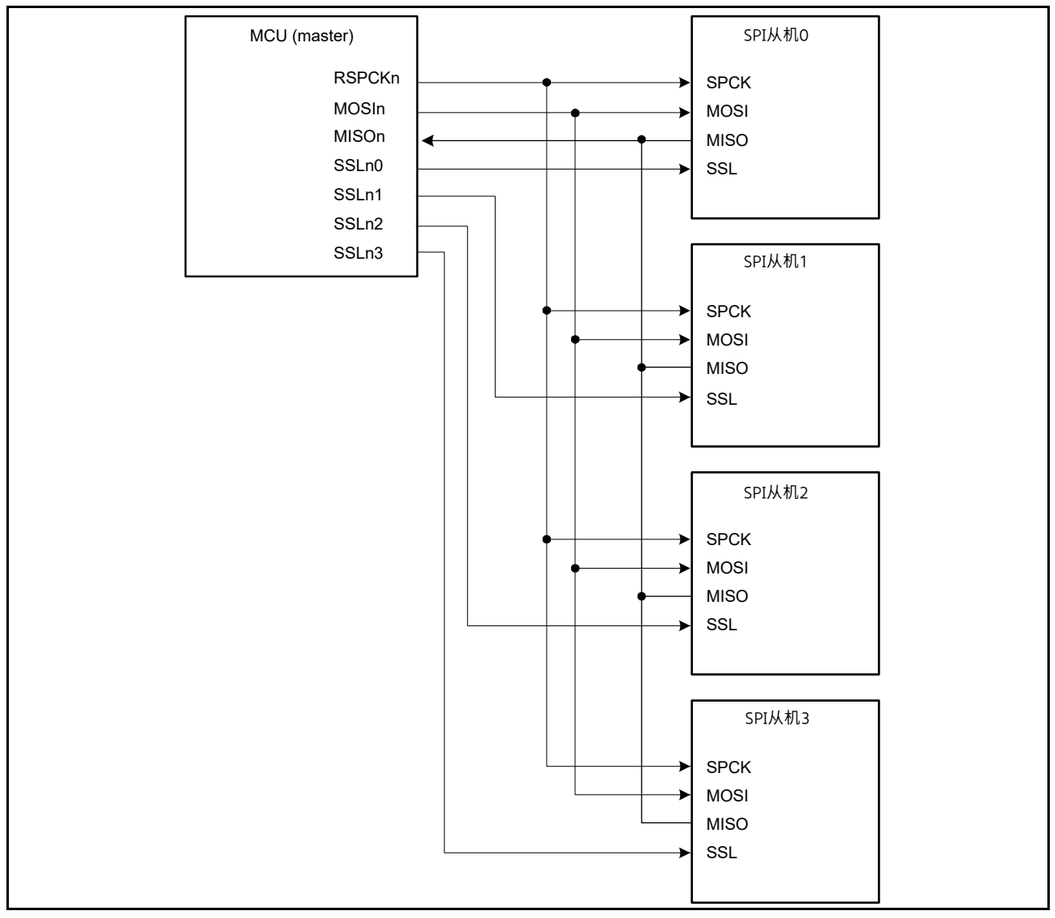

Figure 31.8 MCU为主的单主多从配置示例

31.3.3.4 单主多从，单片机作为从机

图31.9显示了单主多从SPI系统配置示例，其中MCU为从设备。在本例中，SPI系统包括一个SPI主控和两个MCU（从属X和从属Y）。

SPI主机的SPCK和MOSI输出连接到MCU（从机X和Y）的RSPCKn和MOSIn输入。MCU（从X和从Y）的MISOn输出都连接到SPI主控的MISO输入。SPI主机的SSLX和SSLY输出分别连接到MCU（从机X和从机Y）的SSLn0输入。

The SPI master drives the SPCK, MOSI, SSLX, and SSLY signals. Of the MCUs (slave X or slave Y), the slave that receives low-level input into the SSLn0 input drives the MISOn signal.

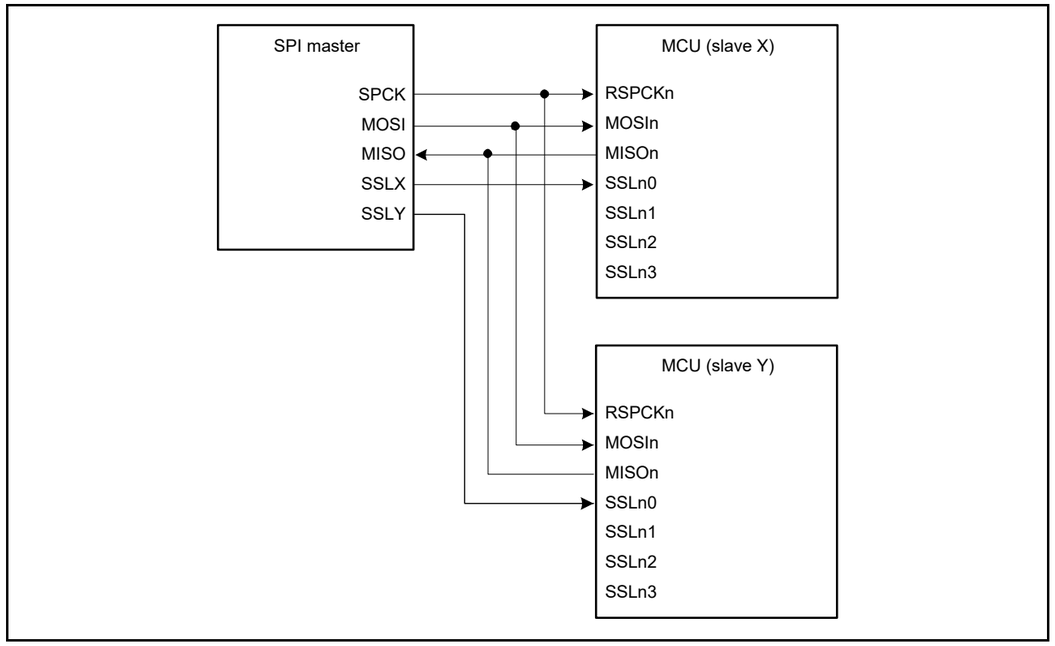

Figure 31.9 Single-master/multi-slave configuration example with the MCU as a slave

31.3.3.5 Multi master and multi slave with the MCU as a master

Figure 31.10 shows a multi-master/multi-slave SPI system configuration example where the MCU is a master. In this example, the SPI system includes two MCUs (master X and master Y) and two SPI slaves (SPI slave 1 and SPI slave 2).

The RSPCKn and MOSIn outputs of the MCUs (master X and master Y) are connected to the RSPCK and MOSI inputs of SPI slaves 1 and 2. The MISO outputs of SPI slaves 1 and 2 are connected to the MISOn inputs of the MCUs (master X and master Y). Any generic port Y output from the MCU (master X) is connected to the SSLn0 input of the MCU (master Y). Any generic port X output of the MCU (master Y) is connected to the SSLn0 input of the MCU (master X). The SSLn1 and SSLn2 outputs of the MCUs (master X and master Y) are connected to the SSL inputs of the SPI slaves 1 and 2. In this configuration example, because the system can be comprised solely of SSLn0 input, and SSLn1, SSLn2 outputs for slave connections, the SSLn3 output of the MCU is not required.

The MCU drives the RSPCKn, MOSIn, SSLn1, and SSLn2 signals when the SSLn0 input level is high. When the SSLn0 input level is low, the MCU detects a mode fault error, sets RSPCKn, MOSIn, SSLn1, and SSLn2 to Hi-Z, and releases the SPI bus directly to the other master. Of the SPI slaves 1 and 2, the slave that receives low-level input into the SSL input drives the MISO signal.

SPI主机驱动SPCK、MOSI、SSLX和SSLY信号。在MCU（从机X或从机Y）中，接收到SSLn0输入的低电平输入的从机驱动MIOn信号。

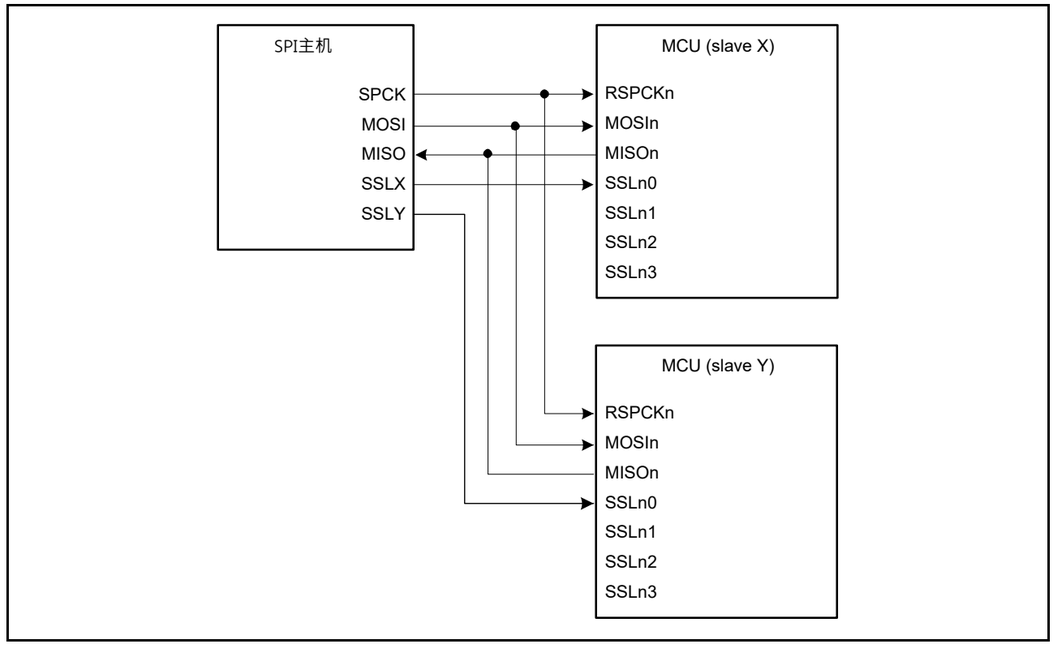

Figure 31.9 MCU作为从机的单主多从配置示例

31.3.3.5 以单片机为主的多主多从

图31.10显示了一个多主多从SPI系统配置示例，其中MCU为主。在本例中，SPI系统包括两个MCU（主X和主Y）和两个SPI从机（SPI从机1和SPI从机2）。

MCU（主X和主Y）的RSPCKn和MOSIn输出连接到SPI从设备1和2的RSPCK和MOSI输入。SPI从设备1和2的MISO输出连接到MCU（主设备）的MISOn输入X和主Y）。来自MCU（主X）的任何通用端口Y输出都连接到MCU（主Y）的SSLn0输入。MCU（主设备Y）的任何通用端口X输出都连接到MCU（主设备X）的SSLn0输入。MCU（主X和主Y）的SSLn1和SSLn2输出连接到SPI从机1和2的SSL输入。在此配置示例中，因为系统可以仅由SSLn0输入和SSLn1、SSLn2输出组成对于从连接，不需要MCU的SSLn3输出。

当SSLn0输入电平为高电平时，MCU驱动RSPCKn、MOSIn、SSLn1和SSLn2信号。当SSLn0输入电平为低时，MCU检测到模式故障错误，将RSPCKn、MOSIn、SSLn1和SSLn2设置为Hi-Z，并将SPI总线直接释放到另一个主控。在SPI从机1和2中，接收到SSL输入的低电平输入的从机驱动MISO信号。

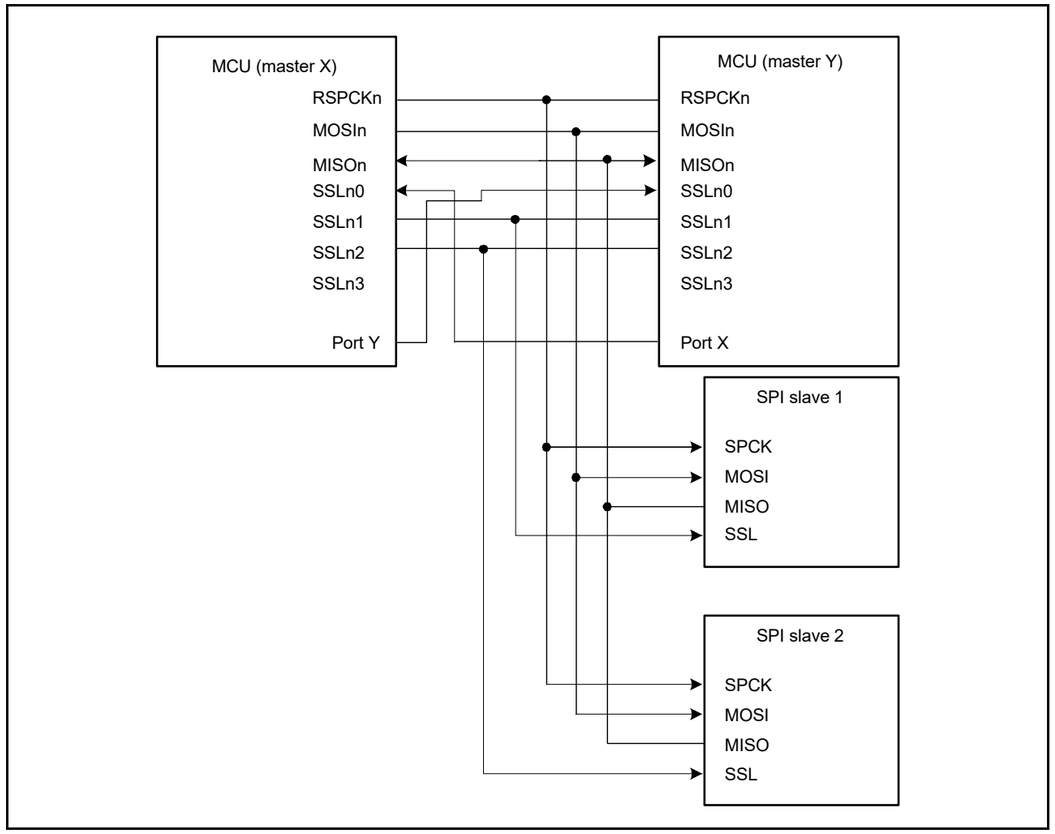

Figure 31.10 Multi-master/multi-slave configuration example with the MCU as a master

31.3.3.6 Master and slave in clock synchronous mode with the MCU as a master

Figure 31.11 shows a master and slave in clock synchronous mode where the MCU is a master. In this configuration, SSLn0 to SSLn3 of the MCU (master) are not used.

The MCU (master) drives the RSPCKn and MOSIn signals. The SPI slave drives the MISO signal.

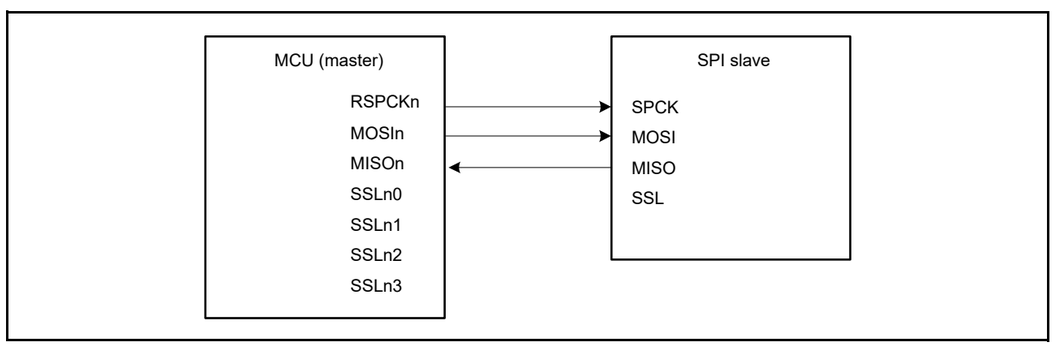

Figure 31.11 Configuration example of master/slave in clock synchronous mode with the MCU as a master

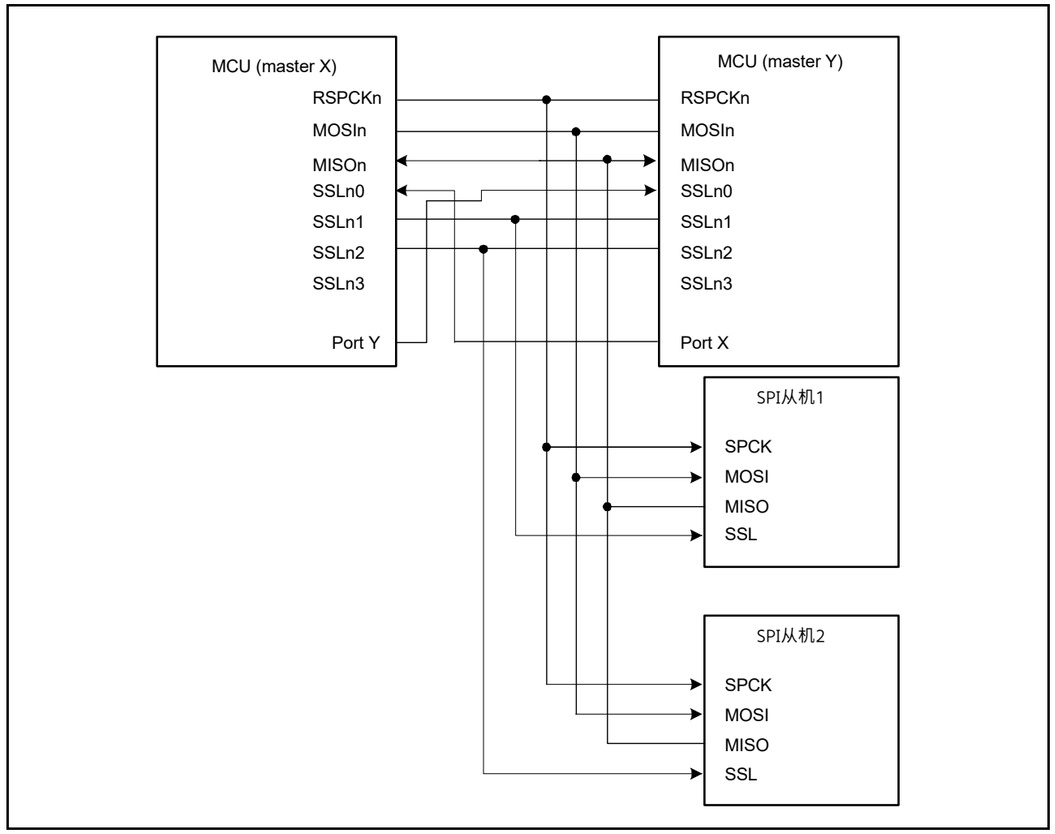

Figure 31.10 MCU为主的多主多从配置示例

31.3.3.6 主从时钟同步模式，单片机作为主控

图31.11显示了时钟同步模式下的主机和从机，其中MCU是主机。在这种配置中，不使用MCU（主）的SSLn0到SSLn3。

MCU（主控）驱动RSPCKn和MOSIn信号。SPI从机驱动MISO信号。

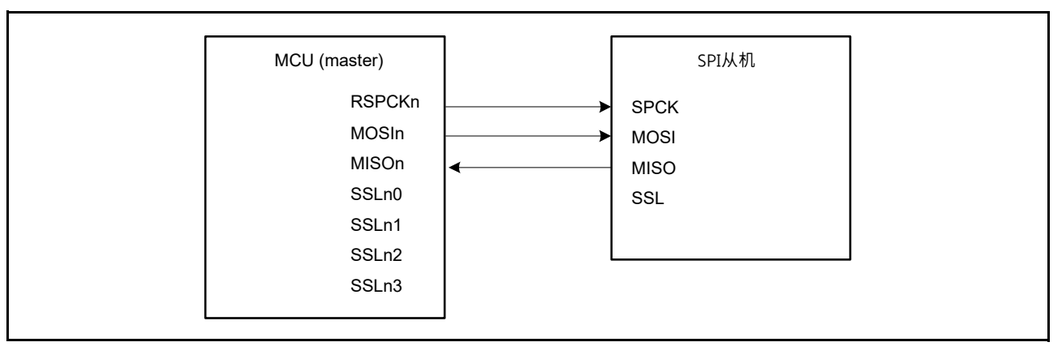

Figure 31.11 MCU作为主控时钟同步模式主从配置示例

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31.3.3.7 Master and slave in clock synchronous mode with the MCU as a slave

Figure 31.12 shows a master and slave in clock synchronous mode configuration where the MCU is a slave. When the MCU operates as a slave in clock synchronous mode, the MCU (slave) drives the MISOn signal and the SPI master drives the SPCK and MOSI signals. SSLn0 to SSLn3 of the MCU (slave) are not used.

The MCU (slave) can only execute serial transfer in the single-slave configuration when the SPCMDm.CPHA bit is set to 1.

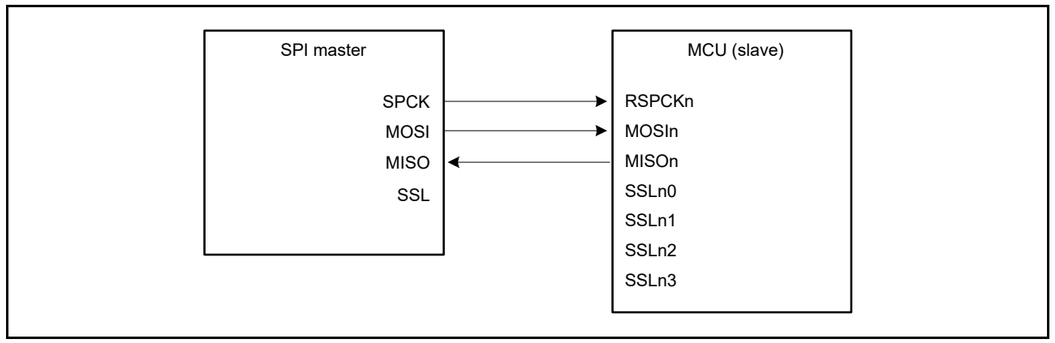


Figure 31.12 Configuration example of master and slave in clock synchronous mode with the MCU as a slave and CPHA = 1

31.3.4 Data Format

The data format of the SPI depends on the settings in the SPI Command Register m (SPCMDm) (m = 0 to 7) and the Parity Enable bit in SPI Control Register 2 (SPCR2.SPPE). Regardless of whether the ordering is MSB- or LSB-first, the SPI treats the range from the LSB bit in the SPI Data Register (SPDR/SPDR_HA) to the bit associated with the selected data length, as transfer data.

This section shows the format of one frame of data before or after transfer.

(a) Data format with parity disabled

When parity is disabled, transmission or reception of data proceeds with the bit length selected in the SPI data length setting bits in SPI Command Register m (SPCMDm.SPB[3:0]).

(b) Data format with parity enabled

When parity is enabled, transmission or reception of data proceeds with the bit length selected in the SPI data length setting bits in the SPI Command Register m (SPCMDm.SPB[3:0]). In this case, however, the last bit is a parity bit.

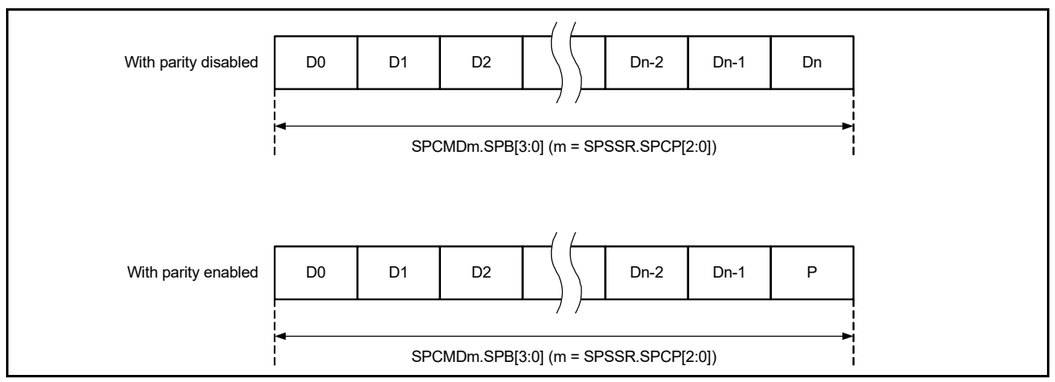


Figure 31.13 Data format with parity disabled and enabled

31.3.3.7 主从时钟同步模式，单片机作为从机

图31.12显示了时钟同步模式配置中的主设备和从设备，其中MCU是从设备。当。。。的时候MCU在时钟同步模式下作为从机运行，MCU（从机）驱动MISON信号，SPI主机驱动SPCK和MOSI信号。不使用MCU（从机）的SSLn0到SSLn3。

当SPCMDm.CPHA位设置为1时，MCU（从机）只能在单从机配置中执行串行传输。

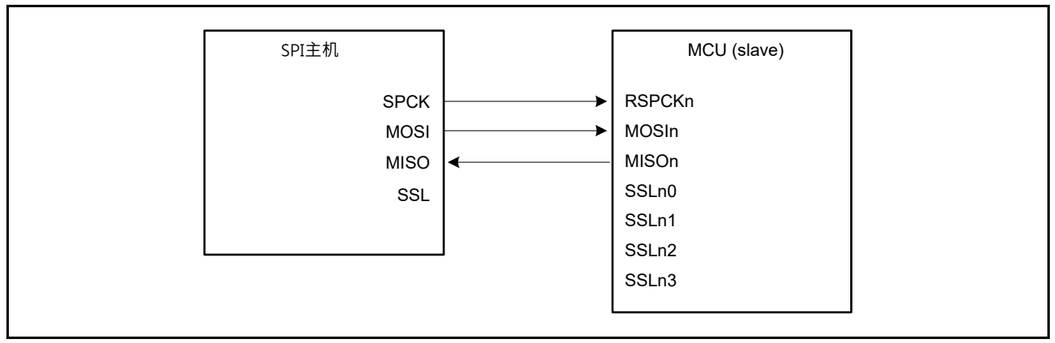


Figure 31.12 单片机作为从机，CPHA=1，时钟同步模式的主从配置示例

31.3.4 数据格式

SPI的数据格式取决于SPI命令寄存器m(SPCMDm)（m=0到7）中的设置和SPI控制寄存器2(SPCR2.SPPE)中的奇偶校验使能位。无论排序是MSB优先还是LSB优先，SPI都将从SPI数据寄存器(SPDRSPDR_HA)中的LSB位到与所选数据长度相关的位的范围视为传输数据。

本节显示传输前后一帧数据的格式。

(a) 禁用奇偶校验的数据格式

当奇偶校验被禁用时，数据的发送或接收将按照在SPI命令寄存器m(SPCMDm.SPB[3:0])中的SPI数据长度设置位中选择的位长度进行。

(b) 启用奇偶校验的数据格式

当奇偶校验使能时，数据的发送或接收按照在SPI命令寄存器m(SPCMDm.SPB[3:0])的SPI数据长度设置位中选择的位长度进行。然而，在这种情况下，最后一位是奇偶校验位。

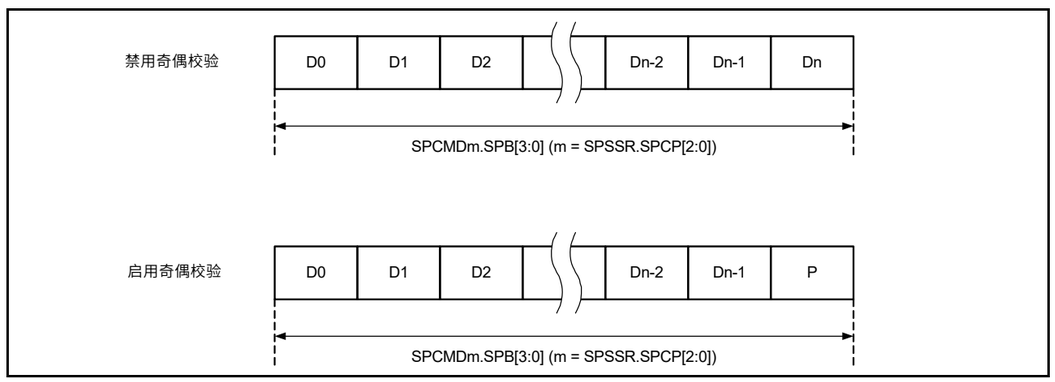


Figure 31.13 禁用和启用奇偶校验的数据格式

31.3.4.1 Operation when parity is disabled (SPCR2.SPPE = 0)

When parity is disabled, data for transmission is copied to the shift register with no pre-processing. This section describes the connection between the SPI Data Register (SPDR/SPDR_HA) and the shift register in terms of the combination of MSB- or LSB-first order and data length.

(1) MSB-first transfer with 32-bit data

Figure 31.14 shows the transfer operations of the SPI Data Register (SPDR) and the shift register with parity disabled, an SPI data length of 32 bits, and MSB-first selected.

In transmission, bits T31 to T00 from the current stage of the transmit buffer are copied to the shift register. Data for transmission is shifted out from the shift register from T31 to T30, and continuing to T00, in that order.

In reception, received data is shifted in bit-by-bit through bit [0] of the shift register. When R31 to R00 bits are collected after input of the required number of RSPCK cycles, the value in the shift register is copied to the receive buffer.

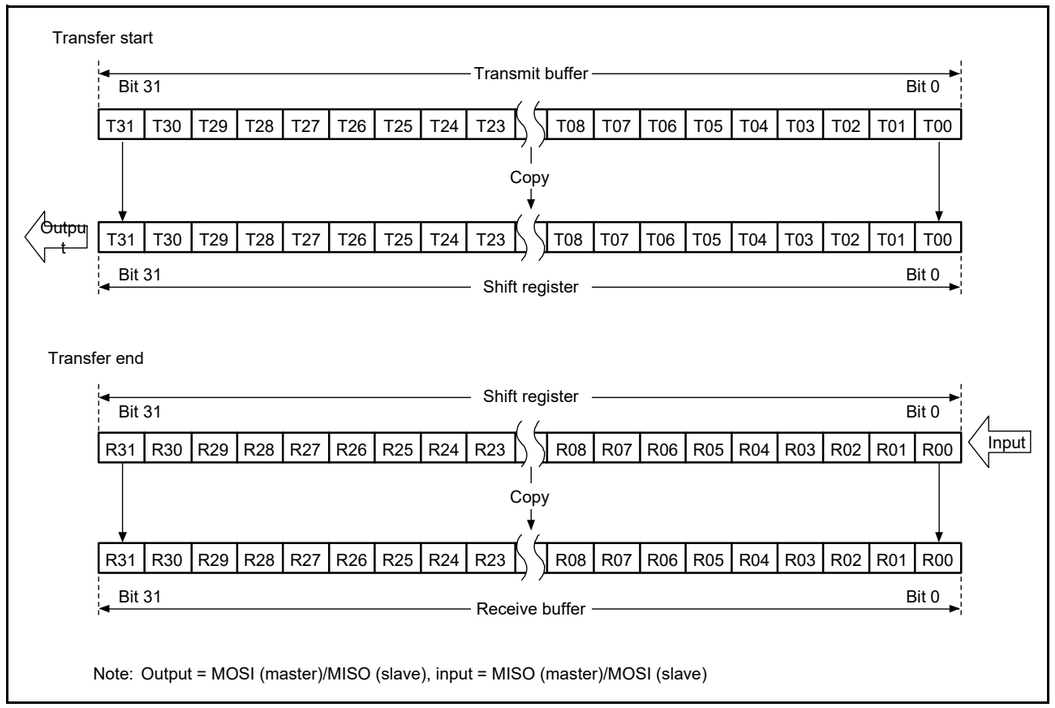


Figure 31.14 MSB-first transfer with 32-bit data and parity disabled

(2) MSB-first transfer with 24-bit data

Figure 31.15 shows the transfer operations of the SPI Data Register (SPDR) and the shift register with parity disabled, an SPI data length of 24 bits, and MSB-first selected.

In transmission, the lower 24 bits (T23 to T00) from the current stage of the transmit buffer are copied to the shift register. Data for transmission is shifted out from the shift register from T23 to T22, and continuing to T00, in that order.

In reception, received data is shifted in bit-by-bit through bit [0] of the shift register. When the R23 to R00 bits are collected after input of the required number of RSPCK cycles, the value in the shift register is copied to the receive buffer. The upper 8 bits of the transmit buffer are stored in the upper 8 bits of the receive buffer. Writing 0 to bits T31 to T24 at the time of transmission leads to 0 being inserted in the upper 8 bits of the receive buffer.

31.3.4.1 禁用奇偶校验时的操作(SPCR2.SPPE=0)

当奇偶校验被禁用时，用于传输的数据被复制到移位寄存器而不进行预处理。本节从MSB或LSB-firstor der和数据长度的组合来描述SPI数据寄存器(SPDRSPDR_HA)和移位寄存器之间的连接。

(1) 32位数据的MSB优先传输

图31.14显示了SPI数据寄存器(SPDR)和禁用奇偶校验的移位寄存器的传输操作，
SPI数据长度为32位，且MSB优先选择。

在发送过程中，发送缓冲器当前级的T31到T00位被复制到移位寄存器。用于发送的数据从移位寄存器中移出，从T31移出到T30，并按此顺序继续移到T00。

在接收时，接收到的数据通过移位寄存器的位[0]逐位移位。在输入所需数量的RSPCK周期后，当R31到R00位被收集时，移位寄存器中的值被复制到接收缓冲区。

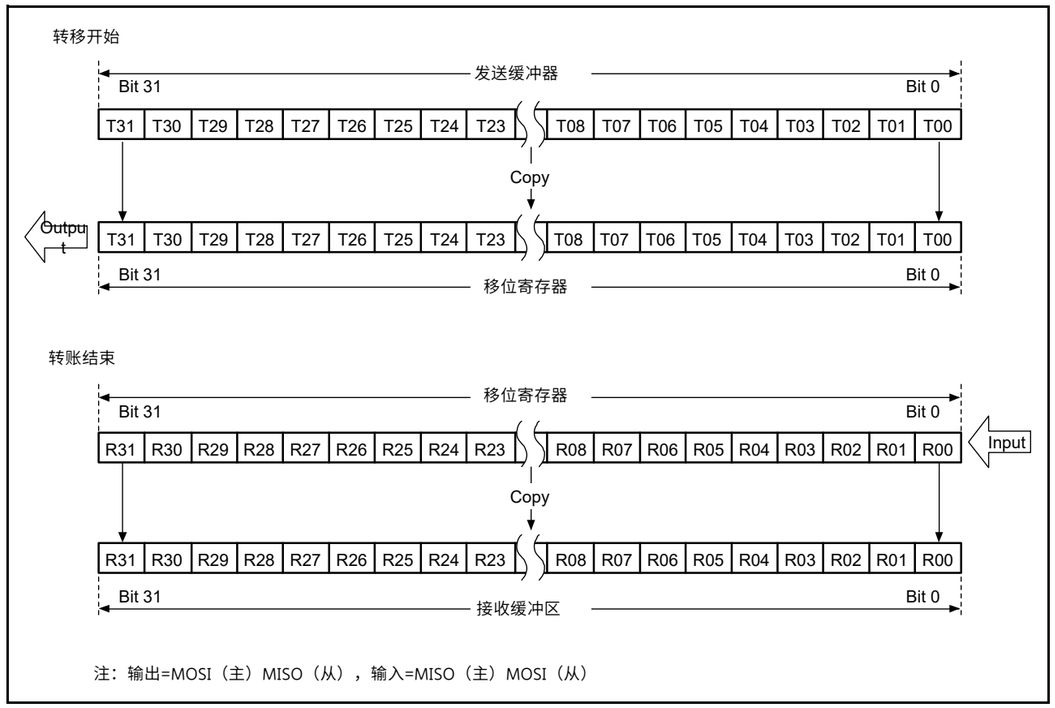


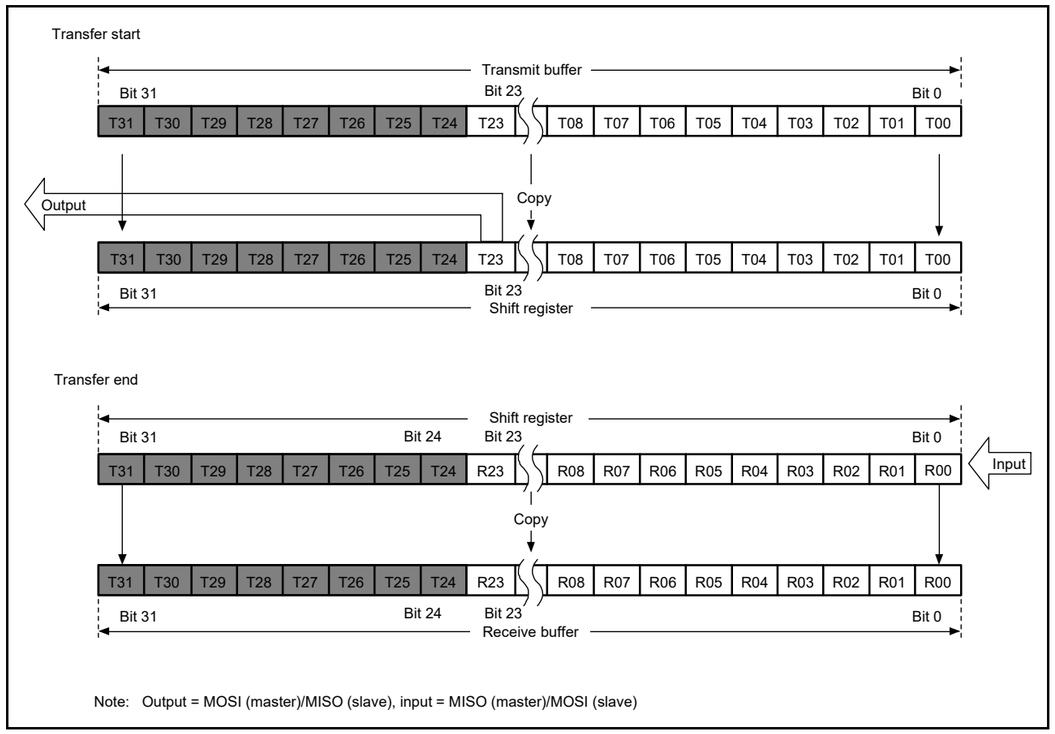
Figure 31.14 禁用32位数据和奇偶校验的MSB优先传输

(2) 24位数据的MSB优先传输

图31.15显示了SPI数据寄存器(SPDR)和禁用奇偶校验的移位寄存器的传输操作，
SPI数据长度为24位，且MSB优先选择。

在发送过程中，来自发送缓冲器当前阶段的低24位（T23到T00）被复制到移位寄存器。用于发送的数据从移位寄存器中从T23移出到T22，并按此顺序继续移到T00。

在接收时，接收到的数据通过移位寄存器的位[0]逐位移位。在输入所需数量的RSPCK周期后，当R23到R00位被收集时，移位寄存器中的值被复制到接收缓冲区。发送缓冲区的高8位存储在接收缓冲区的高8位中。在发送时将0写入位T31至T24会导致将0插入接收缓冲区的高8位。



Note: Output = MOSI (master)/MISO (slave), input = MISO (master)/MOSI (slave)

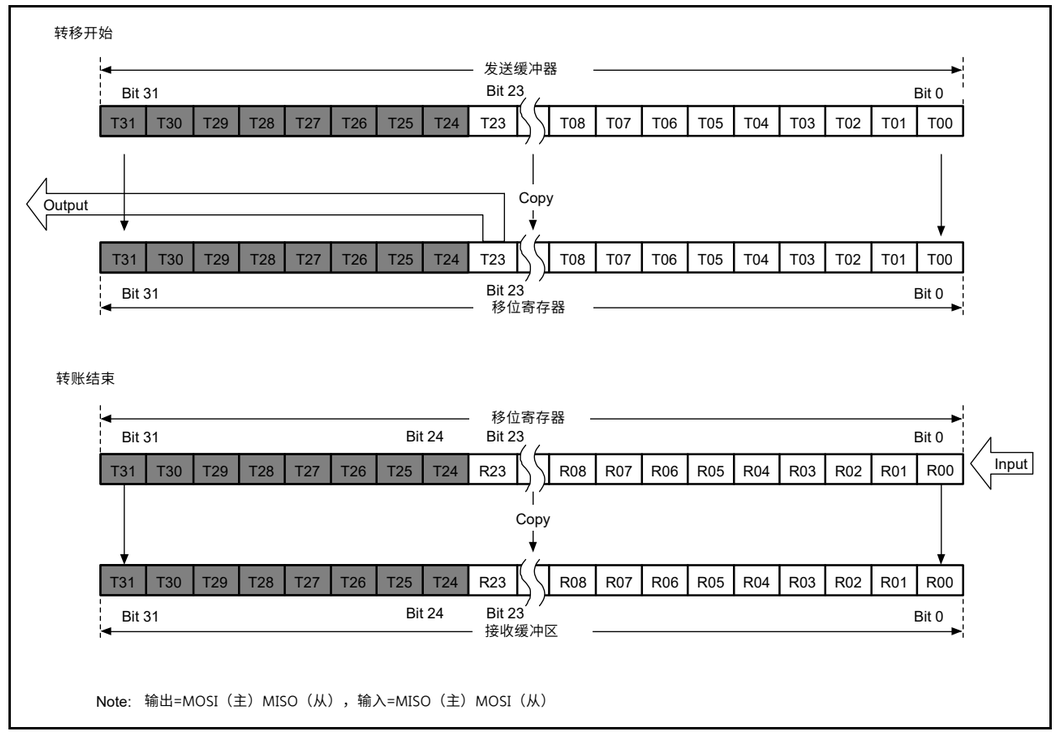
Figure 31.15 MSB-first transfer with 24-bit data and parity disabled

(3) LSB-first transfer with 32-bit data

Figure 31.16 shows the operation of the SPI Data Register (SPDR) and the shift register in a transfer with parity disabled, an SPI data length of 32 bits, and LSB-first selected.

In transmission, bits T31 to T00 from the current stage of the transmit buffer are reordered bit-by-bit to obtain the order T00 to T31 for copying to the shift register. Data for transmission is shifted out from the shift register from T00 to T01, and continuing to T3, in that order.

In reception, received data is shifted in bit-by-bit through bit [0] of the shift register. When the R00 to R31 bits are collected after input of the required number of RSPCK cycles, the value in the shift register is copied to the receive buffer.



Note: 输出=MOSI（主）MISO（从），输入=MISO（主）MOSI（从）

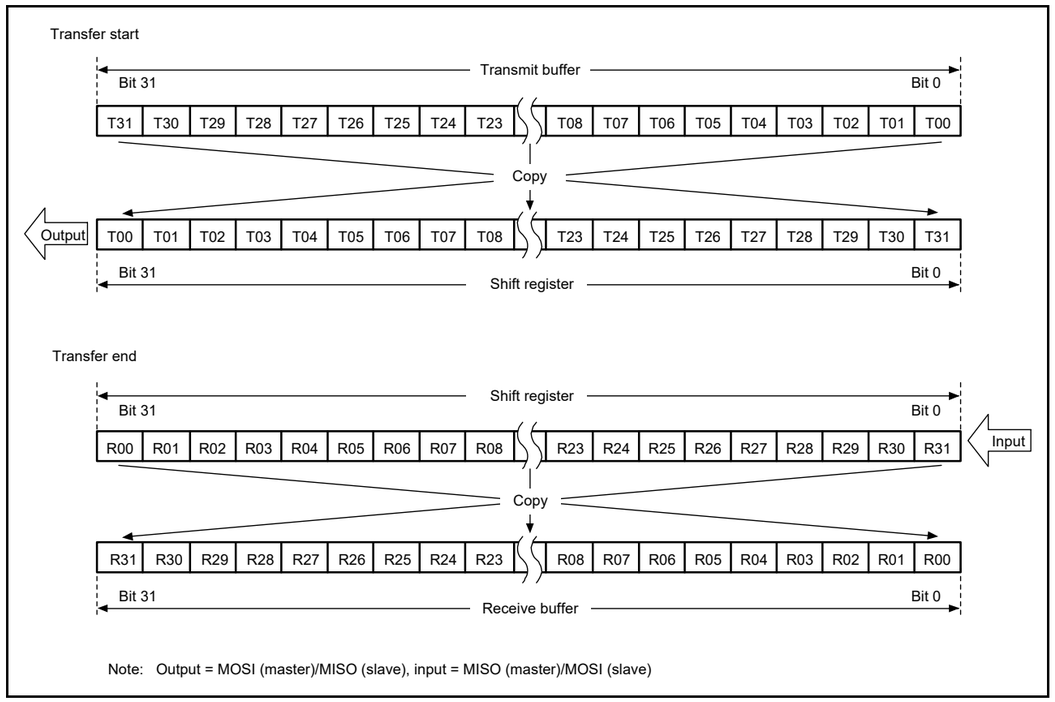
Figure 31.15 禁用24位数据和奇偶校验的MSB优先传输

(3) 32位数据的LSB优先传输

图31.16显示了SPI数据寄存器(SPDR)和移位寄存器在奇偶校验禁用、SPI数据长度为32位且选择LSB在先的传输中的操作。

在传输过程中，传输缓冲器当前级的位T31到T00被逐位重新排序，以获得用于复制到移位寄存器的顺序T00到T31。用于发送的数据从移位寄存器中从T00移出到T01，并按此顺序继续到T3。

在接收时，接收到的数据通过移位寄存器的位[0]逐位移位。在输入所需数量的RSPCK周期后收集R00至R31位时，将移位寄存器中的值复制到接收缓冲区。



Note: Output = MOSI (master)/MISO (slave), input = MISO (master)/MOSI (slave)

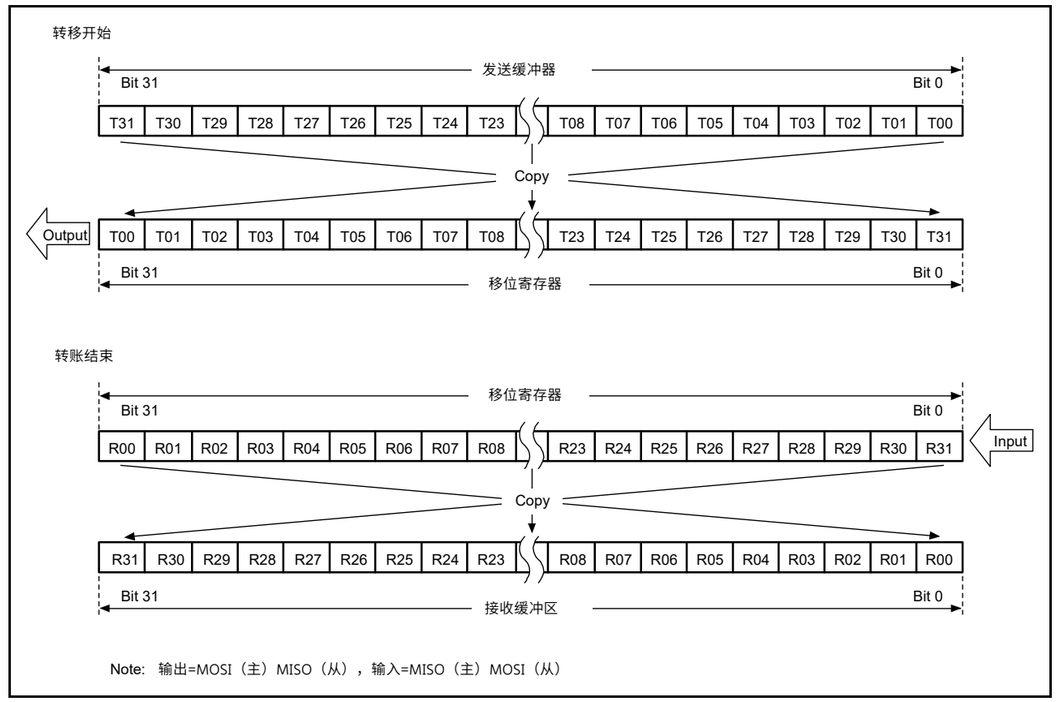
Figure 31.16 LSB-first transfer with 32-bit data and parity disabled

(4) LSB-first transfer with 24-bit data

Figure 31.17 shows the transfer operations of the SPI Data Register (SPDR) and the shift register with parity disabled, an SPI data length of 24 bits, and LSB-first selected.

In transmission, the lower 24 bits (T23 to T00) from the current stage of the transmit buffer are reordered bit-by-bit to obtain the order T00 to T23 for copying to the shift register. Data for transmission is shifted out from the shift register from T00 to T01, and continuing to T23, in that order.

In reception, received data is shifted in bit-by-bit through bit [8] of the shift register. When the R00 to R23 bits are collected after input of the required number of RSPCK cycles, the value in the shift register is copied to the receive buffer. The upper 8 bits of the transmit buffer are stored in the upper 8 bits of the receive buffer. Writing 0 to the T31 to T24 bits at the time of transmission leads to 0 being inserted in the upper 8 bits of the receive buffer.



Note: 输出=MOSI（主）MISO（从），输入=MISO（主）MOSI（从）

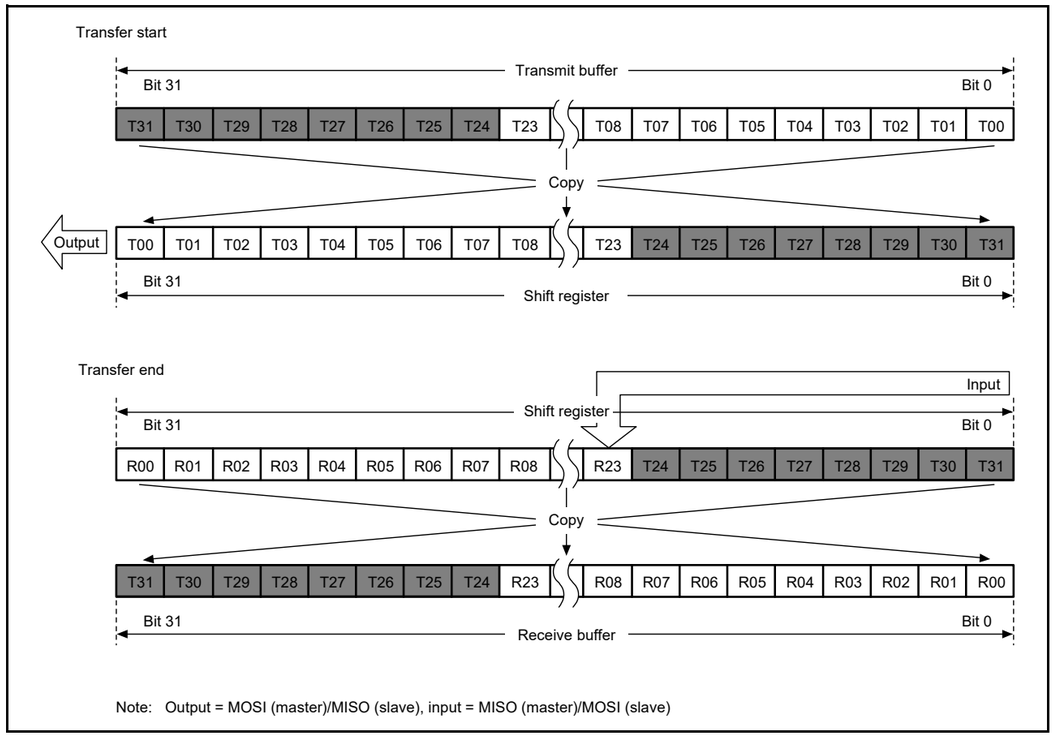
Figure 31.16 LSB优先传输，32位数据和奇偶校验禁用

(4) 24位数据的LSB优先传输

图31.17显示了SPI数据寄存器(SPDR)和禁用奇偶校验的移位寄存器的传输操作，
SPI数据长度为24位，并选择LSB优先。

发送时，将发送缓冲器当前级的低24位（T23到T00）逐位重新排序，得到T00到T23的顺序，用于复制到移位寄存器。用于发送的数据从移位寄存器移出，从T00移出到T01，并按此顺序继续移到T23。

在接收中，接收到的数据通过移位寄存器的位[8]逐位移位。在输入所需的RSPCK周期数后收集R00至R23位时，将移位寄存器中的值复制到接收缓冲区。发送缓冲区的高8位存储在接收缓冲区的高8位中。在发送时将0写入T31到T24位会导致0被插入到接收缓冲区的高8位中。



Note: Output = MOSI (master)/MISO (slave), input = MISO (master)/MOSI (slave)

Figure 31.17 LSB-first transfer with 24-bit data and parity disabled

31.3.4.2 Operation when parity is enabled (SPCR2.SPPE = 1)

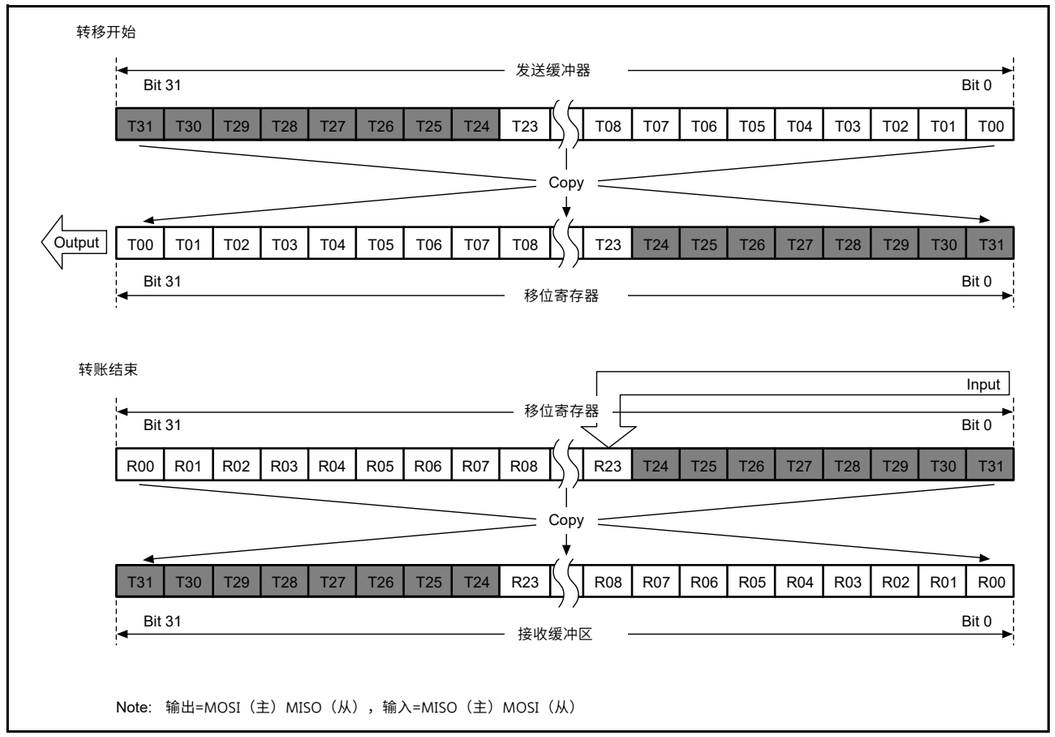
When parity is enabled, the lowest-order bit of the data for transmission becomes a parity bit. Hardware calculates the value of the parity bit.

(1) MSB-first transfer with 32-bit data

Figure 31.18 shows the transfer operation of the SPI Data Register (SPDR) and the shift register with parity enabled, an SPI data length of 32 bits, and MSB-first selected.

In transmission, the value of the parity bit (P) is calculated from bits T31 to T01. This replaces the final bit, T00, and the whole value is copied to the shift register. Data is transmitted in the order T31, T30, …, T01, and P.

In reception, received data is shifted in bit-by-bit through bit [0] of the shift register. When the R31 to P bits are collected after input of the required number of RSPCK cycles, the value in the shift register is copied to the receive buffer. On copying of data to the shift register, data from R31 to P is checked for parity.



Note: 输出=MOSI（主）MISO（从），输入=MISO（主）MOSI（从）

Figure 31.17 LSB优先传输，24位数据和奇偶校验禁用

31.3.4.2 启用奇偶校验时的操作(SPCR2.SPPE=1)

启用奇偶校验时，传输数据的最低位变为奇偶校验位。硬件计算奇偶校验位的值。

(1) 32位数据的MSB优先传输

图31.18显示了SPI数据寄存器(SPDR)和启用奇偶校验的移位寄存器的传输操作，
SPI数据长度为32位，且MSB优先选择。

在传输中，奇偶校验位(P)的值是从位T31到T01计算的。这将替换最后一位T00，并将整个值复制到移位寄存器。数据按T31、T30、……、T01和P的顺序传输。

在接收时，接收到的数据通过移位寄存器的位[0]逐位移位。在输入所需数量的RSPCK周期后收集R31至P位时，将移位寄存器中的值复制到接收缓冲区。在将数据复制到移位寄存器时，检查从R31到P的数据的奇偶性。

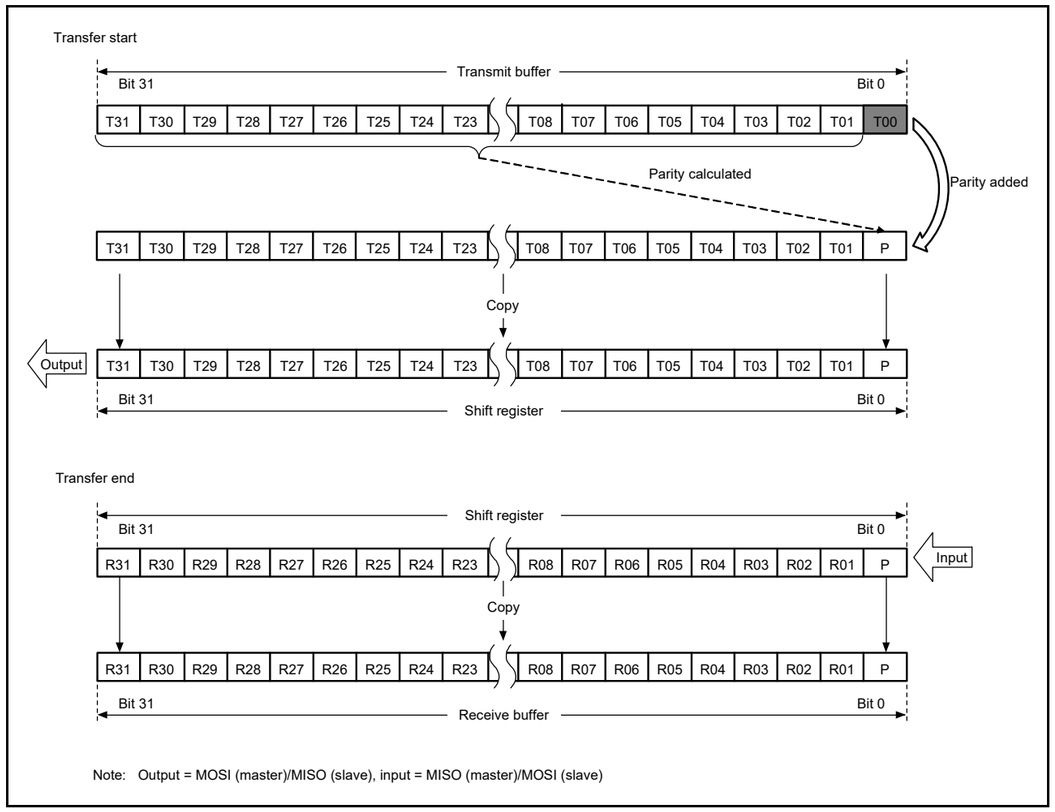


Figure 31.18 MSB-first transfer with 32-bit data and parity enabled

(2) MSB-first transfer with 24-bit data

Figure 31.19 shows the transfer operation of the SPI Data Register (SPDR) and the shift register with parity enabled, an SPI data length of 24 bits, and MSB-first selected.

In transmission, the value of the parity bits (P) is calculated from bits T23 to T01. This replaces the final bit, T00, and the whole value is copied to the shift register. Data is transmitted in the order T23, T22, …, T01, and P.

In reception, received data is shifted in bit-by-bit through bit [0] of the shift register. When the R23 to P bits are collected after input of the required number of RSPCK cycles, the value in the shift register is copied to the receive buffer. After data is copied to the shift register, data from R23 to P is checked for parity. The upper 8 bits of the transmit buffer are stored in the upper 8 bits of the receive buffer. Writing 0 to the T31 to T24 bits at the time of transmission leads to 0 being inserted in the upper 8 bits of the receive buffer.

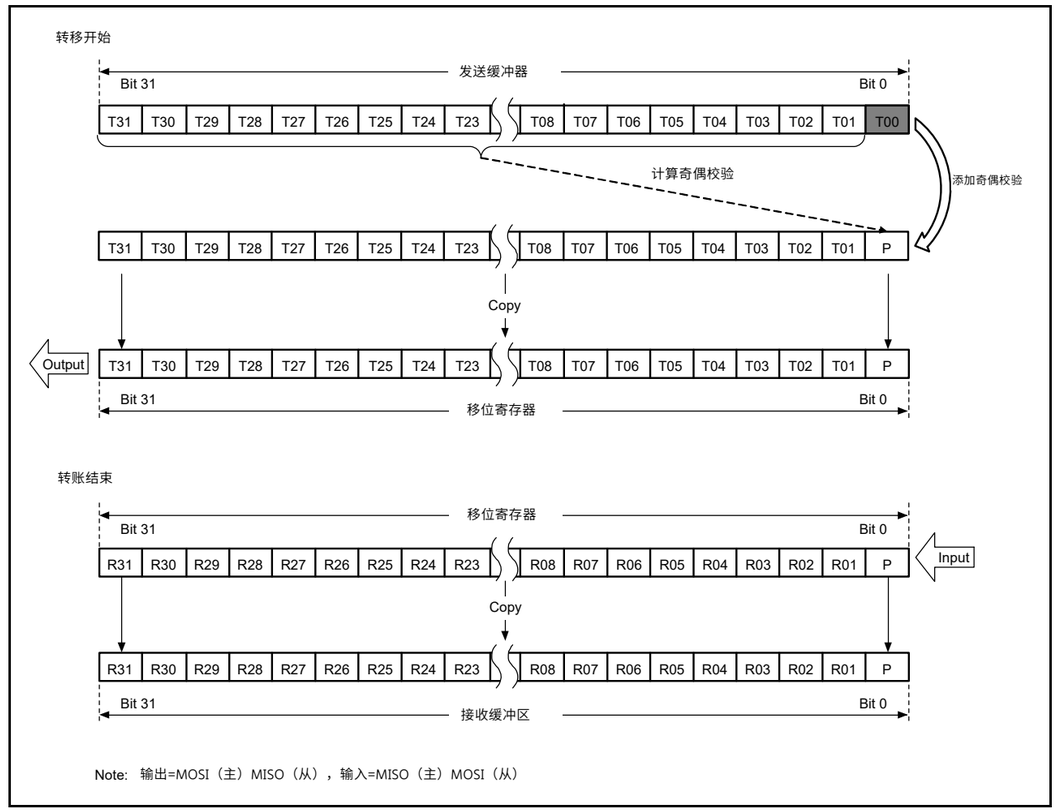


Figure 31.18 启用32位数据和奇偶校验的MSB优先传输

(2) 24位数据的MSB优先传输

图31.19显示了SPI数据寄存器(SPDR)和启用奇偶校验的移位寄存器的传输操作，SPI数据长度为24位，且MSB优先选择。

在传输中，奇偶校验位(P)的值是从位T23到T01计算的。这将替换最后一位T00，并将整个值复制到移位寄存器。数据按T23、T22、……、T01和P的顺序传输。

在接收时，接收到的数据通过移位寄存器的位[0]逐位移位。在输入所需数量的RSPCK周期后收集R23至P位时，将移位寄存器中的值复制到接收缓冲区。将数据复制到移位寄存器后，对R23到P的数据进行奇偶校验。发送缓冲区的高8位存储在接收缓冲区的高8位中。在发送时将0写入T31到T24位会导致0被插入到接收缓冲区的高8位中。

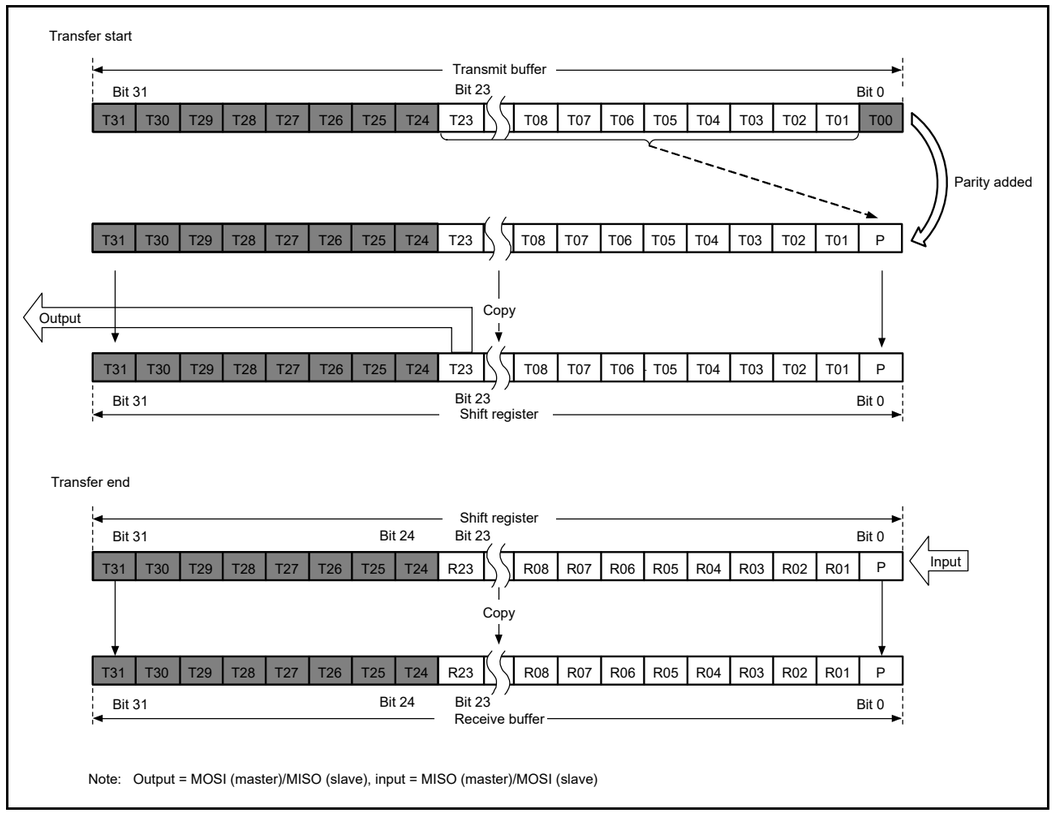


Figure 31.19 MSB-first transfer with 24-bit data and parity enabled

(3) LSB-first transfer with 32-bit data

Figure 31.20 shows the transfer operation of the SPI Data Register (SPDR) and the shift register with parity enabled, an SPI data length of 32 bits, and LSB-first selected.

In transmission, the value of the parity bit (P) is calculated from the T30 to T00 bits. This replaces the final bit, T31, and the whole value is copied to the shift register. Data is transmitted in the order T00, T01, …, T30, and P.

In reception, received data is shifted in bit-by-bit through bit [0] of the shift register. When the R00 to P bits are collected after input of the required number of RSPCK cycles, the value in the shift register is copied to the receive buffer. After data is copied to the shift register, the data from R00 to P is checked for parity.

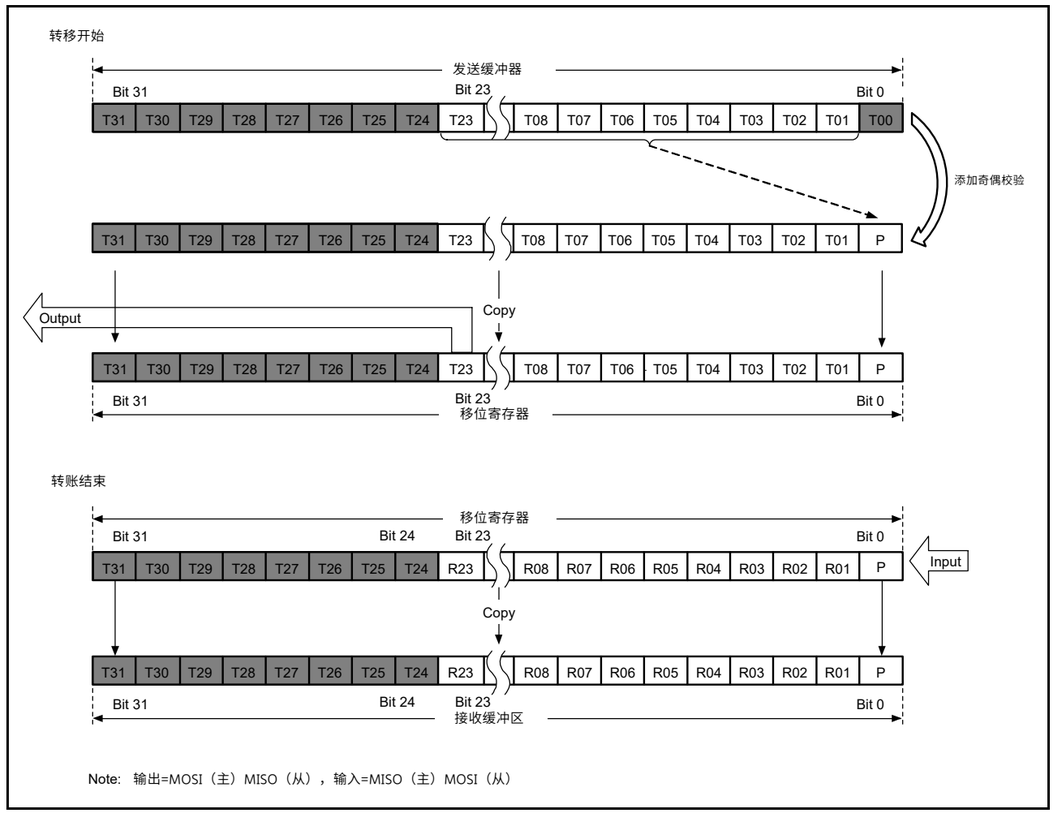


Figure 31.19 启用24位数据和奇偶校验的MSB优先传输

(3) 32位数据的LSB优先传输

图31.20显示了SPI数据寄存器(SPDR)和启用奇偶校验的移位寄存器的传输操作，SPI数据长度为32位，并选择LSB-first。

在传输中，奇偶校验位(P)的值是从T30到T00位计算的。这将替换最后一位T31，并将整个值复制到移位寄存器。数据按T00、T01、……、T30和P的顺序传输。

在接收时，接收到的数据通过移位寄存器的位[0]逐位移位。在输入所需数量的RSPCK周期后收集R00至P位时，将移位寄存器中的值复制到接收缓冲区。数据复制到移位寄存器后，对R00到P的数据进行奇偶校验。

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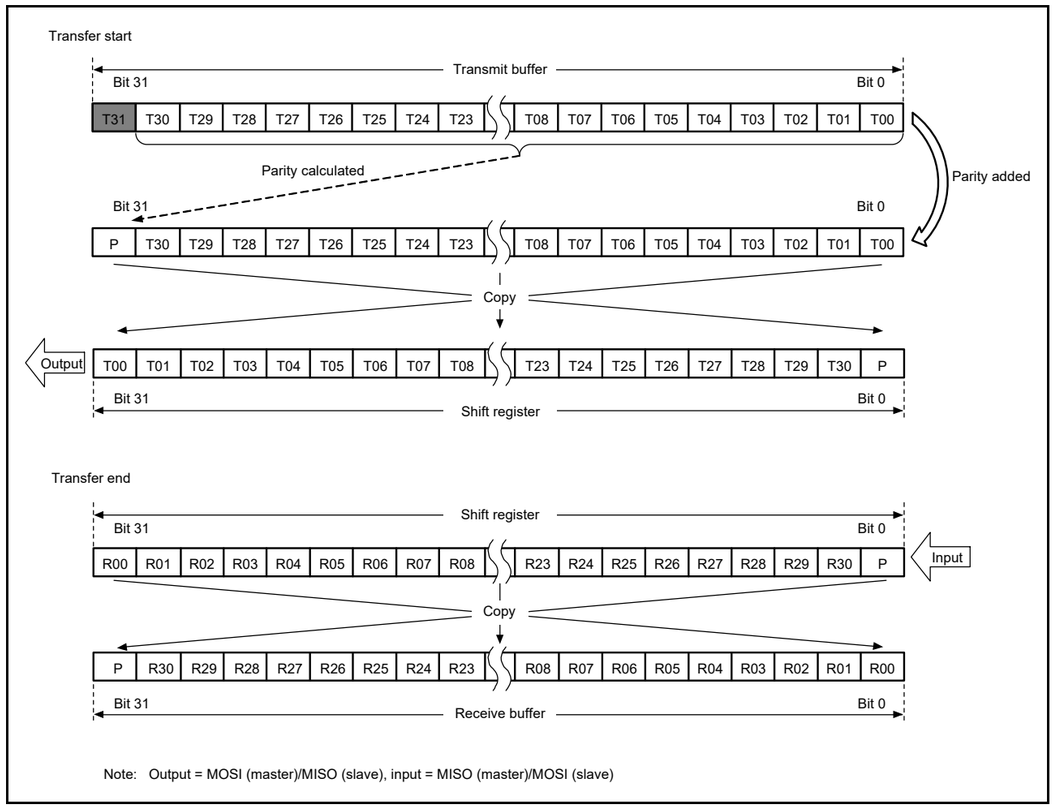

Figure 31.20 LSB-first transfer with 32-bit data and parity enabled

(4) LSB-first transfer with 24-bit data

Figure 31.21 shows the transfer operation of the SPI Data Register (SPDR) and the shift register with parity enabled, an SPI data length of 24 bits, and LSB-first selected.

In transmission, the value of the parity bit (P) is calculated from the T22 to T00 bits. This replaces the final bit, T23, and the whole is copied to the shift register. Data is transmitted in the order T00, T01, …, T22, and P.

In reception, received data is shifted in bit-by-bit through bit [8] of the shift register. When the R00 to P bits are collected after input of the required number of RSPCK cycles, the value in the shift register is copied to the receive buffer. On copying of data to the shift register, the data from R00 to P is checked for parity. The upper 8 bits of the transmit buffer are stored in the upper 8 bits of the receive buffer. Writing 0 to the T31 to T24 bits at transmission leads to 0 being inserted in the upper 8 bits of the receive buffer.

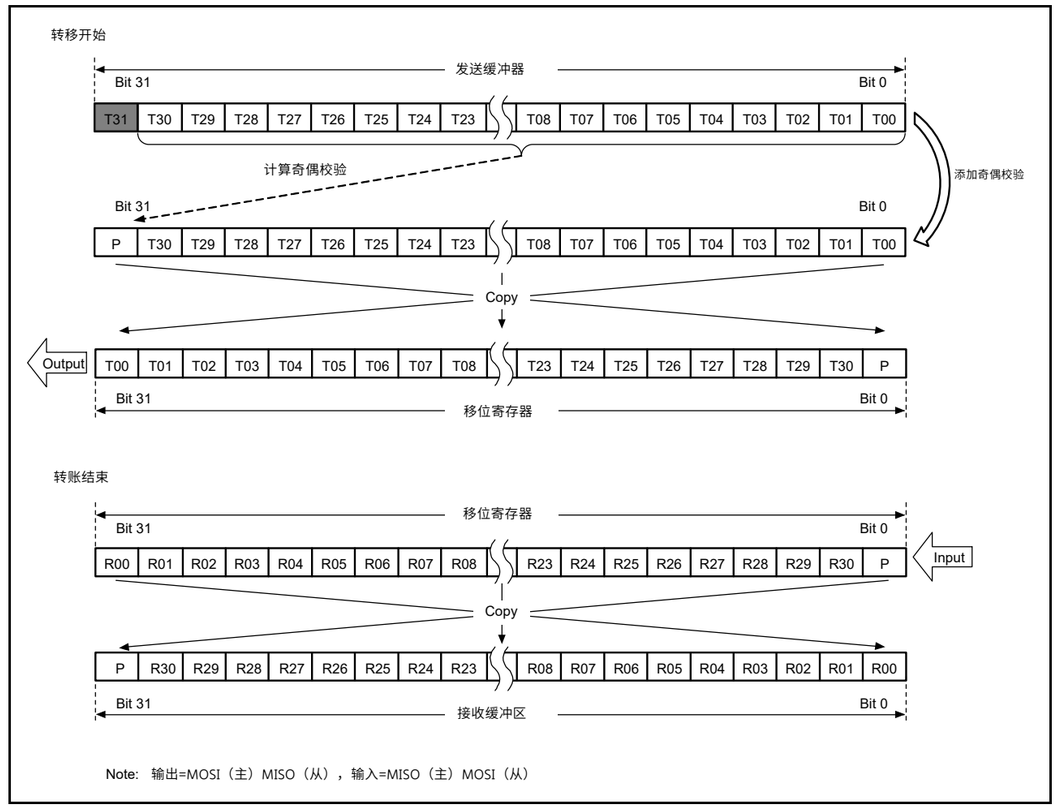

Figure 31.20 启用32位数据和奇偶校验的LSB优先传输

(4) 24位数据的LSB优先传输

图31.21显示了SPI数据寄存器(SPDR)和启用奇偶校验的移位寄存器的传输操作，
SPI数据长度为24位，并选择LSB优先。

在传输中，奇偶校验位(P)的值是从T22到T00位计算的。这将替换最后一位T23，并将整体复制到移位寄存器中。数据按T00、T01、……、T22和P的顺序传输。

在接收中，接收到的数据通过移位寄存器的位[8]逐位移位。在输入所需数量的RSPCK周期后收集R00至P位时，将移位寄存器中的值复制到接收缓冲区。在将数据复制到移位寄存器时，会检查从R00到P的数据的奇偶性。发送缓冲区的高8位存储在接收缓冲区的高8位中。在发送时将0写入T31到T24位会导致将0插入接收缓冲区的高8位。

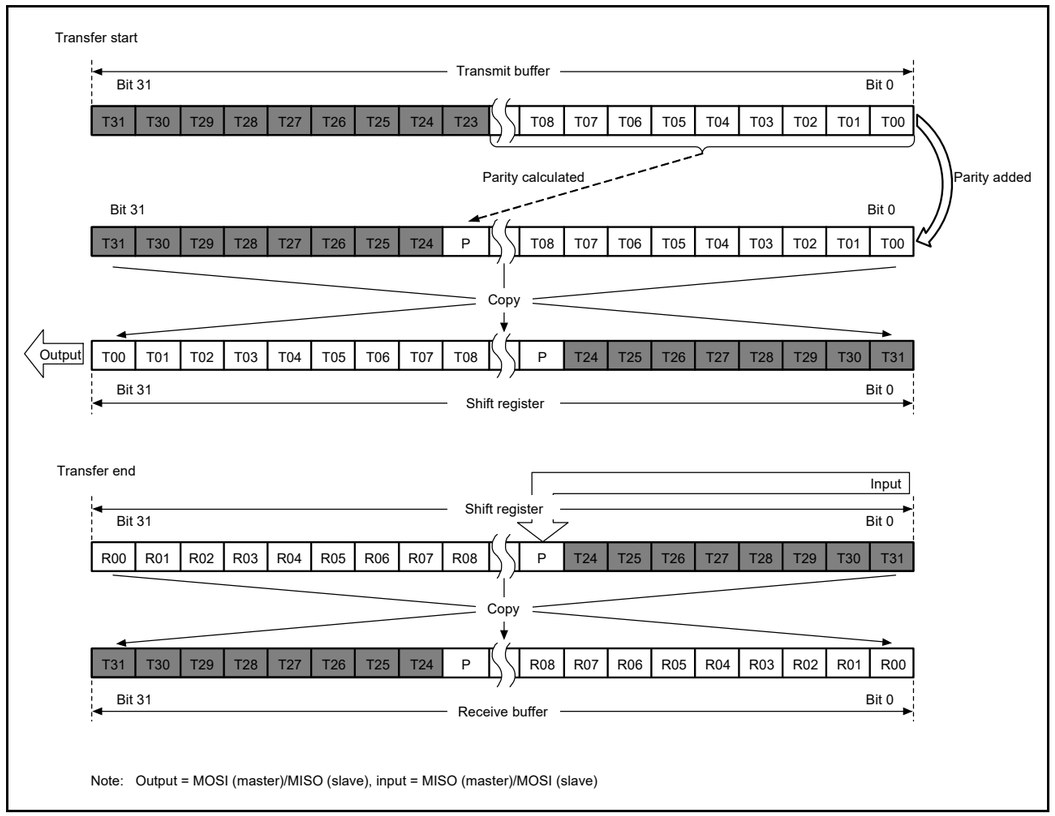

Figure 31.21 LSB-first transfer with 24-bit data and parity enabled

31.3.5 Transfer Format

31.3.5.1 Transfer format when CPHA = 0

Figure 31.22 shows an example transfer format for the serial transfer of 8-bit data when the SPCMDm.CPHA bit is 0. Do not perform clock synchronous operation (SPCR.SPMS = 1) when the SPI operates in slave mode (SPCR.MSTR = 0) and the CPHA bit is 0. In Figure 31.22, RSPCKn (CPOL = 0) indicates the RSPCKn signal waveform when the SPCMDm.CPOL bit is 0, and RSPCKn (CPOL = 1) indicates the RSPCKn signal waveform when the CPOL bit is 1. The sampling timing represents the timing at which the SPI fetches serial transfer data into the shift register. The I/O directions of the signals depend on the SPI settings. For details, see section 31.3.2, Controlling the SPI Pins.

When the SPCMDm.CPHA bit is 0, the driving of valid data to the MOSIn and MISOn signals begins at an SSLni signal assertion. The first RSPCKn signal change that occurs after the SSLni signal assertion becomes the first transfer data fetch. After this, data is sampled every 1 RSPCK cycle. The change timing for the MOSIn and MISOn signals is 1/2 RSPCK cycles after the transfer data fetch timing. The CPOL bit setting does not affect the RSPCK signal operation timing as it only affects the signal polarity.

t1 denotes the RSPCK delay, the period from an SSLni signal assertion to RSPCKn oscillation. t2 denotes the SSL negation delay, the period from the termination of RSPCKn oscillation to an SSLni signal negation. t3 denotes the next-access delay, the period in which SSLni signal assertion is suppressed for the next transfer after the end of the serial transfer. t1, t2, and t3 are controlled by a master device running on the SPI system. For a description of t1, t2, and t3 when the SPI of the MCU is in master mode, see section 31.3.10.1, Master mode operation.

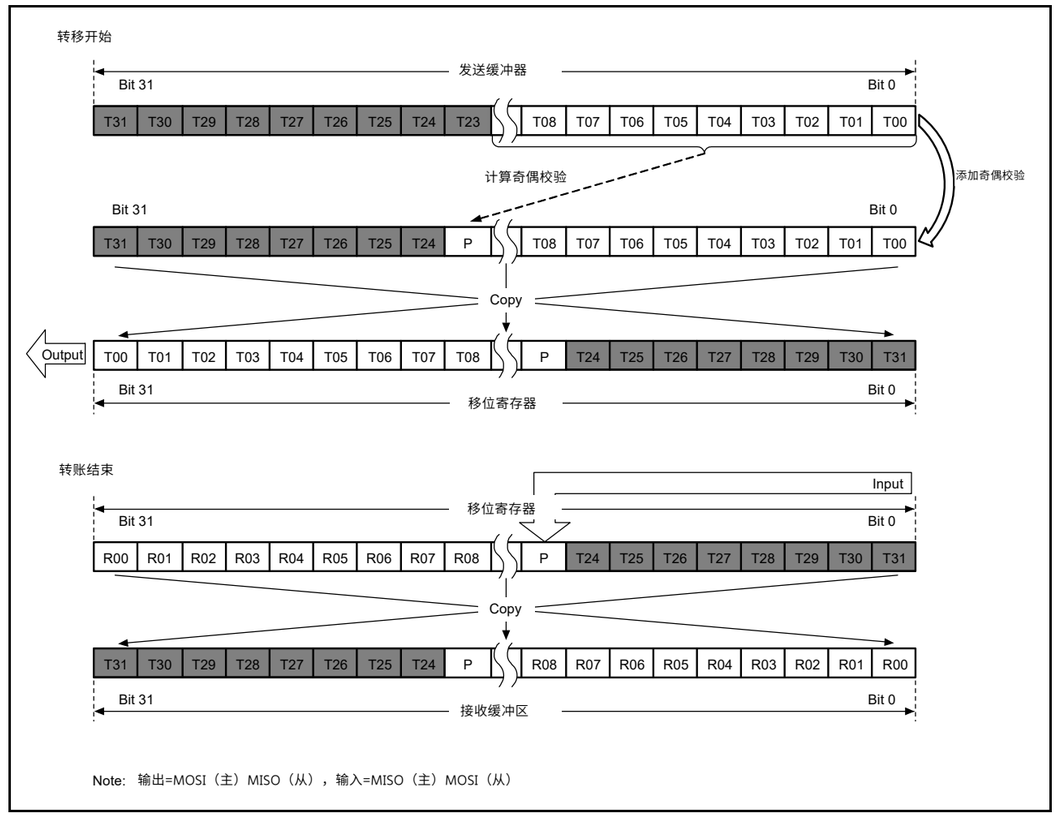

Figure 31.21 启用24位数据和奇偶校验的LSB优先传输

31.3.5 传输格式

31.3.5.1 CPHA=0时的传输格式

图31.22显示了当SPCMDm.CPHA位为0时串行传输8位数据的示例传输格式。当SPI在从机模式下运行时（SPCR.MSTR=0)且CPHA位为0。在图31.22中，RSPCKn(CPOL=0)表示SPCMDm.CPOL位为0时的RSPCKn信号波形，RSPCKn(CPOL=1)表示CPOL位为0时的RSPCKn信号波形1.采样时序表示SPI将串行传输数据取入移位寄存器的时序。信号的IO方向取决于SPI设置。有关详细信息，请参见第31.3.2节，控制SPI引脚。

当SPCMDm.CPHA位为0时，将有效数据驱动到MOSIn和MISOn信号开始于SSLni信号断言。在SSLni信号断言之后发生的第一个RSPCKn信号变化成为第一次传输数据获取。此后，每1个RSPCK周期对数据进行采样。MOSIn和MIOn信号的变化时序是传输数据获取时序之后的12RSPCK周期。CPOL位设置不影响RSPCK信号操作时序，因为它只影响信号极性。

t1表示RSPCK延迟，即从SSLni信号断言到RSPCKn振荡的周期。t2表示SSL否定延迟，即从RSPCKn振荡终止到SSLni信号否定的周期。t3表示下一次访问延迟，即在串行传输结束后为下一次传输抑制SSLni信号断言的时间段。t1、t2和t3由在SPI系统上运行的主设备控制。有关MCU的SPI处于主机模式时的t1、t2和t3的说明，请参见第31.3.10.1节，主机模式操作。

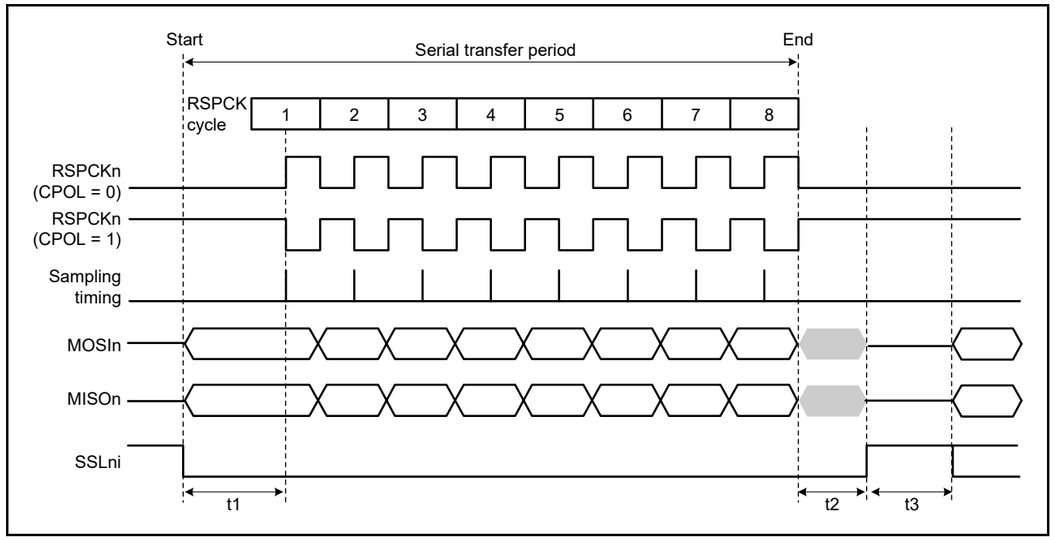

Figure 31.22 SPI transfer format when CPHA = 0

31.3.5.2 When CPHA = 1

Figure 31.23 shows an example transfer format for the serial transfer of 8-bit data when the SPCMDm.CPHA bit is 1. However, when the SPCR.SPMS bit is 1, the SSLni signals are not used, and only the three signals RSPCKn, MOSIn, and MISOn handle communications. In Figure 31.23, RSPCK (CPOL = 0) indicates the RSPCKn signal waveform when the SPCMDm.CPOL bit is 0, and RSPCK (CPOL = 1) indicates the RSPCKn signal waveform when the CPOL bit is 1. The sampling timing represents the timing at which the SPI fetches serial transfer data into the shift register. The I/O directions of the signals depend on the SPI mode (master or slave). For details, see section 31.3.2, Controlling the SPI Pins.

When the SPCMDm.CPHA bit is 1, the driving of invalid data to the MISOn signal begins at an SSLni signal assertion. The output of valid data to the MOSIn and MISOn signals begins at the first RSPCKn signal change that occurs after the SSLni signal assertion. After this, data is updated every 1 RSPCK cycle. The transfer data fetch timing is 1/2 RSPCK cycles after the data update timing. The SPCMDm.CPOL bit setting does not affect the RSPCKn signal operation timing. It only affects the signal polarity.

t1, t2, and t3 are the same as those when CPHA = 0. For a description of t1, t2, and t3 when the SPI of the MCU is in master mode, see section 31.3.10.1, Master mode operation.

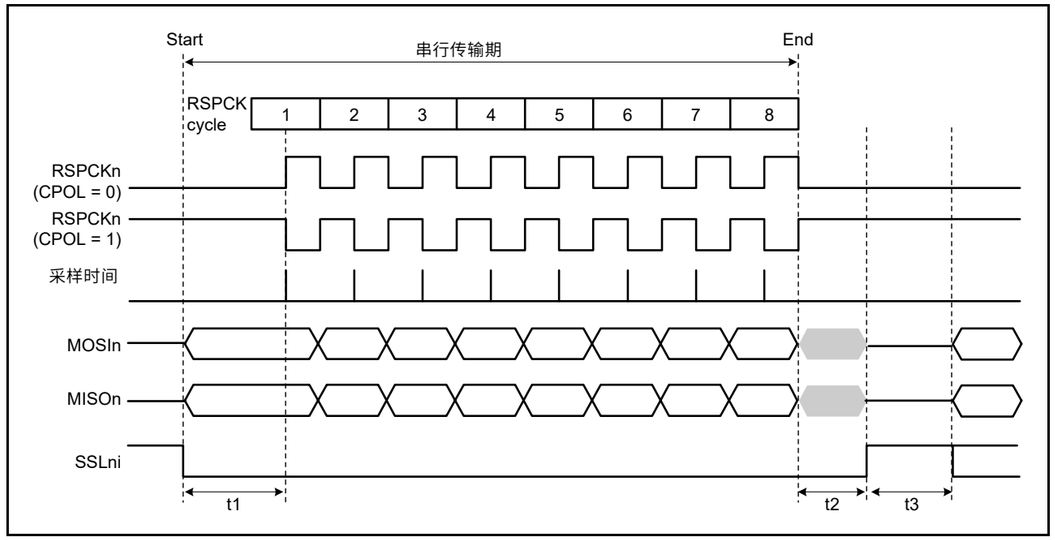

Figure 31.22 CPHA=0时的SPI传输格式

31.3.5.2 When CPHA = 1

图31.23显示了SPCMDm.CPHA位为1时串行传输8位数据的示例传输格式。但是，当SPCR.SPMS位为1时，不使用SSLni信号，仅使用三个信号RSPCKn，MOSIn和MISon处理通信。在图31.23中，RSPCK(CPOL=0)表示SPCMDm.CPOL位为0时的RSPCKn信号波形，RSPCK(CPOL=1)表示CPOL位为1时的RSPCKn信号波形。SPI将串行传输数据提取到移位寄存器中。信号的IO方向取决于SPI模式（主机或从机）。有关详细信息，请参见第31.3.2节，控制SPI引脚。

当SPCMDm.CPHA位为1时，将无效数据驱动到MIOn信号开始于SSLni信号断言。在SSLni信号置位后发生的第一个RSPCKn信号变化时，开始向MOSIn和MISOn信号输出有效数据。此后，每1个RSPCK周期更新一次数据。传输数据获取时序是数据更新时序之后的12个RSPCK周期。SPCMDm.CPOL位设置不影响RSPCKn信号操作时序。它只影响信号极性。

t1、t2、t3与CPHA=0时相同。关于MCU的SPI处于主机模式时的t1、t2和t3说明，请参见第31.3.10.1节，主机模式操作。

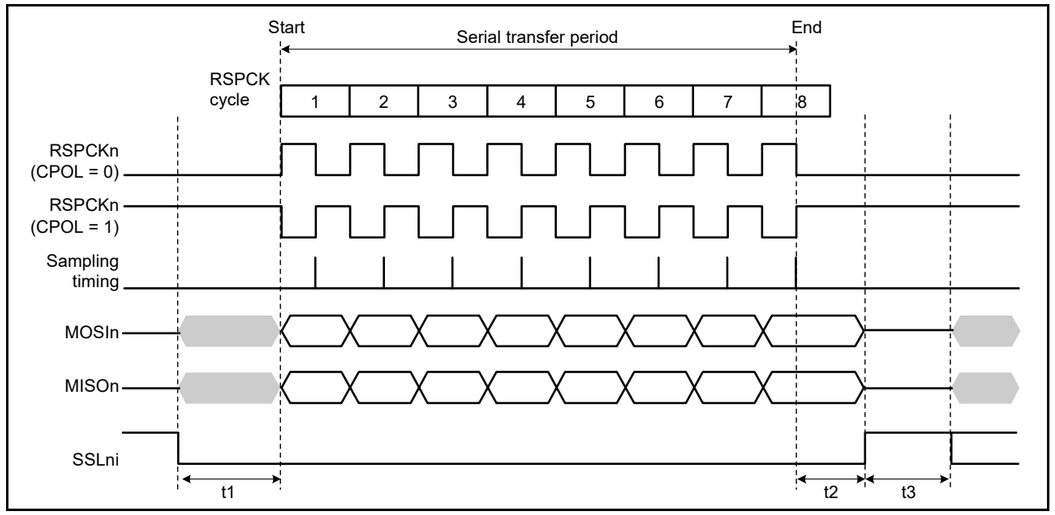

Figure 31.23 SPI transfer format when CPHA = 1

31.3.6 Data Transfer Modes

Full-duplex synchronous serial communications or transmit operations can only be selected in the Communications Operating Mode Select bit (SPCR.TXMD). The SPDR/SPDR_HA access shown in Figure 31.24 and Figure 31.25 indicate the condition of access to the register, where W denotes a write cycle.

31.3.6.1 Full-duplex synchronous serial communications (SPCR.TXMD = 0)

Figure 31.24 shows an example of operation where the Communications Operating Mode Select bit (SPCR.TXMD) is set to 0. In this example, the SPI performs an 8-bit serial transfer in which the SPDCR.SPFC[1:0] bits are 00b, the SPCMDm.CPHA bit is 1, and the SPCMDm.CPOL bit is 0. The numbers given for RSPCKn in the waveform represent the number of RSPCK cycles, such as the number of transferred bits.

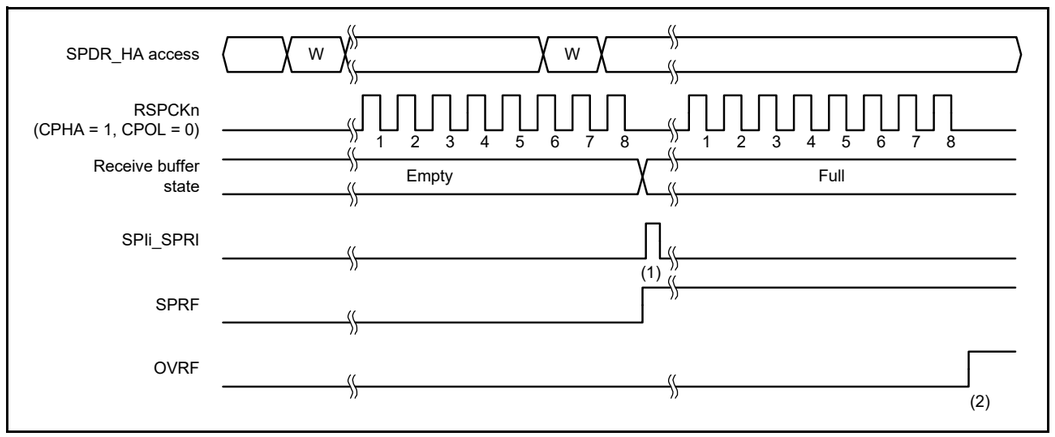

Figure 31.24 Operation example when SPCR.TXMD = 0

The operation of the flags at timings (1) and (2) in Figure 31.24 is as follows:

1. When a serial transfer ends with the SPDR_HA receive buffer empty, the SPI generates a receive buffer full interrupt request (SPIi_SPRI), the SPI sets the SPSR.SPRF flag to 1, and the received data is copied in the shift register to the receive buffer.

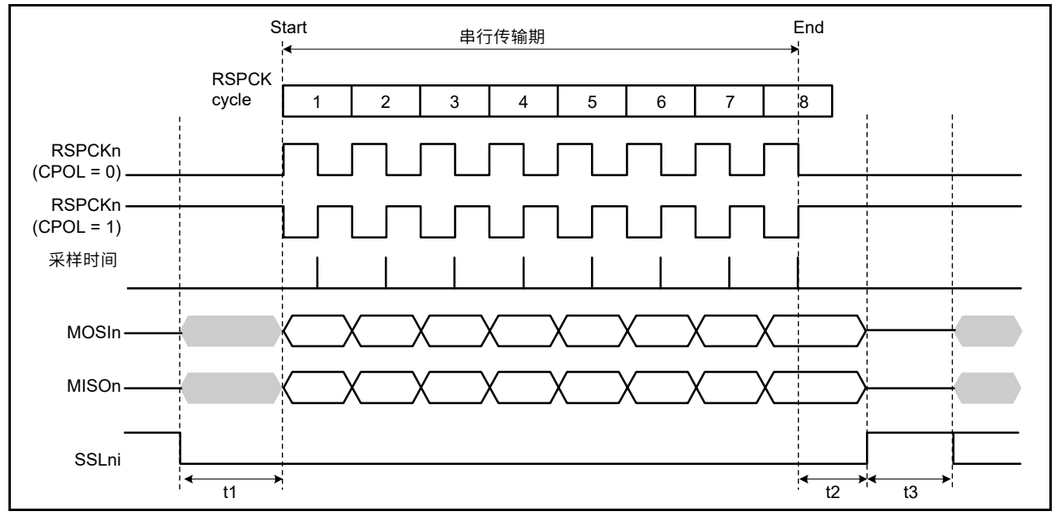

Figure 31.23 CPHA=1时的SPI传输格式

31.3.6 数据传输模式

全双工同步串行通信或发送操作只能在通信操作模式选择位(SPCR.TXMD)中选择。图31.24和图31.25所示的SPDRSPDR_HA访问表示访问寄存器的条件，其中W表示写周期。

31.3.6.1 全双工同步串行通信(SPCR.TXMD=0)

图31.24显示了通信操作模式选择位(SPCR.TXMD)设置为0的操作示例。在此示例中，SPI执行8位串行传输，其中SPDCR.SPFC[1:0]位为00b，SPCMDm.CPHA位为1，SPCMDm.CPOL位为0。波形中给RSPCKn的数字表示RSPCK周期数，例如传输的位数。

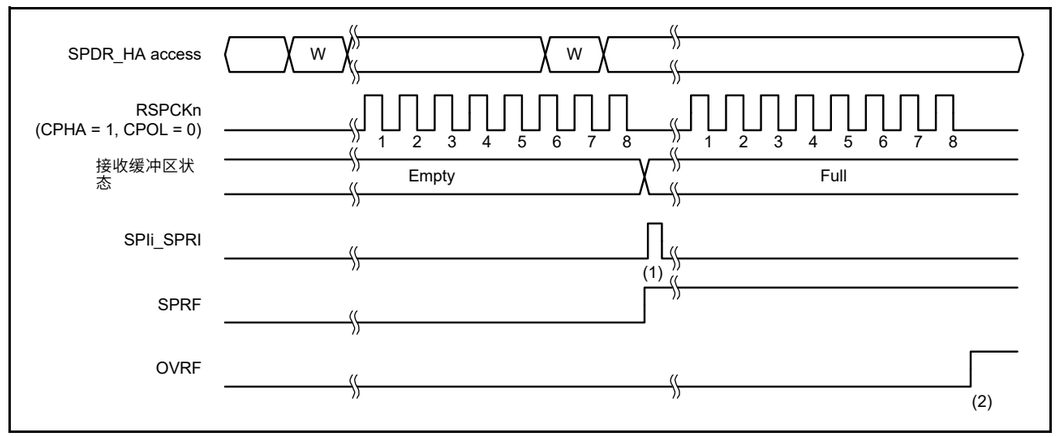

Figure 31.24 SPCR.TXMD=0时的操作示例

图31.24中时序(1)和(2)的标志操作如下：

1. 当串行传输结束且SPDR_HA接收缓冲区为空时，SPI产生接收缓冲区满中断请求（SPIi_SPRI），SPI将SPSR.SPRF标志设置为1，并将接收到的数据在移位寄存器中复制到接收缓冲区.

2. When a serial transfer ends with the SPDR_HA receive buffer holding data that was received in the previous serial transfer, the SPI sets the SPSR.OVRF flag to 1, and discards the received data in the shift register.

31.3.6.2 Transmit-only operations (SPCR.TXMD = 1)

Figure 31.25 shows an example of operation where the Communications Operating Mode Select bit (SPCR.TXMD) is set to 1. In this example, the SPI performs an 8-bit serial transfer in which the SPDCR.SPFC[1:0] bits are 00b, the SPCMDm.CPHA bit is 1, and the SPCMDm.CPOL bit is 0. The numbers given for RSPCKn in the waveform represent the number of RSPCK cycles, such as the number of transferred bits.

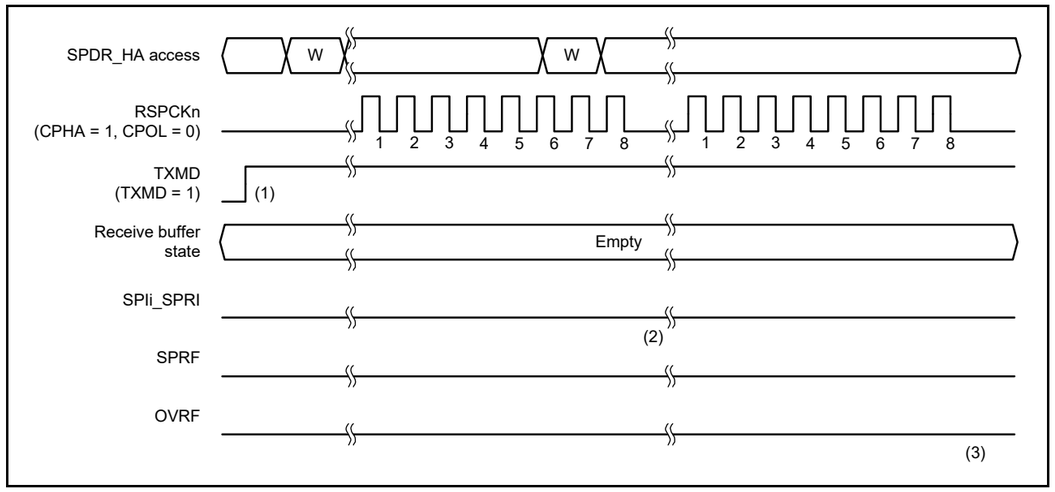

Figure 31.25 Operation example when SPCR.TXMD = 1

The operation of the flags at timings (1) to (3) in Figure 31.25 is as follows:

1. Make sure there is no data left in the receive buffer (SPSR.SPRF flag is 0) and the SPSR.OVRF flag is 0 before entering the transmit-only mode (SPCR.TXMD = 1).
2. When a serial transfer ends with the SPDR_HA receive buffer empty, if the transmit-only mode is selected (SPCR.TXMD = 1), the SPSR.SPRF flag remains 0, and the SPI does not copy the data in the shift register to the receive buffer.
3. Because the SPDR_HA receive buffer does not hold data that was received in the previous serial transfer, even when a serial transfer ends, the SPSR.OVRF flag remains 0, and the data in the shift register is not copied to the receive buffer.

In transmit-only mode (SPCR.TXMD = 1), the SPI transmits but does not receive data. Therefore, the SPSR.SPRF and SPSR.OVRF flags remain 0 at timings (1) to (3).

31.3.7 Transmit Buffer Empty and Receive Buffer Full Interrupts

Figure 31.26 and Figure 31.27 show operation examples of the transmit buffer empty interrupt (SPIi_SPTI) and the receive buffer full interrupt (SPIi_SPRI). The register accesses shown in these figures indicate the conditions of access to the SPDR_HA register, where W denotes a write cycle and R a read cycle. In Figure 31.26, the SPI performs an 8-bit serial transfer when SPCR.TXMD bit is 0, the SPDCR.SPFC[1:0] bits are 00b, the SPCMDm.CPHA bit is 0, and the SPCMDm.CPOL bit is 0.

In Figure 31.27, the SPI performs an 8-bit serial transfer in which SPCR.TXMD bit is 0, the SPDCR.SPFC[1:0] bits are 00b, the SPCMDm.CPHA bit is 1, and the SPCMDm.CPOL bit is 0. The numbers given for RSPCKn in the waveform represent the number of RSPCK cycles, such as the number of transferred bits.

2. 当串行传输结束时，SPDR_HA接收缓冲区保存了先前串行传输中接收到的数据，SPI将SPSR.OVRF标志设置为1，并丢弃移位寄存器中的接收数据。

31.3.6.2 Transmit-only operations (SPCR.TXMD = 1)

图31.25显示了通信操作模式选择位(SPCR.TXMD)设置为1的操作示例。在此示例中，SPI执行8位串行传输，其中SPDCR.SPFC[1:0]位为00b，SPCMDm.CPHA位为1，SPCMDm.CPOL位为0。波形中给RSPCKn的数字表示RSPCK周期数，例如传输的位数。

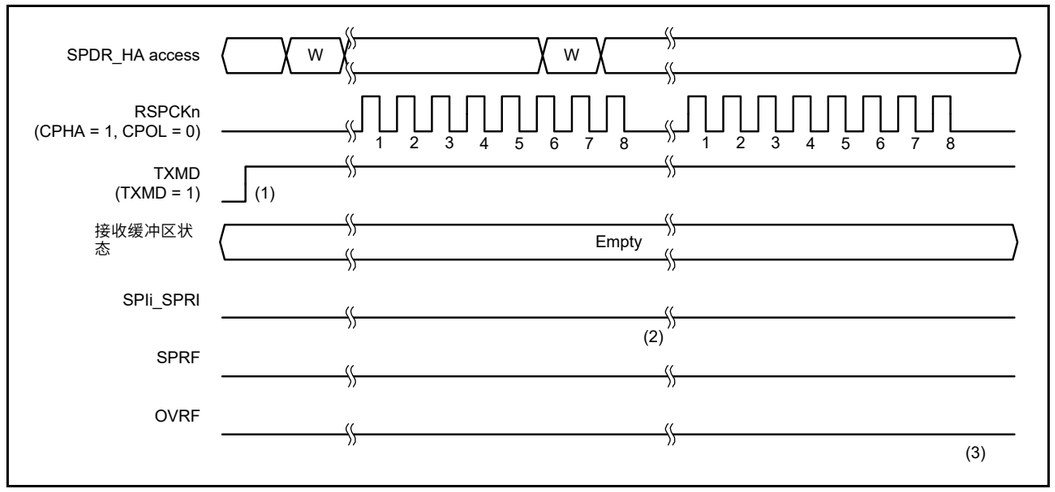

Figure 31.25 SPCR.TXMD=1时的操作示例

图31.25中时序(1)到(3)的标志操作如下：

1. 在进入仅发送模式（SPCR.TXMD=1）之前，确保接收缓冲区中没有剩余数据（SPSR.SPRF标志为0）并且SPSR.OVRF标志为0。
2. 当串行传输结束且SPDR_HA接收缓冲区为空时，如果选择了仅发送模式（SPCR.TXMD=1），则SPSR.SPRF标志保持为0，并且SPI不会将移位寄存器中的数据复制到接收缓冲区。
3. 因为SPDR_HA接收缓冲区不保存在先前串行传输中接收到的数据，所以即使串行传输结束，SPSR.OVRF标志仍保持为0，并且移位寄存器中的数据不会复制到接收缓冲区。

在仅发送模式（SPCR.TXMD=1）下，SPI发送但不接收数据。因此，SPSR.SPRF和SPSR.OVRF标志在时间(1)到(3)处保持为0。

31.3.7 发送缓冲区空和接收缓冲区满中断

图31.26和图31.27显示了发送缓冲区空中断(SPIi_SPTI)和接收缓冲区满中断(SPIi_SPRI)的操作示例。这些图中显示的寄存器访问表示访问SPDR_HA寄存器的条件，其中W表示写周期，R表示读周期。在图31.26中，当SPCR.TXMD位为0、SPDCR.SPFC[1:0]位为00b、SPCMDm.CPHA位为0、SPCMDm.CPOL位为0时，SPI执行8位串行传输.

在图31.27中，SPI执行8位串行传输，其中SPCR.TXMD位为0，SPDCR.SPFC[1:0]位为00b，SPCMDm.CPHA位为1，SPCMDm.CPOL位为0.波形中为RSPCKn给出的数字表示RSPCK周期数，例如传输的位数。

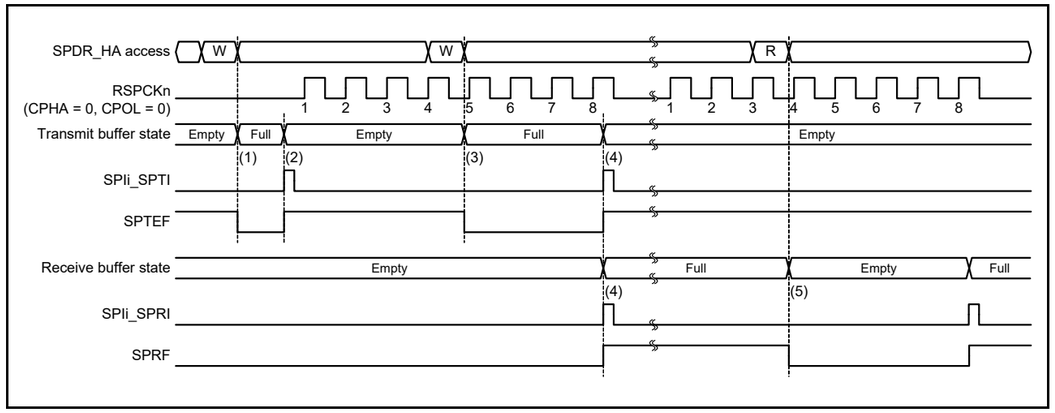

Figure 31.26 Operation example of SPIi_SPTI and SPIi_SPRI interrupts when CPHA = 0 and CPOL = 0

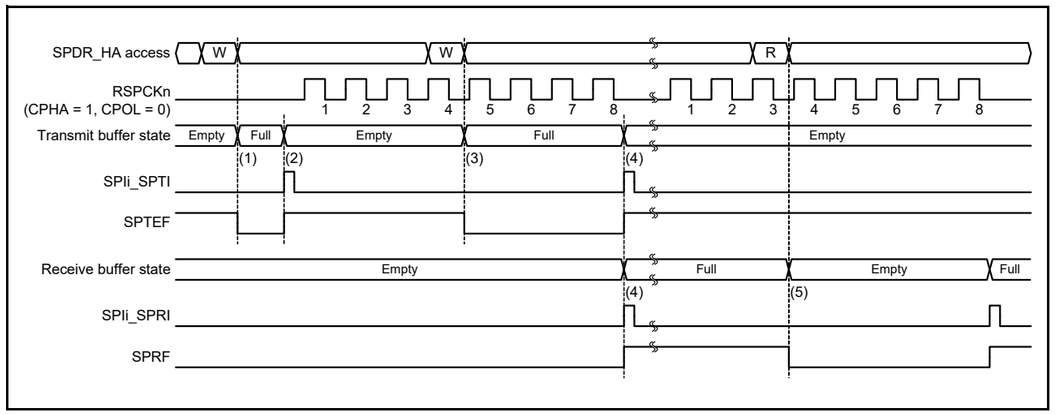

Figure 31.27 Operation example of SPIi_SPTI and SPIi_SPRI interrupts when CPHA = 1 and CPOL = 0

The operation of the SPI at timings (1) to (5) in Figure 31.27 is as follows:

1. When transmit data is written to SPDR_HA with the transmit buffer of SPDR_HA empty and data for the next transfer not set, the SPI writes data to the transmit buffer and clears the SPSR.SPTEF flag to 0.
2. If the shift register is empty, the SPI copies the data in the transmit buffer to the shift register, generates a transmit buffer empty interrupt request (SPIi_SPTI), and sets the SPSR.SPTEF flag to 1. How a serial transfer is started depends on the SPI mode. For details, see section 31.3.10, SPI Operation, and section 31.3.11, Clock Synchronous Operation.
3. When transmit data is written to SPDR_HA either by the transmit buffer empty interrupt routine, or by the processing of the transmit buffer empty using the SPTEF flag, the SPI writes data to the transmit buffer and clears the SPTEF flag to 0. Because the data being transferred serially is stored in the shift register, the SPI does not copy the data in the transmit buffer to the shift register.
4. When the serial transfer ends with the SPDR_HA receive buffer empty, the SPI copies the receive data in the shift register to the receive buffer, generates a receive buffer full interrupt request (SPIi_SPRI), and sets the SPRF flag to 1. Because the shift register becomes empty on completion of the serial transfer, if the transmit buffer is full before the serial transfer ended, the SPI sets the SPTEF flag to 1 and copies data in the transmit buffer to the shift register. Even when received data is not copied from the shift register to the receive buffer in an overrun error status, on completion of the serial transfer, the SPI determines that the shift register is empty, so data transfer from the transmit buffer to the shift register is enabled.

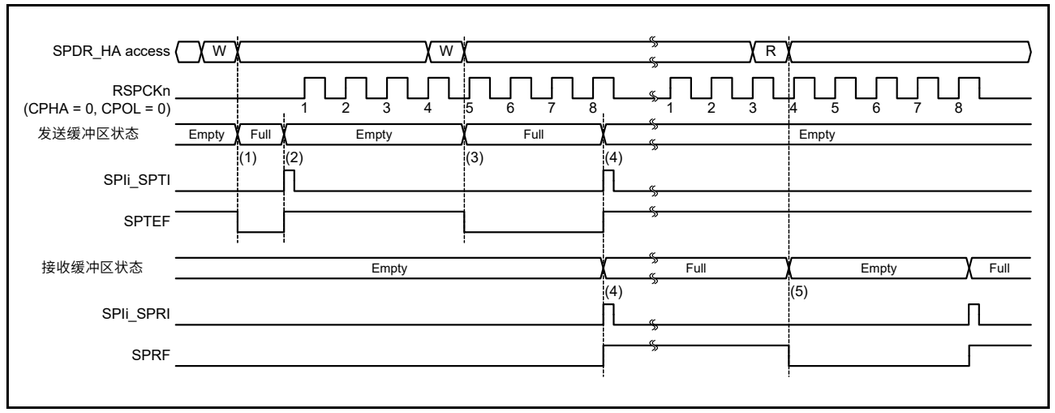

Figure 31.26 CPHA=0和CPOL=0时SPIi_SPTI和SPIi_SPRI中断的操作示例

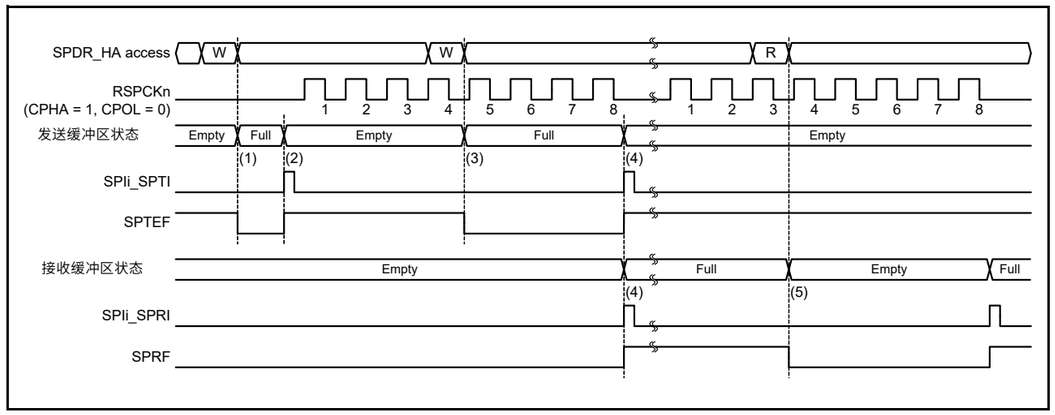

Figure 31.27 CPHA=1和CPOL=0时SPIi_SPTI和SPIi_SPRI中断的操作示例

SPI在图31.27中时序(1)到(5)的操作如下：

1. 当发送数据写入SPDR_HA且SPDR_HA的发送缓冲区为空且未设置下一次传输的数据时，SPI将数据写入发送缓冲区并将SPSR.SPTEF标志清除为0。
2. 如果移位寄存器为空，则SPI将发送缓冲区中的数据复制到移位寄存器，产生发送缓冲区空中断请求（SPIi_SPTI），并将SPSR.SPTEF标志设置为1。如何启动串行传输取决于SPI模式。有关详细信息，请参见第31.3.10节，SPI操作和第31.3.11节，时钟同步操作。
3. 当发送数据被发送缓冲区空中断程序写入SPDR_HA时，或者通过使用SPTEF标志对发送缓冲区空的处理，SPI将数据写入发送缓冲区并将SPTEF标志清除为0。因为数据正在串行传输的数据存储在移位寄存器中，SPI不会将发送缓冲区中的数据复制到移位寄存器中。
4. 当串行传输结束且SPDR_HA接收缓冲区为空时，SPI将移位寄存器中的接收数据复制到接收缓冲区，产生接收缓冲区满中断请求（SPIi_SPRI），并将SPRF标志设置为1。因为移位寄存器串行传输完成后变为空，如果在串行传输结束之前发送缓冲区已满，则SPI将SPTEF标志设置为1，并将发送缓冲区中的数据复制到移位寄存器。即使接收到的数据在溢出错误状态下没有从移位寄存器复制到接收缓冲区，在串行传输完成时，SPI会确定移位寄存器为空，因此从发送缓冲区到移位寄存器的数据传输是启用。

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5. When SPDR_HA is read either by the receive buffer full interrupt routine or by the processing of the receive buffer full interrupt using the SPRF flag, the receive data can be read.

If SPDR_HA is written to when the transmit buffer holds untransmitted data (SPTEF flag is 0), the SPI does not update data in the transmit buffer. When writing to SPDR_HA, make sure to use either a transmit buffer empty interrupt request or to process a transmit buffer empty interrupt using the SPTEF flag. To use a transmit buffer empty interrupt, set the SPTIE bit in SPCR to 1. If the SPI function is disabled (SPCR.SPE bit is 0), set the SPTIE bit to 0.

When serial transfer ends with the receive buffer full (SPRF flag is 1), the SPI does not copy data from the shift register to the receive buffer, and detects an overrun error (see section 31.3.8, Error Detection). To prevent a receive data overrun error, read the received data using a receive buffer full interrupt request before the next serial transfer ends. To use an SPI receive buffer full interrupt, set the SPCR.SPRIE bit to 1.

Transmission and reception interrupts or the associated IELSRn.IR flags in the ICU, where n is the interrupt vector number, can be used to confirm the states of the transmit and receive buffers. Similarly, the SPTEF and SPRF flags can be used to confirm the states of the transmit and receive buffers. See section 13, Interrupt Controller Unit (ICU) for the interrupt vector numbers.

31.3.8 Error Detection

In normal SPI serial transfer, data written to the SPDR/SPDR_HA transmit buffer is transmitted, and received data can be read from the receive buffer of SPDR/SPDR_HA. If access is made to SPDR/SPDR_HA, an abnormal transfer might occur, depending on the status of the transmit or receive buffer, or the status of the SPI at the beginning or end of the serial transfer.

If an abnormal transfer occurs, the SPI detects the event as an underrun error, overrun error, parity error, or mode fault error. Table 31.8 lists the relationship between non-normal transfer operations and the SPI error detection function.

Table 31.8 Relationship between non-normal transfer operations and SPI error detection function

Operation	Occurrence condition	SPI operation	Error detection
1	SPDR/SPDR_HA is written when the transmit buffer is full	• The contents of the transmit buffer are kept • Write data is missing.	None
2	SPDR/SPDR_HA is read when the receive buffer is empty	The contents of the receive buffer and previously received data are output	None
3	Serial transfer is started in slave mode when the SPI is not able to transmit data	• Serial transfer is suspended • Transmit or receive data is missing • Driving of the MISOA output signal is stopped • SPI function is disabled.	Underrun error
4	Serial transfer terminates when the receive buffer is full	• The contents of the receive buffer are kept • Receive data is missing.	Overrun error
5	An incorrect parity bit is received during full-duplex synchronous serial communications with the parity function enabled	The parity error flag is asserted	Parity error
6	The SSLn0 input signal is asserted when the serial transfer is idle in multi-master mode	• Driving of the RSPCKn, MOSIn, SSLn1 to SSLn3 output signals is stopped • SPI function is disabled.	Mode fault error
7	The SSLn0 input signal is asserted during serial transfer in multi-master mode	• Serial transfer is suspended • Transmit or receive data is missing • Driving of the RSPCKn, MOSIn, SSLn1 to SSLn3 output signals is stopped • SPI function is disabled.	Mode fault error
8	The SSLn0 input signal is negated during serial transfer in slave mode	• Serial transfer is suspended • Missing transmit/receive data • Driving of the MISOn output signal is stopped • SPI function is disabled.	Mode fault error

In operation 1 described in Table 31.8, the SPI does not detect an error. To prevent data omission during writes to SPDR/SPDR_HA, the writes to SPDR/SPDR_HA must be executed using a transmit buffer empty interrupt request (when SPSR.SPTEF flag is 1). Similarly, the SPI does not detect an error in operation 2. To prevent extraneous data from

5. 当接收缓冲区满中断程序或使用SPRF标志处理接收缓冲区满中断读取SPDR_HA时，可以读取接收数据。

如果在发送缓冲区保存未发送数据（SPTEF标志为0）时写入SPDR_HA，则SPI不会更新发送缓冲区中的数据。写入SPDR_HA时，请确保使用发送缓冲区空中断请求或使用SPTEF标志处理发送缓冲区空中断。要使用发送缓冲区空中断，请将SPCR中的SPTIE位设置为1。如果禁用SPI功能（SPCR.SPE位为0），请将SPTIE位设置为0。

当串行传输以接收缓冲区已满（SPRF标志为1）结束时，SPI不会将数据从移位寄存器复制到接收缓冲区，并检测到溢出错误（参见第31.3.8节，错误检测）。为防止接收数据溢出错误，请在下一次串行传输结束前使用接收缓冲区满中断请求读取接收数据。要使用SPI接收缓冲区满中断，请将SPCR.SPRIE位设置为1。

ICU中的发送和接收中断或相关的IELSRn.IR标志，其中n是中断向量号，可用于确认发送和接收缓冲区的状态。类似地，SPTEF和SPRF标志可用于确认发送和接收缓冲区的状态。有关中断向量编号，请参见第13节，中断控制器单元(ICU)。

31.3.8 错误检测

在正常的SPI串行传输中，写入到SPDRSPDR_HA发送缓冲区的数据被发送，接收到的数据可以从SPDRSPDR_HA的接收缓冲区中读取。如果访问SPDRSPDR_HA，可能会发生异常传输，具体取决于发送或接收缓冲区的状态，或者串行传输开始或结束时SPI的状态。

如果发生异常传输，SPI会将事件检测为欠载错误、溢出错误、奇偶校验错误或模式故障错误。表31.8列出了非正常传输操作与SPI错误检测功能之间的关系。

Table 31.8 非正常传输操作与SPI错误检测功能的关系

Operation	发生条件	SPI操作	错误检测
1	SPDRSPDR_HA在发送缓冲区已满时写入	发送缓冲区的内容被保留 写数据丢失。	None
2	SPDR接收缓冲区为空时读取SPDR_HA	输出接收缓冲区的内容和先前接收的数据	None
3	当SPI无法传输数据时，串行传输在从模式下启动	串行传输暂停 发送或接收数据丢失 MISOA输出信号的驱动已停止 SPI功能已禁用。	Underrun error
4	当接收缓冲区已满时串行传输终止	接收缓冲区的内容被保留 接收数据丢失。	溢出错误
5	在启用奇偶校验功能的全双工同步串行通信期间接收到错误的奇偶校验位	奇偶错误标志被置位	奇偶校验错误
6	当串行传输在多主模式下空闲时，SSLn0输入信号被置位	停止驱动RSPCKn、MOSIn、SSLn1至SSLn3输出信号 禁用SPI功能。	模式故障错误
7	SSLn0输入信号在多主机模式下的串行传输期间被置位	串行传输暂停 发送或接收数据丢失 RSPCK MOSIn、SSLn1至SSLn3输出信号的驱动已停止 SPI功能已禁用。	模式故障错误
8	SSLn0输入信号在从机模式下的串行传输期间被否定	串行传输暂停 缺少发送接收数据 停止MIOn输出信号的驱动 禁用SPI功能。	模式故障错误

在表31.8中描述的操作1中，SPI未检测到错误。为了防止写入过程中的数据遗漏SPDRSPDR_HA，必须使用发送缓冲区空中断请求（当SPSR.SPTEF标志为1时）执行对SPDRSPDR_HA的写入。同样，SPI不会检测到操作2中的错误。为了防止无关数据从

being read, SPDR/SPDR_HA reads must be executed using an SPI receive buffer full interrupt request (when SPSR.SPRF flag is 1).

For information on the other errors, see the following sections:

- Underrun errors, indicated in operation 3, see section 31.3.8.4, Underrun errors
- Overrun errors, indicated in operation 4, see section 31.3.8.1, Overrun errors
- Parity errors, indicated in operation 5, see section 31.3.8.2, Parity errors
- Mode fault error, indicated in operations 6 to 8, see section 31.3.8.3, Mode fault errors.

For the transmit and receive interrupts, see section 31.3.7, Transmit Buffer Empty and Receive Buffer Full Interrupts.

31.3.8.1 Overrun errors

If a serial transfer ends when the receive buffer of SPDR/SPDR_HA is full, the SPI detects an overrun error and sets the SPSR.OVRF flag to 1. When the OVRF flag is 1, the SPI does not copy data from the shift register to the receive buffer, so the data before the error occurrence is saved in the receive buffer. To set the OVRF flag to 0, write 0 to it after the CPU reads SPSR with the OVRF flag set to 1.

Figure 31.28 shows an example operation of the OVRF and SPRF flags. The SPSR and SPDR_HA accesses shown in Figure 31.28 indicate the condition of accesses to the register, where W denotes a write cycle and R a read cycle. In the example, the SPI performs an 8-bit serial transfer in which the SPCMDm.CPHA bit is 1 and the SPCMDm.CPOL bit is 0. The numbers given for RSPCKn in the waveform represent the number of RSPCK cycles, such as the number of transferred bits.

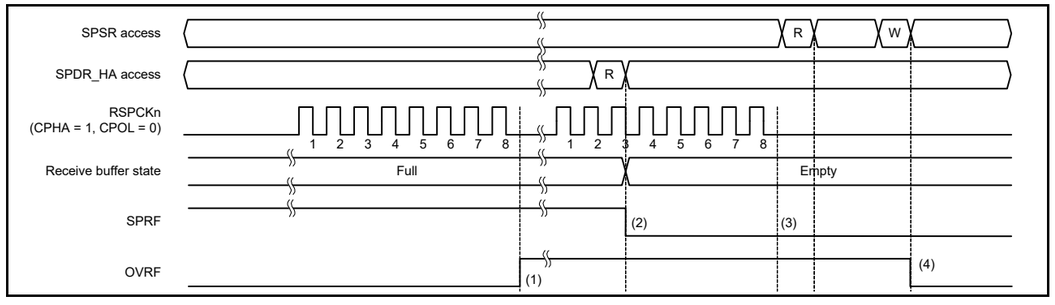

Figure 31.28 Operation example of OVRF and SPRF flags

The operation of the flags at timings (1) to (4) in Figure 31.28 is as follows:

1. If a serial transfer terminates with the SPRF flag set to 1 (receive buffer full), the SPI detects an overrun error, and sets the OVRF flag to 1. The SPI does not copy the data in the shift register to the receive buffer. Even when the SPPE bit is 1, parity errors are not detected. In master mode, the SPI copies the value of the SPCMDm pointer to the SPSSR.SPECM[2:0] bits.
2. When SPDR_HA is read, the SPI outputs the data in the receive buffer. The SPRF flag is then set to 0. The receive buffer becoming empty does not set the OVRF flag to 0.
3. If the serial transfer ends with the OVRF flag set to 1 (overrun error occurred), the SPI does not copy data in the shift register to the receive buffer (the SPRF flag is not set to 1). A receive buffer full interrupt is not generated. Even when the SPPE bit is 1, parity errors are not detected. In master mode, the SPI does not update the SPSSR.SPECM[2:0] bits. When an overrun error occurs and the SPI does not copy the received data from the shift register to the receive buffer, on termination of the serial transfer, the SPI determines that the shift register is empty. This enables data transfer from the transmit buffer to the shift register.
4. If 0 is written to the OVRF flag after SPSR is read when the OVRF flag is 1, the OVRF flag is set to 0.

The occurrence of an overrun can be checked either by reading SPSR or by using an SPI error interrupt and reading SPSR. When executing a serial transfer, make sure that overrun errors are detected early, for instance, by reading SPSR immediately after SPDR_HA is read. In master mode, the value of the pointer to the SPCMDm register on the error occurrence can be checked by reading the SPSSR.SPECM[2:0] bits.

在读取时，必须使用SPI接收缓冲区满中断请求（当SPSR.SPRF标志为1时）执行SPDRSPDR_HA读取。

有关其他错误的信息，请参阅以下部分：

- 运行3中指示的欠载错误，请参阅第31.3.8.4节，欠载错误
- 操作4中指示的溢出错误，请参见第31.3.8.1节，溢出错误
- 奇偶校验错误，在操作5中指示，请参阅第31.3.8.2节，奇偶校验错误
- 模式故障错误，在操作6至8中指示，请参阅第31.3.8.3节，模式故障错误。

对于发送和接收中断，请参见第31.3.7节，发送缓冲区空和接收缓冲区满中断。

31.3.8.1 溢出错误

如果串行传输在SPDRSPDR_HA的接收缓冲区已满时结束，则SPI检测到溢出错误并将SPSR.OVRF标志设置为1。当OVRF标志为1时，SPI不会将数据从移位寄存器复制到接收缓冲区，因此错误发生前的数据保存在接收缓冲区中。要将OVRF标志设置为0，请在CPU读取OVRF标志设置为1的SPSR后向其写入0。

图31.28显示了OVRF和SPRF标志的示例操作。图31.28所示的SPSR和SPDR_HA访问表示访问寄存器的条件，其中W表示写周期，R表示读周期。在示例中，SPI执行8位串行传输，其中SPCMDm.CPHA位为1，SPCMDm.CPOL位为0。波形中为RSPCKn给出的数字表示RSPCK周期数，例如传输的位。

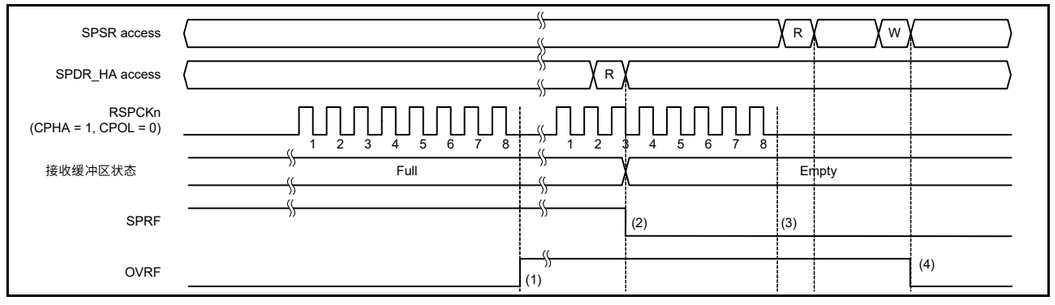

Figure 31.28 OVRF和SPRF标志的操作示例

图31.28中时间(1)到(4)的标志操作如下：

1. 如果串行传输终止且SPRF标志设置为1（接收缓冲区已满），则SPI检测到溢出错误，并将OVRF标志设置为1。SPI不会将移位寄存器中的数据复制到接收缓冲区。即使SPPE位为1，也不会检测到奇偶校验错误。在主机模式下，SPI将SPMDm指针的值复制到

   SPSSR.SPECM[2:0] bits.
2. 当读取SPDR_HA时，SPI输出接收缓冲区中的数据。然后SPRF标志设置为0。接收缓冲区变空不会将OVRF标志设置为0。
3. 如果串行传输结束时OVRF标志设置为1（发生溢出错误），则SPI不会将移位寄存器中的数据复制到接收缓冲区（SPRF标志未设置为1）。不产生接收缓冲区满中断。即使SPPE位为1，也不会检测到奇偶校验错误。在主模式下，SPI不更新

   SPSSR.SPECM[2:0]位。当发生溢出错误并且SPI没有将接收到的数据从移位寄存器复制到接收缓冲区时，在串行传输终止时，SPI确定移位寄存器为空。这使数据能够从发送缓冲器传输到移位寄存器。
4. 如果在OVRF标志为1时读取SPSR后将0写入OVRF标志，则OVRF标志设置为0。

可以通过读取SPSR或使用SPI错误中断并读取SPSR来检查溢出的发生。执行串行传输时，请确保及早检测到溢出错误，例如，在读取SPDR_HA后立即读取SPSR。在主模式下，可以通过读取SPSSR.SPECM[2:0]位来检查发生错误时指向SPCMDm寄存器的指针的值。

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If an overrun error occurs and the OVRF flag is set to 1, normal reception operations cannot be performed until the OVRF flag is set to 0.

When the RSPCK auto-stop function is enabled in master mode, an overrun error does not occur. Figure 31.29 and Figure 31.30 show the clock stop waveform when a serial transfer continues while the receive buffer is full in master mode.

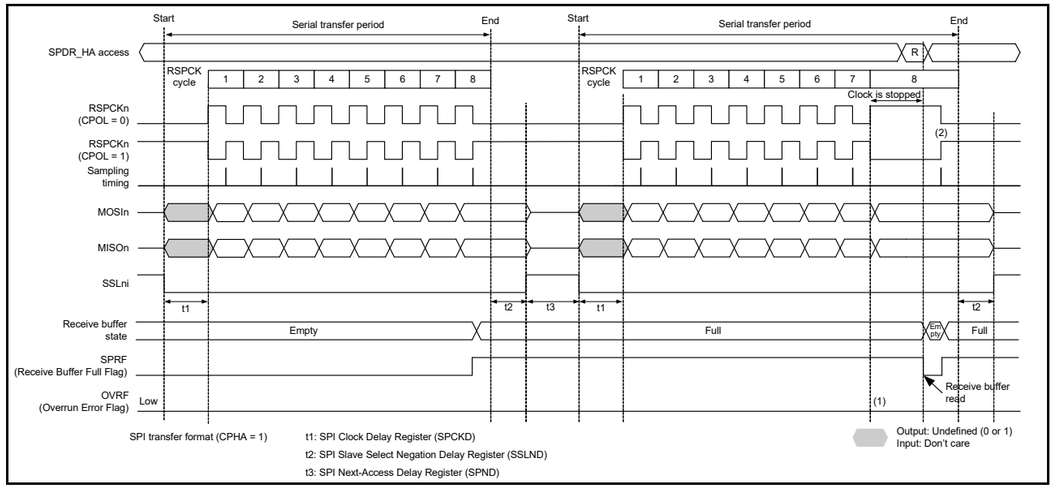

Figure 31.29 Clock stop waveform when serial transfer continues while receive buffer is full in master mode with CPHA = 1

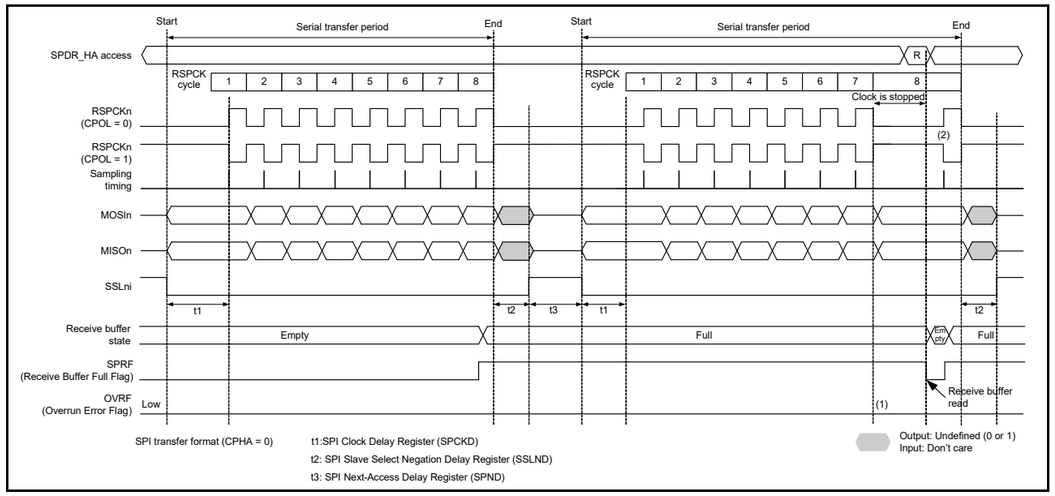

Figure 31.30 Clock stop waveform when serial transfer continues while receive buffer is full in master mode with CPHA = 0

The operation of the flags at timings (1) and (2) in Figure 31.29 and Figure 31.30 is as follows:

1. When the receive buffer is full, an overrun error does not occur because the RSPCK clock is stopped.
2. If SPDR_HA is read while the clock is stopped, data in the receive buffer can be read. The RSPCK clock restarts after reading the receive buffer (after SPSR.SPRF is set to 0).

如果发生溢出错误并且OVRF标志设置为1，则无法执行正常的接收操作，直到OVRF标志设置为0。

在主机模式下启用RSPCK自动停止功能时，不会发生溢出错误。图31.29和图31.30显示了在主机模式下接收缓冲区已满时串行传输继续时的时钟停止波形。

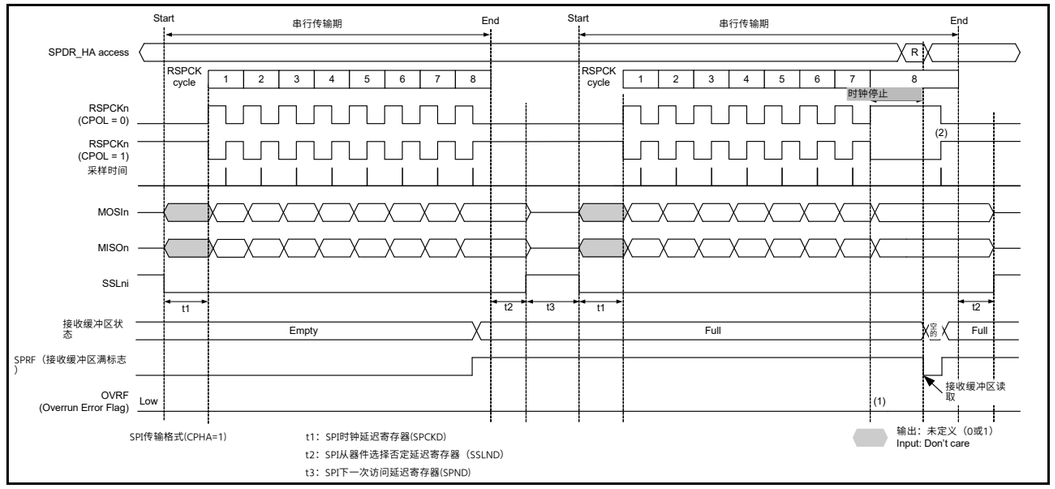

Figure 31.29 在CPHA=1的主模式下，当接收缓冲区已满时串行传输继续时的时钟停止波形

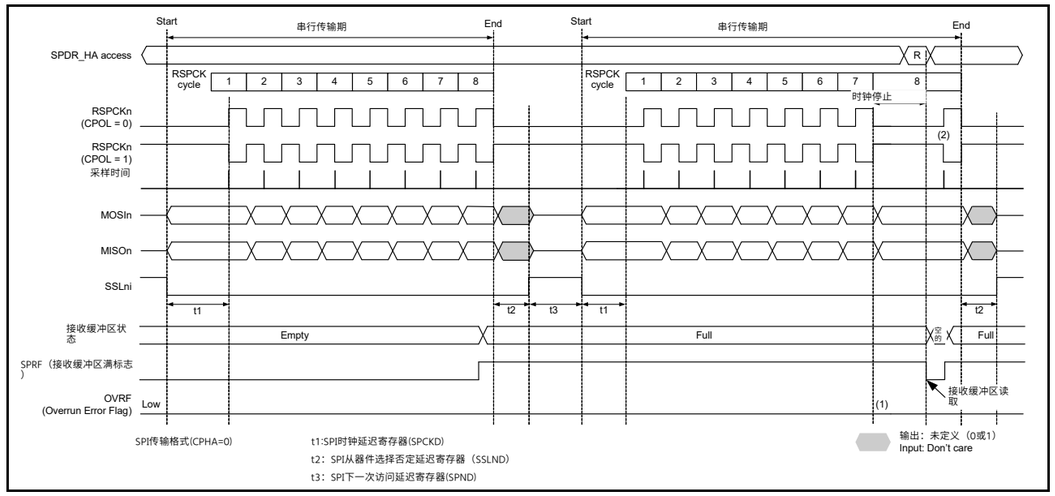

Figure 31.30 在CPHA=0的主模式下，当接收缓冲区已满时串行传输继续时的时钟停止波形

图31.29和图31.30中时序（1）和（2）的标志操作如下：

1. 当接收缓冲器已满时，不会发生溢出错误，因为RSPCK时钟已停止。
2. 如果在时钟停止时读取SPDR_HA，则可以读取接收缓冲区中的数据。RSPCK时钟在读取接收缓冲区后重新启动（在SPSR.SPRF设置为0之后）。

31.3.8.2 Parity errors

When full-duplex synchronous serial communication is performed with the SPCR.TXMD bit set to 0 and the SPCR2.SPPE bit set to 1, the SPI checks for parity errors when serial transfer ends. On detecting a parity error in the received data, the SPI sets the SPSR.PERF flag to 1. Because the SPI does not copy data in the shift register to the receive buffer when the SPSR.OVRF flag is set to 1, parity error detection is not performed for the received data. To set the PERF flag to 0, write 0 to the PERF flag after the SPSR register is read with the PERF flag set to 1.

Figure 31.31 shows an example operation of the OVRF and PERF flags. The SPSR access shown in Figure 31.31 indicates the condition of access to the SPSR register, where W denotes a write cycle, and R a read cycle. In the example, full-duplex synchronous serial communication is performed while the SPCR.TXMD bit is 0 and the SPCR2.SPPE bit is 1. The SPI performs an 8-bit serial transfer in which SPCMDm.CPHA bit is 1 and the SPCMDm.CPOL bit is 0. The numbers given for RSPCKn in the waveform represent the number of RSPCK cycles, such as the number of transferred bits.

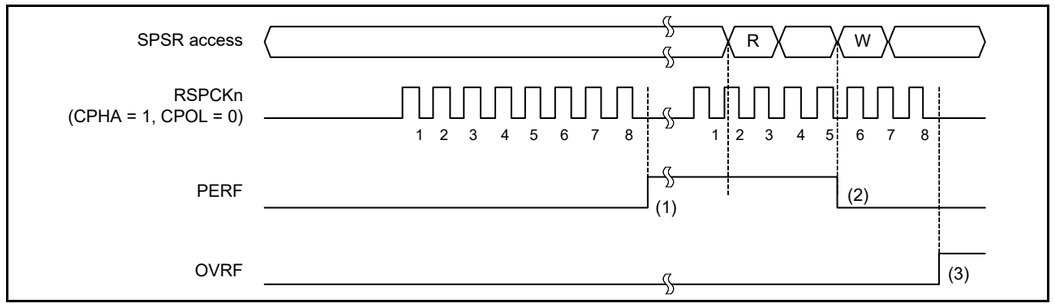

Figure 31.31 Operation example of the PERF flag

The operation of the flags at timings (1) to (3) in Figure 31.31 is as follows:

1. If a serial transfer terminates with the SPI not detecting an overrun error, the SPI copies the data in the shift register to the receive buffer. The SPI checks the received data at this time and sets the PERF flag to 1 if a parity error is detected. In master mode, the SPI copies the value of the SPCMDm pointer to the SPSSR.SPECM[2:0] bits.
2. If 0 is written to the PERF flag after the SPSR register is read when the PERF flag is 1, the PERF flag is set to 0.
3. When the SPI detects an overrun error and serial transfer is terminated, the data in the shift register is not copied to the receive buffer. The SPI does not perform parity error detection at this time.

Parity errors can be checked by reading the SPSR register or by using an SPI error interrupt and reading the SPSR register. When executing a serial transfer, make sure that parity errors are detected early, for instance by reading SPSR errors. When the SPI is in master mode, the pointer value to the SPCMDm register at the error occurrence can be checked by reading the SPSSR.SPECM[2:0] bits.

31.3.8.3 Mode fault errors

The SPI operates in multi-master mode when the SPCR.MSTR bit is 1, the SPCR.SPMS bit is 0, and the SPCR.MODFEN bit is 1. If the active level is input for the SSLn0 input signal of the SPI in multi-master mode, the SPI detects a mode fault error regardless of the status of the serial transfer, and sets the SPSR.MODF flag to 1. On detecting the mode fault error, the SPI copies the value of the SPCMDm pointer to the SPSSR.SPECM[2:0] bits. The active level of the SSLn0 signal is determined by the SSLP.SSL0P bit.

When the MSTR bit is 0, the SPI operates in slave mode. The SPI detects a mode fault error if the MODFEN bit of the SPI in slave mode is 1, and the SPMS bit is 0, and if the SSLn0 input signal is negated during the serial transfer period (from the time the driving of valid data is started to the time the final valid data is fetched).

On detecting a mode fault error, the SPI stops the driving of output signals and clears the SPCR.SPE bit to 0 (see section 31.3.9, Initializing the SPI). For multi-master configuration, detection of a mode fault error is used to stop the driving of output signals and the SPI function, which allows the master to be released.

The occurrence of a mode fault error can be checked either by reading SPSR or by using an SPI error interrupt and reading SPSR. Detecting mode fault errors without using the SPI error interrupt requires polling of SPSR. When using

31.3.8.2 奇偶校验错误

当SPCR.TXMD位设置为0且
SPCR2.SPPE位设置为1，SPI在串行传输结束时检查奇偶校验错误。在检测到接收数据中的奇偶校验错误时，SPI将SPSR.PERF标志设置为1。因为当SPSR.OVRF标志设置为1时，SPI不会将移位寄存器中的数据复制到接收缓冲区，所以奇偶校验错误检测不针对接收到的数据执行。要将PERF标志设置为0，请在读取SPSR寄存器并将PERF标志设置为1后将0写入PERF标志。

图31.31显示了OVRF和PERF标志的示例操作。图31.31所示的SPSR访问表示访问SPSR寄存器的条件，其中W表示写周期，R表示读周期。在示例中，当SPCR.TXMD位为0且SPCR2.SPPE位为1时执行全双工同步串行通信。SPI执行8位串行传输，其中SPCMDm.CPHA位为1和SPCMDm。CPOL位为0。波形中为RSPCKn给出的数字表示RSPCK周期数，例如传输的位数。

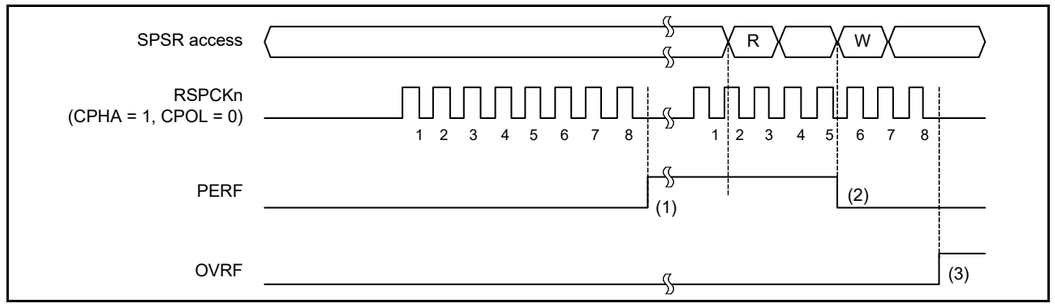

Figure 31.31 PERF标志的操作示例

图31.31中时序(1)到(3)的标志操作如下：

1. 如果串行传输因SPI未检测到溢出错误而终止，则SPI将移位寄存器中的数据复制到接收缓冲区。此时SPI会检查接收到的数据，如果检测到奇偶校验错误，则将PERF标志设置为1。在主模式下，SPI将SPCMDm指针的值复制到SPSSR.SPECM[2:0]位。
2. 如果在PERF标志为1时读取SPSR寄存器后将0写入PERF标志，则PERF标志设置为0。
3. 当SPI检测到溢出错误并终止串行传输时，移位寄存器中的数据不会复制到接收缓冲区。此时SPI不执行奇偶校验错误检测。

可以通过读取SPSR寄存器或使用SPI错误中断并读取SPSR寄存器来检查奇偶校验错误。执行串行传输时，请确保尽早检测到奇偶校验错误，例如通过读取SPSR错误。当SPI处于主机模式时，可以通过读取SPSSR.SPECM[2:0]位来检查发生错误时指向SPCMDm寄存器的指针值。

31.3.8.3 模式故障错误

当SPCR.MSTR位为1、SPCR.SPMS位为0且
SPCR.MODFEN位为1。如果在多主机模式下为SPI的SSLn0输入信号输入有效电平，则无论串行传输的状态如何，SPI都会检测到模式故障错误，并设置SPSR.MODF标志为1.在检测到模式故障错误时，SPI将SPCMDm指针的值复制到SPSSR.SPECM[2:0]位。SSLn0信号的有效电平由SSLP.SSL0P位决定。

当MSTR位为0时，SPI工作在从机模式。如果从机模式下SPI的MODFEN位为1，SPMS位为0，并且在串行传输期间（从驱动有效数据开始开始到获取最终有效数据的时间）。

在检测到模式故障错误时，SPI会停止驱动输出信号并将SPCR.SPE位清除为0（请参见第31.3.9节，初始化SPI）。对于多主机配置，检测到模式故障错误用于停止驱动输出信号和SPI功能，从而释放主机。

可以通过读取SPSR或使用SPI错误中断并读取SPSR来检查模式故障错误的发生。在不使用SPI错误中断的情况下检测模式故障错误需要轮询SPSR。使用时

the SPI in master mode, the value of the pointer to the SPCMDm register at the occurrence of the error can be checked by reading the SPSSR.SPECM[2:0] bits.

When the MODF flag is 1, writing 1 to the SPE bit is ignored by the SPI. To enable the SPI function after the detection of a mode fault error, the MODF flag must be set to 0.

31.3.8.4 Underrun errors

When a serial transfer begins with the SPCR.MSTR bit set to 0 (slave mode), the SPCR.SPE bit is set to 1 and the transmission data not prepared, the SPI detects an underrun error. The SPI then sets the SPSR.MODF and SPSR.UDRF flags to 1. On detecting an underrun error, the SPI stops the driving of output signals and clears the SPCR.SPE bit to 0 (see section 31.3.9, Initializing the SPI).

The occurrence of an underrun error can be checked either by reading SPSR or by using an SPI error interrupt and reading SPSR. Detecting underrun errors without using the SPI error interrupt requires polling of SPSR.

When the MODF flag is 1, writing 1 to the SPE bit is ignored by the SPI. To enable the SPI function after the detection of an underrun error, the MODF flag must be set to 0.

31.3.9 Initializing the SPI

If 0 is written to the SPCR.SPE bit or if the SPI sets the SPE bit to 0 because it detected a mode fault error or an underrun error, the SPI disables the SPI function and initializes some of the module functions. When a system reset occurs, the SPI initializes all of the module functions. This section describes initialization by clearing of the SPCR.SPE bit, and by a system reset.

31.3.9.1 Initialization by clearing the SPE bit

When the SPCR.SPE bit is set to 0, the SPI initializes by:

- Suspending any serial transfer that is being executed
- Stopping the driving of output signals (Hi-Z) in slave mode
- Initializing the internal state of the SPI
- Initializing the transmit buffer of the SPI (SPSR.SPTEF flag is set to 1).

Initialization by clearing of the SPE bit does not initialize the control bits of the SPI. For this reason, the SPI can be started in the same transfer mode that is in use before initialization when the SPE bit is set to 1 again.

The SPRF, OVRF, MODF, PERF and UDRF flags in the SPSR register are not initialized, and the SPI Sequence Status Register (SPSSR) is not initialized. Therefore, even after the SPI is initialized, data from the receive buffer can be read to check the error status during an SPI transfer.

The transmit buffer is initialized to an empty state (SPSR.SPTEF flag is set to 1). Therefore, if the SPCR.SPTIE bit is set to 1 after SPI initialization, a transmit buffer empty interrupt is generated. When the SPI is initialized, to disable any transmit buffer empty interrupts, write 0 to the SPTIE bit simultaneously while writing 0 to the SPE bit.

31.3.9.2 Initialization by system reset

A system reset completely initializes the SPI by initializing all bits that control the SPI, the status bits, and the data registers, in addition to meeting the requirements described in section 31.3.9.1, Initialization by clearing the SPE bit.

31.3.10 SPI Operation

31.3.10.1 Master mode operation

The only difference between single-master mode and multi-master mode operation is the use of mode fault error detection (see section 31.3.8, Error Detection). In single-master mode, the SPI does not detect mode fault errors whereas in multi-master mode, it does. This section explains the operations that are common to both modes.

(1) Starting serial transfer

The SPI updates the data in the transmit buffer (SPTX) when data is written to the SPI Data Register (SPDR/SPDR_HA) with the SPI transmit buffer is empty, and data for the next transfer is not set (SPSR.SPTEF flag is 1). When the shift

SPI在主模式下，在发生错误时指向SPCMDm寄存器的指针的值可以通过读取SPSSR.SPECM[2:0]位来检查。

当MODF标志为1时，向SPE位写入1会被SPI忽略。要在检测到模式故障错误后启用SPI功能，MODF标志必须设置为0。

31.3.8.4 Underrun errors

当串行传输开始时SPCR.MSTR位设置为0（从模式），SPCR.SPE位设置为1且未准备好传输数据，SPI检测到欠载错误。然后SPI将SPSR.MODF和SPSR.UDRF标志设置为1。在检测到欠载错误时，SPI停止驱动输出信号并将SPCR.SPE位清除为0（参见第31.3.9节，初始化SPI）.

可以通过读取SPSR或使用SPI错误中断并读取SPSR来检查欠载错误的发生。在不使用SPI错误中断的情况下检测欠载错误需要轮询SPSR。

当MODF标志为1时，向SPE位写入1会被SPI忽略。要在检测到欠载错误后启用SPI功能，MODF标志必须设置为0。

31.3.9 初始化SPI

如果将0写入SPCR.SPE位，或者如果SPI由于检测到模式故障错误或欠载错误而将SPE位设置为0，则SPI将禁用SPI功能并初始化一些模块功能。发生系统复位时，SPI会初始化所有模块功能。本节介绍通过清除SPCR.SPE位和系统复位进行的初始化。

31.3.9.1 通过清除SPE位进行初始化

当SPCR.SPE位设置为0时，SPI通过以下方式初始化：

- 暂停正在执行的任何串行传输
- 在从模式下停止驱动输出信号(Hi-Z)
- 初始化SPI的内部状态
- 初始化SPI的发送缓冲区（SPSR.SPTEF标志设置为1）。

通过清除SPE位进行的初始化不会初始化SPI的控制位。因此，当SPE位再次设置为1时，SPI可以在初始化之前使用的相同传输模式下启动。

SPSR寄存器中的SPRF、OVRF、MODF、PERF和UDRF标志未初始化，SPI序列状态寄存器（SPSSR）未初始化。因此，即使在SPI初始化之后，也可以从接收缓冲区读取数据以检查SPI传输期间的错误状态。

发送缓冲区初始化为空状态（SPSR.SPTEF标志设置为1）。因此，如果SPCR.SPTIE位在SPI初始化后设置为1，则会产生发送缓冲区空中断。当SPI初始化时，要禁用任何发送缓冲区空中断，请同时将0写入SPTIE位，同时将0写入SPE位。

31.3.9.2 通过系统复位初始化

除了满足第31.3.9.1节中描述的要求外，系统复位还通过初始化控制SPI的所有位、状态位和数据寄存器来完全初始化SPI，通过清除SPE位进行初始化。

31.3.10 SPI操作

31.3.10.1 主模式操作

单主机模式和多主机模式操作之间的唯一区别是使用模式故障错误检测（请参阅第31.3.8节，错误检测）。在单主机模式下，SPI不检测模式故障错误，而在多主机模式下，它可以。本节介绍两种模式共有的操作。

(1) 开始串行传输

当数据写入SPI数据寄存器(SPDRSPDR_HA)且SPI发送缓冲区为空且未设置下一次传输的数据（SPSR.SPTEF标志为1）时，SPI更新发送缓冲区(SPTX)中的数据.换班的时候

register is empty after the number of frames set in the SPDCR.SPFC[1:0] bits are written to the SPDR/SPDR_HA, the SPI copies data from the transmit buffer to the shift register and starts serial transfer. On copying transmit data to the shift register, the SPI changes the status of the shift register to full, and on termination of serial transfer, it changes the status of the shift register to empty. The status of the shift register cannot be referenced.

The polarity of the SSLni output pins depends on the SSLP register settings. For details on the SPI transfer format, see section 31.3.5, Transfer Format.

(2) Terminating a serial transfer

Regardless of the SPCMDm.CPHA bit setting, the SPI terminates a serial transfer after transmitting an RSPCKn edge associated with the final sampling timing. If free space is available in the receive buffer (SPRX) (SPSR.SPRF flag is 0), on termination of the serial transfer, the SPI copies data from the shift register to the receive buffer of the SPDR/SPDR_HA register.

The final sampling timing varies depending on the bit length of transfer data. In master mode, the SPI data length depends on the SPCMDm.SPB[3:0] bit setting. The polarity of the SSLni output pin depends on the SSLP register settings. For details on the SPI transfer format, see section 31.3.5, Transfer Format.

(3) Sequence control

The transfer format used in master mode is determined by the SPSCR, SPCMDm, SPBR, SPCKD, SSLND, and SPND registers.

The SPSCR register determines the sequence configuration for serial transfers that the SPI executes in master mode. The following parameters are set in the SPCMDm register:

- SSLni pin output signal value
- MSB- or LSB-first
- Data length
- Some of the bit rate settings
- RSPCK polarity/phase
- Whether SPCKD is to be referenced
- Whether SSLND is to be referenced
- Whether SPND is to be referenced.

SPBR holds some of the bit rate settings, such as the SPI clock delay value (SPCKD), the SSL negation delay value (SSLND), and the next-access delay value (SPND).

Based on the sequence length assigned in SPSCR, the SPI makes up a sequence comprised of a part or all of the SPCMDm register. The SPI contains a pointer to the SPCMDm register that makes up the sequence. The value of this pointer can be checked by reading the SPSSR.SPCP[2:0] bits. When the SPCR.SPE bit is set to 1 and the SPI function is enabled, the SPI loads the pointer to the commands in SPCMD0, and incorporates the SPCMD0 settings into the transfer format at the beginning of serial transfer. The SPI increments the pointer each time the next-access delay period for a data transfer ends. On completion of the serial transfer that corresponds to the final command in the sequence, the SPI sets the pointer to SPCMD0 to execute the sequence repeatedly.

将SPDCR.SPFC[1:0]位中设置的帧数写入SPDRSPDR_HA后，寄存器为空，SPI将数据从发送缓冲区复制到移位寄存器并开始串行传输。将发送数据复制到移位寄存器时，SPI将移位寄存器的状态更改为满，而在串行传输终止时，它将移位寄存器的状态更改为空。无法引用移位寄存器的状态。

SSLni输出引脚的极性取决于SSLP寄存器设置。有关SPI传输格式的详细信息，请参阅第31.3.5节，传输格式。

(2) 终止串行传输

无论SPMDm.CPHA位设置如何，SPI在发送与最终采样时序相关的RSPCKn边沿后终止串行传输。如果接收缓冲区(SPRX)中有可用空间（SPSR.SPRF标志为0），则在串行传输终止时，SPI将数据从移位寄存器复制到SPDRSPDR_HA寄存器的接收缓冲区。

最终的采样时序根据传输数据的位长而变化。在主机模式下，SPI数据长度取决于SPMDm.SPB[3:0]位设置。SSLni输出引脚的极性取决于SSLP寄存器设置。有关SPI传输格式的详细信息，请参阅第31.3.5节，传输格式。

(3) 顺序控制

主机模式中使用的传输格式由SPSCR、SPCMDm、SPBR、SPCKD、SSLND和SPND寄存器决定。

SPSCR寄存器确定SPI在主模式下执行的串行传输的序列配置。在SPCMDm寄存器中设置以下参数：

- SSLni管脚输出信号值
- MSB- or LSB-first
- 数据长度
- 一些比特率设置
- RSPCK polarity/phase
- 是否要引用SPCKD
- 是否要引用SSLND
- 是否要引用SPND。

SPBR保存一些比特率设置，例如SPI时钟延迟值(SPCKD)、SSL否定延迟值(SSLND)和下一次访问延迟值(SPND)。

基于在SPSCR中分配的序列长度，SPI组成一个序列，由部分或全部SPMDm寄存器。SPI包含一个指向构成序列的SPCMDm寄存器的指针。该指针的值可以通过读取SPSSR.SPCP[2:0]位来检查。当SPCR.SPE位设置为1且SPI功能使能时，SPI加载指向SPCMD0中命令的指针，并在串行传输开始时将SPCMD0设置合并到传输格式中。每次数据传输的下一个访问延迟周期结束时，SPI都会递增指针。在完成对应于序列中最终命令的串行传输后，SPI将指针设置为SPMD0以重复执行序列。

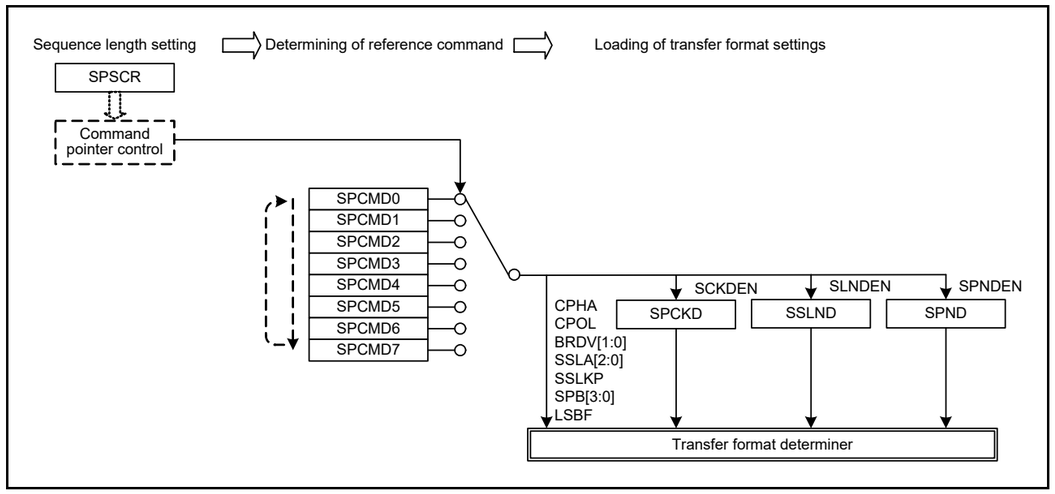

Figure 31.32 Procedure for determining serial transfer format in master mode

In this section, a frame is the combination of the SPDR/SPDR_HA data and the SPCMDm settings.

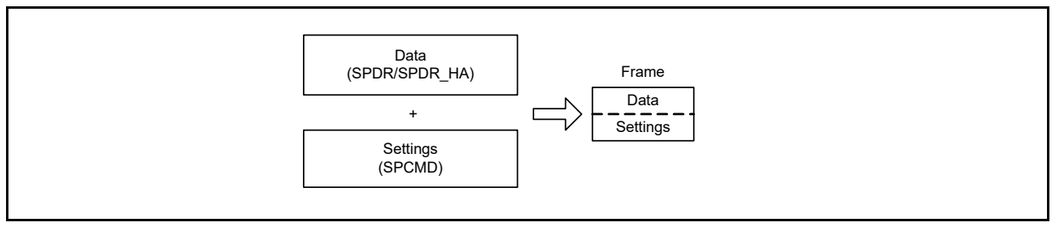

Figure 31.33 Conceptual diagram of frames

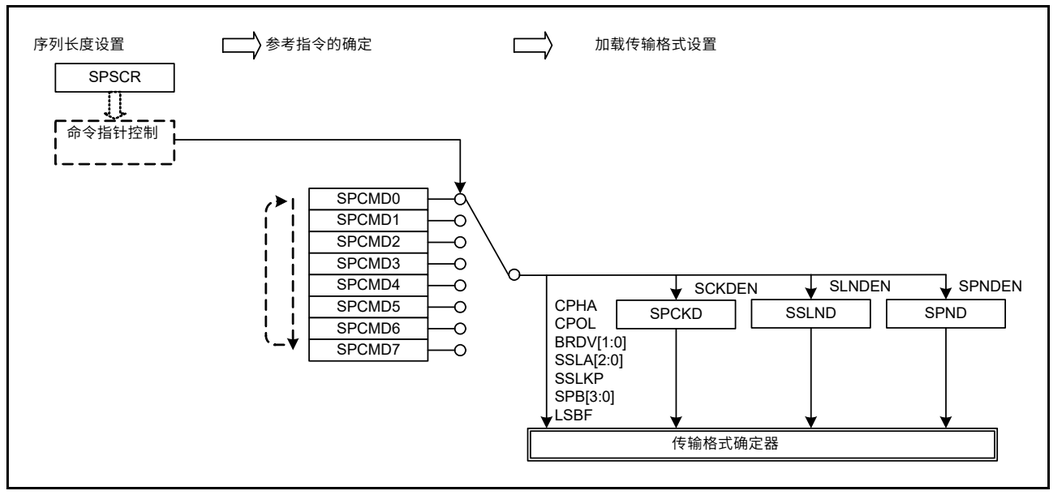

Figure 31.32 在主模式下确定串行传输格式的程序

在本节中，帧是SPDRSPDR_HA数据和SPMDm设置的组合。

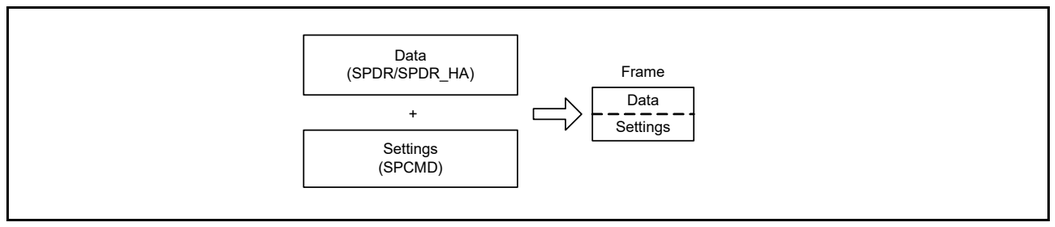

Figure 31.33 框架的概念图

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Figure 31.34 shows the relationship between the commands and the transmit and receive buffers in the sequence of operations specified by the settings in Table 31.4.

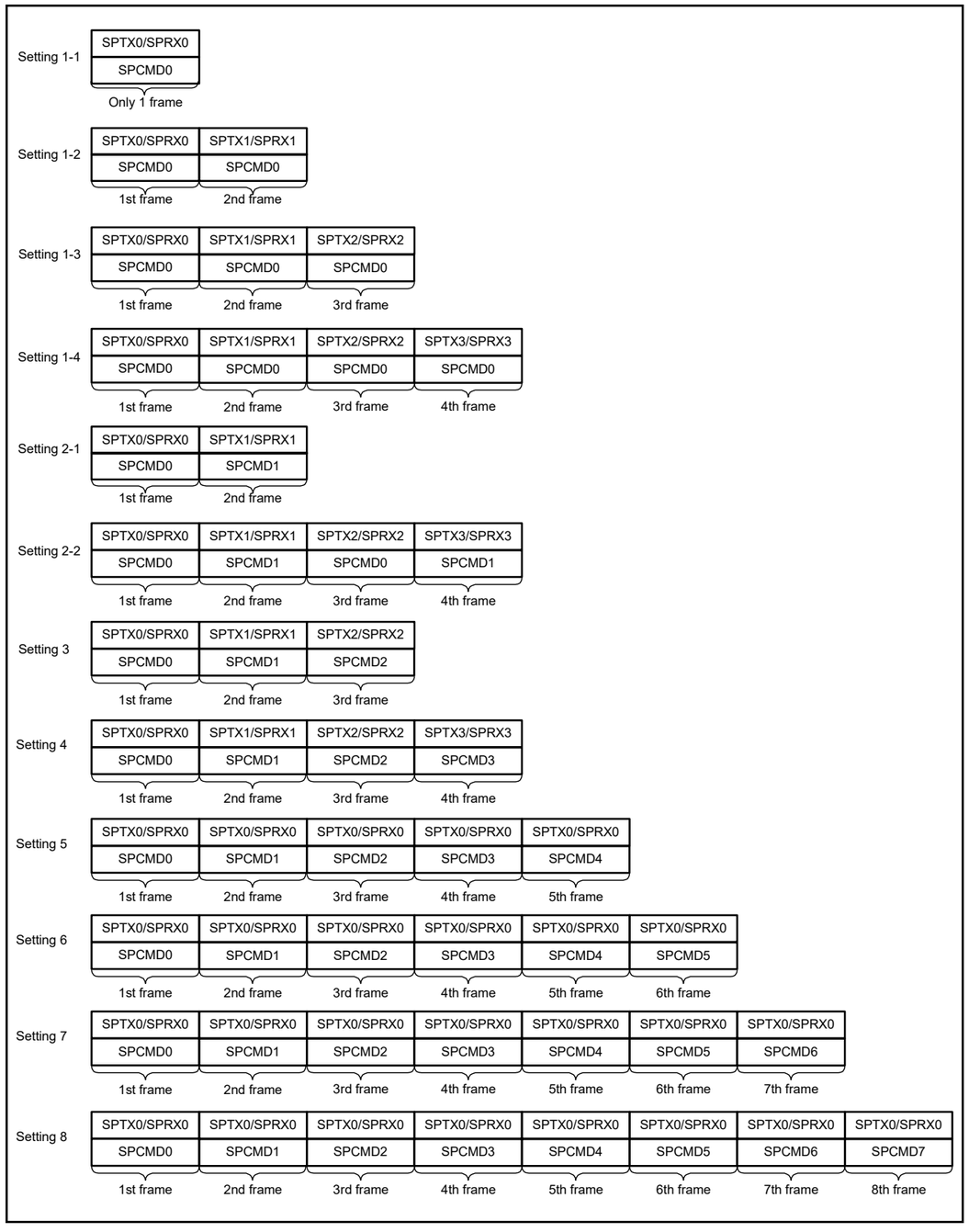


Figure 31.34 Relationship between SPI Command register and transmit and receive buffers in sequence operations

图31.34显示了在表31.4中的设置指定的操作序列中命令与发送和接收缓冲区之间的关系。

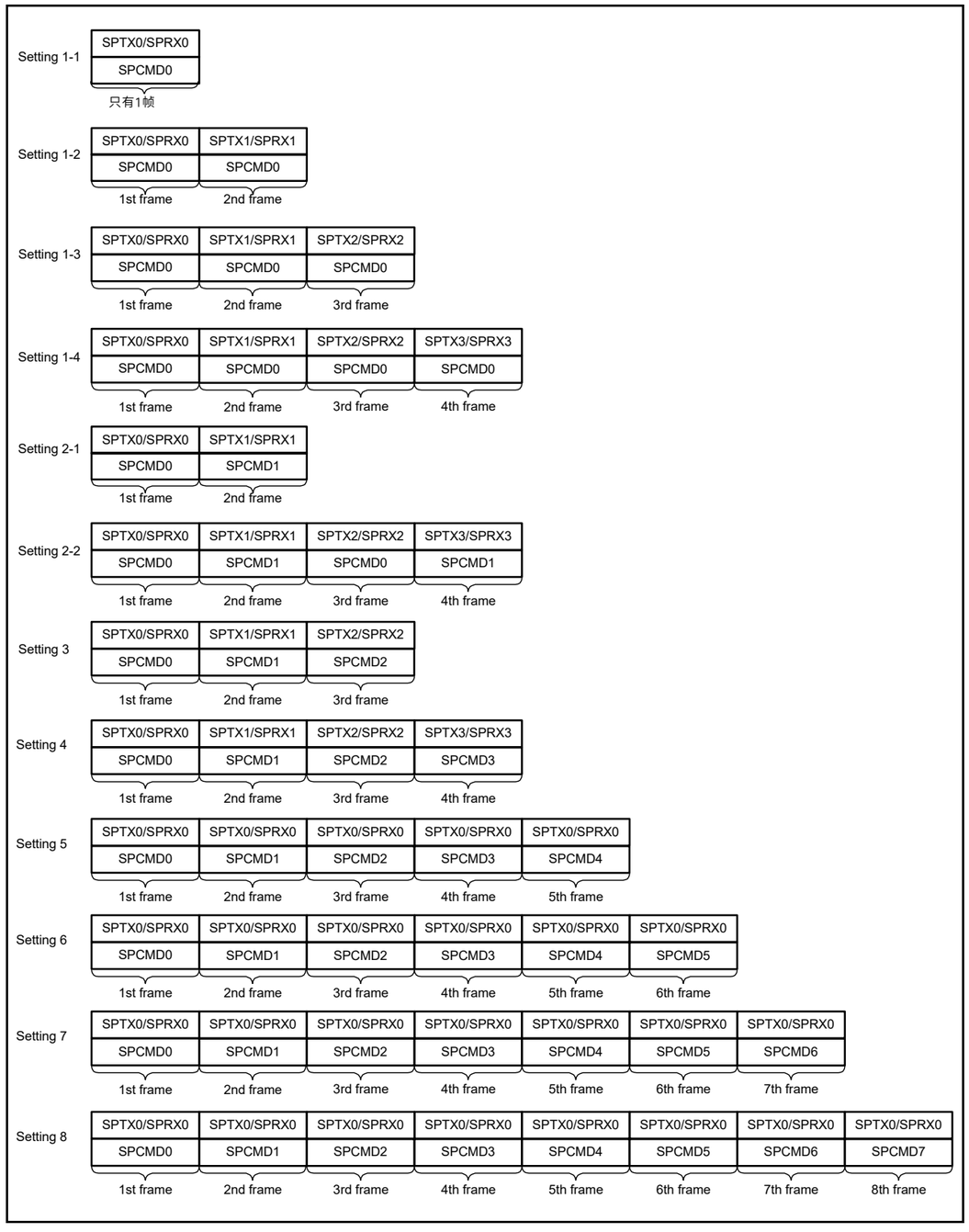


Figure 31.34 顺序操作中SPI命令寄存器与发送和接收缓冲区的关系

(4) Burst transfers

If the SPCMDm.SSLKP bit that the SPI references during the current serial transfer is 1, the SPI maintains the SSLni signal level during the serial transfer until the beginning of the SSLni signal assertion for the next serial transfer. If the SSLni signal level for the next serial transfer is the same as the SSLni signal level for the current serial transfer, the SPI can execute continuous serial transfers while keeping the SSLni signal assertion status (burst transfer).

Figure 31.35 shows an example of an SSLni signal operation for a burst transfer that is implemented using the SPCMD0 and SPCMD1 register settings. This section describes SPI operations (1) to (7) shown in Figure 31.35.

Note: The polarity of the SSLni output signal depends on the SSLP register settings.

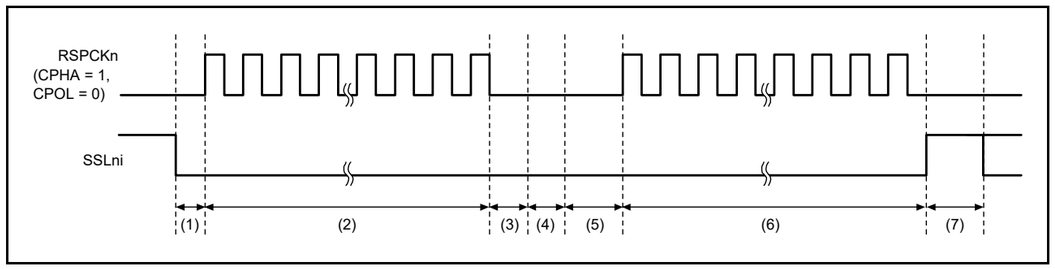


Figure 31.35 Example of burst transfer operation using the SSLKP bit

The SPI operation at timings (1) to (7) in Figure 31.35 is as follows:

1. Based on the SPCMD0 settings, the SPI asserts the SSLni signal and inserts RSPCK delays.
2. The SPI executes serial transfers according to the SPCMD0 settings.
3. The SPI inserts an SSL negation delay.
4. Because the SPCMD0.SSLKP bit is 1, the SPI keeps the SSLni signal value specified in SPCMD0. This period is sustained at a minimum for a period equal to the next-access delay in SPCMD0. If the shift register is empty after the passage of the minimum period, this period is sustained until the transmit data is stored in the shift register for the next transfer.
5. Based on the SPCMD1 settings, the SPI asserts the SSLni signal and inserts RSPCK delays.
6. The SPI executes serial transfers according to the SPCMD1 settings.
7. Because the SPCMD1.SSLKP bit is 0, the SPI negates the SSLni signal. In addition, a next-access delay is inserted according to SPCMD1.

If the SSLni signal output settings in the SPCMDm register where 1 is assigned to the SSLKP bit are different from the SSLni signal output settings in the SPCMDm register to be used in the next transfer, the SPI switches the SSLni signal status to SSLni signal assertion as shown in (5) in Figure 31.35. This corresponds to the command for the next transfer.

Note: If such an SSLni signal switching occurs, the slaves that drive the MISOn signal compete, and the collision of signal levels might occur.

The SPI in master mode references the SSLni signal operation within the module when the SSLKP bit is not used. When the SPCMDm.CPHA bit is 0, the SPI can accurately start serial transfers using the SSLni signal assertion for the next transfer that is detected internally.

(5) RSPCK delay (t1)

The RSPCK delay value of the SPI in master mode depends on the SPCMDm.SCKDEN bit setting and the SPCKD register setting. The SPI determines the SPCMDm register to be referenced during a serial transfer by pointer control, and determines the RSPCK delay value using the SPCMDm.SCKDEN bit and SPCKD, as listed in Table 31.9. For a definition of the RSPCK delay, see section 31.3.5, Transfer Format.

(4) 突发传输

如果SPI在当前串行传输期间引用的SPCMDm.SSLKP位为1，则SPI在串行传输期间保持SSLni信号电平，直到下一次串行传输的SSLni信号断言开始。如果下一次串行传输的SSLni信号电平与当前串行传输的SSLni信号电平相同，则SPI可以在保持SSLni信号断言状态（突发传输）的同时执行连续串行传输。

图31.35显示了使用SPCMD0和SPCMD1寄存器设置实现的突发传输的SSLni信号操作示例。本节介绍图31.35所示的SPI操作(1)至(7)。

Note: SSLni输出信号的极性取决于SSLP寄存器设置。

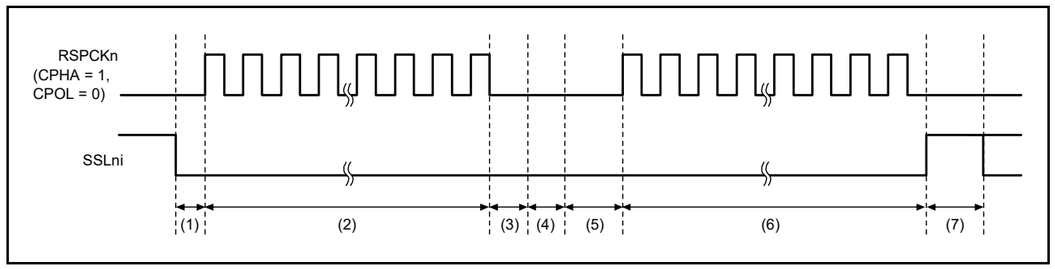


Figure 31.35 使用SSLKP位的突发传输操作示例

图31.35中时序(1)到(7)的SPI操作如下：

1. 基于SPCMD0设置，SPI断言SSLni信号并插入RSPCK延迟。
2. SPI根据SPMD0设置执行串行传输。
3. SPI插入SSL否定延迟。
4. 由于SPCMD0.SSLKP位为1，SPI保持SPCMD0中指定的SSLni信号值。该周期至少持续一段时间，等于SPMD0中的下一次访问延迟。如果经过最小周期后移位寄存器为空，则该周期一直持续到发送数据存储在移位寄存器中以供下一次传输。
5. 基于SPCMD1设置，SPI断言SSLni信号并插入RSPCK延迟。
6. SPI根据SPMD1设置执行串行传输。
7. 因为SPCMD1.SSLKP位为0，SPI否定SSLni信号。此外，根据SPMD1插入下一个访问延迟。

如果SPCMDm寄存器中SSLKP位为1的SSLni信号输出设置与下次传输使用的SPCMDm寄存器中的SSLni信号输出设置不同，则SPI将SSLni信号状态切换为SSLni信号断言，如下所示如图31.35（5）所示。这对应于下一次传输的命令。

Note: 如果发生这样的SSLni信号切换，驱动MISon信号的从机竞争，可能会发生信号电平的冲突。

当不使用SSLKP位时，主模式下的SPI参考模块内的SSLni信号操作。当SPCMDm.CPHA位为0时，SPI可以使用SSLni信号断言准确启动串行传输，以进行内部检测到的下一次传输。

(5) RSPCK delay (t1)

主机模式下SPI的RSPCK延迟值取决于SPMDm.SCKDEN位设置和SPCKD寄存器设置。SPI通过指针控制确定串行传输期间要引用的SPCMDm寄存器，并使用SPCMDm.SCKDEN位和SPCKD确定RSPCK延迟值，如表31.9中所列。有关RSPCK延迟的定义，请参阅第31.3.5节，传输格式。

Table 31.9 Relationship between the SCKDEN bit, SPCKD register, and RSPCK delay

SPCMDm.SCKDEN bit	SPCKD.SCKDL[2:0] bits	RSPCK delay
0	000b to 111b	1 RSPCK
1	000b	1 RSPCK
	001b	2 RSPCK
	010b	3 RSPCK
	011b	4 RSPCK
	100b	5 RSPCK
	101b	6 RSPCK
	110b	7 RSPCK
	111b	8 RSPCK

(6) SSL negation delay (t2)

The SSL negation delay value of the SPI in master mode depends on the SPCMDm.SLNDEN bit setting and the SSLND register setting. The SPI determines the SPCMDm register to be referenced by pointer control during a serial transfer, and determines the SSL negation delay by using the SPCMDm.SLNDEN bit and SSLND, as listed in Table 31.10. For a definition of the SSL negation delay, see section 31.3.5, Transfer Format.

Table 31.10 Relationship between the SLNDEN bit, SSLND, and SSL negation delay

SPCMDm.SLNDEN bit	SSLND.SLNDL[2:0] bits	SSL negation delay
0	000b to 111b	1 RSPCK
1	000b	1 RSPCK
	001b	2 RSPCK
	010b	3 RSPCK
	011b	4 RSPCK
	100b	5 RSPCK
	101b	6 RSPCK
	110b	7 RSPCK
	111b	8 RSPCK

(7) Next-access delay (t3)

The next-access delay value of the SPI in master mode depends on the SPCMDm.SPNDEN bit setting and the SPND register setting. The SPI determines the SPCMDm register to be referenced by pointer control during serial transfer, and determines a next-access delay during serial transfer using the SPCMDm.SPNDEN bit and SPND.SPNDL[2:0] bits, as listed in Table 31.11. For a definition of the next-access delay, see section 31.3.5, Transfer Format.

Table 31.11 Relationship between the SPNDEN bit, SPND bit, and next-access delay

SPCMDm.SPNDEN bit	SPND.SPNDL[2:0] bits	Next-access delay
0	000b to 111b	1 RSPCK + 2 PCLKA
1	000b	1 RSPCK + 2 PCLKA
	001b	2 RSPCK + 2 PCLKA
	010b	3 RSPCK + 2 PCLKA
	011b	4 RSPCK + 2 PCLKA
	100b	5 RSPCK + 2 PCLKA
	101b	6 RSPCK + 2 PCLKA
	110b	7 RSPCK + 2 PCLKA
	111b	8 RSPCK + 2 PCLKA

Table 31.9 SCKDEN位、SPCKD寄存器和RSPCK延迟之间的关系

SPCMDm.SCKDEN bit	SPCKD.SCKDL[2:0] bits	RSPCK delay
0	000b to 111b	1 RSPCK
1	000b	1 RSPCK
	001b	2 RSPCK
	010b	3 RSPCK
	011b	4 RSPCK
	100b	5 RSPCK
	101b	6 RSPCK
	110b	7 RSPCK
	111b	8 RSPCK

(6) SSL否定延迟(t2)

主模式下SPI的SSL否定延迟值取决于SPMDm.SLNDEN位设置和SSLND寄存器设置。SPI确定串行传输期间指针控制要引用的SPCMDm寄存器，并通过使用SPCMDm.SLNDEN位和SSLND确定SSL否定延迟，如表31.10中所列。有关SSL否定延迟的定义，请参阅第31.3.5节，传输格式。

Table 31.10 SLNDEN位、SSLND和SSL否定延迟之间的关系

SPCMDm.SLNDEN bit	SSLND.SLNDL[2:0] bits	SSL否定延迟
0	000b to 111b	1 RSPCK
1	000b	1 RSPCK
	001b	2 RSPCK
	010b	3 RSPCK
	011b	4 RSPCK
	100b	5 RSPCK
	101b	6 RSPCK
	110b	7 RSPCK
	111b	8 RSPCK

(7) Next-access delay (t3)

主机模式下SPI的下一次访问延迟值取决于SPMDm.SPNDEN位设置和SPND寄存器设置。SPI确定串行传输期间指针控制要引用的SPCMDm寄存器，并使用SPCMDm.SPNDEN位和SPND.SPNDL[2:0]位确定串行传输期间的下一次访问延迟，如表31.11中所列。有关下一次访问延迟的定义，请参阅第31.3.5节，传输格式。

Table 31.11 SPNDEN位、SPND位和下一次访问延迟之间的关系

SPCMDm.SPNDEN bit	SPND.SPNDL[2:0] bits	Next-access delay
0	000b to 111b	1 RSPCK + 2 PCLKA
1	000b	1 RSPCK + 2 PCLKA
	001b	2 RSPCK + 2 PCLKA
	010b	3 RSPCK + 2 PCLKA
	011b	4 RSPCK + 2 PCLKA
	100b	5 RSPCK + 2 PCLKA
	101b	6 RSPCK + 2 PCLKA
	110b	7 RSPCK + 2 PCLKA
	111b	8 RSPCK + 2 PCLKA

(8) Initialization flow

Figure 31.36 shows an example of SPI initialization flow when the SPI is in master mode. For information on how to set up the ICU, DMAC, and I/O ports, see the individual block descriptions.

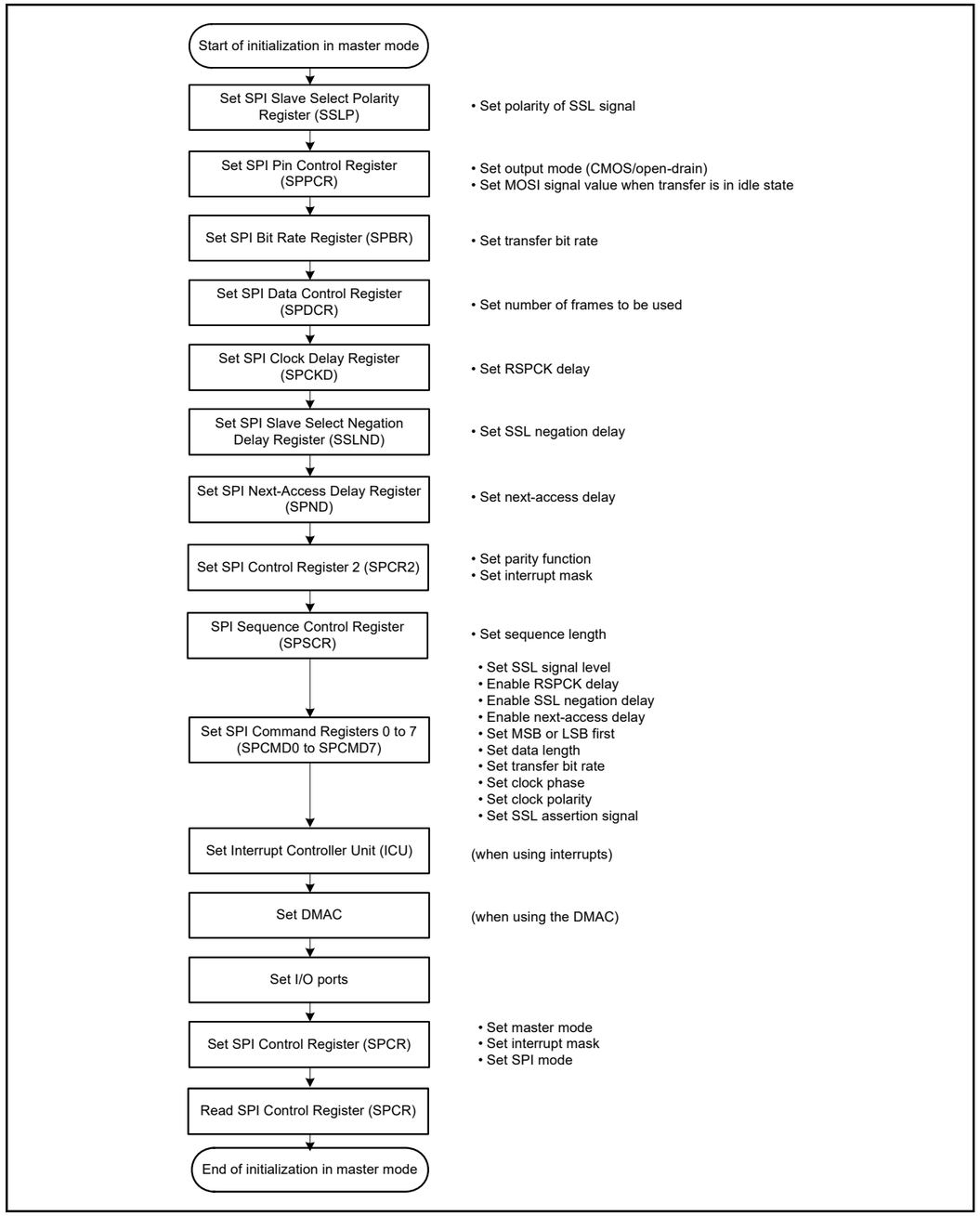


Figure 31.36 Example of initialization flow in master mode for SPI operation

(8) 初始化流程

图31.36显示了SPI处于主机模式时的SPI初始化流程示例。有关如何设置ICU、DMAC和IO端口的信息，请参阅各个模块说明。

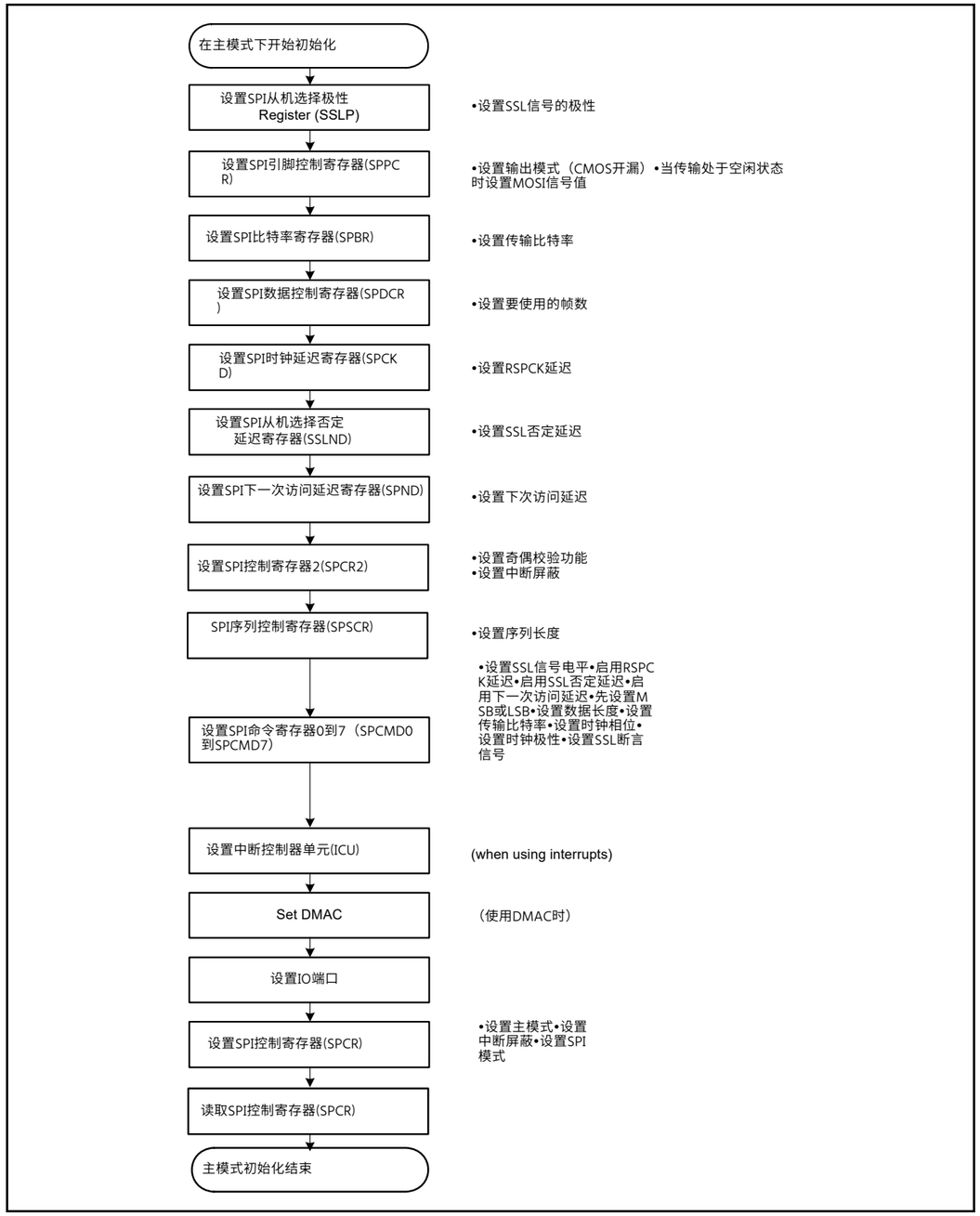


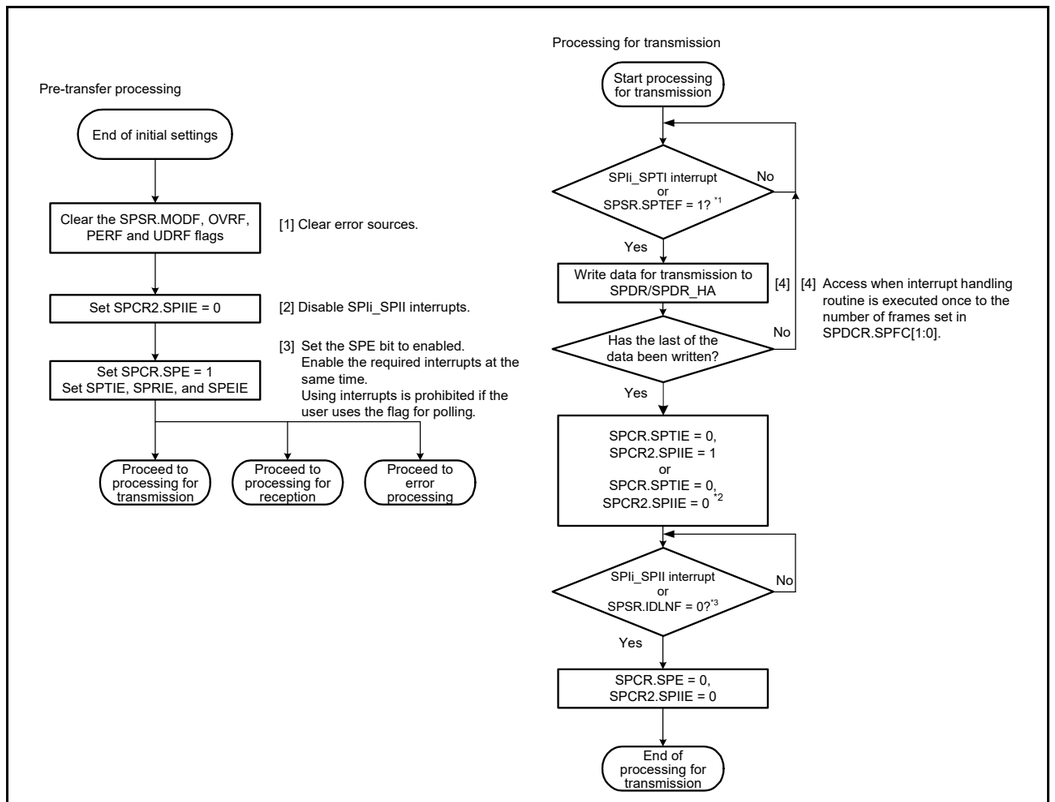
Figure 31.36 SPI操作的主模式初始化流程示例

(9) Software processing flow

Figure 31.37 to Figure 31.39 show examples of the software processing flow.

(a) Transmit processing flow

When transmitting data, with the SPIi_SPII interrupt enabled, the CPU is notified of the completion of data transmission after the last data write for transmission.



Note 1. Before writing data for transmission to SPDR/SPDR_HA, check the transmit buffer empty interrupt by reading the SPSR.SPTEF flag, if the flag for polling is used.
Note 2. Setting the idle interrupt is prohibited (SPCR2.SPIIE = 0), if the flag for polling is used.
Note 3. Wait more than 1 PCLKA after writing data for transmission to SPDE and before starting to poll PSR.IDLNF, if the flag for polling is used.

Figure 31.37 Transmission flow in master mode

(b) Receive processing flow

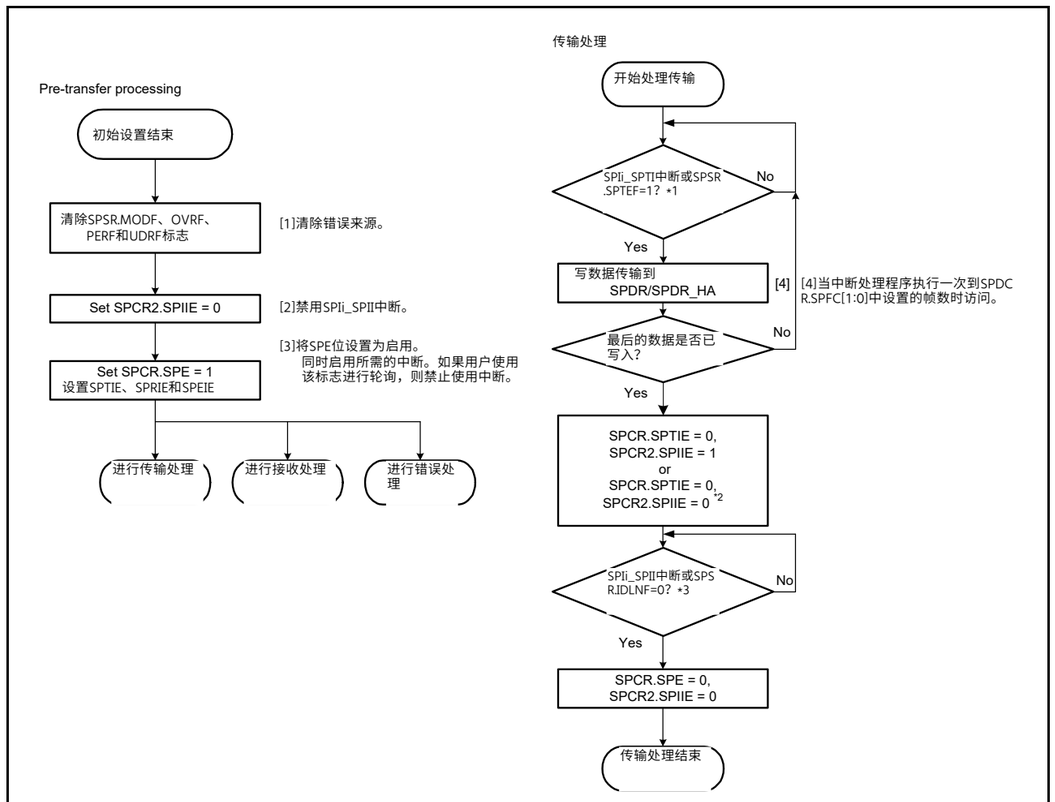
The SPI does not handle receive-only operations, so processing for transmission is required.

(9) 软件处理流程

图31.37至图31.39显示了软件处理流程的示例。

(a) 传输处理流程

发送数据时，SPIi_SPII中断使能，在最后一次数据写入发送后通知CPU数据发送完成。



Note 1. 在将数据写入SPDRSPDR_HA之前，如果使用轮询标志，则通过读取SPSR.SPTEF标志检查发送缓冲区空中断。
Note 2. 如果使用轮询标志，则禁止设置空闲中断(SPCR2.SPIIE=0)。
Note 3. 如果使用轮询标志，则在将数据写入传输到SPDE之后以及开始轮询PSR.IDLNF之前等待超过1个PCLKA。

Figure 31.37 主模式下的传输流

(b) 接收处理流程

SPI不处理只接收操作，因此需要处理传输。

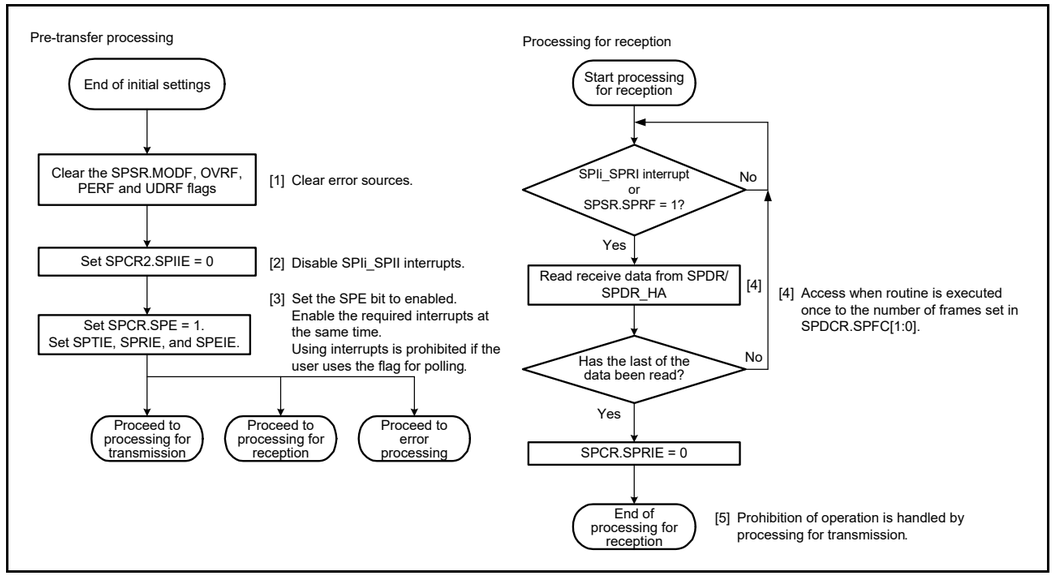


Figure 31.38 Reception flow in master mode

(c) Error processing flow

The SPI detects the following errors:

- Mode fault
- Underrun
- Overrun
- Parity.

When a mode fault error is generated, the SPCR.SPE bit is automatically cleared, stopping operations for transmission and reception. For errors from other sources, the SPCR.SPE bit is not cleared and operations for transmission and reception continue. Renesas recommends clearing the SPCR.SPE bit to stop operations for errors other than mode fault errors. Not doing so leads to updating of the SPSSR.SPECM[2:0] bits.

When an error is detected using an interrupt, clear the ICU.IELSRn.IR flag in the error processing routine. If this is not done, the ICU.IELSRn.IR flag might continue to indicate a SPIi_SPTI or SPIi_SPRI interrupt request. If an SPIi_SPRI interrupt request is indicated, read the receive buffer and initialize the sequencer in the SPI.

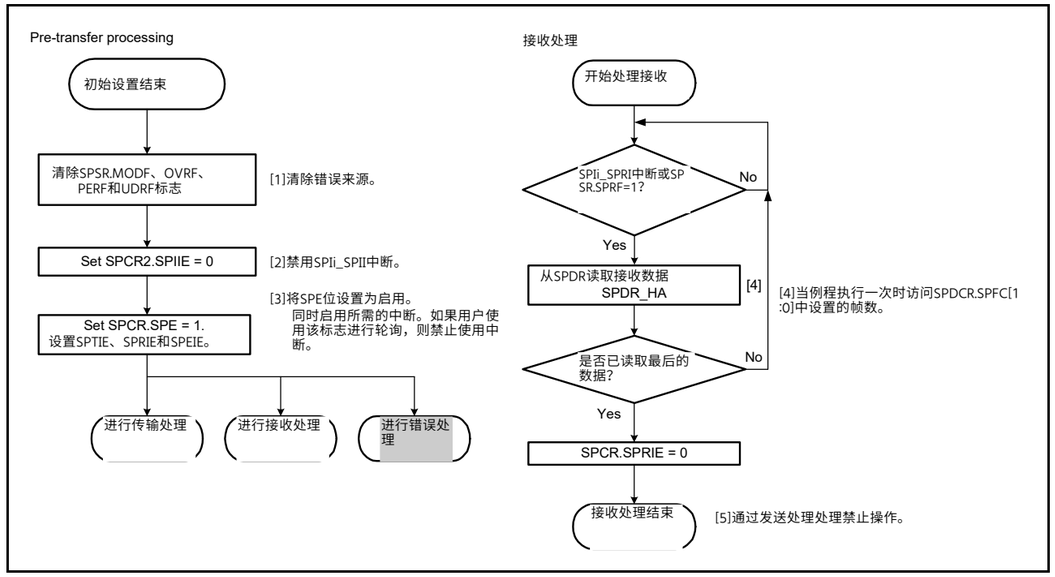


Figure 31.38 主模式下的接收流程

(c) 错误处理流程

SPI检测到以下错误：

- 模式故障
- Underrun
- Overrun
- Parity.

当产生模式故障错误时，SPCR.SPE位自动清零，停止发送和接收操作。对于其他来源的错误，SPCR.SPE位不会被清除，发送和接收操作会继续。Renesas建议清除SPCR.SPE位以停止除模式故障错误以外的错误操作。不这样做会导致更新SPSSR.SPECM[2:0]位。

当使用中断检测到错误时，清除错误处理例程中的ICU.IELSRn.IR标志。如果不这样做，ICU.IELSRn.IR标志可能会继续指示SPIi_SPTI或SPIi_SPRI中断请求。如果指示SPIi_SPRI中断请求，则读取接收缓冲区并初始化SPI中的定序器。

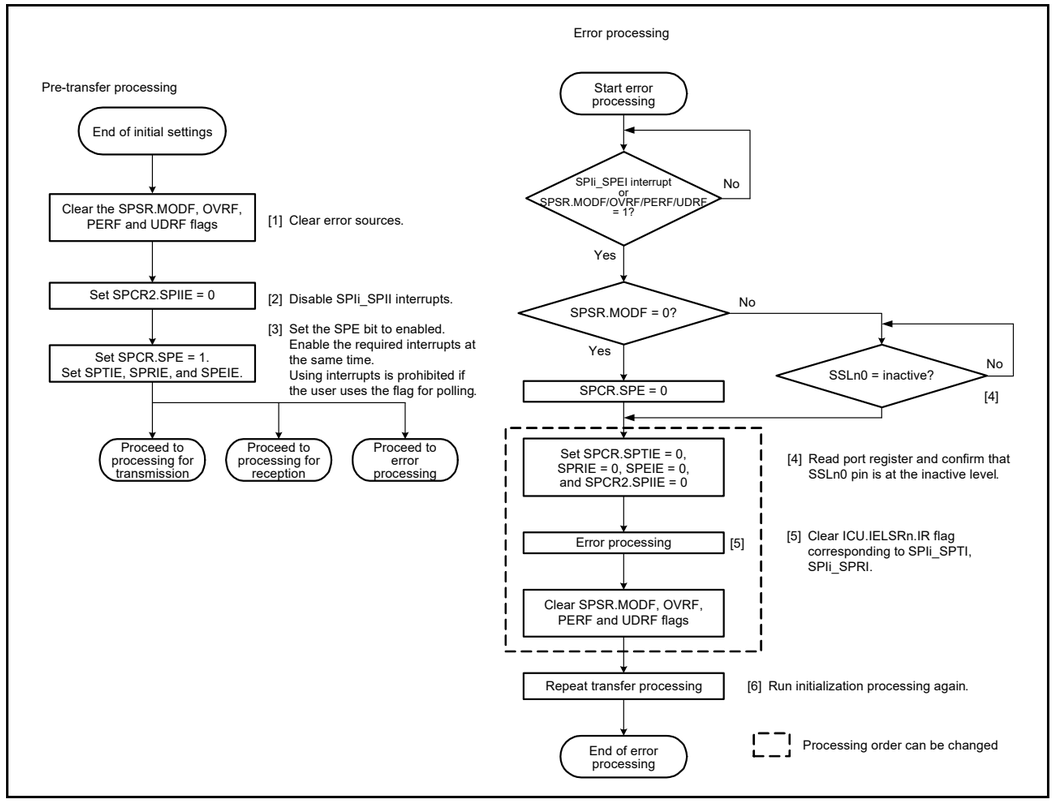


Figure 31.39 Error processing flow in master mode

31.3.10.2 Slave mode operation

(1) Starting a serial transfer

When the SPCMD0.CPHA bit is 0, if the SPI detects an SSLn0 input signal assertion, it must drive valid data to the MISOn output signal. For this reason, when the CPHA bit is 0, the assertion of the SSLn0 input signal triggers the start of a serial transfer.

When the CPHA bit is 1, if the SPI detects the first RSPCKn edge in an SSLn0 signal asserted condition, it must drive valid data to the MISOn output signal. So, when the CPHA bit is 1, the first RSPCKn edge in an SSLn0 signal asserted condition triggers the start of a serial transfer.

Regardless of the CPHA bit setting, the SPI drives the MISOn output signal on SSLn0 signal assertion. The data that is output by the SPI is either valid or invalid, depending on the CPHA bit setting.

The polarity of the SSLn0 input signal depends on the SSLP.SSL0P setting. For details on the SPI transfer format, see section 31.3.5, Transfer Format.

(2) Terminating a serial transfer

Regardless of the SPCMD0.CPHA bit setting, the SPI terminates the serial transfer after detecting an RSPCKn edge associated with the final sampling timing. When free space is available in the receive buffer (the SPSR.SPRF flag is 0), on termination of a serial transfer, the SPI copies the received data from the shift register to the receive buffer of the SPDR/SPDR_HA register. On termination of a serial transfer, the SPI changes the status of the shift register to empty, regardless of the receive buffer state. A mode fault error occurs if the SPI detects an SSLn0 input signal negation from the beginning of the serial transfer to the end of the serial transfer (see section 31.3.8, Error Detection).

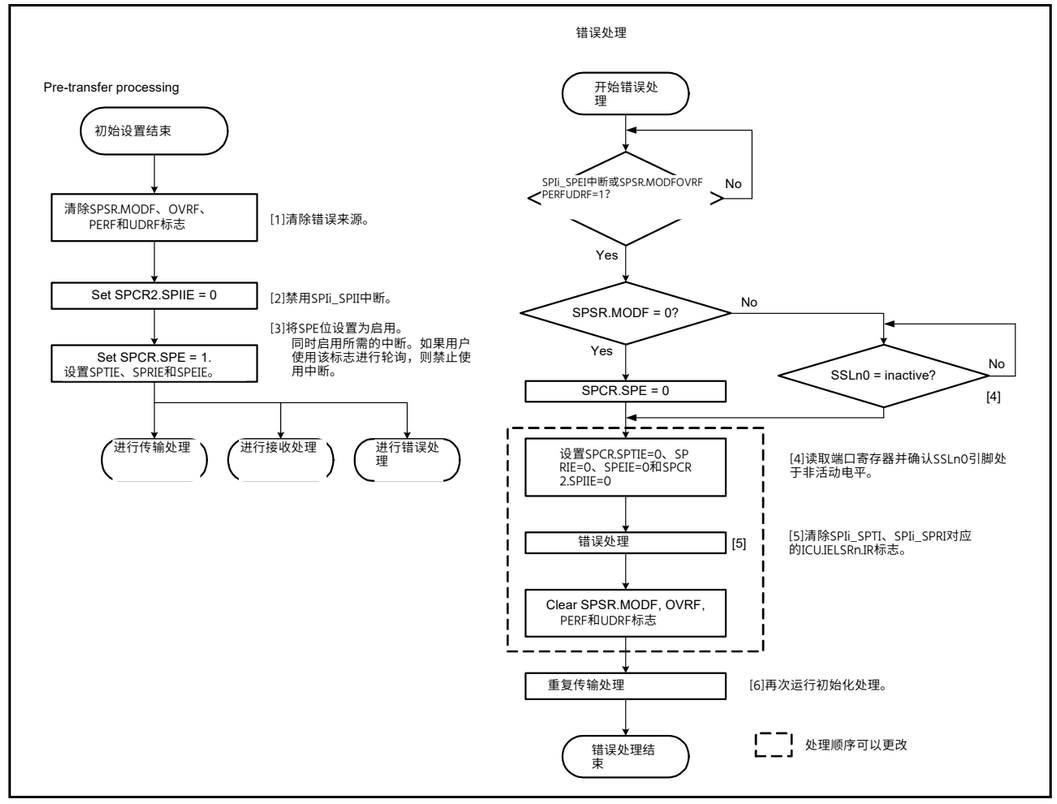


Figure 31.39 主模式下的错误处理流程

31.3.10.2 从模式操作

(1) 开始串行传输

当SPCMD0.CPHA位为0时，如果SPI检测到SSLn0输入信号断言，它必须将有效数据驱动到MISon输出信号。因此，当CPHA位为0时，SSLn0输入信号的断言触发串行传输的开始。

当CPHA位为1时，如果SPI在SSLn0信号置位条件下检测到第一个RSPCKn边沿，它必须将有效数据驱动到MISOn输出信号。因此，当CPHA位为1时，SSLn0信号置位条件中的第一个RSPCKn边沿触发串行传输的开始。

无论CPHA位设置如何，SPI都会在SSLn0信号置位时驱动MIOn输出信号。SPI输出的数据是有效还是无效，取决于CPHA位设置。

SSLn0输入信号的极性取决于SSLP.SSL0P设置。有关SPI传输格式的详细信息，请参阅第31.3.5节，传输格式。

(2) 终止串行传输

无论SPMD0.CPHA位设置如何，SPI在检测到与最终采样时序相关的RSPCKn边沿后都会终止串行传输。当接收缓冲区中有可用空间时（SPSR.SPRF标志为0），在串行传输终止时，SPI将接收到的数据从移位寄存器复制到SPDRSPDR_HA寄存器的接收缓冲区。在串行传输终止时，SPI将移位寄存器的状态更改为空，而与接收缓冲区状态无关。如果SPI从串行传输开始到串行传输结束检测到SSLn0输入信号取反，则会发生模式故障错误（请参阅第31.3.8节，错误检测）。

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The final sampling timing changes depending on the bit length of the transfer data. In slave mode, the SPI data length is determined by the SPCMD0.SPB[3:0] bit setting. The polarity of the SSLn0 input signal is determined by the SSLP.SSL0P bit setting. For details on the SPI transfer format, see section 31.3.5, Transfer Format.

(3) Notes on single-slave operations

If the SPCMD0.CPHA bit is 0, the SPI starts serial transfers when it detects the assertion edge for an SSLn0 input signal. In the configuration example shown in Figure 31.7, if the SPI is in single-slave mode, the SSLn0 signal is fixed at an active state. Therefore, when the CPHA bit is set to 0, the SPI cannot correctly start a serial transfer. For the SPI to correctly execute transmit and receive operations in slave mode when the SSLn0 input signal is fixed at an active state, the CPHA bit must be set to 1. If the application requires setting the CPHA bit to 0, the SSLn0 input signal must not be fixed.

(4) Burst transfer

If the SPCMD0.CPHA bit is 1, continuous serial transfer (burst transfer) can be executed while retaining the assertion state for the SSLn0 input signal. When the CPHA bit is 1, the serial transfer period is the period from the first RSPCKn edge to the sampling timing for the reception of the final bit in an SSLn0 signal active state. Even when the SSLn0 input signal remains at an active level, the SPI can accommodate burst transfers because it can detect the start of an access.

When the CPHA bit is 0, the second and subsequent serial transfers during burst transfer cannot be executed correctly.

(5) Initialization flow

Figure 31.40 shows an example of initialization flow for SPI operation when the SPI is in slave mode. For information on how to set up the ICU, DMAC, and I/O ports, see the individual block descriptions.

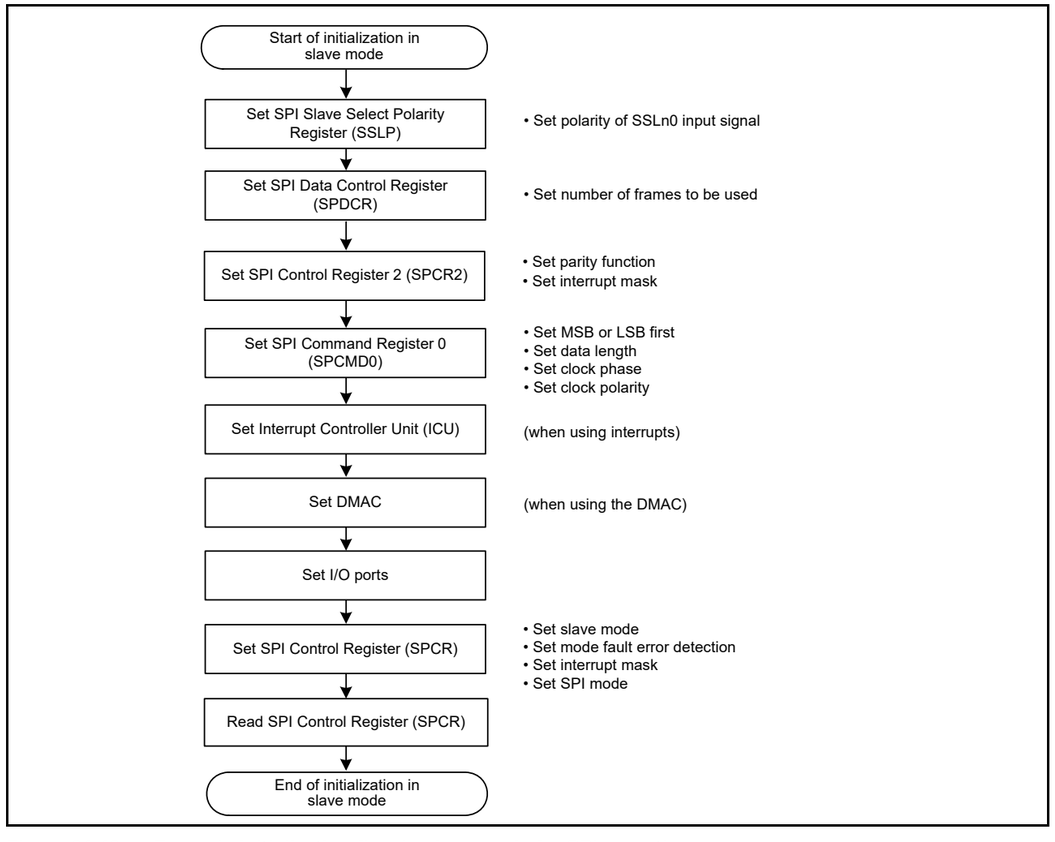


Figure 31.40 Example initialization flow in slave mode for SPI operation

最终的采样时序根据传输数据的位长而变化。在从机模式下，SPI数据长度由SPCMD0.SPB[3:0]位设置决定。SSLn0输入信号的极性由SSLP.SSL0P位设置决定。有关SPI传输格式的详细信息，请参阅第31.3.5节，传输格式。

(3) 单从操作注意事项

如果SPCMD0.CPHA位为0，则SPI在检测到SSLn0输入信号的断言边沿时开始串行传输。
在图31.7所示的配置示例中，如果SPI处于单从模式，则SSLn0信号固定在活动状态。因此，当CPHA位设置为0时，SPI无法正确启动串行传输。为使SPI在SSLn0输入信号固定为有效状态时在从机模式下正确执行发送和接收操作，必须将CPHA位设置为1。如果应用程序需要将CPHA位设置为0，则SSLn0输入信号必须不能固定。

(4) 突发传输

如果SPCMD0.CPHA位为1，则可以执行连续串行传输（突发传输），同时保持SSLn0输入信号的断言状态。当CPHA位为1时，串行传输周期是从第一个RSPCKn边沿到SSLn0信号有效状态下接收最后一个位的采样时序的周期。即使SSLn0输入信号保持有效电平，SPI也可以适应突发传输，因为它可以检测访问的开始。

当CPHA位为0时，突发传输期间的第二次和后续串行传输无法正确执行。

(5) 初始化流程

图31.40显示了SPI处于从机模式时SPI操作的初始化流程示例。有关如何设置ICU、DMAC和IO端口的信息，请参阅各个模块说明。

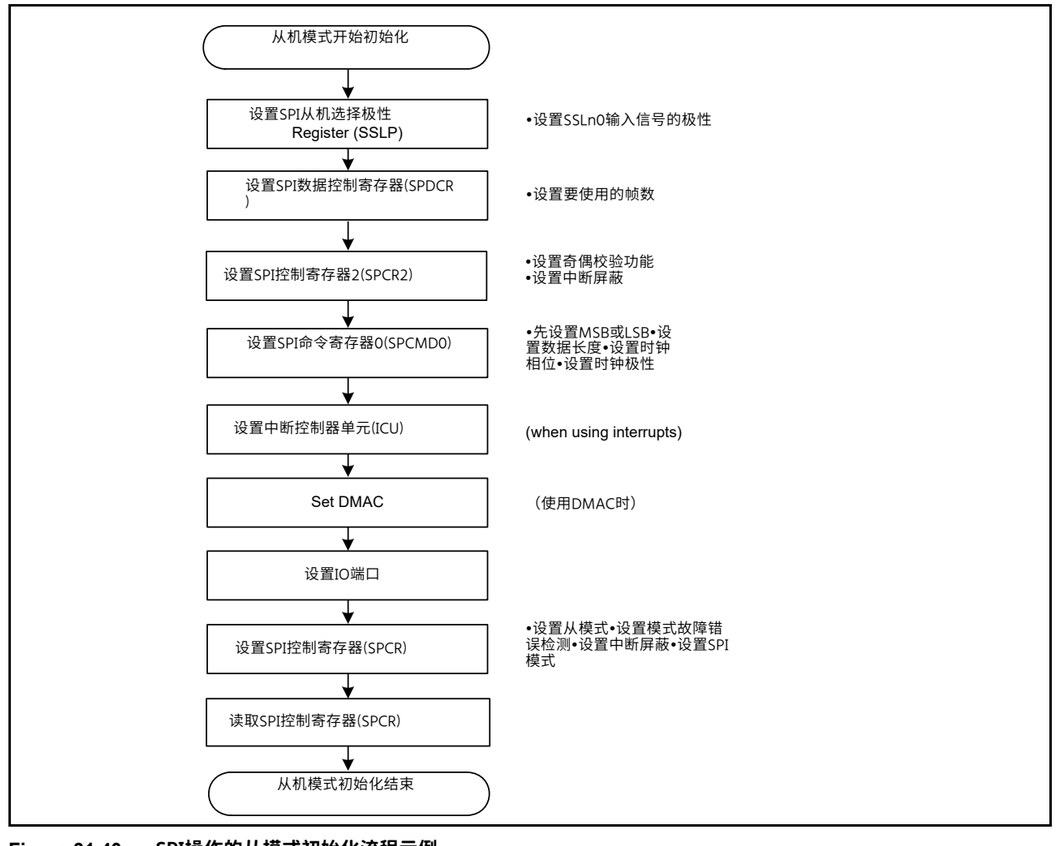
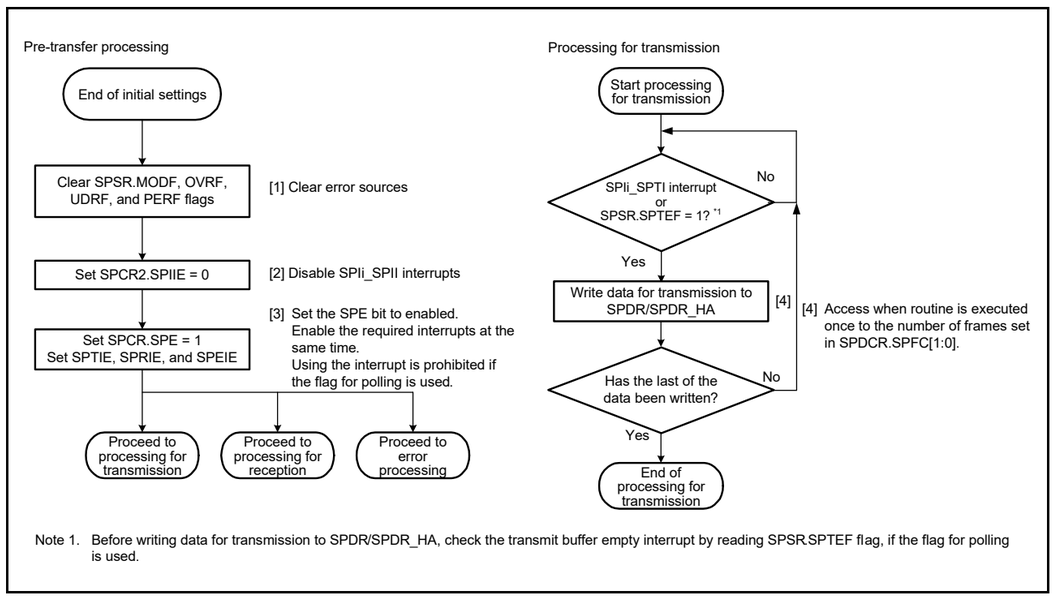


Figure 31.40 SPI操作的从模式初始化流程示例

(6) Software processing flow

Figure 31.41 to Figure 31.43 show examples of the software processing flow.

(a) Transmit processing flow



Note 1. Before writing data for transmission to SPDR/SPDR_HA, check the transmit buffer empty interrupt by reading SPSR.SPTEF flag, if the flag for polling is used.

Figure 31.41 Transmission flow in slave mode

(b) Receive processing flow

The SPI does not handle receive-only operations, so processing for transmission is required.

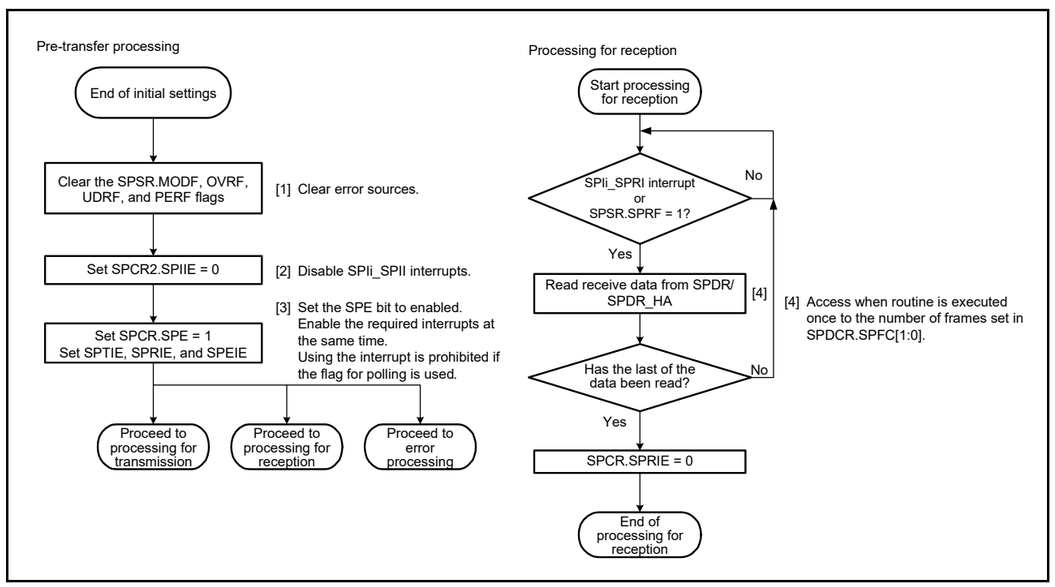
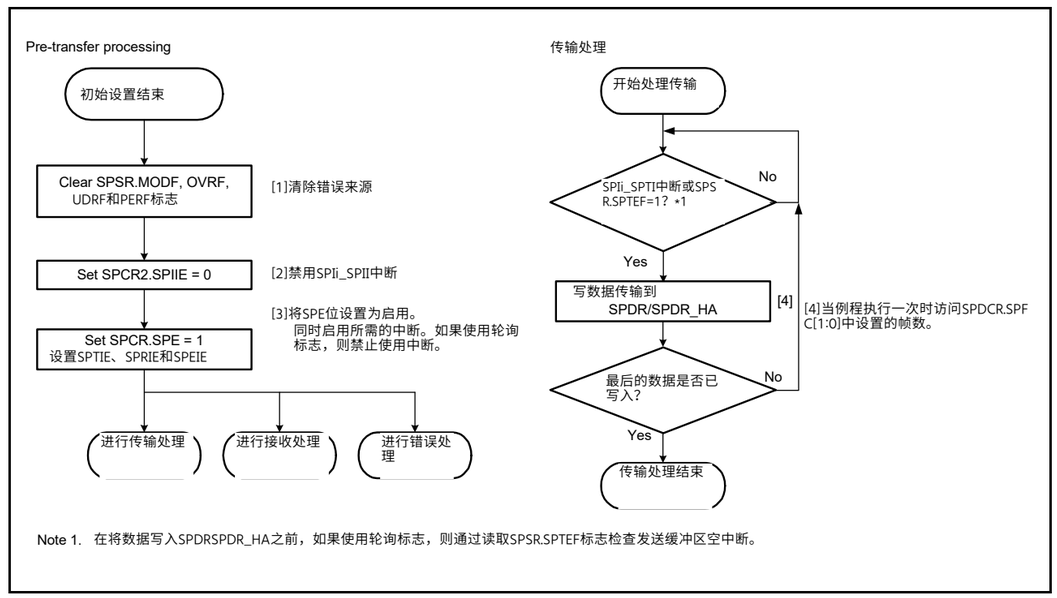


Figure 31.42 Reception flow in slave mode

(6) 软件处理流程

图31.41至图31.43显示了软件处理流程的示例。

(a) 传输处理流程



Note 1. 在将数据写入SPDRSPDR_HA之前，如果使用轮询标志，则通过读取SPSR.SPTEF标志检查发送缓冲区空中断。

Figure 31.41 从模式下的传输流

(b) 接收处理流程

SPI不处理只接收操作，因此需要处理传输。

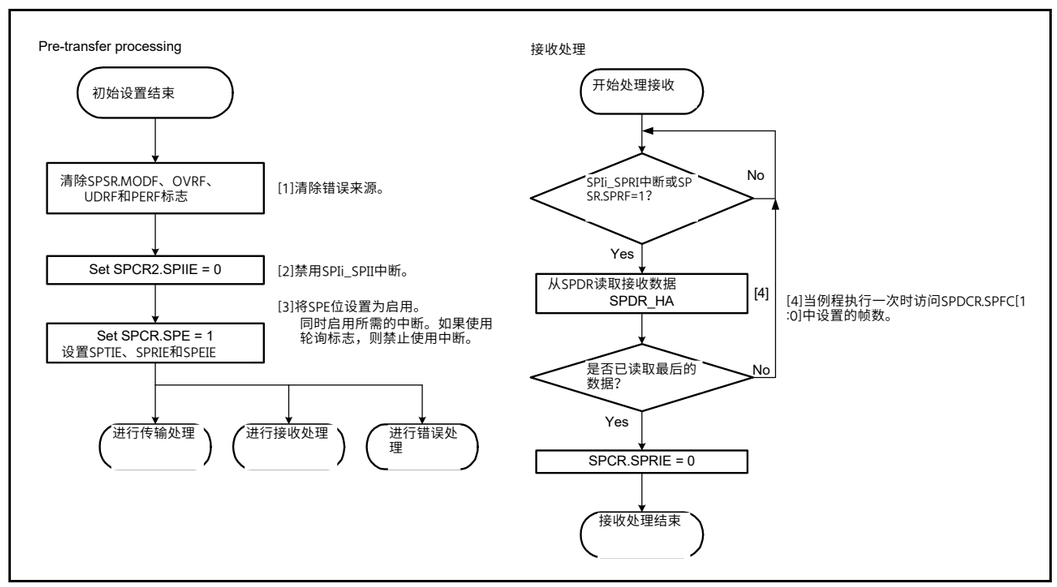


Figure 31.42 从机模式下的接收流程

(c) Error processing flow

In slave operation, even when a mode fault error is generated, the SPSR.MODF flag can be cleared regardless of the state of the SSLn0 pin.

When an error is detected by using an interrupt, clear the ICU.IELSRn.IR flag in the error processing routine. If this is not done, the ICU.IELSRn.IR flag might continue to indicate the SPIi_SPTI or SPIi_SPRI interrupt request. If the SPIi_SPRI interrupt request is indicated, read the receive buffer and initialize the sequencer in the SPI.

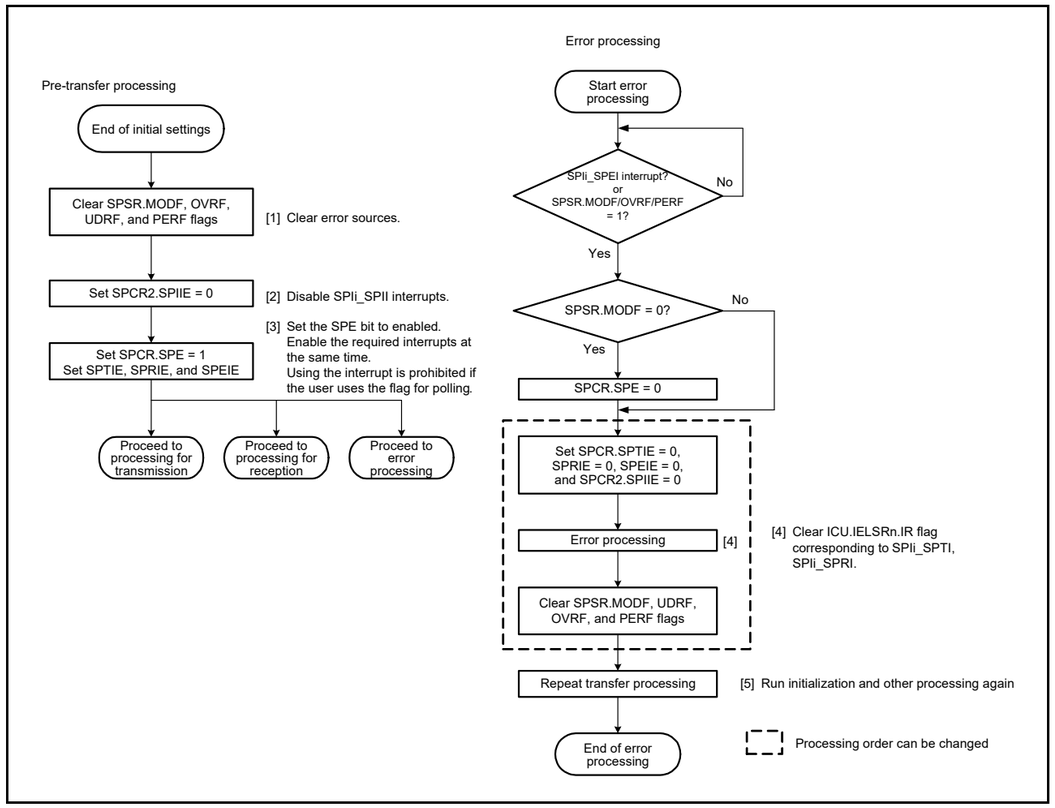


Figure 31.43 Error processing flow for slave mode

31.3.11 Clock Synchronous Operation

Setting the SPCR.SPMS bit to 1 selects clock synchronous operation of the SPI. In clock synchronous operation, the SSLni pin is not used, and the RSPCKn, MOSIn, and MISOn pins handle communication. All SSLni pins are available as I/O port pins.

Although clock synchronous operation does not require the use of the SSLni pin, operation of the module is the same as in SPI operation. In both master and slave operations, communications can be performed with the same flow as in SPI operation. However, mode fault errors are not detected because the SSLni pin is not used.

Additionally, do not perform operation if the clock synchronous operation is enabled when the SPCMDm.CPHA bit is set to 0 in slave mode (SPCR.MSTR = 0).

(c) 错误处理流程

在从机操作中，即使产生模式故障错误，SPSR.MODF标志也可以被清除，而与SSLn0引脚的状态无关。

当使用中断检测到错误时，清除错误处理例程中的ICU.IELSRn.IR标志。如果不这样做，ICU.IELSRn.IR标志可能会继续指示SPIi_SPTI或SPIi_SPRI中断请求。如果指示了SPIi_SPRI中断请求，则读取接收缓冲区并初始化SPI中的定序器。

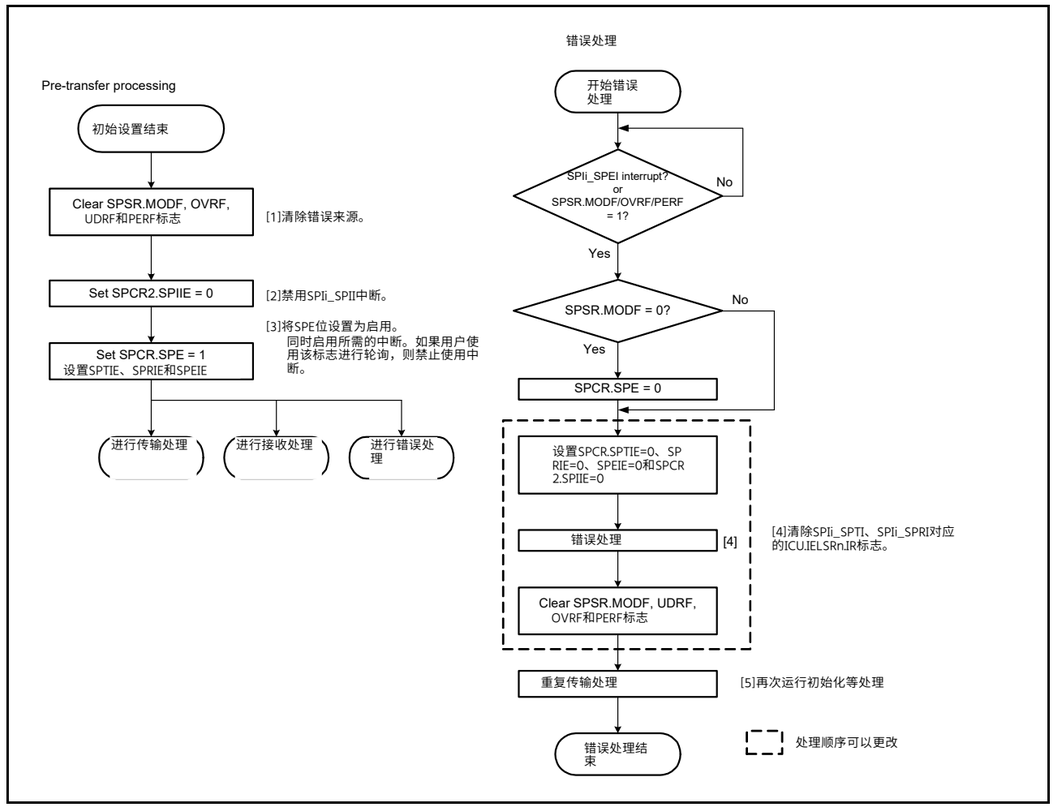


Figure 31.43 从机模式的错误处理流程

31.3.11 时钟同步操作

将SPCR.SPMS位设置为1可选择SPI的时钟同步操作。在时钟同步操作中，不使用SSLni引脚，而RSPCKn、MOSIn和MISOn引脚处理通信。所有SSLni引脚都可用作IO端口引脚。

虽然时钟同步操作不需要使用SSLni引脚，但模块的操作与SPI操作相同。在主机和从机操作中，可以使用与SPI操作相同的流程执行通信。但是，由于未使用SSLni引脚，因此未检测到模式故障错误。

此外，如果在从模式(SPCR.MSTR=0)下SPCMDm.CPHA位设置为0时使能时钟同步操作，则不要执行操作。

31.3.11.1 Master mode operation

(1) Starting serial transfer

The SPI updates the data in the transmit buffer (SPTX) of SPDR/SPDR_HA when data is written to the SPDR/SPDR_HA register with the transmit buffer empty, the data for the next transfer not set and the SPSR.SPTEF flag is 1. When the shift register is empty after the number of frames set in the SPDCR.SPFC[1:0] bits are written to the SPDR/SPDR_HA, the SPI copies data from the transmit buffer to the shift register and starts serial transmission. On copying transmit data to the shift register, the SPI changes the status of the shift register to full, and on termination of serial transfer, it changes the status of the shift register to empty. The status of the shift register cannot be referenced.

Transfer in clock synchronous operation is conducted without the SSLn0 output signal. For details on the SPI transfer format, see section 31.3.5, Transfer Format.

(2) Terminating serial transfer

The SPI terminates the serial transfer after transmitting an RSPCKn edge associated with the sampling timing. If free space is available in the receive buffer (the SPSR.SPRF flag is 0), on termination of serial transfer, the SPI copies data from the shift register to the receive buffer of the SPI Data Register (SPDR/SPDR_HA).

The final sampling timing varies depending on the bit length of transfer data. In master mode, the SPI data length depends on the SPCMDm.SPB[3:0] bit setting. Transfer in clock synchronous operation is conducted without the SSLn0 output signal. For details on the SPI transfer format, see section 31.3.5, Transfer Format.

(3) Sequence control

The transfer format used in master mode is determined by the SPSCR, SPCMDm, SPBR, SPCKD, SSLND, and SPND registers. Although the SSLni signals are not output in clock synchronous operation, these settings are valid.

The SPSCR register determines the sequence configuration for serial transfers that are executed by the SPI in master mode. The following parameters are specified in the SPCMDm register:

- SSLni output signal value
- MSB- or LSB-first
- Data length
- Some of the bit rate settings
- RSPCKn polarity and phase
- Whether SPCKD is to be referenced
- Whether SSLND is to be referenced
- Whether SPND is to be referenced.

SPBR holds some of the bit rate settings such as the SPCKD (SPI clock delay), SSLND (SSL negation delay), and SPND (next-access delay).

Based on the sequence length that is assigned to SPSCR, the SPI makes up a sequence comprised of a part or all of SPCMDm register. The SPI contains a pointer to the SPCMDm register that makes up the sequence. The value of this pointer can be checked by reading the SPSSR.SPCP[2:0] bits. When the SPCR.SPE bit is set to 1 and the SPI function is enabled, the SPI loads the pointer to the commands in the SPCMD0 register, and incorporates the SPCMD0 register setting into the transfer format at the beginning of the serial transfer. The SPI increments the pointer each time the next-access delay period for a data transfer ends. On completion of the serial transfer that corresponds to the final command comprising the sequence, the SPI sets the pointer to the SPCMD0 register to execute the sequence repeatedly.

31.3.11.1 主模式操作

(1) 开始串行传输

SPI更新SPDRSPDR_HA的发送缓冲区(SPTX)中的数据
SPDRSPDR_HA寄存器，发送缓冲区为空，未设置下一次传输的数据，SPSR.SPTEF标志为1。当在SPDCR.SPFC[1:0]位中设置的帧数后移位寄存器为空时写入SPDRSPDR_HA，SPI将数据从发送缓冲区复制到移位寄存器并开始串行传输。将发送数据复制到移位寄存器时，SPI将移位寄存器的状态更改为满，而在串行传输终止时，它将移位寄存器的状态更改为空。无法引用移位寄存器的状态。

在没有SSLn0输出信号的情况下进行时钟同步操作的传输。有关SPI传输格式的详细信息，请参阅第31.3.5节，传输格式。

(2) 终止串行传输

SPI在发送与采样时序相关的RSPCKn边沿后终止串行传输。如果接收缓冲区中有可用空间（SPSR.SPRF标志为0），则在串行传输终止时，SPI将数据从移位寄存器复制到SPI数据寄存器(SPDRSPDR_HA)的接收缓冲区。

最终的采样时序根据传输数据的位长而变化。在主机模式下，SPI数据长度取决于SPMDm.SPB[3:0]位设置。在没有SSLn0输出信号的情况下进行时钟同步操作的传输。有关SPI传输格式的详细信息，请参阅第31.3.5节，传输格式。

(3) 顺序控制

主机模式中使用的传输格式由SPSCR、SPCMDm、SPBR、SPCKD、SSLND和SPND寄存器决定。虽然在时钟同步操作中不输出SSLni信号，但这些设置是有效的。

SPSCR寄存器确定由SPI在主模式下执行的串行传输的序列配置。SPCMDm寄存器中指定了以下参数：

- SSLni输出信号值
- MSB- or LSB-first
- 数据长度
- 一些比特率设置
- RSPCKn极性和相位
- 是否要引用SPCKD
- 是否要引用SSLND
- 是否要引用SPND。

SPBR保存一些比特率设置，例如SPCKD（SPI时钟延迟）、SSLND（SSL否定延迟）和SPND（下一次访问延迟）。

根据分配给SPSCR的序列长度，SPI组成一个序列，该序列由部分或全部
SPMDm寄存器。SPI包含一个指向构成序列的SPCMDm寄存器的指针。该指针的值可以通过读取SPSSR.SPCP[2:0]位来检查。当SPCR.SPE位设置为1且启用SPI功能时，SPI将指针加载到SPCMD0寄存器中的命令，并在串行传输开始时将SPCMD0寄存器设置合并到传输格式中。每次数据传输的下一个访问延迟周期结束时，SPI都会增加指针。完成对应于包含序列的最终命令的串行传输后，SPI将指针设置为SPMD0寄存器以重复执行序列。

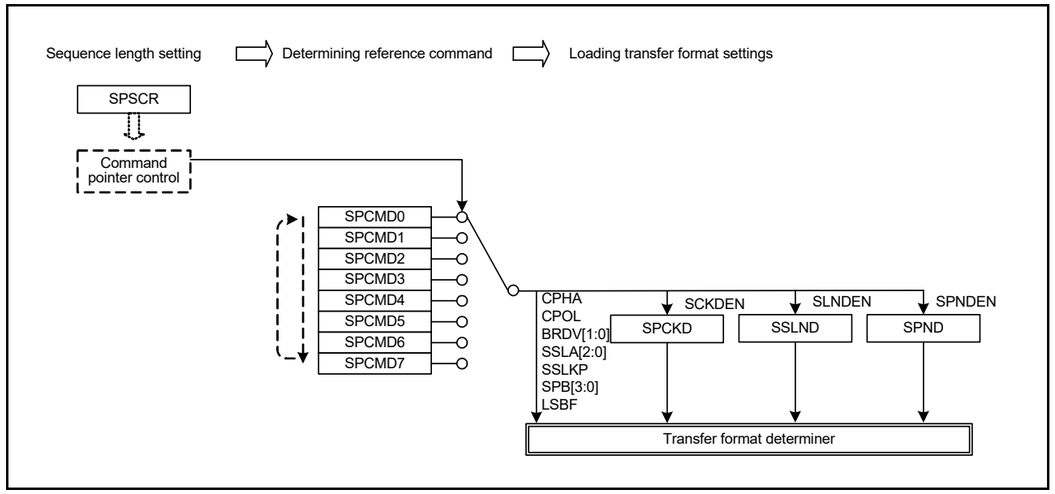


Figure 31.44 Procedure to determine the format of serial transmission in master mode

In this section, a frame is the combination of the SPDR/SPDR_HA data and SPCMDm settings.

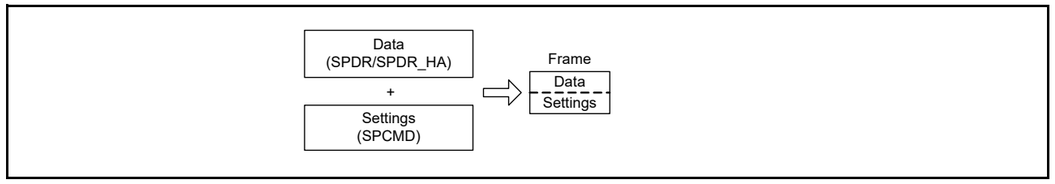


Figure 31.45 Conceptual diagram of frames

Figure 31.46 shows the relationship between the command and the transmit and receive buffers in the sequence of operations specified by the settings in Table 31.4.

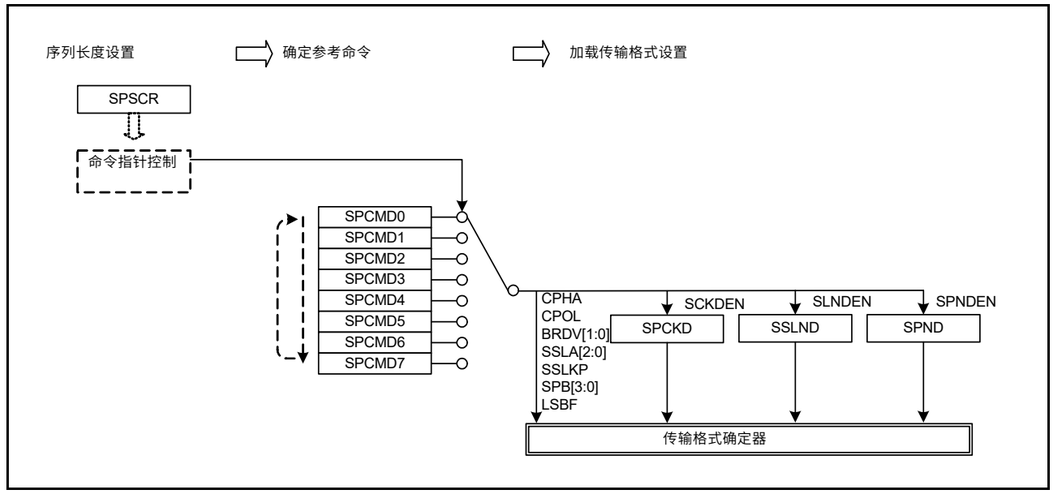


Figure 31.44 确定主机模式下串行传输格式的程序

在本节中，帧是SPDRSPDR_HA数据和SPMDm设置的组合。

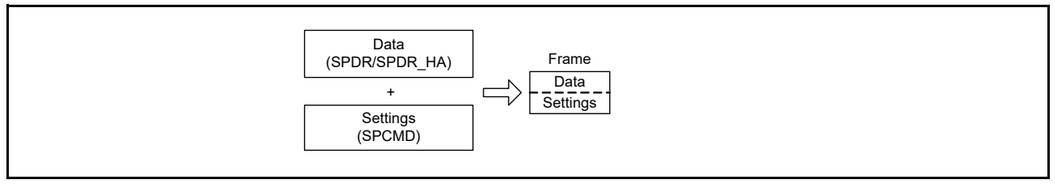


Figure 31.45 框架的概念图

图31.46显示了在表31.4中的设置指定的操作序列中命令与发送和接收缓冲区之间的关系。

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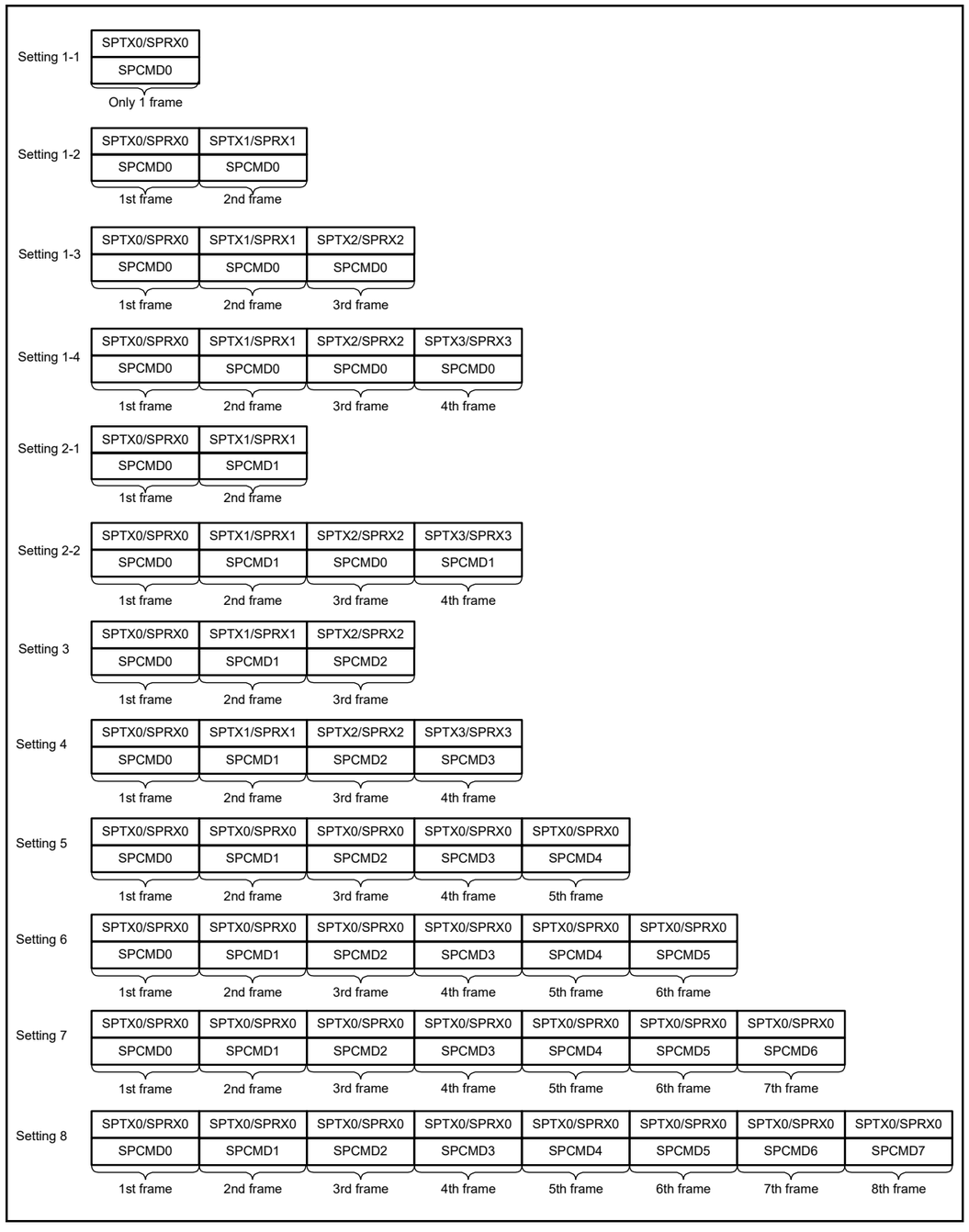

Figure 31.46 Relationship between the SPI Command register and the transmit and receive buffers in sequence operations

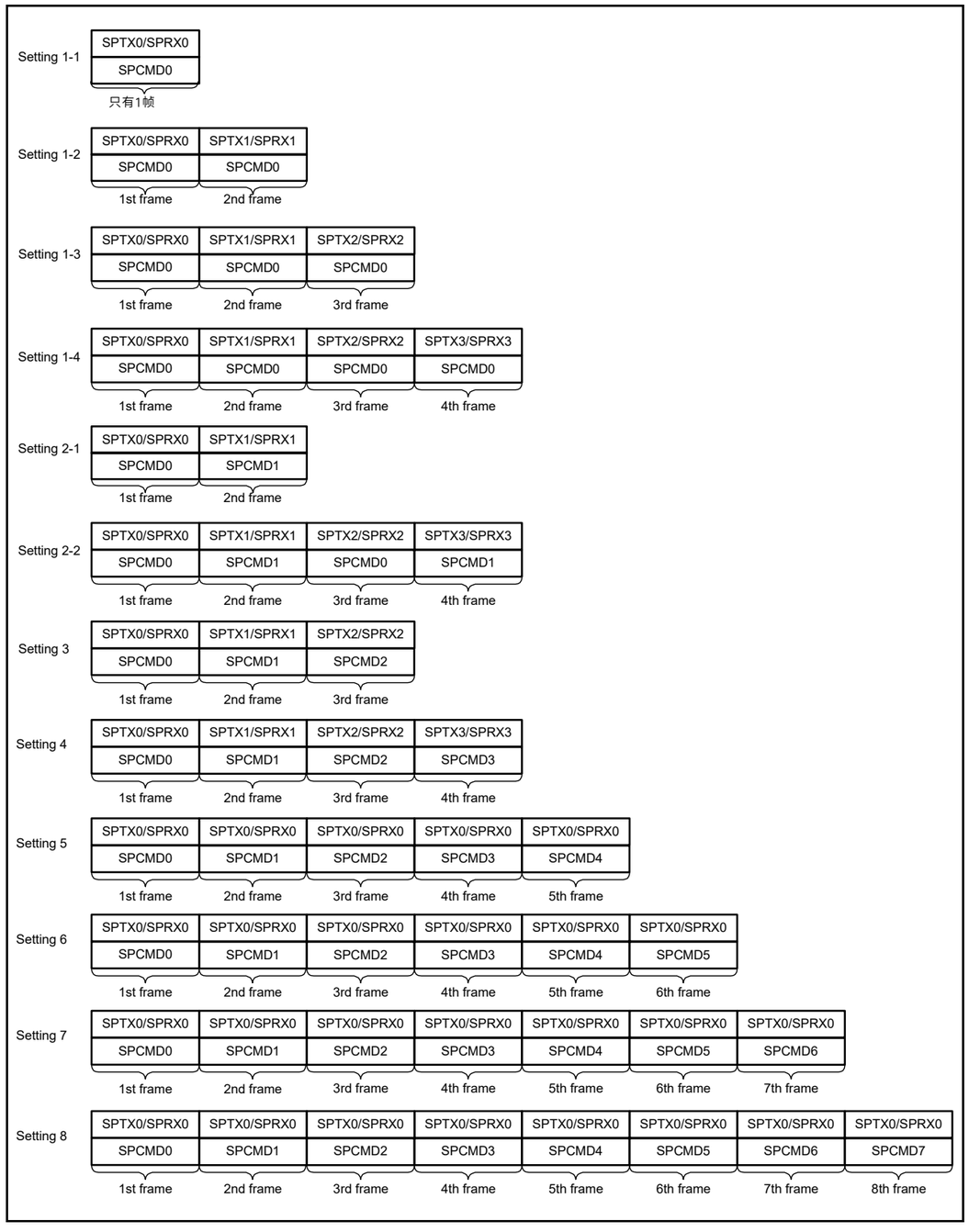

Figure 31.46 串行操作中SPI命令寄存器与发送和接收缓冲区的关系

(4) Initialization flow

Figure 31.47 shows an example of initialization flow for clock synchronous operation when the SPI is used in master mode. For information on how to set up the ICU, DMAC, and I/O ports, see the descriptions given in the individual blocks.

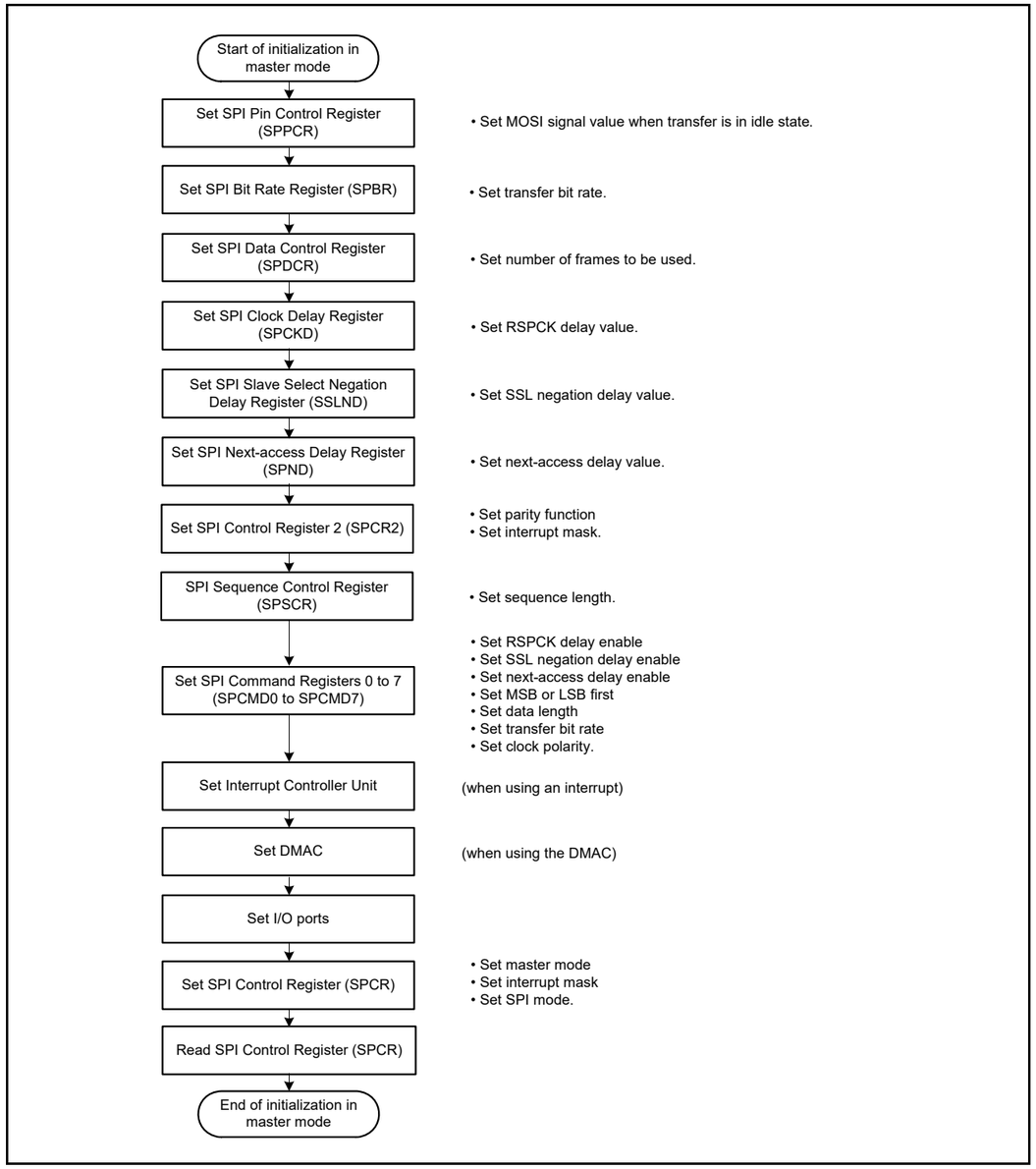

Figure 31.47 Example of initialization flow in master mode for clock synchronous operation

(5) Software processing flow

Software processing during clock synchronous master operation is the same as that for SPI master operation. For details, see section 31.3.10.1, (9) Software processing flow. Mode fault errors are not generated in clock synchronous operation.

(4) 初始化流程

图31.47显示了在主模式下使用SPI时时钟同步操作的初始化流程示例。有关如何设置ICU、DMAC和IO端口的信息，请参阅各个块中给出的说明。

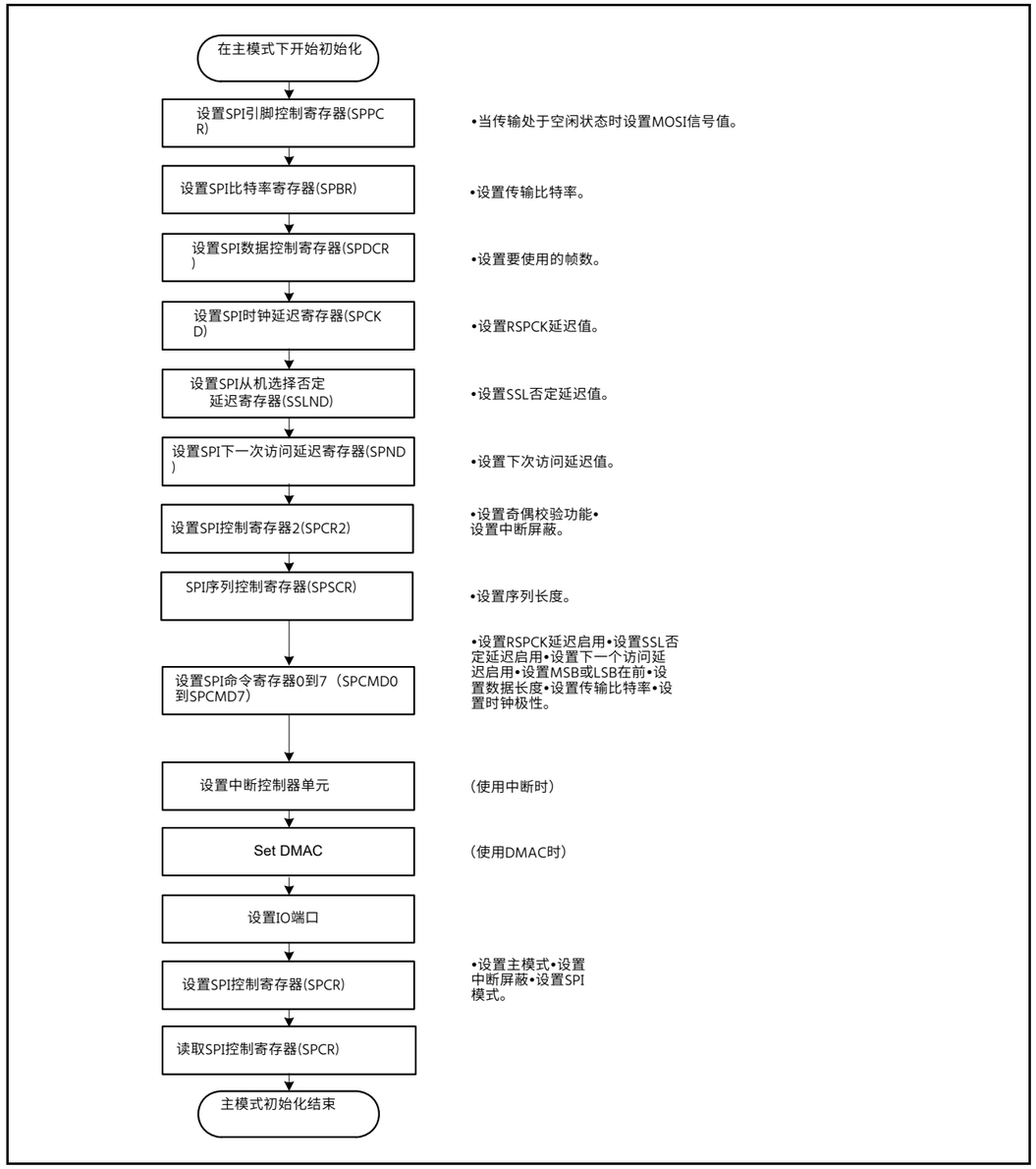

Figure 31.47 时钟同步操作的主模式初始化流程示例

(5) 软件处理流程

时钟同步主机操作期间的软件处理与SPI主机操作相同。详见31.3.10.1节，（9）软件处理流程。时钟同步操作中不会产生模式故障错误。

31.3.11.2 Slave mode operation

(1) Starting serial transfer

When the SPCR.SPMS bit is 1, the first RSPCKn edge triggers the start of a serial transfer in the SPI, and the SPI drives the MISOn output signal. The SSLn0 input signal is not used in clock synchronous operation. For details on the SPI transfer format, see section 31.3.5, Transfer Format.

(2) Terminating serial transfer

The SPI terminates the serial transfer after detecting an RSPCKn edge associated with the final sampling timing. When free space is available in the receive buffer (the SPSR.SPRF flag is 0), on termination of a serial transfer, the SPI copies received data from the shift register to the receive buffer of the SPDR/SPDR_HA register. On termination of a serial transfer, the SPI changes the status of the shift register to empty regardless of the receive buffer.

The final sampling timing changes depending on the bit length of transfer data. In slave mode, the SPI data length is determined by the SPCMD0.SPB[3:0] bit setting. For details on the SPI transfer format, see section 31.3.5, Transfer Format.

(3) Initialization flow

Figure 31.48 shows an example of initialization flow for clock synchronous operation when the SPI is used in slave mode. For information on how to set up the ICU, DMAC, and I/O ports, see the descriptions given in the individual blocks.

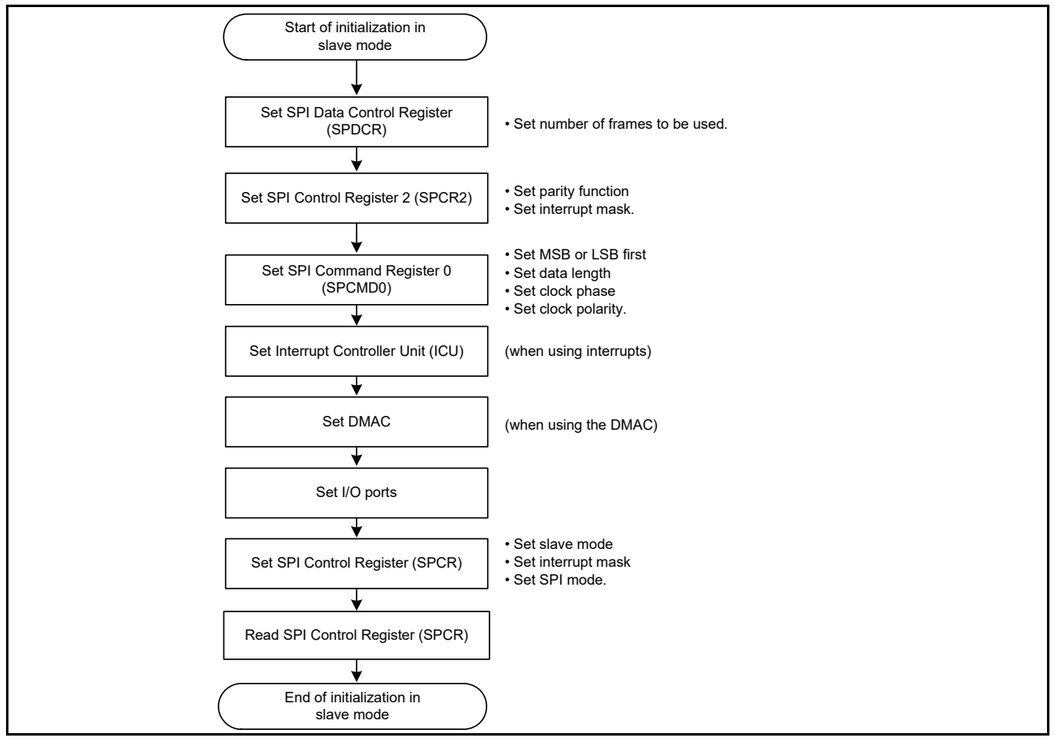

Figure 31.48 Example of initialization flow in slave mode for clock synchronous operation

(4) Software processing flow

Software processing during clock synchronous slave operation is the same as that for SPI slave operation. For details, see section 31.3.10.2, (6) Software processing flow.

Note: Mode fault errors are not generated in clock synchronous mode.

31.3.11.2 从模式操作

(1) 开始串行传输

当SPCR.SPMS位为1时，第一个RSPCKn边沿触发SPI中串行传输的开始，SPI驱动MISOn输出信号。SSLn0输入信号不用于时钟同步操作。有关SPI传输格式的详细信息，请参阅第31.3.5节，传输格式。

(2) 终止串行传输

SPI在检测到与最终采样时序相关的RSPCKn边沿后终止串行传输。当接收缓冲区中有可用空间（SPSR.SPRF标志为0）时，在串行传输终止时，SPI将接收到的数据从移位寄存器复制到SPDRSPDR_HA寄存器的接收缓冲区。在串行传输终止时，SPI将移位寄存器的状态更改为空，而与接收缓冲区无关。

最终的采样时序根据传输数据的位长而变化。在从机模式下，SPI数据长度由SPCMD0.SPB[3:0]位设置决定。有关SPI传输格式的详细信息，请参阅第31.3.5节，传输格式。

(3) 初始化流程

图31.48显示了在从模式下使用SPI时时钟同步操作的初始化流程示例。有关如何设置ICU、DMAC和IO端口的信息，请参阅各个块中给出的说明。

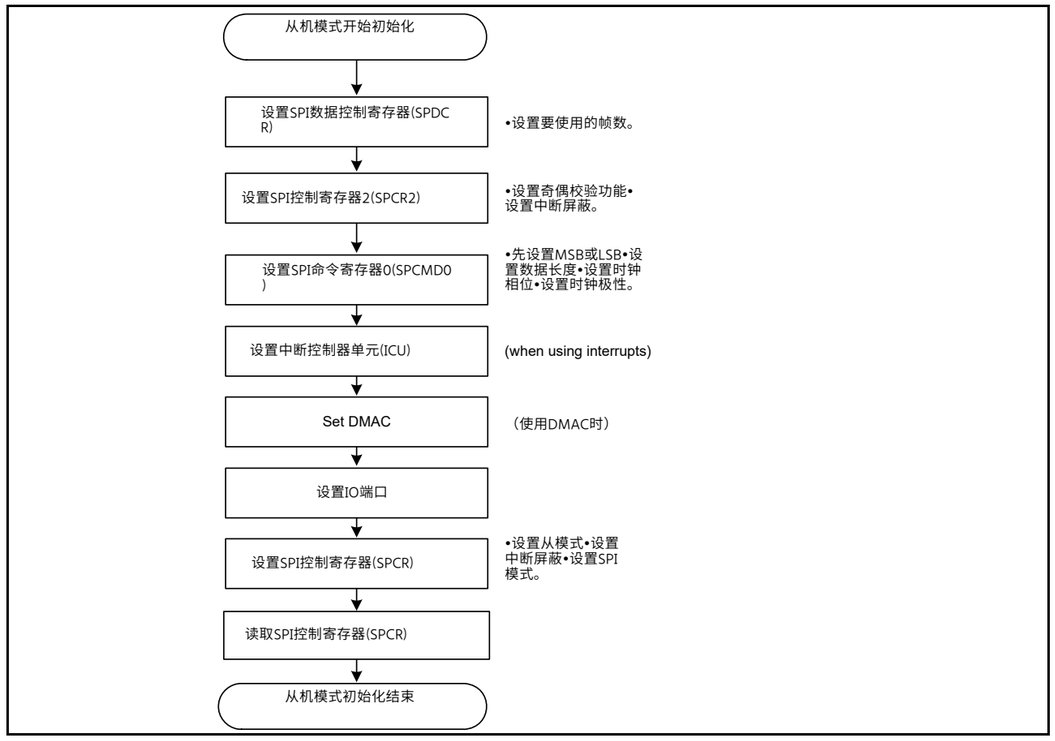

Figure 31.48 时钟同步操作的从模式初始化流程示例

(4) 软件处理流程

时钟同步从机操作期间的软件处理与SPI从机操作相同。详见31.3.10.2节，（6）软件处理流程。

Note: 时钟同步模式下不会产生模式故障错误。

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31.3.12 Loopback Mode

When 1 is written to the SPPCR.SPLP2 bit or SPPCR.SPLP bit, the SPI shuts off the path between the MISOn pin and the shift register if the SPCR.MSTR bit is 1, or between the MOSIn pin and the shift register if the SPCR.MSTR bit is 0, and connects the input and output paths of the shift register, establishing a loopback mode. The SPI does not shut off the path between the MOSIn pin and the shift register if the SPCR.MSTR bit is 1, or between the MISOn pin and the shift register if the SPCR.MSTR bit is 0. When a serial transfer is executed in loopback mode, the transmit data for the SPI or the reversed transmit data becomes the received data for the SPI.

Table 31.12 lists the relationship between the SPLP2 and SPLP bits and the received data. Figure 31.49 shows the configuration of the shift register I/O paths when the SPI in master mode is set to loopback mode (SPPCR.SPLP2 = 1, SPPCR.SPLP = 0 or 1).

Table 31.12 SPLP2 and SPLP bit settings and received data

SPPCR.SPLP2 bit	SPPCR.SPLP bit	Received data
0	0	Input data from the MOSIn pin or MISOn pin
0	1	Inverted transmit data
1	0	Transmit data
1	1	Transmit data

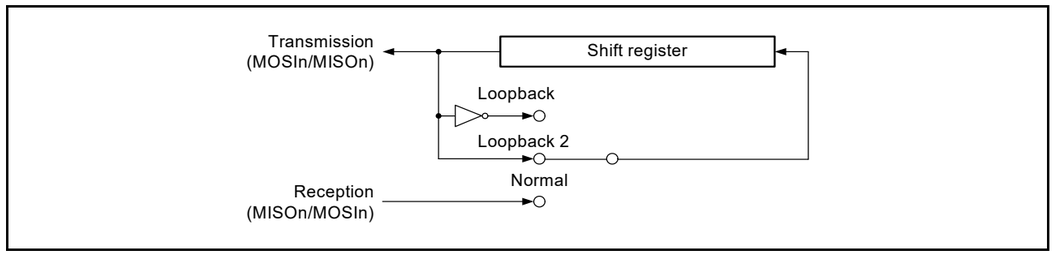

Figure 31.49 Configuration of Shift register I/O paths in loopback mode for master mode

31.3.13 Self-Diagnosis of Parity Bit Function

The parity circuit consists of a parity bit adding unit used for transmit data and an error detecting unit used for received data. To detect defects in these units, the parity circuit performs self-diagnosis as shown in Figure 31.50.

31.3.12 Loopback Mode

当向SPPCR.SPLP2位或SPPCR.SPLP位写入1时，如果SPCR.MSTR位为1，则SPI关闭MISOn引脚和移位寄存器之间的路径，或者如果SPCR.MSTR位为0，连接移位寄存器的输入和输出路径，建立环回模式。如果SPCR.MSTR位为1，SPI不关闭MOSIn引脚和移位寄存器之间的路径，如果SPCR.MSTR位为0，则SPI不关闭MOSIn引脚和移位寄存器之间的路径。环回模式下，SPI的发送数据或反向发送数据成为SPI的接收数据。

表31.12列出了SPLP2和SPLP位与接收数据之间的关系。图31.49显示了当主模式下的SPI设置为环回模式（SPPCR.SPLP2=1，SPPCR.SPLP=0或1）时移位寄存器IO路径的配置。

Table 31.12 SPLP2和SPLP位设置和接收数据

SPPCR.SPLP2 bit	SPPCR.SPLP bit	接收数据
0	0	从MOSIn引脚或MIOn引脚输入数据
0	1	反相传输数据
1	0	传输数据
1	1	传输数据

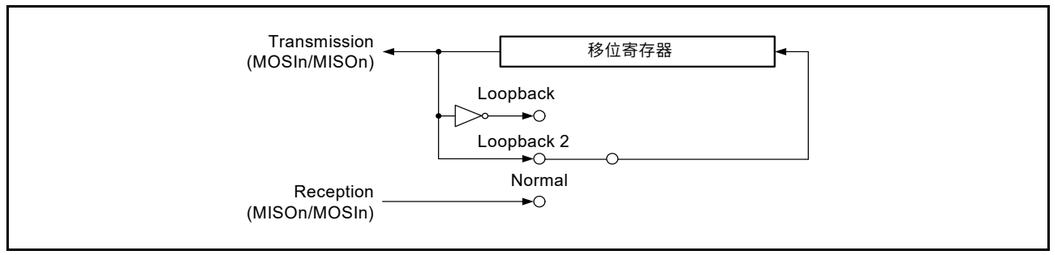

Figure 31.49 在主模式的环回模式下配置移位寄存器IO路径

31.3.13 奇偶校验位功能自诊断

奇偶校验电路由用于发送数据的奇偶校验位添加单元和用于接收数据的错误检测单元组成。为了检测这些单元中的缺陷，奇偶校验电路执行自诊断，如图31.50所示。

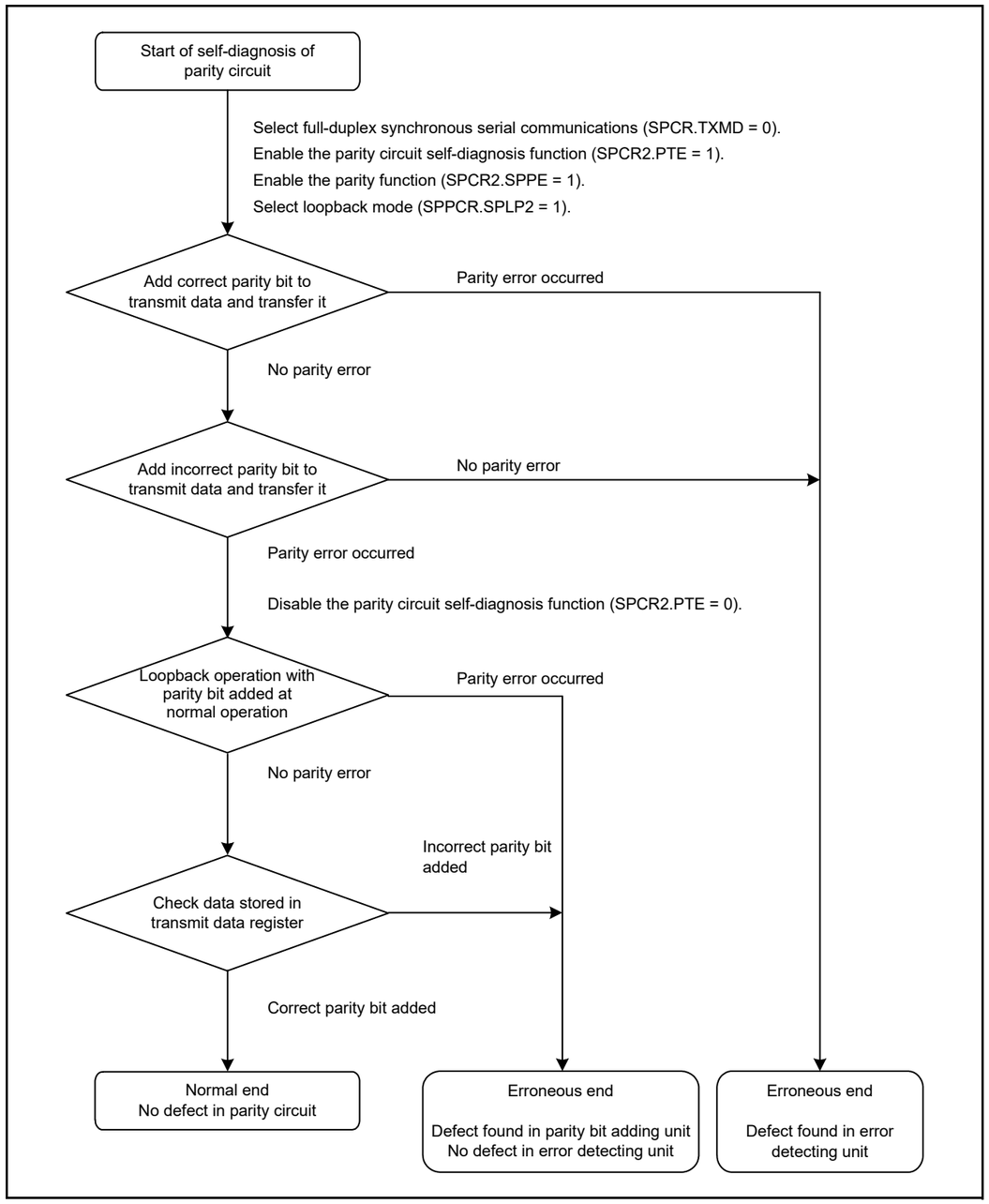

Figure 31.50 Self-diagnosis flow for parity circuit

31.3.14 Interrupt Sources

The SPI interrupt sources include:

- Receive buffer full
- Transmit buffer empty

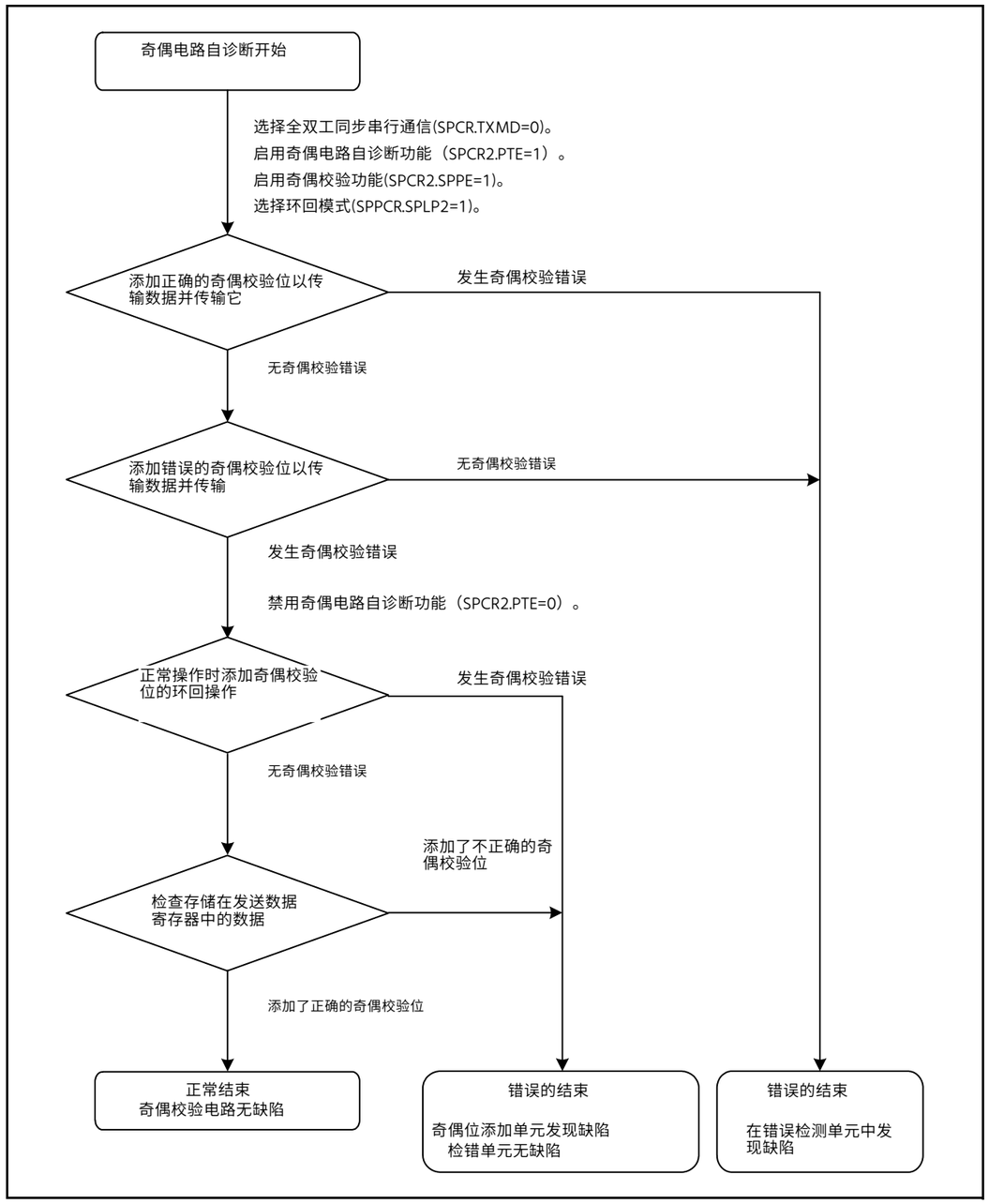

Figure 31.50 奇偶校验电路的自诊断流程

31.3.14 中断源

SPI中断源包括：

- 接收缓冲区已满
- 发送缓冲区为空

- SPI error (mode-fault, underrun, overrun, or parity error)
- SPI idle
- Transmission-complete.

The DTC or DMAC can be activated by the receive buffer full or transmit buffer empty interrupt to perform data transfer.

Because the vector address for the SPIi_SPEI (SPI error interrupt) is allocated to interrupt requests on mode-fault, underrun, overrun, and parity errors, the actual interrupt source must be determined from the flags. Table 31.13 lists the interrupt sources for the SPI. An interrupt is generated on satisfaction of one of the interrupt conditions in Table 31.13. Clear the receive buffer full and transmit buffer empty sources through a data transfer.

When using the DTC or DMAC to perform data transmission and reception, you must first set up the DTC or DMAC to be in a transfer-enabled status before setting the SPI. For information on setting up the DTC or DMAC, see section 16, DMA Controller (DMAC), or section 17, Data Transfer Controller (DTC).

If the conditions for generating a transmit buffer empty or receive buffer full interrupt occur while the ICU.IELSRn.IR flag is 1, the interrupt is not output as a request for the ICU but is saved internally (the capacity for retention is one request per source). A saved interrupt request is output when the ICU.IELSRn.IR flag becomes 0. A saved interrupt request is automatically discarded when it is output as an actual interrupt request. The interrupt enable bit (the SPCR.SPTIE or SPCR.SPRIE bit) for an internally saved interrupt request can also be set to 0.

Table 31.13 SPI interrupt sources

Interrupt source	Symbol	Interrupt condition	DMAC/DTC activation
Receive buffer full	SPIi_SPRI	The receive buffer becomes full (SPSR.SPRF flag is 1) while the SPCR.SPRIE bit is 1	Possible
Transmit buffer empty	SPIi_SPTI	The transmit buffer becomes empty (SPSR.SPTEF flag is 1) while the SPCR.SPTIE bit is 1	Possible
SPI errors (mode-fault, underrun, overrun, and parity error)	SPIi_SPEI	The SPSR.MODF, OVRF, PERF, or UDRF flag is set to 1 while the SPCR.SPEIE bit is 1	Impossible
SPI idle	SPIi_SPII	The SPSR.IDLNF flag is set to 0 while the SPCR2.SPIIE bit is 1	Impossible
Transmission-complete	SPIi_SPTEND	In master mode, an interrupt is generated when the IDLNF flag (SPI idle flag) changes from 1 to 0. In slave mode, an interrupt occurs on conditions shown in Table 31.15.	Impossible

31.4 Output to the Event Link Controller (ELC)

The ELC can produce the following event output signals:

- Receive buffer full event output
- Transmit buffer empty event output
- Mode-fault, underrun, overrun, or parity error event output
- SPI idle event output
- Transmission-completed event output.

The event link output signal is output regardless of the interrupt enable bit setting.

31.4.1 Receive Buffer Full Event Output

This event signal is output when received data is transferred from the shift register to the SPDR/SPDR_HA on completion of serial transfer.

31.4.2 Transmit Buffer Empty Event Output

This event signal is output when data for transmission is transferred from the transmit buffer to the shift register and when the value of the SPE bit changes from 0 to 1.

- SPI错误（模式错误、欠载、溢出或奇偶校验错误）
- SPI空闲
- Transmission-complete.

DTC或DMAC可以由接收缓冲区满或发送缓冲区空中断激活以执行数据传输。

由于SPIi_SPEI（SPI错误中断）的向量地址分配给模式错误、欠载、溢出和奇偶校验错误的中断请求，因此必须根据标志确定实际中断源。表31.13列出了SPI的中断源。满足表31.13中的中断条件之一时会产生中断。通过数据传输清除接收缓冲区满和发送缓冲区空源。

使用DTC或DMAC进行数据收发时，必须先将DTC或DMAC设置为传输使能状态，然后再设置SPI。有关设置DTC或DMAC的信息，请参阅第16节，DMA控制器(DMAC)或第17节，数据传输控制器(DTC)。

如果在ICU.IELSRn.IR标志为1时发生发送缓冲区空或接收缓冲区满中断的条件，则该中断不会作为对ICU的请求输出，而是在内部保存（保留容量为每个请求一个请求）资源）。当ICU.IELSRn.IR标志变为0时，输出保存的中断请求。保存的中断请求在作为实际中断请求输出时自动丢弃。内部保存的中断请求的中断使能位（SPCR.SPTIE或SPCR.SPRIE位）也可以设置为0。

Table 31.13 SPI中断源

中断源	Symbol	中断条件	DMAC/DTC activation
接收缓冲区已满	SPIi_SPRI	当SPCR.SPRIE位为1时，接收缓冲区变满（SPSR.SPRF标志为1）	Possible
发送缓冲区为空	SPIi_SPTI	当SPCR.SPTIE位为1时，发送缓冲区变为空（SPSR.SPTEF标志为1）	Possible
SPI错误（模式故障、欠载、溢出和奇偶校验错误）	SPIi_SPEI	SPSR.MODF、OVRF、PERF或UDRF标志设置为1，而SPCR.SPEIE位为1	Impossible
SPI空闲	SPIi_SPII	SPSR.IDLNF标志设置为0，而SPCR2.SPIIE位为1	Impossible
Transmission-complete	SPIi_SPTEND	在主机模式下，当 IDLNF标志（SPI空闲标志）从1变为0。 在从机模式下，中断发生在所示的条件 Table 31.15.	Impossible

31.4 输出到事件链接控制器(ELC)

ELC可以产生以下事件输出信号：

- 接收缓冲区满事件输出
- 发送缓冲区空事件输出
- 模式故障、欠载、溢出或奇偶校验错误事件输出
- SPI空闲事件输出
- 传输完成事件输出。

无论中断允许位设置如何，都会输出事件链接输出信号。

31.4.1 接收缓冲区满事件输出

串行传输完成后，当接收到的数据从移位寄存器传输到SPDRSPDR_HA时，输出此事件信号。

31.4.2 发送缓冲区空事件输出

当要发送的数据从发送缓冲器传送到移位寄存器时，以及SPE位的值从0变为1时，输出该事件信号。

31.4.3 Mode-Fault, Underrun, Overrun, or Parity Error Event Output

This event signal is output when mode-fault, underrun, overrun, or parity error is detected. See section 31.5.4, Constraints on Mode-Fault, Underrun, Overrun, or Parity Error Event Output if using this event signal.

(1) Mode-fault

Table 31.14 lists the conditions for occurrence of a mode-fault event.

Table 31.14 Conditions for mode-fault occurrence

Condition	SPCR.MODFEN bit	SSLn0 pin	Remarks
• SPI operation (SPMS = 0) • Slave (SPCR.MSTR bit = 0)	1	Not active	Event is output only when the pin is deactivated during transmission

(2) Underrun

This event signal is output in response to an underrun when a serial transfer starts while the transmission data is not ready, and the SPCR.MSTR bit is 0, and the SPCR.SPE bit is 1. Under these conditions, the MODF and UDRF flags are set to 1.

(3) Overrun

This event signal is output in response to an overrun when a serial transfer completes while the receive buffer contains unread data and the SPCR.TXMD bit is 0. Under these conditions, the OVRF flag is set to 1.

(4) Parity error

This event signal is output in response to a parity error detected on completion of a serial transfer while the value of the TXMD bit in SPCR is 0 and the SPPE bit in SPCR2 is 1.

31.4.4 SPI Idle Event Output

(1) In master mode

In master mode, an event is output when the condition for setting the IDLNF flag (SPI idle flag) to 0 is satisfied.

(2) In slave mode

In slave mode, an event is output when the SPCR.SPE bit is set to 0 (SPI is initialized).

31.4.5 Transmission-Completed Event Output

During both SPI and clock synchronous operations in master mode, an event is output when the IDLNF flag (SPI idle flag) changes from 1 to 0. Table 31.15 lists the conditions for occurrence of a transmission-completed event in slave mode.

Table 31.15 Conditions for generation of transmission-completed event in slave mode

Mode of operation	Transmit buffer state	Shift register state	Others
SPI operation (SPMS = 0)	Empty	Empty	Negation of SSLn0 input
Clock synchronous operation (SPMS = 1)	Empty	Empty	Edge detection of the last RSPCKn

Whether the operation is in master mode or slave mode, an event is not output if 0 is written to the SPCR.SPE bit in transmission or the SPCR.SPE bit is cleared by the mode-fault error or underrun error.

31.5 Usage Notes

31.5.1 Settings for the Module-Stop State

The Module Stop Control Register B (MSTPCRB) can enable or disable SPI operation. The SPI is initially stopped after reset. Releasing the module-stop state enables access to the registers. For details on the Module Stop Control Register B, see section 11, Low Power Modes.

31.4.3 模式故障、欠载、溢出或奇偶校验错误事件输出

当检测到模式故障、欠载、溢出或奇偶校验错误时，输出此事件信号。见第31.5.4节，如果使用此事件信号，则对模式故障、欠载、溢出或奇偶校验错误事件输出的约束。

(1) Mode-fault

表31.14列出了模式故障事件发生的条件。

Table 31.14 模式故障发生的条件

Condition	SPCR.MODFEN bit	SSLn0 pin	Remarks
SPI操作（SPMS=0） SPCR.MSTR位=0）	从设备（1	不活跃	仅当在传输过程中禁用该引脚时才输出事件

(2) Underrun

当串行传输开始而传输数据尚未准备好，并且SPCR.MSTR位为0，SPCR.SPE位为1时，输出此事件信号以响应欠载。在这些条件下，MODF和UDRF标志设置为1。

(3) Overrun

当串行传输完成而接收缓冲区包含未读数据且SPCR.TXMD位为0时，输出此事件信号以响应溢出。在这些情况下，OVRF标志设置为1。

(4) 奇偶校验错误

该事件信号是响应在串行传输完成时检测到的奇偶校验错误而输出的，而SPCR中的TXMD位为0，SPCR2中的SPPE位为1。

31.4.4 SPI空闲事件输出

(1) 在主模式

在主机模式下，当将IDLNF标志（SPI空闲标志）设置为0的条件成立时输出事件。

(2) 在从模式

在从机模式下，当SPCR.SPE位设置为0（SPI初始化）时，会输出一个事件。

31.4.5 传输完成事件输出

在主机模式下的SPI和时钟同步操作期间，当IDLNF标志（SPI空闲标志）从1变为0时输出事件。表31.15列出了在从机模式下发生传输完成事件的条件。

Table 31.15 从机模式下发生传输完成事件的条件

操作模式	发送缓冲区状态	移位寄存器状态	Others
SPI操作(SPMS=0)	Empty	Empty	SSLn0输入的否定
时钟同步操作(SPMS=1)	Empty	Empty	最后一个RSPCKn的边缘检测

无论操作是在主机模式还是从机模式，如果在传输过程中向SPCR.SPE位写入0或SPCR.SPE位因模式故障错误或欠载错误而清零，则不输出事件。

31.5 使用说明

31.5.1 模块停止状态的设置

模块停止控制寄存器B(MSTPCRB)可以启用或禁用SPI操作。SPI在复位后最初停止。释放模块停止状态可以访问寄存器。有关模块停止控制寄存器B的详细信息，请参见第11节，低功耗模式。

31.5.2 Constraints on Low Power Functions

When using the module-stop function and entering a low power mode other than Sleep mode, set the SPCR.SPE bit to 0 before completing communication.

31.5.3 Constraints on Starting Transfer

If the ICU.IELSRn.IR flag is 1 when transfer starts, the interrupt request is internally saved, which can lead to unanticipated behavior of the ICU.IELSRn.IR flag.

To prevent this, use the following procedure to clear interrupt requests before enabling operations (by setting the SPCR.SPE bit to 1):

1. Confirm that the transfer stopped (SPCR.SPE is 0).
2. Set the associated interrupt enable bit (SPCR.SPTIE or SPCR.SPRIE) to 0.
3. Read the associated interrupt enable bit (SPCR.SPTIE or SPCR.SPRIE) and confirm that its value is 0.
4. Set the ICU.IELSRn.IR flag to 0.

31.5.4 Constraints on Mode-Fault, Underrun, Overrun, or Parity Error Event Output

Using the mode-fault, underrun, overrun, or parity error event is prohibited if the SPI is in multi-master mode (when the SPCR.SPMS bit is 0, the SPCR.MSTR bit is 1, and the SPCR.MODFEN bit is 1).

31.5.5 Constraints on SPRF/SPTEF Flags

If the polling flags, SPRF and SPTEF, are used, interrupt usage is prohibited, and you must set the SPCR.SPRIE and SPCR.SPTIE bits to 0. Either the interrupts or the flags can be used, but not both.

31.5.2 对低功耗函数的约束

当使用模块停止功能并进入除休眠模式以外的低功耗模式时，在完成通信之前将SPCR.SPE位设置为0。

31.5.3 开始传输的限制

如果ICU.IELSRn.IR标志在传输开始时为1，则内部保存中断请求，这可能导致ICU.IELSRn.IR标志的意外行为。

为防止这种情况发生，请使用以下过程在启用操作之前清除中断请求（通过设置SPCR.SPE位为1）：

1. 确认传输已停止（SPCR.SPE为0）。
2. 将相关的中断使能位（SPCR.SPTIE或SPCR.SPRIE）设置为0。
3. 读取相关的中断使能位（SPCR.SPTIE或SPCR.SPRIE）并确认其值为0。
4. 将ICU.IELSRn.IR标志设置为0。

31.5.4 模式故障、欠载、溢出或奇偶校验错误事件输出的约束

如果SPI处于多主模式（当SPCR.SPMS位为0，SPCR.MSTR位为1，SPCR.MODFEN位为1）。

31.5.5 SPRFSPTEF标志的约束

如果使用轮询标志SPRF和SPTEF，则禁止使用中断，您必须设置SPCR.SPRIE和SPCR.SPTIE位为0。可以使用中断或标志，但不能同时使用。

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32. Cyclic Redundancy Check (CRC) Calculator

The Cyclic Redundancy Check (CRC) calculator generates CRC codes to detect errors in the data. The bit order of CRC calculation results can be switched for LSB-first or MSB-first communication. Additionally, various CRC generation polynomials are available. The snoop function allows monitoring of reads from and writes to specific addresses. This function is useful in applications that require the CRC code to be generated automatically in certain events, such as monitoring writes to the serial transmit buffer and reads from the serial receive buffer.

32.1 Overview

Table 32.1 lists the CRC calculator specifications, and Figure 32.1 shows a block diagram.

Table 32.1 CRC calculator specifications

Parameter	Specifications for 8-bit data	Specifications for 32-bit data
Data size	8-bit	32-bit
Data for CRC calculation*1	CRC code generated for data in 8n-bit units (where n is a whole number)	CRC code generated for data in 32n-bit units (where n is a whole number)
CRC processor unit	Operation executed on 8 bits in parallel	Operation executed on 32 bits in parallel
CRC generating polynomial	One of three generating polynomials that is selectable: [8-bit CRC] • $X^8 + X^2 + X + 1$ (CRC-8) [16-bit CRC] • $X^{16} + X^{15} + X^2 + 1$ (CRC-16) • $X^{16} + X^{12} + X^5 + 1$ (CRC-CCITT).	One of two generating polynomials that is selectable: [32-bit CRC] • $X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^2 + X + 1$ (CRC-32) • $X^{32} + X^{28} + X^{27} + X^{26} + X^{25} + X^{23} + X^{22} + X^{20} + X^{19} + X^{18} + X^{14} + X^{13} + X^{11} + X^{10} + X^9 + X^8 + X^6 + 1$ (CRC-32C).
CRC calculation switching	The bit order of CRC calculation results can be switched for LSB-first or MSB-first communication	
Module-stop function	Module-stop state can be set to reduce power consumption	
CRC snoop	Monitor reads from and writes to a certain register address	-

Note 1. The circuit cannot divide data used in CRC calculations. Write data in 8-bit or 32-bit units.

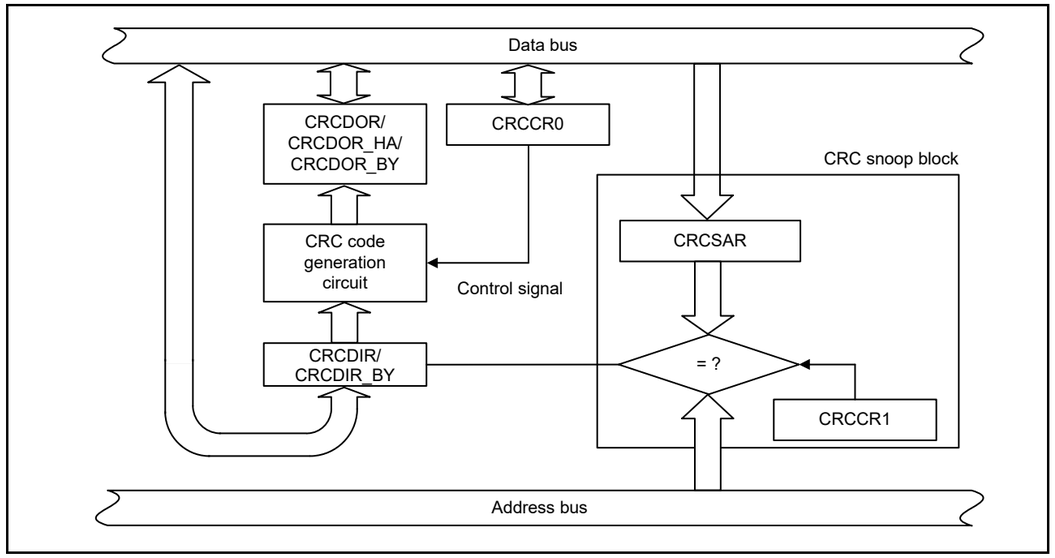

Figure 32.1 CRC calculator block diagram

32. 循环冗余校验(CRC)计算器

循环冗余校验(CRC)计算器生成CRC代码以检测数据中的错误。CRC计算结果的位顺序可以切换为LSB-first或MSB-first通信。此外，还可以使用各种CRC生成多项式。snoop功能允许监视对特定地址的读取和写入。此功能在需要在某些事件中自动生成CRC代码的应用中很有用，例如监视对串行发送缓冲区的写入和从串行接收缓冲区的读取。

32.1 Overview

表32.1列出了CRC计算器规格，图32.1显示了框图。

Table 32.1 CRC计算器规格

Parameter	8位数据规格	32位数据规格
数据大小	8-bit	32-bit
CRC计算数据*1	为8n位单元中的数据生成的CRC码（其中n是整数）	为32n位单元中的数据生成的CRC码（其中n是整数）
CRC处理器单元	在8位上并行执行的操作	在32位上并行执行的操作
CRC生成多项式	三个可选择的生成多项式之一：[8位CRC] X8+X2+X+1(CRC-8)[16位CRC] X16+X15+X2+1(CRC-16) X16+X12+X5+1(CRC-CCITT)。	可选择的两个生成多项式之一：[32位CRC] X32+X26+X23+X22+X16+X12+X11+X10+X8+X7+X5+X4+X2+X+1(CRC-32) X32+X28+X27+X26+X25+X23+X22+X20+X19+X18+X14+X13+X11+X10+X9+X8+X6+1(CRC-32C)。
CRC计算切换	CRC计算结果的位顺序可以切换为LSB-first或MSB-first通信	
Module-stop function	可设置模块停止状态以降低功耗	
CRC snoop	监视器读取和写入某个寄存器地址	-

Note 1. 该电路不能划分用于CRC计算的数据。以8位或32位为单位写入数据。

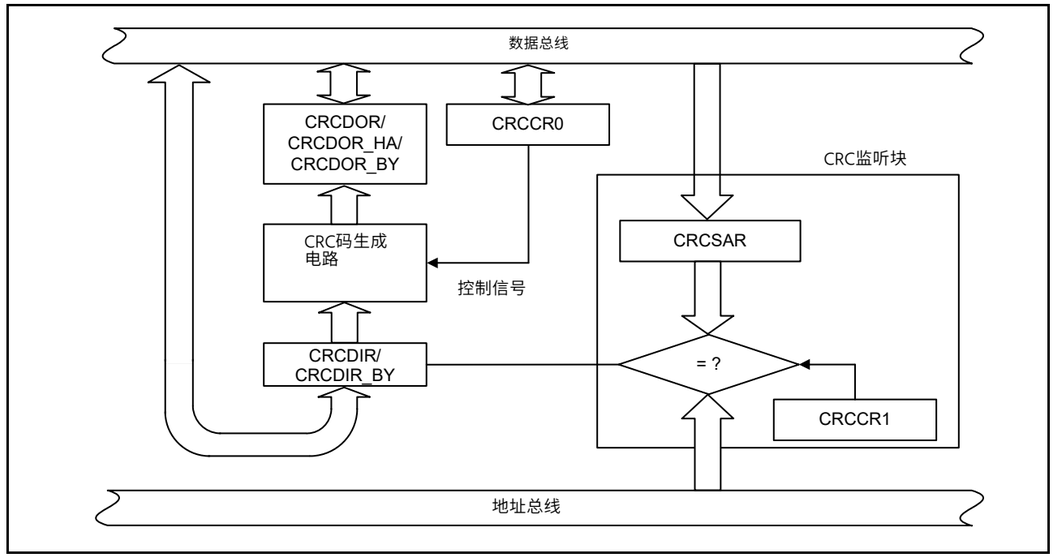

Figure 32.1 CRC计算器框图

32.2 Register Descriptions

32.2.1 CRC Control Register 0 (CRCCR0)

Address(es): CRC.CRCCR0 4007 4000h

	b7	b6	b5	b4	b3	b2	b1	b0
	DORCLR	LMS	—	—	—	GPS[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	GPS[2:0]	CRC Generating Polynomial Switching	b2 b0 0 0 0: No calculation is executed 0 0 1: 8-bit CRC-8 ($X^8 + X^2 + X + 1$) 0 1 0: 16-bit CRC-16 ($X^{16} + X^{15} + X^2 + 1$) 0 1 1: 16-bit CRC-CCITT ($X^{16} + X^{12} + X^5 + 1$) 1 0 0: 32-bit CRC-32 ($X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^2 + X + 1$) 1 0 1: 32-bit CRC-32C ($X^{32} + X^{28} + X^{27} + X^{26} + X^{25} + X^{23} + X^{22} + X^{20} + X^{19} + X^{18} + X^{14} + X^{13} + X^{11} + X^{10} + X^9 + X^8 + X^6 + 1$) Other: No calculation is executed.	R/W
b5 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	LMS	CRC Calculation Switching	0: Generate CRC for LSB-first communication 1: Generate CRC for MSB-first communication.	R/W
b7	DORCLR	CRCDOR/CRCDOR_HA/CRCDOR_BY Register Clear	1: Clear the CRCDOR/CRCDOR_HA/CRCDOR_BY register. This bit is read as 0.	W*1

Note 1. This bit must always be set to 1 when writing to this register.

GPS[2:0] bits (CRC Generating Polynomial Switching)

The GPS[2:0] bits select the CRC generating polynomial.

LMS bit (CRC Calculation Switching)

The LMS bit selects the bit order of generated CRC code. Transmit the lower byte of the CRC code first for LSB-first communication and the upper byte first for MSB-first communication. For details on transmitting and receiving CRC code, see section 32.3, Operation.

DORCLR bit (CRCDOR/CRCDOR_HA/CRCDOR_BY)

Write 1 to the DORCLR bit to set the CRCDOR/CRCDOR_HA/CRCDOR_BY register to 0000 0000h. This bit is read as 0. Only 1 can be written to it.

32.2.2 CRC Control Register 1 (CRCCR1)

Address(es): CRC.CRCCR1 4007 4001h

	b7	b6	b5	b4	b3	b2	b1	b0
	CRCSEN	CRCSWR	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b5 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	CRCSWR	Snoop-On-Write/Read Switch	0: Snoop-on-read 1: Snoop-on-write.	R/W

32.2 注册说明

32.2.1 CRC控制寄存器0(CRCCR0)

Address(es): CRC.CRCCR0 4007 4000h

	b7	b6	b5	b4	b3	b2	b1	b0
	DORCLR	LMS	—	—	—	GPS[2:0]		
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	GPS[2:0]	CRC生成多项式 Switching	b2 b0 0 0 0：不执行计算 0 0 1: 8-bit CRC-8 ($X^8 + X^2 + X + 1$) 0 1 0: 16-bit CRC-16 ($X^{16} + X^{15} + X^2 + 1$) 0 1 1: 16-bit CRC-CCITT ($X^{16} + X^{12} + X^5 + 1$) 1 0 0: 32-bit CRC-32 ($X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^2 + X + 1$) 1 0 1: 32-bit CRC-32C ($X^{32} + X^{28} + X^{27} + X^{26} + X^{25} + X^{23} + X^{22} + X^{20} + X^{19} + X^{18} + X^{14} + X^{13} + X^{11} + X^{10} + X^9 + X^8 + X^6 + 1$) 其他：不执行计算。	R/W
b5 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	LMS	CRC计算切换	0：为LSB-first通信生成CRC1：为MSB-first通信生成CRC。	R/W
b7	DORCLR	CRCDOR/CRCDOR_HA/CRCDOR_BY寄存器清除	1：清除CRCDORCRCDOR_HACRCDOR_BY寄存器。该位读为0。	W*1

Note 1. 写入该寄存器时，该位必须始终设置为1。

GPS[2:0]位（CRC生成多项式切换）

GPS[2:0]位选择CRC生成多项式。

LMS位（CRC计算切换）

LMS位选择生成的CRC码的位顺序。对于LSB在先的通信，首先发送CRC码的低字节，对于MSB在先的通信，首先发送高字节。有关发送和接收CRC码的详细信息，请参阅第32.3节，操作。

DORCLR bit (CRCDOR/CRCDOR_HA/CRCDOR_BY)

将1写入DORCLR位以将CRCDORCRCDOR_HACRCDOR_BY寄存器设置为00000000h。该位读为0。只能写入1。

32.2.2 CRC控制寄存器1(CRCCR1)

Address(es): CRC.CRCCR1 4007 4001h

	b7	b6	b5	b4	b3	b2	b1	b0
	CRCSEN	CRCSWR	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b5 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	CRCSWR	Snoop-On-Write/Read Switch	0: Snoop-on-read 1: Snoop-on-write.	R/W

Bit	Symbol	Bit name	Description	R/W
b7	CRCSEN	Snoop Enable	0: Disabled 1: Enabled.	R/W

CRCSWR bit (Snoop-On-Write/Read Switch)

The CRCSWR bit selects the direction of access in the address monitoring function.

When this bit is set to 0 (initial value), the CRC snoop operation to read a specific register address is enabled. When the bit is set to 1, the CRC snoop operation to write to a specific register address is enabled.

CRCSEN bit (Snoop Enable)

When the CRCSEN bit is set to 1, the CRC snoop operation is enabled. When the bit is set to 0, CRC snoop operation is disabled.

32.2.3 CRC Data Input Register (CRCDIR/CRCDIR_BY)

Address(es): CRC.CRCDIR/CRCDIR_BY 4007 4004h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRCDIR is a 32-bit read/write register to write data for CRC-32 or CRC-32C calculation. CRCDIR_BY is an 8-bit read/write register to write data for CRC-8, CRC-16, or CRC-CCITT calculation.

32.2.4 CRC Data Output Register (CRCDOR/CRCDOR_HA/CRCDOR_BY)

Address(es): CRC.CRCDOR/CRCDOR_HA/CRCDOR_BY 4007 4008h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRCDOR is a 32-bit read/write register for CRC-32 or CRC-32C calculation. CRCDOR_HA is a 16-bit read/write register for CRC-16 or CRC-CCITT calculation. CRCDOR_BY is an 8-bit read/write register for CRC-8 calculation. Because its initial value is 0000 0000h, rewrite the CRCDOR/CRCDOR_HA/CRCDOR_BY register to perform the calculations using a value other than the initial value.

Data written to the CRCDIR/CRCDIR_BY register is CRC calculated and the result is stored in the CRCDOR/CRCDOR_HA/CRCDOR_BY register. If the CRC code is calculated following the transferred data and the result is 0000 0000h, there is no CRC error.

When an 8-bit CRC ($X^8 + X^2 + X + 1$ polynomial) is in use, the valid CRC code is obtained in CRCDOR_BY.

When a 16-bit CRC ($X^{16} + X^{15} + X^2 + 1$ or $X^{16} + X^{12} + X^5 + 1$ polynomial) is in use, the valid CRC code is obtained in CRCDOR_HA.

Bit	Symbol	位名称	Description	R/W
b7	CRCSEN	侦听启用	0：禁用1 ：启用。	R/W

CRCSWR位（Snoop-On-Write读开关）

CRCSWR位选择地址监控功能中的访问方向。

当该位设置为0（初始值）时，启用读取特定寄存器地址的CRC侦听操作。当该位设置为1时，将启用写入特定寄存器地址的CRC侦听操作。

CRCSEN位（侦听启用）

当CRCSEN位设置为1时，启用CRC侦听操作。当该位设置为0时，CRC侦听操作被禁用。

32.2.3 CRC数据输入寄存器(CRCDIRCRCDIR_BY)

Address(es): CRC.CRCDIR/CRCDIR_BY 4007 4004h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRCDIR是一个32位读写寄存器，用于写入数据以进行CRC-32或CRC-32C计算。CRCDIR_BY是一个8位读写寄存器，用于为CRC-8、CRC-16或CRC-CCITT计算写入数据。

32.2.4 CRC数据输出寄存器(CRCDORCRCDOR_HACRCDOR_BY)

Address(es): CRC.CRCDOR/CRCDOR_HA/CRCDOR_BY 4007 4008h

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CRCDOR是用于CRC-32或CRC-32C计算的32位读写寄存器。CRCDOR_HA是一个16位读写寄存器，用于CRC-16或CRC-CCITT计算。CRCDOR_BY是用于CRC-8计算的8位读写寄存器。由于其初始值为00000000h，因此重写CRCDORCRCDOR_HACRCDOR_BY寄存器以使用初始值以外的值执行计算。

写入CRCDIRCRCDIR_BY寄存器的数据经过CRC计算，结果存储在CRCDORCRCDOR_HACRCDOR_BY寄存器。如果在传输数据之后计算CRC码，结果为00000000h，则没有CRC错误。

当使用8位CRC（X8+X2+X+1多项式）时，在CRCDOR_BY中获得有效的CRC码。

当使用16位CRC（X16+X15+X2+1或X16+X12+X5+1多项式）时，有效的CRC码在CRCDOR_HA.

32.2.5 Snoop Address Register (CRCSAR)

Address(es): CRC.CRCSAR 4007 400Ch

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	CRCSA[13:0]													
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b13 to b0	CRCSA[13:0]	Register Snoop Address	These bits store the TDR or RDR address in the SCI module to snoop	R/W
b15, b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CRCSA[13:0] bits (Register Snoop Address)

The CRCSA[13:0] bits specify the lower 14 bits of the register address monitored by the CRC snoop operation.

Only the following addresses can be used for the CRCSA[13:0] bits:

- 4007 0003h: SCI0.TDR, 4007 0005h: SCI0.RDR
- 4007 0023h: SCI1.TDR, 4007 0025h: SCI1.RDR
- 4007 0043h: SCI2.TDR, 4007 0045h: SCI2.RDR
- 4007 0063h: SCI3.TDR, 4007 0065h: SCI3.RDR
- 4007 0083h: SCI4.TDR, 4007 0085h: SCI4.RDR
- 4007 0103h: SCI8.TDR, 4007 0105h: SCI8.RDR
- 4007 0123h: SCI9.TDR, 4007 0125h: SCI9.RDR
- 4007 000Fh: SCI0.FTDRL, 4007 0011h: SCI0.FRDRL
- 4007 002Fh: SCI1.FTDRL, 4007 0031h: SCI1.FRDRL
- 4007 004Fh: SCI2.FTDRL, 4007 0051h: SCI2.FRDRL
- 4007 006Fh: SCI3.FTDRL, 4007 0071h: SCI3.FRDRL
- 4007 008Fh: SCI4.FTDRL, 4007 0091h: SCI4.FRDRL
- 4007 010Fh: SCI8.FTDRL, 4007 0111h: SCI8.FRDRL
- 4007 012Fh: SCI9.FTDRL, 4007 0131h: SCI9.FRDRL.

32.3 Operation

32.3.1 Basic Operation

The CRC calculator generates CRC codes for use in LSB-first or MSB-first transfers.

The following examples illustrate CRC code generation for input data (F0h) using the 16-bit CRC-CCITT generating polynomial ($X^{16} + X^{12} + X^5 + 1$). In these examples, the value of the CRC Data Output Register (CRCDOR_HA) is cleared before CRC calculation.

When an 8-bit CRC (with the polynomial $X^8 + X^2 + X + 1$) is in use, the valid bits of the CRC code are obtained in CRCDOR_BY. When a 32-bit CRC is in use, the valid bits of the CRC code are obtained in CRCDOR.

Figure 32.2 and Figure 32.3 show the LSB-first and MSB-first data transmission examples respectively, and Figure 32.4 and Figure 32.5 show the LSB-first and MSB-first data reception examples.

32.2.5 监听地址寄存器(CRCSAR)

Address(es): CRC.CRCSAR 4007 400Ch

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	CRCSA[13:0]													
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b13 to b0	CRCSA[13:0]	注册监听地址	这些位存储SCI模块中的TDR或RDR地址以进行监听	R/W
b15, b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CRCSA[13:0]位（寄存器监听地址）

CRCSA[13:0]位指定由CRC侦听操作监视的寄存器地址的低14位。

CRCSA[13:0]位只能使用以下地址：

- 4007 0003h: SCI0.TDR, 4007 0005h: SCI0.RDR
- 4007 0023h: SCI1.TDR, 4007 0025h: SCI1.RDR
- 4007 0043h: SCI2.TDR, 4007 0045h: SCI2.RDR
- 4007 0063h: SCI3.TDR, 4007 0065h: SCI3.RDR
- 4007 0083h: SCI4.TDR, 4007 0085h: SCI4.RDR
- 4007 0103h: SCI8.TDR, 4007 0105h: SCI8.RDR
- 4007 0123h: SCI9.TDR, 4007 0125h: SCI9.RDR
- 4007 000Fh: SCI0.FTDRL, 4007 0011h: SCI0.FRDRL
- 4007 002Fh: SCI1.FTDRL, 4007 0031h: SCI1.FRDRL
- 4007 004Fh: SCI2.FTDRL, 4007 0051h: SCI2.FRDRL
- 4007 006Fh: SCI3.FTDRL, 4007 0071h: SCI3.FRDRL
- 4007 008Fh: SCI4.FTDRL, 4007 0091h: SCI4.FRDRL
- 4007 010Fh: SCI8.FTDRL, 4007 0111h: SCI8.FRDRL
- 4007 012Fh: SCI9.FTDRL, 4007 0131h: SCI9.FRDRL.

32.3 Operation

32.3.1 基本操作

CRC计算器生成用于LSB优先或MSB优先传输的CRC代码。

以下示例说明使用16位CRC-CCITT生成多项式(X16+X12+X5+1)为输入数据(F0h)生成CRC码。在这些示例中，CRC数据输出寄存器(CRCDOR_HA)的值在CRC计算之前被清除。

当使用8位CRC（多项式X8+X2+X+1）时，CRC码的有效位在CRCDOR_BY。使用32位CRC时，在CRCDOR中获取CRC码的有效位。

图32.2和图32.3分别显示了LSB-first和MSB-first数据传输示例，图32.4和图32.5显示了LSB-first和MSB-first数据接收示例。

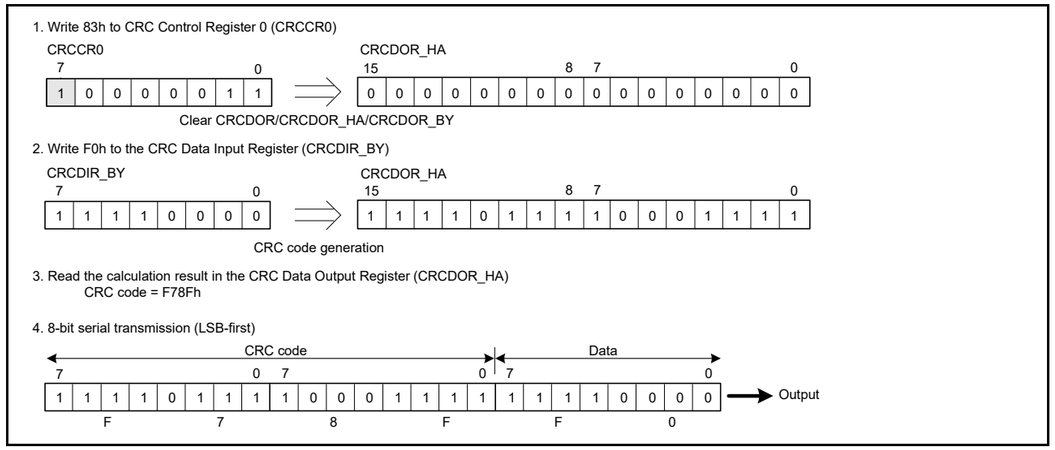

Figure 32.2 LSB-first data transmission

Figure 32.3 MSB-first data transmission

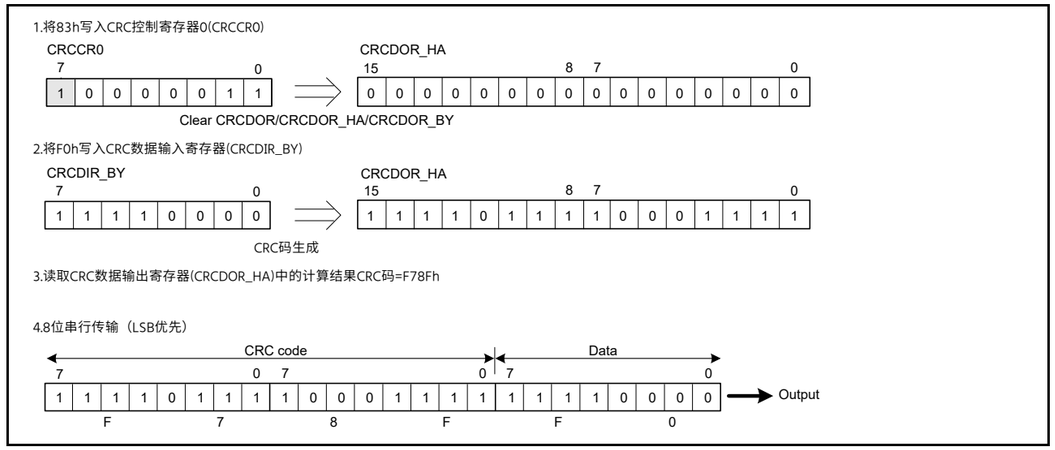

Figure 32.2 LSB−first数据传输

Figure 32.3 MSB优先数据传输

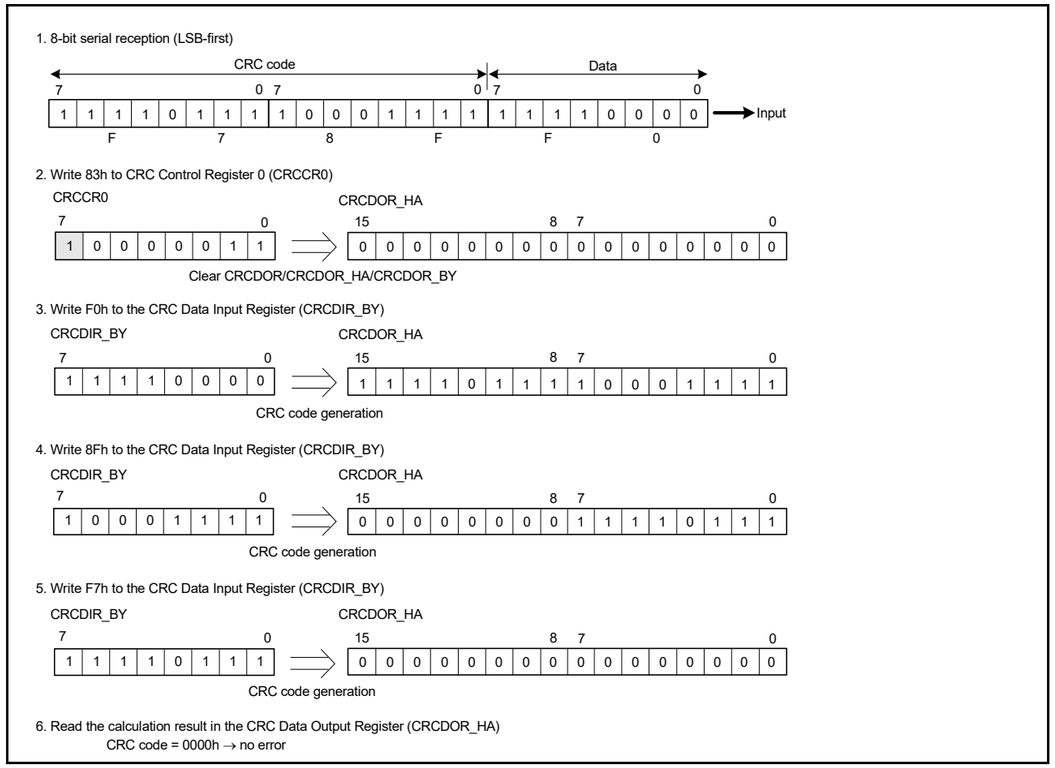

Figure 32.4 LSB-first data reception

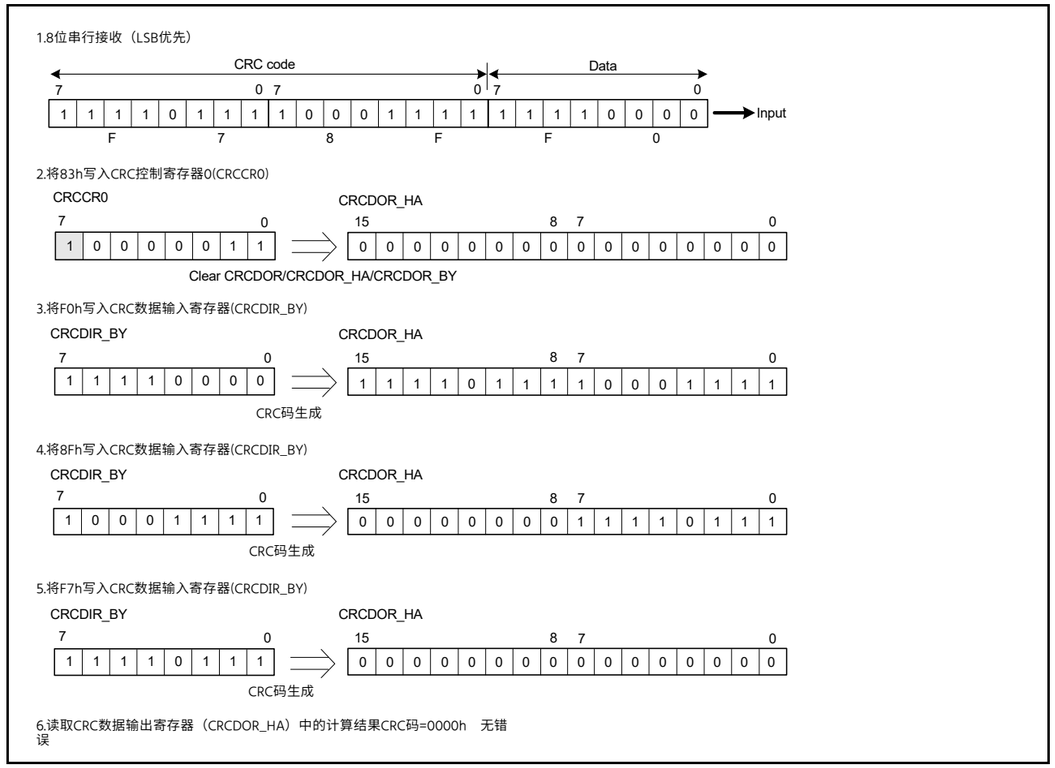

Figure 32.4 LSB-first数据接收

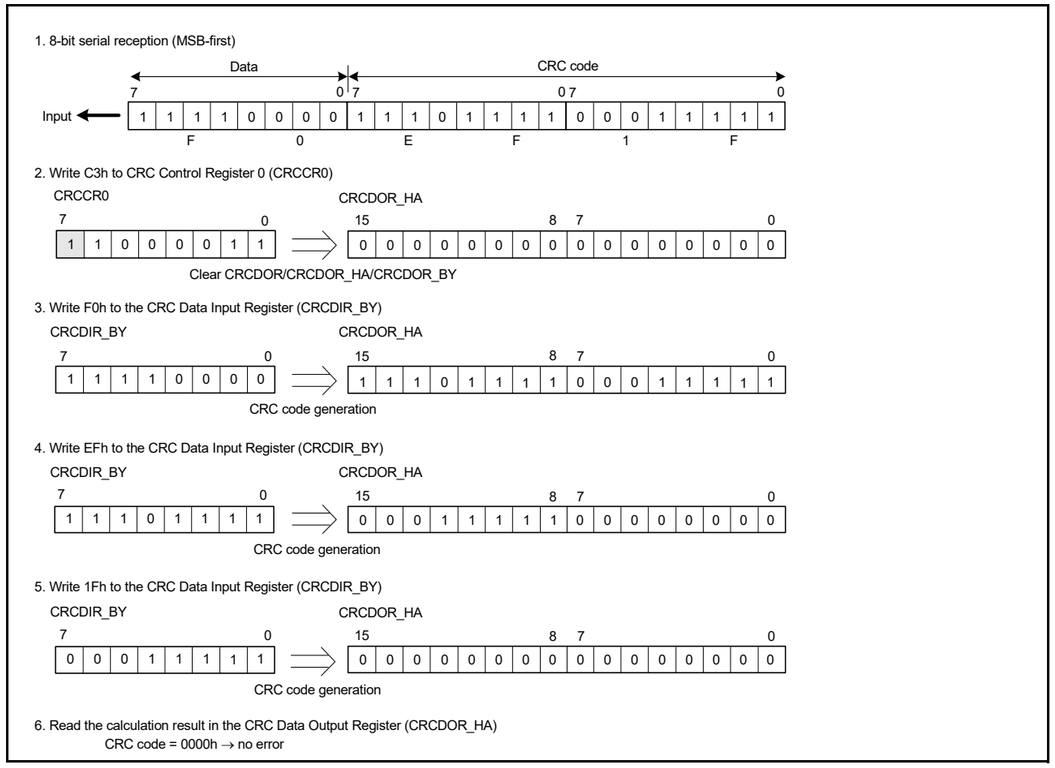

Figure 32.5 MSB-first data reception

32.3.2 CRC Snoop

The CRC snoop function monitors reads from and writes to a specific register address and performs CRC calculations on the data read from and written to the register address automatically. Because the CRC snoop recognizes writes to and reads from a specific register address as a trigger to automatically perform CRC calculations, there is no need to write data to the CRCDIR_BY register. All I/O register addresses specified in section 32.2.5, Snoop Address Register (CRCSAR) are subject to the CRC snoop. The CRC snoop is useful in monitoring writes to the serial transmit buffer, and reads from the serial receive buffer.

To use this function, write a target I/O register address to the CRCSA13 to CRCSA0 bits in the CRCSAR register, and set the CRCSEN bit in the CRCCR1 register to 1. Then, set the CRCSWR bit in the CRCCR1 register to 1 to enable snooping on the writes to the target address, or set the CRCSWR bit in the CRCCR1 register to 0 to enable snooping on the reads from the target address.

When both the CRCSEN and CRCSWR bits are set to 1, and data is written to a target I/O register address in a bus master module such as the CPU, DMAC, and DTC, the CRC calculator stores the data in the CRCDIR_BY register and performs CRC calculation. Similarly, when the CRCSEN bit is set to 1, CRCSWR bit is set to 0, and data is read from a target I/O register address in a bus master module such as the CPU, DMAC, and DTC, the CRC calculator stores the data in the CRCDIR_BY register and performs a CRC calculation.

CRC calculation is performed 1 byte at a time. When the target I/O register address is accessed in words (16 bits) or long words (32 bits), a CRC code is generated on the lower byte (1 byte) of data.

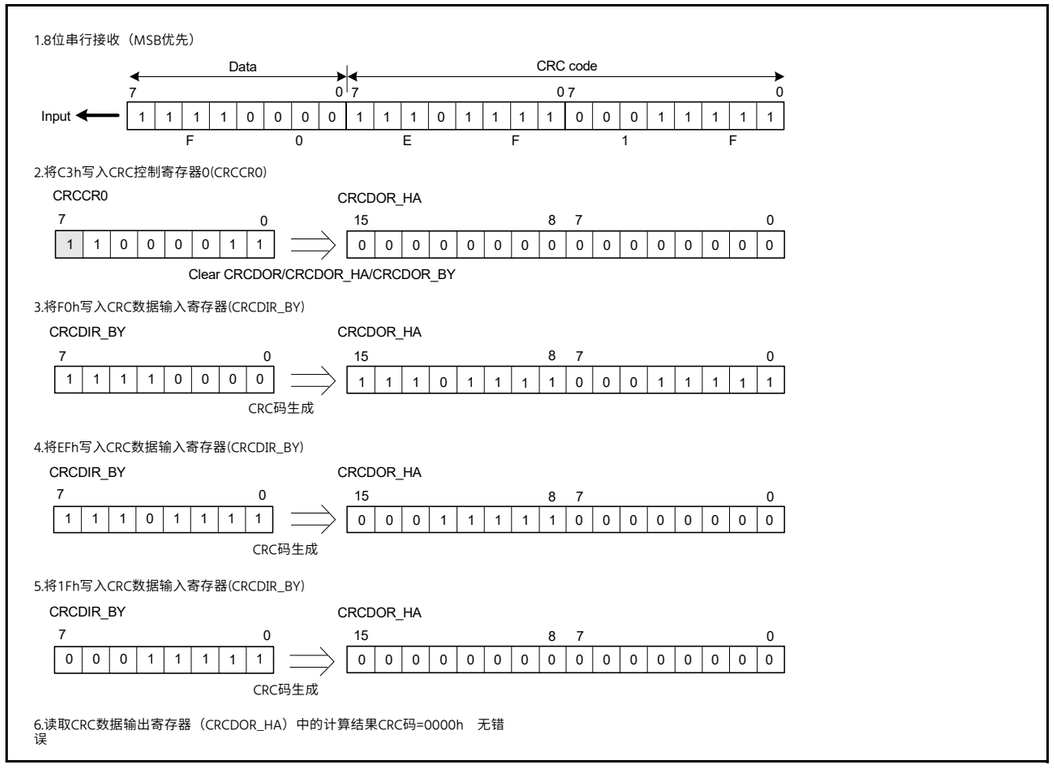

Figure 32.5 MSB优先数据接收

32.3.2 CRC Snoop

CRCsnoop功能监视对特定寄存器地址的读取和写入，并自动对从寄存器地址读取和写入的数据执行CRC计算。由于CRCsnoop将特定寄存器地址的写入和读取识别为触发以自动执行CRC计算，因此无需将数据写入CRCDIR_BY寄存器。在第32.2.5节，SnoopAddressRegister(CRCSAR)中指定的所有IO寄存器地址都受CRCsnoop的约束。CRCsnoop在监视对串行发送缓冲区的写入和从串行接收缓冲区读取时很有用。

要使用此功能，将目标IO寄存器地址写入CRCSA13到CRCSAR寄存器中的CRCSA0位，并将CRCCR1寄存器中的CRCSEN位设置为1。然后，将CRCCR1寄存器中的CRCSWR位设置为1以启用监听写入目标地址，或将CRCCR1寄存器中的CRCSWR位设置为0，以启用对目标地址读取的侦听。

当CRCSEN和CRCSWR位都设置为1，并且数据写入总线主模块（如CPU、DMAC和DTC）中的目标IO寄存器地址时，CRC计算器将数据存储在CRCDIR_BY寄存器中并执行CRC计算。同样，当CRCSEN位设置为1时，CRCSWR位设置为0，从CPU、DMAC、DTC等总线主控模块中的目标IO寄存器地址读取数据，CRC计算器将数据存储在CRCDIR_BY寄存器并执行CRC计算。

每次执行1个字节的CRC计算。当以字（16位）或长字（32位）访问目标IO寄存器地址时，会在数据的低字节（1字节）上生成CRC码。

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32.4 Usage Notes

32.4.1 Settings for the Module-Stop State

The Module Stop Control Register C (MSTPCRC) can enable or disable the operation of the CRC calculator. The CRC calculator is stopped after a reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

32.4.2 Note on Transmission

The transmission sequence for the CRC code differs depending on whether transmission is LSB-first or MSB-first. Figure 32.6 shows an LSB-first and MSB-first data transmission.

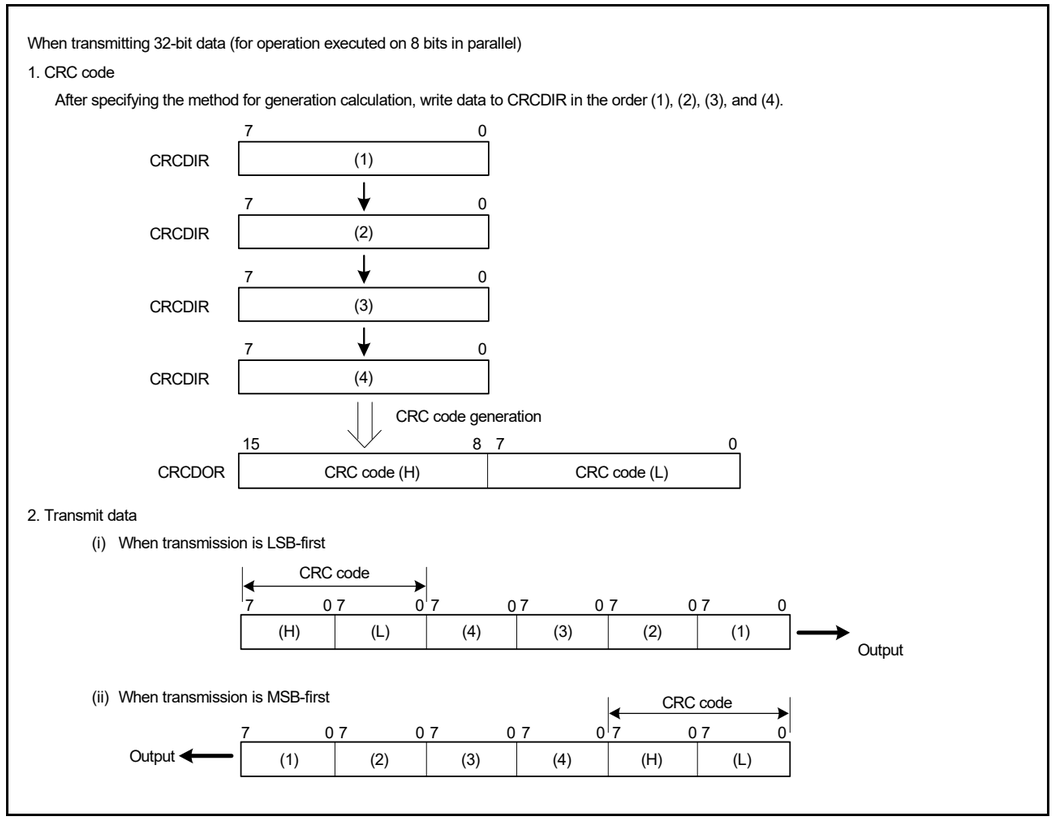

Figure 32.6 LSB-first and MSB-first data transmission

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32.4 使用说明

32.4.1 模块停止状态的设置

模块停止控制寄存器C(MSTPCRC)可以启用或禁用CRC计算器的操作。CRC计算器在复位后停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

32.4.2 传输注意事项

CRC码的传输顺序根据传输是LSB优先还是MSB优先而有所不同。
图32.6显示了LSB优先和MSB优先的数据传输。

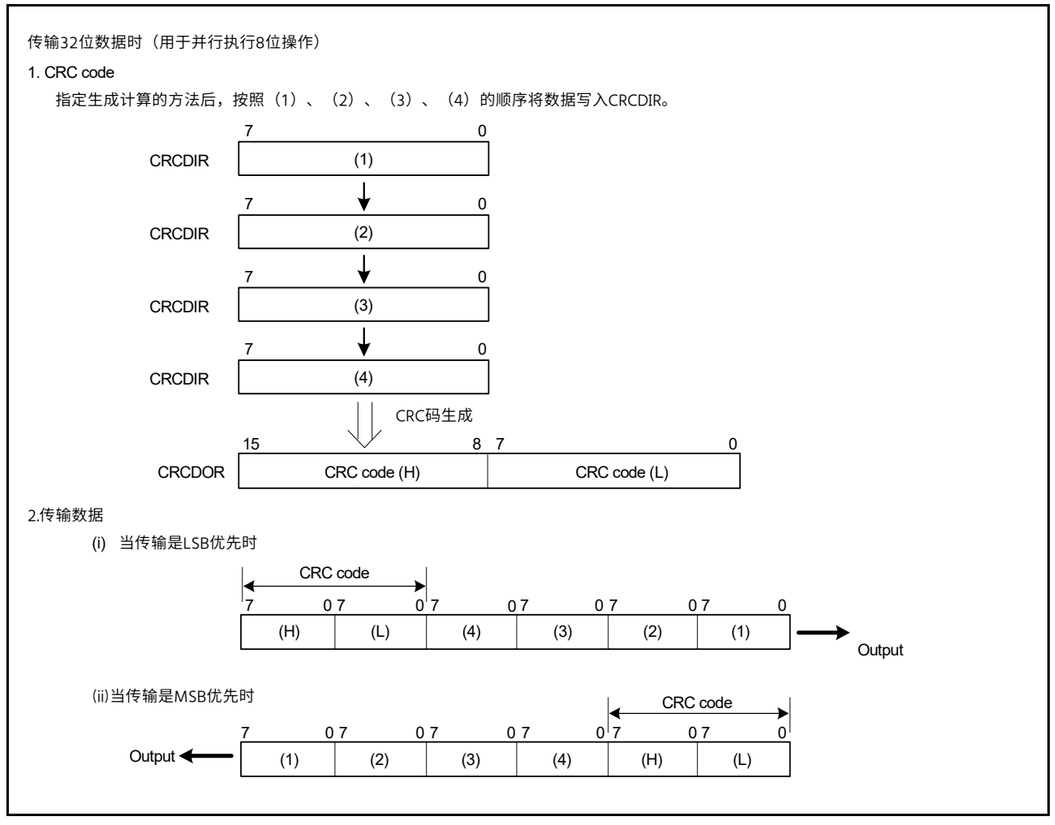


Figure 32.6 LSB−first和MSB−first数据传输

33. Boundary Scan

33.1 Overview

The boundary scan function provides a serial I/O interface based on the JTAG (Joint Test Action Group), IEEE Std. 1149.1, and IEEE Standard Test Access Port, and Boundary Scan Architecture.

Table 33.1 lists the boundary scan specifications, Figure 33.1 shows a block diagram, and Table 33.2 lists the I/O pins.

Table 33.1 Boundary scan specifications

Parameter	Specifications
Execution condition	Boundary scan must be executed when the RES pin is driven low
Test modes	• BYPASS mode • EXTEST mode • SAMPLE/PRELOAD mode • CLAMP mode • HIGHZ mode • IDCODE mode.

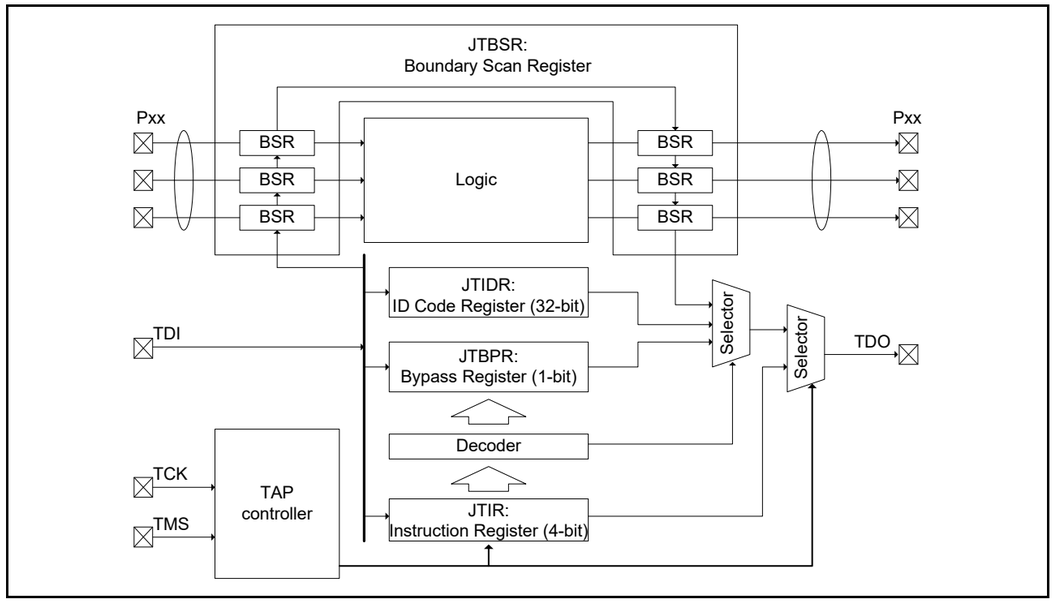


Figure 33.1 Boundary scan function block diagram

Table 33.2 Boundary scan I/O pins

Pin name	I/O	Description
TCK	Input	Test clock input pin. Clock signal for boundary scan. The input clock duty cycle is 50% when the boundary scan function is used.
TMS	Input	Test mode select pin
TDI	Input	Test data input pin
TDO	Output	Test data output pin

Note: This MCU does not support the TRST pin for the JTAG interface.

33. 边界扫描

33.1 Overview

边界扫描功能提供基于JTAG（联合测试行动组）、IEEEStd.的串行IO接口。1149.1、IEEE标准测试访问端口和边界扫描架构。

表33.1列出了边界扫描规范，图33.1显示了框图，表33.2列出了IO引脚。

Table 33.1 边界扫描规格

Parameter	Specifications
执行条件	当RES引脚被驱动为低电平时，必须执行边界扫描
测试模式	BYPASS模式 EXTEST模式 SAMPLEPRELOAD模式 CLAMP模式 HIGHZ模式 IDCODE模式。

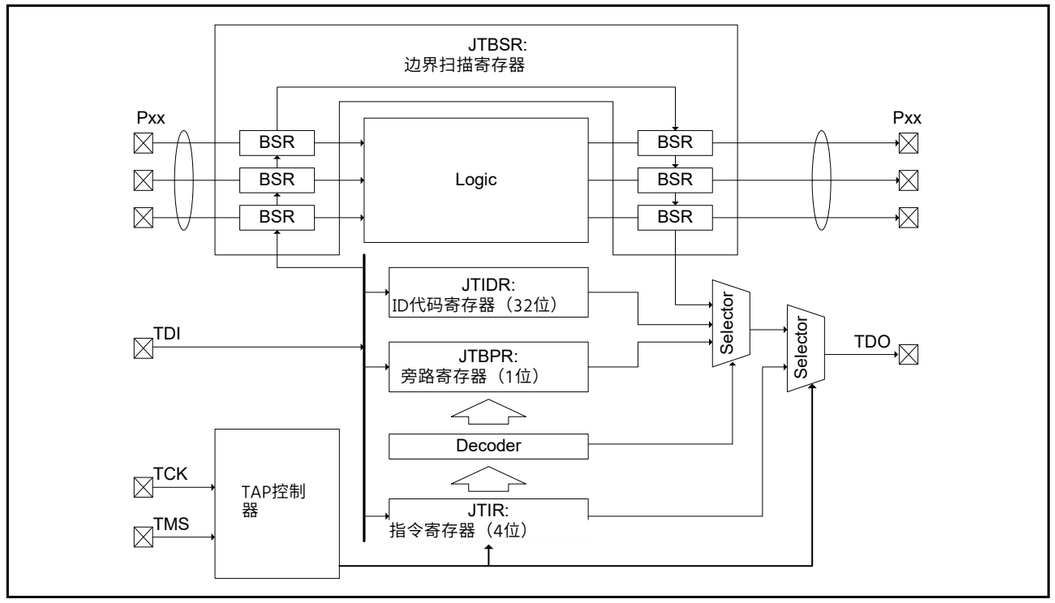


Figure 33.1 边界扫描功能框图

Table 33.2 边界扫描IO引脚

引脚名称	I/O	Description
TCK	Input	测试时钟输入引脚。 边界扫描的时钟信号。使用边界扫描功能时，输入时钟占空比为50%。
TMS	Input	测试模式选择引脚
TDI	Input	测试数据输入引脚
TDO	Output	测试数据输出引脚

Note: 此MCU不支持JTAG接口的TRST引脚。

33.2 Register Descriptions

Table 33.3 lists the boundary scan registers.

Table 33.3 Boundary scan registers

Register name	Symbol	Value after reset
Instruction Register	JTIR	Eh
ID Code Register	JTIDR	083D 8447h
Bypass Register	JTBPR	Undefined
Boundary Scan Register	JTBSR	Undefined

Usage notes for the boundary scan registers:

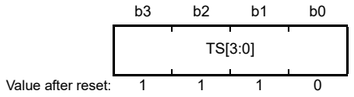
- Instructions can be input to the Instruction Register (JTIR) through the TDI pin by serial transfer
- The Bypass Register (JTBPR), which is a 1-bit register, is connected between the TDI and TDO pins in BYPASS mode
- The Boundary Scan Register (JTBSR), which is configured according to the BSDL description, is connected between the TDI and TDO pins when test data is being shifted in.

Table 33.4 shows the availability of serial transfer for the registers.

Table 33.4 Serial transfer for registers

Register name	Serial input	Serial output
Instruction Register (JTIR)	Available	Available
ID Code Register (JTIDR)	Available	Available
Bypass Register (JTBPR)	Available	Available
Boundary Scan Register (JTBSR)	Available	Available

33.2.1 Instruction Register (JTIR)



Bit	Symbol	Bit name	Description	R/W
b3 to b0	TS[3:0]	Test Bit Set	The command configuration for these bits is shown in Table 33.5	—

Table 33.5 Command configuration

TS3	TS2	TS1	TS0	Instruction
0	0	0	0	EXTEST
0	0	0	1	SAMPLE/PRELOAD
0	0	1	1	IDCODE (Renesas code)
0	1	0	1	CLAMP
0	1	1	0	HIGHZ
1	1	1	1	BYPASS
Other settings				Reserved

JTAG instructions can be transferred to the JTIR register by serial input from the TDI pin. The JTIR register is initialized when a power-on reset occurs, or when the TAP controller is in the Test-Logic-Reset state.

33.2 注册说明

表33.3列出了边界扫描寄存器。

Table 33.3 边界扫描寄存器

注册名称	Symbol	重置后的值
指令寄存器	JTIR	Eh
ID代码寄存器	JTIDR	083D 8447h
绕过寄存器	JTBPR	Undefined
边界扫描寄存器	JTBSR	Undefined

边界扫描寄存器的使用说明：

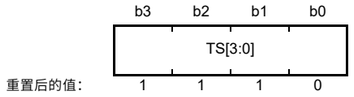
- 指令可以通过串行传输通过TDI引脚输入到指令寄存器(JTIR)
- 旁路寄存器(JTBPR)是一个1位寄存器，在BYPASS模式下连接在TDI和TDO引脚之间
- 根据BSDL描述配置的边界扫描寄存器(JTBSR)在移入测试数据时连接在TDI和TDO引脚之间。

表33.4显示了寄存器串行传输的可用性。

Table 33.4 寄存器的串行传输

注册名称	串行输入	串行输出
指令寄存器(JTIR)	Available	Available
ID代码寄存器(JTIDR)	Available	Available
旁路寄存器(JTBPR)	Available	Available
边界扫描寄存器(JTBSR)	Available	Available

33.2.1 指令寄存器(JTIR)



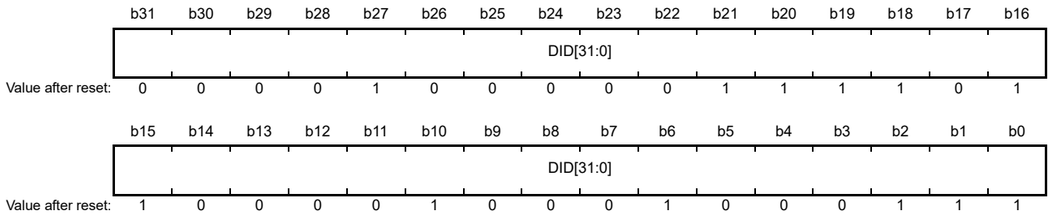
Bit	Symbol	位名称	Description	R/W
b3 to b0	TS[3:0]	测试位组	这些位的命令配置如表33.5所示	—

Table 33.5 命令配置

TS3	TS2	TS1	TS0	Instruction
0	0	0	0	EXTEST
0	0	0	1	SAMPLE/PRELOAD
0	0	1	1	IDCODE (Renesas code)
0	1	0	1	CLAMP
0	1	1	0	HIGHZ
1	1	1	1	BYPASS
其他设置				Reserved

JTAG指令可以通过TDI引脚的串行输入传输到JTIR寄存器。当发生上电复位或TAP控制器处于Test-Logic-Reset状态时，JTIR寄存器被初始化。

33.2.2 ID Code Register (JTIDR)



Bit	Symbol	Bit name	Description	R/W
b31 to b0	DID[31:0]	Device ID	These bits store the fixed value that indicates the device IDCODE	—

JTIDR data is output from the TDO pin when the IDCODE instruction is executed. After a reset release, the IDCODE of JTIDR changes into the Arm® debug code. See the *ARM® CoreSight™ SoC-400 Technical Reference Manual* (ARM DDI 0480F).

33.2.3 Bypass Register (JTBPR)

JTBPR is a 1-bit register and is connected between the TDI and TDO pins when the JTIR register is set to BYPASS mode. The JTBPR register cannot be read from or written to by the CPU.

33.2.4 Boundary Scan Register (JTBSR)

JTBSR is a shift register used for controlling the external input and output pins of the MCU, and is distributed across the pads. To apply the JTBSR register in boundary-scan testing, issue the EXTEST, SAMPLE/PRELOAD, CLAMP, and HIGHZ instructions. The BSDL file describes the associations between the JTBSR bits and the MCU pins. The value after reset is undefined.

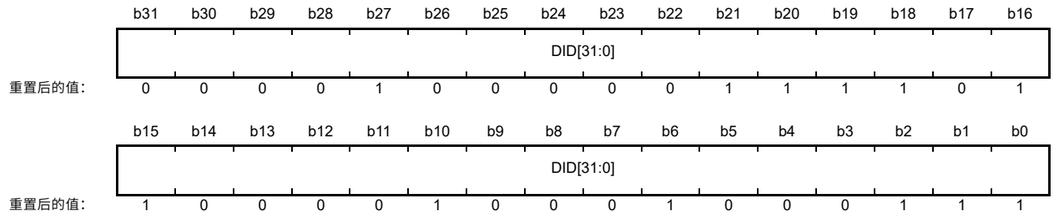
33.3 Operation

During a reset, the JTAG ports, TCK, TMS, TDI, and TDO, are assigned as default pin functions. The TCK, TMS, and TDI pins are pulled up by the pull-up resistors. Boundary scan testing can be executed after the setup time elapses, when POR is negated, and RES is driven low.

33.3.1 TAP Controller

Figure 33.2 shows the state transition diagram of the TAP controller. All transitions are controlled by the TMS signal.

33.2.2 ID代码寄存器(JTIDR)



Bit	Symbol	位名称	Description	R/W
b31 to b0	DID[31:0]	设备ID	这些位存储指示设备IDCODE的固定值	—

执行IDCODE指令时，从TDO引脚输出JTIDR数据。复位释放后，IDCODE JTIDR更改为Arm®调试代码。请参阅ARM®CoreSight SoC-400技术参考手册（ARM DDI 0480F).

33.2.3 旁路寄存器(JTBPR)

JTBPR是一个1位寄存器，当JTIR寄存器设置为BYPASS模式时，连接在TDI和TDO引脚之间。CPU无法读取或写入JTBPR寄存器。

33.2.4 边界扫描寄存器(JTBSR)

JTBSR是一个移位寄存器，用于控制MCU的外部输入和输出引脚，分布在各个焊盘上。要在边界扫描测试中应用JTBSR寄存器，请发出EXTEST、SAMPLEPRELOAD、CLAMP和HIGHZ指令。BSDL文件描述了JTBSR位和MCU引脚之间的关联。复位后的值未定义。

33.3 Operation

在复位期间，JTAG端口、TCK、TMS、TDI和TDO被分配为默认引脚功能。TCK、TMS和TDI引脚由上拉电阻上拉。边界扫描测试可以在设置时间过去后执行，当
POR被否定，RES被驱动为低电平。

33.3.1 水龙头控制器

图33.2显示了TAP控制器的状态转换图。所有转换都由TMS信号控制。

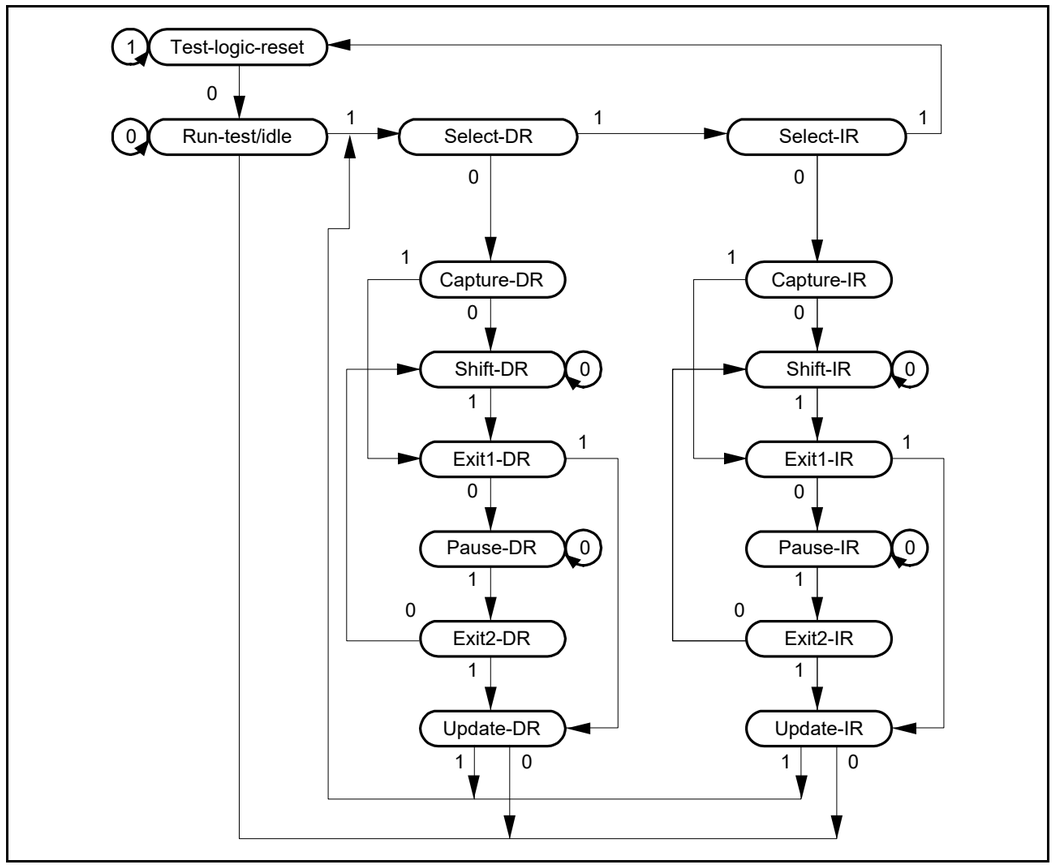


Figure 33.2 State transition diagram of TAP controller

33.3.2 Commands

(1) BYPASS

The BYPASS instruction drives the Bypass Register (JTBPR). This instruction shortens the shift path, facilitating the transfer of serial data to the other LSIs on a printed circuit board at higher speeds. While this instruction is being executed, the test circuit has no effect on the system circuits.

The Bypass Register (JTBPR) is connected between the TDI and TDO pins. Bypass operation is initiated from the Shift-DR operation. The TDO is low in the first clock cycle in the Shift-DR state. In the subsequent clock cycles, the TDI signal is output on the TDO pin.

(2) EXTEST

The EXTEST instruction is used to test external circuits when the MCU is installed on the printed circuit board. If this instruction is executed, the output pins are used to output test data (specified in the SAMPLE/PRELOAD instruction) from the Boundary Scan Register (JTBSR) to the print circuit board, and the input pins are used to input the test result.

(3) SAMPLE/PRELOAD

The SAMPLE/PRELOAD instruction is used to input data from the internal circuits of the MCU to the Boundary Scan Register (JTBSR), output data from the scan path, and reload the data to the scan path. While this instruction is executed, the input signals are directly input to the MCU and output signals are also directly output to the external circuits. The MCU system circuit is not affected by this instruction.

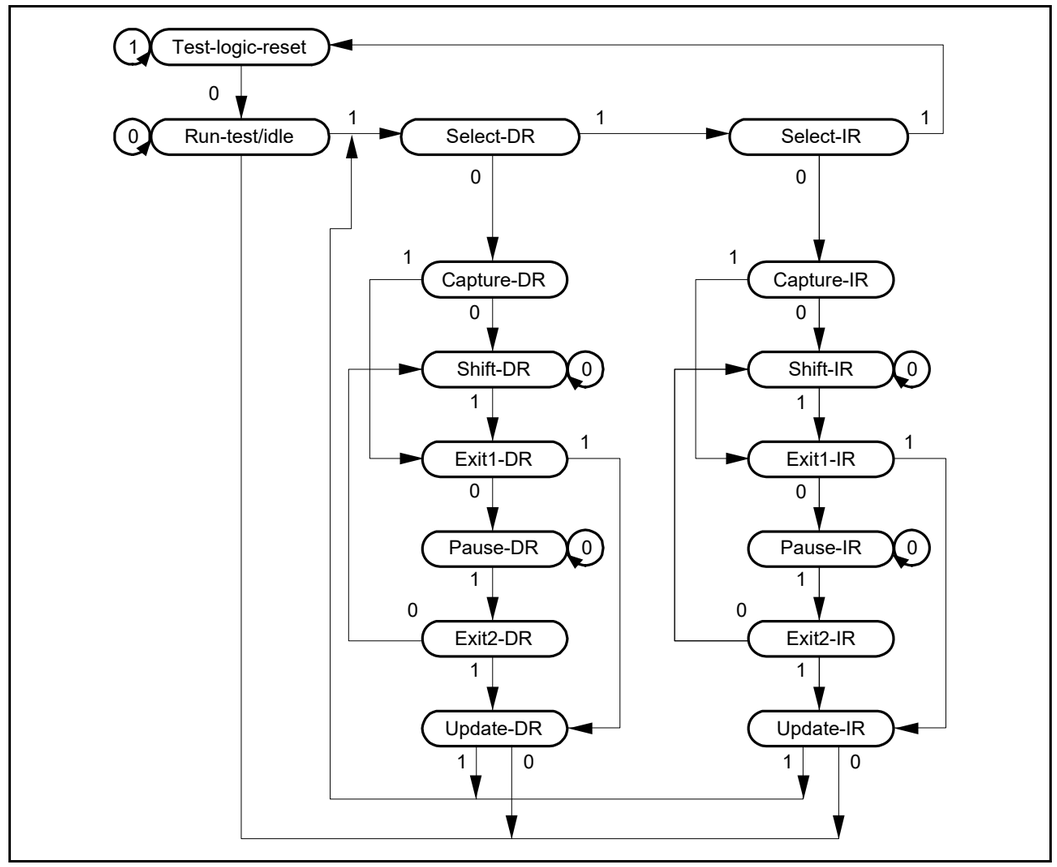


Figure 33.2 TAP控制器的状态转移图

33.3.2 Commands

(1) BYPASS

BYPASS指令驱动旁路寄存器(JTBPR)。该指令缩短了移位路径，便于将串行数据以更高的速度传输到印刷电路板上的其他LSI。在执行该指令时，测试电路对系统电路没有影响。

旁路寄存器(JTBPR)连接在TDI和TDO引脚之间。旁路操作从Shift启动DR操作。TDO在Shift-DR状态的第一个时钟周期内为低电平。在随后的时钟周期中，TDI信号在TDO引脚上输出。

(2) EXTEST

EXTEST指令用于单片机安装在印刷电路板上时测试外部电路。如果执行该指令，输出引脚用于将测试数据（在SAMPLEPRELOAD指令中指定）从边界扫描寄存器（JTBSR）输出到印刷电路板，输入引脚用于输入测试结果。

(3) SAMPLE/PRELOAD

SAMPLEPRELOAD指令用于将数据从MCU内部电路输入到边界扫描寄存器（JTBSR），从扫描路径输出数据，并将数据重新加载到扫描路径。在执行该指令的同时，输入信号直接输入到MCU，输出信号也直接输出到外部电路。MCU系统电路不受该指令影响。

In SAMPLE operation, the Boundary Scan Register (JTBSR) latches a snapshot of the data transferred from the input pins to the internal circuit, or data transferred from the internal circuit to the output pins. The latched data is read from the scan path. The JTBSR register latches the data snapshot on the rising edge of the TCK pin in the Capture-DR state. The data snapshot is only transferred from the internal circuit to the output pins during a reset.

In PRELOAD operation, the initial value is written from the scan path to the parallel output latch of the Boundary Scan Register (JTBSR) prior to the EXTEST instruction execution. If EXTEST is executed without executing this PRELOAD operation, undefined values are output from the beginning of the EXTEST sequence to the end (transfer to the output latch). In the EXTEST instruction, output parallel latches are always output to the output pins.

(4) IDCODE

When the IDCODE instruction is selected, the ID Code Register (JTIDR) value is output to the TDO pin in the Shift-DR state of the TAP controller. In this case, the JTIDR register value is output LSB-first. During this instruction execution, the test circuit does not affect the system circuit.

(5) CLAMP

When the CLAMP instruction is selected, the output pins output the Boundary Scan Register (JTBSR) value that was specified in the SAMPLE/PRELOAD instruction in advance. While the CLAMP instruction is selected, the status of the JTBSR register is maintained regardless of the TAP controller state.

The Bypass Register (JTBPR) is connected between the TDI and TDO pins, leading to the same operation as when the BYPASS instruction is selected.

(6) HIGHZ

When the HIGHZ instruction is selected, all output pins enter a high-impedance state. While the HIGHZ instruction is selected, the status of Boundary Scan Register (JTBSR) is maintained regardless of the state of the TAP controller.

The Bypass Register (JTBPR) is connected between the TDI and TDO pins, leading to the same operation as when the BYPASS instruction is selected.

33.4 Usage Notes

The boundary scan function is subject to the following constraints:

- The boundary scan must be executed when the RES pin is driven low
- Serial data input/output is in LSB order, as shown in Figure 33.3.

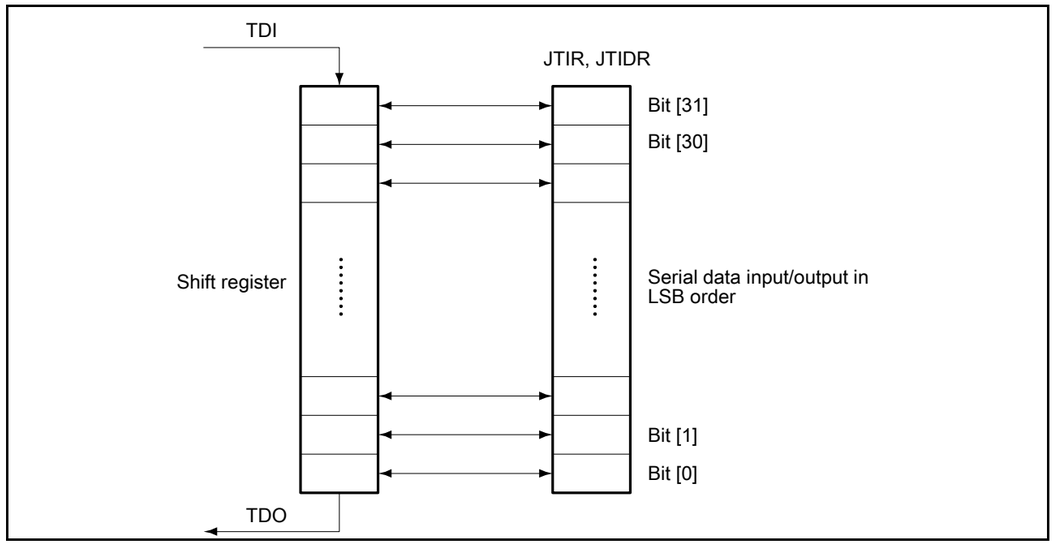


Figure 33.3 Serial data input/output

在SAMPLE操作中，边界扫描寄存器(JTBSR)锁存从输入引脚传输到内部电路或从内部电路传输到输出引脚的数据的快照。从扫描路径读取锁存的数据。在Capture-DR状态下，JTBSR寄存器在TCK引脚的上升沿锁存数据快照。数据快照仅在复位期间从内部电路传输到输出引脚。

在PRELOAD操作中，在执行EXTEST指令之前，将初始值从扫描路径写入边界扫描寄存器(JTBSR)的并行输出锁存器。如果在不执行此PRELOAD操作的情况下执行EXTEST，则从EXTEST序列的开头到结尾输出未定义的值（传输到输出锁存器）。在EXTEST指令中，输出并行锁存器始终输出到输出引脚。

(4) IDCODE

WhentheIDCODEinstructionisselected theIDCodeRegister(JTIDR)valueisoutputtotheTDOpinintheShift-DRstateoftheTAPcontroller.在这种情况下，JTIDR寄存器值首先输出LSB。在该指令执行期间，测试电路不影响系统电路。

(5) CLAMP

选择CLAMP指令时，输出引脚输出预先在SAMPLEPRELOAD指令中指定的边界扫描寄存器(JTBSR)值。选择CLAMP指令时，无论TAP控制器状态如何，都将保持JTBSR寄存器的状态。

旁路寄存器(JTBPR)连接在TDI和TDO引脚之间，导致与当
选择了BYPASS指令。

(6) HIGHZ

选择Highz指令时，所有输出引脚都进入高阻抗状态。选择HIGHZ指令时，无论TAP控制器的状态如何，边界扫描寄存器(JTBSR)的状态都会保持不变。

旁路寄存器(JTBPR)连接在TDI和TDO引脚之间，导致与当
选择了BYPASS指令。

33.4 使用说明

边界扫描函数受以下约束：

- 当RES引脚驱动为低电平时，必须执行边界扫描
- 串行数据输入输出按LSB顺序排列，如图33.3所示。

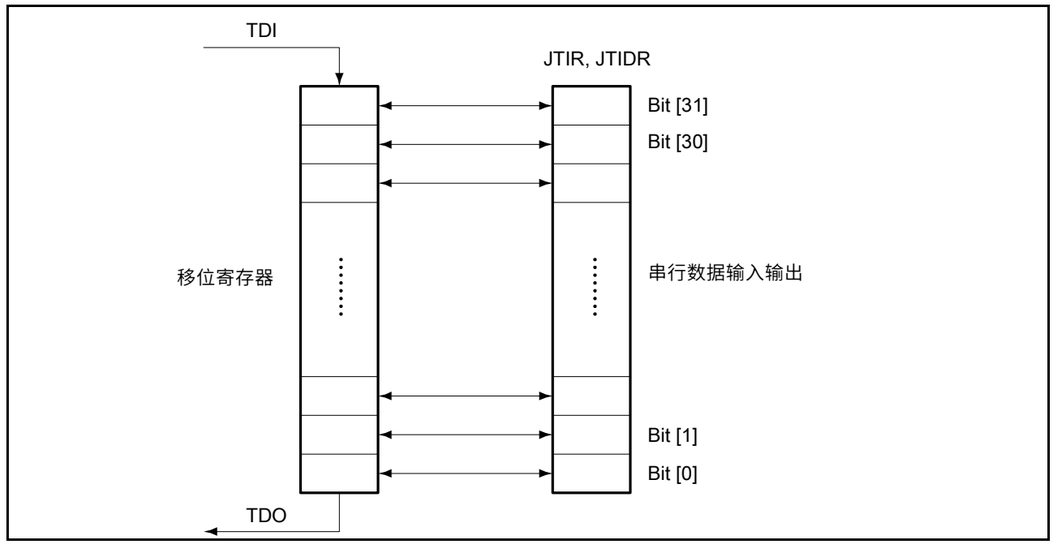


Figure 33.3 串行数据输入输出

The following pins cannot be boundary-scanned:

- Power supply pins (VCC, VCL, VCL0, VSS, AVCC0, and AVSS0)
- Analog reference pins (VREFH0, VREFL0, VREFH, and VREFL)
- Clock pins (EXTAL, XTAL, XCIN, and XCOUT)
- Reset signal (RES)
- Boundary-scan pins (TCK, TMS, TDI, and TDO).

以下引脚不能进行边界扫描：

- 电源引脚（VCC、VCL、VCL0、VSS、AVCC0和AVSS0）
- 模拟参考引脚（VREFH0、VREFL0、VREFH和VREFL）
- 时钟引脚（EXTAL、XTAL、XCIN和XCOUT）
- 复位信号(RES)
- 边界扫描引脚（TCK、TMS、TDI和TDO）。

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34. Secure Cryptographic Engine (SCE7)

34.1 Overview

The MCU incorporates a Secure Cryptographic Engine (SCE7) module to provide security functions. The module consists of an access management circuit, encryption engine, and random number generator.

Table 34.1 shows the SCE7 specifications and Figure 34.1 shows a block diagram.

Table 34.1 SCE7 specifications (1 of 2)

Parameter	Specifications
Access control	Access management circuit • In case of irregular access to the SCE7 due to a falsified program or runaway execution of a program, this circuit blocks all subsequent accesses and stops the output of data from the SCE7.
Encryption engine	Advanced Encryption Standard (AES): Compliant with NIST FIPS PUB 197 algorithm • Key sizes: 128, 192, or 256 bits • Block size: 128 bits • Chaining modes ECB, CBC, CTR: Compliant with NIST SP 800-38A GCM: Compliant with NIST SP 800-38D XTS: Compliant with NIST SP 800-38E. GCTR • Throughput for 128-bit data 11 PCLKB cycles for 128-bit key 15 PCLKB cycles for 256-bit key. AES-GCM • AES-GCM is realized by combining AES-GCTR and GHASH. Triple Data Encryption Standard (3DES) • 192-bit key length • Operates on a fixed 8-byte block of data • Used in legacy Secure Socket Layer (SSL) and Transport Layer Security (TLS) protocols. • Throughput for 64-bit data 16 PCLKB cycles for 56-bit key. Alleged RC4 (ARC4) • 2048-bit key length • Throughput for 128-bit data 16 PCLKB cycles for 2048-bit key.
Generation of random numbers	128-bit true random number generator
Signature generation and verification	RSA • Support for 1024-bit and 2048-bit key sizes • Signature generation, signature verification, public-key encryption, private-key decryption. DSA • Support for DSA key sizes: • (1024-bit, 160-bit) • (2048-bit, 224-bit) • (2048-bit, 256-bit). • Signature generation, signature verification. ECC • Support for curve P-192, P-224, P-256, and P-384 • Signature generation, signature verification • Scalar multiplication.
Message digest computation	HASH • SHA1, SHA224, SHA256, and MD5.
Unique ID	• An ID unique to the MCU (unique ID) is accessible from the access management circuit through the dedicated bus • Combining the unique ID with the key generation information prevents illicit copying of data to another MCU.

34. 安全加密引擎(SCE7)

34.1 Overview

MCU包含一个安全加密引擎(SCE7)模块以提供安全功能。该模块由访问管理电路、加密引擎和随机数发生器组成。

表34.1显示了SCE7规范，图34.1显示了框图。

Table 34.1 SCE7规范（2个中的1个）

Parameter	Specifications
访问控制	访问管理电路　如果由于伪造程序或程序执行失控导致对SCE7的不正常访问，该电路将阻止所有后续访问并停止从SCE7输出数据。
加密引擎	高级加密标准(AES)：符合NISTFIPSPUB197算法　密钥大小：128、192或256位　块大小：128位　链接模式 ECB、CBC、CTR：符合NISTSP800-38A GCM：符合NISTSP800-38DXTS：符合NISTSP800-38E。 GCTR　128位数据的吞吐量 128位密钥的11个PCLKB周期256位密钥的15个PCLKB周期。 AES-GCM　AES-GCM是通过结合AES-GCTR和GHASH实现的。 三重数据加密标准(3DES)　192位密钥长度　对固定的8字节数据块进行操作　用于传统的安全套接字层(SSL)和传输层安全(TLS)协议。　64位数据的吞吐量 56位密钥的16个PCLKB周期。 所谓的RC4(ARC4)　2048位密钥长度　128位数据的吞吐量 2048位密钥的16个PCLKB周期。
随机数的产生	128位真随机数发生器
签名生成和验证	RSA　支持1024位和2048位密钥大小　签名生成、签名验证、公钥加密、私钥解密。 DSA　支持DSA密钥大小：　（1024位、160位）（2048位、224位）　（2048位、256位）。 签名生成、签名验证。 ECC 支持曲线P-192、P-224、P-256和P-384　签名生成、签名验证　标量乘法。
消息摘要计算	哈希　SHA1、SHA224、SHA256和MD5。
唯一身份	MCU唯一的ID（唯一ID）可通过专用总线从访问管理电路访问。　将唯一ID与密钥生成信息相结合可防止将数据非法复制到另一个MCU。

Table 34.1 SCE7 specifications (2 of 2)

Parameter	Specifications
Privileged mode	• The privileged mode signal is connected to the access management circuit and is used to limit control of the SCE7 module to privileged mode only.
Low power consumption	Setting of the module-stop state is possible

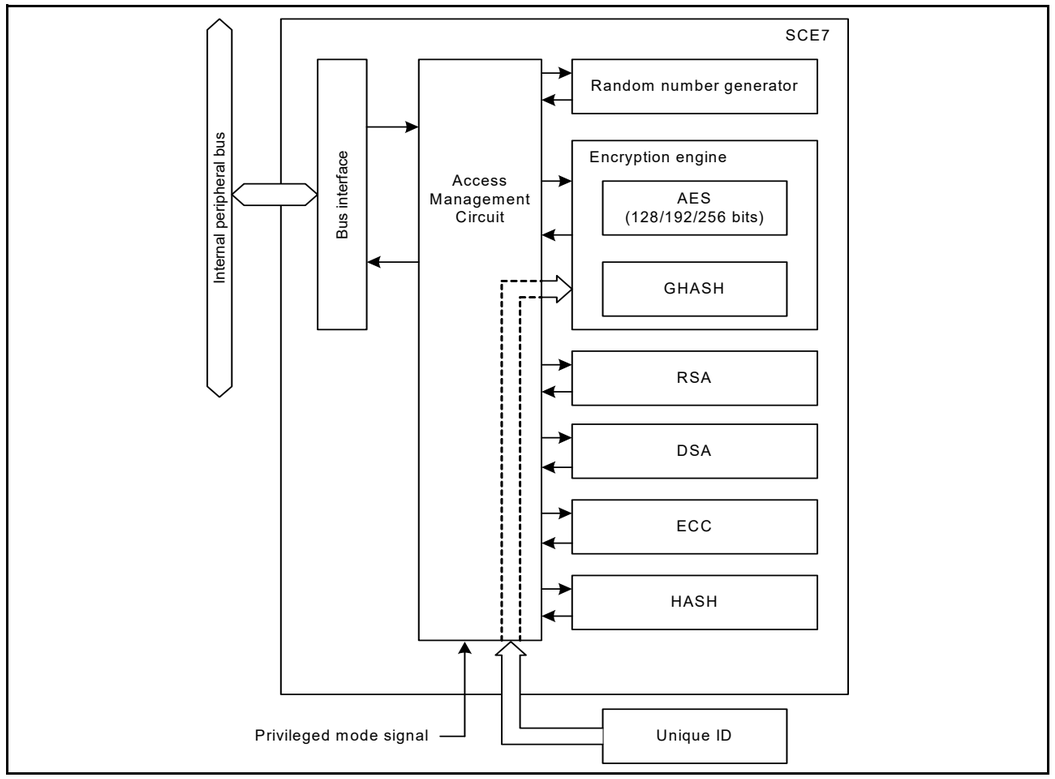

Figure 34.1 SCE7 block diagram

Table 34.1 SCE7规范（2个中的2个）

Parameter	Specifications
特权模式	特权模式信号连接到访问管理电路，用于将SCE7模块的控制仅限于特权模式。
低功耗	可以设置模块停止状态

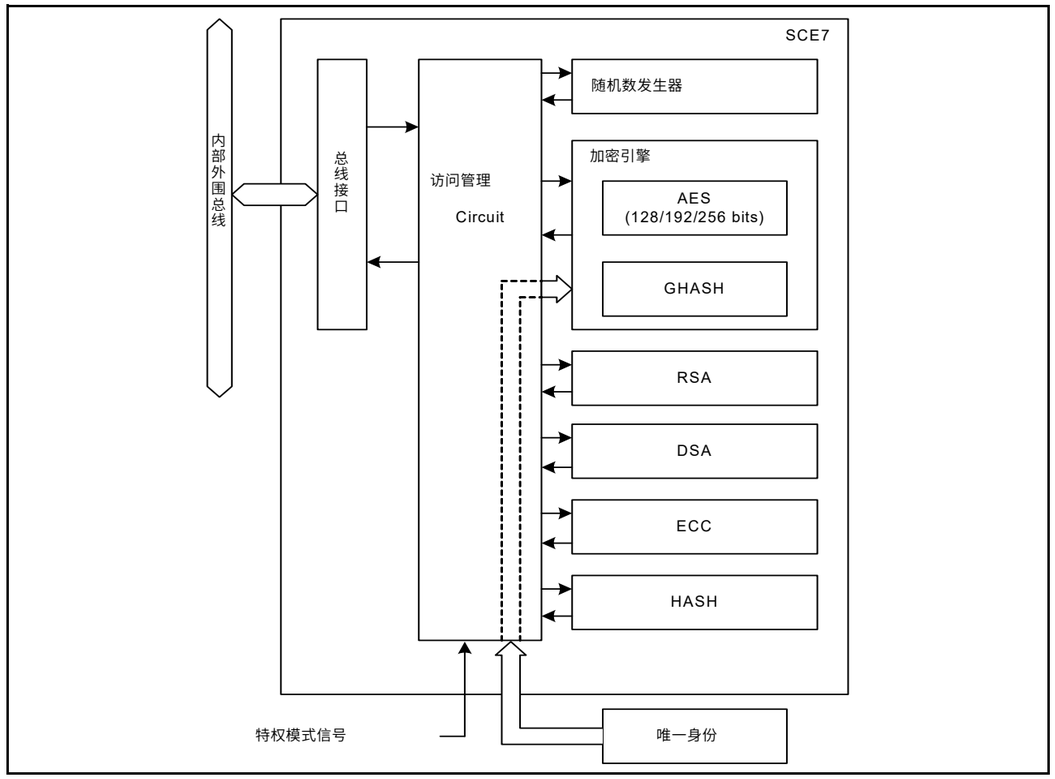

Figure 34.1 SCE7框图

34.2 Operation

34.2.1 Encryption Engine

The encryption engine performs the following operation in hardware, see Figure 34.2:

- Plaintext to ciphertext encryption
- Ciphertext to plaintext decryption.

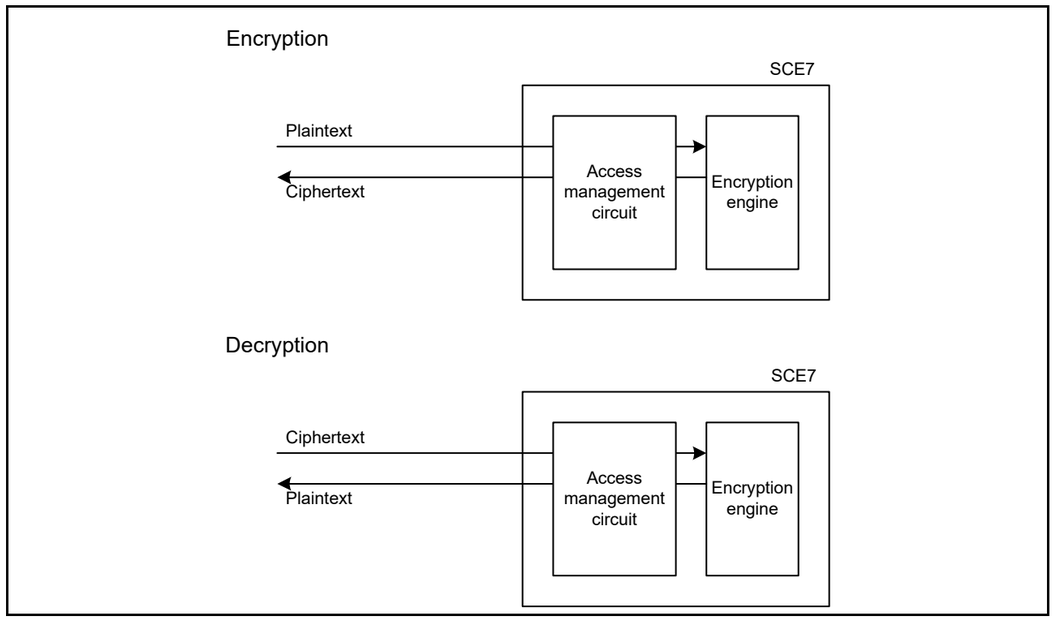

Figure 34.2 Encryption and decryption processes by encryption engine

34.2 Operation

34.2.1 加密引擎

加密引擎在硬件中执行以下操作，见图34.2：

- 明文到密文加密
- 密文转明文解密。

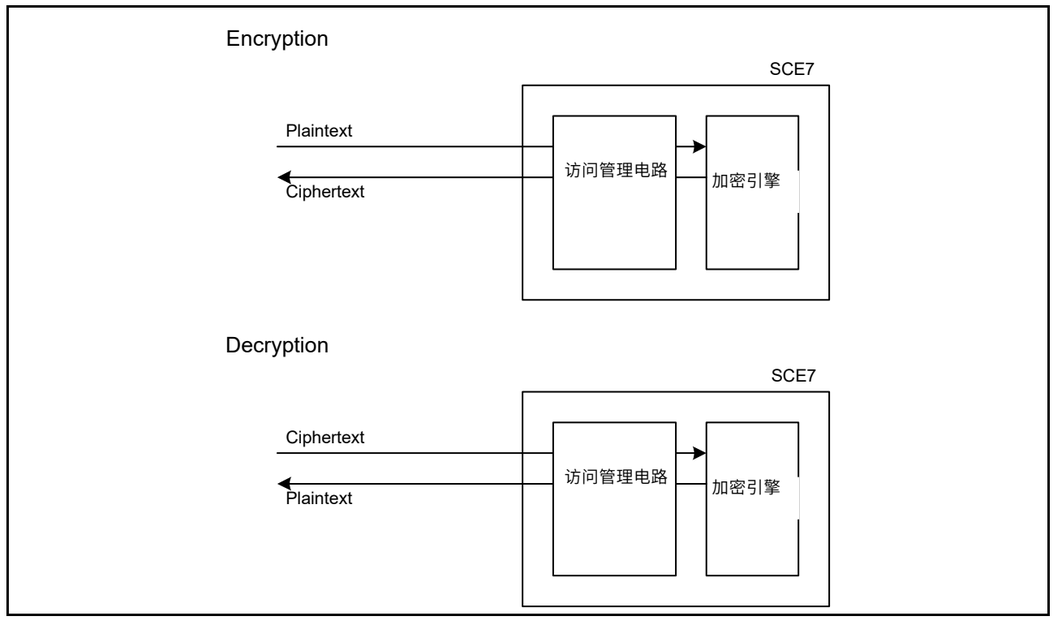

Figure 34.2 加密引擎的加解密过程

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34.2.2 Encryption and Decryption

To encrypt or decrypt data:

1. Input the data to encrypt or decrypt in the SCE7.
   The SCE7 converts the plaintext data to ciphertext or ciphertext data to plaintext.
2. Read the converted data.

The encryption engine has an input buffer and an output buffer, enabling encryption/decryption to proceed in parallel with data input/output. Figure 34.3 shows the encryption and decryption engine timing.

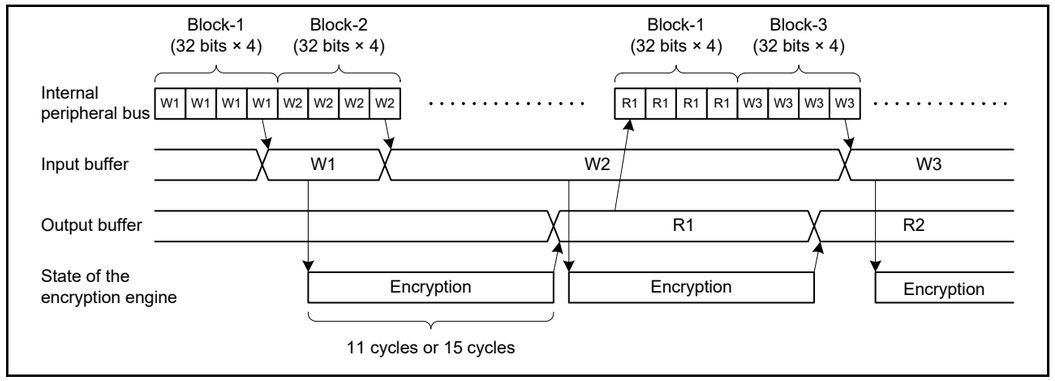


Figure 34.3 Encryption and decryption timing (AES)

34.3 Usage Notes

34.3.1 Software Standby Mode

When Software Standby mode is entered while the encryption engine is processing, proper processing cannot be resumed after exiting Software Standby mode. Software Standby mode should therefore be entered while the encryption engine is not running.

34.3.2 Settings for the Module-Stop Function

SCE7 operation can be disabled or enabled using Module Stop Control Register C (MSTPCRC). The SCE7 module is initially stopped after reset. Releasing the module-stop state enables access to the registers.

34.2.2 加密和解密

要加密或解密数据：

1. 在SCE7中输入要加密或解密的数据。
   SCE7将明文数据转换为密文或将密文数据转换为明文。
2. 读取转换后的数据。

加密引擎有一个输入缓冲区和一个输出缓冲区，使加密解密与数据输入输出并行进行。图34.3显示了加密和解密引擎的时序。

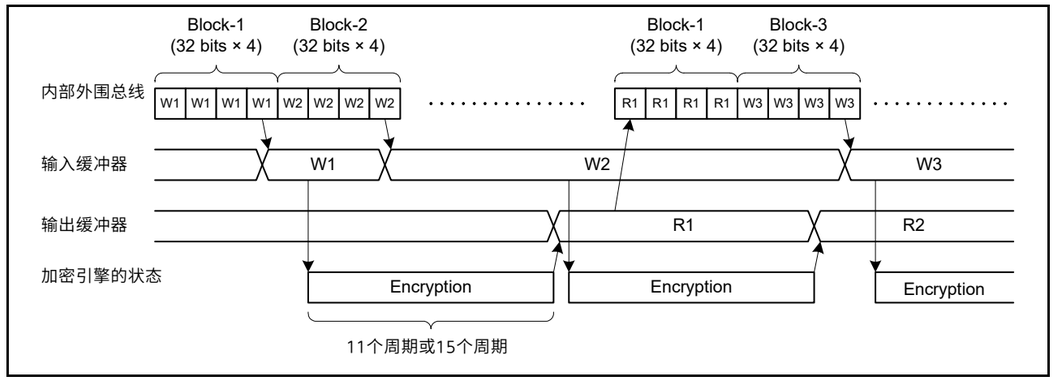


Figure 34.3 加密和解密时序（AES）

34.3 使用说明

34.3.1 软件待机模式

在加密引擎处理过程中进入软件待机模式时，退出软件待机模式后无法恢复正常处理。因此，应在加密引擎未运行时进入软件待机模式。

34.3.2 模块停止功能的设置

可以使用模块停止控制寄存器C(MSTPCRC)禁用或启用SCE7操作。SCE7模块在复位后最初停止。释放模块停止状态可以访问寄存器。

35. 12-Bit A/D Converter (ADC12)

35.1 Overview

The MCU provides two 12-bit successive approximation A/D converter (ADC12) units. In unit 0, up to 11 analog input channels are selectable. In unit 1, up to eight analog input channels, temperature sensor output, and internal reference voltage are selectable for conversion. The A/D conversion accuracy is selectable from 12-, 10-, and 8-bit conversion, making it possible to optimize the trade-off between speed and resolution in generating a digital value.

ADC12 features include:

- 11 channels (unit 0), 8 channels (unit 1)
- PCLKB = 60 MHz (maximum)
- PCLKC = 60 MHz (maximum)
- Analog channels: AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020 (unit 0), AN100 to AN102, AN105 to AN107, AN116, AN117 (unit 1)
- Resolution: 12-bit, 10-bit, 8-bit
- Dedicated sample-and-hold circuit embedded
- Programmable Gain Amplifier embedded.

The ADC12 supports the following operating modes:

- Single scan mode for converting analog inputs of arbitrarily selected channels in ascending order of channel number
- Continuous scan mode for sequentially converting analog inputs of arbitrarily selected channels continuously in ascending order of channel number
- Group scan mode for arbitrarily dividing the analog inputs of channels into two groups (A and B) and converting the analog input of the selected channel for each group in ascending order of channel number.

In group scan mode, you can start group A and group B A/D conversion at different times by individually selecting their scan start conditions. In addition, when a priority control operation for group A is set, ADC12 accepts group A scan starting during group B A/D conversion, suspending group B conversion. This allows you to assign higher priority to A/D conversion start for group A.

In double trigger mode, the analog input of an arbitrarily selected channel is converted in single scan mode or group scan mode (group A), and the data converted by the first and second A/D conversion start triggers are stored in different registers, providing duplexing of A/D-converted data.

Self-diagnosis is performed once at the beginning of each scan, and one of the three voltage values generated in ADC12 is A/D-converted.

The temperature sensor output and internal reference voltage are selectable at the same time as the analog input of the channel. A/D conversion is performed first for the analog input of the channel, next for the temperature sensor output, and then for the internal reference voltage.

The ADC12 provides a compare function (window A and window B). This compare function specifies the upper reference value for window A and lower reference value for window B, and outputs an interrupt request when the A/D-converted value of the selected channel meets the comparison conditions.

Table 35.1 lists the ADC12 specifications, Table 35.2 list the functions, and Table 35.3 lists the I/O pins. Figure 35.1 shows a block diagram of ADC12 unit 0, and Figure 35.2 shows a block diagram of ADC12 unit 1.

Table 35.1 ADC12 specifications (1 of 3)

Parameter	Specifications
Number of units	Two units, 0 and 1
Input channels	• Unit 0: Up to 11 channels • Unit 1: Up to 8 channels.

35. 12-Bit A/D Converter (ADC12)

35.1 Overview

MCU提供两个12位逐次逼近模数转换器(ADC12)单元。在单元0中，最多可选择11个模拟输入通道。在单元1中，最多可选择8个模拟输入通道、温度传感器输出和内部参考电压进行转换。AD转换精度可从12位、10位和8位转换中选择，从而可以在生成数字值时优化速度和分辨率之间的权衡。

ADC12 features include:

- 11 channels (unit 0), 8 channels (unit 1)
- PCLKB = 60 MHz (maximum)
- PCLKC = 60 MHz (maximum)
- 模拟通道：AN000到AN003、AN005到AN007、AN016到AN018、AN020（单元0）、AN100到AN102、AN105 to AN107, AN116, AN117 (unit 1)
- Resolution: 12-bit, 10-bit, 8-bit
- 嵌入式专用采样保持电路
- 嵌入式可编程增益放大器。

ADC12支持以下工作模式：

- 单次扫描模式，用于按通道编号升序转换任意选择通道的模拟输入
- 连续扫描模式，用于按通道编号升序连续转换任意选择通道的模拟输入
- 组扫描模式，用于将通道的模拟输入任意分成两组（A和B），并按通道编号升序对每组转换所选通道的模拟输入。

在组扫描模式下，您可以通过单独选择它们的扫描开始条件，在不同的时间开始A组和B组AD转换。此外，当设置了A组的优先控制操作时，ADC12在B组AD转换期间接受A组扫描开始，暂停B组转换。这允许您为A组的AD转换启动分配更高的优先级。

在双触发模式下，任意选择通道的模拟输入转换为单扫描模式或组扫描模式（A组），第一次和第二次A/D转换开始触发转换的数据存储在不同的寄存器中，提供双工一个D转换数据。

每次扫描开始时执行一次自诊断，ADC12中生成的三个电压值之一进行AD转换。

温度传感器输出和内部参考电压可与通道的模拟输入同时选择。首先对通道的模拟输入执行D转换，然后对温度传感器输出执行D转换，然后对内部参考电压执行D转换。

ADC12提供比较功能（窗口A和窗口B）。该比较函数指定窗口A的上参考值和窗口B的下参考值，并在所选通道的AD转换值满足比较条件时输出中断请求。

表35.1列出了ADC12规格，表35.2列出了功能，表35.3列出了IO引脚。图35.1显示了ADC12单元0的框图，图35.2显示了ADC12单元1的框图。

Table 35.1 ADC12规格(1of3)

Parameter	Specifications
单位数量	两个单位，0和1
输入通道	单元0：最多11个通道 单元1：最多8个通道。

Table 35.1 ADC12 specifications (2 of 3)

Parameter	Specifications
Extended analog function	Temperature sensor output, internal reference voltage
A/D conversion method	Successive approximation method
Resolution	12 bits, selectable to 12-bit, 10-bit, or 8-bit conversion
Conversion time	0.4 µs/channel, when A/D conversion clock PCLKC (ADCLK) is operating at 60 MHz. See Table 43.27 and Table 43.28 about the condition.
A/D conversion clock	Peripheral module clock PCLKB*1 and A/D conversion clock PCLKC (ADCLK)*1 can be set with the following division ratios: PCLKB to PCLKC (ADCLK) frequency ratios = 1:1, 2:1, 4:1, 8:1, 1:2, 1:4
Data registers	• 19 registers for analog input (11 for unit 0, 8 for unit 1), one for A/D-converted data duplication in double trigger mode in each unit, and two for A/D-converted data duplication in extended operation in double trigger mode in each unit • One register for temperature sensor output • One register for internal reference voltage • One register for self-diagnosis • A/D conversion results are stored in A/D data registers • 8-, 10-, and 12-bit accuracy output for A/D conversion results • A/D-converted value addition mode, in which the sum of all A/D conversion results are stored in the A/D data registers as the conversion accuracy bit count + 2 bits.*4 • Double trigger mode (selectable in single scan and group scan modes): The first unit of A/D-converted analog-input data on one selected channel is stored in the data register for the channel, and the second unit is stored in the duplication register. • Extended operation in double trigger mode (available for specific triggers): A/D-converted analog-input data on one selected channel is stored in the duplication register provided for the associated trigger.
Operating modes	• Single scan mode: - A/D conversion is performed only once on the analog inputs of arbitrarily selected channels, the temperature sensor output, and the internal reference voltage. • Continuous scan mode: - A/D conversion is performed repeatedly on the analog inputs of arbitrarily selected channels, the temperature sensor output, and the internal reference voltage. • Group scan mode: -A/D conversion is performed only once on the analog inputs of arbitrarily selected channels divided into group A and group B, the temperature sensor output, and the internal reference voltage -The scan start conditions can be independently selected for group A and group B, allowing A/D conversion of group A and group B to be started independently. • Group scan mode (when group A is given priority): -If a group A trigger is input during A/D conversion on group B, the A/D conversion on group B stops and A/D conversion is processed on group A. -Restart (rescan) of group B conversion after completion of group A conversion can be set.
Conditions for A/D conversion start	• Software trigger • Synchronous trigger from the Event Link Controller (ELC) • Asynchronous trigger from the external trigger pins, ADTRG0 (unit 0) and ADTRG1 (unit 1).
Functions	• Dedicated sample-and-hold function with optional constant sampling and 3 channels in units 0 and 1 • Variable sampling state count • Self-diagnosis of ADC12 • Selectable A/D-converted value addition mode or average mode • Analog input disconnection detection function (discharge and precharge functions) • Double trigger mode (duplication of A/D conversion data) • Switching function for 8-, 10-, and 12-bit conversion*2 • Automatic clear function for A/D data registers • Digital comparison of values in the comparison and data registers, and between values in the data registers.
Programmable gain amplifier	• Amplification of analog input signals to enable A/D conversion, with 3 channels in units 0 and 1 • Compatible with single end input and pseudo-differential input.
Interrupt sources and ELC events	• ADC12i_ADI: A/D scan end interrupt • ADC12i_GBADI: A/D scan end interrupt for group B • ADC12i_CMPAI: window A compare match • ADC12i_CMPBI: window B compare match • ADC12i_WCMPM: compare match • ADC12i_WCMPUM: compare mismatch.

Table 35.1 ADC12规格（2个，共3个）

Parameter	Specifications
扩展模拟功能	温度传感器输出，内部参考电压
AD转换方式	逐次逼近法
Resolution	12位，可选择12位、10位或8位转换
转换时间	0.4µs通道，当AD转换时钟PCLKC(ADCLK)以60MHz运行时。条件见表43.27和表43.28 。
AD转换时钟	外围模块时钟PCLKB*1和AD转换时钟PCLKC(ADCLK)*1可设置为以下分频比：PCLKB与PCLKC(ADCLK) 频率比=1:1、2:1、4:1、8:1、1:2 1:4
数据寄存器	19个用于模拟输入的寄存器（11个用于单元0，8个用于单元1），每个单元中双触发模式下的AD转换数据复制一个，双触发模式下扩展操作中的AD转换数据复制两个每个单元中 一个寄存器用于温度传感器输出 一个寄存器用于内部参考电压 一个寄存器用于自诊断 AD转换结果存储在AD数据寄存器中 用于AD转换的8位、10位和12位精度输出结果 AD转换值加法模式，其中所有AD转换结果的总和作为转换精度位数+2位存储在AD数据寄存器中。*4 双触发模式（在单次扫描和组扫描中可选模式）： 一个选定通道上的AD转换模拟输入数据的第一个单元存储在该通道的数据寄存器中，第二个单元存储在复制寄存器中。 双触发模式下的扩展操作（适用于特定触发）： 一个选定通道上的D转换模拟输入数据存储在为相关触发提供的复制寄存器中。
操作模式	单次扫描模式： D转换仅在任意选择通道的模拟输入、温度传感器输出和内部参考电压上执行一次。 连续扫描模式： 对任意选择通道的模拟输入、温度传感器输出和内部参考电压重复执行D转换。 组扫描模式： -A/D转换仅对任意选择的A组和B组通道的模拟输入、温度传感器输出和内部参考电压执行一次-A组和B组的扫描开始条件可以独立选择，允许A组和B组的AD转换独立启动。 组扫描模式（当A组优先时）： -如果在B组的AD转换期间输入A组触发，则B组的AD转换将停止，并在A组上进行AD转换。-可以设置在A组转换完成后重新启动（重新扫描）B组转换。
AD转换开始的条件	软件触发 来自事件链接控制器(ELC)的同步触发 来自外部触发引脚ADTRG0（单元0）和ADTRG1（单元1）的异步触发。
Functions	专用采样保持功能，可选恒定采样和3个通道，单元0和1 可变采样状态计数 ADC12自诊断 可选择AD转换值加法模式或平均模式 模拟输入断开检测功能（放电和预充电功能） 双触发模式（AD转换数据的复制） 8位、10位和12位转换的切换功能*2 AD数据寄存器的自动清除功能 比较中的值的数字比较和数据寄存器，以及数据寄存器中的值之间。
可编程增益放大器	放大模拟输入信号以实现AD转换，单元0和1具有3个通道 兼容单端输入和伪差分输入。
中断源和 ELC events	ADC12i_ADI：AD扫描结束中断 ADC12i_GBADI：A组B的D扫描结束中断 ADC12i_CMPAI：窗口A比较匹配 ADC12i_CMPBI：窗口B比较匹配 ADC12i_WCMPM：比较匹配 ADC12i_WCMPUM：比较不匹配。

Table 35.1 ADC12 specifications (3 of 3)

Parameter	Specifications
ELC interface	Scan can be started by a trigger from the ELC
Bus interface	Bus clock synchronized with peripheral clock (PCLKB), maximum frequency = 60 MHz
Reference voltage	• Unit 0: - VREFH0 is the high potential reference voltage - VREFL0 is the low potential reference voltage. • Unit 1: - VREFH is the high potential reference voltage - VREFL is the low potential reference voltage.
Module-stop function	Module-stop state can be set to reduce power consumption*3

i = 0 for unit 0, and i = 1 for unit 1.

Note 1. Peripheral module clock PCLKB is specified in the SCKDIVCR.PCKB[2:0] bits, and A/D conversion clock ADCLK in the SCKDIVCR.PCKC[2:0] bits in units 0 and 1.
Note 2. Changing the A/D conversion accuracy also changes the A/D conversion time. For details, see section 35.3.6, Analog Input Sampling and Scan Conversion Time.
Note 3. For details, see section 11, Low Power Modes.
Note 4. The number of extended bits for addition varies with the A/D conversion accuracy and the number of addition times. A 2-bit extension is up to 4 times conversion (3 times addition) when the A/D conversion accuracy is 8, 10, or 12 bits. A 4-bit extension is 16 times conversion (15 times addition) when the A/D conversion accuracy is 12 bits.

Table 35.2 ADC12 functions

Parameter			Unit 0 (ADC120)	Unit 1 (ADC121)
Analog input channel			AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020 Internal reference voltage Temperature sensor output	AN100 to AN102, AN105 to AN107, AN116, AN117 Internal reference voltage Temperature sensor output
Conditions for A/D conversion start	Software	Software trigger	Enabled	Enabled
	External trigger	Trigger input pin	ADTRG0	ADTRG1
	Synchronous trigger (trigger from ELC)	ELC trigger	ELC_AD00, ELC_AD01	ELC_AD10, ELC_AD11
Channel-dedicated sample-and-hold function	Target channel		AN000 to AN002	AN100 to AN102
Programmable gain amplifier	Target channel		AN000 to AN002	AN100 to AN102
	Pseudo-differential input pin		PGAVSS000	PGAVSS100
Interrupt			ADC120_ADI ADC120_GBADI ADC120_CMPAI ADC120_CMPBI	ADC121_ADI ADC121_GBADI ADC121_CMPAI ADC121_CMPBI
Output to ELC			ADC120_ADI ADC120_WCMPM ADC120_WCMPUM	ADC121_ADI ADC121_WCMPM ADC121_WCMPUM
Module-stop function settings*1, *2			MSTPCRD.MSTPD16 bit	MSTPCRD.MSTPD15 bit

Note 1. For details, see section 11, Low Power Modes.
Note 2. Wait for 1 µs or longer to start A/D conversion after release from the module-stop state.

Table 35.1 ADC12规格（3个中的3个）

Parameter	Specifications
ELC interface	扫描可以通过来自ELC的触发器启动
总线接口	与外设时钟(PCLKB)同步的总线时钟，最大频率=60MHz
参考电压	• Unit 0: VREFH0是高电位参考电压VREFL0是低电位参考电压。 单元1： VREFH是高电位参考电压VREFL是低电位参考电压。
Module-stop function	可设置模块停止状态以降低功耗*3

对于单元0，i=0，对于单元1，i=1。

Note 1. 外围模块时钟PCLKB在SCKDIVCR.PCKB[2:0]位中指定，AD转换时钟ADCLK在SCKDIVCR.PCKC[2:0]位在单元0和1中。
Note 2. 改变AD转换精度也会改变AD转换时间。有关详细信息，请参阅第35.3.6节，模拟输入采样和扫描转换时间。
Note 3. 有关详细信息，请参阅第11节，低功耗模式。
Note 4. 加法的扩展位数随AD转换精度和加法次数而变化。当AD转换精度为8、10或12位时，2位扩展最多可进行4次转换（3次加法）。当AD转换精度为12位时，4位扩展是16次转换（15次加法）。

Table 35.2 ADC12 functions

Parameter			Unit 0 (ADC120)	Unit 1 (ADC121)
模拟输入通道			AN000 to AN003, AN005 to AN007, AN016至AN018、AN020 内部参考电压温度传感器输出	AN100 to AN102, AN105 to AN107, AN116, AN117 内部参考电压温度传感器输出
AD转换开始的条件	Software	软件触发	Enabled	Enabled
	外部触发	触发输入引脚	ADTRG0	ADTRG1
	同步触发（来自ELC的触发）	ELC trigger	ELC_AD00, ELC_AD01	ELC_AD10, ELC_AD11
Channel-dedicated sample-and-hold function	目标渠道		AN000 to AN002	AN100 to AN102
可编程增益放大器	目标渠道		AN000 to AN002	AN100 to AN102
	伪差分输入引脚		PGAVSS000	PGAVSS100
Interrupt			ADC120_ADI ADC120_GBADI ADC120_CMPAI ADC120_CMPBI	ADC121_ADI ADC121_GBADI ADC121_CMPAI ADC121_CMPBI
输出到ELC			ADC120_ADI ADC120_WCMPM ADC120_WCMPUM	ADC121_ADI ADC121_WCMPM ADC121_WCMPUM
Module-stop function settings*1, *2			MSTPCRD.MSTPD16 bit	MSTPCRD.MSTPD15 bit

Note 1. 有关详细信息，请参阅第11节，低功耗模式。
Note 2. 从模块停止状态释放后，等待1µs或更长时间开始AD转换。

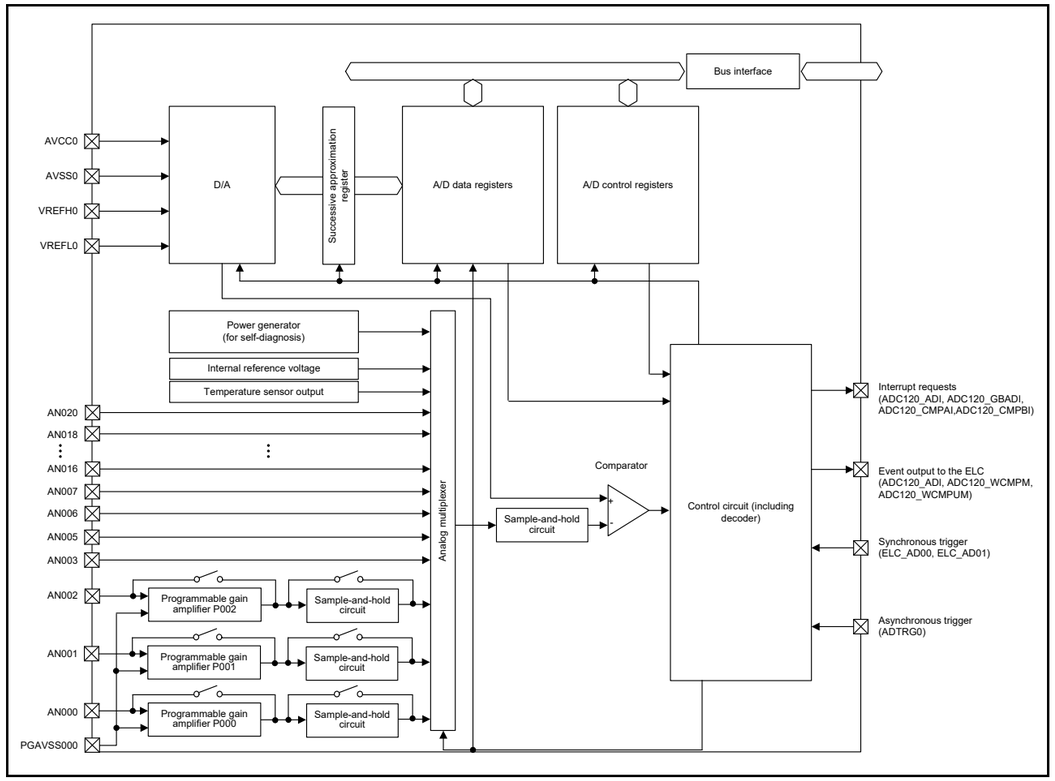


Figure 35.1 ADC12 unit 0 block diagram

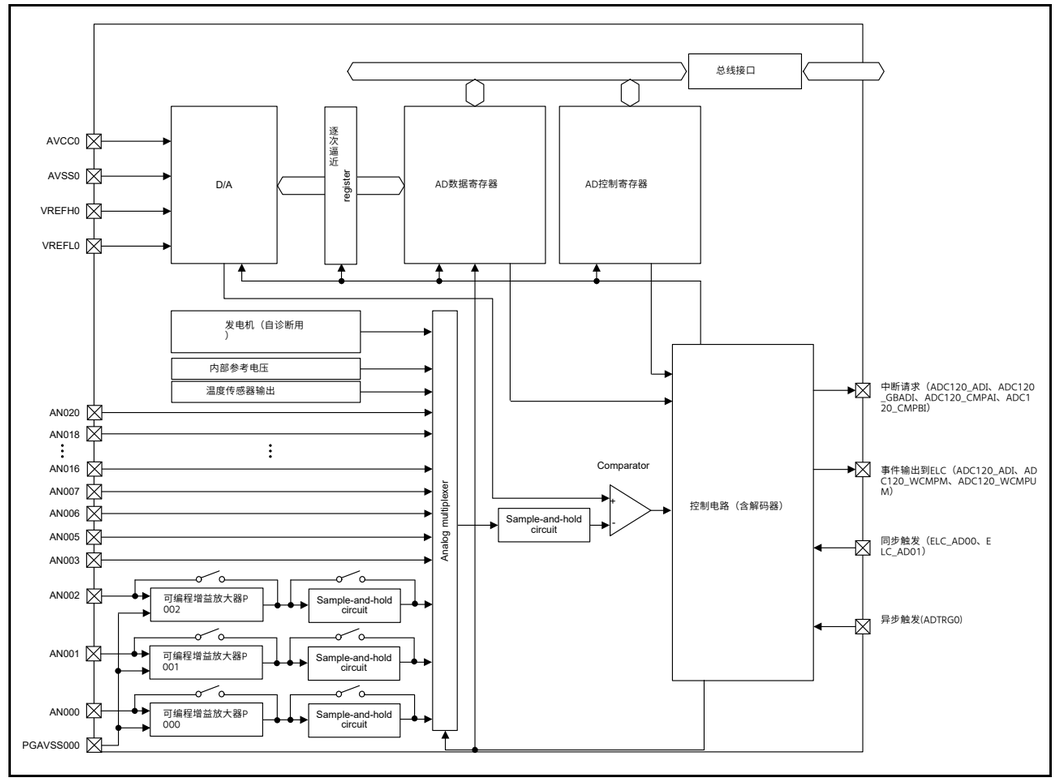


Figure 35.1 ADC12单元0框图

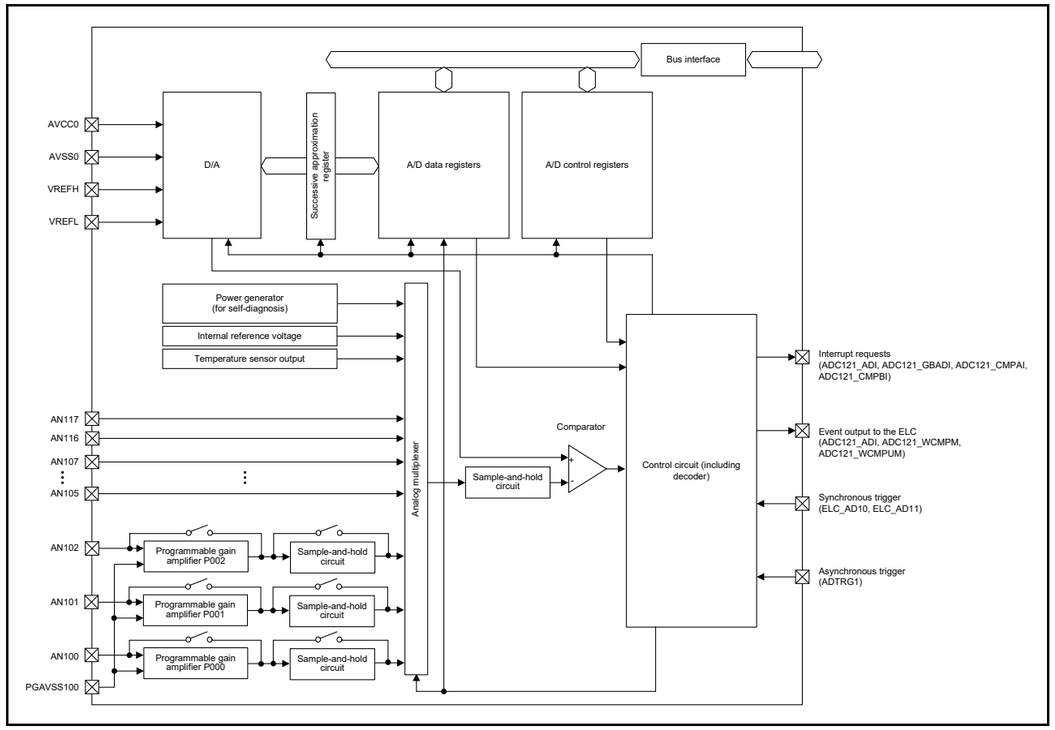


Figure 35.2 ADC12 unit 1 block diagram

Table 35.3 ADC12 I/O pins

Unit	Pin name	I/O	Function
Unit 0	AVCC0	Input	Analog block power supply pin
	AVSS0	Input	Analog block power supply ground pin
	VREFH0	Input	Reference power supply pin
	VREFL0	Input	Reference power supply ground pin
	AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020	Input	Analog input pins 0 to 3, 5 to 7, 16 to 18, and 20
	ADTRG0	Input	External trigger input pin for starting A/D conversion, active low
	PGAVSS000	Input	Pseudo-differential input pin
Unit 1	AVCC0	Input	Analog block power supply pin
	AVSS0	Input	Analog block power supply ground pin
	VREFH	Input	Reference power supply pin for ADC12 unit 1 and DAC
	VRELF	Input	Reference power supply ground pin for ADC12 unit 1 and DAC
	AN100 to AN102, AN105 to AN107, AN116, AN117	Input	Analog input pins 0 to 2, 5 to 7, 16, and 17
	ADTRG1	Input	External trigger input pin for starting A/D conversion, active low
	PGAVSS100	Input	Pseudo-differential input pin

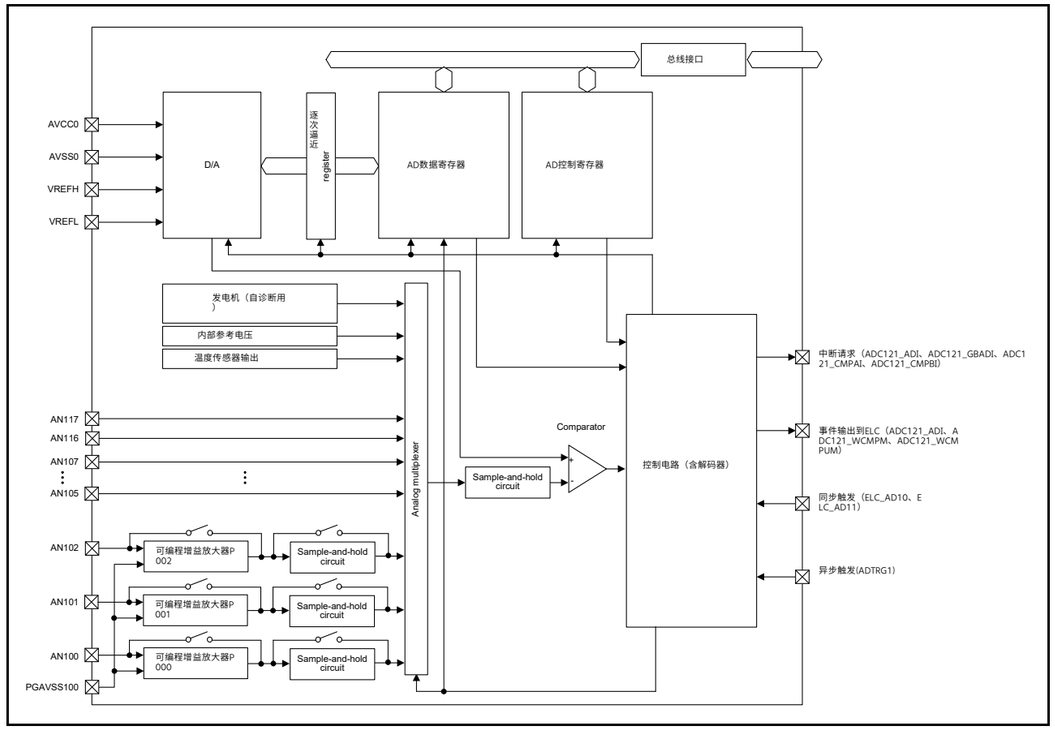


Figure 35.2 ADC12单元1框图

Table 35.3 ADC12 I/O pins

Unit	引脚名称	I/O	Function
Unit 0	AVCC0	Input	模拟模块电源引脚
	AVSS0	Input	模拟模块电源接地引脚
	VREFH0	Input	参考电源引脚
	VREFL0	Input	参考电源接地引脚
	AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020	Input	模拟输入引脚0至3、5至7、16至18和20
	ADTRG0	Input	用于启动AD转换的外部触发输入引脚，低电平有效
	PGAVSS000	Input	伪差分输入引脚
Unit 1	AVCC0	Input	模拟模块电源引脚
	AVSS0	Input	模拟模块电源接地引脚
	VREFH	Input	ADC12单元1和DAC的参考电源引脚
	VRELF	Input	ADC12单元1和DAC的参考电源接地引脚
	AN100 to AN102, AN105 to AN107, AN116, AN117	Input	模拟输入引脚0至2、5至7、16和17
	ADTRG1	Input	用于启动AD转换的外部触发输入引脚，低电平有效
	PGAVSS100	Input	伪差分输入引脚

35.2 Register Descriptions

35.2.1 A/D Data Registers y (ADDRy), A/D Data Duplexing Register (ADDBLDR), A/D Data Duplexing Register A (ADDBLDRA), A/D Data Duplexing Register B (ADDBLDRB), A/D Temperature Sensor Data Register (ADTSDR), A/D Internal Reference Voltage Data Register (ADOCDR)

The data registers include:

- ADDRy registers (y = 0 to 3, 5 to 7, 16 to 18, 20 in unit 0, and y = 0 to 2, 5 to 7, 16, 17 in unit 1): 16-bit read-only registers for storing the A/D conversion results
- ADDBLDR register: 16-bit read-only register for storing the A/D conversion results in response to the second trigger in double trigger mode
- ADDBLDRA and ADDBLDRB registers: 16-bit read-only registers for storing the A/D conversion results in response to the respective triggers during extended operation in double trigger mode
- ADTSDR register: 16-bit read-only register for storing the A/D conversion result of the temperature sensor output
- ADOCDR register: 16-bit read-only register for storing the A/D result of the internal reference voltage.

The following conditions determine the formats for data in the preceding registers:

- The setting in the A/D Data Register Format Select bit (ADCER.ADRFMT) (flush-left or flush-right setting)
- The setting in the A/D Conversion Accuracy Specify bits (ADCER.ADPRC[1:0]) (8-, 10-, or 12-bit setting).

This section describes the data formats for these conditions in different modes.

(1) When A/D-converted value addition/average mode is not selected

The data formats for each condition are as follows:

Settings for flush-right data with 12-bit accuracy

Address(es): ADC120.ADDR0 4005 C020h to ADC120.ADDR3 4005 C026h, ADC120.ADDR5 4005 C02Ah to ADC120.ADDR7 4005 C02Eh, ADC120.ADDR16 4005 C040h to ADC120.ADDR18 4005 C044h, ADC120.ADDR20 4005 C048h, ADC120.ADDBLDR 4005 C018h, ADC120.ADDBLDRA 4005 C084h, ADC120.ADDBLDRB 4005 C086h, ADC120.ADTSDR 4005 C01Ah, ADC120.ADOCDR 4005 C01Ch, ADC121.ADDR0 4005 C220h to ADC121.ADDR2 4005 C224h, ADC121.ADDR5 4005 C22Ah to ADC121.ADDR7 4005 C22Eh, ADC121.ADDR16 4005 C240h, ADC121.ADDR17 4005 C242h, ADC121.ADDBLDR 4005 C218h, ADC121.ADDBLDRA 4005 C284h, ADC121.ADDBLDRB 4005 C286h, ADC121.ADTSDR 4005 C21Ah, ADC121.ADOCDR 4005 C21Ch

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	AD[11:0]											
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b11 to b0	AD[11:0]	Converted Value 11 to 0	12-bit A/D-converted value	R
b15 to b12	—	Reserved	These bits are read as 0	R

35.2 注册说明

35.2.1 AD数据寄存器y(ADDRy)、AD数据双工寄存器(ADDBLDR)、AD数据双工寄存器A(ADDBLDRA) AD数据双工寄存器B(ADDBLDRB) AD温度传感器数据寄存器(ADTSDR) AD内部参考电压数据寄存器(ADOCDR)

数据寄存器包括：

- ADDRy寄存器（单元0中y=0到3、5到7、16到18、20，单元1中y=0到2、5到7、16、17）：用于存储的16位只读寄存器AD转换结果
- ADDBLDR寄存器：16位只读寄存器，用于存储双触发模式下第二次触发的AD转换结果
- ADDBLDRA和ADDBLDRB寄存器：16位只读寄存器，用于存储双触发模式下扩展操作期间响应相应触发的AD转换结果
- ADTSDR寄存器：16位只读寄存器，用于存储温度传感器输出的A/D转换结果
- AOCDR寄存器：16位只读寄存器，用于存储内部参考电压的AD结果。

以下条件决定了上述寄存器中数据的格式：

- AD数据寄存器格式选择位(ADCER.ADRFMT)中的设置（左对齐或右对齐设置）
- AD转换精度指定位(ADCER.ADPRC[1:0])中的设置（8位、10位或12位设置）。

本节介绍不同模式下这些条件的数据格式。

(1) 未选择AD转换值加法平均模式时

每个条件的数据格式如下：

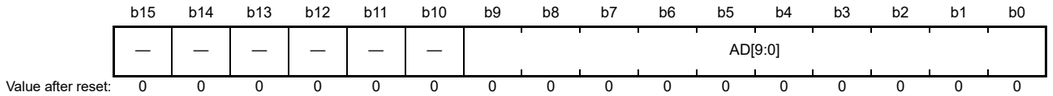
具有12位精度的右冲洗数据设置

Address(es): ADC120.ADDR0 4005 C020h to ADC120.ADDR3 4005 C026h, ADC120.ADDR5 4005 C02Ah to ADC120.ADDR7 4005 C02Eh, ADC120.ADDR16 4005 C040h to ADC120.ADDR18 4005 C044h, ADC120.ADDR20 4005 C048h, ADC120.ADDBLDR 4005 C018h, ADC120.ADDBLDRA 4005 C084h, ADC120.ADDBLDRB 4005 C086h, ADC120.ADTSDR 4005 C01Ah, ADC120.ADOCDR 4005 C01Ch, ADC121.ADDR0 4005 C220h to ADC121.ADDR2 4005 C224h, ADC121.ADDR5 4005 C22Ah to ADC121.ADDR7 4005 C22Eh, ADC121.ADDR16 4005 C240h, ADC121.ADDR17 4005 C242h, ADC121.ADDBLDR 4005 C218h, ADC121.ADDBLDRA 4005 C284h, ADC121.ADDBLDRB 4005 C286h, ADC121.ADTSDR 4005 C21Ah, ADC121.ADOCDR 4005 C21Ch

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	AD[11:0]											
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b11 to b0	AD[11:0]	将值11转换为0	12-bit A/D-converted value	R
b15 to b12	—	Reserved	这些位被读为0	R

Settings for flush-right data with 10-bit accuracy

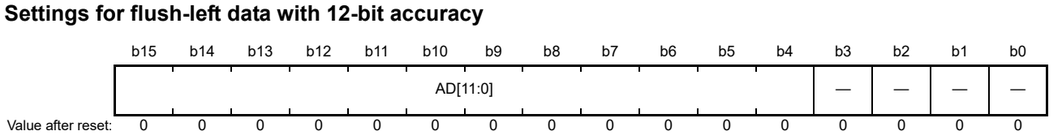


Bit	Symbol	Bit name	Description	R/W
b9 to b0	AD[9:0]	Converted Value 9 to 0	10-bit A/D-converted value	R
b15 to b10	—	Reserved	These bits are read as 0	R

Settings for flush-right data with 8-bit accuracy

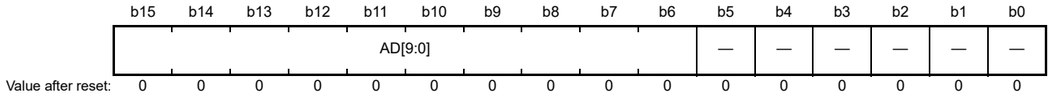
Bit	Symbol	Bit name	Description	R/W
b7 to b0	AD[7:0]	Converted Value 7 to 0	8-bit A/D-converted value	R
b15 to b8	—	Reserved	These bits are read as 0	R

Settings for flush-left data with 12-bit accuracy



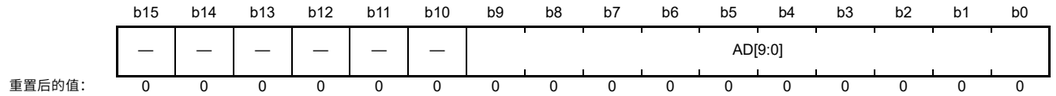
Bit	Symbol	Bit name	Description	R/W
b3 to b0	—	Reserved	These bits are read as 0	R
b15 to b4	AD[11:0]	Converted Value 11 to 0	12-bit A/D-converted value	R

Settings for flush-left data with 10-bit accuracy



Bit	Symbol	Bit name	Description	R/W
b5 to b0	—	Reserved	These bits are read as 0	R
b15 to b6	AD[9:0]	Converted Value 9 to 0	10-bit A/D-converted value	R

具有10位精度的右冲洗数据设置

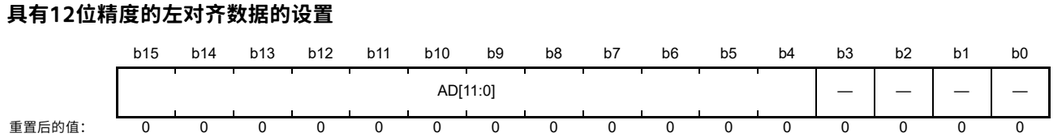


Bit	Symbol	位名称	Description	R/W
b9 to b0	AD[9:0]	将值9转换为0	10-bit A/D-converted value	R
b15 to b10	—	Reserved	这些位被读为0	R

具有8位精度的右对齐数据设置

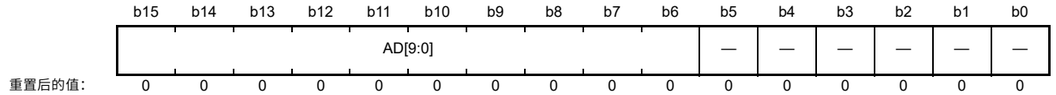
Bit	Symbol	位名称	Description	R/W
b7 to b0	AD[7:0]	将值7转换为0	8-bit A/D-converted value	R
b15 to b8	—	Reserved	这些位被读为0	R

具有12位精度的左对齐数据的设置



Bit	Symbol	位名称	Description	R/W
b3 to b0	—	Reserved	这些位被读为0	R
b15 to b4	AD[11:0]	将值11转换为0	12-bit A/D-converted value	R

具有10位精度的左对齐数据的设置



Bit	Symbol	位名称	Description	R/W
b5 to b0	—	Reserved	这些位被读为0	R
b15 to b6	AD[9:0]	将值9转换为0	10-bit A/D-converted value	R

Settings for flush-left data with 8-bit accuracy

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[7:0]								—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	—	Reserved	These bits are read as 0	R
b15 to b8	AD[7:0]	Converted Value 7 to 0	8-bit A/D-converted value	R

(2) When A/D-converted value average mode is selected

A/D-converted value average mode can be selected when 2 or 4 times is specified in A/D-converted value addition mode. When A/D-converted value average mode is selected, this register indicates the mean of the A/D-converted values on the specified channel. The value is stored in the A/D data register based on the setting in the A/D Data Register Format Select bit in the same way as in normal A/D conversion.

(3) When A/D-converted value addition mode is selected

For 8-, 10-, or 12-bit accuracy (ADPRC bit setting), 1, 2, 3 or 4 times can be selected for A/D-converted value addition. 16 times can also be selected for addition mode, but only with 12-bit accuracy selected. In addition mode, this register indicates the value that is obtained by adding the A/D-converted values on a specific channel. The conversion results sum is retained in the A/D data register as a 2-bit-extended value of the conversion accuracy specified. The value is stored in the A/D data register based on the setting in the A/D Data Register Format Select bit in the same way as for normal A/D conversion.

When converting 1, 2, 3, or 4 times in addition mode with 8-, 10-, or 12-bit accuracy specified, the conversion result is stored in the A/D data register as a 2-bit-extended value with the specified accuracy.

When converting 16 times in addition mode with 12-bit accuracy specified, the conversion result is stored in the A/D data register as a 4-bit-extended value with the specified accuracy.

The data formats for each condition are as follows.

Settings for flush-right data with 12-bit accuracy in A/D-converted value addition mode

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[15:0]*1															
	—	—	AD[13:0]*2													
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b15 to b0	AD[15:0]*1	Added Value 15 to 0	16-bit sum of A/D conversion results	R

Bit	Symbol	Bit name	Description	R/W
b13 to b0	AD[13:0]*2	Added Value 13 to 0	14-bit sum of A/D conversion results	R
b15, b14	—	Reserved	These bits are read as 0	R

Note 1. Used when 16 conversion times is specified in A/D-converted value addition mode.
Note 2. Used when 1, 2, 3, or 4 conversion times is specified in A/D-converted value addition mode.

8位精度的左对齐数据设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[7:0]								—	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	—	Reserved	这些位被读为0	R
b15 to b8	AD[7:0]	将值7转换为0	8-bit A/D-converted value	R

(2) 选择AD转换值平均模式时

当在AD转换值相加模式中指定2或4次时，可以选择D转换值平均模式。WhenAD-convertedvalueaveragemodeisselected thisregisterindicatesthemeanoftheAD-convertedvaluesonthespecifiedchannel.该值根据AD数据寄存器格式选择位中的设置以与正常AD转换相同的方式存储在AD数据寄存器中。

(3) 选择AD转换值相加模式时

对于8位、10位或12位精度（ADPRC位设置），可以选择1、2、3或4次进行AD转换值相加。加法模式也可以选择16次，但只能选择12位精度。在加法模式下，该寄存器指示通过将特定通道上的AD转换值相加而获得的值。转换结果和作为指定转换精度的2位扩展值保留在AD数据寄存器中。该值根据AD数据寄存器格式选择位中的设置以与正常AD转换相同的方式存储在AD数据寄存器中。

在指定精度为8、10或12位的加法模式下转换1、2、3或4次时，转换结果以指定精度的2位扩展值存储在AD数据寄存器中.

在指定精度为12位的加法模式下转换16次时，转换结果以指定精度的4位扩展值存储在AD数据寄存器中。

每个条件的数据格式如下。

在AD转换值相加模式下以12位精度设置刷新数据

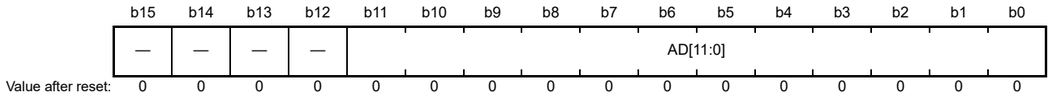
	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[15:0]*1															
	—	—	AD[13:0]*2													
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b15 to b0	AD[15:0]*1	附加值15到0	AD转换结果的16位和	R

Bit	Symbol	位名称	Description	R/W
b13 to b0	AD[13:0]*2	附加值13到0	AD转换结果的14位和	R
b15, b14	—	Reserved	这些位被读为0	R

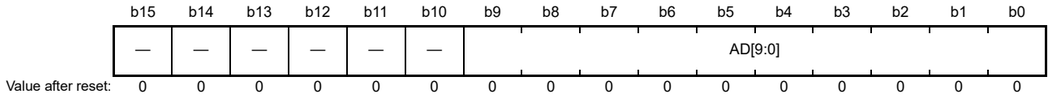
Note 1. 在AD转换值加法模式中指定16次转换时使用。
Note 2. 在AD转换值相加模式中指定1、2、3或4转换时间时使用。

Settings for flush-right data with 10-bit accuracy in A/D-converted value addition mode



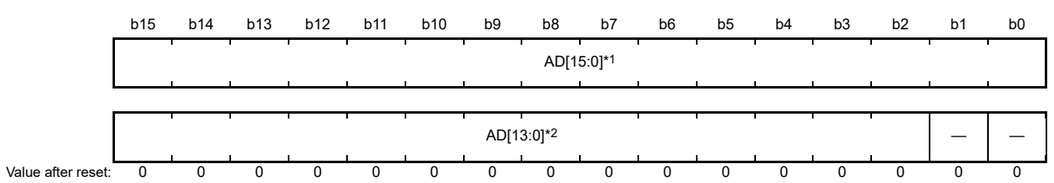
Bit	Symbol	Bit name	Description	R/W
b11 to b0	AD[11:0]	Added Value 11 to 0	12-bit sum of A/D conversion results	R
b15 to b12	—	Reserved	These bits are read as 0	R

Settings for flush-right data with 8-bit accuracy in A/D-converted value addition mode



Bit	Symbol	Bit name	Description	R/W
b9 to b0	AD[9:0]	Added Value 9 to 0	10-bit sum of A/D conversion results	R
b15 to b10	—	Reserved	These bits are read as 0	R

Settings for flush-left data with 12-bit accuracy in A/D-converted value addition mode

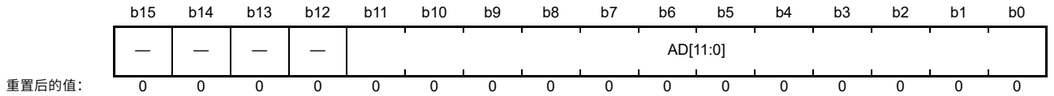


Bit	Symbol	Bit name	Description	R/W
b15 to b0	AD[15:0]*1	Added Value 15 to 0	16-bit sum of A/D conversion results	R

Bit	Symbol	Bit name	Description	R/W
b1, b0	—	Reserved	These bits are read as 0	R
b15 to b2	AD[13:0]*2	Added Value 13 o 0	14-bit sum of A/D conversion results	R

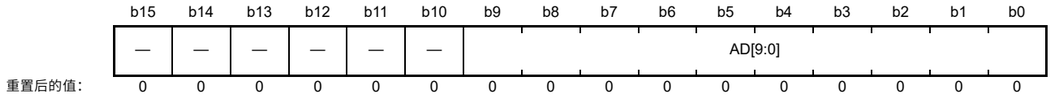
Note 1. Used when 16 conversion times is selected in A/D-converted value addition mode.
Note 2. Used when 1, 2, 3, or 4 conversion times is selected in A/D-converted value addition mode.

AD转换值加法模式下10位精度的右冲洗数据设置



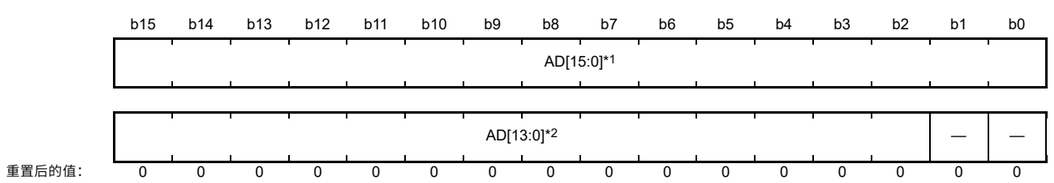
Bit	Symbol	位名称	Description	R/W
b11 to b0	AD[11:0]	附加值11到0	AD转换结果的12位和	R
b15 to b12	—	Reserved	这些位被读为0	R

在AD转换值相加模式下以8位精度设置右对齐数据



Bit	Symbol	位名称	Description	R/W
b9 to b0	AD[9:0]	附加值9到0	AD转换结果的10位和	R
b15 to b10	—	Reserved	这些位被读为0	R

AD转换值相加模式下12位精度的左对齐数据的设置



Bit	Symbol	位名称	Description	R/W
b15 to b0	AD[15:0]*1	附加值15到0	AD转换结果的16位和	R

Bit	Symbol	位名称	Description	R/W
b1, b0	—	Reserved	这些位被读为0	R
b15 to b2	AD[13:0]*2	附加值13o0	AD转换结果的14位和	R

Note 1. 在AD转换值相加模式中选择16次转换时使用。
Note 2. 在AD转换值相加模式中选择1、2、3或4转换时间时使用。

Settings for flush-left data with 10-bit accuracy in A/D-converted value addition mode

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[11:0]												—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	—	Reserved	These bits are read as 0	R
b15 to b4	AD[11:0]	Added Value 11 to 0	12-bit sum of A/D conversion results	R

Settings for flush-left data with 8-bit accuracy in A/D-converted value addition mode

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[9:0]										—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b5 to b0	—	Reserved	These bits are read as 0	R
b15 to b6	AD[9:0]	Added Value 9 to 0	10-bit sum of A/D conversion results	R

35.2.2 A/D Self-Diagnosis Data Register (ADRD)

ADRD is a 16-bit read-only register that holds the A/D conversion results based on the self-diagnosis of the ADC12. In addition to the AD[11:0] bits indicating the A/D-converted value, it includes the Self-diagnosis Status (DIAGST) bit.

The following conditions determine the formats for data in this register:

- Setting in the A/D Data Register Format Select bit (ADCER.ADRFMT) (flush-left or flush-right setting)
- Setting in the A/D Conversion Accuracy Specify bits (ADCER.ADPRC[1:0]) (8-, 10-, or 12-bit setting).

The A/D-converted value addition and average modes cannot be applied to the A/D self-diagnosis function. For details on self-diagnosis, see section 35.2.11, A/D Control Extended Register (ADCER).

This section describes the data formats for each condition.

Settings for flush-right data with 12-bit accuracy

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	DIAGST[1:0]		—	—	AD[11:0]											
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b11 to b0	AD[11:0]	Converted Value 11 to 0	12-bit A/D-converted value	R
b13, b12	—	Reserved	These bits are read as 0	R
b15, b14	DIAGST[1:0]	Self-Diagnosis Status	b15 b14 0 0: Self-diagnosis not executed after power-on 0 1: Self-diagnosis was executed using the 0 V voltage 1 0: Self-diagnosis was executed using the reference power supply*1 voltage x 1/2 1 1: Self-diagnosis was executed using the reference power supply*1 voltage. For details on self-diagnosis, see section 35.2.11, A/D Control Extended Register (ADCER).	R

AD转换值加法模式下10位精度的左对齐数据设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[11:0]												—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	—	Reserved	这些位被读为0	R
b15 to b4	AD[11:0]	附加值11到0	AD转换结果的12位和	R

AD转换值加法模式中8位精度的左对齐数据的设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[9:0]										—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b5 to b0	—	Reserved	这些位被读为0	R
b15 to b6	AD[9:0]	附加值9到0	AD转换结果的10位和	R

35.2.2 AD自诊断数据寄存器(ADRD)

ADRD是一个16位只读寄存器，保存基于ADC12自诊断的AD转换结果。除了指示AD转换值的AD[11:0]位外，它还包括自诊断状态(DIAGST)位。

以下条件决定了该寄存器中数据的格式：

- AD数据寄存器格式选择位(ADCER.ADRFMT)中的设置（左对齐或右对齐设置）
- AD转换精度指定位(ADCER.ADPRC[1:0])中的设置（8位、10位或12位设置）。

AD转换值加法和平均模式不能应用于AD自诊断功能。有关自诊断的详细信息，请参见第35.2.11节，AD控制扩展寄存器(ADCER)。

本节介绍每个条件的数据格式。

具有12位精度的右冲洗数据设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	DIAGST[1:0]		—	—	AD[11:0]											
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b11 to b0	AD[11:0]	将值11转换为0	12-bit A/D-converted value	R
b13, b12	—	Reserved	这些位被读为0	R
b15, b14	DIAGST[1:0]	Self-Diagnosis Status	b15b1400：上电后不执行自诊断01：使用0V电压执行自诊断10：使用参考电源执行自诊断*1电压x1211：自-使用参考电源*1电压执行诊断。有关自诊断的详细信息，请参阅第35.2.11节，AD控制 扩展寄存器(ADCER)。	R

Note 1. The reference voltage refers to VREFH0 for unit 0 and to VREFH for unit 1.

Settings for flush-right data with 10-bit accuracy

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	DIAGST[1:0]		—	—	—	—	AD[9:0]									
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b9 to b0	AD[9:0]	Converted Value 9 to 0	10-bit A/D-converted value	R
b13 to b10	—	Reserved	These bits are read as 0	R
b15, b14	DIAGST[1:0]	Self-Diagnosis Status	b15 b14 0 0: Self-diagnosis not executed after power-on 0 1: Self-diagnosis executed using the 0 V voltage 1 0: Self-diagnosis executed using the reference power supply*1 voltage x 1/2 1 1: Self-diagnosis executed using the reference power supply*1 voltage For details on self-diagnosis, see section 35.2.11, A/D Control Extended Register (ADCER).	R

Note 1. The reference voltage refers to VREFH0 for unit 0 and to VREFH for unit 1.

Settings for flush-right data with 8-bit accuracy

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	DIAGST[1:0]		—	—	—	—	—	—	AD[7:0]							
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	AD[7:0]	Converted Value 7 to 0	8-bit A/D-converted value	R
b13 to b8	—	Reserved	These bits are read as 0	R
b15, b14	DIAGST[1:0]	Self-Diagnosis Status	b15 b14 0 0: Self-diagnosis not executed after power-on 0 1: Self-diagnosis executed using the 0 V voltage 1 0: Self-diagnosis executed using the reference power supply*1 voltage x 1/2 1 1: Self-diagnosis executed using the reference power supply*1 voltage. For details on self-diagnosis, see section 35.2.11, A/D Control Extended Register (ADCER).	R

Note 1. The reference voltage refers to VREFH0 for unit 0 and to VREFH for unit 1.

Note 1. 参考电压是指单元0的VREFH0和单元1的VREFH。

具有10位精度的右冲洗数据设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	DIAGST[1:0]		—	—	—	—	AD[9:0]									
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b9 to b0	AD[9:0]	将值9转换为0	10-bit A/D-converted value	R
b13 to b10	—	Reserved	这些位被读为0	R
b15, b14	DIAGST[1:0]	Self-Diagnosis Status	b15b1400：上电后不执行自诊断01：使用0V电压执行自诊断10：使用参考电源执行自诊断*1电压x1211：自诊断使用参考电源*1电压执行有关自诊断的详细信息，请参阅第35.2.11节，AD控制 扩展寄存器(ADCER)。	R

Note 1. 参考电压是指单元0的VREFH0和单元1的VREFH。

具有8位精度的右对齐数据设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	DIAGST[1:0]		—	—	—	—	—	—	AD[7:0]							
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	AD[7:0]	将值7转换为0	8-bit A/D-converted value	R
b13 to b8	—	Reserved	这些位被读为0	R
b15, b14	DIAGST[1:0]	Self-Diagnosis Status	b15b1400：上电后不执行自诊断01：使用0V电压执行自诊断10：使用参考电源执行自诊断*1电压x1211：自诊断使用参考电源*1电压执行。有关自诊断的详细信息，请参阅第35.2.11节，AD控制 扩展寄存器(ADCER)。	R

Note 1. 参考电压是指单元0的VREFH0和单元1的VREFH。

Settings for flush-left data with 12-bit accuracy

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[11:0]												—	—	DIAGST[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	DIAGST[1:0]	Self-Diagnosis Status	b1 b0 0 0: Self-diagnosis not executed after power-on 0 1: Self-diagnosis executed using the voltage of 0 V 1 0: Self-diagnosis executed using the voltage of reference power supply*1 × 1/2 1 1: Self-diagnosis executed using the voltage of reference power supply*1. For details on self-diagnosis, see section 35.2.11, A/D Control Extended Register (ADCER).	R
b3, b2	—	Reserved	These bits are read as 0	R
b15 to b4	AD[11:0]	Converted Value 11 to 0	12-bit A/D-converted value	R

Note 1. The reference voltage refers to VREFH0 for unit 0 and to VREFH for unit 1.

Settings for flush-left data with 10-bit accuracy

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[9:0]										—	—	—	—	DIAGST[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	DIAGST[1:0]	Self-Diagnosis Status	b1 b0 0 0: Self-diagnosis not executed after power-on 0 1: Self-diagnosis executed using the 0 V voltage 1 0: Self-diagnosis executed using the reference power supply*1 × 1/2 voltage 1 1: Self-diagnosis executed using the reference power supply*1 voltage. For details on self-diagnosis, see section 35.2.11, A/D Control Extended Register (ADCER).	R
b5 to b2	—	Reserved	These bits are read as 0	R
b15 to b6	AD[9:0]	Converted Value 9 to 0	10-bit A/D-converted value	R

Note 1. The reference voltage refers to VREFH0 for unit 0 and to VREFH for unit 1.

具有12位精度的左对齐数据的设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[11:0]												—	—	DIAGST[1:0]	
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	DIAGST[1:0]	Self-Diagnosis Status	b1b000：上电后不执行自诊断01：使用0V电压执行自诊断10：使用参考电源电压执行自诊断*1×1211：自-使用参考电源电压*1执行诊断。有关自诊断的详细信息，请参阅第35.2.11节，AD控制扩展寄存器(ADCER)。	R
b3, b2	—	Reserved	这些位被读为0	R
b15 to b4	AD[11:0]	将值11转换为0	12-bit A/D-converted value	R

Note 1. 参考电压是指单元0的VREFH0和单元1的VREFH。

具有10位精度的左对齐数据的设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[9:0]										—	—	—	—	DIAGST[1:0]	
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	DIAGST[1:0]	Self-Diagnosis Status	b1b000：上电后不执行自诊断01：使用0V电压执行自诊断10：使用参考电源执行自诊断*1×12电压11：自诊断使用参考电源*1电压执行。有关自诊断的详细信息，请参阅第35.2.11节，AD控制扩展寄存器(ADCER)。	R
b5 to b2	—	Reserved	这些位被读为0	R
b15 to b6	AD[9:0]	将值9转换为0	10-bit A/D-converted value	R

Note 1. 参考电压是指单元0的VREFH0和单元1的VREFH。

Settings for flush-left data with 8-bit accuracy

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[7:0]								—	—	—	—	—	—	DIAGST[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	DIAGST[1:0]	Self-Diagnosis Status	b1 b0 0 0: Self-diagnosis not executed after power-on 0 1: Self-diagnosis executed using the 0 V voltage 1 0: Self-diagnosis executed using the reference power supply*1 × 1/2 voltage 1 1: Self-diagnosis executed using the reference power supply*1 voltage. For details on self-diagnosis, see section 35.2.11, A/D Control Extended Register (ADCER).	R
b7 to b2	—	Reserved	These bits are read as 0	R
b15 to b8	AD[7:0]	Converted Value 7 to 0	8-bit A/D-converted value	R

Note 1. The reference voltage refers to VREFH0 for unit 0 and to VREFH for unit 1.

35.2.3 A/D Control Register (ADCSR)

Address(es): ADC120.ADCSR 4005 C000h, ADC121.ADCSR 4005 C200h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ADST	ADCS[1:0]			—		TRGE	EXTRG	DBLE	GBADIE	—	DBLANS[4:0]				
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b4 to b0	DBLANS[4:0]	Double Trigger Channel Select	These bits select one analog input channel for double-triggered operation. The setting is only valid in double trigger mode.	R/W
b5	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b6	GBADIE	Group B Scan End Interrupt and ELC Event Enable	0: Disable ADC12i_GBADI interrupt generation on group B scan completion 1: Enable ADC12i_GBADI interrupt generation on group B scan completion. Group B scan only works in group scan mode.	R/W
b7	DBLE	Double Trigger Mode Select	0: Deselect double trigger mode 1: Select double trigger mode.	R/W
b8	EXTRG	Trigger Select*1	0: Start A/D conversion by a synchronous trigger (ELC) 1: Start A/D conversion by the asynchronous trigger (ADTRGi).	R/W
b9	TRGE	Trigger Start Enable	0: Disable A/D conversion to be started by the synchronous or asynchronous trigger 1: Enable A/D conversion to be started by the synchronous or asynchronous trigger.	R/W
b12 to b10	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b14, b13	ADCS[1:0]	Scan Mode Select	b14 b13 0 0: Single scan mode 0 1: Group scan mode 1 0: Continuous scan mode 1 1: Setting prohibited.	R/W
b15	ADST	A/D Conversion Start	0: Stop A/D conversion process 1: Start A/D conversion process.	R/W

8位精度的左对齐数据设置

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	AD[7:0]								—	—	—	—	—	—	DIAGST[1:0]	
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	DIAGST[1:0]	Self-Diagnosis Status	b1b000：上电后不执行自诊断01：使用0V电压执行自诊断10：使用参考电源执行自诊断*1×12电压11：自诊断使用参考电源*1电压执行。有关自诊断的详细信息，请参阅第35.2.11节，AD控制扩展寄存器(ADCER)。	R
b7 to b2	—	Reserved	这些位被读为0	R
b15 to b8	AD[7:0]	将值7转换为0	8-bit A/D-converted value	R

Note 1. 参考电压是指单元0的VREFH0和单元1的VREFH。

35.2.3 AD控制寄存器(ADCSR)

Address(es): ADC120.ADCSR 4005 C000h, ADC121.ADCSR 4005 C200h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ADST	ADCS[1:0]			—		TRGE	EXTRG	DBLE	GBADIE	—	DBLANS[4:0]				
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b4 to b0	DBLANS[4:0]	双触发通道 Select	这些位选择一个模拟输入通道进行双触发操作。该设置仅在双触发模式下有效。	R/W
b5	—	Reserved	该位读取为0。写入值应为0。	R/W
b6	GBADIE	B组扫描结束中断和ELC事件 Enable	0：在B组扫描完成时禁用ADC12i_GBADI中断生成1：在B组扫描完成时启用ADC12i_GBADI中断生成。B组扫描仅适用于组扫描模式。	R/W
b7	DBLE	双触发模式 Select	0：取消选择双触发模式1：选择双触发模式。	R/W
b8	EXTRG	触发选择 *1	0：通过同步触发（ELC）开始AD转换1：通过异步触发（ADTRGi）开始AD转换。	R/W
b9	TRGE	触发启动启用	0：禁止由同步或异步触发启动AD转换1：使能由同步或异步触发启动AD转换。	R/W
b12 to b10	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b14, b13	ADCS[1:0]	扫描模式选择	b14b1300：单次扫描模式01：组扫描模式10：连续扫描模式11：禁止设置。	R/W
b15	ADST	AD转换开始	0：停止AD转换过程1：开始AD转换过程。	R/W

i = 0 for unit 0, and i = 1 for unit 1.

Note 1. To start A/D conversion using an external pin (asynchronous trigger):
After a high-level signal is input to the external pin (ADTRG0 in unit 0; ADTRG1 in unit 1), write 1 to both the TRGE and EXTRG bits in ADCSR and drive the external pin signals low. With these settings, the scan conversion process starts on detection of the falling edge of ADTRG0 in unit 0 and ADTRG1 in unit 1. For this configuration, the pulse width of the low-level input must be at least 1.5 PCLKB clock cycles.

DBLANS[4:0] bits (Double Trigger Channel Select)

The DBLANS[4:0] bits select one of the channels for A/D conversion data duplication in double trigger mode. The A/D conversion results from the specified analog input channel are stored in A/D Data Register y when conversion is started by the first trigger, and in the A/D Data Duplexing Register when started by the second trigger. Table 35.4 shows the channel selection settings for double-triggered operation.

A/D-converted value addition/average mode can be set with double trigger mode for the channel selected in the DBLANS[4:0] bits by using the ADADS0 and ADADS1 registers. In double trigger mode, the channels selected in the ADANSA0 and ADANSA1 registers are invalid, and the channel selected in the DBLANS[4:0] bits is A/D-converted instead.

When double trigger mode is used in group scan mode, double-trigger control is only applied to group A and not to group B. This means that multi-channel analog input, temperature sensor output, and internal reference voltage can be selected for group B even in double trigger mode.

Only set the DBLANS[4:0] bits while the ADST bit is 0. Do not set them at the same time that you write 1 to the ADST bit.

To enter A/D-converted value addition/average mode when in double trigger mode, set the channel selected in the DBLANS[4:0] bits in the ADANSA0 and ADANSA1 registers.

Table 35.4 Relationship between DBLANS bit settings and double-trigger enabled channels

Unit 0		Unit 1	
DBLANS[4:0]	Duplication channel	DBLANS[4:0]	Duplication channel
00000	AN000	00000	AN100
00001	AN001	00001	AN101
00010	AN002	00010	AN102
00011	AN003	00011	-
00100	-	00100	-
00101	AN005	00101	AN105
00110	AN006	00110	AN106
00111	AN007	00111	AN107
10000	AN016	10000	AN116
10001	AN017	10001	AN117
10010	AN018	10010	-
10011	-	10011	-
10100	AN020	10100	-

Note: A/D-converted data from the self-diagnosis function, temperature sensor output, and internal reference voltage cannot be used in double trigger mode.
Settings other than those listed in Table 35.4 are prohibited.

GBADIE bit (Group B Scan End Interrupt and ELC Event Enable)

The GBADIE bit enables or disables group B scan end interrupt (ADC12i_GBADI (i = 0, 1)) in group scan mode.

DBLE bit (Double Trigger Mode Select)

The DBLE bit selects or deselects double trigger mode. Double trigger mode can only be operated by the synchronous trigger (ELC) selected in the ADSTRGR.TRSA[5:0] bits.

对于单元0，i=0，对于单元1，i=1。

Note 1. 使用外部引脚（异步触发）启动AD转换：
向外部引脚（单元0中的ADTRG0；单元1中的ADTRG1）输入高电平信号后，向ADCSR的TRGE和EXTRG位写入1，并将外部引脚信号驱动为低电平。使用这些设置，扫描转换过程在检测到单元0中的ADTRG0和单元1中的ADTRG1的下降沿时开始。对于这种配置，低电平输入的脉冲宽度必须至少为1.5个PCLKB时钟周期。

DBLANS[4:0]位（双触发通道选择）

DBLANS[4:0]位选择通道之一，用于双触发模式下的AD转换数据复制。指定模拟输入通道的AD转换结果在第一次触发开始转换时存储在AD数据寄存器y中，在第二次触发开始时存储在AD数据双工寄存器中。表35.4显示了双触发操作的通道选择设置。

D转换值加法平均模式可以设置为双触发模式，用于在
DBLANS[4:0]位通过使用ADADS0和ADADS1寄存器。在双触发模式下，ADANSA0和ADANSA1寄存器中选择的通道无效，DBLANS[4:0]位中选择的通道改为AD转换。

在组扫描模式下使用双触发模式时，双触发控制只适用于A组，不适用于B组。这意味着B组可以选择多通道模拟输入、温度传感器输出和内部参考电压即使在双触发模式下。

仅在ADST位为0时设置DBLANS[4:0]位。不要在将1写入ADST位的同时设置它们。

要在双触发模式下进入AD转换值加法平均模式，请将
ADANSA0和ADANSA1寄存器中的DBLANS[4:0]位。

Table 35.4 DBLANS位设置与双触发启用通道之间的关系

Unit 0		Unit 1	
DBLANS[4:0]	复制通道	DBLANS[4:0]	复制通道
00000	AN000	00000	AN100
00001	AN001	00001	AN101
00010	AN002	00010	AN102
00011	AN003	00011	-
00100	-	00100	-
00101	AN005	00101	AN105
00110	AN006	00110	AN106
00111	AN007	00111	AN107
10000	AN016	10000	AN116
10001	AN017	10001	AN117
10010	AN018	10010	-
10011	-	10011	-
10100	AN020	10100	-

Note: 自诊断功能、温度传感器输出和内部参考电压的D转换数据不能用于双触发模式。禁止在表35.4中列出以外的设置。

GBADIE位（B组扫描结束中断和ELC事件使能）

GBADIE位在组扫描模式下启用或禁用组B扫描结束中断(ADC12i_GBADI(i=0 1))。

DBLE位（双触发模式选择）

DBLE位选择或取消选择双触发模式。双触发模式只能通过在ADSTRGR.TRSA[5:0]位中选择的同步触发(ELC)操作。

Double-trigger operation is as follows:

1. The ADC12i_ADI (i = 0, 1) interrupt is not output on completion of the first conversion but on completion of the second conversion.
2. The A/D conversion results from the duplication channel (selected in DBLANS[4:0]) started by the first trigger are stored in A/D Data Register y and those started by the second trigger are stored in the A/D Data Duplexing Register.

When DBLE is set, selecting double trigger mode, the channels specified in the ADANSA0 and ADANSA1 registers are invalid. Double trigger mode is deselected by setting DBLE to 0. Setting DBLE to 1 again enables the same double-trigger operation described in 1. and 2. for first time scanning with the first trigger.

Do not select double trigger mode in continuous scan mode. Additionally, do not select double trigger mode for conversion of the temperature sensor output or internal reference voltage except for group B scan in group scan mode. Software triggering cannot be set in double trigger mode. Always clear the ADST bit to 0 before setting the DBLE bit. In other words, do not set the DBLE bit at that same time as writing 1 to the ADST bit.

EXTRG bit (Trigger Select)

The EXTRG bit selects the synchronous or asynchronous trigger as the trigger for starting A/D conversion.

TRGE bit (Trigger Start Enable)

The TRGE bit enables or disables A/D conversion by the synchronous and asynchronous triggers. In group scan mode, set this bit to 1.

ADCS[1:0] bits (Scan Mode Select)

The ADCS[1:0] bits select the scan mode.

In single scan mode, A/D conversion is performed for the analog inputs, up to a maximum of 11 channels in unit 0 and 8 channels in unit 1, and selected in the ADANSA0 and ADANSA1 registers in ascending order of channel number. When 1 cycle of A/D conversion completes for all the selected channels, the scan conversion stops. When the temperature sensor output or internal reference voltage is selected, A/D conversion of the designated analog input channels is followed by A/D conversion of the temperature sensor output and the internal reference voltage, in that order.

In continuous scan mode, while the ADCSR.ADST bit is 1, A/D conversion is performed for the analog inputs selected in the ADANSA0 and ADANSA1 registers in ascending order of channel number, and when 1 cycle of A/D conversion completes for all the selected channels, A/D conversion is repeated from the first channel. If the ADCSR.ADST bit is set to 0 during continuous scan, A/D conversion stops even if scanning is in progress. When the temperature sensor output or internal reference voltage is selected, A/D conversion of the designated analog input channels is followed by A/D conversion of the temperature sensor output and the internal reference voltage, in that order.

In group scan mode, scanning is started by the synchronous trigger (ELC) selected in the TRSA[5:0] bits in ADSTRGR. A/D conversion is performed on the group A analog inputs, up to the maximum channels selected in the ADANSA0 and ADANSA1 registers, in ascending order of channel number. When 1 cycle of A/D conversion completes for all the selected channels, A/D conversion stops. On the same trigger, A/D conversion is also performed on the group B analog inputs, up to the maximum channels selected in the ADANSB0 and ADANSB1 registers, in ascending order of channel number. When 1 cycle of A/D conversion completes for all the selected channels, A/D conversion stops. If the conversion processes in group A and group B occur at the same time, those conversions cannot be controlled separately. In this case, set the Group A Priority Control Setting bit (ADGSPCR.PGS) in the A/D Group Scan Priority Control Register (ADGSPCR) to 1 to give priority to group A conversion. When the temperature sensor output or internal reference voltage is selected, A/D conversion of the designated analog input channels is followed by A/D conversion of the temperature sensor output and the internal reference voltage, in that order.

In group scan mode, select different channels and triggers for group A and group B. Clear the ADST bit to 0 before setting the ADCS[1:0] bits. In other words, do not set the ADCS[1:0] bits at the same time as writing 1 to the ADST bit.

双触发操作如下：

1. ADC12i_ADI(i=0 1)中断不会在第一次转换完成时输出，而是在第二次转换完成时输出。
2. 由第一个触发器启动的复制通道（在DBLANS[4:0]中选择）的AD转换结果存储在AD数据寄存器y中，由第二个触发器启动的数据存储在AD数据双工寄存器中。

设置DBLE时，选择双触发模式，ADANSA0和ADANSA1寄存器中指定的通道无效。通过将DBLE设置为0可以取消选择双触发模式。再次将DBLE设置为1可以启用与1.和2.中描述的相同的双触发操作，以使用第一个触发进行首次扫描。

在连续扫描模式下不要选择双触发模式。此外，不要选择双触发模式来转换温度传感器输出或内部参考电压，组扫描模式下的B组扫描除外。双触发模式下不能设置软件触发。在设置DBLE位之前，始终将ADST位清零。换言之，不要在将1写入ADST位的同时设置DBLE位。

EXTRG位（触发选择）

EXTRG位选择同步或异步触发作为启动AD转换的触发。

TRGE位（触发启动使能）

TRGE位通过同步和异步触发启用或禁用AD转换。在组扫描模式下，将此位设置为1。

ADCS[1:0]位（扫描模式选择）

ADCS[1:0]位选择扫描模式。

在单次扫描模式下，对模拟输入进行AD转换，单元0中最多11个通道，单元1中最多8个通道，并在ADANSA0和ADANSA1寄存器中按通道号的升序进行选择。当所有选定通道的1个AD转换周期完成时，扫描转换停止。WhenthetemperaturesensoroutputorinternalreferencevoltageisselectedADconversionofthedesignatedanaloginputchannelsisfollowedbyADconversionofthetemperaturesensoroutputandtheinternalreferencevoltage inthatorder.

在连续扫描模式下，当ADCSR.ADST位为1时，ADANSA0和ADANSA1寄存器中选择的模拟输入按通道编号升序执行AD转换，当所有选择的通道完成1个周期的AD转换时，从第一个通道重复D转换。如果在连续扫描期间ADCSR.ADST位设置为0，即使扫描正在进行，AD转换也会停止。WhenthetemperaturesensoroutputorinternalreferencevoltageisselectedADconversionofthedesignatedanaloginputchannelsisfollowedbyADconversionofthetemperaturesensoroutputandtheinternalreferencevoltage inthatorder.

在组扫描模式下，扫描由在ADSTRGR的TRSA[5:0]位中选择的同步触发(ELC)启动。AD转换在A组模拟输入上执行，直至在ADANSA0和ADANSA1寄存器中选择的最大通道，按通道编号的升序排列。当所有选定通道完成1个AD转换周期时，AD转换停止。在同一个触发器上，B组模拟输入也执行AD转换，直到ADANSB0和ADANSB1寄存器中选择的最大通道，按通道编号的升序排列。当所有选定通道完成1个AD转换周期时，AD转换停止。如果A组和B组中的转换过程同时发生，则不能单独控制这些转换。在这种情况下，设置AD组扫描优先级控制中的组A优先级控制设置位(ADGSPCR.PGS)

寄存器(ADGSPCR)为1以优先A组转换。WhenthetemperaturesensoroutputorinternalreferencevoltageisselectedADconversionofthedesignatedanaloginputchannelsisfollowedbyADconversionofthetemperaturesensoroutputandtheinternalreferencevoltage inthatorder.

在组扫描模式下，为A组和B组选择不同的通道和触发器。在设置ADCS[1:0]位之前将ADST位清零。换言之，不要在将1写入ADST位的同时设置ADCS[1:0]位。

Table 35.5 Selectable targets for A/D conversion depending on scan and double trigger mode settings

Scan mode setting	Double trigger mode setting	Targets for A/D conversion				
		Self-diagnosis	Analog input (including group A)	Analog input (group B)	Temperature sensor output	Internal reference voltage
Single scan	DBLE = 0	✓	✓	-	✓	✓
	DBLE = 1	-	✓ (1 ch only)	-	-	-
Continuous scan	DBLE = 0	✓	✓	-	✓	✓
	DBLE = 1	-	-	-	-	-
Group scan	DBLE = 0	✓	✓	✓	✓	✓
	DBLE = 1	-	✓ (1 ch only)	✓	✓	✓

✓: Selectable. -: Not selectable.

ADST bit (A/D Conversion Start)

The ADST bit starts or stops the A/D conversion process. Before setting the ADST bit to 1, set the A/D conversion clock, conversion mode, and analog input for the conversion target.

[Setting conditions]

- 1 is written by software
- The synchronous trigger (ELC) selected in the ADSTRGR.TRSA[5:0] bits is detected when ADCSR.EXTRG is 0 and ADCSR.TRGE is 1
- The synchronous trigger (ELC) selected in the ADSTRGR.TRSB[5:0] bits is detected when ADCSR.TRGE is set to 1 in group scan mode
- The asynchronous trigger is detected when the ADCSR.TRGE and ADCSR.EXTRG bits are set to 1 and the ADSTRGR.TRSA[5:0] bits are set to 000000b
- When group A priority control operation mode is enabled (ADCSR.ADCS[1:0] bits = 01b and ADGSPCR.PGS bit = 1), the ADGSPCR.GBRP bit is set to 1, and A/D conversion of group B starts.

[Clearing conditions]

- 0 is written by software
- The A/D conversion of all the selected channels, the temperature sensor output or the internal reference voltage completes in single scan mode
- Group A scan completes in group scan mode
- Group B scan completes in group scan mode
- When group A priority control operation mode is enabled (ADCSR.ADCS[1:0] bits = 01b and ADGSPCR.PGS bit = 1), the ADGSPCR.GBRP bit is set to 1, and a scanning of group B completes.

Note: When group A priority control operation mode is enabled (ADCSR.ADCS[1:0] bits = 01b and ADGSPCR.PGS bit = 1), do not set the ADST bit to 1.

Note: When group A priority control operation mode is enabled (ADCSR.ADCS[1:0] bits = 01b and ADGSPCR.PGS bit = 1), do not set the ADST bit to 0. When forcing A/D conversion to terminate, follow the procedure for clearing the ADST bit.

Note: If the single scan continuous function is used (ADGSPCR.GBRP = 1) when the group priority operation mode is enabled (ADCSR.ADCS[1:0] = 01b and ADGSPCR.PGS = 1), the ADST bit is retained to 1.

Table 35.5 AD转换的可选目标取决于扫描和双触发模式设置

扫描模式设置	双触发模式设置	AD转换的目标				
		Self-diagnosis	模拟量输入（包括A组）	模拟输入（B组）	温度传感器输出	内部参考电压
单次扫描	DBLE = 0	✓	✓	-	✓	✓
	DBLE = 1	-	✓ (1 ch only)	-	-	-
连续扫描	DBLE = 0	✓	✓	-	✓	✓
	DBLE = 1	-	-	-	-	-
组扫描	DBLE = 0	✓	✓	✓	✓	✓
	DBLE = 1	-	✓ (1 ch only)	✓	✓	✓

：可选择。–：不可选择。

ADST位（AD转换开始）

ADST位启动或停止AD转换过程。在将ADST位设置为1之前，设置转换目标的AD转换时钟、转换模式和模拟输入。

[Setting conditions]

- 1由软件编写
- 当ADCSR.EXTRG为0且ADCSR.TRGE为1时，检测到在ADSTRGR.TRSA[5:0]位中选择的同步触发(ELC)
- 在组扫描模式下，当ADCSR.TRGE设置为1时，检测到在ADSTRGR.TRSB[5:0]位中选择的同步触发(ELC)
- 当ADCSR.TRGE和ADCSR.EXTRG位设置为1并且ADSTRGR.TRSA[5:0]位设置为000000b
- 当A组优先控制操作模式使能时（ADCSR.ADCS[1:0]位=01b和ADGSPCR.PGS位=1），ADGSPCR.GBRP位设置为1，并且B组的AD转换开始。

[Clearing conditions]

- 0是软件写的
- 所有选定通道的AD转换、温度传感器输出或内部参考电压在单次扫描模式下完成
- A组扫描在组扫描模式下完成
- B组扫描在组扫描模式下完成
- 当A组优先控制操作模式使能时（ADCSR.ADCS[1:0]位=01b和ADGSPCR.PGS位=1），ADGSPCR.GBRP位设置为1，B组扫描完成。

Note: 当启用A组优先控制操作模式时（ADCSR.ADCS[1:0]位=01b和ADGSPCR.PGS位=1），请勿将ADST位设置为1。

Note: 当启用A组优先控制操作模式时（ADCSR.ADCS[1:0]位=01b和ADGSPCR.PGS位=1），请勿将ADST位设置为0。当强制AD转换终止时，请遵循以下步骤清除ADST位。

Note: 如果在启用组优先操作模式（ADCSR.ADCS[1:0]=01b和ADGSPCR.PGS=1）时使用单次扫描连续功能（ADGSPCR.GBRP=1），则ADST位保持为1。

35.2.4 A/D Channel Select Register A0 (ADANSA0)

Address(es): ADC120.ADANSA0 4005 C004h, ADC121.ADANSA0 4005 C204h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	ANSA07	ANSA06	ANSA05	—	ANSA03	ANSA02	ANSA01	ANSA00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	ANSA03 to ANSA00	A/D Conversion Channels Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7 to b5	ANSA07 to ANSA05	A/D Conversion Channels Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b15 to b8	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

ANSAn bits (n = 00 to 03, 05 to 07) (A/D Conversion Channels Select)

The ADANSA0.ANSAn bits select or deselect the analog input channels for A/D conversion for AN000 to AN003, AN005 to AN007 (unit 0) and AN100 to AN102, AN105 to AN107 (unit 1). The channels and the number of channels can be set arbitrarily. In unit 0, the ANSA00 bit is associated with AN000 and the ANSA07 bit with AN007. In unit 1, the ANSA00 bit is associated with AN100 and the ANSA07 bit with AN107.

In double trigger mode, the channel selected in the ADANSA0 register is invalid, and the channel selected in the ADCSR.DBLANS[4:0] bits is selected in group A instead.

In group scan mode, do not select the channels specified in A/D Channel Select Register B0 (ADANSB0) and A/D Channel Select Register B1 (ADANSB1). Only set the ADANSA0 register while the ADCSR.ADST bit is 0.

35.2.5 A/D Channel Select Register A1 (ADANSA1)

Address(es): ADC120.ADANSA1 4005 C006h, ADC121.ADANSA1 4005 C206h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	ANSA20	—	ANSA18	ANSA17	ANSA16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	ANSA18 to ANSA16	A/D Conversion Channels Select	0: Do not select associated input channel 1: Select associated input channel	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	ANSA20	A/D Conversion Channel Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

ANSAn bits (n = 16 to 18, 20) (A/D Conversion Channels Select)

The ADANSA1.ANSAn bits select or deselect the analog input channels for A/D conversion for AN016 to AN018, AN020 (unit 0) and AN116, AN117 (unit 1). The channels and the number of channels can be set arbitrarily. In unit 0, the ANSA16 bit is associated with AN016 and the ANSA20 bit with AN020. In unit 1, the ANSA16 bit is associated with AN116 and the ANSA17 bit with AN117.

In double trigger mode, the ANSA1[15:0] bits are invalid, and the channel selected in the ADCSR.DBLANS[15:0] bits is selected in group A instead.

35.2.4 AD通道选择寄存器A0(ADANSA0)

Address(es): ADC120.ADANSA0 4005 C004h, ADC121.ADANSA0 4005 C204h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	ANSA07	ANSA06	ANSA05	—	ANSA03	ANSA02	ANSA01	ANSA00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	ANSA03 to ANSA00	AD转换通道选择	0：不选择关联输入通道1：选择关联输入通道。	R/W
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b7 to b5	ANSA07 to ANSA05	AD转换通道选择	0：不选择关联输入通道1：选择关联输入通道。	R/W
b15 to b8	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ANSAN位（n=00到03、05到07）（AD转换通道选择）

ADANSA0.ANSAN位选择或取消选择AN000到AN003的AD转换的模拟输入通道，AN005至AN007（单元0）和AN100至AN102、AN105至AN107（单元1）。通道和通道数可以任意设置。在单元0中，ANSA00位与AN000相关联，ANSA07位与AN007相关联。在单元1中，ANSA00位与AN100相关联，ANSA07位与AN107相关联。

双触发模式下，ADANSA0寄存器中选择的通道无效，在ADANSA0寄存器中选择的通道无效。改为在A组中选择ADCSR.DBLANS[4:0]位。

在组扫描模式下，不要选择AD通道选择寄存器B0(ADANSB0)和AD中指定的通道通道选择寄存器B1(ADANSB1)。仅在ADCSR.ADST位为0时设置ADANSA0寄存器。

35.2.5 AD通道选择寄存器A1(ADANSA1)

Address(es): ADC120.ADANSA1 4005 C006h, ADC121.ADANSA1 4005 C206h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	ANSA20	—	ANSA18	ANSA17	ANSA16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	ANSA18 to ANSA16	AD转换通道 Select	0：不选择关联输入通道1：选择关联输入通道	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	ANSA20	AD转换通道 Select	0：不选择关联输入通道1：选择关联输入通道。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ANSAN位（n=16至18、20）（AD转换通道选择）

ADANSA1.ANSAN位选择或取消选择用于AN016到AN018的AD转换的模拟输入通道，AN020（单元0）和AN116、AN117（单元1）。通道和通道数可以任意设置。在单元0中，ANSA16位与AN016相关联，ANSA20位与AN020相关联。在单元1中，ANSA16位与AN116和ANSA17位与AN117。

双触发模式下，ANSA1[15:0]位无效，ADCSR.DBLANS[15:0]位选择的通道改为A组。

In group scan mode, do not select the channels specified in A/D Channel Select Register B0 (ADANSB0) and A/D Channel Select Register B1 (ADANSB1). Only set the ADANSA1 register while the ADCSR.ADST bit is 0.

35.2.6 A/D Channel Select Register B0 (ADANSB0)

Address(es): ADC120.ADANSB0 4005 C014h, ADC121.ADANSB0 4005 C214h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	ANSB07	ANSB06	ANSB05	—	ANSB03	ANSB02	ANSB01	ANSB00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	ANSB03 to ANSB00	A/D Conversion Channels Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7 to b5	ANSB07 to ANSB05	A/D Conversion Channels Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b15 to b8	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

ANSBn bits (n = 00 to 03, 05 to 07) (A/D Conversion Channels Select)

The ADANSB0.ANSBn bits select the analog input channels for A/D conversion for AN000 to AN003, AN005 to AN007 (unit 0) and AN100 to AN102, AN105 to AN107 (unit 1) in group B in group scan mode. The ADANSB0 register is only used for group scan mode, not for any other modes. Exclude the channels specified in group A (the channels associated with group A, selected in the ADANSA0 and ADANSA1 registers and the ADCSR.DBLANS[4:0] bits in double trigger mode), both the selected channels and the number of channels to be set.

In unit 0, the ANSB00 bit is associated with AN000 and the ANSB07 bit with AN007. In unit 1, the ANSB00 bit is associated with AN100 and the ANSB07 bit with AN107. Only set the ADANSB0 register while the ADCSR.ADST bit is 0.

35.2.7 A/D Channel Select Register B1 (ADANSB1)

Address(es): ADC120.ADANSB1 4005 C016h, ADC121.ADANSB1 4005 C216h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	ANSB20	—	ANSB18	ANSB17	ANSB16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	ANSB18 to ANSB16	A/D Conversion Channels Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	ANSB20	A/D Conversion Channel Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

ANSBn bits (n = 16 to 18, 20) (A/D Conversion Channels Select)

The ADANSB1.ANSBn bits select the analog input channels for A/D conversion for AN016 to AN018, AN020 (unit 0) and AN116, AN117 (unit 1) in group B in group scan mode. The ADANSB1 register is only used for group scan mode, not for any other modes. Exclude the channels specified in group A (the channels associated with group A, selected in the ADANSA0 and ADANSA1 registers and the ADCSR.DBLANS[4:0] bits in double trigger mode), both the selected channels and the number of channels to be set.

在组扫描模式下，不要选择AD通道选择寄存器B0(ADANSB0)和AD中指定的通道通道选择寄存器B1(ADANSB1)。仅在ADCSR.ADST位为0时设置ADANSA1寄存器。

35.2.6 AD通道选择寄存器B0(ADANSB0)

Address(es): ADC120.ADANSB0 4005 C014h, ADC121.ADANSB0 4005 C214h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	ANSB07	ANSB06	ANSB05	—	ANSB03	ANSB02	ANSB01	ANSB00
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	ANSB03 to ANSB00	AD转换通道 Select	0：不选择关联输入通道1：选择关联输入通道。	R/W
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b7 to b5	ANSB07 to ANSB05	AD转换通道 Select	0：不选择关联输入通道1：选择关联输入通道。	R/W
b15 to b8	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ANSBn位（n=00到03、05到07）（AD转换通道选择）

ADANSB0.ANSBn位在组扫描模式下为B组中的AN000到AN003、AN005到AN007（单元0）和AN100到AN102、AN105到AN107（单元1）选择AD转换的模拟输入通道。ADANSB0寄存器仅用于组扫描模式，不用于任何其他模式。排除A组中指定的通道（与A组关联的通道，在ADANSA0和ADANSA1寄存器以及双触发模式下的ADCSR.DBLANS[4:0]位中选择），选择的通道和通道数都是放。

在单元0中，ANSB00位与AN000相关联，ANSB07位与AN007相关联。在单元1中，ANSB00位与AN100相关联，ANSB07位与AN107相关联。仅在ADCSR.ADST位为0时设置ADANSB0寄存器。

35.2.7 AD通道选择寄存器B1(ADANSB1)

Address(es): ADC120.ADANSB1 4005 C016h, ADC121.ADANSB1 4005 C216h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	ANSB20	—	ANSB18	ANSB17	ANSB16
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	ANSB18 to ANSB16	AD转换通道 Select	0：不选择关联输入通道1：选择关联输入通道。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	ANSB20	AD转换通道 Select	0：不选择关联输入通道1：选择关联输入通道。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ANSBn位（n=16至18、20）（AD转换通道选择）

ADANSB1.ANSBn位在组扫描模式下选择B组中AN016到AN018、AN020（单元0）和AN116、AN117（单元1）的AD转换的模拟输入通道。ADANSB1寄存器仅用于组扫描模式，不用于任何其他模式。排除A组中指定的通道（与A组关联的通道，在ADANSA0和ADANSA1寄存器以及双触发模式下的ADCSR.DBLANS[4:0]位中选择），选择的通道和通道数都是放。

In unit 0, the ANSB16 bit is associated with AN016 and the ANSB20 bit with AN020. In unit 1, the ANSB16 bit is associated with AN116 and the ANSB17 bit with AN117. Only set the ADANSB1 register bits while the ADST bit is 0.

35.2.8 A/D-Converted Value Addition/Average Channel Select Register 0 (ADADS0)

Address(es): ADC120.ADADS0 4005 C008h, ADC121.ADADS0 4005 C208h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	ADS07	ADS06	ADS05	—	ADS03	ADS02	ADS01	ADS00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	ADS03 to ADS00	A/D-Converted Value Addition/Average Channel Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7 to b5	ADS07 to ADS05	A/D-Converted Value Addition/Average Channel Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b15 to b8	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

ADSn bits (n = 00 to 03, 05 to 07) (A/D-Converted Value Addition/Average Channel Select)

When the ADSn bit with the same number as the A/D-converted channel selected in the ANSAn bits (n = 00 to 03, 05 to 07) in ADANSA0, or the ADCSR.DBLANS[4:0] bits and the ANSBn bits (n = 00 to 03, 05 to 07) in ADANSB0 is set to 1, A/D conversion of the analog input of the selected channels is performed successively 1 to 16 times, as specified in the ADC[2:0] bits in ADADC. When the ADADC.AVEE bit is 0, the value obtained by addition is stored in the A/D data register. When the ADADC.AVEE bit is 1, the mean value of the results obtained by addition is stored in the A/D data register. For A/D-converted channels for which addition or average mode is not selected, a normal one-time conversion is executed, and the conversion result is stored in the A/D data register.

In unit 0, the ADS00 bit is associated with AN000 and the ADS07 bit with AN007. In unit 1, the ADS00 bit is associated with AN100 and the ADS07 bit with AN107.

Only set the ADADS0 register bits while the ADCSR.ADST bit is 0.

35.2.9 A/D-Converted Value Addition/Average Channel Select Register 1 (ADADS1)

Address(es): ADC120.ADADS1 4005 C00Ah, ADC121.ADADS1 4005 C20Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	ADS20	—	ADS18	ADS17	ADS16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	ADS18 to ADS16	A/D-Converted Value Addition/Average Channel Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	ADS20	A/D-Converted Value Addition/Average Channel Select	0: Do not select associated input channel 1: Select associated input channel.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

ADSn bits (n = 16 to 18, 20) (A/D-Converted Value Addition/Average Channel Select)

When the ADSn bit with the same number as the A/D-converted channel selected in the ANSAn bits (n = 16 to 18, 20) in ADANSA1 or the ADCSR.DBLANS[4:0] and ANSBn bits (n = 16 to 18, 20) in ADANSB1 is set to 1, A/D conversion

在单元0中，ANSB16位与AN016相关联，ANSB20位与AN020相关联。在单元1中，ANSB16位与AN116相关联，ANSB17位与AN117相关联。仅当ADST位为0时设置ADANSB1寄存器位。

35.2.8 D转换值加法平均通道选择寄存器0(ADADS0)

Address(es): ADC120.ADADS0 4005 C008h, ADC121.ADADS0 4005 C208h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	ADS07	ADS06	ADS05	—	ADS03	ADS02	ADS01	ADS00
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	ADS03 to ADS00	A/D-Converted Value 加法平均频道选择	0：不选择关联输入通道1：选择关联输入通道。	R/W
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b7 to b5	ADS07 to ADS05	A/D-Converted Value 加法平均频道选择	0：不选择关联输入通道1：选择关联输入通道。	R/W
b15 to b8	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ADSn位（n=00至03、05至07）（AD转换值加法平均通道选择）

当在ADANSA0的ANSAn位（n=00至03、05至07）或ADCSR.DBLANS[4:0]位和ANSBn位（ADANSB0中的n=00到03 05到07)设置为1，所选通道的模拟输入的AD转换连续执行1到16次，如ADADC中的ADC[2:0]位指定。当ADADC.AVEE位为0时，相加得到的值存储在AD数据寄存器中。当ADADC.AVEE位为1时，加法所得结果的平均值存储在AD数据寄存器中。对于未选择加法或平均模式的AD转换通道，将执行一次正常的一次性转换，并将转换结果存储在AD数据寄存器中。

在单元0中，ADS00位与AN000相关联，ADS07位与AN007相关联。在单元1中，ADS00位与AN100相关联，ADS07位与AN107相关联。

仅在ADCSR.ADST位为0时设置ADADS0寄存器位。

35.2.9 D转换值加法平均通道选择寄存器1(ADADS1)

Address(es): ADC120.ADADS1 4005 C00Ah, ADC121.ADADS1 4005 C20Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	ADS20	—	ADS18	ADS17	ADS16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	ADS18 to ADS16	A/D-Converted Value 加法平均频道选择	0：不选择关联输入通道1：选择关联输入通道。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	ADS20	A/D-Converted Value 加法平均频道选择	0：不选择关联输入通道1：选择关联输入通道。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ADSn位（n=16到18、20）（AD转换的增值平均通道选择）

当ADSn位与在ADANSA1的ANSAn位（n=16到18、20）或ADCSR.DBLANS[4:0]和ANSBn位（n=16到18 20)在ADANSB1中设置为1 AD转换

of the analog input of the selected channels is performed successively 1 to 16 times, as specified in the ADC[2:0] bits in ADADC. When the ADADC.AVEE bit is 0, the value obtained by addition (integration) is stored in the A/D data register. When the ADADC.AVEE bit is 1, the mean value of the results obtained by addition is stored in the A/D data register. For A/D-converted channels for which addition/average mode is not selected, a normal one-time conversion is executed and the conversion result is stored in the A/D data register.

In unit 0, the ADS16 bit is associated with AN016 and the ADS20 bit with AN020. In unit 1, the ADS16 bit is associated with AN116 and the ADS17 bit with AN117. Only set the ADADS1 register while the ADCSR.ADST bit is 0.

Figure 35.3 shows a scanning operation sequence in which both the ADADS0.ADS02 and ADS07 bits are set to 1.

In this example, addition mode is selected (ADADS.AVEE = 0), the time conversion is set to 4 (ADADC.ADC[1:0] = 11b), and the AN000 to AN003 and AN005 to AN007 channels are selected (ADANSA0.ANSA0[15:0] = 00EFh) in continuous scan mode (ADCSR.ADCS[1:0] = 10b). The conversion process begins with AN000. The AN002 conversion is performed successively 4 times, and the added (integrated) value is returned to A/D data register ADDR2. Next, the AN003 conversion process starts. The AN007 conversion is performed successively 4 times and the added (integrated) value is returned to A/D data register, ADDR7. After conversion of AN007, the conversion operation is once again performed in the same sequence from AN000.

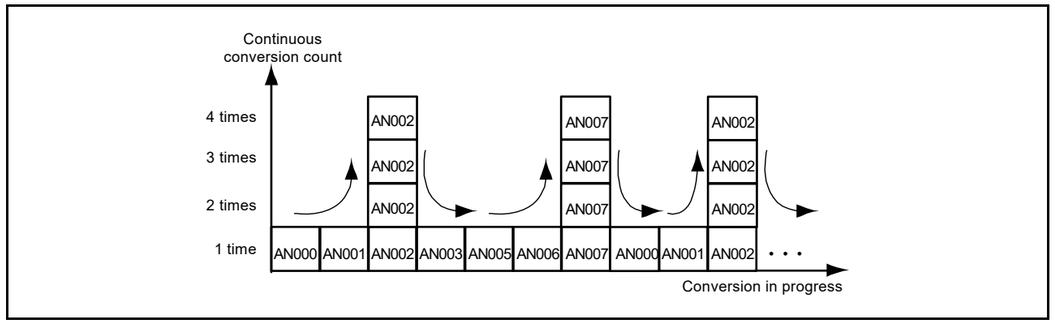


Figure 35.3 Scan conversion sequence with ADADC.ADC[2:0] = 011b, ADADS0.ADS02 = 1, and ADS07 = 1

35.2.10 A/D-Converted Value Addition/Average Count Select Register (ADADC)

Address(es): ADC120.ADADC 4005 C00Ch, ADC121.ADADC 4005 C20Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	AVEE	—	—	—	—	ADC[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	ADC[2:0]	Count Select	b2 b0 0 0: 0: 1-time conversion (no addition, same as normal conversion) 0 0: 1: 2 time conversion (one addition) 0 1: 0: 3-time conversion (two additions) 0 1: 1: 4 time conversion (three additions) 1 0: 1: 16-time conversion (15 additions). Other settings are prohibited.	R/W
b6 to b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	AVEE	Average Mode Enable	0: Disable average mode*1 1: Enable average mode.*2	R/W

Note 1. When average mode is deselected by setting the ADADC.AVEE bit to 0, set addition count to 1, 2, 3, 4 or 16-time conversion. 16-time conversion can only be used with 12-bit accuracy selected.

Note 2. When average mode is selected by setting the ADADC.AVEE bit to 1, set the addition count to 1-, 2-, or 4-time conversion. Do not set the addition count to 3- or 16-time conversion (ADC[2:0] = 010b or 101b).

按照ADADC中的ADC[2:0]位的规定，对选定通道的模拟输入连续执行1到16次。当ADADC.AVEE位为0时，加法（积分）得到的值存储在AD数据寄存器中。当ADADC.AVEE位为1时，加法所得结果的平均值存储在AD数据寄存器中。对于未选择加法平均模式的AD转换通道，将执行正常的一次性转换，并将转换结果存储在AD数据寄存器中。

在单元0中，ADS16位与AN016相关联，ADS20位与AN020相关联。在单元1中，ADS16位与AN116相关联，ADS17位与AN117相关联。仅在ADCSR.ADST位为0时设置ADADS1寄存器。

图35.3显示了扫描操作序列，其中ADADS0.ADS02和ADS07位都设置为1。

在本例中，选择了加法模式（ADADS.AVEE=0），时间转换设置为4（ADADC.ADC[1:0]=11b），选择了AN000到AN003和AN005到AN007通道（ADANSA0.ANSA0[15:0]=00EFh)处于连续扫描模式(ADCSR.ADCS[1:0]=10b)。转换过程从AN000开始。AN002转换连续执行4次，相加（积分）的值返回到AD数据寄存器ADDR2。接下来，AN003转换过程开始。AN007转换连续执行4次，相加（积分）的值返回到AD数据寄存器ADDR7。在AN007转换后，转换操作从AN000以相同的顺序再次执行。

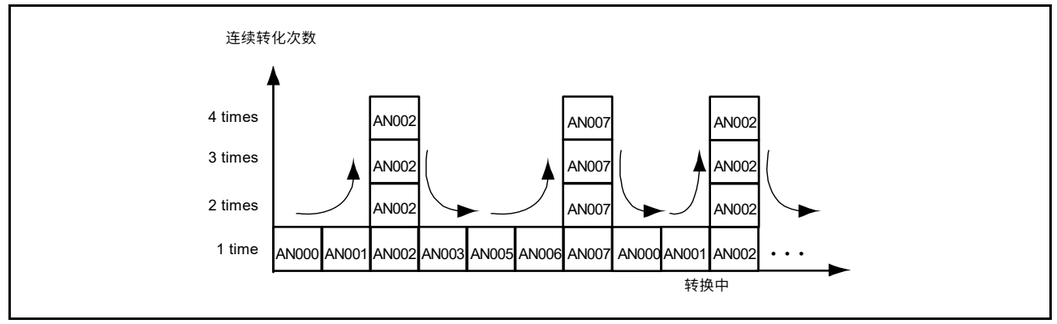


Figure 35.3 使用ADADC.ADC[2:0]=011b、ADADS0.ADS02=1和ADS07=1的扫描转换序列

35.2.10 D转换值加法平均计数选择寄存器(ADADC)

Address(es): ADC120.ADADC 4005 C00Ch, ADC121.ADADC 4005 C20Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	AVEE	—	—	—	—	ADC[2:0]		
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	ADC[2:0]	计数选择	b2 b0 0 0: 0：1次转换（不加，同普通转换） 0 0: 1：2时间转换（一加） 0 1: 0: 3-time conversion (two additions) 0 1: 1：4时间转换（三加法） 01：16次转换（15次加法）。禁止其他设置。	R/W
b6 to b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	AVEE	平均模式启用	0：禁用平均模式*11：启用平均模式。*2	R/W

Note 1. 当通过将ADADC.AVEE位设置为0取消选择平均模式时，将加法计数设置为1、2、3、4或16次转换。16次转换只能在选择12位精度的情况下使用。

Note 2. 当通过将ADADC.AVEE位设置为1来选择平均模式时，将加法计数设置为1次、2次或4次转换。不要将加法计数设置为3次或16次转换（ADC[2:0]=010b或101b）。

ADC[2:0] bits (Count Select)

The ADC[2:0] bits set the count for all channels for which A/D conversion and addition/average mode are selected, including the channels selected in double trigger mode in the ADCSR.DBLANS[4:0] bits. The count also applies to A/D conversion of temperature sensor output and internal reference voltage.

When average mode is selected by setting the ADADC.AVEE bit to 1, do not set the count to 3-time conversion (ADADC.ADC[2:0] = 010b). Additionally, the combination of 16-time conversion (ADADC.ADC[2:0] = 101b) with a conversion accuracy setting of 8 or 10 bits (ADCER.ADPRC[1:0] = 10b or 01b) is a prohibited setting, as described in section 35.2.1.

Only set the ADC[2:0] bits while the ADCSR.ADST bit is 0. When self-diagnosis is executed (ADCER.DIAGM = 1), do not set the ADC[2:0] bits to any value other than 000b. When the conversion accuracy is 8 or 10 bits (ADCER.ADPRC[1:0] = 10b or 01b), do not set the ADC[2:0] bits to 101b.

AVEE bit (Average Mode Enable)

The AVEE bit selects addition or average mode for all channels for which A/D conversion and addition/average mode are selected, including the channels selected in double trigger mode in the ADCSR.DBLANS[4:0] bits, temperature sensor output, and internal reference voltage.

When average mode is selected by setting the ADADC.AVEE bit to 1, do not set the addition count to 3-time conversion (ADADC.ADC[2:0] = 010b).

Only set the AVEE bits while the ADCSR.ADST bit is 0.

35.2.11 A/D Control Extended Register (ADCER)

Address(es): ADC120.ADCER 4005 C00Eh, ADC121.ADCER 4005 C20Eh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ADRFMT	—	—	—	DIAGM	DIAGLD	DIAGVAL[1:0]		—	—	ACE	—	—	ADPRC[1:0]		—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b2, b1	ADPRC[1:0]	A/D Conversion Accuracy Specify	b2 b1 0 0: 12-bit accuracy 0 1: 10-bit accuracy 1 0: 8-bit accuracy 1 1: Setting prohibited.	R/W
b4, b3	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b5	ACE	A/D Data Register Automatic Clearing Enable	0: Disable automatic clearing 1: Enable automatic clearing.	R/W
b7, b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b9, b8	DIAGVAL[1:0]	Self-Diagnosis Conversion Voltage Select	b9 b8 0 0: Setting prohibited when self-diagnosis is enabled 0 1: 0 V 1 0: Reference power supply voltage*1 x 1/2 1 1: Reference power supply voltage.*1	R/W
b10	DIAGLD	Self-Diagnosis Mode Select	0: Select rotation mode for self-diagnosis voltage 1: Select mixed mode for self-diagnosis voltage.	R/W
b11	DIAGM	Self-Diagnosis Enable	0: Disable ADC12 self-diagnosis 1: Enable ADC12 self-diagnosis.	R/W
b14 to b12	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15	ADRFMT	A/D Data Register Format Select	0: Select flush-right for the A/D data register format 1: Select flush-left for the A/D data register format.	R/W

Note 1. The reference voltage refers to VREFH0 for unit 0 and to VREFH for unit 1.

ADC[2:0]位（计数选择）

ADC[2:0]位设置选择AD转换和加法平均模式的所有通道的计数，包括在ADCSR.DBLANS[4:0]位中以双触发模式选择的通道。该计数也适用于温度传感器输出和内部参考电压的AD转换。

当通过将ADADC.AVEE位设置为1来选择平均模式时，不要将计数设置为3次转换(ADADC.ADC[2:0]=010b)。此外，16次转换(ADADC.ADC[2:0]=101b)与8位或10位转换精度设置(ADCER.ADPRC[1:0]=10b或01b)的组合是禁止设置，如第35.2.1节所述。

仅在ADCSR.ADST位为0时设置ADC[2:0]位。执行自诊断时(ADCER.DIAGM=1)，请勿将ADC[2:0]位设置为000b以外的任何值.当转换精度为8位或10位时（ADCER.ADPRC[1:0]=10b或01b），请勿将ADC[2:0]位设置为101b。

AVEE位（平均模式启用）

AVEE位为所有选择AD转换和加法平均模式的通道选择加法或平均模式，包括在ADCSR.DBLANS[4:0]位、温度传感器输出和内部参考电压中选择双触发模式的通道.

当通过将ADADC.AVEE位设置为1来选择平均模式时，不要将加法计数设置为3次转换(ADADC.ADC[2:0]=010b)。

仅在ADCSR.ADST位为0时设置AVEE位。

35.2.11 AD控制扩展寄存器(ADCER)

Address(es): ADC120.ADCER 4005 C00Eh, ADC121.ADCER 4005 C20Eh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	ADRFMT	—	—	—	DIAGM	DIAGLD	DIAGVAL[1:0]		—	—	ACE	—	—	ADPRC[1:0]		—
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	—	Reserved	该位读取为0。写入值应为0。	R/W
b2, b1	ADPRC[1:0]	AD转换精度指定	b2b100：12位精度01：10位精度10：8位精度11：禁止设置。	R/W
b4, b3	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b5	ACE	AD数据寄存器自动清零Enable	0：禁用自动清零1：启用自动清零。	R/W
b7, b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b9, b8	DIAGVAL[1:0]	自诊断转换电压Select	b9b800：自诊断有效时禁止设置01：0V10：参考电源电压*1x1211：参考电源电压*1	R/W
b10	DIAGLD	自诊断模式选择	0：自诊断电压选择旋转模式1：自诊断电压选择混合模式。	R/W
b11	DIAGM	Self-Diagnosis Enable	0：禁用ADC12自诊断1：启用ADC12自诊断。	R/W
b14 to b12	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15	ADRFMT	AD数据寄存器格式选择	0：AD数据寄存器格式选择flush-right1：AD数据寄存器格式选择flush-left。	R/W

Note 1. 参考电压是指单元0的VREFH0和单元1的VREFH。

ADPRC[1:0] bits (A/D Conversion Accuracy Specify)

The ADPRC[1:0] bits set the A/D conversion accuracy to 8-, 10-, or 12-bit accuracy. Changing the A/D conversion accuracy also changes the bit width of valid data stored in the result register and the A/D conversion time. For details, see section 35.3.6, Analog Input Sampling and Scan Conversion Time.

Only set the ADPRC[1:0] bits while the ADCSR.ADST bit is 0.

ACE bit (A/D Data Register Automatic Clearing Enable)

The ACE bit enables or disables automatic clearing (all 0s) of ADDRy, ADRD, ADDBLDR, ADDBLDRA, ADDBLDRB, ADTSDR, or ADOCDR after any of these registers is read by the CPU, DTC, or DMAC. Automatic clearing of the A/D data registers enables detection of failures that do not update the A/D data registers.

DIAGVAL[1:0] bits (Self-Diagnosis Conversion Voltage Select)

The DIAGVAL[1:0] bits select the voltage value used in self-diagnosis fixed voltage mode. For details, see the ADCER.DIAGLD bit description.

Do not execute self-diagnosis by setting the ADCER.DIAGLD bit to 1 when the ADCER.DIAGVAL[1:0] bits are set to 00b.

DIAGLD bit (Self-Diagnosis Mode Select)

The DIAGLD bit selects whether the three voltage values are rotated, or fixed voltage is used in self-diagnosis. Setting this bit to 0 allows conversion of the voltages in rotation mode where 0 V, the reference power supply × 1/2, and the reference power supply are converted, in that order. After reset, when the self-diagnosis voltage rotation mode is selected, self-diagnosis is executed from 0 V. The fixed voltage specified in the ADCER.DIAGVAL[1:0] bits is converted when self-diagnosis fixed voltage mode is selected. In self-diagnosis voltage rotation mode, the self-diagnosis voltage value does not return to 0 when scan conversion completes. When scan conversion restarts, rotation starts at the voltage value following the previous value. If fixed mode is switched to rotation mode, rotation starts at the fixed voltage value.

Only set the DIAGLD bit while the ADCSR.ADST bit is 0.

DIAGM bit (Self-Diagnosis Enable)

The DIAGM bit enables or disables self-diagnosis. Self-diagnosis is used to detect a failure of the ADC12. In self-diagnosis mode, one of the internally generated voltage values (0, the reference power supply × 1/2, or the reference power supply) is converted. When conversion completes, information on the converted voltage and the conversion result is stored in the A/D Self-Diagnosis Data Register (ADRD). ADRD can be read by software to determine whether the conversion result falls within the normal range (normal) or not (abnormal). Self-diagnosis is executed once at the beginning of each scan, and one of the three voltages is converted. When the double trigger mode is set (ADCSR.DBLE = 1), always deselect self-diagnosis (DIAGM = 0). When self-diagnosis is selected in group scan mode, self-diagnosis is executed separately on group A and group B.

Only set the DIAGM bit while the ADCSR.ADST bit is 0.

ADRFMT bit (A/D Data Register Format Select)

The ADRFMT bit specifies flush-right or flush-left for the data to be stored in ADDRy, ADDBLDR, ADDBLDRA, ADDBLDRB, ADTSDR, ADOCDR, ADCMPDR0/1, ADWINLLB, ADWINULB, or ADRD.

Only set the ADRFMT bit when the ADCSR.ADST bit is 0.

ADPRC[1:0]位（AD转换精度指定）

ADPRC[1:0]位将AD转换精度设置为8位、10位或12位精度。更改AD转换精度也会更改存储在结果寄存器中的有效数据的位宽和AD转换时间。有关详细信息，请参见第35.3.6节，模拟输入采样和扫描转换时间。

仅在ADCSR.ADST位为0时设置ADPRC[1:0]位。

ACE位（AD数据寄存器自动清除使能）

ACE位启用或禁用ADDRy、ADRD、ADDBLDR、ADDBLDRA、
在CPU、DTC或DMAC读取任何这些寄存器之后的ADDBLDRB、ADTSDR或ADOCDR。自动清除AD数据寄存器可以检测不更新AD数据寄存器的故障。

DIAGVAL[1:0]位（自诊断转换电压选择）

DIAGVAL[1:0]位选择用于自诊断固定电压模式的电压值。有关详细信息，请参阅
ADCER.DIAGLD位描述。

当ADCER.DIAGVAL[1:0]位设置为00b时，不要通过将ADCER.DIAGLD位设置为1来执行自诊断。

DIAGLD位（自诊断模式选择）

DIAGLD位选择是轮换三个电压值，还是使用固定电压进行自诊断。将此位设置为0允许在旋转模式下转换电压，其中0V、参考电源×12和参考电源按此顺序转换。Afterreset whentheself-diagnosisvoltagerotationmodeisselected self-diagnosisisexecutedfrom0V.ThefixedvoltagespecifiedintheADCER.DIAGVAL[1:0]bitsisconvertedwhenself-diagnosisfixedvoltagemodeisselected.在自诊断电压旋转模式下，扫描转换完成时自诊断电压值不会返回0。扫描转换重新开始时，从前一个值之后的电压值开始旋转。如果将固定模式切换到旋转模式，则从固定电压值开始旋转。

仅在ADCSR.ADST位为0时设置DIAGLD位。

DIAGM位（自诊断使能）

DIAGM位启用或禁用自诊断。自诊断用于检测ADC12的故障。在自诊断模式下，转换内部产生的电压值之一（0，参考电源×12，或参考电源）。转换完成后，转换电压和转换结果的信息存储在AD自诊断数据寄存器(ADRD)中。ADRD可以通过软件读取来判断转换结果是否在正常范围内（正常）或不在（异常）范围内。自诊断在每次扫描开始时执行一次，并转换三个电压之一。当设置双触发模式(ADCSR.DBLE=1)时，始终取消选择自诊断(DIAGM=0)。在组扫描模式下选择自诊断时，对A组和B组分别进行自诊断。

仅在ADCSR.ADST位为0时设置DIAGM位。

ADRFMT位（AD数据寄存器格式选择）

ADRFMT位指定要存储在ADDRy、ADDBLDR、ADDBLDRA、
ADDBLDRB, ADTSDR, ADOCDR, ADCMPDR0/1, ADWINLLB, ADWINULB, or ADRD.

仅当ADCSR.ADST位为0时才设置ADRFMT位。

35.2.12 A/D Conversion Start Trigger Select Register (ADSTRGR)

Address(es): ADC120.ADSTRGR 4005 C010h, ADC121.ADSTRGR 4005 C210h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	TRSA[5:0]						—	—	TRSB[5:0]					
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b5 to b0	TRSB[5:0]	A/D Conversion Start Trigger Select for Group B	These bits specify the A/D conversion start trigger for group B in group scan mode	R/W
b7, b6	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b13 to b8	TRSA[5:0]	A/D Conversion Start Trigger Select	These bits specify the A/D conversion start trigger in single scan mode and continuous mode. In group scan mode, the A/D conversion start trigger for group A is selected.	R/W
b15, b14	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

TRSB[5:0] bits (A/D Conversion Start Trigger Select for Group B)

The TRSB[5:0] bits select the trigger to start scanning of the analog input selected in group B. The TRSB[5:0] bits must only be set in group scan mode and are not used in any other scan mode. For the scan conversion start trigger for group B, setting a software trigger or an asynchronous trigger is prohibited. In group scan mode, set the TRSB[5:0] bits to a value other than 000000b, and set the ADCSR.TRGE bit to 1.

When group A is given priority in group scan mode, setting the ADGSPCR.GBRP bit to 1 allows group B to continuously operate in single scan mode. When setting the ADGSPCR.GBRP bit to 1, set the TRSB[5:0] bits to 3Fh. The issuance period for a conversion trigger must be more than or equal to the actual scan conversion time (t_{SCAN}). If the issuance period is less than t_{SCAN}, A/D conversion by the trigger might have no effect.

When the trigger from a module operated at 120 MHz (GPT) is selected as an A/D conversion start trigger, a delay for synchronization processing occurs. For details, see section 35.3.6, Analog Input Sampling and Scan Conversion Time.

Table 35.6 lists the A/D conversion startup sources selected in the TRSB[5:0] bits.

TRSA[5:0] bits (A/D Conversion Start Trigger Select)

The TRSA[5:0] bits select the trigger to start A/D conversion in single scan mode and continuous scan mode. In group scan mode, the trigger to start scanning of the analog input selected in group A is selected. When scanning is executed in group scan mode or double trigger mode, setting a software trigger or an asynchronous trigger is prohibited.

When using a synchronous trigger (ELC) as the A/D conversion start source, set the TRGE bit in ADCSR to 1 and the EXTRG bit in ADCSR to 0.

When using the asynchronous trigger (ADTRGn), set the TRGE bit in ADCSR to 1 and the EXTRG bit in ADCSR to 1.

The software trigger (ADCSR.ADST) is enabled regardless of the settings in the ADCSR.TRGE bit, the ADCSR.EXTRG bit, or the TRSA[5:0] bits. The issuance period for a conversion trigger must be more than or equal to the actual scan conversion time (t_{SCAN}). If the issuance period is less than t_{SCAN}, A/D conversion by the trigger might have no effect.

When the trigger from a module operated at 120 MHz (GPT) is selected as an A/D conversion start trigger, a delay period for synchronization processing occurs. For details, see section 35.3.6, Analog Input Sampling and Scan Conversion Time.

Table 35.7 lists the A/D conversion start sources selected in the TRSA[5:0] bits.

35.2.12 AD转换开始触发选择寄存器(ADSTRGR)

Address(es): ADC120.ADSTRGR 4005 C010h, ADC121.ADSTRGR 4005 C210h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	TRSA[5:0]						—	—	TRSB[5:0]					
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b5 to b0	TRSB[5:0]	B组的AD转换开始触发选择	这些位指定组扫描模式下B组的AD转换启动触发	R/W
b7, b6	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b13 to b8	TRSA[5:0]	AD转换开始触发选择	这些位指定单次扫描模式和连续模式下的AD转换启动触发。在组扫描模式下，选择A组的AD转换启动触发。	R/W
b15, b14	—	Reserved	这些位被读取为0。写入值应为0。	R/W

TRSB[5:0]位（B组的AD转换开始触发选择）

TRSB[5:0]位选择触发以开始扫描组B中选择的模拟输入。TRSB[5:0]位只能在组扫描模式下设置，不得用于任何其他扫描模式。对于B组的扫描转换开始触发，禁止设置软件触发或异步触发。在组扫描模式下，将TRSB[5:0]位设置为000000b以外的值，并将ADCSR.TRGE位设置为1。

当A组在组扫描模式下具有优先权时，将ADGSPCR.GBRP位设置为1允许B组在单次扫描模式下连续工作。将ADGSPCR.GBRP位设置为1时，将TRSB[5:0]位设置为3Fh。转换触发的发布周期必须大于或等于实际扫描转换时间(tSCAN)。如果发行周期小于tSCAN，触发器的AD转换可能无效。

当从120MHz（GPT）操作的模块中选择触发器作为AD转换启动触发器时，会发生同步处理的延迟。有关详细信息，请参见第35.3.6节，模拟输入采样和扫描转换时间。

表35.6列出了在TRSB[5:0]位中选择的AD转换启动源。

TRSA[5:0]位（AD转换开始触发选择）

TRSA[5:0]位选择触发以在单次扫描模式和连续扫描模式下启动AD转换。在组扫描模式下，选择触发开始扫描A组中选择的模拟输入。在组扫描模式或双触发模式下执行扫描时，禁止设置软件触发或异步触发。

当使用同步触发(ELC)作为AD转换启动源时，将ADCSR中的TRGE位设置为1，然后
ADCSR中的EXTRG位为0。

使用异步触发(ADTRGn)时，将ADCSR中的TRGE位设置为1，并将ADCSR中的EXTRG位设置为1。

无论ADCSR.TRGE位的设置如何，软件触发(ADCSR.ADST)都被启用，
ADCSR.EXTRG位或TRSA[5:0]位。转换触发的发布周期必须大于或等于实际扫描转换时间(tSCAN)。如果发行周期小于tSCAN，触发器的AD转换可能无效。

当从120MHz（GPT）操作的模块中选择触发器作为AD转换启动触发器时，会发生同步处理的延迟期。有关详细信息，请参见第35.3.6节，模拟输入采样和扫描转换时间。

表35.7列出了在TRSA[5:0]位中选择的AD转换起始源。

Table 35.6 Selection of A/D conversion start sources in the TRSB[5:0] bits

Source	Remarks	TRSB[5]	TRSB[4]	TRSB[3]	TRSB[2]	TRSB[1]	TRSB[0]
Trigger source deselected state		1	1	1	1	1	1
ELC_ADC00 (unit 0), ELC_ADC10 (unit 1)	ELC	0	0	1	0	0	1
ELC_ADC01 (unit 0), ELC_ADC11 (unit 1)	ELC	0	0	1	0	1	0
ELC_ADC00/ELC_ADC01 (unit 0) ELC_ADC10/ELC_ADC11 (unit 1)	ELC	0	0	1	0	1	1

Table 35.7 Selection of A/D activation sources in the TRSA[5:0] bits

Source	Remarks	TRSA[5]	TRSA[4]	TRSA[3]	TRSA[2]	TRSA[1]	TRSA[0]
Trigger source deselected state		1	1	1	1	1	1
ADTRGn	Input pin for the trigger	0	0	0	0	0	0
ELC_ADC00 (unit 0), ELC_ADC10 (unit 1)	ELC	0	0	1	0	0	1
ELC_ADC01 (unit 0), ELC_ADC11 (unit 1)	ELC	0	0	1	0	1	0
ELC_ADC00/ELC_ADC01 (unit 0) ELC_ADC10/ELC_ADC11 (unit 1)	ELC	0	0	1	0	1	1

35.2.13 A/D Conversion Extended Input Control Register (ADEXICR)

Address(es): ADC120.ADEXICR 4005 C012h, ADC121.ADEXICR 4005 C212h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	OCSB	TSSB	OCSA	TSSA	—	—	—	—	—	—	OCSAD	TSSAD
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	TSSAD	Temperature Sensor Output A/D-Converted Value Addition/Average Mode Select	0: Do not select addition/average mode for temperature sensor output 1: Select addition/average mode for temperature sensor output.	R/W
b1	OCSAD	Internal Reference Voltage A/D-Converted Value Addition/Average Mode Select	0: Do not select addition/average mode for internal reference voltage 1: Select addition/average mode for internal reference voltage.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b8	TSSA	Temperature Sensor Output A/D Conversion Select	0: Disable A/D conversion of temperature sensor output 1: Enable A/D conversion of temperature sensor output.	R/W
b9	OCSA	Internal Reference Voltage A/D Conversion Select	0: Disable A/D conversion of internal reference voltage 1: Enable A/D conversion of internal reference voltage.	R/W
b10	TSSB	Temperature Sensor Output A/D Conversion Select for group B	Selection for group B in group scan mode: 0: Disable A/D conversion of temperature sensor output 1: Enable A/D conversion of temperature sensor output.	R/W

Table 35.6 在TRSB[5:0]位中选择AD转换起始源

Source	Remarks	TRSB[5]	TRSB[4]	TRSB[3]	TRSB[2]	TRSB[1]	TRSB[0]
触发源取消选择状态		1	1	1	1	1	1
ELC_ADC00 (unit 0), ELC_ADC10 (unit 1)	ELC	0	0	1	0	0	1
ELC_ADC01 (unit 0), ELC_ADC11 (unit 1)	ELC	0	0	1	0	1	0
ELC_ADC00/ELC_ADC01 (unit 0) ELC_ADC10/ELC_ADC11 (unit 1)	ELC	0	0	1	0	1	1

Table 35.7 在TRSA[5:0]位中选择AD激活源

Source	Remarks	TRSA[5]	TRSA[4]	TRSA[3]	TRSA[2]	TRSA[1]	TRSA[0]
触发源取消选择状态		1	1	1	1	1	1
ADTRGn	触发器的输入引脚	0	0	0	0	0	0
ELC_ADC00 (unit 0), ELC_ADC10 (unit 1)	ELC	0	0	1	0	0	1
ELC_ADC01 (unit 0), ELC_ADC11 (unit 1)	ELC	0	0	1	0	1	0
ELC_ADC00/ELC_ADC01 (unit 0) ELC_ADC10/ELC_ADC11 (unit 1)	ELC	0	0	1	0	1	1

35.2.13 AD转换扩展输入控制寄存器(ADEXICR)

Address(es): ADC120.ADEXICR 4005 C012h, ADC121.ADEXICR 4005 C212h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	OCSB	TSSB	OCSA	TSSA	—	—	—	—	—	—	OCSAD	TSSAD
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	TSSAD	温度传感器输出AD转换后的增值平均值模式选择	0：温度传感器输出不选择加法平均模式1：温度传感器输出选择加法平均模式。	R/W
b1	OCSAD	内部参考电压AD转换后的增值平均值模式选择	0：内部参考电压不选择加法平均模式1：内部参考电压选择加法平均模式。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b8	TSSA	温度传感器输出AD转换选择	0：禁止温度传感器输出AD转换1：使能温度传感器输出AD转换。	R/W
b9	OCSA	内部参考电压AD转换选择	0：禁止内部参考电压的AD转换1：使能内部参考电压的AD转换。	R/W
b10	TSSB	温度传感器输出AD B组转换选择	组扫描模式下B组选择：0：禁止温度传感器输出AD转换1：使能温度传感器输出AD转换。	R/W

Bit	Symbol	Bit name	Description	R/W
b11	OCSB	Internal Reference Voltage A/D Conversion Select for group B	Selection for group B in group scan mode: 0: Disable A/D conversion of internal reference voltage 1: Enable A/D conversion of internal reference voltage.	R/W
b15 to b12	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

TSSAD bit (Temperature Sensor Output A/D-Converted Value Addition/Average Mode Select)

When the TSSAD bit is set to 1, A/D conversion of the temperature sensor output is selected and performed successively for the number of times specified in the ADC[2:0] bits in ADADC. The maximum addition count depends on the conversion accuracy, see section 35.2.1. When the ADADC.AVEE bit is 0, the value obtained by addition (integration) is returned to the A/D Temperature sensor Data Register (ADTSDR). When the ADADC.AVEE bit is 1, the mean value is returned to ADTSDR.

Only set the TSSAD bit while the ADCSR.ADST bit is 0.

OCSAD bit (Internal Reference Voltage A/D-Converted Value Addition/Average Mode Select)

When the OCSAD bit is set to 1, A/D conversion of the internal reference voltage is selected and performed successively the number of times specified in the ADC[2:0] bits in ADADC. The maximum addition count differs depending on the conversion accuracy as described in section 35.2.1. When the ADADC.AVEE bit is 0, the value obtained by addition is returned to the A/D Internal Reference Voltage Data Register (ADOCDR). When the ADADC.AVEE bit is 1, the mean value is returned to ADOCDR.

Only set the OCSAD bit while the ADCSR.ADST bit is 0.

TSSA bit (Temperature Sensor Output A/D Conversion Select)

The TSSA bit selects A/D conversion of the temperature sensor output for group A in single scan mode, continuous scan mode, or group scan mode. When A/D conversion of the temperature sensor output is selected and performed, set the ADCSR.DBLE bit to 0.

Only set the TSSA bit when the ADCSR.ADST bit is 0.

OCSA bit (Internal Reference Voltage A/D Conversion Select)

The OCSA bit selects A/D conversion of the internal reference voltage for group A in single scan mode, continuous scan mode, or group scan mode. When A/D conversion of the internal reference voltage is selected and performed, set the ADCSR.DBLE bit to 0.

Only set the OCSA bit while the ADCSR.ADST bit is 0. In addition, wait for 400 ns or more after the OCSA bit is set to 1 before starting A/D conversion.

TSSB bit (Temperature Sensor Output A/D Conversion Select for group B)

The TSSB bit selects A/D conversion of the temperature sensor output for group B in group scan mode.

Only set the TSSB bit while the ADCSR.ADST bit is 0. Do not set the TSSB bit to 1 while the TSSA bit is 1.

OCSB bit (Internal Reference Voltage A/D Conversion Select for group B)

The OCSB bit selects A/D conversion of the internal reference voltage for group B in group scan mode.

Only set the OCSB bit while the ADCSR.ADST bit is 0. Do not set the OCSB bit to 1 while the OCSA bit is 1. In addition, start the A/D conversion after waiting for 400 ns or more after the OCSB bit is set to 1.

Bit	Symbol	位名称	Description	R/W
b11	OCSB	内部参考电压AD B组转换选择	组扫描模式下B组选择：0：禁止内部参考电压AD转换1 ：允许内部参考电压AD转换。	R/W
b15 to b12	—	Reserved	这些位被读取为0。写入值应为0。	R/W

TSSAD位（温度传感器输出AD转换值加法平均模式选择）

当TSSAD位设置为1时，温度传感器输出的AD转换被选择并连续执行ADADC的ADC[2:0]位指定的次数。最大加法计数取决于转换精度，请参阅第35.2.1节。当ADADC.AVEE位为0时，通过加法（积分）获得的值返回到AD温度传感器数据寄存器(ADTSDR)。当ADADC.AVEE位为1时，平均值返回给ADTSDR。

仅在ADCSR.ADST位为0时设置TSSAD位。

OCSAD位（内部参考电压AD转换值加法平均模式选择）

当OCSAD位设置为1时，选择内部参考电压的AD转换，并按ADADC的ADC[2:0]位指定的次数连续执行。如第35.2.1节所述，最大加法计数因转换精度而异。当ADADC.AVEE位为0时，加法得到的值返回到AD内部参考电压数据寄存器(ADOCDR)。当ADADC.AVEE位为1时，平均值返回给ADOCDR。

仅在ADCSR.ADST位为0时设置OCSAD位。

TSSA位（温度传感器输出AD转换选择）

TSSA位在单次扫描模式、连续扫描模式或组扫描模式下选择A组温度传感器输出的AD转换。WhenADconversionofthetemperaturesensoroutputisselectedandperformed settheADCSR.DBLEbitto0.

仅当ADCSR.ADST位为0时设置TSSA位。

OCSA位（内部参考电压AD转换选择）

OCSA位在单次扫描模式、连续扫描模式或组扫描模式下选择A组内部参考电压的AD转换。WhenADconversionoftheinternalreferencevoltageisselectedandperformed settheADCSR.DBLEbitto0.

仅在ADCSR.ADST位为0时设置OCSA位。此外，在OCSA位设置为1后等待400ns或更长时间，然后再开始AD转换。

TSSB位（B组温度传感器输出AD转换选择）

TSSB位选择组扫描模式下B组温度传感器输出的AD转换。

仅在ADCSR.ADST位为0时设置TSSB位。不要在TSSA位为1时将TSSB位设置为1。

OCSB位（B组的内部参考电压AD转换选择）

OCSB位选择组扫描模式下B组内部参考电压的AD转换。

仅在ADCSR.ADST位为0时设置OCSB位。不要在OCSA位为1时将OCSB位设置为1。此外，在OCSB位设置为0后等待400ns或更长时间后开始AD转换1.

35.2.14 A/D Sampling State Register n (ADSSTRn) (n = 00 to 03, 05 to 07, L, T, O)

Address(es): ADC120.ADSSTR00 4005 C0E0h to ADC120.ADSSTR03 4005 C0E3h, ADC120.ADSSTR05 4005 C0E5h to ADC120.ADSSTR07 4005 C0E7h, ADC120.ADSSTRL 4005 C0DDh, ADC120.ADSSTRT 4005 C0DEh, ADC120.ADSSTRO 4005 C0DFh, ADC121.ADSSTR00 4005 C2E0h to ADC121.ADSSTR02 4005 C2E2h, ADC121.ADSSTR05 4005 C2E5h to ADC121.ADSSTR07 4005 C2E7h, ADC121.ADSSTRL 4005 C2DDh, ADC121.ADSSTRT 4005 C2DEh, ADC121.ADSSTRO 4005 C2DFh

	b7	b6	b5	b4	b3	b2	b1	b0
	SST[7:0]							
Value after reset:	0	0	0	0	1	0	1	1

Bit	Symbol	Bit name	Description	R/W
b7 to b0	SST[7:0]	Sampling Time Setting	These bits set the sampling time in the range from 5 to 255 states	R/W

The ADSSTRn register sets the sampling time for analog input. If one state is 1 ADCLK (A/D conversion clock) cycle and the ADCLK clock is 60 MHz, one state is 16.7 ns. The initial value is 11 states.

The sampling time can be adjusted if the impedance of the analog input signal source is too high to secure sufficient sampling time, or if the ADCLK clock is slow.

Only set the SST[7:0] bits while the ADCSR.ADST bit is 0.

The lower limit of the sampling time setting depends on the frequency ratio, as follows:

- If the frequency ratio of PCLKB to PCLKC(ADCLK) = 1:1, 2:1, 4:1, or 8:1, the sampling time must be set to a value of more than 5 states
- If the frequency ratio of PCLKB to PCLKC(ADCLK) = 1:2 or 1:4, the sampling time must be set to a value of more than 6 states.

Table 35.8 shows the relationship between the A/D Sampling State Register and the associated channels. For details, see section 35.3.6, Analog Input Sampling and Scan Conversion Time.

Table 35.8 Relationship between A/D Sampling State Register and associated channels

	Associated channels	
Bit name	Unit 0	Unit 1
ADSSTR00.SST[7:0] bits*1	AN000	AN100
ADSSTR01.SST[7:0] bits	AN001	AN101
ADSSTR02.SST[7:0] bits	AN002	AN102
ADSSTR03.SST[7:0] bits	AN003	-
ADSSTR05.SST[7:0] bits	AN005	AN105
ADSSTR06.SST[7:0] bits	AN006	AN106
ADSSTR07.SST[7:0] bits	AN007	AN107
ADSSTRL.SST[7:0] bits	AN016 to AN018 and AN020	AN116 and AN117
ADSSTRT.SST[7:0] bits	Temperature sensor output	Temperature sensor output
ADSSTRO.SST[7:0] bits	Internal reference voltage	Internal reference voltage

Note 1. When the self-diagnosis function is selected, the sampling time set in the ADSSTR00.SST[7:0] bits is applied.

35.2.14 AD采样状态寄存器n(ADSSTRn)（n=00至03、05至07、L、T、O）

Address(es): ADC120.ADSSTR00 4005 C0E0h to ADC120.ADSSTR03 4005 C0E3h, ADC120.ADSSTR05 4005 C0E5h to ADC120.ADSSTR07 4005 C0E7h, ADC120.ADSSTRL 4005 C0DDh, ADC120.ADSSTRT 4005 C0DEh, ADC120.ADSSTRO 4005 C0DFh, ADC121.ADSSTR00 4005 C2E0h to ADC121.ADSSTR02 4005 C2E2h, ADC121.ADSSTR05 4005 C2E5h to ADC121.ADSSTR07 4005 C2E7h, ADC121.ADSSTRL 4005 C2DDh, ADC121.ADSSTRT 4005 C2DEh, ADC121.ADSSTRO 4005 C2DFh

	b7	b6	b5	b4	b3	b2	b1	b0
	SST[7:0]							
重置后的值：	0	0	0	0	1	0	1	1

Bit	Symbol	位名称	Description	R/W
b7 to b0	SST[7:0]	采样时间设置	这些位在5到255个状态范围内设置采样时间	R/W

ADSSTRn寄存器设置模拟输入的采样时间。如果一种状态是1个ADCLK（AD转换时钟）周期并且ADCLK时钟是60MHz，则一种状态是16.7ns。初始值为11个状态。

如果模拟输入信号源的阻抗太高而无法保证足够的采样时间，或者如果ADCLK时钟很慢，则可以调整采样时间。

仅在ADCSR.ADST位为0时设置SST[7:0]位。

采样时间设置的下限取决于频率比，如下：

- 如果PCLKB与PCLKC(ADCLK)的频率比=1:1、2:1、4:1或8:1，则必须将采样时间设置为5个以上状态的值
- 如果PCLKB与PCLKC(ADCLK)的频率比=1:2或1:4，则必须将采样时间设置为6个以上状态的值。

表35.8显示了AD采样状态寄存器和相关通道之间的关系。有关详细信息，请参见第35.3.6节，模拟输入采样和扫描转换时间。

Table 35.8 AD采样状态寄存器和相关通道之间的关系

	关联频道	
位名称	Unit 0	Unit 1
ADSSTR00.SST[7:0] bits*1	AN000	AN100
ADSSTR01.SST[7:0] bits	AN001	AN101
ADSSTR02.SST[7:0] bits	AN002	AN102
ADSSTR03.SST[7:0] bits	AN003	-
ADSSTR05.SST[7:0] bits	AN005	AN105
ADSSTR06.SST[7:0] bits	AN006	AN106
ADSSTR07.SST[7:0] bits	AN007	AN107
ADSSTRL.SST[7:0] bits	AN016至AN018和AN020	AN116 and AN117
ADSSTRT.SST[7:0] bits	温度传感器输出	温度传感器输出
ADSSTRO.SST[7:0] bits	内部参考电压	内部参考电压

Note 1. 选择自诊断功能时，将应用ADSSTR00.SST[7:0]位中设置的采样时间。

35.2.15 A/D Sample and Hold Circuit Control Register (ADSHCR)

Address(es): ADC120.ADSHCR 4005 C066h, ADC121.ADSHCR 4005 C266h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SHANS[2:0]			SSTSH[7:0]							
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0

Bit	Symbol	Bit name	Description	R/W
b7 to b0	SSTSH[7:0]	Channel-Dedicated Sample-and-Hold Circuit Sampling Time Setting	Sampling time (4 to 255 states)	R/W
b10 to b8	SHANS[2:0]	Channel-Dedicated Sample-and-Hold Circuit Bypass Select	Select whether to use or bypass channel-dedicated sample-and-hold circuits for AN000 to AN002 (unit 0) and AN100 to AN102 (unit 1). 0: Bypass the circuits 1: Use the circuits.	R/W
b15 to b11	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

SSTSH[7:0] bits (Channel-Dedicated Sample-and-Hold Circuit Sampling Time Setting)

The SSTSH[7:0] bits set the sampling time for the channel-dedicated sample-and-hold circuits. If one state is 1 ADCLK (A/D conversion clock) cycle and the ADCLK clock is 60 MHz, one state is 16.7 ns. The initial value is 24 states. The sampling time can be adjusted if the impedance of the analog input signal source is too high to secure sufficient sampling time, or if the ADCLK clock is slow.

Only set the SSTSH[7:0] bits while the ADCSR.ADST bit is 0. The sampling time must be set to a value that is 4 states or more and 255 or less.

SHANS[2:0] bits (Channel-Dedicated Sample-and-Hold Circuit Bypass Select)

The SHANS[2:0] bits select whether to use or bypass the channel-dedicated sample-and-hold circuits for AN000 to AN002 (unit 0) and AN100 to AN102 (unit 1). In unit 0, the SHANS[0] bit is associated with AN000, the SHANS[1] bit with AN001, and the SHANS[2] bit with AN002. In unit 1, the SHANS[0] bit is associated with AN100, the SHANS[1] bit with AN101, and the SHANS[2] bit with AN102.

If any channel from AN000 to AN002 (unit 0) or AN100 to AD102 (unit 1) is selected for group B while operation is in group scan mode under group A priority control, use this setting to bypass the dedicated sample-and-hold circuit of the channel.

Only set the SHANS[2:0] bits while the ADCSR.ADST bit is 0 and the ADSHMSR.SHMD bit is 0.

35.2.16 A/D Sample and Hold Operation Mode Selection Register (ADSHMSR)

Address(es): ADC120.ADSHMSR 4005 C07Ch, ADC121.ADSHMSR 4005 C27Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	SHMD
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SHMD	Sampling Operation Selection	0: Disable continuous sampling function 1: Enable continuous sampling function.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

35.2.15 AD采样保持电路控制寄存器(ADSHCR)

Address(es): ADC120.ADSHCR 4005 C066h, ADC121.ADSHCR 4005 C266h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	SHANS[2:0]			SSTSH[7:0]							
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0

Bit	Symbol	位名称	Description	R/W
b7 to b0	SSTSH[7:0]	Channel-Dedicated Sample-and-Hold 电路采样时间设置	采样时间（4到255个状态）	R/W
b10 to b8	SHANS[2:0]	Channel-Dedicated Sample-and-Hold 电路旁路选择	选择是使用还是绕过AN000至AN002（单元0）和AN100至AN102（单元1）的通道专用采样保持电路。0：绕过电路1：使用电路。	R/W
b15 to b11	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SSTSH[7:0]位（通道专用采样保持电路采样时间设置）

SSTSH[7:0]位设置通道专用采样保持电路的采样时间。如果一种状态是1个ADCLK（AD转换时钟）周期并且ADCLK时钟是60MHz，则一种状态是16.7ns。初始值为24个状态。如果模拟输入信号源的阻抗太高而无法保证足够的采样时间，或者如果ADCLK时钟很慢，则可以调整采样时间。

仅当ADCSR.ADST位为0时设置SSTSH[7:0]位。采样时间必须设置为4个或更多状态且255或更少的值。

SHANS[2:0]位（通道专用采样保持电路旁路选择）

SHANS[2:0]位选择是使用还是绕过AN000的通道专用采样保持电路
AN002（单元0）和AN100到AN102（单元1）。在单元0中，SHANS[0]位与AN000相关联，SHANS[1]位与AN001相关联，SHANS[2]位与AN002相关联。在单元1中，SHANS[0]位与AN100相关联，SHANS[1]位与AN101相关联，SHANS[2]位与AN102相关联。

如果在A组优先控制下的组扫描模式下操作时为B组选择了从AN000到AN002（单元0）或AN100到AD102（单元1）的任何通道，则使用此设置绕过专用的采样保持电路的频道。

仅在ADCSR.ADST位为0且ADSHMSR.SHMD位为0时设置SHANS[2:0]位。

35.2.16 AD采样和保持操作模式选择寄存器(ADSHMSR)

Address(es): ADC120.ADSHMSR 4005 C07Ch, ADC121.ADSHMSR 4005 C27Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	SHMD
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SHMD	采样操作选择	0：禁用连续采样功能1：启用连续采样功能。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

SHMD bit (Sampling Operation Selection)

Setting SHMD to 1 enables the constant sampling function of the channel-dedicated sample-and-hold selected in the ADSHCR.SHANS[2:0] bits. Only set the SHMD bit while the ADCSR.ADST bit is 0.

When the sampling function is enabled, the sample-and-hold circuit operates sampling while the ADC12 is not operating, and operates holding while the ADC12 is operating.

Note: The ADCSR.ADST bit must become 1 after 400 ns or more elapses after the SHMD bit is set to 1 (when the permissible signal source impedance is 1 kΩ). The sampling period of the sample-and-hold circuit must be 400 ns or more (when the permissible signal source impedance is 1 kΩ).

35.2.17 A/D Disconnection Detection Control Register (ADDISCR)

Address(es): ADC120.ADDISCR 4005 C07Ah, ADC121.ADDISCR 4005 C27Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	PCHG	ADNDIS[3:0]			
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	ADNDIS[3:0]	Disconnection Detection Assist Setting	b3 b0 0 0 0 0: Disconnection detection assist function is disabled 0 0 0 1: Setting prohibited Others : Number of states for the discharge or precharge period.	R/W
b4	PCHG	Precharge/discharge select	0: Discharge 1: Precharge.	R/W
b7 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The ADDISCR register selects either precharge or discharge, and the period of precharge or discharge for the A/D disconnection detection assist function.

Only set the ADDISCR register when the ADCSR.ADST bit is 0.

If any of the following functions are used, the disconnection detection assist function should be disabled:

- Temperature sensor
- Internal reference voltage
- A/D self-diagnosis
- Programmable gain amplifier without bypass enabled.

ADNDIS[3:0] bits (Disconnection Detection Assist Setting)

The ADNDIS[3:0] bits specify the period of precharge or discharge. When ADNDIS[3:0] = 0000b, the disconnection detection assist function is disabled. Setting the ADNDIS[3:0] bits to 0001b is prohibited. Except when ADNDIS[3:0] = 0000b or 0001b, the specified value indicates the number of states for the period of precharge or discharge. When the ADNDIS[3:0] bits are set to any values other than 0000b or 0001b, the disconnection detection assistance function is enabled.

PCHG bit (Precharge/discharge select)

Setting the PCHG bit to 1 selects precharge and setting the PCHG bit to 0 selects discharge.

SHMD位（采样操作选择）

将SHMD设置为1启用在
ADSHCR.SHANS[2:0]位。仅在ADCSR.ADST位为0时设置SHMD位。

当采样功能使能时，采样保持电路在ADC12不工作时进行采样，在ADC12工作时进行保持。

Note: ADCSR.ADST位必须在SHMD位设置为1后经过400ns或更长时间后变为1（当允许的信号源阻抗为1kΩ时）。采样保持电路的采样周期必须为400ns或更长（当允许的信号源阻抗为1kΩ时）。

35.2.17 AD断线检测控制寄存器(ADDISCR)

Address(es): ADC120.ADDISCR 4005 C07Ah, ADC121.ADDISCR 4005 C27Ah

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	PCHG	ADNDIS[3:0]			
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	ADNDIS[3:0]	断线检测辅助 Setting	b3 b0 0 0 0 0：断线检测辅助功能无效 0 0 0 1：禁止设置 Others ：放电或预充电期的状态数。	R/W
b4	PCHG	Precharge/discharge select	0: Discharge 1: Precharge.	R/W
b7 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

ADDISCR寄存器选择预充电或放电，以及AD断线检测辅助功能的预充电或放电周期。

仅当ADCSR.ADST位为0时设置ADDISCR寄存器。

如果使用以下任一功能，应禁用断线检测辅助功能：

- 温度感应器
- 内部参考电压
- A/D self-diagnosis
- 不启用旁路的可编程增益放大器。

ADNDIS[3:0]位（断线检测辅助设置）

ADNDIS[3:0]位指定预充电或放电周期。当ADNDIS[3:0]=0000b时，断线检测辅助功能被禁用。禁止将ADNDIS[3:0]位设置为0001b。除了ADNDIS[3:0]=0000b或0001b时，指定值表示预充电或放电期间的状态数。当ADNDIS[3:0]位设置为0000b或0001b以外的任何值时，将启用断线检测辅助功能。

PCHG位（预充电放电选择）

将PCHG位设置为1选择预充电，将PCHG位设置为0选择放电。

35.2.18 A/D Group Scan Priority Control Register (ADGSPCR)

Address(es): ADC120.ADGSPCR 4005 C080h, ADC121.ADGSPCR 4005 C280h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	GBRP	—	—	—	—	—	—	—	—	—	—	—	—	—	GBRSCN	PGS
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	PGS	Group A Priority Control Setting*1	0: Operate without group A priority control 1: Operate with group A priority control.	R/W
b1	GBRSCN	Group B Restart Setting	This bit is enabled only when PGS = 1. It is reserved when PGS = 0. 0: Do not restart group B scanning after it is stopped by group A priority control 1: Restart group B scanning after it is stopped by group A priority control.	R/W
b14 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15	GBRP	Group B Single Scan Continuous Start*2	This bit is enabled only when PGS = 1. It is reserved when PGS = 0. 0: Do not continuously activate single scan for group B 1: Continuously activate single scan for group B.	R/W

Note 1. The ADCSR.ADCS[1:0] bits must be set to 01b (group scan mode) before setting PGS to 1. Operation is not guaranteed if these bits are set to any other value.

Note 2. When the GBRP bit is set to 1, single scan is performed continuously for group B regardless of the setting in the GBRSCN bit.

PGS bit (Group A Priority Control Setting)

Set the PGS bit to 1 to give priority to operation on group A. The ADCSR.ADCS[1:0] bits must be set to 01b (group scan mode) before setting the PGS bit to 1. Operation is not guaranteed if the bits are set to any other value.

When the PGS bit is set to 0, a clear operation must be performed by software as described in section 35.6.2, Constraints on Stopping A/D Conversion. When the PGS bit is set to 1, use the settings described in section 35.3.4.3, Operation with group A priority control.

GBRSCN bit (Group B Restart Setting)

The GBRSCN bit controls the restarting of scan operation on group B when operation on group A is given priority. If a scan operation on group B is stopped by a group A trigger input with the GBRSCN bit set to 1, the scan operation is restarted on completion of group A conversion. Also, if a group B trigger is input during A/D conversion on group A, the scan operation on group B is restarted on completion of group A conversion.

When the GBRSCN bit is set to 0, trigger inputs during A/D conversion are ignored. Only set the GBRSCN bit while the ADCSR.ADST bit is 0.

The setting in the GBRSCN bit is valid when the PGS bit is 1.

GBRP bit (Group B Single Scan Continuous Start)

The GBRP bit performs a single scan operation continuously on group B. Setting the GBRP bit to 1 starts a single scan on group B. On completion of the scan, another single scan on group B starts automatically. If a group B conversion stops because of an operation on group A, the group A operation takes priority, and single scan on group B restarts automatically on completion of the group A conversion.

Disable group B trigger input before setting the GBRP bit to 1. Setting the GBRP bit to 1 invalidates the setting in the GBRSCN bit. Only set the GBRP bit while the ADCSR.ADST is 0.

The setting in the GBRP bit is valid when the PGS bit is 1.

35.2.18 AD组扫描优先控制寄存器(ADGSPCR)

Address(es): ADC120.ADGSPCR 4005 C080h, ADC121.ADGSPCR 4005 C280h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	GBRP	—	—	—	—	—	—	—	—	—	—	—	—	—	GBRSCN	PGS
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	PGS	A组优先控制 Setting*1	0：无A组优先控制运行1：有A组优先控制运行。	R/W
b1	GBRSCN	B组重启设置	该位仅在PGS=1时启用。 PGS=0。0：B组扫描被A组优先控制停止后不重新开始扫描1：B组扫描被A组优先控制停止后重新开始B组扫描。	R/W
b14 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15	GBRP	B组单次扫描连续 Start*2	该位仅在PGS=1时启用。 PGS=0。0：不连续激活B组单次扫描1：连续激活B组单次扫描。	R/W

注1.ADCSR.ADCS[1:0]位必须在PGS设置为1之前设置为01b（组扫描模式）。如果这些位设置为任何其他值，则无法保证操作。注2.当GBRP位设置为1时，对B组连续执行单次扫描，而与

GBRSCN bit.

PGS位（A组优先控制设置）

将PGS位设置为1以优先对组A进行操作。在将PGS位设置为1之前，必须将ADCSR.ADCS[1:0]位设置为01b（组扫描模式）。如果这些位不保证操作设置为任何其他值。

当PGS位设置为0时，必须由软件执行清零操作，如第35.6.2节“停止AD转换的约束”中所述。当PGS位设置为1时，使用第35.3.4.3节“A组优先控制操作”中描述的设置。

GBRSCN位（B组重启设置）

当A组操作优先时，GBRSCN位控制B组扫描操作的重新启动。如果B组的扫描操作被GBRSCN位设置为1的A组触发输入停止，则扫描操作在A组转换完成后重新开始。此外，如果在A组的AD转换期间输入了B组触发，则在A组转换完成时重新开始对B组的扫描操作。

当GBRSCN位设置为0时，AD转换期间的触发输入将被忽略。仅设置GBRSCN位，而ADCSR.ADST位为0。

当PGS位为1时GBRSCN位中的设置有效。

GBRP位（B组单次扫描连续启动）

GBRP位在B组上连续执行单次扫描操作。将GBRP位设置为1将启动B组上的单次扫描。扫描完成后，自动开始B组上的另一次单次扫描。如果B组转换因A组操作而停止，则A组操作优先，B组单次扫描在A组转换完成后自动重新开始。

在将GBRP位设置为1之前禁用B组触发输入。将GBRP位设置为1会使GBRSCN位。仅在ADCSR.ADST为0时设置GBRP位。

GBRP位中的设置在PGS位为1时有效。

35.2.19 A/D Compare Function Control Register (ADCMPCR)

Address(es): ADC120.ADCMPCR 4005 C090h, ADC121.ADCMPCR 4005 C290h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	CMPAIE	WCMPE	CMPBIE	—	CMPAE	—	CMPBE	—	—	—	—	—	—	—	CMPAB[1:0]	
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	CMPAB[1:0]	Window A/B Composite Conditions Setting	b1 b0 0 0: Output ADC12i_WCMPM when window A OR window B comparison conditions are met. Otherwise, output ADC12i_WCMPUM 0 1: Output ADC12i_WCMPM when window A EXOR window B comparison conditions are met. Otherwise, output ADC12i_WCMPUM 1 0: Output ADC12i_WCMPM when window A AND window B comparison conditions are met. Otherwise, output ADC12i_WCMPUM 1 1: Setting prohibited. These bits are valid when both window A and window B are enabled (CMPAE = 1 and CMPBE = 1).	R/W
b8 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b9	CMPBE	Compare Window B Operation Enable	0: Disable compare window B operation. Disable ADC12i_WCMPM and ADC12i_WCMPUM outputs. 1: Enable compare window B operation.	R/W
b10	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b11	CMPAE	Compare Window A Operation Enable	0: Disable compare window A operation. Disable ADC12i_WCMPM and ADC12i_WCMPUM outputs. 1: Enable compare window A operation.	R/W
b12	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b13	CMPBIE	Compare B Interrupt Enable	0: Disable ADC12i_CMPBI interrupt when comparison conditions (window B) are met 1: Enable ADC12i_CMPBI interrupt when comparison conditions (window B) are met.	R/W
b14	WCMPE	Window Function Setting	0: Disable window function. Window A and window B operate as a comparator to compare the single value on the lower side with the A/D conversion result. 1: Enable window function. Window A and window B operate as a comparator to compare the two values on the upper and lower sides with the A/D conversion result.	R/W
b15	CMPAIE	Compare A Interrupt Enable	0: Disable ADC12i_CMPAI interrupt when comparison conditions (window A) are met 1: Enable ADC12i_CMPAI interrupt when comparison conditions (window A) are met.	R/W

Note: i = 0: unit 0, i = 1: unit 1.

CMPAB[1:0] bits (Window A/B Composite Conditions Setting)

The CMPAB[1:0] bits are valid when both window A and window B are enabled (CMPAE = 1 and CMPBE = 1) in single scan mode. These bits specify the compare function match/mismatch event output conditions and monitoring conditions of ADWINMON.MONCONB.

Only set the CMPAB[1:0] bits when the ADCSR.ADST bit is 0.

CMPBE bit (Compare Window B Operation Enable)

The CMPBE bit enables or disables the compare window B operation. Set the CMPBE bit when the ADCSR.ADST bit is 0.

35.2.19 AD比较功能控制寄存器(ADCMPCR)

Address(es): ADC120.ADCMPCR 4005 C090h, ADC121.ADCMPCR 4005 C290h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	CMPAIE	WCMPE	CMPBIE	—	CMPAE	—	CMPBE	—	—	—	—	—	—	—	CMPAB[1:0]	
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	CMPAB[1:0]	窗口AB复合条件设定	b1 b0 0 0：当窗口AOR窗口B比较条件满足时输出ADC12i_WCMPM。否则，输出ADC12i_WCMPUM 0 1：当窗口AEXOR窗口B比较条件满足时输出ADC12i_WCMPM。否则，输出ADC12i_WCMPUM 1 0：当窗口A和窗口B比较条件满足时，输出ADC12i_WCMPM。否则，输出ADC12i_WCMPUM 11：禁止设置。当窗口A和窗口B都使能（CMPAE=1和CMPBE=1）时，这些位有效。	R/W
b8 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b9	CMPBE	比较窗口B操作启用	0：禁止比较窗口B操作。 禁用ADC12i_WCMPM和ADC12i_WCMPUM输出。1：启用比较窗口B操作。	R/W
b10	—	Reserved	该位读取为0。写入值应为0。	R/W
b11	CMPAE	比较窗口A操作启用	0：禁止比较窗口A操作。 禁用ADC12i_WCMPM和ADC12i_WCMPUM输出。1：启用比较窗口A操作。	R/W
b12	—	Reserved	该位读取为0。写入值应为0。	R/W
b13	CMPBIE	比较B中断Enable	0：满足比较条件（窗口B）时禁用ADC12i_CMPBI中断1：满足比较条件（窗口B）时启用ADC12i_CMPBI中断。	R/W
b14	WCMPE	窗口功能设置	0：关闭窗口功能。 窗口A和窗口B用作比较器，将下侧的单个值与AD转换结果进行比较。1：启用窗口功能。 窗口A和窗口B用作比较器，将上下两个值与AD转换结果进行比较。	R/W
b15	CMPAIE	比较中断Enable	0：满足比较条件（窗口A）时禁用ADC12i_CMPAI中断1：满足比较条件（窗口A）时启用ADC12i_CMPAI中断。	R/W

Note: i = 0: unit 0, i = 1: unit 1.

CMPAB[1:0]位（窗口AB复合条件设置）

当窗口A和窗口B在单次扫描模式下启用（CMPAE=1和CMPBE=1）时，CMPAB[1:0]位有效。这些位指定比较函数匹配不匹配事件输出条件和ADWINMON.MONCONB的监视条件。

仅当ADCSR.ADST位为0时设置CMPAB[1:0]位。

CMPBE位（比较窗口B操作使能）

CMPBE位启用或禁用比较窗口B操作。当ADCSR.ADST位为0时，设置CMPBE位。

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Set this bit to 0 before setting the following registers:

- A/D Channel Select Registers A0, A1, B0, and B1 (ADANSA0, ADANSA1, ADANSB0, and ADANSB1)
- OCSB, TSSB, OCSA, or TSSA bits in the A/D Conversion Extended Input Control Register (ADEXICR)
- CMPCHB[5:0] bits in the Window B Channel Select Register (ADCMPBNSR).

CMPAE bit (Compare Window A Operation Enable)

The CMPAE bit enables or disables the compare window A operation. Set the CMPAE bit when the ADCSR.ADST bit is 0.

Set this bit to 0 before setting the following registers:

- A/D Channel Select Registers A0, A1, B0, and B1 (ADANSA0, ADANSA1, ADANSB0, and ADANSB1)
- OCSB, TSSB, OCSA, or TSSA bits in the A/D Conversion Extended Input Control Register (ADEXICR)
- Window A Channel Select Registers 0 and 1 (ADCMPANSR0 and ADCMPANSR1)
- Window A Extended Input Select Register (ADCMPANSER).

CMPBIE bit (Compare B Interrupt Enable)

The CMPBIE bit enables or disables the ADC12i_CMPBI (i = 0, 1) interrupt output when the comparison conditions (window B) are met.

WCMPE bit (Window Function Setting)

The WCMPE bit enables or disables the window function. Set the WCMPE bit when the ADCSR.ADST bit is 0.

CMPAIE bit (Compare A Interrupt Enable)

The CMPAIE bit enables or disables the ADC12i_CMPAI (i = 0, 1) interrupt output when the comparison conditions (window A) are met.

35.2.20 A/D Compare Function Window A Channel Select Register 0 (ADCMPANSR0)

Address(es): ADC120.ADCMPANSR0 4005 C094h, ADC121.ADCMPANSR0 4005 C294h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	CMPCHA07	CMPCHA06	CMPCHA05	—	CMPCHA03	CMPCHA02	CMPCHA01	CMPCHA00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	CMPCHA03 to CMPCHA00	Compare Window A Channel Select	0: Disable compare function for associated input channel 1: Enable compare function for associated input channel. In unit 0, bit 3 (CMPCHA03) is associated with to AN003 and bit 0 (CMPCHA00) with AN000. In unit 1, bit 2 (CMPCHA02) is associated with AN102 and bit 0 (CMPCHA00) with AN100.	R/W
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7 to b5	CMPCHA07 to CMPCHA05	Compare Window A Channel Select	0: Disable compare function for associated input channel 1: Enable compare function for associated input channel. In unit 0, bit 7 (CMPCHA07) is associated with to AN007 and bit 5 (CMPCHA05) with AN005. In unit 1, bit 7 (CMPCHA07) is associated with AN107 and bit 5 (CMPCHA05) with AN105.	R/W
b15 to b8	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CMPCHAn bits (n = 00 to 03, 05 to 07) (Compare Window A Channel Select)

The compare function is enabled by writing 1 to the CMPCHAn bit with the same number as the A/D conversion channel

在设置以下寄存器之前将此位设置为0：

- AD通道选择寄存器A0、A1、B0和B1（ADANSA0、ADANSA1、ADANSB0和ADANSB1）
- AD转换扩展输入控制寄存器(ADEXICR)中的OCSB、TSSB、OCSA或TSSA位
- 窗口B通道选择寄存器(ADCMPBNSR)中的CMPCHB[5:0]位。

CMPAE位（比较窗口A操作使能）

CMPAE位启用或禁用比较窗口A操作。当ADCSR.ADST位为0时，设置CMPAE位。

在设置以下寄存器之前将此位设置为0：

- AD通道选择寄存器A0、A1、B0和B1（ADANSA0、ADANSA1、ADANSB0和ADANSB1）
- AD转换扩展输入控制寄存器(ADEXICR)中的OCSB、TSSB、OCSA或TSSA位
- 窗口A通道选择寄存器0和1（ADCMPANSR0和ADCMPANSR1）
- 窗口A扩展输入选择寄存器(ADCMPANSER)。

CMPBIE位（比较B中断使能）

当满足比较条件（窗口B）时，CMPBIE位启用或禁用ADC12i_CMPBI(i=0 1)中断输出。

WCMPE位（窗口功能设置）

WCMPE位启用或禁用窗口功能。当ADCSR.ADST位为0时，设置WCMPE位。

CMPAIE位（比较中断使能）

当满足比较条件（窗口A）时，CMPAIE位启用或禁用ADC12i_CMPAI(i=0 1)中断输出。

35.2.20 AD比较功能窗口A通道选择寄存器0(ADCMPANSR0)

Address(es): ADC120.ADCMPANSR0 4005 C094h, ADC121.ADCMPANSR0 4005 C294h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	CMPCHA07	CMPCHA06	CMPCHA05	—	CMPCHA03	CMPCHA02	CMPCHA01	CMPCHA00
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	CMPCHA03 to CMPCHA00	比较窗口A通道 Select	0：禁用关联输入通道的比较功能1：启用关联输入通道的比较功能。在单元0中，位3(CMPCHA03)与AN003相关联，位0(CMPCHA00)与AN000相关联。在单元1中，位2(CMPCHA02)与AN102相关联，位0(CMPCHA00)与AN100相关联。	R/W
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b7 to b5	CMPCHA07 to CMPCHA05	比较窗口A通道 Select	0：禁用关联输入通道的比较功能1：启用关联输入通道的比较功能。在单元0中，位7(CMPCHA07)与AN007相关联，位5(CMPCHA05)与AN005相关联。在单元1中，位7(CMPCHA07)与AN107相关联，位5(CMPCHA05)与AN105相关联。	R/W
b15 to b8	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPCHAn位（n=00到03、05到07）（比较窗口A通道选择）

比较功能通过向CMPCHAn位写入1来使能，该位与AD转换通道的编号相同

selected in the ADANSA0.ANSAn bits (n = 00 to 03, 05 to 07) and the ADANSB0.ANSBn bits (n = 00 to 03, 05 to 07).

Set the CMPCHAn bits while the ADCSR.ADST bit is 0.

35.2.21 A/D Compare Function Window A Channel Select Register 1 (ADCMPANSR1)

Address(es): ADC120.ADCMPANSR1 4005 C096h, ADC121.ADCMPANSR1 4005 C296h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	CMPCHA20	—	CMPCHA18	CMPCHA17	CMPCHA16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	CMPCHA18 to CMPCHA16	Compare Window A Channel Select	0: Disable compare function for associated input channel 1: Enable compare function for associated input channel. In unit 0, bit 2 (CMPCHA18) is associated with AN018, and bit 0 (CMPCHA16) with AN016. In unit 1, bit 1 (CMPCHA17) is associated with AN117 and bit 0 (CMPCHA16) with AN116.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	CMPCHA20	Compare Window A Channel Select	0: Disable compare function for associated input channel 1: Enable compare function for associated input channel. In unit 0, bit 4 (CMPCHA20) is associated with AN020. In unit 1, bit 4 (CMPCHA20) is not associated.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CMPCHAn bits (n = 16 to 18, 20) (Compare Window A Channel Select)

The compare function is enabled by writing 1 to the CMPCHAn bit with the same number as the A/D conversion channel selected in the ADANSA1.ANSAn bits (n = 16 to 18, 20) and the ADANSB1.ANSBn bits (n = 16 to 18, 20).

Set the CMPCHAn bits while the ADCSR.ADST bit is 0.

35.2.22 A/D Compare Function Window A Extended Input Select Register (ADCMPANSER)

Address(es): ADC120.ADCMPANSER 4005 C092h, ADC121.ADCMPANSER 4005 C292h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	CMPOCA	CMPTSA
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CMPTSA	Temperature Sensor Output Compare Select	0: Exclude the temperature sensor output from the compare window A target range 1: Include the temperature sensor output in the compare window A target range.	R/W
b1	CMPOCA	Internal Reference Voltage Compare Select	0: Exclude the internal reference voltage from the compare window A target range. 1: Include the internal reference voltage in the compare window A target range.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CMPTSA bit (Temperature Sensor Output Compare Select)

The compare window A function is enabled by setting the CMPTSA bit to 1 while the ADEXICR.TSSA bit or the

在ADANSA0.ANSAN位（n=00到03、05到07）和ADANSB0.ANSBn位（n=00到03、05到07）中选择。

当ADCSR.ADST位为0时，设置CMPCHAn位。

35.2.21 AD比较功能窗口A通道选择寄存器1(ADCMPANSR1)

Address(es): ADC120.ADCMPANSR1 4005 C096h, ADC121.ADCMPANSR1 4005 C296h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	CMPCHA20	—	CMPCHA18	CMPCHA17	CMPCHA16
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	CMPCHA18 to CMPCHA16	比较窗口A通道 Select	0：禁用关联输入通道的比较功能1：启用关联输入通道的比较功能。在单元0中，位2(CMPCHA18)与AN018相关联，位0(CMPCHA16)与AN016相关联。在单元1中，位1(CMPCHA17)与AN117相关联，位0(CMPCHA16)与AN116相关联。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	CMPCHA20	比较窗口A通道 Select	0：禁用关联输入通道的比较功能1：启用关联输入通道的比较功能。在单元0中，位4(CMPCHA20)与AN020相关联。 在单元1中，位4(CMPCHA20)没有关联。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPCHAn位（n=16至18、20）（比较窗口A通道选择）

通过将1写入CMPCHAn位来启用比较功能，该位与在ADANSA1.ANSAN位（n=16至18、20）和ADANSB1.ANSBn位（n=16至18、20)。

当ADCSR.ADST位为0时，设置CMPCHAn位。

35.2.22 AD比较功能窗口A扩展输入选择寄存器(ADCMPANSER)

Address(es): ADC120.ADCMPANSER 4005 C092h, ADC121.ADCMPANSER 4005 C292h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	CMPOCA	CMPTSA
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CMPTSA	温度感应器输出比较选择	0：将温度传感器输出排除在比较窗口A目标范围内1：将温度传感器输出包括在比较窗口A目标范围内。	R/W
b1	CMPOCA	内部参考电压比较选择	0：将内部参考电压排除在比较窗口A的目标范围之外。1：在比较窗口A目标范围内包含内部参考电压。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPTSA位（温度传感器输出比较选择）

比较窗口A功能通过将CMPTSA位设置为1而ADEXICR.TSSA位或

ADEXICR.TSSB bit is 1. Only set the CMPTSA bit when the ADCSR.ADST bit is 0.

CMPOCA bit (Internal Reference Voltage Compare Select)

The compare window A function is enabled by setting the CMPOCA bit to 1 while the ADEXICR.OCSA bit or the ADEXICR.OCSB bit is 1. Only set the CMPOCA bit when the ADCSR.ADST bit is 0.

35.2.23 A/D Compare Function Window A Comparison Condition Setting Register 0 (ADCMPLR0)

Address(es): ADC120.ADCMPLR0 4005 C098h, ADC121.ADCMPLR0 4005 C298h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	CMPLCHA07	CMPLCHA06	CMPLCHA05	—	CMPLCHA03	CMPLCHA02	CMPLCHA01	CMPLCHA00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	CMPLCHA03 to CMPLCHA00	Compare Window A Comparison Condition Select	These bits set comparison conditions for channels to which window A comparison conditions are applied, selected from AN000 to AN003 (unit 0), and AN100 to AN102 (unit 1). Comparison conditions are shown in Figure 35.4. • When window function is disabled (ADCMPCR.WCMPE = 0): 0: ADCMPDR0 value > A/D-converted value 1: ADCMPDR0 value < A/D-converted value. • When window function is enabled (ADCMPCR.WCMPE = 1): 0: A/D-converted value < ADCMPDR0 value, or ADCMPDR1 value < A/D-converted value 1: ADCMPDR0 value < A/D-converted value < ADCMPDR1 value.	R/W
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7 to b5	CMPLCHA07 to CMPLCHA05	Compare Window A Comparison Condition Select	These bits set comparison conditions for channels to which window A comparison conditions are applied, selected from AN005 to AN007 (unit 0), and AN105 to AN107 (unit 1). Comparison conditions are shown in Figure 35.4. • When the window function is disabled (ADCMPCR.WCMPE = 0): 0: ADCMPDR0 value > A/D-converted value 1: ADCMPDR0 value < A/D-converted value. • When the window function is enabled (ADCMPCR.WCMPE = 1): 0: A/D-converted value < ADCMPDR0 value, or ADCMPDR1 value < A/D-converted value 1: ADCMPDR0 value < A/D-converted value < ADCMPDR1 value.	R/W
b15 to b8	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CMPLCHAn bits (n = 00 to 03, 05 to 07) (Compare Window A Comparison Condition Select)

The CMPLCHAn bits specify the comparison conditions for channels to which window A comparison conditions are applied, selected from AN000 to AN003, AN005 to AN007 (unit 0) and AN100 to AN102, AN105 to AN107 (unit 1). These bits can be set for each analog input to be compared. In unit 0, CMPLCHA00 is associated with AN000 and CMPLCHA07 with AN007. In unit 1, CMPLCHA00 is associated with AN100 and CMPLCHA07 with AN107. When the comparison result of each analog input meets the set condition, the ADCMPSR0.CMPSTCHAn flag is set to 1, and a compare interrupt (ADC12i_CMPAI (i = 0, 1)) is generated.

ADXICR.TSSB位为1。仅当ADCSR.ADST位为0时设置CMPTSA位。

CMPOCA位（内部参考电压比较选择）

比较窗口A功能通过将CMPOCA位设置为1而ADEXICR.OCSA位或ADXICR.OCSB位为1。仅当ADCSR.ADST位为0时设置CMPOCA位。

35.2.23 AD比较功能窗口A比较条件设置寄存器0(ADCMPLR0)

Address(es): ADC120.ADCMPLR0 4005 C098h, ADC121.ADCMPLR0 4005 C298h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	CMPLCHA07	CMPLCHA06	CMPLCHA05	—	CMPLCHA03	CMPLCHA02	CMPLCHA01	CMPLCHA00
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	CMPLCHA03 to CMPLCHA00	比较窗口A比较条件Select	这些位设置通道的比较条件到哪个窗口应用比较条件，从AN000中选择到AN003（单元0）和AN100至AN102（单元1）。比较条件如图35.4所示。 禁用窗口功能时(ADCMPCR.WCMPE=0)：0：ADCMPDR0值>AD转换值1：ADCMPDR0值<AD转换值。 当窗口功能启用时（ADCMPCR.WCMPE=1）：0：D转换值<ADCMPDR0值，或ADCMPDR1值<AD转换值1：ADCMPDR0值<AD转换值<ADCMPDR1值。	R/W
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b7 to b5	CMPLCHA07 to CMPLCHA05	比较窗口A比较条件Select	这些位设置通道的比较条件到哪个窗口应用比较条件，从AN005中选择到AN007（单元0）和AN105至AN107（单元1）。 比较条件如图35.4所示。 当窗口功能被禁用时（ADCMPCR.WCMPE=0）：0：ADCMPDR0值>AD转换值1：ADCMPDR0值<AD转换值。 启用窗口功能时(ADCMPCR.WCMPE=1)：0：D转换值<ADCMPDR0值，或ADCMPDR1值<AD转换值1：ADCMPDR0值<AD转换值<ADCMPDR1值。	R/W
b15 to b8	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPLCHAn位（n=00到03、05到07）（比较窗口A比较条件选择）

CMPLCHAn位指定应用窗口A比较条件的通道的比较条件，从AN000到AN003、AN005到AN007（单元0）和AN100到AN102、AN105到AN107（单元1）中选择。可以为要比较的每个模拟输入设置这些位。在单元0中，CMPLCHA00与AN000相关联，并且

CMPLCHA07与AN007。在单元1中，CMPLCHA00与AN100相关联，CMPLCHA07与AN107相关联。当每个模拟输入的比较结果满足设置条件时，ADCMPSR0.CMPSTCHAn标志置1，并产生比较中断（ADC12i_CMPAI(i=01)）。

Comparison conditions when the window function is disabled

CMPLCHAn = 0		CMPLCHAn = 1	
ADCMPDR0 value ≤ A/D converted value	Not met	ADCMPDR0 value < A/D converted value	Met
ADCMPDR0 value > A/D converted value	Met	ADCMPDR0 value ≥ A/D converted value	Not met

Comparison conditions when the window function is enabled

CMPLCHAn = 0	
ADCMPDR1 value < A/D converted value	Met
ADCMPDR0 value ≤ A/D converted value ≤ ADCMPDR1 value	Not met
A/D converted value < ADCMPDR0 value	Met

CMPLCHAn = 1	
ADCMPDR1 value ≤ A/D converted value	Not met
ADCMPDR0 value < A/D converted value < ADCMPDR1 value	Met
A/D converted value ≤ ADCMPDR0 value	Not met

Figure 35.4 Explanation of comparison conditions for compare function window A

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禁用窗口功能时的比较条件

CMPLCHAn = 0		CMPLCHAn = 1	
ACMPDDR0值　AD转换值	没见过	ACMPDDR0值<AD转换值	Met
ACMPDDR0值>AD转换值	Met	ACMPDDR0值　AD转换值	没见过

启用窗口功能时的比较条件

CMPLCHAn = 0	
ADCMPDDR1值<AD转换值	Met
ADCMPDR0值　AD转换值　ADCMPDR1值	没见过
AD转换值<ADCMPDR0值	Met

CMPLCHAn = 1	
ACMPDDR1值　AD转换值	没见过
ADCMPDR0值<AD转换值<ADCMPDR1值	Met
AD转换值　ADCMPDR0值	没见过

Figure 35.4 比较功能窗口A的比较条件说明

35.2.24 A/D Compare Function Window A Comparison Condition Setting Register 1 (ADCMPLR1)

Address(es): ADC120.ADCMPLR1 4005 C09Ah, ADC121.ADCMPLR1 4005 C29Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	CMPLCHA20	—	CMPLCHA18	CMPLCHA17	CMPLCHA16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	CMPLCHA18 to CMPLCHA16	Compare Window A Comparison Condition Select	These bits set comparison conditions for channels to which window A comparison conditions are applied, selected from AN016 to AN018 (unit 0) and AN116, AN117 (unit 1). Comparison conditions are shown in Figure 35.4. • When window function is disabled (ADCMPCR.WCMPE = 0) 0: ADCMPDR0 value > A/D-converted value 1: ADCMPDR0 value < A/D-converted value. • When window function is enabled (ADCMPCR.WCMPE = 1) 0: A/D-converted value < ADCMPDR0 value, or ADCMPDR1 value < A/D-converted value 1: ADCMPDR0 value < A/D-converted value < ADCMPDR1 value.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	CMPLCHA20	Compare Window A Comparison Condition Select	This bit sets comparison condition for channels to which window A comparison condition is applied, selected as AN020 (unit 0). Comparison condition is shown in Figure 35.4. • When window function is disabled (ADCMPCR.WCMPE = 0) 0: ADCMPDR0 value > A/D-converted value 1: ADCMPDR0 value < A/D-converted value. • When window function is enabled (ADCMPCR.WCMPE = 1) 0: A/D-converted value < ADCMPDR0 value, or ADCMPDR1 value < A/D-converted value 1: ADCMPDR0 value < A/D-converted value < ADCMPDR1 value.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CMPLCHAn bits (n = 16 to 18, 20) (Compare Window A Comparison Condition Select)

The CMPLCHAn bits specify the comparison conditions for channels to which window A comparison conditions are applied, selected from AN016 to AN018, AN020 (unit 0) and AN116, AN117 (unit 1). These bits can be set for each analog input to be compared. In unit 0, CMPLCHA16 is associated with AN016, and CMPLCHA20 with AN020. In unit 1, CMPLCHA16 is associated with AN116, and CMPLCHA17 with AN117. When the comparison result of each analog input meets the set condition, the ADCMPSR1.CMPSTCHAn flag is set to 1 and a compare interrupt (ADC12i_CMPAI (i = 0, 1)) is generated.

35.2.24 AD比较功能窗口A比较条件设置寄存器1(ADCMPLR1)

Address(es): ADC120.ADCMPLR1 4005 C09Ah, ADC121.ADCMPLR1 4005 C29Ah

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	CMPLCHA20	—	CMPLCHA18	CMPLCHA17	CMPLCHA16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	CMPLCHA18 to CMPLCHA16	比较窗口A比较条件Select	这些位设置应用窗口A比较条件的通道的比较条件，从AN016到AN018（单元0）和AN116、AN117（单元1）中选择。比较条件如图35.4所示。 禁用窗口功能时(ADCMPCR.WCMPE=0)0：ADCMPDR0值>AD转换值1：ADCMPDR0值<AD转换值。 启用窗口功能时(ADCMPCR.WCMPE=1)0：D转换值<ADCMPDR0值，或ADCMPDR1值<AD转换值1：ADCMPDR0值<AD转换值<ADCMPDR1值。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	CMPLCHA20	比较窗口A比较条件Select	该位设置应用窗口A比较条件的通道的比较条件，选择为AN020（单元0）。比较条件如图35.4所示。 禁用窗口功能时(ADCMPCR.WCMPE=0)0：ADCMPDR0值>AD转换值1：ADCMPDR0值<AD转换值。 启用窗口功能时(ADCMPCR.WCMPE=1)0：D转换值<ADCMPDR0值，或ADCMPDR1值<AD转换值1：ADCMPDR0值<AD转换值<ADCMPDR1值。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPLCHAn位（n=16到18、20）（比较窗口A比较条件选择）

CMPLCHAn位指定应用窗口A比较条件的通道的比较条件，从AN016到AN018、AN020（单元0）和AN116、AN117（单元1）中选择。可以为要比较的每个模拟输入设置这些位。在单元0中，CMPLCHA16与AN016相关联，CMPLCHA20与AN020相关联。在单元1中，CMPLCHA16与AN116相关联，CMPLCHA17与AN117相关联。当每个模拟输入的比较结果满足设置条件时，ADCMPSR1.CMPSTCHAn标志设置为1，并产生比较中断(ADC12i_CMPAI(i=0 1))。

35.2.25 A/D Compare Function Window A Extended Input Comparison Condition Setting Register (ADCMPLER)

Address(es): ADC120.ADCMPLER 4005 C093h, ADC121.ADCMPLER 4005 C293h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	CMPLOCA	CMPLTSA
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CMPLTSA	Compare Window A Temperature Sensor Output Comparison Condition Select	Comparison conditions are shown in Figure 35.4. • When window function is disabled (ADCMPCR.WCMPE = 0) 0: ADCMPDR0 value > A/D-converted value 1: ADCMPDR0 value < A/D-converted value. • When window function is enabled (ADCMPCR.WCMPE = 1) 0: A/D-converted value < ADCMPDR0 value, or A/D-converted value > ADCMPDR1 value 1: ADCMPDR0 value < A/D-converted value < ADCMPDR1 value.	R/W.
b1	CMPLOCA	Compare Window A Internal Reference Voltage Comparison Condition Select	Comparison conditions are shown in Figure 35.4. • When window function is disabled (ADCMPCR.WCMPE = 0) 0: ADCMPDR0 register value > A/D-converted value 1: ADCMPDR0 register value < A/D-converted value. • When window function is enabled (ADCMPCR.WCMPE = 1) 0: A/D-converted value < ADCMPDR0 register value, or A/D-converted value > ADCMPDR1 register value 1: ADCMPDR0 register value < A/D-converted value < ADCMPDR1 register value.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R

CMPLTSA bit (Compare Window A Temperature Sensor Output Comparison Condition Select)

The CMPLTSA bit specifies comparison conditions when the temperature sensor output is the target for the window A comparison condition. When the temperature sensor output comparison result meets the set condition, the ADCMPSER.CMPSTTSA flag is set to 1 and a compare interrupt (ADC12i_CMPAI (i = 0, 1)) is generated.

CMPLOCA bit (Compare Window A Internal Reference Voltage Comparison Condition Select)

The CMPLOCA bit specifies comparison conditions when the internal reference voltage is the target for the window A comparison condition. When the internal reference voltage comparison result meets the set condition, the ADCMPSER.CMPSTOCA flag is set to 1 and a compare interrupt (ADC12i_CMPAI) is generated.

35.2.25 AD比较功能窗口A扩展输入比较条件设置寄存器(ADCMPLER)

Address(es): ADC120.ADCMPLER 4005 C093h, ADC121.ADCMPLER 4005 C293h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	CMPLOCA	CMPLTSA
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CMPLTSA	比较窗口A温度传感器输出比较 条件选择	比较条件如图35.4所示。 禁用窗口功能时(ADCMPCR.WCMPE=0)0：ADCMPDR0值>AD转换值1：ADCMPDR0值<AD转换值。 启用窗口功能时(ADCMPCR.WCMPE=1)0：D转换值<ADCMPDR0值，或D转换值>ADCMPDR1值1：ADCMPDR0值<AD转换值<ADCMPDR1值。	R/W.
b1	CMPLOCA	比较窗口A内部参考 电压比较 条件选择	比较条件如图35.4所示。 当窗口功能禁用时(ADCMPCR.WCMPE=0)0：ADCMPDR0寄存器值>AD转换值1：ADCMPDR0寄存器值<AD转换值。 启用窗口功能时(ADCMPCR.WCMPE=1)0：D转换值<ADCMPDR0寄存器值，或D转换值>ADCMPDR1寄存器值1：ADCMPDR0寄存器值<AD转换值<ADCMPDR1寄存器值.	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R

CMPLTSA位（比较窗口A温度传感器输出比较条件选择）

当温度传感器输出是窗口A比较条件的目标时，CMPLTSA位指定比较条件。当温度传感器输出比较结果满足设置条件时，ADCMPSER.CMPSTTSA标志设置为1并产生比较中断(ADC12i_CMPAI(i=0 1))。

CMPLOCA位（比较窗口A内部参考电压比较条件选择）

当内部参考电压是窗口A比较条件的目标时，CMPLOCA位指定比较条件。当内部参考电压比较结果满足设置条件时，ADCMPSER.CMPSTOCA标志设置为1，并产生比较中断（ADC12i_CMPAI）。

35.2.26 A/D Compare Function Window A Lower-Side Level Setting Register (ADCMPDR0), A/D Compare Function Window A Upper-Side Level Setting Register (ADCMPDR1), A/D Compare Function Window B Lower-Side Level Setting Register (ADWINLLB), A/D Compare Function Window B Upper-Side Level Setting Register (ADWINULB)

Address(es): ADC120.ADCMPDR0 4005 C09Ch, ADC120.ADCMPDR1 4005 C09Eh, ADC120.ADWINLLB 4005 C0A8h, ADC120.ADWINULB 4005 C0AAh, ADC121.ADCMPDR0 4005 C29Ch, ADC121.ADCMPDR1 4005 C29Eh, ADC121.ADWINLLB 4005 C2A8h, ADC121.ADWINULB 4005 C2AAh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b15 to b0	—	—	Reference value	R/W

The ADCMPDRy (y = 0, 1) register specifies the reference data when the compare window A function is used. ADCMPDR0 sets the lower reference for window A, and ADCMPDR1 sets the upper reference for window A.

ADWINULB and ADWINLLB specify the reference data when the compare window B function is used. ADWINLLB sets the lower reference for window B, and ADWINULB sets the upper reference for window B. The ADCMPDRy, ADWINULB, and ADWINLLB are read/write registers.

ADCMPDRy, ADWINULB, and ADWINLLB can be written to, even during A/D conversion. The reference data can be dynamically changed by rewriting the register values during A/D conversion.

Set these registers so that the upper reference is not less than the lower reference (ADCMPDR1 ≥ ADCMPDR0 and ADWINULB ≥ ADWINLLB). ADCMPDR1 and ADWINULB are not used when the window function is disabled.

Note: The lower and upper references are changed when each register is written. For example, when the upper reference value changed and the lower reference value are changed, the MCU compares the upper reference (after a rewrite), and the lower reference (before a rewrite) with the A/D conversion result. See Figure 35.5. If the comparison during the rewriting of these two references is erroneous, then rewrite these reference values when both ADCSR.ADST and the associated compare window operation enable bit (ADCMPCR.CMPAE or ADCMPCR.CMPBE) are 0.

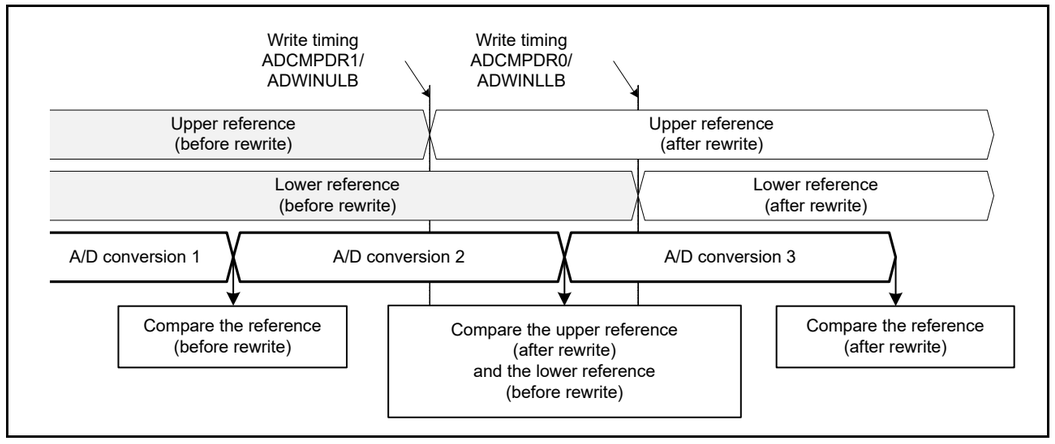


Figure 35.5 Comparison between upper and lower references before and after a rewrite

35.2.26 AD比较功能窗口A低端电平设置寄存器(ADCMPDR0) AD比较功能窗口A高端电平设置寄存器(ADCMPDR1) AD比较功能窗口B低端电平设置寄存器(ADWINLLB) AD比较功能窗口B上侧

电平设置寄存器(ADWINULB)

Address(es): ADC120.ADCMPDR0 4005 C09Ch, ADC120.ADCMPDR1 4005 C09Eh, ADC120.ADWINLLB 4005 C0A8h, ADC120.ADWINULB 4005 C0AAh, ADC121.ADCMPDR0 4005 C29Ch, ADC121.ADCMPDR1 4005 C29Eh, ADC121.ADWINLLB 4005 C2A8h, ADC121.ADWINULB 4005 C2AAh

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b15 to b0	—	—	参考值	R/W

ADCMPDRy(y=0 1)寄存器指定使用比较窗口A功能时的参考数据。ADCMPDDR0设置窗口A的下参考值，而ADCMPDR1设置窗口A的上参考值。

ADWINULB和ADWINLLB指定使用比较窗口B函数时的参考数据。ADWINLLB设置窗口B的下参考，ADWINULB设置窗口B的上参考。ADCMPDRy、ADWINULB和ADWINLLB是读写寄存器。

ADCMPDRy、ADWINULB和ADWINLLB可以写入，即使在AD转换期间也是如此。参考数据可以通过在AD转换期间重写寄存器值来动态更改。

设置这些寄存器，使参考上限不小于参考下限（ADCMPDR1≥ADCMPDR0且ADWINULB≥ADWINLLB）。禁用窗口功能时不使用ACMPDDR1和ADWINULB。

Note: 写入每个寄存器时会更改下参考和上参考。例如，当上参考值改变和下参考值改变时，MCU将上参考（重写后）和下参考（重写前）与AD转换结果进行比较。请参见图35.5。如果在重写这两个参考时比较错误，则在ADCSR.ADST和相关的比较窗口操作使能位（ADCMPCR.CMPAE或ADCMPCR.CMPBE）都为0时重写这些参考值。

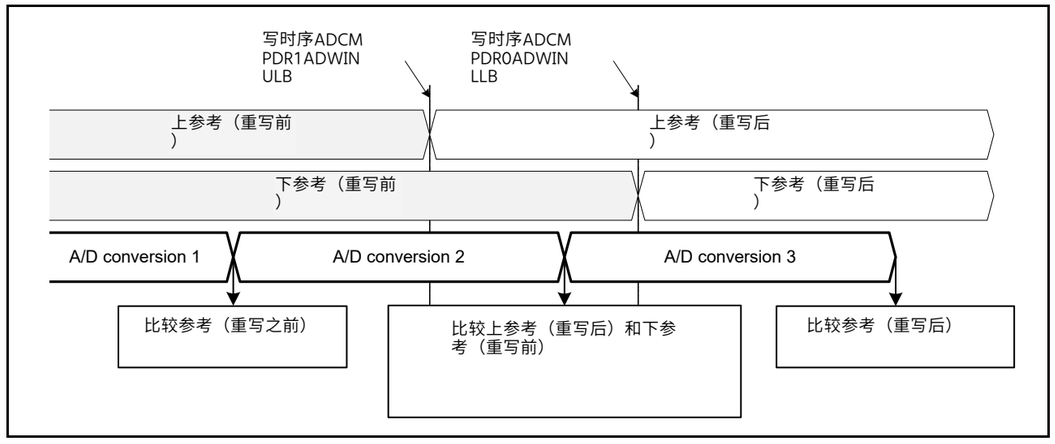


Figure 35.5 重写前后上下引用的比较

The ADCMPDRy, ADWINLLB, and ADWINULB registers use different formats depending on the following conditions:

- The value in the A/D Data Register Format Select bit (flush-right or flush-left)
- The value in the A/D Conversion Accuracy Specify bit (12-bit, 10-bit, or 8-bit)
- The value in the A/D-Converted Value Addition/Average Channel Select bits (A/D-converted value addition mode selected or not selected).

The data formats for each condition are described in this section.

(1) When A/D-converted value addition mode is not selected

- Flush-right data with 12-bit accuracy: Lower 12 bits ([11:0]) are valid
- Flush-right data with 10-bit accuracy: Lower 10 bits ([9:0]) are valid
- Flush-right data with 8-bit accuracy: Lower 8 bits ([7:0]) are valid
- Flush-left data with 12-bit accuracy: Upper 12 bits ([15:4]) are valid
- Flush-left data with 10-bit accuracy: Upper 10 bits ([15:6]) are valid
- Flush-left data with 8-bit accuracy: Upper 8 bits ([15:8]) are valid.

(2) When A/D-converted value addition mode is selected

- Flush-right data with 12-bit accuracy: Lower 14 bits ([13:0]) are valid
- Flush-right data with 10-bit accuracy: Lower 12 bits ([11:0]) are valid
- Flush-right data with 8-bit accuracy: Lower 10 bits ([9:0]) are valid
- Flush-left data with 12-bit accuracy: Upper 14 bits ([15:2]) are valid
- Flush-left data with 10-bit accuracy: Upper 12 bits ([15:4]) are valid
- Flush-left data with 8-bit accuracy: Upper 10 bits ([15:6]) are valid.

35.2.27 A/D Compare Function Window A Channel Status Register 0 (ADCMPSR0)

Address(es): ADC120.ADCMPSR0 4005 C0A0h, ADC121.ADCMPSR0 4005 C2A0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	CMPSTCHA07	CMPSTCHA06	CMPSTCHA05	—	CMPSTCHA03	CMPSTCHA02	CMPSTCHA01	CMPSTCHA00
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	CMPSTCHA03 to CMPSTCHA00	Compare Window A Flag	When window A operation is enabled (ADCMPCR.CMPAE = 1b), these bits indicate the comparison result of the channels to which window A comparison conditions are applied, selected from AN000 to AN003 (unit 0) and AN100 to AN102 (unit 1). 0: Comparison conditions are not met 1: Comparison conditions are met.	R/W
b4	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7 to b5	CMPSTCHA07 to CMPSTCHA05	Compare Window A Flag	When window A operation is enabled (ADCMPCR.CMPAE = 1b), these bits indicate the comparison result of the channels to which window A comparison conditions are applied, selected from AN005 to AN007 (unit 0) and AN105 to AN107 (unit 1). 0: Comparison conditions are not met 1: Comparison conditions are met.	R/W
b15 to b8	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

ADCMPDRy、ADWINLLB和ADWINULB寄存器根据以下条件使用不同的格式：

- AD数据寄存器格式选择位中的值（右对齐或左对齐）
- AD转换精度指定位（12位、10位或8位）中的值
- AD转换值加法平均通道选择位中的值（选择或未选择AD转换值加法模式）。

本节描述了每个条件的数据格式。

(1) 未选择AD转换值相加模式时

- 12位精度的右冲洗数据：低12位([11:0])有效
- 10位精度的右冲洗数据：低10位([9:0])有效
- 8位精度的右冲洗数据：低8位([7:0])有效
- 12位精度的左刷新数据：高12位([15:4])有效
- 10位精度的左刷新数据：高10位([15:6])有效
- 8位精度的左刷新数据：高8位([15:8])有效。

(2) 选择AD转换值相加模式时

- 12位精度的右冲洗数据：低14位([13:0])有效
- 10位精度的右冲洗数据：低12位([11:0])有效
- 8位精度的右冲洗数据：低10位([9:0])有效
- 12位精度的左刷新数据：高14位([15:2])有效
- 10位精度的左刷新数据：高12位([15:4])有效
- 8位精度的左刷新数据：高10位([15:6])有效。

35.2.27 AD比较功能窗口A通道状态寄存器0(ADCMPSR0)

Address(es): ADC120.ADCMPSR0 4005 C0A0h, ADC121.ADCMPSR0 4005 C2A0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	CMPSTCHA07	CMPSTCHA06	CMPSTCHA05	—	CMPSTCHA03	CMPSTCHA02	CMPSTCHA01	CMPSTCHA00
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	CMPSTCHA03 to CMPSTCHA00	比较窗口A标志	当窗口A操作使能（ADCMPCR.CMPAE=1b）时，这些位指示应用窗口A比较条件的通道的比较结果，从AN000到AN003（单元0）和AN100到AN102（单元1）中选择。0：不满足比较条件1：满足比较条件。	R/W
b4	—	Reserved	该位读取为0。写入值应为0。	R/W
b7 to b5	CMPSTCHA07 to CMPSTCHA05	比较窗口A标志	当窗口A操作使能（ADCMPCR.CMPAE=1b）时，这些位指示应用窗口A比较条件的通道的比较结果，从AN005到AN007（单元0）和AN105到AN107（单元1）中选择。0：不满足比较条件1：满足比较条件。	R/W
b15 to b8	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPSTCHAn flags (n = 00 to 03, 05 to 07) (Compare Window A Flag)

The CMPSTCHAn flags indicate the comparison results for channels to which window A comparison conditions are applied, selected from AN000 to AN003, AN005 to AN007 (unit 0), and AN100 to AN102, AN105 to AN107 (unit 1). When a comparison condition set in ADCMPLR0.CMPLCHAn is met at the end of A/D conversion, the associated CMPSTCHAn flag is set to 1. When the ADCMPCR.CMPAIE bit is 1, a compare interrupt request (ADC12i_CMPAI (i = 0, 1)) is generated when this flag is set to 1. In unit 0, CMPSTCHA00 is associated with AN000, and CMPSTCHA07 with AN007. In unit 1, CMPSTCHA00 is associated with AN100, and CMPSTCHA07 with AN107.

Writing 1 to the CMPSTCHAn flags is invalid.

[Setting condition]

- The condition set in ADCMPLR0.CMPLCHAn is met when ADCMPCR.CMPAE = 1.

[Clearing condition]

- Writing 0 after reading 1.

35.2.28 A/D Compare Function Window A Channel Status Register1 (ADCMPSR1)

Address(es): ADC120.ADCMPSR1 4005 C0A2h, ADC121.ADCMPSR1 4005 C2A2h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	CMPSTCHA20	—	CMPSTCHA18	CMPSTCHA17	CMPSTCHA16
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	CMPSTCHA18 to CMPSTCHA16	Compare Window A Flag	When window A operation is enabled (ADCMPCR.CMPAE = 1), these bits indicate the comparison result of the channels to which window A comparison conditions are applied, selected from AN016 to AN018 (unit 0) and AN116, AN117 (unit 1). 0: Comparison conditions are not met 1: Comparison conditions are met.	R/W
b3	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b4	CMPSTCHA20	Compare Window A Flag	When window A operation is enabled (ADCMPCR.CMPAE = 1b), this bit indicates the comparison result of the channel to which window A comparison condition is applied, selected AN020(unit 0). 0: Comparison conditions are not met 1: Comparison conditions are met.	R/W
b15 to b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CMPSTCHAn flags (n = 16 to 18, 20) (Compare Window A Flag)

The CMPSTCHAn flags indicate the comparison results for channels to which window A comparison conditions are applied, selected from AN016 to AN018, AN020 (unit 0), and AN116, AN117 (unit 1). When the comparison condition set in ADCMPLR1.CMPLCHAn is met at the end of A/D conversion, the associated CMPSTCHAn flag is set to 1. When the ADCMPCR.CMPAIE bit is 1, a compare interrupt request (ADC12i_CMPAI (i = 0, 1)) is generated when this flag is set to 1. In unit 0, CMPSTCHA16 is associated with AN016, and CMPSTCHA20 with AN020. In unit 1, CMPSTCHA16 is associated with AN116, and CMPSTCHA17 with AN117.

Writing 1 to the CMPSTCHAn flags is invalid.

[Setting condition]

- The condition set in ADCMPLR1.CMPLCHAn is met when ADCMPCR.CMPAE = 1.

[Clearing condition]

- Writing 0 after reading 1.

CMPSTCHAn标志（n=00到03、05到07）（比较窗口A标志）

CMPSTCHAn标志指示应用窗口A比较条件的通道的比较结果，从AN000到AN003、AN005到AN007（单元0）和AN100到AN102、AN105到AN107（单元1）中选择。当ADCMPLR0.CMPLCHAn中设置的比较条件在AD转换结束时满足时，相关的

CMPSTCHAn标志设置为1。当ADCMPCR.CMPAIE位为1时，当该标志设置为1时，会产生比较中断请求(ADC12i_CMPAI(i=0 1))。在单元0中，CMPSTCHA00与AN000相关联，以及带有AN007的CMPSTHA07。在单元1中，CMPSTCHA00与AN100相关联，CMPSTCHA07与AN107相关联。

将1写入CMPSTCHAn标志是无效的。

[Setting condition]

- 当ADCMPCR.CMPAE=1时，满足ADCMPLR0.CMPLCHAn中设置的条件。

[Clearing condition]

- 读1后写0。

35.2.28 AD比较功能窗口A通道状态寄存器1(ADCMPSR1)

Address(es): ADC120.ADCMPSR1 4005 C0A2h, ADC121.ADCMPSR1 4005 C2A2h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	CMPSTCHA20	—	CMPSTCHA18	CMPSTCHA17	CMPSTCHA16
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	CMPSTCHA18 to CMPSTCHA16	比较窗口A标志	当窗口A操作使能（ADCMPCR.CMPAE=1）时，这些位指示应用窗口A比较条件的通道的比较结果，从AN016到AN018（单元0）和AN116、AN117（单元1）中选择。0：不满足比较条件1：满足比较条件。	R/W
b3	—	Reserved	该位读取为0。写入值应为0。	R/W
b4	CMPSTCHA20	比较窗口A标志	当窗口A操作使能时（ADCMPCR.CMPAE=1b），该位指示应用窗口A比较条件的通道的比较结果，选择AN020（单元0）。0：不满足比较条件1：满足比较条件。	R/W
b15 to b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPSTCHAn标志（n=16到18、20）（比较窗口A标志）

CMPSTCHAn标志指示应用窗口A比较条件的通道的比较结果，从AN016到AN018、AN020（单元0）和AN116、AN117（单元1）中选择。当ADCMPLR1.CMPLCHAn中设置的比较条件在AD转换结束时满足，相关的CMPSTCHAn标志设置为1。当ADCMPCR.CMPAIE位为1时，一个比较中断请求（ADC12i_CMPAI(i=0 1)）此标志设置为1时生成。在单元0中，CMPSTTCHA16与AN016相关联，CMPSTTCHA20与AN020相关联。在单元1中，CMPSTCHA16与AN116相关联，CMPSTMHA17与AN117相关联。

将1写入CMPSTCHAn标志是无效的。

[Setting condition]

- 当ADCMPCR.CMPAE=1时，满足ADCMPLR1.CMPLCHAn中设置的条件。

[Clearing condition]

- 读1后写0。

35.2.29 A/D Compare Function Window A Extended Input Channel Status Register (ADCMPSER)

Address(es): ADC120.ADCMPSER 4005 C0A4h, ADC121.ADCMPSER 4005 C2A4h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	CMPSTOCA	CMPSTTSA
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CMPSTTSA	Compare Window A Temperature Sensor Output Compare Flag	When window A operation is enabled (ADCMPCR.CMPAE = 1), this bit indicates the temperature sensor output comparison result. 0: Comparison conditions are not met 1: Comparison conditions are met.	R/W
b1	CMPSTOCA	Compare Window A Internal Reference Voltage Compare Flag	When window A operation is enabled (ADCMPCR.CMPAE = 1), this bit indicates the internal reference voltage comparison result. 0: Comparison conditions are not met 1: Comparison conditions are met.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CMPSTTSA flag (Compare Window A Temperature Sensor Output Compare Flag)

The CMPSTTSA flag indicates the temperature sensor output comparison result. When the comparison condition set in ADCMPLER.CMPLTSA is met at the end of A/D conversion, this flag is set to 1. When the ADCMPCR.CMPAIE bit is 1, a compare interrupt request (ADC12i_CMPAI (i = 0, 1)) is generated when this flag is set to 1.

Writing 1 to the CMPSTTSA flag is invalid.

[Setting condition]

- The condition set in ADCMPLER.CMPLTSA is met when ADCMPCR.CMPAE = 1.

[Clearing condition]

- Writing 0 after reading 1.

CMPSTOCA flag (Compare Window A Internal Reference Voltage Compare Flag)

The CMPSTOCA flag indicates the internal reference voltage comparison result. When the comparison condition set in ADCMPLER.CMPLOCA is met at the end of A/D conversion, this flag is set to 1. When the ADCMPCR.CMPAIE bit is 1, a compare interrupt request (ADC12i_CMPAI) is generated when this flag is set to 1.

Writing 1 to the CMPSTOCA flag is invalid.

[Setting condition]

- The condition set in ADCMPLER.CMPLOCA is met when ADCMPCR.CMPAE = 1.

[Clearing condition]

- Writing 0 after reading 1.

35.2.29 AD比较功能窗口A扩展输入通道状态寄存器(ADCMPSER)

Address(es): ADC120.ADCMPSER 4005 C0A4h, ADC121.ADCMPSER 4005 C2A4h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	CMPSTOCA	CMPSTTSA
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CMPSTTSA	比较窗口A 温度传感器输出 比较标志	当窗口A操作使能时（ADCMPCR.CMPAE=1），该位指示温度传感器输出比较结果。0：不满足比较条件1：满足比较条件。	R/W
b1	CMPSTOCA	比较窗口A内部参考电压比较 Flag	当窗口A操作使能时（ADCMPCR.CMPAE=1），该位指示内部参考电压比较结果。0：不满足比较条件1：满足比较条件。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPSTTSA标志（比较窗口A温度传感器输出比较标志）

CMPSTTSA标志指示温度传感器输出比较结果。当ADCMPLER.CMPLTSA中设置的比较条件在AD转换结束时满足，该标志设置为1。当ADCMPCR.CMPAIE位为1时，产生比较中断请求(ADC12i_CMPAI(i=0 1))当此标志设置为1时。

将1写入CMPSTTSA标志无效。

[Setting condition]

- 当ADCMPCR.CMPAE=1时，满足ADCMPLER.CMPLTSA中设置的条件。

[Clearing condition]

- 读1后写0。

CMPSTOCA标志（比较窗口A内部参考电压比较标志）

CMPSTOCA标志指示内部参考电压比较结果。当ADCMPLER.CMPLOCA中设置的比较条件在AD转换结束时满足，该标志设置为1。当ADCMPCR.CMPAIE位为1时，当该标志设置为1时产生比较中断请求（ADC12i_CMPAI）.

将1写入CMPSTOCA标志无效。

[Setting condition]

- 当ADCMPCR.CMPAE=1时，满足ADCMPLER.CMPLOCA中设置的条件。

[Clearing condition]

- 读1后写0。

35.2.30 A/D Compare Function Window B Channel Select Register (ADCMPBNSR)

Address(es): ADC120.ADCMPBNSR 4005 C0A6h, ADC121.ADCMPBNSR 4005 C2A6h

	b7	b6	b5	b4	b3	b2	b1	b0
	CMPLB	—	CMPCHB[5:0]					
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b5 to b0	CMPCHB[5:0]	Compare Window B Channel Select	These bits select channels to be compared with the compare window B conditions. The maximum channel is AN020 in unit 0 and AN117 in unit 1. b5 b0 Unit 0 Unit 1 0 0 0 0 0 0: AN000 AN100 0 0 0 0 0 1: AN001 AN101 0 0 0 0 1 0: AN002 AN102 0 0 0 0 1 1: AN003 — 0 0 0 1 0 1: AN005 AN105 0 0 0 1 1 0: AN006 AN106 0 0 0 1 1 1: AN007 AN107 0 1 0 0 0 0: AN016 AN116 0 1 0 0 0 1: AN017 AN117 0 1 0 0 1 0: AN018 — 0 1 0 1 0 0: AN020 — 1 0 0 0 0 0: Temperature sensor 1 0 0 0 0 1: Internal reference voltage 1 1 1 1 1 1: Do no select. Other settings are prohibited.	R/W
b6	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7	CMPLB	Compare Window B Comparison Condition Setting	This bit sets comparison conditions for the channels for window B. The comparison conditions are shown in Figure 35.6. • When window function is disabled (ADCMPCR.WCMPE = 0) 0: CMPLLB value > A/D-converted value 1: CMPLLB value < A/D-converted value. • When window function is enabled (ADCMPCR.WCMPE = 1) 0: A/D-converted value < CMPLLB value, or CMPULB value < A/D-converted value 1: CMPLLB value < A/D-converted value < CMPULB value.	R/W

CMPCHB[5:0] bits (Compare Window B Channel Select)

The CMPCHB[5:0] bits specify the channels to be compared with the compare window B conditions from AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020 (unit 0), AN100 to AN102, AN105 to AN107, AN116, AN117 (unit 1), the temperature sensor, and the internal reference voltage. The compare window B function is enabled by specifying the hexadecimal number of the A/D conversion channel selected in the following bits:

Unit 0

- ADANSA0.ANSA00 to ANSA03 bits
- ADANSA0.ANSA05 to ANSA07 bits
- ADANSA1.ANSA16 toANSA018, ANSA20 bits
- ADANSB0.ANSB00 to ANSB03 bits
- ADANSB0.ANSB05 to ANSB07 bits
- ADANSB1.ANSB16 to ANSB18, ANSB20 bits.

Unit 1

- ADANSA0.ANSA00 to ANSA02 bits

35.2.30 AD比较功能窗口B通道选择寄存器(ADCMPBNSR)

Address(es): ADC120.ADCMPBNSR 4005 C0A6h, ADC121.ADCMPBNSR 4005 C2A6h

	b7	b6	b5	b4	b3	b2	b1	b0
	CMPLB	—	CMPCHB[5:0]					
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b5 to b0	CMPCHB[5:0]	比较窗口B通道 Select	这些位选择要与比较窗口B条件进行比较的通道。最大通道为单元0中的AN020和单元1中的AN117。b5b0单元0单元1 0 0 0 0 0 0: AN000 AN100 0 0 0 0 0 1: AN001 AN101 0 0 0 0 1 0: AN002 AN102 0 0 0 0 1 1: AN003 — 0 0 0 1 0 1: AN005 AN105 0 0 0 1 1 0: AN006 AN106 0 0 0 1 1 1: AN007 AN107 0 1 0 0 0 0: AN016 AN116 0 1 0 0 0 1: AN017 AN117 0 1 0 0 1 0: AN018 — 0 1 0 1 0 0: AN020 — 1 0 0 0 0 0：温度传感器 1 0 0 0 0 1：内部参考电压 11：不选择。禁止其他设置。	R/W
b6	—	Reserved	该位读取为0。写入值应为0。	R/W
b7	CMPLB	比较窗口B 比较条件设置	该位设置窗口B的通道比较条件。比较条件如图35.6所示。 禁用窗口功能时(ADCMPCR.WCMPE=0)0：CMPLLB值>AD转换值1：CMPLLB值<AD转换值。 启用窗口功能时(ADCMPCR.WCMPE=1)0：D转换值<CMPLLB值，或CMPULB值<AD转换值1：CMPLLB值<AD转换值<CMPULB值。	R/W

CMPCHB[5:0]位（比较窗口B通道选择）

CMPCHB[5:0]位指定要与比较窗口B条件比较的通道，从AN000到AN003、AN005到AN007、AN016到AN018、AN020（单元0）、AN100到AN102、AN105到AN107、AN116、AN117（单元1）、温度传感器和内部参考电压。通过指定在以下位中选择的AD转换通道的十六进制数来启用比较窗口B功能：

Unit 0

- ADANSA0.ANSA00到ANSA03位
- ADANSA0.ANSA05到ANSA07位
- ADANSA1.ANSA16 toANSA018, ANSA20 bits
- ADANSB0.ANSB00至ANSB03位
- ADANSB0.ANSB05至ANSB07位
- ADANSB1.ANSB16至ANSB18、ANSB20位。

Unit 1

- ADANSA0.ANSA00到ANSA02位

- ADANSA0.ANSA05 to ANSA07 bits
- ADANSA1.ANSA16, ANSA17 bits
- ADANSB0.ANSB00 to ANSB02 bits
- ADANSB0.ANSB05 to ANSB07 bits
- ADANSB1.ANSB16, ANSB17 bits.

Set the CMPCHB[5:0] bits while the ADCSR.ADST bit is 0.

CMPLB bit (Compare Window B Comparison Condition Setting)

The CMPLB bit specifies the comparison conditions for the channels for window B. When the comparison result of an analog input meets the set condition, the associated ADCMPBSR.CMPSTB flag is set to 1, and a compare interrupt request (ADC12i_CMPBI (i = 0, 1)) is generated.

Compare conditions when the window function is disabled

CMPLB = 0		CMPLB = 1	
ADWINLLB value ≤ A/D converted value	Not met	ADWINLLB value < A/D converted value	Met
ADWINLLB value > A/D converted value	Met	ADWINLLB value ≥ A/D converted value	Not met

Compare conditions when the window function is enabled

CMPLB = 0

A/D converted value > ADWINULB value	Met
ADWINLLB value ≤ A/D converted value ≤ ADWINULB value	Not met
A/D converted value < ADWINLLB value	Met

CMPLB = 1

A/D converted value ≥ ADWINULB value	Not met
ADWINLLB value <A/D converted value < ADWINULB value	Met
A/D converted value ≤ ADWINLLB value	Not met

Figure 35.6 Explanation of compare conditions for compare function for window B

- ADANSA0.ANSA05到ANSA07位
- ADANSA1.ANSA16, ANSA17 bits
- ADANSB0.ANSB00到ANSB02位
- ADANSB0.ANSB05至ANSB07位
- ADANSB1.ANSB16, ANSB17 bits.

当ADCSR.ADST位为0时，设置CMPCHB[5:0]位。

CMPLB位（比较窗口B比较条件设置）

CMPLB位指定窗口B通道的比较条件。当模拟输入的比较结果满足设置条件时，相关的ADCMPBSR.CMPSTB标志设置为1，并且比较中断请求(ADC12i_CMPBI(i=0 1))生成。

比较禁用窗口功能时的条件

CMPLB = 0		CMPLB = 1	
ADWINLLB值 AD转换值	没见过	ADWINLLB值<AD转换值	Met
ADWINLLB值>AD转换值	Met	ADWINLLB值 AD转换值	没见过

启用窗口功能时比较条件

CMPLB = 0

AD转换值>ADWINULB值	Met
ADWINLLB值 AD转换值 ADWINULB值	没见过
AD转换值<ADWINLLB值	Met

CMPLB = 1

AD转换值 ADWINULB值	没见过
ADWINLLB值<AD转换值<ADWINULB值	Met
AD转换值 ADWINLLB值	没见过

Figure 35.6 窗口B比较功能的比较条件说明

35.2.31 A/D Compare Function Window B Status Register (ADCMPBSR)

Address(es): ADC120.ADCMPBSR 4005 C0ACh, ADC121.ADCMPBSR 4005 C2ACh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CMPSTB
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CMPSTB	Compare Window B Flag	When window B operation is enabled (ADCMPCR.CMPBE = 1), this bit indicates the comparison result of the channels to which window B comparison conditions are applied, selected from AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020 (unit 0), AN100 to AN102, AN105 to AN107, and AN116, AN117 (unit 1), temperature sensor output, and internal reference voltage. 0: Comparison conditions are not met 1: Comparison conditions are met.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

CMPSTB flag (Compare Window B Flag)

The CMPSTB flag indicates the comparison result of the channels to which window B comparison conditions are applied, selected from AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020 (unit 0), AN100 to AN102, AN105 to AN107, AN116, AN117 (unit 1), the temperature sensor, and the internal reference voltage. When the comparison condition set in ADCMPBNSR.CMPLB is met at the end of A/D conversion, this flag is set to 1. When the ADCMPCR.CMPBIE bit is 1, a compare interrupt request (ADC12i_CMPBI (i = 0, 1)) is generated when this flag is set to 1.

Writing 1 to the CMPSTB flag is invalid.

[Setting condition]

- The condition set in ADCMPBNSR.CMPLB is met when ADCMPCR.CMPBE = 1.

[Clearing condition]

- Writing 0 after reading 1.

35.2.32 A/D Compare Function Window A/B Status Monitor Register (ADWINMON)

Address(es): ADC120.ADWINMON 4005 C08Ch, ADC121.ADWINMON 4005 C28Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	MONCMPB	MONCMPA	—	—	—	MONCOMB
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	MONCOMB	Combination Result Monitor	This bit indicates the combination result. This bit is valid when both window A and window B operations are enabled. 0: Window A/B composite conditions are not met 1: Window A/B composite conditions are met.	R
b3 to b1	—	Reserved	These bits are read as 0	R
b4	MONCMPA	Comparison Result Monitor A	0: Window A comparison conditions are not met 1: Window A comparison conditions are met.	R
b5	MONCMPB	Comparison Result Monitor B	0: Window B comparison conditions are not met 1: Window B comparison conditions are met.	R

35.2.31 AD比较功能窗口B状态寄存器(ADCMPBSR)

Address(es): ADC120.ADCMPBSR 4005 C0ACh, ADC121.ADCMPBSR 4005 C2ACh

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CMPSTB
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CMPSTB	比较窗口B标志	当窗口B操作使能时（ADCMPCR.CMPBE=1），该位指示应用窗口B比较条件的通道的比较结果，选择从AN000到AN003、AN005到AN007、AN016到AN018、AN020（单元0）、AN100至AN102、AN105至AN107和AN116、AN117（单元1）、温度传感器输出和内部参考电压。0：不满足比较条件1：满足比较条件。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

CMPSTB标志（比较窗口B标志）

CMPSTB标志表示应用窗口B比较条件的通道的比较结果，从AN000到AN003、AN005到AN007、AN016到AN018、AN020（单元0）、AN100到AN102、AN105到AN107、AN116、AN117中选择（单元1）、温度传感器和内部参考电压。当ADCMPBNSR.CMPLB中设置的比较条件在AD转换结束时满足，该标志设置为1。当ADCMPCR.CMPBIE位为1时，产生比较中断请求(ADC12i_CMPBI(i=0 1))当此标志设置为1时。

将1写入CMPSTB标志无效。

[Setting condition]

- 当ADCMPCR.CMPBE=1时，满足ADCMPBNSR.CMPLB中设置的条件。

[Clearing condition]

- 读1后写0。

35.2.32 AD比较功能窗口AB状态监控寄存器(ADWINMON)

Address(es): ADC120.ADWINMON 4005 C08Ch, ADC121.ADWINMON 4005 C28Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	MONCMPB	MONCMPA	—	—	—	MONCOMB
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	MONCOMB	组合结果监视器	该位指示组合结果。当窗口A和窗口B操作都使能时，该位有效。0：不满足窗口AB合成条件1：满足窗口AB合成条件。	R
b3 to b1	—	Reserved	这些位被读为0	R
b4	MONCMPA	比较结果监视器A	0：不满足窗口A比较条件1：满足窗口A比较条件。	R
b5	MONCMPB	比较结果监视器B	0：不满足窗口B比较条件1：满足窗口B比较条件。	R

Bit	Symbol	Bit name	Description	R/W
b7, b6	—	Reserved	These bits are read as 0	R

MONCOMB bit (Combination Result Monitor)

The read-only MONCOMB bit indicates the combined result of comparison condition results A and B based on the combination condition set in the ADCMPCR.CMPAB[1:0] bits.

[Setting condition]

- The combined result meets the combination condition set in the ADCMPCR.CMPAB[1:0] bits when ADCMPCR.CMPAE = 1 and ADCMPCR.CMPBE = 1.

[Clearing conditions]

- The combined result does not meet the combination condition set in the ADCMPCR.CMPAB[1:0] bits
- ADCMPCR.CMPAE = 0 or ADCMPCR.CMPBE = 0.

MONCMPA bit (Comparison Result Monitor A)

The read-only MONCMPA bit is read as 1 when the A/D-converted value of the window A target channel meets the condition set in the ADCMPLR0/ADCMPLR1 and ADCMPLER registers. Otherwise, it is read as 0.

[Setting condition]

- The A/D-converted value meets the condition set in ADCMPLR0.CMPLCHAn when ADCMPCR.CMPAE = 1.

[Clearing conditions]

- The A/D-converted value does not meet the condition set in ADCMPLR0.CMPLCHAn when ADCMPCR.CMPAE = 1
- ADCMPCR.CMPAE = 0 (automatically cleared when the ADCMPCR.CMPAE value changes from 1 to 0).

MONCMPB bit (Comparison Result Monitor B)

The read-only MONCMPB bit is read as 1 when the A/D-converted value of the window B target channel meets the condition set in the ADCMPBNSR.CMPLB bit. Otherwise, it is read as 0.

[Setting condition]

- The A/D-converted value meets the condition set in ADCMPBNSR.CMPLB when ADCMPCR.CMPBE = 1.

[Clearing conditions]

- The A/D-converted value does not meet the condition set in ADCMPBNSR.CMPLB when ADCMPCR.CMPBE = 1
- ADCMPCR.CMPBE = 0 (automatically cleared when the ADCMPCR.CMPBE value changes from 1 to 0).

35.2.33 A/D Programmable Gain Amplifier Control Register (ADPGACR)

Address(es): ADC120.ADPGACR 4005 C1A0h, ADC121.ADPGACR 4005 C3A0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	P002GEN	P002ENAMP	P002SEL1	P002SEL0	P001GEN	P001ENAMP	P001SEL1	P001SEL0	P000GEN	P000ENAMP	P000SEL1	P000SEL0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	P000SEL0	PGA P000 Amplifier Bypass Enable	0: Do not output the signal in a path bypassing the PGA amplifier 1: Output the signal in a path bypassing the PGA amplifier.	R/W
b1	P000SEL1	PGA P000 Amplifier Transit Enable	0: Do not output the signal in a path through the PGA amplifier 1: Output the signal in a path through the PGA amplifier.	R/W

Bit	Symbol	位名称	Description	R/W
b7, b6	—	Reserved	这些位被读为0	R

MONCOMB位（组合结果监视器）

只读MONCOMB位指示比较条件结果A和B基于ADCMPCR.CMPAB[1:0]位中设置的组合条件的组合结果。

[Setting condition]

- 当组合结果满足ADCMPCR.CMPAB[1:0]位中设置的组合条件时
  ADCMPCR.CMPAE = 1 and ADCMPCR.CMPBE = 1.

[Clearing conditions]

- 组合结果不满足ADCMPCR.CMPAB[1:0]位中设置的组合条件
- ADCMPCR.CMPAE = 0 or ADCMPCR.CMPBE = 0.

MONCMPA位（比较结果监视器A）

当窗口A目标通道的AD转换值满足ADCMPLR0ADCMPLR1和ADCMPLER寄存器中设置的条件时，只读MONCMPA位被读取为1。否则，读为0。

[Setting condition]

- 当ADCMPCR.CMPAE=1时，AD转换后的值满足ADCMPLR0.CMPLCHAn中设置的条件。

[Clearing conditions]

- 当ADCMPCR.CMPAE=1时，AD转换后的值不满足ADCMPLR0.CMPLCHAn中设置的条件
- ADCMPCR.CMPAE=0（ADCMPCR.CMPAE值从1变为0时自动清零）。

MONCMPB位（比较结果监视器B）

当窗口B目标通道的AD转换值满足ADCMPBNSR.CMPLB位中设置的条件时，只读MONCMPB位被读取为1。否则，读为0。

[Setting condition]

- 当ADCMPCR.CMPBE=1时，AD转换后的值满足ADCMPBNSR.CMPLB中设置的条件。

[Clearing conditions]

- 当ADCMPCR.CMPBE=
  1
- ADCMPCR.CMPBE=0（ADCMPCR.CMPBE值从1变为0时自动清零）。

35.2.33 AD可编程增益放大器控制寄存器(ADPGACR)

Address(es): ADC120.ADPGACR 4005 C1A0h, ADC121.ADPGACR 4005 C3A0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	P002GEN	P002ENAMP	P002SEL1	P002SEL0	P001GEN	P001ENAMP	P001SEL1	P001SEL0	P000GEN	P000ENAMP	P000SEL1	P000SEL0
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	P000SEL0	PGAP000放大器旁路Enable	0：不输出绕过PGA放大器的路径1：输出绕过PGA放大器的路径。	R/W
b1	P000SEL1	PGAP000放大器传输Enable	0：不通过PGA放大器的路径输出信号1：通过PGA放大器的路径输出信号。	R/W

Bit	Symbol	Bit name	Description	R/W
b2	P000ENAMP	PGA P000 Amplifier Enable	0: Do not use the PGA amplifier 1: Use the PGA amplifier.	R/W
b3	P000GEN	PGA P000 Gain Setting Enable	0: Disable gain setting 1: Enable gain setting.	R/W
b4	P001SEL0	PGA P001 Amplifier Bypass Enable	0: Do not output the signal in a path bypassing the PGA amplifier 1: Output the signal in a path bypassing the PGA amplifier.	R/W
b5	P001SEL1	PGA P001 Amplifier Transit Enable	0: Do not output the signal in a path through the PGA amplifier 1: Output the signal in a path through the PGA amplifier.	R/W
b6	P001ENAMP	PGA P001 Amplifier Enable	0: Do not use the PGA amplifier 1: Use the PGA amplifier.	R/W
b7	P001GEN	PGA P001 Gain Setting Enable	0: Disable gain setting 1: Enable gain setting.	R/W
b8	P002SEL0	PGA P002 Amplifier Bypass Enable	0: Do not output the signal in a path bypassing the PGA amplifier 1: Output the signal in a path bypassing the PGA amplifier.	R/W
b9	P002SEL1	PGA P002 Amplifier Transit Enable	0: Do not output the signal in a path through the PGA amplifier 1: Output the signal in a path through the PGA amplifier.	R/W
b10	P002ENAMP	PGA P002 Amplifier Enable	0: Do not use the PGA amplifier 1: Use the PGA amplifier.	R/W
b11	P002GEN	PGA P002 Gain Setting Enable	0: Disable gain setting 1: Enable gain setting.	R/W
b12	—	Reserved	This bit is read as 1. The write value should be 1.	R/W
b14, b13	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b15	—	Reserved	This bit is read as 1. The write value should be 1.	R/W

Note: See section 35.3.12, Programmable Gain Amplifiers, for details on setting these bits.

PnSEL0 bit (PGA Pn Amplifier Bypass Enable) (n = 000 to 002)

The PnSEL0 bit selects whether to output the signal in a path that bypasses the amplifier in the PGA for each programmable gain amplifier Pn.

PnSEL1 bit (PGA Pn Amplifier Transit Enable) (n = 000 to 002)

The PnSEL1 bit selects whether to output the signal in a path through the amplifier in the PGA for each programmable gain amplifier Pn.

PnENAMP bit (PGA Pn Amplifier Enable) (n = 000 to 002)

The PnENAMP bit selects whether to use the amplifier in the PGA for each programmable gain amplifier Pn.

PnGEN bit (PGA Pn Input Resistance Side Gain Selection Signal Enable) (n = 000 to 002)

The PnGEN bit enables or disables the gain setting for each programmable gain amplifier Pn.

Bit	Symbol	位名称	Description	R/W
b2	P000ENAMP	PGAP000放大器启用	0：不使用PGA放大器1：使用PGA放大器。	R/W
b3	P000GEN	PGAP000增益设置Enable	0：禁用增益设置1：启用增益设置。	R/W
b4	P001SEL0	PGAP001放大器旁路Enable	0：不输出绕过PGA放大器的路径1：输出绕过PGA放大器的路径。	R/W
b5	P001SEL1	PGAP001放大器传输Enable	0：不通过PGA放大器的路径输出信号1：通过PGA放大器的路径输出信号。	R/W
b6	P001ENAMP	PGAP001放大器启用	0：不使用PGA放大器1：使用PGA放大器。	R/W
b7	P001GEN	PGAP001增益设置Enable	0：禁用增益设置1：启用增益设置。	R/W
b8	P002SEL0	PGAP002放大器旁路Enable	0：不输出绕过PGA放大器的路径1：输出绕过PGA放大器的路径。	R/W
b9	P002SEL1	PGAP002放大器传输Enable	0：不通过PGA放大器的路径输出信号1：通过PGA放大器的路径输出信号。	R/W
b10	P002ENAMP	PGAP002放大器启用	0：不使用PGA放大器1：使用PGA放大器。	R/W
b11	P002GEN	PGAP002增益设置Enable	0：禁用增益设置1：启用增益设置。	R/W
b12	—	Reserved	该位读取为1。写入值应为1。	R/W
b14, b13	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b15	—	Reserved	该位读取为1。写入值应为1。	R/W

Note: 有关设置这些位的详细信息，请参见第35.3.12节，可编程增益放大器。

PnSEL0位（PGAPn放大器旁路使能）（n=000至002）

PnSEL0位为每个可编程增益放大器Pn选择是否在绕过PGA中放大器的路径输出信号。

PnSEL1位（PGAPn放大器传输使能）（n=000至002）

PnSEL1位为每个可编程增益放大器Pn选择是否在通过PGA中的放大器的路径中输出信号。

PnENAMP位（PGAPn放大器启用）（n=000至002）

PnENAMP位为每个可编程增益放大器Pn选择是否使用PGA中的放大器。

PnGEN位（PGAPn输入电阻侧增益选择信号使能）（n=000至002）

PnGEN位启用或禁用每个可编程增益放大器Pn的增益设置。

35.2.34 A/D Programmable Gain Amplifier Gain Setting Register 0 (ADPGAGS0)

Address(es): ADC120.ADPGAGS0 4005 C1A2h, ADC121.ADPGAGS0 4005 C3A2h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	P002GAIN[3:0]				P001GAIN[3:0]				P000GAIN[3:0]			
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	P000GAIN[3:0]	PGA P000 Gain Setting	• When pseudo-differential input is disabled (ADPGADCR0.PnDEN = 0) 0 0 0 0: × 2.000 0 0 0 1: × 2.500 0 0 1 0: × 2.667 0 0 1 1: × 2.857 0 1 0 0: × 3.077 0 1 0 1: × 3.333 0 1 1 0: × 3.636 0 1 1 1: × 4.000 1 0 0 0: × 4.444 1 0 0 1: × 5.000 1 0 1 0: × 5.714 1 0 1 1: × 6.667 1 1 0 0: × 8.000 1 1 0 1: × 10.000 1 1 1 0: × 13.333. • When pseudo-differential input is enabled (ADPGADCR0.PnDEN = 1)*1 0 0 0 1: × 1.500 0 1 0 1: × 2.333 1 0 0 1: × 4.000 1 0 1 1: × 5.667. Other settings are prohibited.	R/W
b7 to b4	P001GAIN[3:0]	PGA P001 Gain Setting		R/W
b11 to b8	P002GAIN[3:0]	PGA P002 Gain Setting		R/W
b15 to b12	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. For details on setting these bits, see section 35.3.12, Programmable Gain Amplifiers.

PnGAIN[3:0] bits (PGA Pn Gain Setting) (n = 000 to 002)

The PnGAIN[3:0] bits specify the gain of each PGA amplifier Pn. For pseudo-differential inputs (ADPGADCR0.PnDEN = 1 and ADPGACR.PnGEN = 1), these bits set the gain in combination with ADPGADCR0.PnDG[1:0].

35.2.34 AD可编程增益放大器增益设置寄存器0(ADPGAGS0)

Address(es): ADC120.ADPGAGS0 4005 C1A2h, ADC121.ADPGAGS0 4005 C3A2h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	P002GAIN[3:0]				P001GAIN[3:0]				P000GAIN[3:0]			
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	P000GAIN[3:0]	PGAP000增益设置	当伪差分输入禁用时(ADPGADCR0.PnDEN=0) 0 0 0 0: × 2.000 0 0 0 1: × 2.500 0 0 1 0: × 2.667 0 0 1 1: × 2.857 0 1 0 0: × 3.077 0 1 0 1: × 3.333 0 1 1 0: × 3.636 0 1 1 1: × 4.000 1 0 0 0: × 4.444 1 0 0 1: × 5.000 1 0 1 0: × 5.714 1 0 1 1: × 6.667 1 1 0 0: × 8.000 1 1 0 1: × 10.000 1 1 1 0: × 13.333. 当启用伪差分输入时(ADPGADCR0.PnDEN=1)*1 0 0 0 1: × 1.500 0 1 0 1: × 2.333 1 0 0 1: × 4.000 11： 5.667。禁止其他设置。	R/W
b7 to b4	P001GAIN[3:0]	PGAP001增益设置		R/W
b11 to b8	P002GAIN[3:0]	PGAP002增益设置		R/W
b15 to b12	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 有关设置这些位的详细信息，请参见第35.3.12节，可编程增益放大器。

PnGAIN[3:0]位（PGAPn增益设置）（n=000至002）

PnGAIN[3:0]位指定每个PGA放大器Pn的增益。对于伪差分输入（ADPGADCR0.PnDEN=1和ADPGACR.PnGEN=1），这些位与ADPGADCR0.PnDG[1:0]一起设置增益。

35.2.35 A/D Programmable Gain Amplifier Pseudo-Differential Input Control Register (ADPGADCR0)

Address(es): ADC120.ADPGADCR0 4005 C1B0h, ADC121.ADPGADCR0 4005 C3B0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	P002DEN	—	P002DG[1:0]		P001DEN	—	P001DG[1:0]		P000DEN	—	P000DG[1:0]	
Value after reset:	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	P000DG[1:0]	P000 Pseudo-Differential Input Gain Setting	When these bits are used, set {P000DEN, P000GEN} to 11b. b1 b0 0 0: × 1.5 0 1: × 2.333 1 0: × 4.0 1 1: × 5.667.	R/W
b2	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b3	P000DEN	P000 Pseudo-Differential Input Enable	0: Disable pseudo-differential input 1: Enable pseudo-differential input.	R/W
b5, b4	P001DG[1:0]	P001 Pseudo-Differential Input Gain Setting	When these bits are used, set {P001DEN, P001GEN} to 11b. b5 b4 0 0: × 1.5 0 1: × 2.333 1 0: × 4.0 1 1: × 5.667.	R/W
b6	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b7	P001DEN	P001 Pseudo-Differential Input Enable	0: Disable pseudo-differential input 1: Enable pseudo-differential input.	R/W
b9, b8	P002DG[1:0]	P002 Pseudo-Differential Input Gain Setting	When these bits are used, set {P002DEN, P002GEN} to 11b. b9 b8 0 0: × 1.5 0 1: × 2.333 1 0: × 4.0 1 1: × 5.667.	R/W
b10	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b11	P002DEN	P002 Pseudo-Differential Input Enable	0: Disable pseudo-differential input 1: Enable pseudo-differential input.	R/W
b15 to b12	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note: For details on setting these bits, see section 35.3.12, Programmable Gain Amplifiers.

PnDG[1:0] bits (Pn Pseudo-Differential Input Gain Setting) (n = 000 to 002)

The PnDG[1:0] bits specify the gain of each PGA amplifier Pn when pseudo-differential inputs are used. These bits are only valid when the PnDEN bit is 1 and the PnGEN bit is 1.

To use the PGA for pseudo-differential inputs, set the ADPGADCR0.PnDG[1:0] bits in conjunction with the ADPGAGS0.PnGAIN[3:0] bits.

Example: To set the gain to × 1.5 using P000 for pseudo-differential input, set:
ADPGAGS0.P000GAIN[3:0] = 0001b
ADPGADCR0.P000DG[1:0] = 00b.

PnDEN bit (Pn Pseudo-Differential Input Enable) (n = 000 to 002)

The PnDEN bit enables or disables pseudo-differential inputs for each PGA amplifier Pn.

35.2.35 AD可编程增益放大器伪差分输入控制寄存器(ADPGADCR0)

Address(es): ADC120.ADPGADCR0 4005 C1B0h, ADC121.ADPGADCR0 4005 C3B0h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	P002DEN	—	P002DG[1:0]		P001DEN	—	P001DG[1:0]		P000DEN	—	P000DG[1:0]	
重置后的值:	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	P000DG[1:0]	P000 Pseudo-Differential Input 增益设置	使用这些位时，将{P000DEN P000GEN 设置为11b。b1b0 0 0: 1.5 0 1: × 2.333 1 0: × 4.0 1 1: × 5.667.	R/W
b2	—	Reserved	该位读取为0。写入值应为0。	R/W
b3	P000DEN	P000 Pseudo-Differential Input Enable	0：禁用伪差分输入1：启用伪差分输入。	R/W
b5, b4	P001DG[1:0]	P001 Pseudo-Differential Input 增益设置	使用这些位时，将{P001DEN P001GEN 设置为11b。b5b4 0 0: 1.5 0 1: × 2.333 1 0: × 4.0 1 1: × 5.667.	R/W
b6	—	Reserved	该位读取为0。写入值应为0。	R/W
b7	P001DEN	P001 Pseudo-Differential Input Enable	0：禁用伪差分输入1：启用伪差分输入。	R/W
b9, b8	P002DG[1:0]	P002 Pseudo-Differential Input 增益设置	使用这些位时，将{P002DEN P002GEN 设置为11b。b9b8 0 0: 1.5 0 1: × 2.333 1 0: × 4.0 1 1: × 5.667.	R/W
b10	—	Reserved	该位读取为0。写入值应为0。	R/W
b11	P002DEN	P002 Pseudo-Differential Input Enable	0：禁用伪差分输入1：启用伪差分输入。	R/W
b15 to b12	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note: 有关设置这些位的详细信息，请参见第35.3.12节，可编程增益放大器。

PnDG[1:0]位（Pn伪差分输入增益设置）（n=000至002）

当使用伪差分输入时，PnDG[1:0]位指定每个PGA放大器Pn的增益。这些位仅在PnDEN位为1且PnGEN位为1时有效。

要将PGA用于伪差分输入，请将ADPGADCR0.PnDG[1:0]位与
ADPGAGS0.PnGAIN[3:0] bits.

示例：要使用P000为伪差分输入将增益设置为 1.5，请设置：
ADPGAGS0.P000GAIN[3:0] = 0001b
ADPGADCR0.P000DG[1:0] = 00b.

PnDEN位（Pn伪差分输入使能）（n=000至002）

PnDEN位启用或禁用每个PGA放大器Pn的伪差分输入。

35.3 Operation

35.3.1 Scanning Operation

In scanning, A/D conversion is performed sequentially on the analog inputs of the specified channels.

Scan conversion is performed in three operating modes:

- Single scan mode
- Continuous scan mode
- Group scan mode.

In single scan mode, one or more specified channels are scanned once. In continuous scan mode, one or more specified channels are scanned repeatedly until the ADCSR.ADST bit is cleared to 0 from 1 by software. In group scan mode, the selected channels in group A and the selected channels in group B are scanned once after scan starts in response to the respective synchronous trigger (ELC).

In single scan mode and continuous scan mode, A/D conversion is performed on the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n. In group scan mode, A/D conversion is performed for the ANn channels in group A selected in the ADANSA0 and ADANSA1 registers first, and then for the ANn channels in group B selected in the ADANSB0 and ADANSB1 registers, starting from the channel with the smallest number n.

When self-diagnosis is selected, it is executed once at the beginning of each scan, and one of the three voltages generated internally in the ADC12 is converted.

The temperature sensor output and internal reference voltage can be selected at the same time as the analog input of the channels, and A/D conversion is performed on the analog input of channels, temperature sensor output, and internal reference voltage, in that order.

Double trigger mode can be used with single scan mode or group scan mode. With double trigger mode enabled (ADCSR.DBLE = 1), A/D conversion data of a channel selected in the ADCSR.DBLANS[4:0] bits is duplicated only if the conversion is started by the synchronous trigger (ELC) selected in the TRSA[5:0] bits in ADSTRGR. Only group A in group scan mode can use the double trigger mode.

The extended operation of double trigger mode means the A/D conversion operation is generated from the synchronous trigger combination. This trigger combination is selected in ADSTRGR.TRSA[5:0] in double trigger mode. ELC_AD00 and ELC_AD01 are associated with unit 0. ELC_AD10 and ELC_AD11 are associated with unit 1.

In the extended operation of double trigger mode, in addition to normal double-trigger operation, A/D conversion data from the ELC_AD00 (unit 0) and ELC_AD10 (unit 1) triggers is stored in the A/D Data Duplexing Register A (ADDBLDRA), and A/D conversion data from the ELC_AD01 (unit 0) and ELC_AD11 (unit 1) triggers is stored in the A/D Data Duplexing Register B (ADDBLDRB). In the extended operation of double trigger mode, when a combination of triggers occurs at the same time, the data duplexing register settings for the specified triggers do not work, and A/D conversion data is stored in the A/D Data Duplexing Register B (ADDBLDRB).

When one synchronous trigger is input during the A/D conversion started by another synchronous trigger, the subsequent trigger is input when the other A/D conversion is canceled.

When any of the AN000 to AN002 (unit 0), and AN100 to AN102 (unit 1) channels are set as a channel-dedicated sample-and-hold circuit in the SHANS[2:0] bits in ADSHCR, the target analog input specified is sampled and held before the first A/D conversion of each scan.

35.3.2 Single Scan Mode

35.3.2.1 Basic operation without channel-dedicated sample-and-hold circuits

In basic operation of single scan mode, A/D conversion is performed once on the analog input of the specified channels. as follows:

1. When the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, synchronous trigger input (ELC), or asynchronous trigger input, A/D conversion is performed on the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.

35.3 Operation

35.3.1 扫描操作

扫描时，对指定通道的模拟输入依次进行AD转换。

扫描转换在三种操作模式下执行：

- 单次扫描模式
- 连续扫描模式
- 组扫描模式。

在单次扫描模式下，一个或多个指定通道被扫描一次。在连续扫描模式下，重复扫描一个或多个指定通道，直到ADCSR.ADST位由软件从1清零。在组扫描模式下，A组中的选定通道和B组中的选定通道在扫描开始后扫描一次，以响应各自的同步触发(ELC)。

在单次扫描模式和连续扫描模式下，在
ADANSA0和ADANSA1寄存器，从编号n最小的通道开始。在组扫描模式下，首先对ADANSA0和ADANSA1寄存器中选择的A组ANn通道进行AD转换，然后对ADANSB0和ADANSB1寄存器中选择的B组ANn通道进行AD转换，从编号最小的通道开始n.

选择自诊断时，在每次扫描开始时执行一次，并转换ADC12内部产生的三个电压之一。

温度传感器输出和内部参考电压可以与通道的模拟输入同时选择，通道的模拟输入、温度传感器输出和内部参考电压依次进行AD转换。

双触发模式可与单扫描模式或组扫描模式一起使用。启用双触发模式(ADCSR.DBLE=1)时，仅当转换由TRSA中选择的同步触发(ELC)启动时，ADCSR.DBLANS[4:0]位中选择的通道的AD转换数据才会复制ADSTRGR中的[5:0]位。只有组扫描模式下的A组可以使用双触发模式。

双触发模式的扩展操作是指A/D转换操作是由同步触发组合产生的。在双触发模式下，此触发组合在ADSTRGR.TRSA[5:0]中选择。ELC_AD00和ELC_AD01与单元0关联。ELC_AD10和ELC_AD11与单元1关联。

在双触发模式的扩展操作中，除了正常的双触发操作外，来自ELC_AD00（单元0）和ELC_AD10（单元1）触发的AD转换数据存储在AD数据双工寄存器A（ADDBLDRA）中，而AD来自ELC_AD01（单元0）和ELC_AD11（单元1）触发器的转换数据存储在AD数据双工寄存器B(ADDBLDRB)中。在双触发模式的扩展操作中，当同时发生多个触发时，指定触发的数据双工寄存器设置不起作用，AD转换数据存储在AD数据双工寄存器B（ADDBLDRB）中。

在由另一个同步触发启动的AD转换期间输入一个同步触发时，在取消另一个AD转换时输入后续触发。

当任何AN000至AN002（单元0）和AN100至AN102（单元1）通道在ADSHCR的SHANS[2:0]位中设置为通道专用采样保持电路时，目标模拟输入指定在每次扫描的第一个AD转换之前被采样和保持。

35.3.2 单次扫描模式

35.3.2.1 无通道专用采样保持电路的基本操作

在单次扫描模式的基本操作中，对指定通道的模拟输入进行一次AD转换。如下：

1. 当ADCSR.ADST位通过软件触发、同步触发输入(ELC)或异步触发输入设置为1（AD转换开始）时，在ADANSA0和ADANSA1寄存器中选择的ANn通道上执行AD转换，从具有最小编号n的通道。

2. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register (ADDRy).
3. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (without register setting).
4. The ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 when A/D conversion of all the selected channels completes. Then the ADC12 enters a wait state.

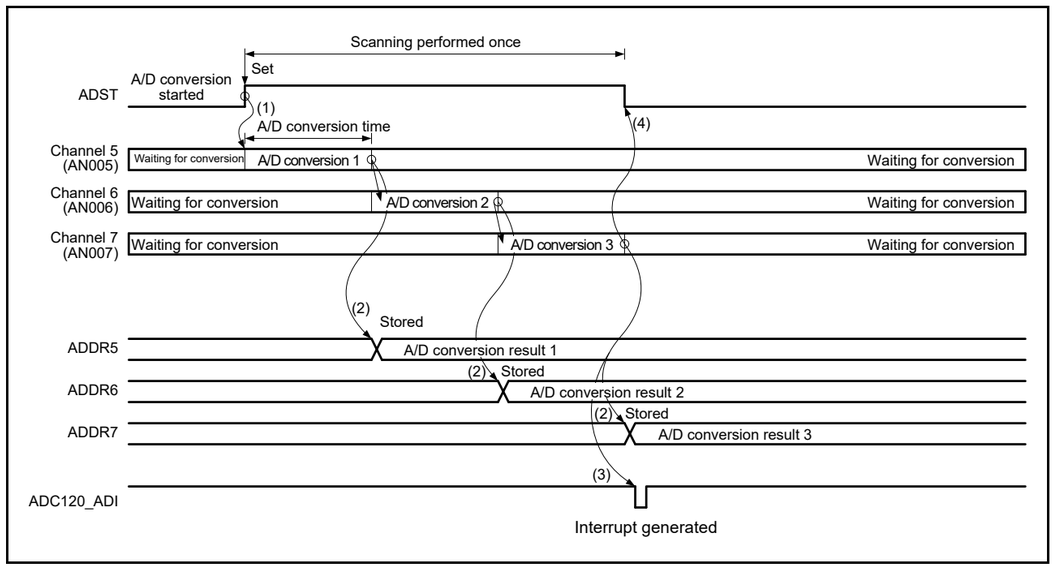


Figure 35.7 Example of basic operation in single scan mode when AN005 to AN007 are selected

35.3.2.2 Basic operation with channel-dedicated sample-and-hold circuits and continuous sampling disabled

When the channel-dedicated sample-and-hold circuit is used, sample-and-hold operation is first performed, and then A/D conversion is performed once on the analog input of all the specified channels. The channels whose dedicated sample-and-hold circuit is to be used can be selected in the SHANS[2:0] bits in ADSHCR.

The operation is as follows:

1. Analog input sampling of all channels whose dedicated sample-and-hold circuit is to be used starts when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, synchronous trigger input (ELC), or asynchronous trigger input.
2. After sample-and-hold operation, A/D conversion is performed on the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
3. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register (ADDRy).
4. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting).
5. The ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 when A/D conversion of all the selected channels completes. Then, the ADC12 enters a wait state.

2. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器(ADDRy)。
3. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无需寄存器设置）。
4. ADST位在AD转换期间保持1（AD转换开始），并在所有选定通道的AD转换完成时自动清零。然后ADC12进入等待状态。

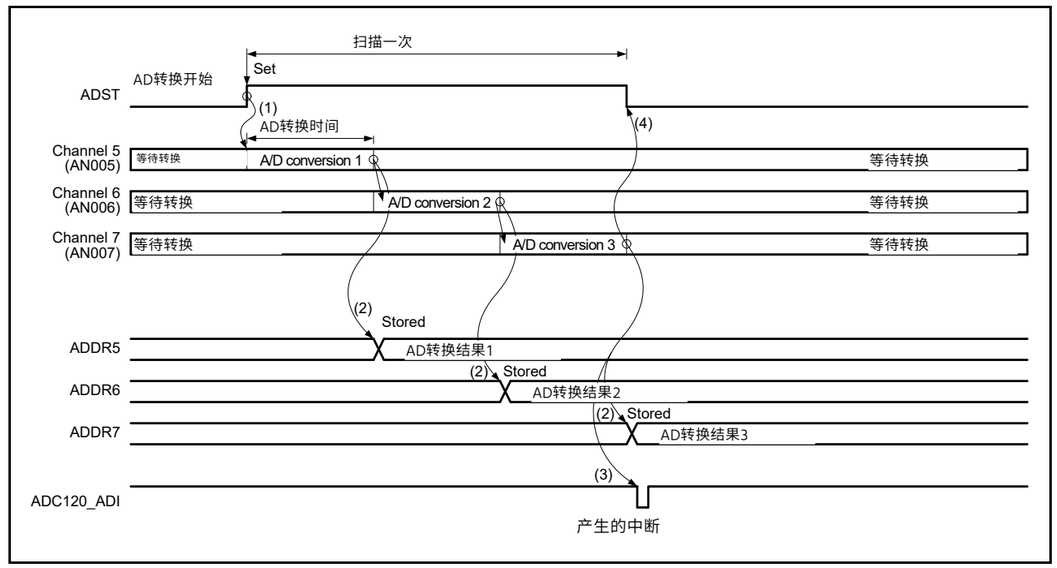


Figure 35.7 选择AN005至AN007时单次扫描模式的基本操作示例

35.3.2.2 通道专用采样保持电路和禁用连续采样的基本操作

当使用通道专用的采样保持电路时，首先进行采样保持操作，然后对所有指定通道的模拟输入进行一次A/D转换。可以在ADSHCR的SHANS[2:0]位中选择要使用专用采样保持电路的通道。

操作如下：

1. 将使用专用采样保持电路的所有通道的模拟输入采样在ADCSR.ADST位通过软件触发、同步触发输入(ELC)或异步触发输入设置为1（AD转换开始）。
2. 采样保持操作后，在ADANSA0中选择的ANn通道上执行AD转换，并ADANSA1寄存器，从编号n最小的通道开始。
3. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器(ADDRy)。
4. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
5. ADST位在AD转换期间保持1（AD转换开始），并在所有选定通道的AD转换完成时自动清零。然后，ADC12进入等待状态。

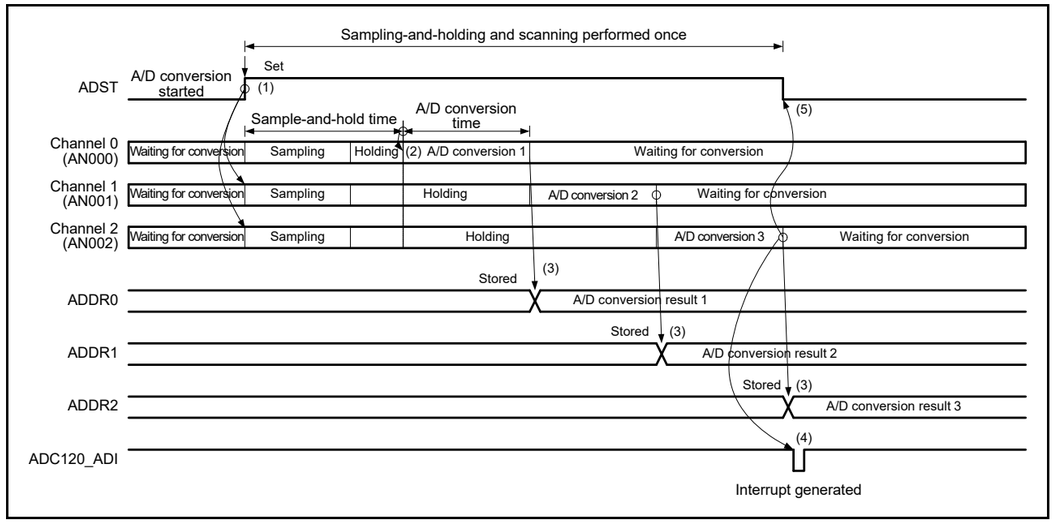


Figure 35.8 Example of operation in single scan mode when the channel-dedicated sample-and-hold circuits are used and AN000 to AN002 are selected

35.3.2.3 Basic operation with channel-dedicated sample-and-hold circuits and continuous sampling enabled

When a channel-dedicated sample-and-hold circuit is used while continuous sampling is enabled, sample-and-hold operation is performed first, followed by A/D conversion once on the analog inputs of all selected channels. The ADSHCR.SHANS[2:0] bits specify the channels for which the channel-dedicated sample-and-hold circuits are to be used.

The operation is as follows:

1. When the ADSHMSR.SHMD bit is set to 1, the sample-and-hold circuits selected in the ADSHCR.SHANS[2:0] bits start continuous sampling.
2. Analog input holding starts for all channels for which the channel-dedicated sample-and-hold circuits are to be used when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, input of a synchronous trigger signal (ELC), or input of an asynchronous trigger.
3. After the stabilization time of the sample-and-hold circuits elapses, A/D conversion is performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
4. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register (ADDRy), and the sample-and-hold circuit restarts continuous sampling.
5. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (without register setting).
6. The ADCSR.ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 when A/D conversion of all the selected channels completes. Then, the ADC12 enters a wait state. If this is followed by single scanning, set the continuous sampling time for the sample-and-hold circuits to at least 400 ns (when the permissible signal source impedance is 1 kΩ).
7. When the ADSHMSR.SHMD bit is set to 0, the sample-and-hold circuits stop.

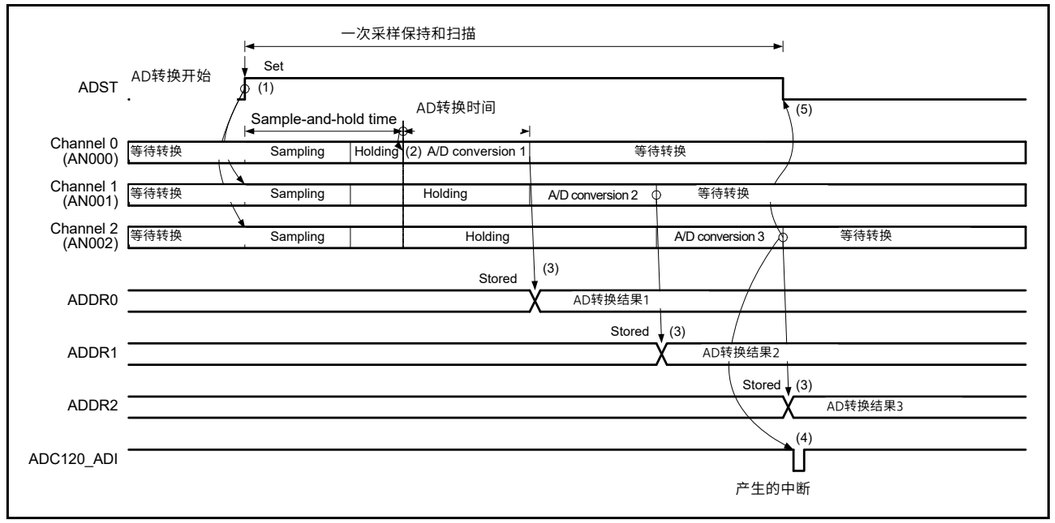


Figure 35.8 使用通道专用采样保持电路并选择AN000至AN002时单次扫描模式的操作示例

35.3.2.3 具有通道专用采样保持电路和连续采样的基本操作

如果在启用连续采样的情况下使用通道专用的采样保持电路，则首先执行采样保持操作，然后在所有选定通道的模拟输入上进行一次AD转换。ADSHCR.SHANS[2:0]位指定要使用通道专用采样保持电路的通道。

操作如下：

1. 当ADSHMSR.SHMD位设置为1时，在ADSHCR.SHANS[2:0]位中选择的采样保持电路开始连续采样。
2. 当ADCSR.ADST位通过软件触发设置为1（AD转换开始），同步触发信号的输入（ELC），或异步触发器的输入。
3. 经过采样保持电路的稳定时间后，从编号n最小的通道开始，对ADANSA0和ADANSA1寄存器中选择的ANn通道执行AD转换。
4. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器（ADDRy），采样保持电路重新开始连续采样。
5. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无需寄存器设置）。
6. ADCSR.ADST位在AD转换期间保持1（AD转换开始），并在所有选定通道的AD转换完成时自动清零。然后，ADC12进入等待状态。如果随后进行单次扫描，请将采样保持电路的连续采样时间设置为至少400ns（当允许的信号源阻抗为1kΩ时）。
7. 当ADSHMSR.SHMD位设置为0时，采样保持电路停止。

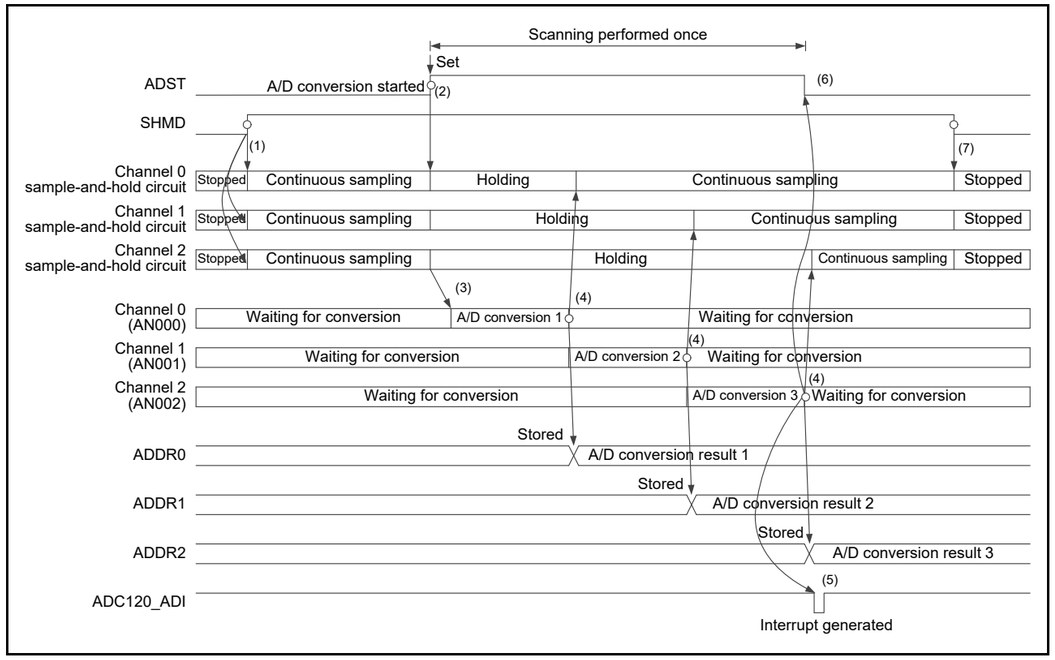


Figure 35.9 Example of operation in single scan mode when channel-dedicated sample-and-hold circuits are used, AN000 to AN002 are selected, and continuous sampling is enabled

35.3.2.4 Channel selection and self-diagnosis without channel-dedicated sample-and-hold circuits

When channels and self-diagnosis are selected, A/D conversion is first performed for the reference voltage VREFH0 (unit 0) or VREFH (unit 1) (× 0, × 1/2, or × 1) supplied to the ADC12, and then A/D conversion is performed once on the analog input of the specified channels.

The operation is as follows:

1. A/D conversion for self-diagnosis is first started when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, synchronous trigger input (ELC), or asynchronous trigger input.
2. When A/D conversion for self-diagnosis completes, the A/D conversion result is stored in the A/D Self-Diagnosis Data Register (ADRD). A/D conversion is then performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
3. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register (ADDRy).
4. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting).
5. The ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 when A/D conversion of all the selected channels completes. Then, the ADC12 enters a wait state.

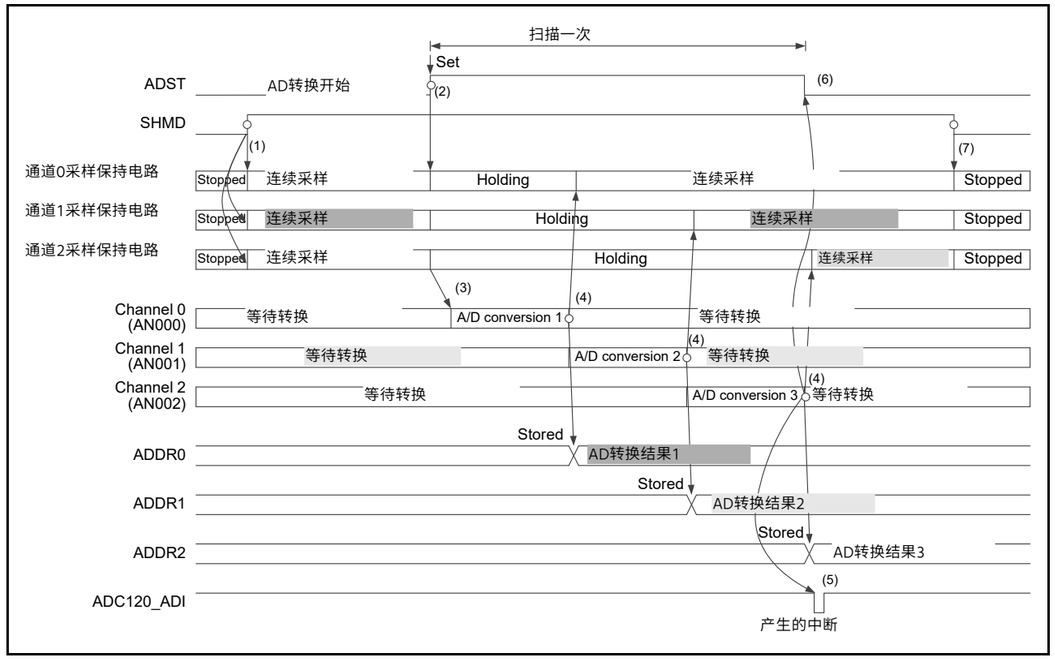


Figure 35.9 使用通道专用采样保持电路、选择AN000至AN002并启用连续采样时的单次扫描模式操作示例

35.3.2.4 通道选择和自诊断，无需通道专用的采样和保持电路

Whenchannelsandself-diagnosisareselected ADconversionisfirstperformedforthereferencevoltageVREFH0(unit0)orVREFH(unit1)(×0 ×12 or×1)suppliedtotheADC12 andthenADconversion在指定通道的模拟输入上执行一次。

操作如下：

1. 通过软件触发、同步触发输入(ELC)或异步触发输入将ADCSR.ADST位设置为1（AD转换开始）时，首先启动用于自诊断的D转换。
2. 自诊断用AD转换完成后，AD转换结果存储在AD自诊断中
数据寄存器(ADRD)。然后对ADANSA0中选择的ANn通道执行D转换，并
ADANSA1寄存器，从编号n最小的通道开始。
3. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中
数据寄存器(ADDRy)。
4. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
5. ADST位在AD转换期间保持1（AD转换开始），并在所有选定通道的AD转换完成时自动清零。然后，ADC12进入等待状态。

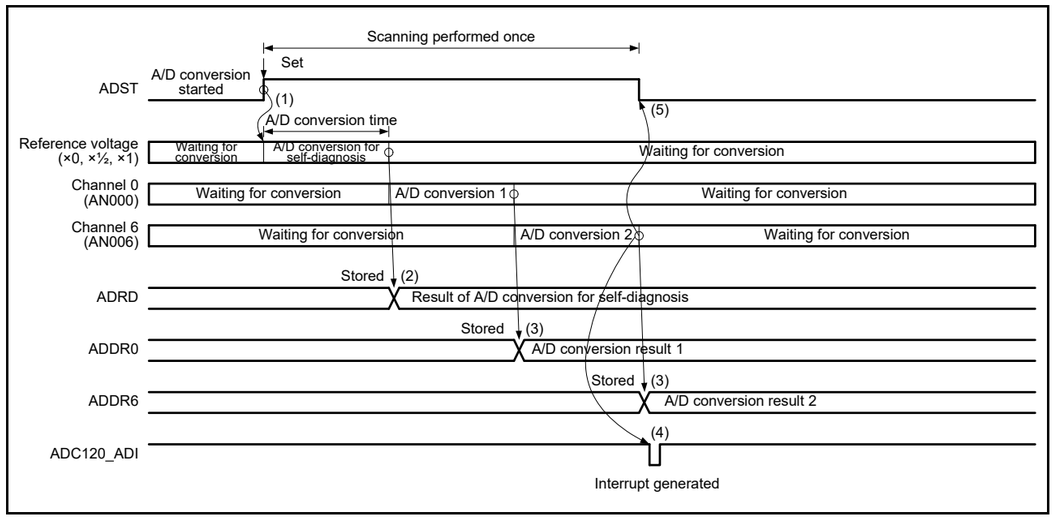


Figure 35.10 Example of basic operation in single scan mode when AN000 and AN006 are selected with self-diagnosis

35.3.2.5 Channel selection and self-diagnosis with channel-dedicated sample-and-hold circuits and continuous sampling disabled

When channels and self-diagnosis are selected and a channel-dedicated sample-and-hold circuit is used while continuous sampling is disabled, the sample-and-hold operation is performed first, and then A/D conversion is performed once for the reference voltage VREFH0 (unit 0) or VREFH (unit 1) (×0, ×1/2, or ×1) supplied to the ADC12. After that, A/D conversion is performed only once on the analog input of the selected channels.

The operation is as follows:

1. Analog input sampling starts for all channels whose dedicated sample-and-hold circuit is to be used when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, synchronous trigger input (ELC), or asynchronous trigger input.
2. After sample-and-hold operation, A/D conversion for self-diagnosis starts.
3. When A/D conversion for self-diagnosis completes, the A/D conversion result is stored in the A/D Self-Diagnosis Data Register (ADRD). A/D conversion is then performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
4. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy).
5. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (without register setting).
6. The ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 when A/D conversion of all the selected channels completes. Then, the ADC12 enters a wait state.

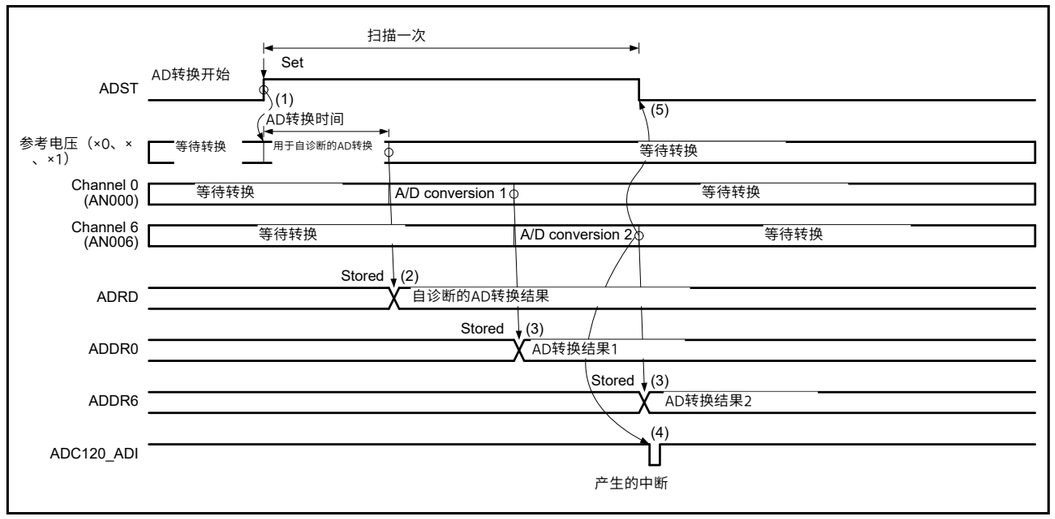


Figure 35.10 自诊断选择AN000和AN006时单次扫描模式的基本操作示例

35.3.2.5 通道专用采样保持电路和禁用连续采样的通道选择和自诊断

Whenchannelsandself-diagnosisareselectedandachannel-dedicatedsample-and-holdcircuitisusedwhileconti nuoussamplingisdisabled thesample-and-holdoperationisperformedfirst andthenADconversionisperformedo nceforthereferencevoltageVREFH0（单元0）或VREFH（单元1）（×0、×12或×1）提供给ADC12。之后，仅对所选通道的模拟输入执行一次AD转换。

操作如下：

1. 模拟输入采样开始于其专用采样保持电路的所有通道，当ADCSR.ADST位通过软件触发、同步触发输入(ELC)或异步触发输入设置为1（AD转换开始）。
2. 采样保持操作后，用于自诊断的AD转换开始。
3. 自诊断用AD转换完成后，AD转换结果存储在AD自诊断中数据寄存器(ADRD)。然后对ADANSA0中选择的ANn通道执行D转换，并ADANSA1寄存器，从编号n最小的通道开始。
4. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)。
5. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无需寄存器设置）。
6. ADST位在AD转换期间保持1（AD转换开始），并在所有选定通道的AD转换完成时自动清零。然后，ADC12进入等待状态。

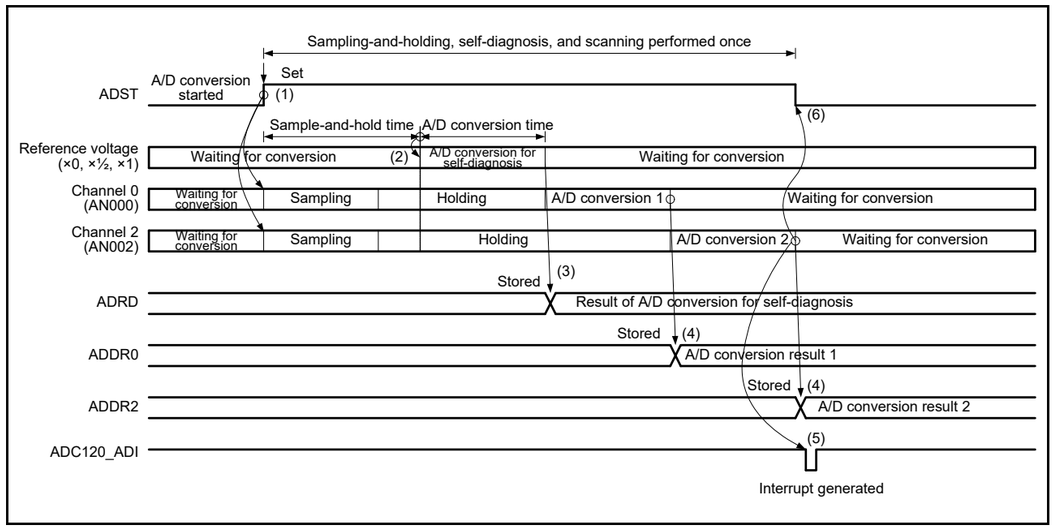


Figure 35.11 Example of operation in single scan mode when channel-dedicated sample-and-hold circuits are used, AN000 and AN002 are selected with self-diagnosis, and continuous sampling is disabled

35.3.2.6 Channel selection and self-diagnosis with channel-dedicated sample-and-hold circuits and continuous sampling enabled

When channels and self-diagnosis are selected and a channel-dedicated sample-and-hold circuit is used while continuous sampling is enabled, sample-and-hold operations are performed first, and this is followed by A/D conversion of the reference voltage VREFH0 (unit 0) or VREFH (unit 1) supplied to the ADC12. After that, A/D conversion is performed only once on the analog input of the selected channels.

The operation is as follows:

1. When the ADSHMSR.SHMD bit is set to 1, the sample-and-hold circuits selected in the ADSHCR.SHANS[2:0] bits start continuous sampling.
2. Analog input holding starts for all channels for which the channel-dedicated sample-and-hold circuits are to be used when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, input of a synchronous trigger signal (ELC), or input of an asynchronous trigger. Set the ADCSR.ADST bit to 1 after at least 400 ns (when the permissible signal source impedance is 1 kΩ) elapse after the ADSHMSR.SHMD bit is set to 1.
3. After the stabilization time of the sample-and-hold circuits elapses, A/D conversion for self-diagnosis starts.
4. When A/D conversion for self-diagnosis completes, the A/D conversion result is stored in the A/D Self-Diagnosis Data Register (ADRD). A/D conversion is then performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
5. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy), and the sample-and-hold circuit restarts continuous sampling.
6. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (without register setting).
7. The ADCSR.ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 when A/D conversion of all the selected channels completes. Then, the ADC12 enters a wait state. If this is followed by single scanning, set the continuous sampling time for the sample-and-hold circuits to at least 400 ns (when the permissible signal source impedance is 1 kΩ).
8. When the ADSHMSR.SHMD bit is set to 0, the sample-and-hold circuits stop.

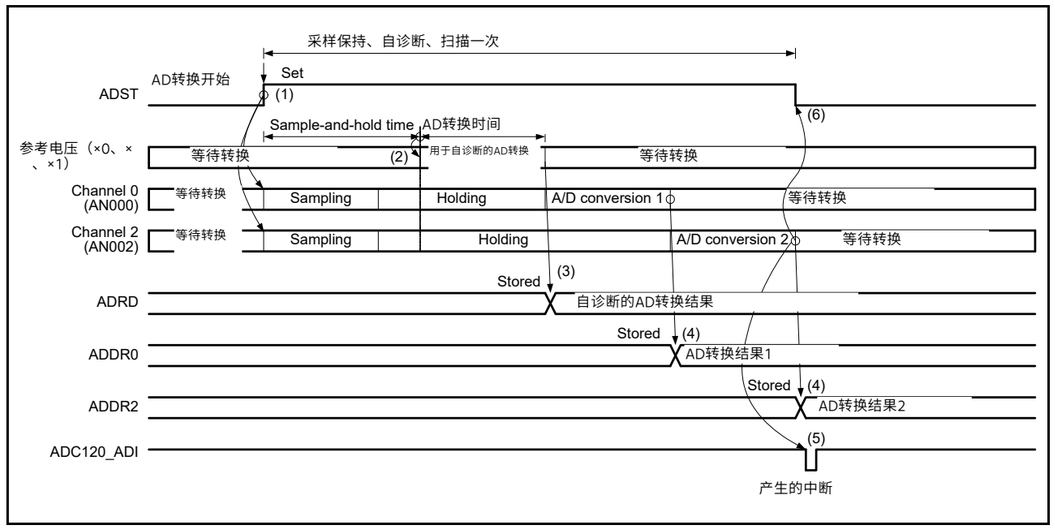


Figure 35.11 使用通道专用采样保持电路、AN000和AN002选择自诊断且禁用连续采样时的单次扫描模式操作示例

35.3.2.6 通道选择和自诊断，带有通道专用的采样保持电路和连续采样使能

Whenchannelsandself-diagnosisareselectedandachannel-dedicatedsample-and-holdcircuitisusedwhilecontinuoussamplingisenabled sample-and-holdoperationsareperformedfirst andthisisfollowedbyADconversionofthereferencevoltageVREFH0(单元0)或VREFH(单元1)提供给ADC12。之后，仅对所选通道的模拟输入执行一次AD转换。

操作如下：

1. 当ADSHMSR.SHMD位设置为1时，在ADSHCR.SHANS[2:0]位中选择的采样保持电路开始连续采样。
2. 当ADCSR.ADST位通过软件触发设置为1（AD转换开始），同步触发信号的输入（ELC），或异步触发器的输入。在ADSHMSR.SHMD位设置为1后至少经过400ns（当允许的信号源阻抗为1kΩ时）后，将ADCSR.ADST位设置为1。
3. 经过采样保持电路的稳定时间后，开始进行自诊断的A/D转换。
4. 自诊断用AD转换完成后，AD转换结果存储在AD自诊断中数据寄存器(ADRD)。然后对ADANSA0中选择的ANn通道执行D转换，并ADANSA1寄存器，从编号n最小的通道开始。
5. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)，采样保持电路重新开始连续采样。
6. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无需寄存器设置）。
7. ADCSR.ADST位在AD转换期间保持1（AD转换开始），并在所有选定通道的AD转换完成时自动清零。然后，ADC12进入等待状态。如果随后进行单次扫描，请将采样保持电路的连续采样时间设置为至少400ns（当允许的信号源阻抗为1kΩ时）。
8. 当ADSHMSR.SHMD位设置为0时，采样保持电路停止。

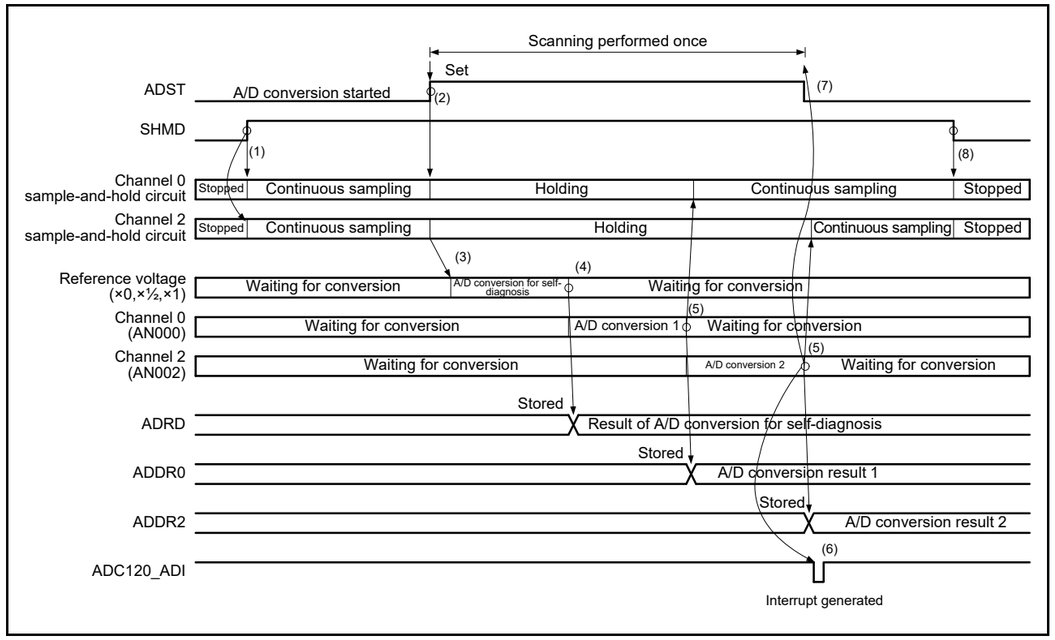


Figure 35.12 Example of operation in single scan mode when channel-dedicated sample-and-hold circuits are used, AN000 to AN002 are selected with self-diagnosis, and continuous sampling is enabled

35.3.2.7 A/D conversion of temperature sensor output or internal reference voltage

When the channels and temperature sensor output or internal reference voltage are selected at the same time, A/D conversion is first performed on the analog input of the selected channels, and then A/D conversion is performed once on the temperature sensor output or internal reference voltage. When both temperature sensor output and internal reference voltage are selected, A/D conversion of the temperature sensor output and internal reference voltage is performed, in that order. With the channels deselected, selecting only the temperature sensor output or internal reference voltage is also possible.

The operation is as follows:

1. When a software trigger, synchronous trigger (ELC), or asynchronous trigger sets the ADCSR.ADST bit to 1 (A/D conversion start), A/D conversion is performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
2. On completion of A/D conversion on the channels, the result is stored in the associated A/D Data Register y (ADDRy), and then A/D conversion of the temperature sensor output starts.
3. On completion of A/D conversion of the temperature sensor output, the result is stored in the associated A/D Temperature Sensor Data Register (ADTSDR), and then A/D conversion of the internal reference voltage starts.
4. On completion of A/D conversion of the internal reference voltage, the result is stored in the associated A/D Internal Reference Voltage Data Register (ADOCDR), and an ADC12i_ADI (i = 0, 1) interrupt request is generated (without register setting).
5. The ADCSR.ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 on completion of A/D conversion. Then, the ADC12 enters a wait state.

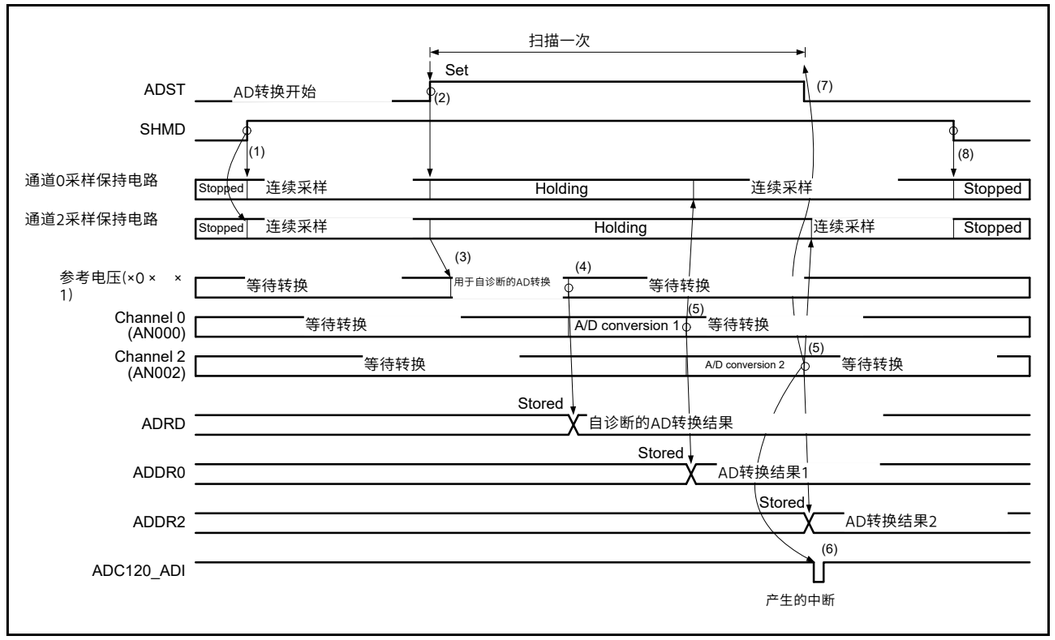


Figure 35.12 使用通道专用采样保持电路、AN000至AN002选择自诊断并启用连续采样时的单次扫描模式操作示例

35.3.2.7 温度传感器输出或内部参考电压的AD转换

当同时选择通道和温度传感器输出或内部参考电压时，首先对所选通道的模拟输入进行AD转换，然后对温度传感器输出或内部参考电压进行一次AD转换。当同时选择温度传感器输出和内部参考电压时，按顺序执行温度传感器输出和内部参考电压的AD转换。取消选择通道后，也可以仅选择温度传感器输出或内部参考电压。

操作如下：

1. 当软件触发、同步触发(ELC)或异步触发将ADCSR.ADST位设置为1（AD转换开始）时，对ADANSA0和ADANSA1寄存器中选择的ANn通道执行AD转换，从具有最小的数n。
2. 在通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中，然后温度传感器输出的AD转换开始。
3. 温度传感器输出的AD转换完成后，结果存储在相关的AD中
温度传感器数据寄存器(ADTSDR)，然后内部参考电压的AD转换开始。
4. 内部参考电压的AD转换完成后，结果存储在相关的AD中
内部参考电压数据寄存器(AOCDR)，并产生一个ADC12i_ADI(i=0 1)中断请求（无需寄存器设置）。
5. ADCSR.ADST位在AD转换期间保持1（AD转换开始），并在AD转换完成时自动清零。然后，ADC12进入等待状态。

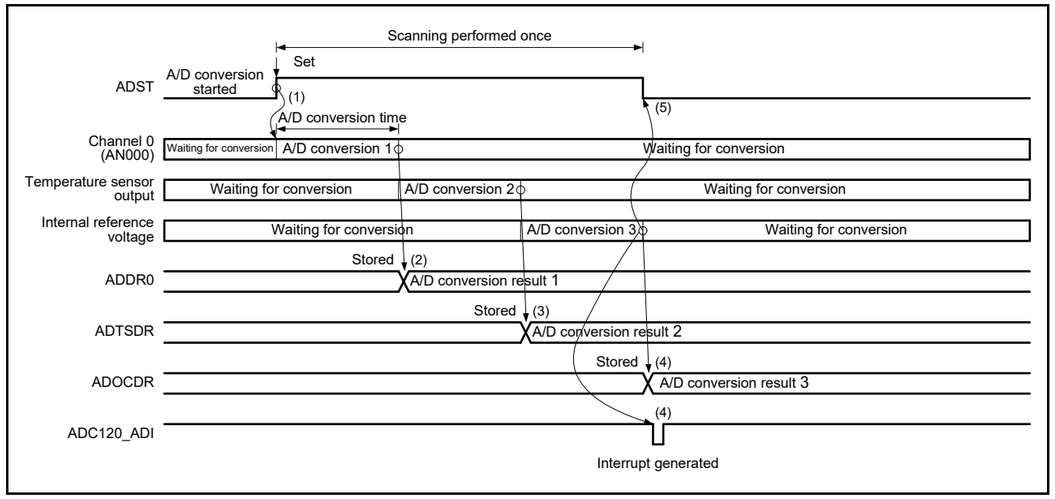


Figure 35.13 Example of basic operation in single scan mode when AN000 and temperature sensor output or internal reference voltage are selected

35.3.2.8 A/D conversion in double trigger mode

When double trigger mode is selected in single scan mode, two rounds of single scan operation started by a synchronous trigger (ELC) are performed in sequence.

Deselect self-diagnosis, and set the addition/average mode select bits for both temperature sensor output (ADEXICR.TSSA) and internal reference voltage (ADEXICR.OCSA) to 0.

Duplication of A/D conversion data is enabled by setting the channel numbers to be duplicated in the ADCSR.DBLANS[4:0] bits and setting the ADCSR.DBLE to 1. When the ADCSR.DBLE bit is set to 1, channel selection using the ADANSA0 and ADANSA1 registers is invalid.

In double trigger mode, select a synchronous trigger (ELC) using the ADSTRGR.TRSA[5:0] bits, and in ADCSR, set the EXTRG bit to 0 and the TRGE bit to 1. Do not use a software trigger.

The operation is as follows:

1. When the ADCSR.ADST bit is set to 1 (A/D conversion start) by a synchronous trigger input (ELC), A/D conversion starts on the single channel selected in the ADCSR.DBLANS[4:0] bits.
2. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy).
3. The ADST bit is automatically cleared to 0 and the ADC12 enters a wait state. An ADC12i_ADI (i = 0, 1) interrupt request is not generated.
4. When the ADCSR.ADST bit is set to 1 (A/D conversion start) by the second trigger input, A/D conversion starts on the single channel selected in the ADCSR.DBLANS[4:0] bits.
5. When A/D conversion completes, the result is stored in the A/D Data Duplexing Register (ADDBLDR), which is exclusively used in double trigger mode.
6. An ADC12i_ADI (i = 0, 1) interrupt request is generated (without register setting).
7. The ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 when A/D conversion completes. Then, the ADC12 enters a wait state.

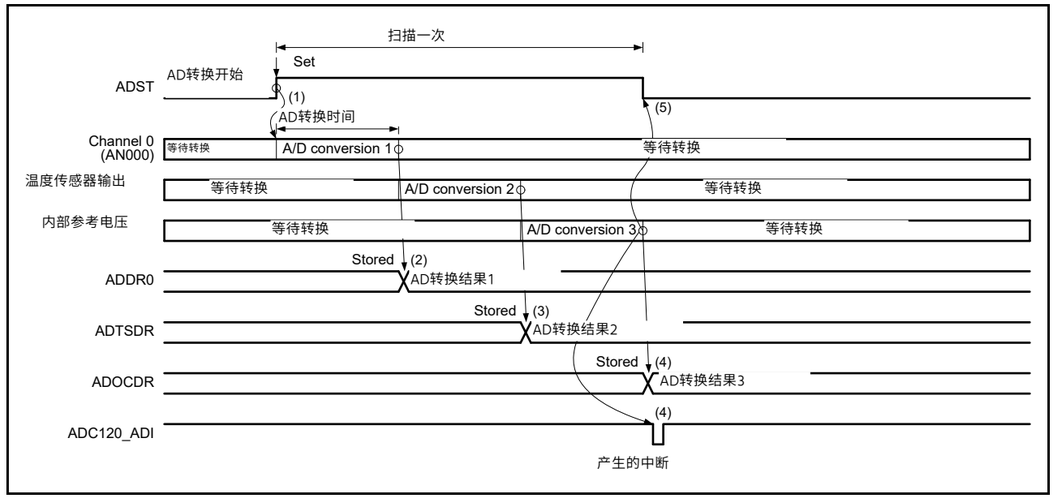


Figure 35.13 选择AN000和温度传感器输出或内部参考电压时单次扫描模式下的基本操作示例

35.3.2.8 双触发模式下的AD转换

在单扫描模式下选择双触发模式时，由同步触发(ELC)启动的两轮单扫描操作将依次执行。

取消选择自诊断，并将温度传感器输出(ADEXICR.TSSA)和内部参考电压(ADEXICR.OCSA)的加法平均模式选择位设置为0。

AD转换数据的复制通过在ADCSR.DBLANS[4:0]位并将ADCSR.DBLE设置为1。当ADCSR.DBLE位设置为1时，使用ADANSA0和ADANSA1寄存器的通道选择无效。

在双触发模式下，使用ADSTRGR.TRSA[5:0]位选择同步触发(ELC)，在ADCSR中，设置EXTRG位为0，TRGE位为1。不要使用软件触发。

操作如下：

1. 当同步触发输入(ELC)将ADCSR.ADST位设置为1（AD转换开始）时，AD转换在ADCSR.DBLANS[4:0]位中选择的单个通道上开始。
2. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)。
3. ADST位自动清零，ADC12进入等待状态。不会产生ADC12i_ADI(i=0 1)中断请求。
4. 当第二个触发输入将ADCSR.ADST位设置为1（AD转换开始）时，AD转换在ADCSR.DBLANS[4:0]位中选择的单个通道上开始。
5. 当AD转换完成时，结果存储在AD数据双工寄存器(ADDBLDR)中，该寄存器专用于双触发模式。
6. 产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
7. ADST位在AD转换期间保持1（AD转换开始），并在AD转换完成时自动清零。然后，ADC12进入等待状态。

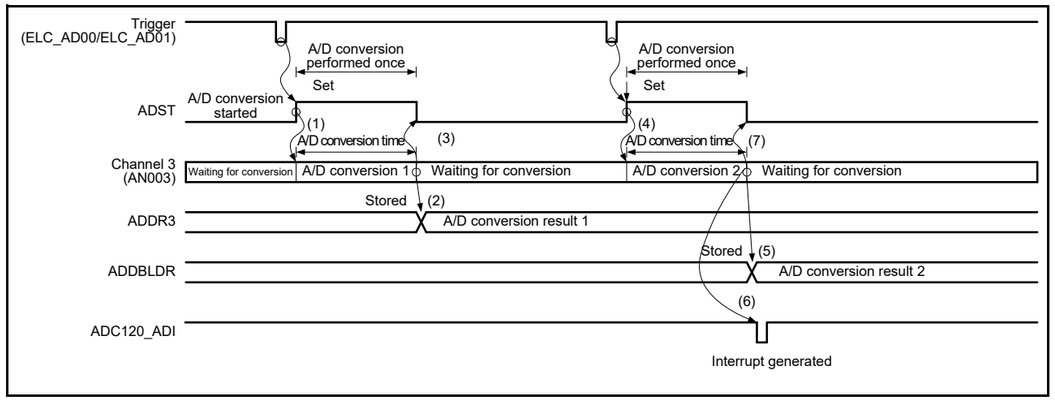


Figure 35.14 Example of operation in single scan mode when double trigger mode is selected and AN003 is duplicated

35.3.2.9 Extended operations when double trigger mode is selected

When double trigger mode is selected in single scan mode, and a synchronous trigger (ELC_AD00/ELC_AD01 (unit 0), ELC_AD10/ELC_AD11 (unit 1)) is selected as the trigger for the start of A/D conversion, two rounds of single scan operation are performed.

Deselect self-diagnosis, and set the addition/average mode select bits for both temperature sensor output (ADEXICR.TSSA and ADEXICR.TSSB) and internal reference voltage (ADEXICR.OCSA and ADEXICR.OCSB) to 0.

Duplication of A/D conversion data is enabled by setting the channel numbers to be duplicated in the ADCSR.DBLANS[4:0] bits, and setting the ADCSR.DBLE bit to 1. When the ADCSR.DBLE bit is set to 1, channel selection using the ADANSA0 and ADANSA1 registers is invalid.

In extended double trigger mode, select a synchronous trigger (ELC_AD00/ELC_AD01 (unit 0), ELC_AD10/ELC_AD11 (unit 1)) by setting the ADSTRGR.TRSA[5:0] bits to 0Bh, and in ADCSR, set the EXTRG bit to 0 and the TRGE bit to 1. Do not use a software trigger.

The operation is as follows:

1. When the ADCSR.ADST bit is set to 1 (A/D conversion start) by a synchronous trigger input (ELC_AD00/ELC_AD01 (unit 0), ELC_AD10/ELC_AD11 (unit 1)), A/D conversion starts on the single channel selected in the ADCSR.DBLANS[4:0] bits.
2. When A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D data register y (ADDRy) and in A/D Data Duplexing Register A (ADDBLDRA) or A/D Data Duplexing Register B (ADDBLDRB) when the trigger of ELC_ADi0 or ELC_ADi1 is input respectively (i = 0, 1).
3. The ADCSR.ADST bit is automatically cleared to 0 and the ADC12 enters a wait state. An ADC12i_ADI (i = 0, 1) interrupt request is not generated.
4. When the ADCSR.ADST bit is set to 1 (A/D conversion start) by the second trigger input (ELC_AD00/ELC_AD01 (unit 0), ELC_AD10/ELC_AD11 (unit 1)), A/D conversion starts on the single channel selected in the ADCSR.DBLANS[4:0] bits.
5. When A/D conversion completes, the result is stored in the A/D Data Duplexing Register (ADDBLDR) and in A/D Data Duplexing Register A (ADDBLDRA) or A/D Data Duplexing Register B (ADDBLDRB) when the trigger of ELC_ADi0 or ELC_ADi1 is input respectively (i = 0, 1).
6. An ADC12i_ADI (i = 0, 1) interrupt request is generated (without register setting).
7. The ADCSR.ADST bit remains 1 (A/D conversion start) during A/D conversion and is automatically cleared to 0 when A/D conversion completes. Then, the ADC12 enters a wait state.

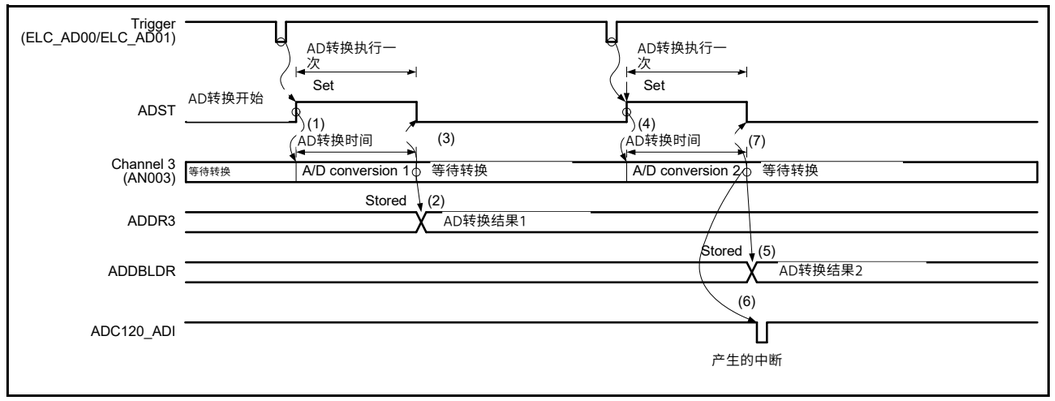


Figure 35.14 选择双触发模式并复制AN003时的单扫描模式操作示例

35.3.2.9 选择双触发模式时的扩展操作

当在单扫描模式下选择双触发模式，并且同步触发（ELC_AD00ELC_AD01（单元0），ELC_AD10ELC_AD11(unit1))被选为AD转换开始的触发器，执行两轮单次扫描操作。

取消选择自诊断，并将温度传感器输出（ADEXICR.TSSA和ADEXICR.TSSB）和内部参考电压（ADEXICR.OCSA和ADEXICR.OCSB）的加法平均模式选择位设置为0。

AD转换数据的复制通过在ADCSR.DBLANS[4:0]位，并将ADCSR.DBLE位设置为1。当ADCSR.DBLE位设置为1时，使用ADANSA0和ADANSA1寄存器的通道选择无效。

在扩展双触发模式下，选择同步触发（ELC_AD00ELC_AD01（单元0），ELC_AD10ELC_AD11(unit1))通过将ADSTRGR.TRSA[5:0]位设置为0Bh，并在ADCSR中将EXTRG位设置为0并将TRGE位设置为1。不要使用软件触发。

操作如下：

1. 当同步触发输入（ELC_AD00ELC_AD01（单元0）、ELC_AD10ELC_AD11（单元1））将ADCSR.ADST位设置为1（AD转换开始）时，ADCSR.DBLANS[中选择的单通道开始AD转换4:0]位。
2. 当单通道AD转换完成时，当ELC_ADi0或ELC_ADi0或分别输入ELC_ADi1(i=0 1)。
3. ADCSR.ADST位自动清零，ADC12进入等待状态。不会产生ADC12i_ADI(i=0 1)中断请求。
4. 当第二个触发输入（ELC_AD00ELC_AD01（单元0）、ELC_AD10ELC_AD11（单元1））将ADCSR.ADST位设置为1（AD转换开始）时，ADCSR.DBLANS[中选择的单通道上开始AD转换4:0]位。
5. 当AD转换完成时，结果存储在AD数据双工寄存器(ADDBLDR)和AD数据双工寄存器A(ADDBLDRA)或AD数据双工寄存器B(ADDBLDRB)中。
   分别输入ELC_ADi0或ELC_ADi1(i=0 1)。
6. 产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
7. ADCSR.ADST位在AD转换期间保持1（AD转换开始），并在AD转换完成时自动清零。然后，ADC12进入等待状态。

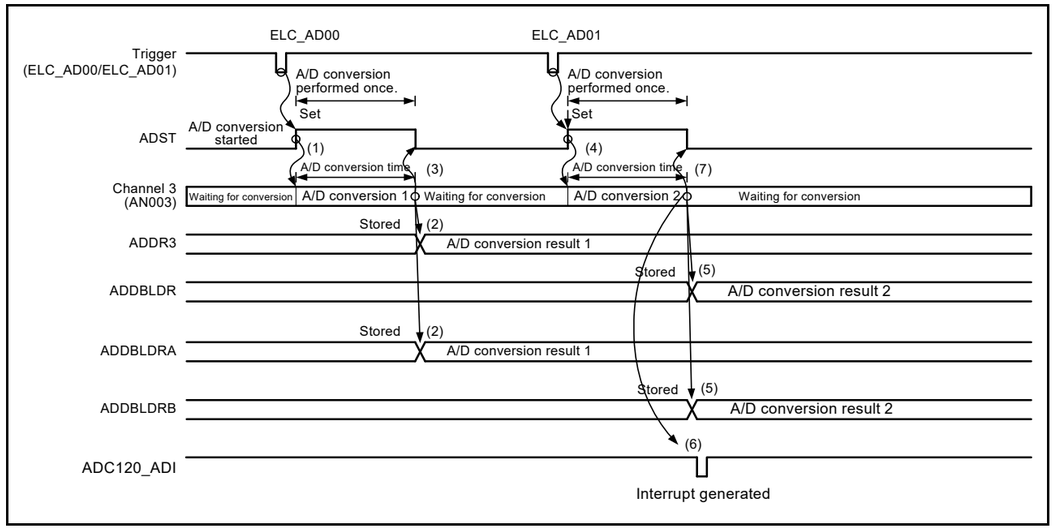


Figure 35.15 Example of extended operation in double trigger mode (1) when duplication is selected for AN003 and ELC_AD00/ELC_AD01 is selected

35.3.3 Continuous Scan Mode

35.3.3.1 Basic operation without channel-dedicated sample-and-hold circuits

In basic operation of continuous scan mode, A/D conversion is performed repeatedly on the analog input of the specified channels.

The operation is as follows:

1. When the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, synchronous trigger input (ELC), or asynchronous trigger input, A/D conversion is performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
2. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy).
3. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0,1) interrupt request is generated (without register setting). The ADC12 sequentially starts A/D conversion for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
4. The ADCSR.ADST bit is not automatically cleared, and steps 2. and 3. are repeated as long as the bit remains 1 (A/D conversion start). When the ADCSR.ADST bit is set to 0 (A/D conversion stop), A/D conversion stops and the ADC12 enters a wait state.
5. When the ADST bit is set to 1 (A/D conversion start), A/D conversion starts again for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.

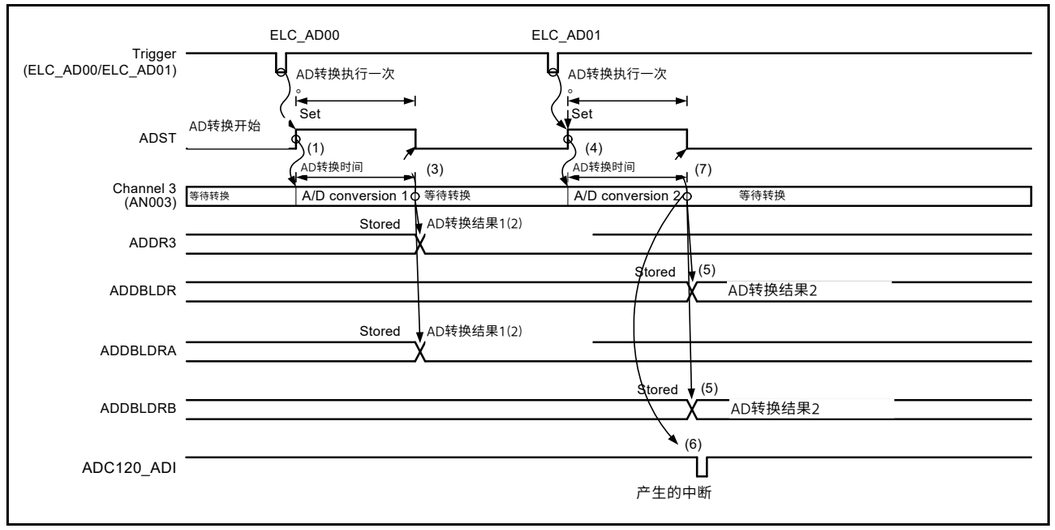


Figure 35.15 双触发模式下的扩展操作示例(1)为AN003选择了复制并选择了ELC_AD00ELC_AD01时

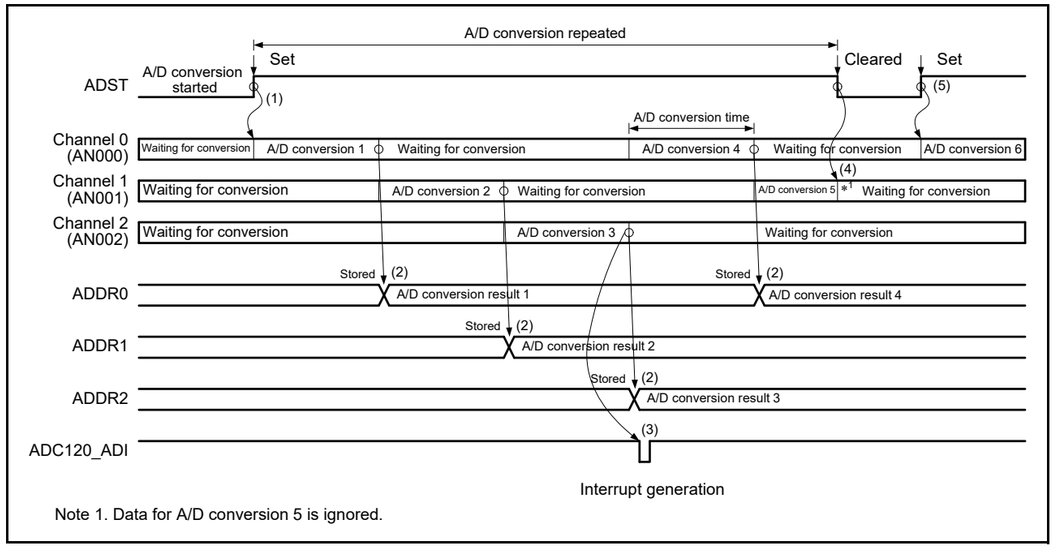
35.3.3 连续扫描模式

35.3.3.1 无通道专用采样保持电路的基本操作

在连续扫描模式的基本操作中，对指定通道的模拟输入重复进行AD转换。

操作如下：

1. 当通过软件触发、同步触发输入(ELC)或异步触发输入将ADCSR.ADST位设置为1（AD转换开始）时，将从ADANSA0和ADANSA1寄存器中选择的ANn通道执行AD转换，从具有最小编号n的通道。
2. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)。
3. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无需寄存器设置）。ADC12从编号n最小的通道开始依次启动ADANSA0和ADANSA1寄存器中选择的ANn通道的A/D转换。
4. ADCSR.ADST位不会自动清零，只要该位保持为1（AD转换开始），就会重复步骤2.和3.。当ADCSR.ADST位设置为0（AD转换停止）时，AD转换停止并且ADC12进入等待状态。
5. 当ADST位设置为1（AD转换开始）时，AD转换再次开始在ADANSA0和ADANSA1寄存器中选择的ANn通道，从具有最小编号n的通道开始。



Note 1. Data for A/D conversion 5 is ignored.

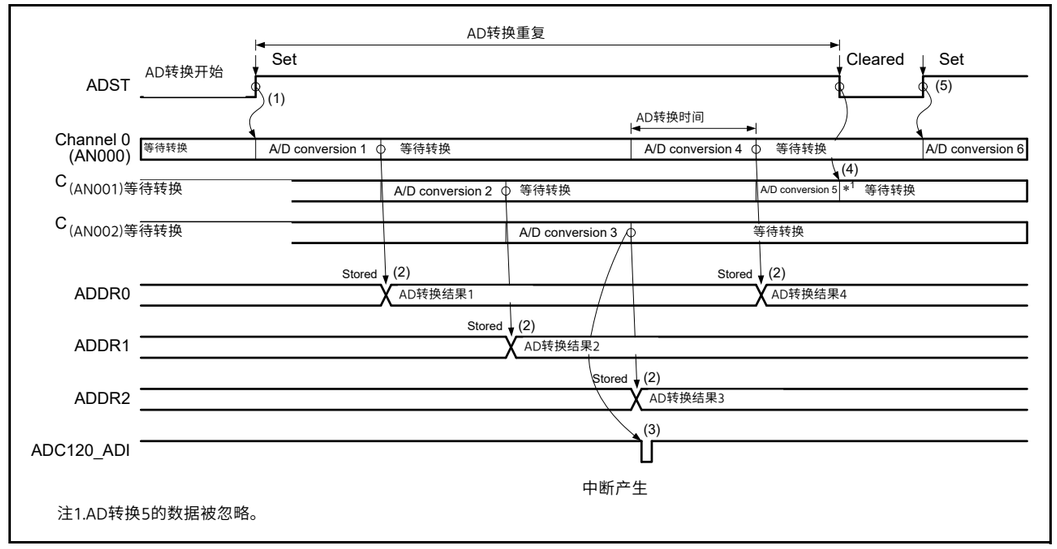
Figure 35.16 Example of basic operation in continuous scan mode when AN000 to AN002 are selected

35.3.3.2 Basic operation with channel-dedicated sample-and-hold circuits and continuous sampling disabled

When the channel-dedicated sample-and-hold circuit is used with continuous sampling disabled, sample-and-hold operation is first performed, and then A/D conversion is repeated on the analog input of all the specified channels. The channels whose dedicated sample-and-hold circuit is to be used can be selected in the SHANS[2:0] bits in ADSHCR.

The operation is as follows:

1. Analog input sampling starts for all channels whose dedicated sample-and-hold circuit is to be used when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, synchronous trigger input (ELC), or asynchronous trigger input.
2. After sample-and-hold operation, A/D conversion is performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
3. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy).
4. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting). At the same time, analog input sampling starts for all channels whose dedicated sample-and-hold circuit is to be used.
5. The ADST bit is not automatically cleared, and steps 2. to 4. are repeated as long as the bit remains at 1. When the ADST bit is set to 0 (A/D conversion stop), A/D conversion stops, and the ADC12 enters a wait state.
6. When the ADST bit is then set to 1 (A/D conversion start), analog input sampling starts again for all channels whose dedicated sample-and-hold circuit is to be used.



注1.AD转换5的数据被忽略。

Figure 35.16 选择AN000至AN002时连续扫描模式下的基本操作示例

35.3.3.2 通道专用采样保持电路和禁用连续采样的基本操作

当通道专用的采样保持电路在禁止连续采样的情况下使用时，首先执行采样保持操作，然后在所有指定通道的模拟输入上重复进行AD转换。可以在ADSHCR的SHANS[2:0]位中选择要使用专用采样保持电路的通道。

操作如下：

1. 模拟输入采样开始于其专用采样保持电路的所有通道，当ADCSR.ADST位通过软件触发、同步触发输入(ELC)或异步触发输入设置为1（AD转换开始）。
2. 采样保持操作后，对ADANSA0和ADANSA1寄存器中选择的ANn通道执行AD转换，从编号n最小的通道开始。
3. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)。
4. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。同时，对所有要使用专用采样保持电路的通道开始模拟输入采样。
5. ADST位不会自动清除，只要该位保持为1，就会重复步骤2.到4.。当ADST位设置为0（AD转换停止），AD转换停止，ADC12进入等待状态。
6. 当ADST位随后设置为1（AD转换开始）时，模拟输入采样将重新开始对所有要使用专用采样保持电路的通道进行。

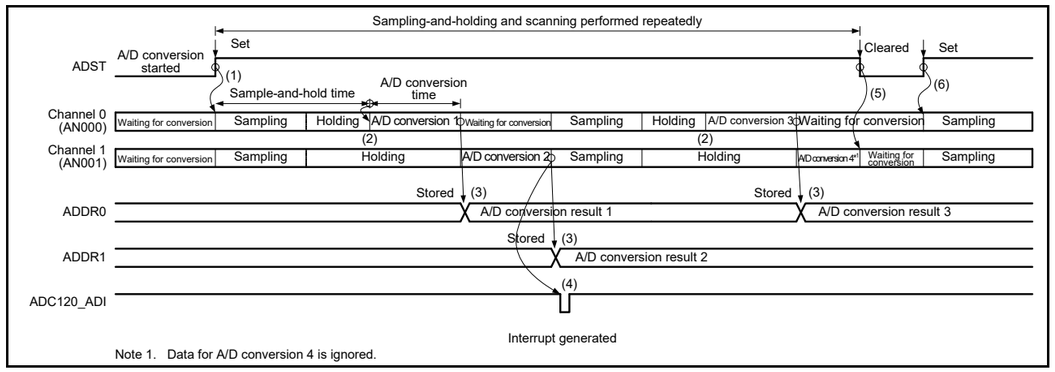


Figure 35.17 Example of operation in continuous scan mode when channel-dedicated sample-and-hold circuits are used and AN000 and AN001 are selected

35.3.3.3 Basic operation with channel-dedicated sample-and-hold circuits and continuous sampling enabled

When a channel-dedicated sample-and-hold circuit is used with continuous sampling enabled, sample-and-hold operations are performed first, after which the analog inputs on all selected channels are A/D-converted as described in this section. The channels for which the channel-dedicated sample-and-hold circuits are to be used can be selected in the ADSHCR.SHANS[2:0] bits.

The operation is as follows:

1. When the ADSHMSR.SHMD bit is set to 1, the sample-and-hold circuits selected in the ADSHCR.SHANS[2:0] bits start continuous sampling.
2. Analog input holding starts for all channels for which the channel-dedicated sample-and-hold circuits are to be used when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, input of a synchronous trigger signal (ELC), or input of an asynchronous trigger. Set the ADCSR.ADST bit to 1 after at least 400 ns (when the permissible signal source impedance is 1 kΩ) elapse after the ADSHMSR.SHMD bit is set to 1.
3. After the stabilization time of the sample-and-hold circuits elapses, A/D conversion is performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
4. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy), and the sample-and-hold circuit restarts continuous sampling.
5. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (without register setting). Also, analog input holding starts for all channels for which the channel-dedicated sample-and-hold circuits are to be used.
6. The ADCSR.ADST bit is not automatically cleared, and steps 3. to 5. are repeated as long as the bit remains 1. When the ADCSR.ADST bit is set to 0 (A/D conversion stop), A/D conversion stops and the ADC12 enters a wait state.
7. When the ADSHMSR.SHMD bit is set to 0, the sample-and-hold circuits stop.
8. When the ADSHMSR.SHMD bit is then set to 1, the sample-and-hold circuits selected in the ADSHCR.SHANS[2:0] bits start continuous sampling.
9. When the ADCSR.ADST bit is then set to 1 (A/D conversion start), analog input holding starts for all channels for which the channel-dedicated sample-and-hold circuits are to be used.

Note: If continuous scanning is performed when only the channels with the sample-and-hold circuits are selected, time for continuous sampling cannot be secured in the second and subsequent continuous scans. When continuous sampling by the channel-dedicated sample-and-hold circuits is enabled for continuous scanning, select one or more channels from AN003 to AN007, AN016 to AN018, AN020, temperature sensor output, and internal reference voltage for unit 0, and AN105 to AN107, AN116, AN117, temperature sensor output, and internal reference voltage for unit 1, and set the continuous sampling time for the sample-and-hold circuits to at least 400 ns (when the permissible signal source impedance is 1 kΩ).

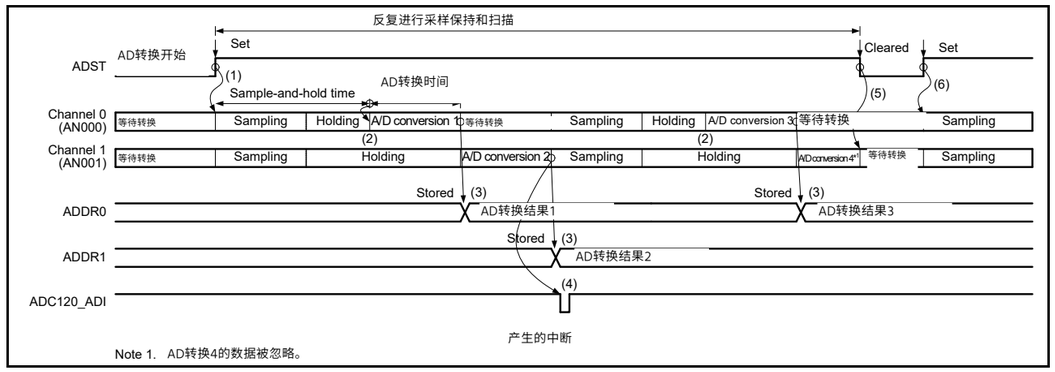


Figure 35.17 使用通道专用采样保持电路并选择AN000和AN001时连续扫描模式下的操作示例

35.3.3.3 具有通道专用采样保持电路和连续采样的基本操作

在启用连续采样的情况下使用通道专用的采样保持电路时，首先执行采样保持操作，然后按照本节所述对所有选定通道上的模拟输入进行AD转换。可以在ADSHCR.SHANS[2:0]位中选择要使用通道专用采样保持电路的通道。

操作如下：

1. 当ADSHMSR.SHMD位设置为1时，在ADSHCR.SHANS[2:0]位中选择的采样保持电路开始连续采样。
2. 当ADCSR.ADST位通过软件触发设置为1（AD转换开始），同步触发信号的输入（ELC），或异步触发器的输入。在ADSHMSR.SHMD位设置为1后至少经过400ns（当允许的信号源阻抗为1kΩ时）后，将ADCSR.ADST位设置为1。
3. 经过采样保持电路的稳定时间后，从编号n最小的通道开始，对ADANSA0和ADANSA1寄存器中选择的ANn通道执行AD转换。
4. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)，采样保持电路重新开始连续采样。
5. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无需寄存器设置）。此外，对于要使用通道专用采样保持电路的所有通道，模拟输入保持开始。
6. ADCSR.ADST位不会自动清零，只要该位保持为1，就会重复步骤3到5。当ADCSR.ADST位设置为0（AD转换停止）时，AD转换停止并且ADC12进入等待状态。
7. 当ADSHMSR.SHMD位设置为0时，采样保持电路停止。
8. 当ADSHMSR.SHMD位被设置为1时，在ADSHCR.SHANS[2:0]位开始连续采样。
9. 然后，当ADCSR.ADST位设置为1（AD转换开始）时，将开始使用通道专用采样保持电路的所有通道的模拟输入保持。

Note: 如果在仅选择带有采样保持电路的通道时执行连续扫描，则在第二次和随后的连续扫描中无法确保连续采样的时间。当启用通道专用采样保持电路的连续采样以进行连续扫描时，选择一个或多个通道，从AN003到AN007、AN016到AN018、AN020、温度传感器输出和单元0的内部参考电压和AN105AN107、AN116、AN117、温度传感器输出和单元1的内部参考电压，并将采样保持电路的连续采样时间设置为至少400ns（当允许的信号源阻抗为1kΩ时）。

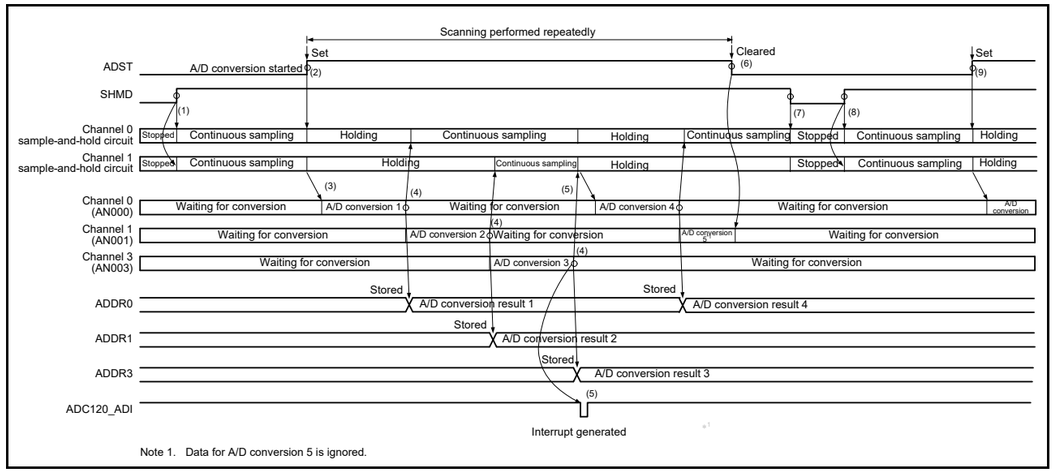


Figure 35.18 Example of operation in continuous scan mode when channel-dedicated sample-and-hold circuits are used, AN000, AN001, and AN003 are selected, and continuous sampling is enabled

35.3.3.4 Channel selection and self-diagnosis without channel-dedicated sample-and-hold circuits

When channels and self-diagnosis are selected at the same time, A/D conversion is first performed for the reference voltage VREFH0 (unit 0) or VREFH (unit 1) (×0, ×1/2, or ×1) supplied to the ADC12, and then A/D conversion is performed on the analog input of the selected channels, this sequence is then repeated.

The operation is as follows:

1. A/D conversion for self-diagnosis is first started when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, synchronous trigger input (ELC), or asynchronous trigger input.
2. When A/D conversion for self-diagnosis completes, the A/D conversion result is stored in the A/D Self-Diagnosis Data Register (ADRD). A/D conversion is then performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
3. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy).
4. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting). At the same time, the ADC12 starts A/D conversion for self-diagnosis and then starts A/D conversion on ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
5. The ADST bit is not automatically cleared, and steps 2 to 4 are repeated as long as the bit remains 1. When the ADST bit is set to 0 (A/D conversion stop), A/D conversion stops and the ADC12 enters a wait state.
6. The ADST bit remains 1 (A/D conversion start) during A/D conversion, and is automatically cleared to 0 when A/D conversion of all the selected channels completes. Then, the ADC12 enters a wait state.

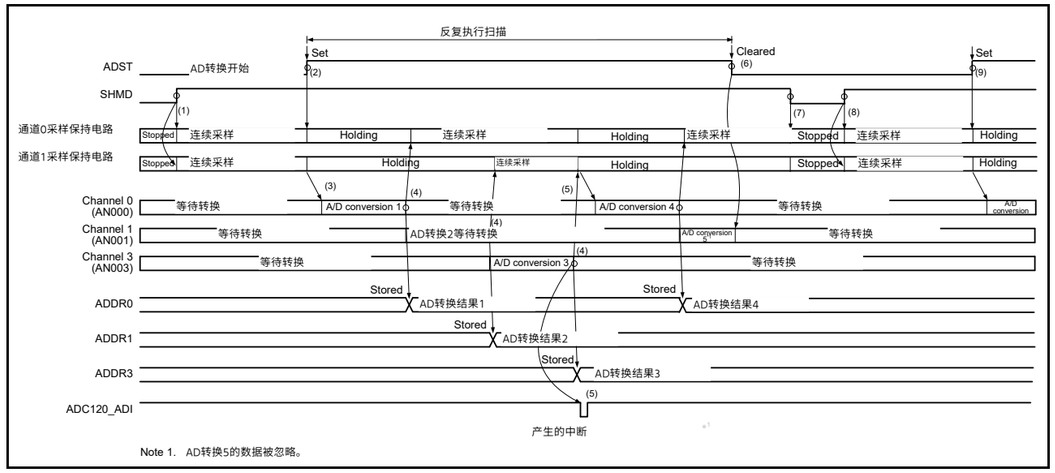


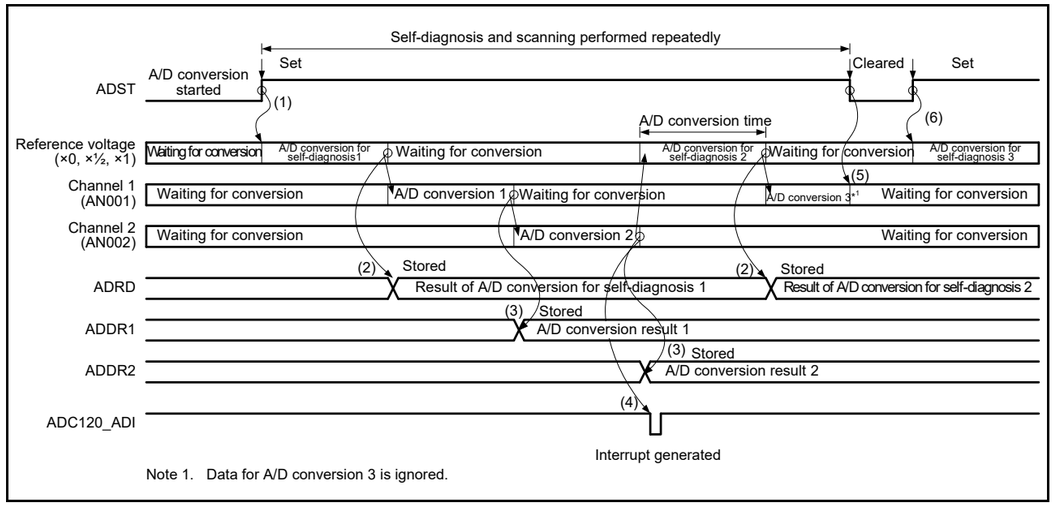
Figure 35.18 使用通道专用采样保持电路、选择AN000、AN001和AN003并启用连续采样时的连续扫描模式操作示例

35.3.3.4 通道选择和自诊断，无需通道专用的采样和保持电路

当同时选择通道和自诊断时，首先对提供给ADC12的参考电压VREFH0（单元0）或VREFH（单元1）（×0、×12或×1）进行AD转换，然后在所选通道的模拟输入上执行AD转换，然后重复此序列。

操作如下：

1. 通过软件触发、同步触发输入(ELC)或异步触发输入将ADCSR.ADST位设置为1（AD转换开始）时，首先启动用于自诊断的D转换。
2. 自诊断用AD转换完成后，AD转换结果存储在AD自诊断中数据寄存器(ADRD)。然后对ADANSA0中选择的ANn通道执行D转换，并ADANSA1寄存器，从编号n最小的通道开始。
3. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)。
4. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。同时，ADC12启动AD转换以进行自诊断，然后从编号n最小的通道开始对ADANSA0和ADANSA1寄存器中选择的ANn通道进行AD转换。
5. ADST位不会自动清零，只要该位保持为1，就会重复步骤2到4。当ADST位设置为0（AD转换停止），AD转换停止，ADC12进入等待状态。
6. ADST位在AD转换期间保持1（AD转换开始），并在所有选定通道的AD转换完成时自动清零。然后，ADC12进入等待状态。



Note 1. Data for A/D conversion 3 is ignored.

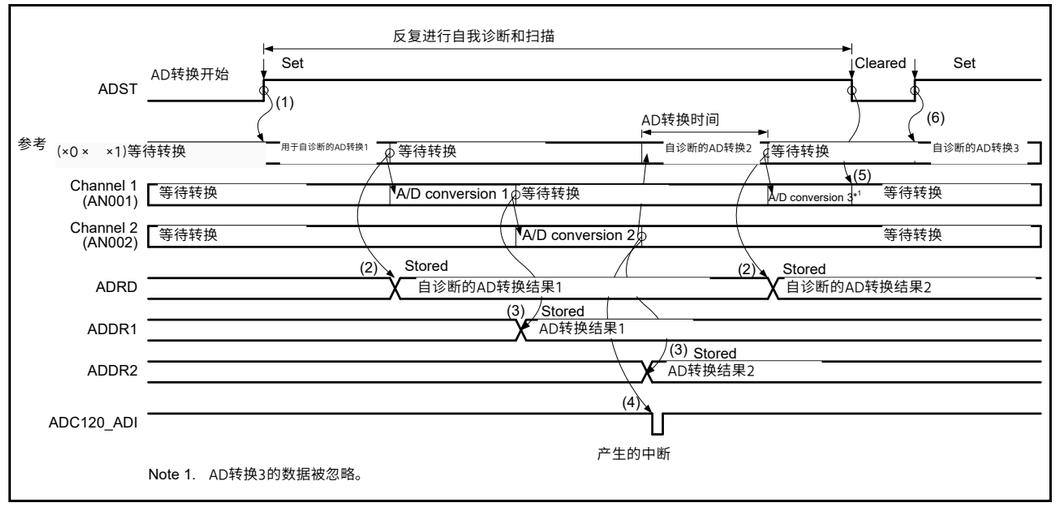
Figure 35.19 Example of basic operation in continuous scan mode when AN001 and AN002 are selected with self-diagnosis

35.3.3.5 Channel selection and self-diagnosis with channel-dedicated sample-and-hold circuits and continuous sampling disabled

When channels and self-diagnosis are selected and a channel-dedicated sample-and-hold circuit is used with continuous sampling disabled, sample-and- hold operation is first performed, and then A/D conversion is performed for the reference voltage VREFH0 (unit 0) or VREFH (unit 1) (×0, ×1/2, or ×1) supplied to the ADC12. A/D conversion is then performed on the analog input of the selected channels, and this sequence is repeated.

The operation is as follows:

1. Analog input sampling starts for all channels whose dedicated sample-and-hold circuit is to be used when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, synchronous trigger input (ELC), or asynchronous trigger input.
2. After sample-and-hold operation, A/D conversion for self-diagnosis starts.
3. When A/D conversion for self-diagnosis completes, the A/D conversion result is stored in the A/D Self-Diagnosis Data Register (ADRD). A/D conversion is then performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
4. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy).
5. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting). At the same time, analog input sampling starts for all channels whose dedicated sample-and-hold circuit is to be used.
6. The ADST bit is not automatically cleared, and steps 2. to 5. are repeated as long as the bit remains 1. When the ADST bit is set to 0 (A/D conversion stop), A/D conversion stops and the ADC12 enters a wait state.
7. When the ADST bit is then set to 1 (A/D conversion start), analog input sampling starts again for all channels whose dedicated sample-and-hold circuit is to be used.



Note 1. AD转换3的数据被忽略。

Figure 35.19 通过自诊断选择AN001和AN002时连续扫描模式下的基本操作示例

35.3.3.5 通道专用采样保持电路和禁用连续采样的通道选择和自诊断

Whenchannelsandself-diagnosisareselectedandachannel-dedicatedsample-and-holdcircuitisusedwithcontinuoussamplingdisabled sample-andholdoperationisfirstperformed andthenADconversionisperformedforthereferencevoltageVREFH0(unit0)or提供给ADC12的VREFH（单元1）（×0、×12或×1）。然后在所选通道的模拟输入上执行D转换，并重复此序列。

操作如下：

1. 模拟输入采样开始于其专用采样保持电路的所有通道，当ADCSR.ADST位通过软件触发、同步触发输入(ELC)或异步触发输入设置为1（AD转换开始）。
2. 采样保持操作后，用于自诊断的AD转换开始。
3. 自诊断用AD转换完成后，AD转换结果存储在AD自诊断中数据寄存器(ADRD)。然后对ADANSA0中选择的ANn通道执行D转换，并ADANSA1寄存器，从编号n最小的通道开始。
4. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)。
5. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。同时，对所有要使用专用采样保持电路的通道开始模拟输入采样。
6. ADST位不会自动清零，只要该位保持为1，就会重复步骤2到5。ADST位设置为0（AD转换停止），AD转换停止，ADC12进入等待状态。
7. 当ADST位随后设置为1（AD转换开始）时，模拟输入采样将重新开始对所有要使用专用采样保持电路的通道进行。

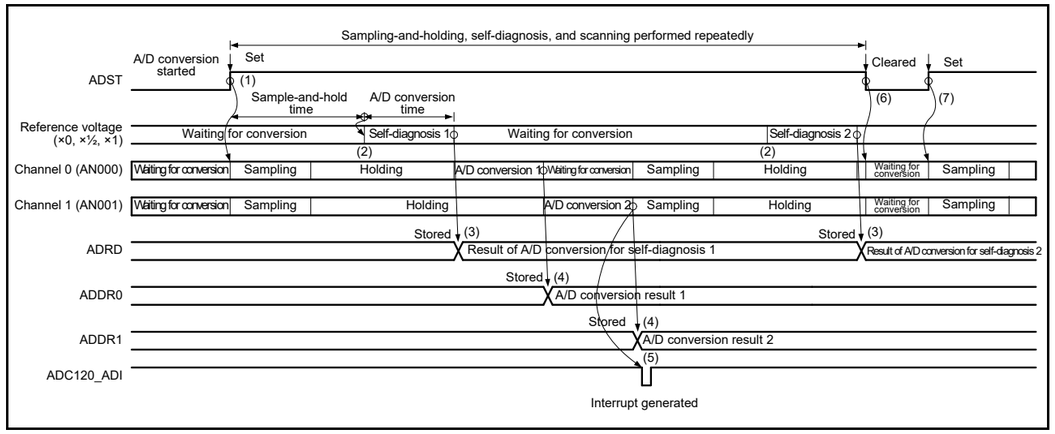


Figure 35.20 Example of operation in continuous scan mode when channel-dedicated sample-and-hold circuits are used, and AN000 and AN001 are selected with self-diagnosis

35.3.3.6 Channel selection and self-diagnosis with channel-dedicated sample-and-hold circuits and continuous sampling enabled

When channels and self-diagnosis are selected and a channel-dedicated sample-and-hold circuit is used with continuous sampling enabled, sample-and-hold operation is first performed, followed by A/D conversion of the reference voltage VREFH0 (unit 0) or VREFH (unit 1) (×0, ×1/2, or ×1) supplied to the ADC12. A/D conversion is then performed on the analog input of the selected channels, and this sequence is repeated.

The operation is as follows:

1. When the ADSHMSR.SHMD bit is set to 1, the sample-and-hold circuits selected in the ADSHCR.SHANS[2:0] bits start continuous sampling.
2. Analog input holding starts for all channels for which the channel-dedicated sample-and-hold circuits are to be used when the ADCSR.ADST bit is set to 1 (A/D conversion start) by a software trigger, input of a synchronous trigger signal (ELC), or input of an asynchronous trigger. Set the ADCSR.ADST bit to 1 after at least 400 ns (when the permissible signal source impedance is 1 kΩ) elapse after the ADSHMSR.SHMD bit is set to 1.
3. After the stabilization time of the sample-and-hold circuits elapses, A/D conversion for self-diagnosis starts.
4. When A/D conversion for self-diagnosis completes, the A/D conversion result is stored in the A/D Self-Diagnosis Data Register (ADRD). A/D conversion is then performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
5. Each time A/D conversion of a single channel completes, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy), and the sample-and-hold circuit restarts continuous sampling.
6. When A/D conversion of all the selected channels completes, an ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting). Also, analog input holding starts for all channels for which the channel-dedicated sample-and-hold circuits are to be used.
7. The ADCSR.ADST bit is not automatically cleared, and steps 3. to 6. are repeated as long as the bit remains 1. When the ADCSR.ADST bit is set to 0 (A/D conversion stop), A/D conversion stops and the ADC12 enters a wait state.
8. When the ADSHMSR.SHMD bit is set to 0, the sample-and-hold circuits stop.
9. When the ADSHMSR.SHMD bit is then set to 1, the sample-and-hold circuits selected in the ADSHCR.SHANS[2:0] bits start continuous sampling.
10. When the ADCSR.ADST bit is then set to 1 (A/D conversion start), analog input holding starts for all channels for which the channel-dedicated sample-and-hold circuits are to be used.

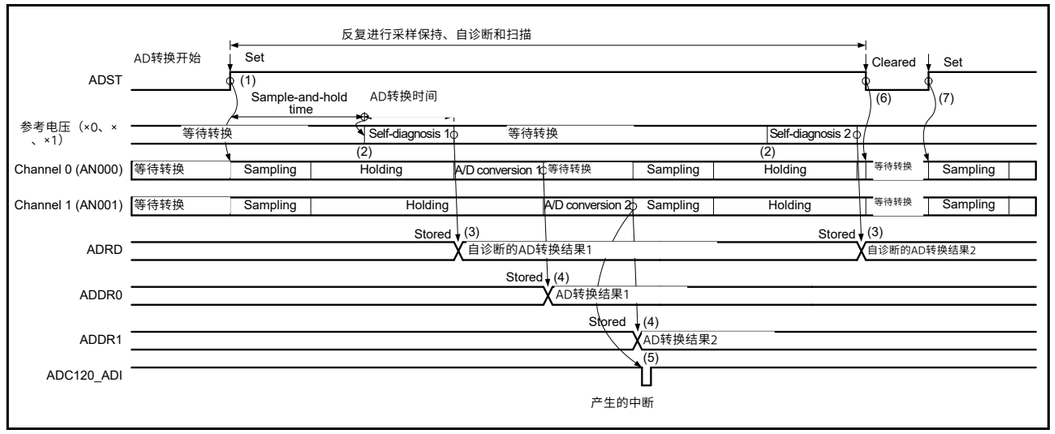


Figure 35.20 使用通道专用的采样保持电路并通过自诊断选择AN000和AN001时在连续扫描模式下的操作示例

35.3.3.6 通道选择和自诊断，带有通道专用的采样保持电路和连续采样使能

Whenchannelsandself-diagnosisareselectedandachannel-dedicatedsample-and-holdcircuitisusedwithcontinuoussamplingenabled sample-and-holdoperationisfirstperformed followedbyADconversionofthereferencevoltageVREFH0(unit0)or提供给ADC12的VREFH（单元1）（×0、×12或×1）。然后在所选通道的模拟输入上执行D转换，并重复此序列。

操作如下：

1. 当ADSHMSR.SHMD位设置为1时，在ADSHCR.SHANS[2:0]位中选择的采样保持电路开始连续采样。
2. 当ADCSR.ADST位通过软件触发设置为1（AD转换开始），同步触发信号的输入（ELC），或异步触发器的输入。在ADSHMSR.SHMD位设置为1后至少经过400ns（当允许的信号源阻抗为1kΩ时）后，将ADCSR.ADST位设置为1。
3. 经过采样保持电路的稳定时间后，开始进行自诊断的A/D转换。
4. 自诊断用AD转换完成后，AD转换结果存储在AD自诊断中数据寄存器(ADRD)。然后对ADANSA0中选择的ANn通道执行D转换，并ADANSA1寄存器，从编号n最小的通道开始。
5. 每次完成单个通道的AD转换，AD转换结果存储在关联的AD中数据寄存器y(ADDRy)，采样保持电路重新开始连续采样。
6. 当所有选定通道的AD转换完成时，会产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。此外，对于要使用通道专用采样保持电路的所有通道，模拟输入保持开始。
7. ADCSR.ADST位不会自动清零，只要该位保持1，就会重复步骤3.到6.。当ADCSR.ADST位设置为0（AD转换停止）时，AD转换停止并且ADC12进入等待状态。
8. 当ADSHMSR.SHMD位设置为0时，采样保持电路停止。
9. 当ADSHMSR.SHMD位被设置为1时，在ADSHCR.SHANS[2:0]位开始连续采样。

10.当ADCSR.ADST位被设置为1（AD转换开始）时，所有通道的模拟输入保持开始，所有通道都将使用通道专用的采样保持电路。

Note: If continuous scanning is performed when only the channels with the sample-and-hold circuits are selected, time for continuous sampling cannot be secured in the second and subsequent continuous scans. When continuous sampling by the channel-dedicated sample-and-hold circuits is enabled for continuous scanning, select one or more channels from AN003 to AN007, AN016 to AN018, AN020, temperature sensor output, and internal reference voltage for unit 0, and AN105 to AN107, AN116, AN117, temperature sensor output, and internal reference voltage for unit 1, and set the continuous sampling time for the sample-and-hold circuits to at least 400 ns (when the permissible signal source impedance is 1 kΩ).

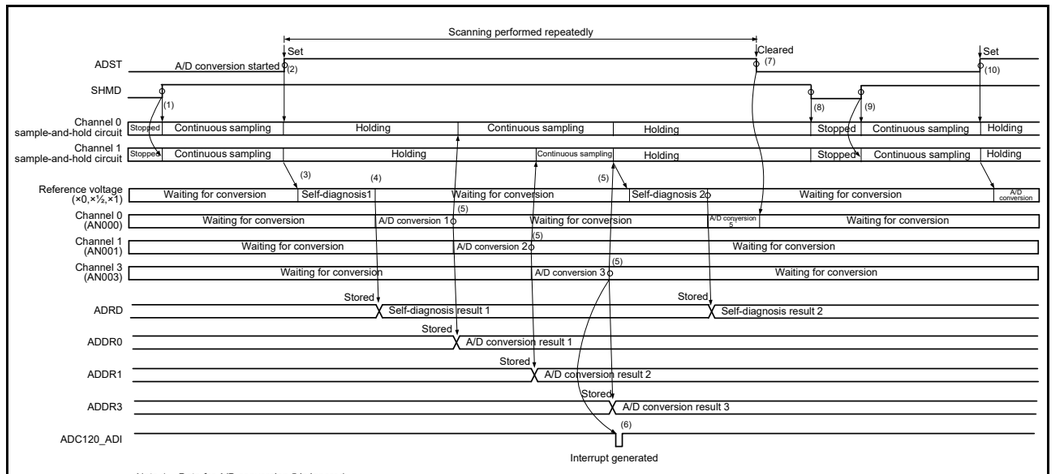


Figure 35.21 Example of operation in continuous scan mode when channel-dedicated sample-and-hold circuits are used, AN000, AN001, and AN003 are selected with self-diagnosis, and continuous sampling is enabled

35.3.3.7 A/D conversion of temperature sensor output or internal reference voltage

When the channels and temperature sensor output or internal reference voltage are selected at the same time, A/D conversion is first performed on the analog input of the selected channels, and then A/D conversion of the temperature sensor output or internal reference voltage is repeated. When both temperature sensor output and internal reference voltage are selected, A/D conversion of the temperature sensor output and internal reference voltage is performed, in that order.

With the channels deselected, selecting only the temperature sensor output or internal reference voltage is also possible.

The operation is as follows:

1. When a software trigger, synchronous trigger (ELC), or asynchronous trigger sets the ADCSR.ADST bit to 1 (A/D conversion start), A/D conversion is performed for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the smallest number n.
2. On completion of A/D conversion on the channels, the result is stored in the associated A/D Data Register y (ADDRy), and then A/D conversion of the temperature sensor output starts.
3. On completion of A/D conversion of the temperature sensor output, the result is stored in the associated A/D Temperature Sensor Data Register (ADTSDR), and then A/D conversion of the internal reference voltage starts.
4. On completion of A/D conversion of the internal reference voltage, the result is stored in the associated A/D Internal Reference Voltage Data Register (ADOCDR), and an ADC12i_ADI interrupt request is generated. In addition, the ADC12 continuously starts A/D conversion for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the lowest number n.
5. The ADCSR.ADST bit is not cleared automatically, and steps 2. to 4. are repeated as long as this bit remains set to 1. When the ADCSR.ADST bit is set to 0 (A/D conversion stop), A/D conversion stops and the ADC12 enters a

Note: 如果在仅选择带有采样保持电路的通道时执行连续扫描，则在第二次和随后的连续扫描中无法确保连续采样的时间。当启用通道专用采样保持电路的连续采样以进行连续扫描时，选择一个或多个通道，从AN003到AN007、AN016到AN018、AN020、温度传感器输出和单元0的内部参考电压和AN105AN107、AN116、AN117、温度传感器输出和单元1的内部参考电压，并将采样保持电路的连续采样时间设置为至少400ns（当允许的信号源阻抗为1kΩ时）。

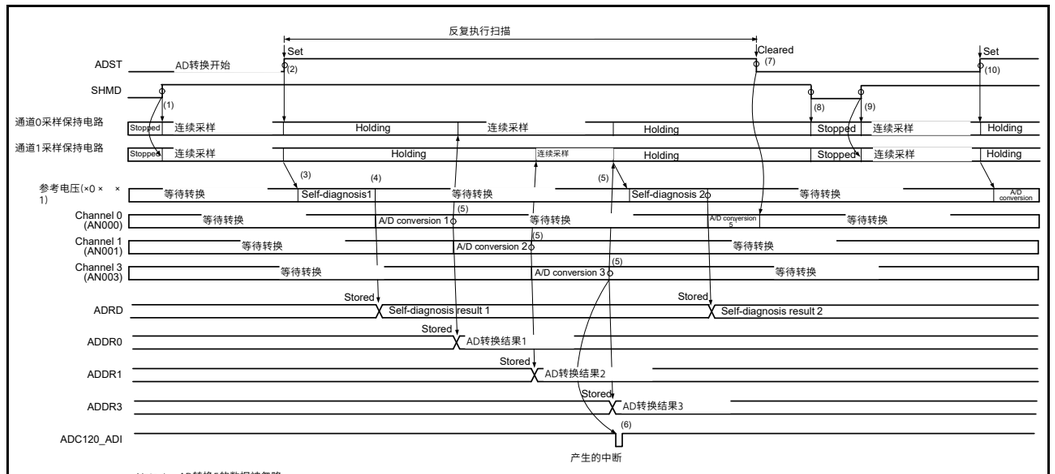


Figure 35.21 使用通道专用采样保持电路、AN000、AN001和AN003选择并进行自诊断并启用连续采样时的连续扫描模式操作示例

35.3.3.7 温度传感器输出或内部参考电压的AD转换

当同时选择通道和温度传感器输出或内部参考电压时，首先对所选通道的模拟输入进行AD转换，然后重复温度传感器输出或内部参考电压的AD转换。当同时选择温度传感器输出和内部参考电压时，按顺序执行温度传感器输出和内部参考电压的AD转换。

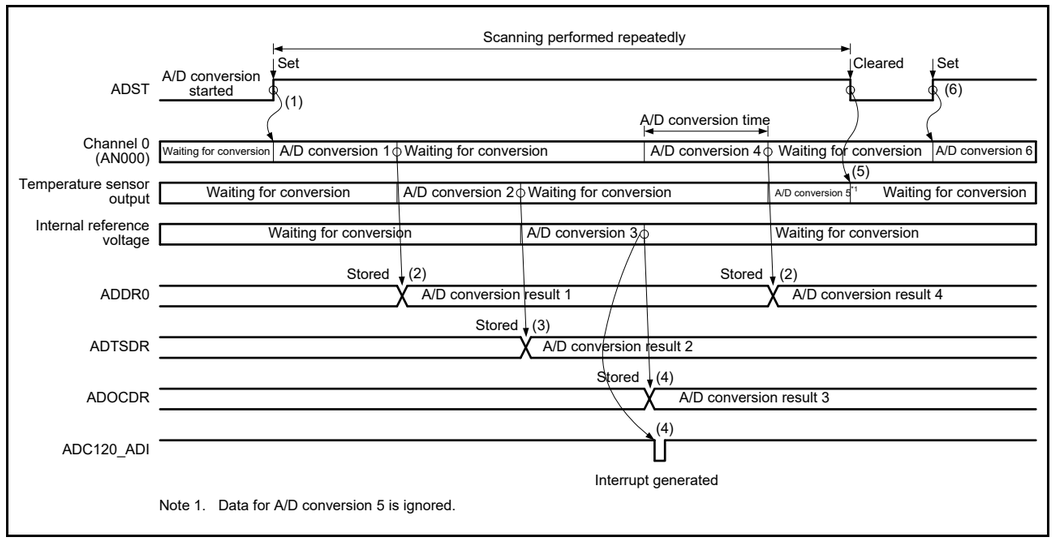
取消选择通道后，也可以仅选择温度传感器输出或内部参考电压。

操作如下：

1. 当软件触发、同步触发(ELC)或异步触发将ADCSR.ADST位设置为1（AD转换开始）时，对ADANSA0和ADANSA1寄存器中选择的ANn通道执行AD转换，从具有最小的数n。
2. 在通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中，然后温度传感器输出的AD转换开始。
3. 温度传感器输出的AD转换完成后，结果存储在相关的AD中
温度传感器数据寄存器(ADTSDR)，然后内部参考电压的AD转换开始。
4. 内部参考电压的AD转换完成后，结果存储在相关的AD中
内部参考电压数据寄存器(AOCDR)，并产生ADC12i_ADI中断请求。此外，ADC12连续启动ADANSA0和ADANSA1寄存器中选择的ANn通道的AD转换，从编号最小的通道n开始。
5. ADCSR.ADST位不会自动清除，只要该位保持设置为1，就会重复步骤2到4。当ADCSR.ADST位设置为0（AD转换停止）时，AD转换停止并且ADC12进入

wait state.

6. When the ADCSR.ADST bit is then set to 1 (A/D conversion start), A/D conversion starts again for the ANn channels selected in the ADANSA0 and ADANSA1 registers, starting from the channel with the lowest number n.



Note 1. Data for A/D conversion 5 is ignored.

Figure 35.22 Example of basic operation in continuous scan mode when AN000 and temperature sensor output or internal reference voltage are selected

35.3.4 Group Scan Mode

35.3.4.1 Basic operation

In group scan mode, A/D conversion is performed once on the analog inputs of all the specified channels in group A and group B after scanning is started by a synchronous trigger (ELC). The scan operation of each group is similar to the scan operation in single scan mode.

The synchronous triggers can be selected in the ADSTRGR.TRSA[5:0] bits for group A and in the ADSTRGR.TRSB[5:0] bits for group B. Use different triggers for group A and group B to prevent simultaneous A/D conversion of the two groups. Do not use a software trigger.

The group A channels to be A/D-converted are selected using the ADANSA0 and ADANSA1 registers and the ADEXICR.TSSA and OCSA bits, while the group B channels to be A/D-converted are selected using the ADANSB0 and ADANSB1 registers and the ADEXICR.TSSB and OCSB bits. Group A and group B cannot use the same channels.

When self-diagnosis is selected in group scan mode, self-diagnosis is separately executed for group A and group B.

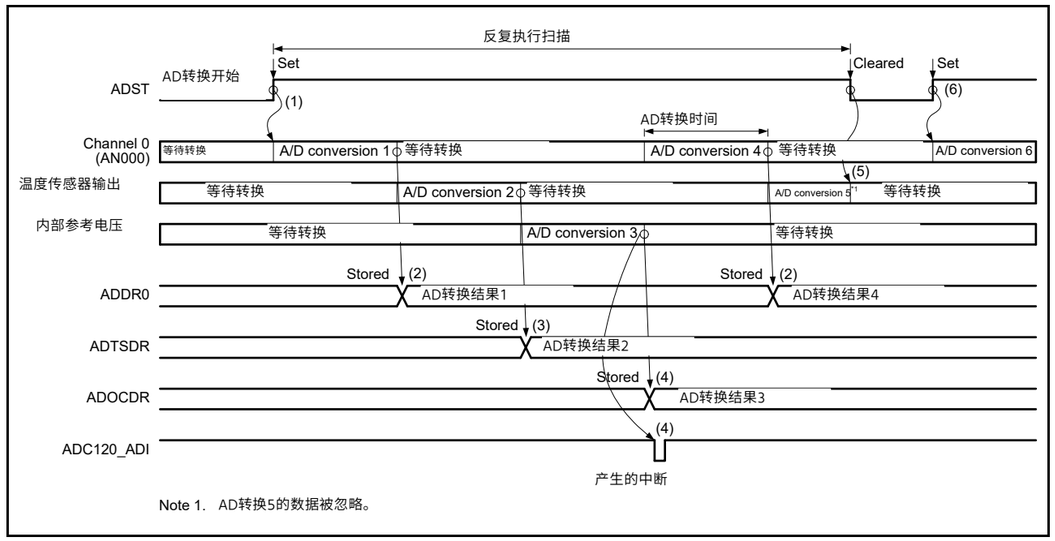
The following example describes operation in group scan mode using a synchronous trigger from the ELC. In this example, the ELC_AD00 and ELC_AD01 (unit 0), and ELC_AD10 and ELC_AD11 (unit 1) triggers from the ELC are used to start conversion of group A and group B, respectively. Also, ELC_AD00 and ELC_AD01 (unit 0), and ELC_AD10 and ELC_AD11 (unit 1) are selected for the GPT event in the associated ELC.ELSRn registers.

The operation is as follows:

1. Scanning of group A is started by ELC_AD00 (unit 0) or ELC_AD10 (unit 1).
2. When group A scanning completes, an ADC12i_ADI (i = 0, 1) interrupt is generated (no register setting).
3. Scanning of group B is started by ELC_AD01 (unit 0) or ELC_AD11 (unit 1).
4. When group B scanning completes, an ADC12i_GBADI interrupt is generated if the ADCSR.GBADIE bit is 1 (ADC12i_GBADI interrupt when scanning completion is enabled).

等待状态。

6. 当ADCSR.ADST位随后设置为1（AD转换开始）时，AD转换再次开始在ADANSA0和ADANSA1寄存器中选择的ANn通道，从编号最小的通道n开始。



Note 1. AD转换5的数据被忽略。

Figure 35.22 选择AN000和温度传感器输出或内部参考电压时连续扫描模式下的基本操作示例

35.3.4 组扫描模式

35.3.4.1 基本操作

在组扫描模式下，通过同步触发（ELC）开始扫描后，对A组和B组中所有指定通道的模拟输入进行一次A/D转换。每组的扫描操作类似于单次扫描模式下的扫描操作。

可以在A组的ADSTRGR.TRSA[5:0]位和
B组的ADSTRGR.TRSB[5:0]位。对A组和B组使用不同的触发，以防止两组同时进行AD转换。不要使用软件触发。

使用ADANSA0和ADANSA1寄存器选择要进行AD转换的A组通道
ADEXICR.TSSA和OCSA位，而要进行AD转换的B组通道使用ADANSB0和ADANSB1寄存器以及ADEXICR.TSSB和OCSB位进行选择。A组和B组不能使用相同的通道。

在组扫描模式下选择自诊断时，对A组和B组分别进行自诊断。

以下示例描述了使用来自ELC的同步触发器在组扫描模式下的操作。在此示例中，ELC_AD00和ELC_AD01（单元0）以及来自ELC的ELC_AD10和ELC_AD11（单元1）触发器分别用于启动A组和B组的转换。此外，ELC_AD00和ELC_AD01（单元0）以及ELC_AD10和ELC_AD11（单元1）被选择用于相关ELC.ELSRn寄存器中的GPT事件。

操作如下：

1. A组的扫描由ELC_AD00（单元0）或ELC_AD10（单元1）启动。
2. 当A组扫描完成时，会产生一个ADC12i_ADI(i=0 1)中断（无寄存器设置）。
3. B组的扫描由ELC_AD01（单元0）或ELC_AD11（单元1）启动。
4. 当B组扫描完成时，如果ADCSR.GBADIE位为1（使能扫描完成时ADC12i_GBADI中断），则产生ADC12i_GBADI中断。

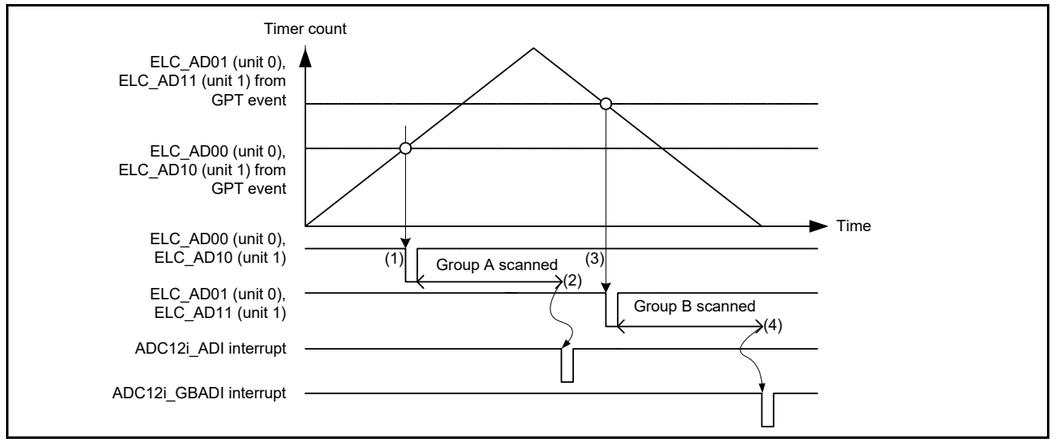


Figure 35.23 Example of basic operation in group scan mode when synchronous triggers from the ELC are used

35.3.4.2 A/D conversion in double trigger mode

When double trigger mode is selected in group scan mode, two rounds of single scan operation started by a synchronous trigger (ELC) are performed as a sequence for group A. For group B, single scan operation started by a synchronous trigger (ELC) is performed once.

In group scan mode, the synchronous triggers can be selected in the TRSA[5:0] bits in ADSTRGR for group A and in the TRSB[5:0] bits in ADSTRGR for group B. Use different triggers for group A and group B to prevent simultaneous A/D conversion of the two groups. Do not use a software trigger or an asynchronous trigger (ADTRGn).

When ELC_AD00/ELC_AD01 (unit 0), ELC_AD10/ELC_AD11 (unit 1) is selected as the group A synchronous triggers by setting the ADSTRGR.TRSA[5:0] bits to 0Bh, operation proceeds in extended double trigger mode.

The channels to be A/D-converted are selected in the DBLANS[4:0] bits in the ADCSR register for group A and in the ADANSB0 and ADANSB1 registers for group B. The same channels cannot be selected for both groups.

When double trigger mode is selected in group scan mode, set the A/D conversion select bits for both the temperature sensor output (ADEXICR.TSSA) and the internal reference voltage (ADEXICR.OCSA) to 0 (deselected). Self-diagnosis cannot be selected when double trigger mode is selected in group scan mode.

Duplication of A/D conversion data is enabled by setting the channel numbers to be duplicated to the ADCSR.DBLANS[4:0] bits and setting the DBLE bit in ADCSR to 1.

The following describes operation in group scan mode with double trigger mode using a synchronous trigger from the ELC. In this example, the ELC_AD00 and ELC_AD01 (unit 0), ELC_AD10 and ELC_AD11 (unit 1) triggers from the ELC are used to start conversion of group A and group B, respectively. Also, ELC_AD00 and ELC_AD01 (unit 0), ELC_AD10 and ELC_AD11 (unit 1) are selected for the GPT event in the associated ELC.ELSRn registers.

The operation is as follows:

1. Scanning of group B is started by the ELC_AD00 (unit 0) or ELC_AD10 (unit 1) trigger from the ELC.
2. When group B scanning completes, an ADC12i_GBADI (i = 0, 1) interrupt is generated if the GBADIE bit in ADCSR is 1 (ADC12i_GBADI interrupt when scanning completion is enabled).
3. The first scan of group A is started by the first ELC_AD01 (unit 0) or ELC_AD11 (unit 1) trigger.
4. When the first scan of group A completes, the conversion result is stored in the associated A/D Data Register y (ADDRy), an ADC12i_ADI interrupt request is not generated.
5. The second scan of group A is started by the second ELC_AD01 (unit 0) or ELC_AD11 (unit 1) trigger.
6. When the second scan of group A completes, the conversion result is stored in ADDBLDR. An ADC12i_ADI interrupt is generated.

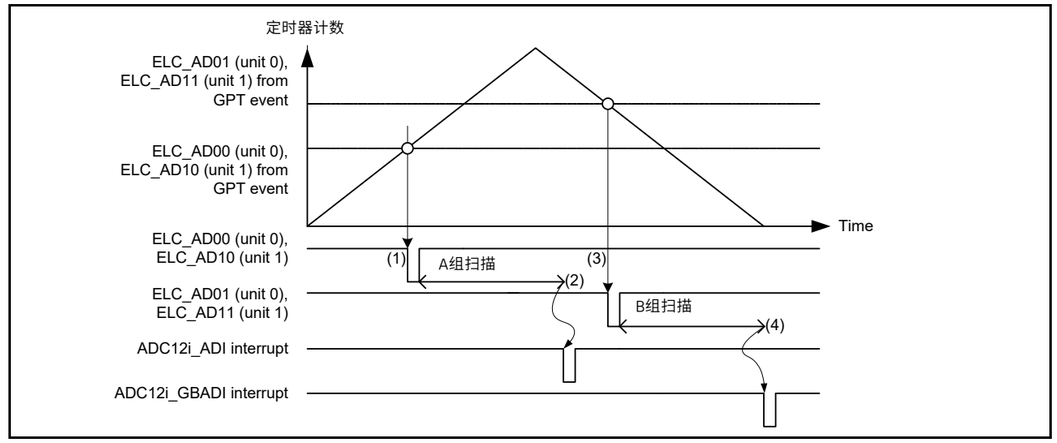


Figure 35.23 使用来自ELC的同步触发时组扫描模式下的基本操作示例

35.3.4.2 双触发模式下的AD转换

在组扫描模式中选择双触发模式时，由同步触发(ELC)启动的两轮单扫描操作作为A组的序列执行。对于B组，由同步触发(ELC)启动的单扫描操作是执行一次。

在组扫描模式下，可以在A组的ADSTRGR的TRSA[5:0]位和B组的ADSTRGR的TRSB[5:0]位中选择同步触发。A组和B组使用不同的触发以防止两组同时进行AD转换。不要使用软件触发或异步触发(ADTRGn)。

当通过将ADSTRGR.TRSA[5:0]位设置为0Bh来选择ELC_AD00ELC_AD01（单元0）、ELC_AD10ELC_AD11（单元1）作为A组同步触发时，操作在扩展双触发模式下进行。

要进行AD转换的通道在A组的ADCSR寄存器的DBLANS[4:0]位和B组的ADANSB0和ADANSB1寄存器。不能为两个组选择相同的通道。

在组扫描模式下选择双触发模式时，将温度传感器输出(ADEXICR.TSSA)和内部参考电压(ADEXICR.OCSA)的AD转换选择位设置为0（取消选择）。在组扫描模式下选择双触发模式时，不能选择自诊断。

AD转换数据的复制通过将要复制的通道号设置为ADCSR.DBLANS[4:0]位并将ADCSR中的DBLE位设置为1。

下面介绍使用来自ELC的同步触发的双触发模式的组扫描模式下的操作。在本例中，ELC_AD00和ELC_AD01（单元0）、ELC_AD10和ELC_AD11（单元1）从ELC分别用于启动A组和B组的转换。此外，ELC_AD00和ELC_AD01（单元0），在关联的ELC.ELSRn寄存器中为GPT事件选择ELC_AD10和ELC_AD11（单元1）。

操作如下：

1. B组的扫描由来自ELC的ELC_AD00（单元0）或ELC_AD10（单元1）触发器启动。
2. 当B组扫描完成时，如果GBADIE位在ADCSR为1（启用扫描完成时ADC12i_GBADI中断）。
3. A组的第一次扫描由第一个ELC_AD01（单元0）或ELC_AD11（单元1）触发器启动。
4. 当A组的第一次扫描完成时，转换结果存储在相关的AD数据寄存器y(ADDRy)中，不会产生ADC12i_ADI中断请求。
5. A组的第二次扫描由第二个ELC_AD01（单元0）或ELC_AD11（单元1）触发器启动。
6. 当A组的第二次扫描完成时，转换结果存储在ADDBLDR中。产生一个ADC12i_ADI中断。

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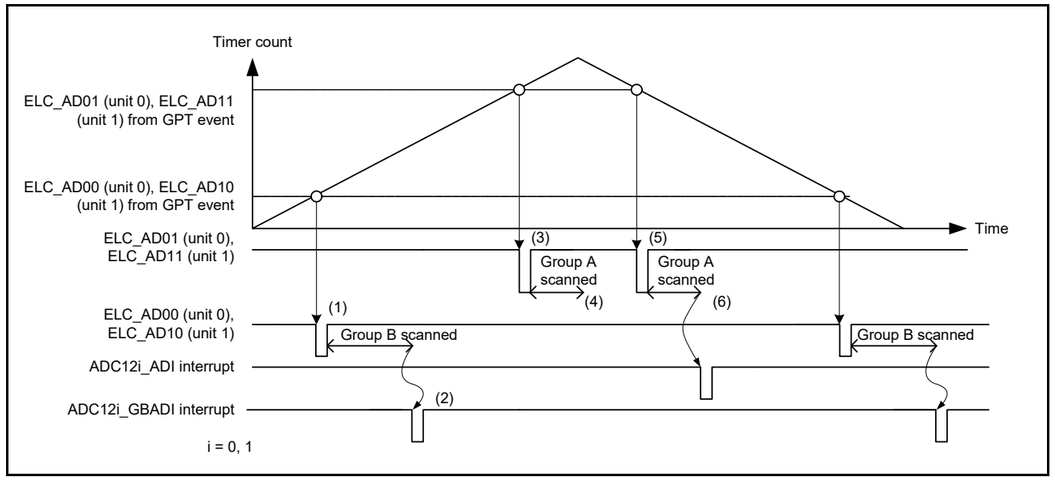

Figure 35.24 Example of basic operation in group scan mode with double trigger mode when synchronous triggers from the ELC are used

35.3.4.3 Operation with group A priority control

Setting the ADGSPCR.PGS bit to 1 in group scan mode enables operation to proceed under group A priority control. When setting the PGS bit in the ADGSPCR register to 1, follow the procedure shown in Figure 35.25. If the procedure is not followed, A/D conversion operation and stored data are not guaranteed.

In basic group scan mode, while A/D conversion is underway for group A or group B, input of the trigger for A/D conversion for the other group is ignored. Under group A priority control, if a group A trigger is input during A/D conversion for group B, A/D conversion for group B is discontinued and A/D conversion for group A proceeds. If the setting in the ADGSPCR.GBRSCN bit is 0, the ADC12 enters wait state on completion of the A/D conversion for group A. If the setting in the ADGSPCR.GBRSCN bit is 1, the ADC12 automatically restarts scanning for group B from the head of the group after completion of the A/D conversion for group A. Table 35.9 summarizes operations in response to the input of a trigger during A/D conversion with the settings in the ADGSPCR.GBRSCN bit.

Scan operations in group A or group B are the same in single scan mode. Additionally, single scanning for group B is continuously operated if the ADGSPCR.GBRP bit is set to 1.

For the trigger settings in group scan mode, select a synchronous trigger for group A using the ADSTRGR.TRSA[5:0] bits, and select a synchronous trigger for group B, different from that of group A, using the ADSTRGR.TRSB[5:0] bits. Set the ADSTRGR.TRSB[5:0] bits to 3Fh when setting the ADGSPCR.GBRP bit to 1.

Additionally, as targets for A/D conversion, select channels for group A using the ADANSA0 and ADANSA1 registers and the ADEXICR.TSSA and OCSA bits, and for group B, select channels different from those for group A using the ADANSB0 and ADANSB1 registers, and the ADEXICR.TSSB and OCSB bits.

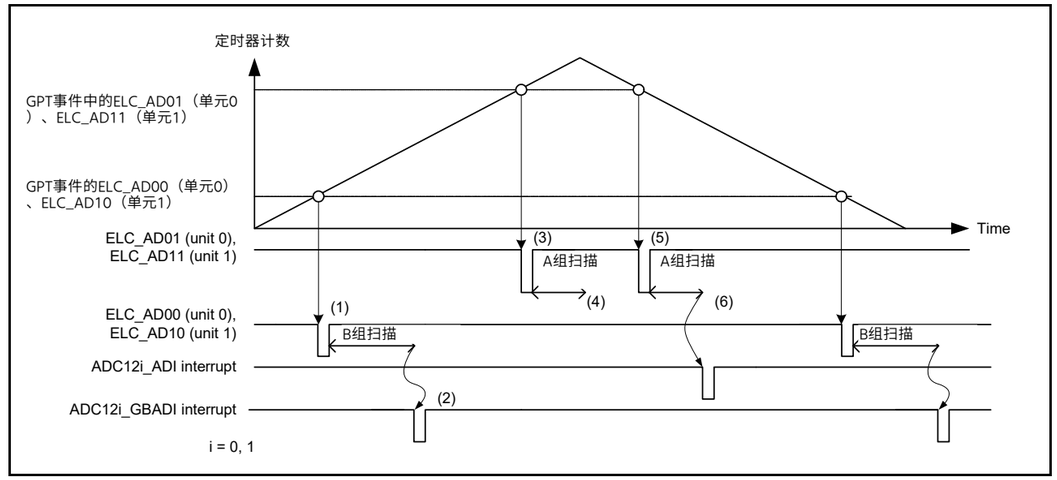

Figure 35.24 使用来自ELC的同步触发时，双触发模式下组扫描模式的基本操作示例

35.3.4.3 A组优先控制操作

在组扫描模式下将ADGSPCR.PGS位设置为1可使操作在A组优先级控制下进行。
将ADGSPCR寄存器中的PGS位设置为1时，请按照图35.25中所示的步骤进行操作。如果不遵循该程序，则无法保证AD转换操作和存储数据。

在基本组扫描模式下，当A组或B组正在进行AD转换时，忽略其他组的AD转换触发输入。在A组优先控制下，如果在B组AD转换期间输入A组触发，则B组AD转换中断，A组AD转换继续。如果ADGSPCR.GBRSCN位设置为0，ADC12在A组AD转换完成时进入等待状态。如果ADGSPCR.GBRSCN位设置为1，ADC12自动从头部重新开始扫描B组完成A组的AD转换后的组。表35.9总结了在ADGSPCR.GBRSCN位中设置的AD转换期间响应触发输入的操作。

A组或B组的扫描操作在单次扫描模式下是相同的。此外，如果ADGSPCR.GBRP位设置为1，则B组的单次扫描将连续运行。

对于组扫描模式下的触发设置，使用ADSTRGR.TRSA[5:0]位为A组选择一个同步触发，并使用ADSTRGR.TRSB[为B组选择一个不同于A组的同步触发5:0]位。将ADGSPCR.GBRP位设置为1时，将ADSTRGR.TRSB[5:0]位设置为3Fh。

此外，作为AD转换的目标，使用ADANSA0和ADANSA1寄存器以及ADEXICR.TSSA和OCSA位为A组选择通道，对于B组，使用ADANSB0和ADANSB1寄存器选择与A组不同的通道，以及ADXICR.TSSB和OCSB位。

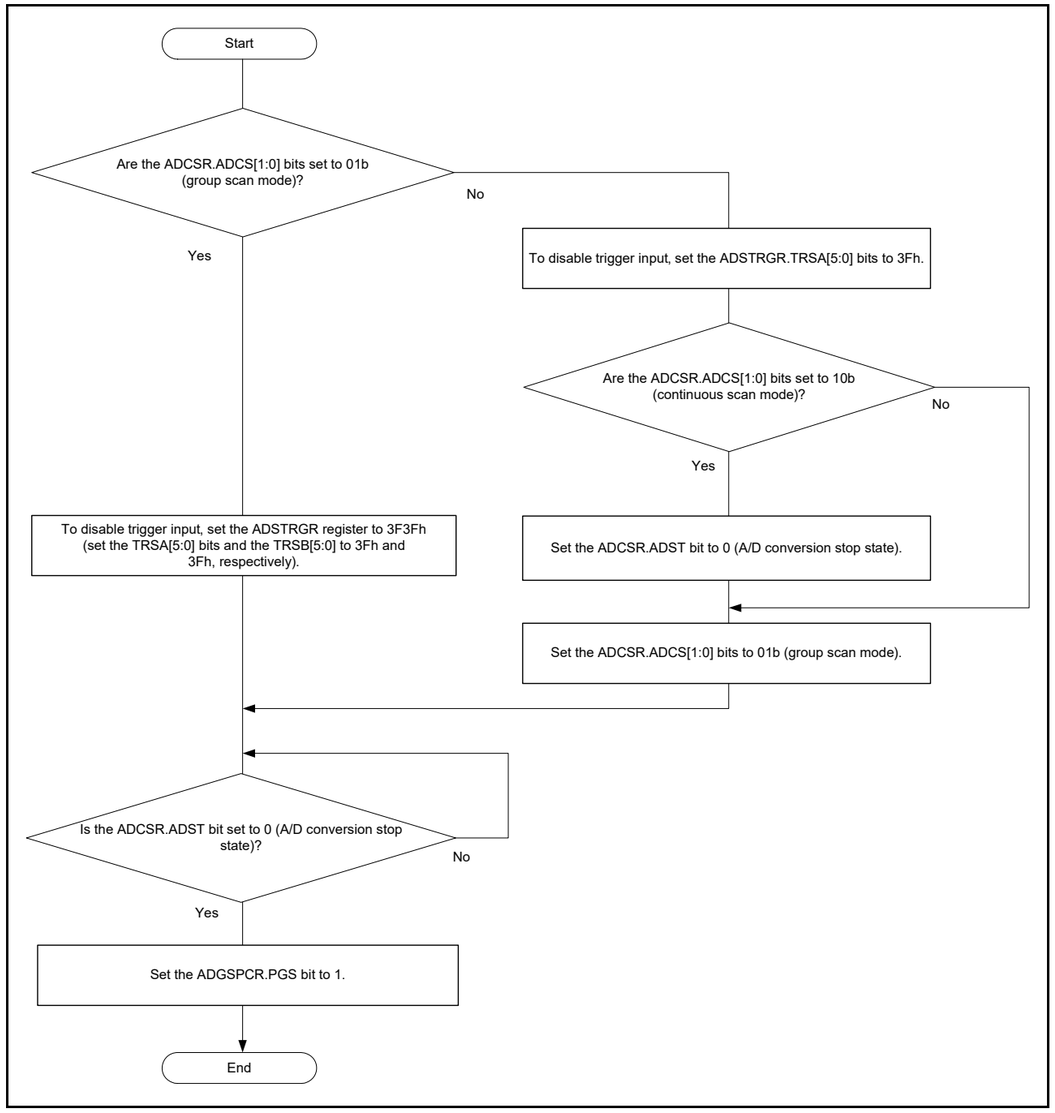

Figure 35.25 Flow for ADGSPCR.PGS bit setting

Table 35.9 Control of A/D conversion operations based on the ADGSPCR.GBRSCN bit settings

A/D conversion operation	Trigger input	ADGSPCR.GBRSCN = 0	ADGSPCR.GBRSCN = 1
When A/D conversion for group A is in progress	Input of group A trigger	Trigger input is invalid	Trigger input is invalid
	Input of group B trigger	Trigger input is invalid	Group B is converted after group A conversion completes
When A/D conversion for group B is in progress	Input of group A trigger	Group B conversion stops and group A conversion starts	• Group B conversion stops and group A conversion starts • Group B Conversion starts after group A conversion completes
	Input of group B trigger	Trigger input is invalid	Trigger input is invalid

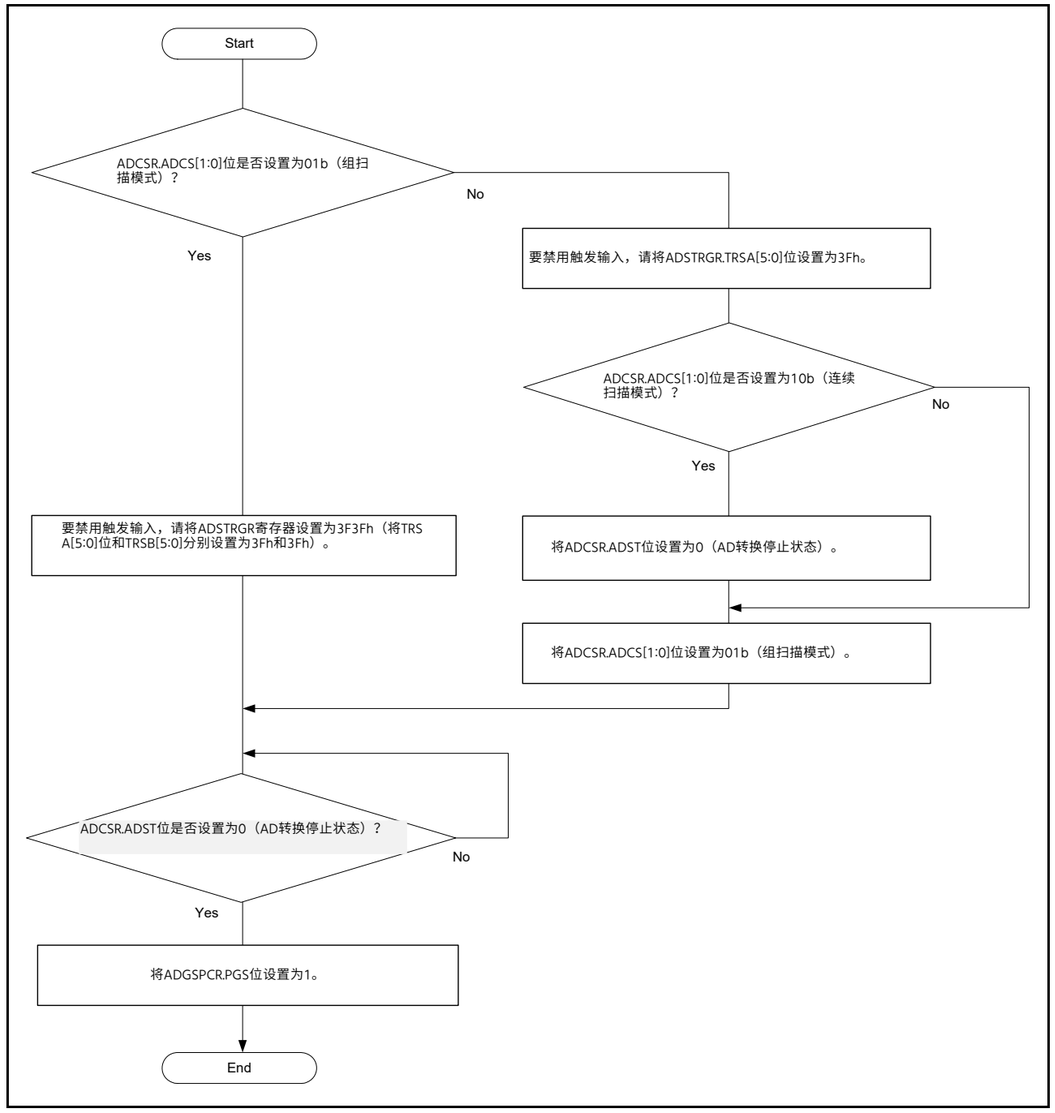

Figure 35.25 ADGSPCR.PGS位设置流程

Table 35.9 根据ADGSPCR.GBRSCN位设置控制AD转换操作

AD转换操作	触发输入	ADGSPCR.GBRSCN = 0	ADGSPCR.GBRSCN = 1
正在进行A组的AD转换时	A组触发器输入	触发器输入无效	触发器输入无效
	B组触发输入	触发器输入无效	B组在组后转换 一次转换完成
正在进行B组的AD转换时	A组触发器输入	B组转换停止，A组转换开始	B组转换停止，A组转换开始 B组转换在A组转换完成后开始
	B组触发输入	触发器输入无效	触发器输入无效

The following example describes the operations in group scan mode under group A priority control (ADGSPCR.GBRSCN = 1 and ADGSPCR.GBRP = 0) when channel 0 is selected for group A and channels 1 to 3 are selected for group B.

The operation is as follows:

1. When input of a trigger for group B sets the ADCSR.ADST bit to 1 (A/D conversion start), conversion for the ANn channels selected in the ADANSB0 and ADANSB1 registers starts in order from the channel with the smallest number n.
2. On completion of A/D conversion, the result is stored in the associated A/D Data Register y (ADDRy).
3. When a group A trigger is input while A/D conversion for group B is in progress, and A/D conversion for group B is discontinued with the ADCSR.ADST bit remaining 1, A/D conversion for the ANn channels selected in the ADANSA0 and ADANSA1 registers starts in order from the channel with the smallest number n. If A/D conversion is not complete when the AD conversion of group B is interrupted, A/D conversion result is not stored in the A/D Data Register (ADDRy).
4. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
5. An ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting).
6. A/D conversion for the ANn channels in group B selected in the ADANSB0 and ADANSB1 registers restarts in order from the channel with the smallest number n with the ADCSR.ADST bit remaining 1.
7. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
8. An ADC12i_GBADI interrupt request is generated if the setting in the ADCSR.GBADIE bit is 1 (ADC12i_GBADI interrupt when group B scanning completion is enabled).
9. The ADCSR.ADST bit is automatically cleared, and the ADC12 enters the wait state when A/D conversion is completed.

以下示例描述了在A组优先级控制（ADGSPCR.GBRSCN=1和ADGSPCR.GBRP=0）下的组扫描模式下，当A组选择通道0，B组选择通道1到3时的操作。

操作如下：

1. 当B组的触发输入将ADCSR.ADST位设置为1（AD转换开始）时，ADANSB0和ADANSB1寄存器中选择的ANn通道的转换从编号n最小的通道开始按顺序开始。
2. 完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
3. 如果在B组的AD转换正在进行时输入A组触发，并且在ADCSR.ADST位保持为1的情况下中断B组的AD转换，则在ADANSA0和ADANSA1寄存器中选择的ANn通道的AD转换按顺序开始从具有最小编号n的通道。如果B组的AD转换中断时AD转换未完成，则AD转换结果不会存储在AD数据寄存器（ADDRy）中。
4. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
5. 产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
6. 在ADANSB0和ADANSB1寄存器中选择的B组ANn通道的AD转换从具有最小编号n的通道开始按顺序重新启动，ADCSR.ADST位保持为1。
7. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
8. 如果ADCSR.GBADIE位中的设置为1（启用B组扫描完成时的ADC12i_GBADI中断），则会产生ADC12i_GBADI中断请求。
9. ADCSR.ADST位自动清零，ADC12在AD转换完成后进入等待状态。

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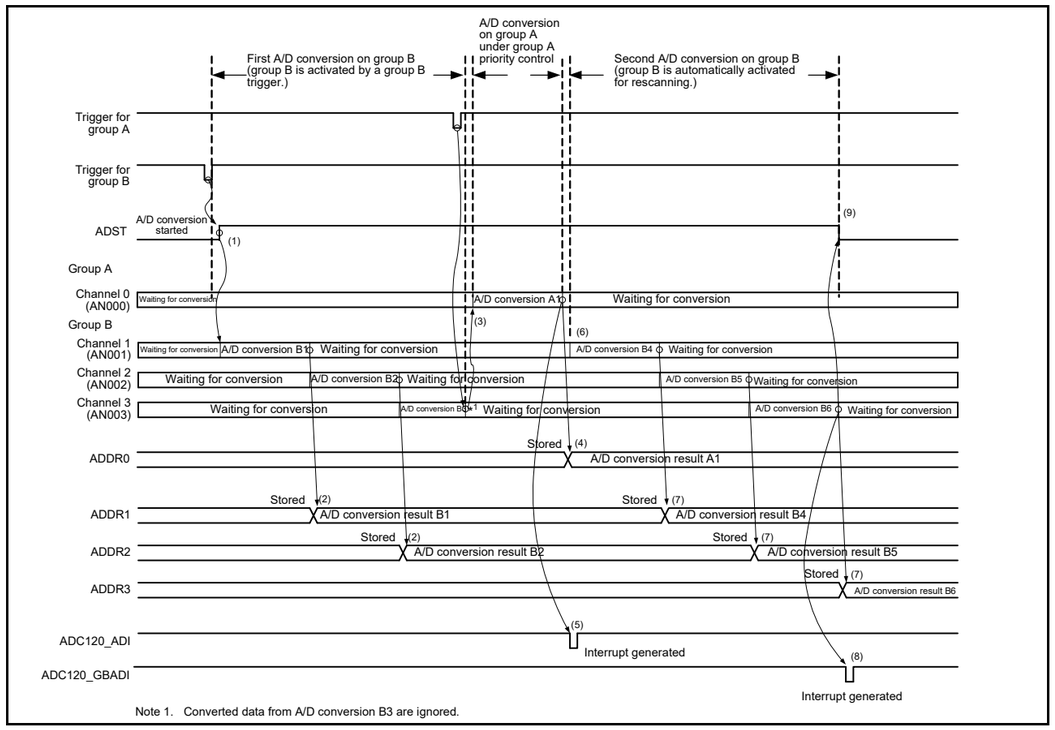


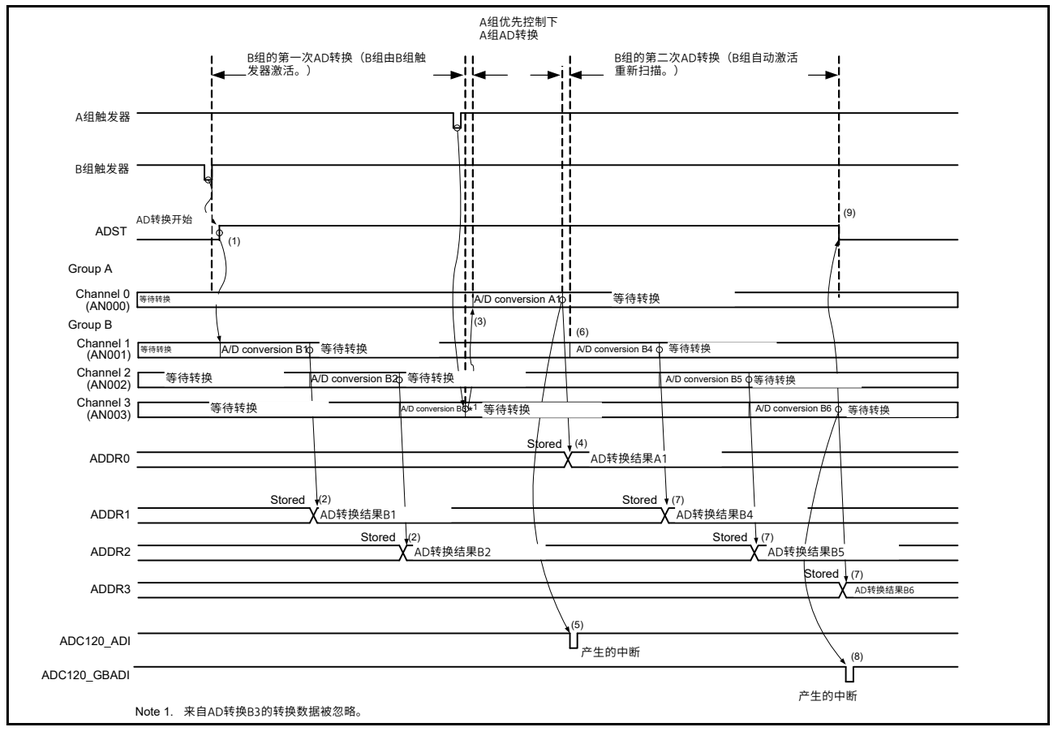
Note 1. Converted data from A/D conversion B3 are ignored.

Figure 35.26 Example of operation with group A priority control (1), when ADGSPCR.GBRSCN = 1 and ADGSPCR.GBRP = 0

This section provides an example of operation when a group A trigger is input again during rescanning operation on group B. In this example, channel 0 is selected for group A and channels 1 to 3 are selected for group B when operation on group A is given priority (ADGSPCR.GBRSCN = 1 and ADGSPCR.GBRP = 0).

The operation is as follows:

1. When a group B trigger input sets the ADCSR.ADST bit to 1 (A/D conversion start), conversion for the ANn channels in group B selected in the ADANSB0 and ADANSB1 registers starts in order from the channel with the smallest number n.
2. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
3. When a group A trigger is input while A/D conversion for group B is in progress, and A/D conversion for group B is discontinued with the ADCSR.ADST bit remaining 1. If A/D conversion is not complete when the AD conversion of group B is interrupted, A/D conversion result is not stored in the A/D Data Register (ADDRy).
4. The A/D conversion for the ANn group A channels selected in the ADANSA0 and ADANSA1 registers starts in order from the channel with the smallest number n.
5. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
6. An ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting).
7. If the ADGSPCR.GBRSCN bit is 1, when the A/D conversion of group A is complete, the ADCSR.ADST bit remains 1 and the group B is rescanned. A/D conversion for the ANn group B channels selected in the ADANSB0 and ADANSB1 registers starts again in order from the channel with the smallest number n.
8. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).



Note 1. 来自AD转换B3的转换数据被忽略。

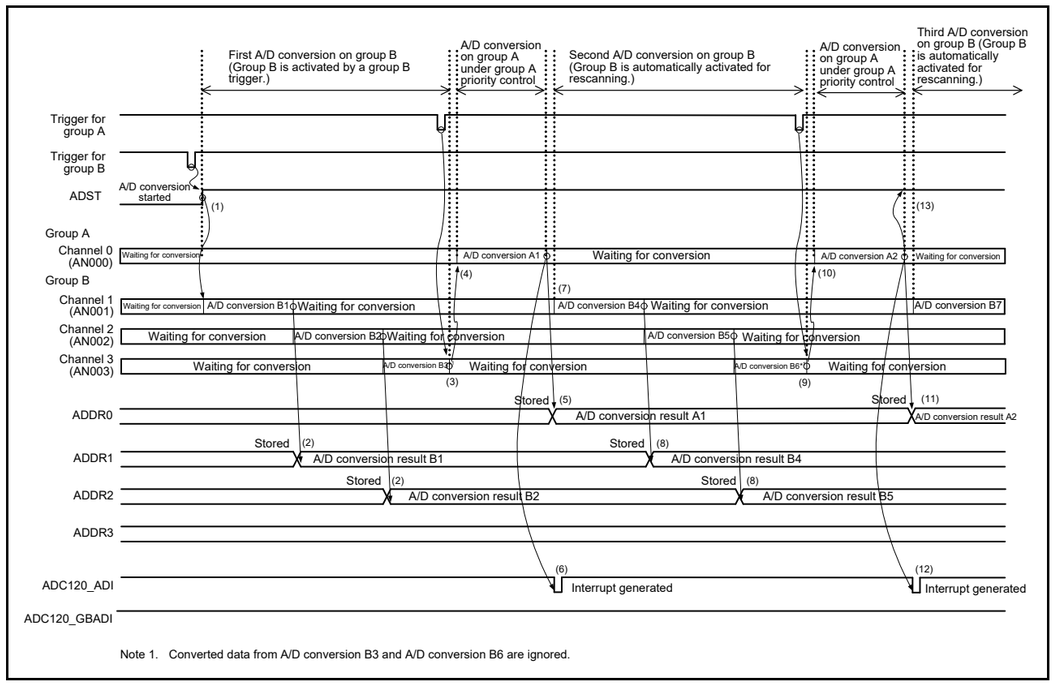
Figure 35.26 使用A组优先级控制(1)的操作示例，当ADGSPCR.GBRSCN=1并且ADGSPCR.GBRP = 0

本节提供在B组重新扫描操作期间再次输入A组触发时的操作示例。在此示例中，当对A组进行操作时，为A组选择通道0，为B组选择通道1至3优先级（ADGSPCR.GBRSCN=1和ADGSPCR.GBRP=0）。

操作如下：

1. 当B组触发输入将ADCSR.ADST位设置为1（AD转换开始）时，ADANSB0和ADANSB1寄存器中选择的B组ANn通道的转换从编号最小的通道开始按顺序开始。
2. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
3. 当B组的AD转换正在进行时输入A组触发，并且B组的AD转换中断且ADCSR.ADST位保持为1。如果B组的AD转换中断时AD转换未完成，AD转换结果不存储在AD数据寄存器(ADDRy)中。
4. 在ADANSA0和ADANSA1寄存器中选择的ANn组A通道的AD转换从编号n最小的通道开始。
5. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
6. 产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
7. 如果ADGSPCR.GBRSCN位为1，则当A组的AD转换完成时，ADCSR.ADST位保持为1，并重新扫描B组。ADANSB0和ADANSB1寄存器中选择的ANnB组通道的AD转换从编号n最小的通道重新开始。
8. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。

9. If a group A trigger is input during A/D conversion on group B for rescanning, the ADCSR.ADST bit remains 1 and the ongoing A/D conversion on group B is discontinued.
10. The A/D conversion for the ANn group A channels selected in the ADANSA0 and ADANSA1 registers starts in order from the channel with the smallest number n.
11. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
12. An ADC12i_ADI interrupt request is generated (no register setting).
13. If the ADGSPCR.GBRSCN bit is 1, when the A/D conversion of group A is complete, the ADCSR.ADST bit remains 1 and the group B is rescanned. A/D conversion for the ANn group B channels selected in the ADANSB0 and ADANSB1 registers starts again in order from the channel with the smallest number n.
14. If a group A trigger is input during A/D conversion on group B for rescanning, steps 9. to 13. are repeated. If a group A trigger is not input, the ADCSR.ADST bit is cleared automatically on completion of A/D conversion on group B, and the ADC12 enters a wait state.



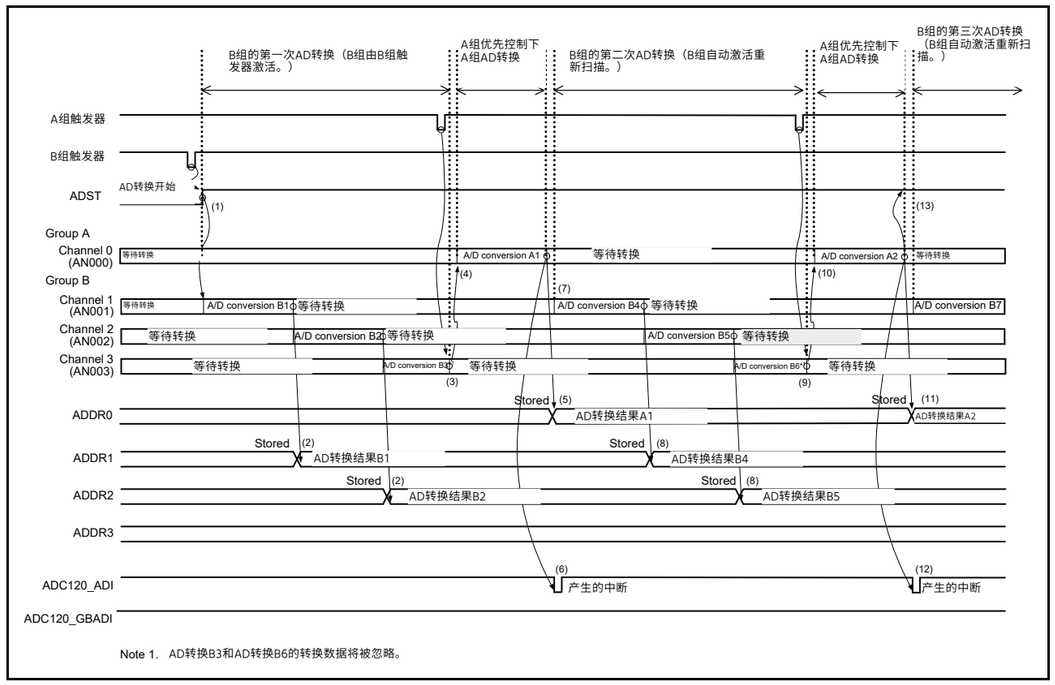
Note 1. Converted data from A/D conversion B3 and A/D conversion B6 are ignored.

Figure 35.27 Example of operation with group A priority control (2), when ADGSPCR.GBRSCN = 1 and ADGSPCR.GBRP = 0

The following sequence is an example of a rescanning operation in which a group B trigger is input during A/D conversion on group A. In this example, channels 1 to 3 are selected for group A and channel 0 is selected for group B when operation on group A is given priority (ADGSPCR.GBRSCN = 1, ADGSPCR.GBRP = 0):

1. When input of a trigger for group A sets the ADCSR.ADST bit to 1 (A/D conversion start), conversion for the ANn channels selected in the ADANSA0 and ADANSA1 registers starts in order from the channel with the smallest number n.
2. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
3. If a group B trigger is input during A/D conversion on group A, A/D conversion on group B can be performed after the A/D conversion on group A completes. However, if group A triggers are input continuously, the scan operation on group B is canceled by group A and is not performed.

9. 如果在B组的AD转换期间输入A组触发以进行重新扫描，则ADCSR.ADST位保持为1，并且停止B组正在进行的AD转换。
10. 在ADANSA0和ADANSA1寄存器中选择的ANn组A通道的AD转换从编号n最小的通道开始。
11. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
12. 产生一个ADC12i_ADI中断请求（无寄存器设置）。
13. 如果ADGSPCR.GBRSCN位为1，当A组AD转换完成时，ADCSR.ADST位保持为1并且B组被重新扫描。ADANSB0和ADANSB1寄存器中选择的ANnB组通道的AD转换从编号n最小的通道重新开始。
14. 如果在B组的AD转换期间输入A组触发以重新扫描，则重复步骤9.至13.。如果没有输入A组触发，ADCSR.ADST位在B组AD转换完成后自动清零，ADC12进入等待状态。



Note 1. AD转换B3和AD转换B6的转换数据将被忽略。

Figure 35.27 使用A组优先级控制(2)的操作示例，当ADGSPCR.GBRSCN=1并且ADGSPCR.GBRP = 0

以下序列是重新扫描操作的示例，其中在A组上进行AD转换期间输入B组触发。在此示例中，为组A选择通道1至3，在组上操作时为组B选择通道0A被赋予优先级（ADGSPCR.GBRSCN=1，ADGSPCR.GBRP=0）：

1. 当A组的触发输入将ADCSR.ADST位设置为1（AD转换开始）时，ADANSA0和ADANSA1寄存器中选择的ANn通道的转换从编号n最小的通道开始按顺序开始。
2. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
3. 如果在A组AD转换期间输入B组触发，则可以在A组AD转换完成后执行B组AD转换。但是，如果连续输入A组触发，则B组的扫描操作被A组取消，不执行。

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4. On completion of the A/D conversion on group A, an ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting).
5. On completion of the group A conversion, the ADCSR.ADST bit remains 1 and the group B is rescanned. Next, A/D conversion for the ANn channels of group B selected in the ADANSB0 and ADANSB1 registers starts in order from the channel with the smallest number n.
6. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
7. On completion of the rescanning operation on group B, an ADC12i_GBADI interrupt request is generated if the setting in the ADCSR.GBADIE bit is 1 (ADC12i_GBADI interrupt when scanning completion is enabled).
8. The ADCSR.ADST bit is automatically cleared and the ADC12 enters the wait state when A/D conversion is complete.

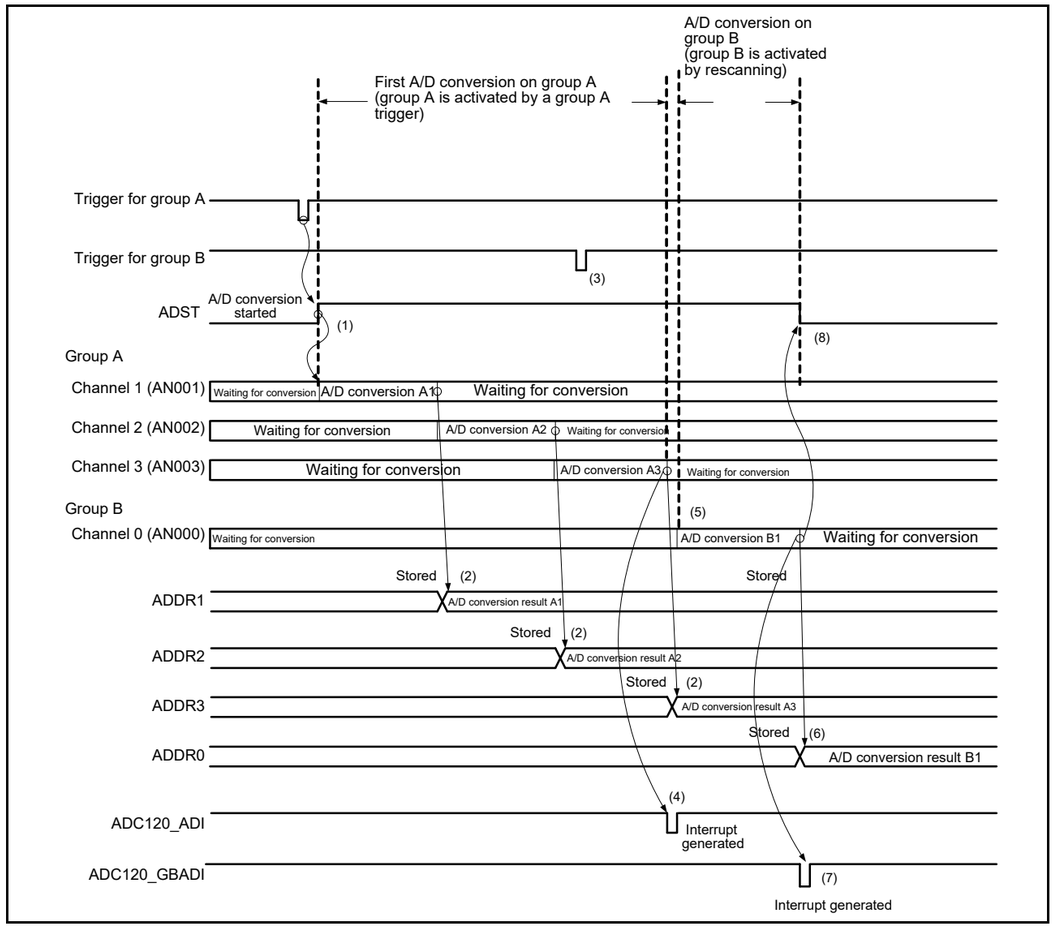

Figure 35.28 Example of operation with group A priority control (3), when ADGSPCR.GBRSCN = 1 and ADGSPCR.GBRP = 0

The following sequence is an example of operation under group A priority control in which channel 0 is selected for group A and channels 1 to 3 are selected for group B (ADGSPCR.GBRSCN = 0, ADGSPCR.GBRP = 0):

1. When input of a trigger for group B sets the ADCSR.ADST bit to 1 (A/D conversion start), conversion for the ANn channels selected in the ADANSB0 and ADANSB1 registers starts in order from the channel with the smallest number n.

4. 完成A组的AD转换后，会产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
5. 完成A组转换后，ADCSR.ADST位保持为1，并重新扫描B组。下一个，ADANSB0和ADANSB1寄存器中选择的B组ANn通道的AD转换从编号n最小的通道开始。
6. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
7. 完成对B组的重新扫描操作后，如果ADCSR.GBADIE位中的设置为1（使能扫描完成时的ADC12i_GBADI中断），则会产生ADC12i_GBADI中断请求。
8. ADCSR.ADST位自动清零，ADC12在AD转换完成后进入等待状态。

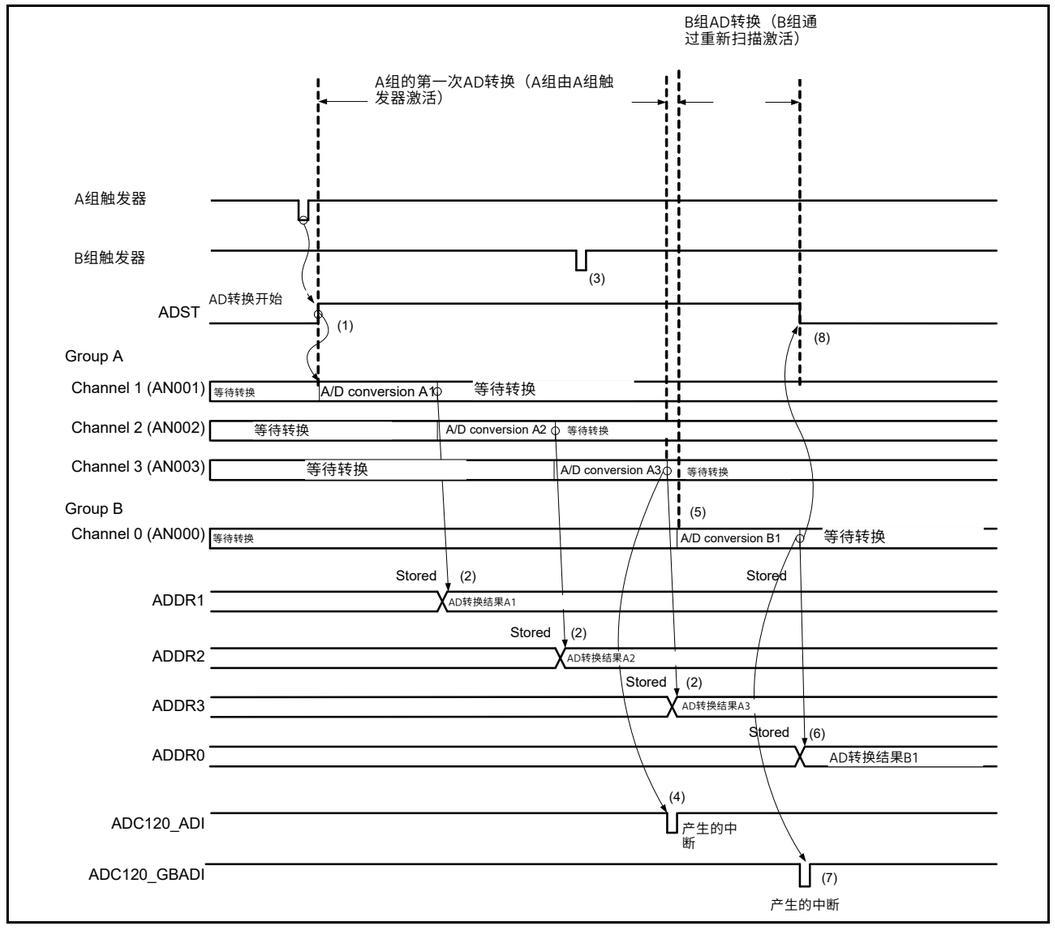

Figure 35.28 当ADGSPCR.GBRSCN=1且A组优先级控制(3)的操作示例 ADGSPCR.GBRP = 0

以下序列是A组优先级控制下的操作示例，其中为A组选择通道0，为B组选择通道1至3（ADGSPCR.GBRSCN =0，ADGSPCR.GBRP=0）：

1. 当B组的触发输入将ADCSR.ADST位设置为1（AD转换开始）时，ADANSB0和ADANSB1寄存器中选择的ANn通道的转换从编号n最小的通道开始按顺序开始。

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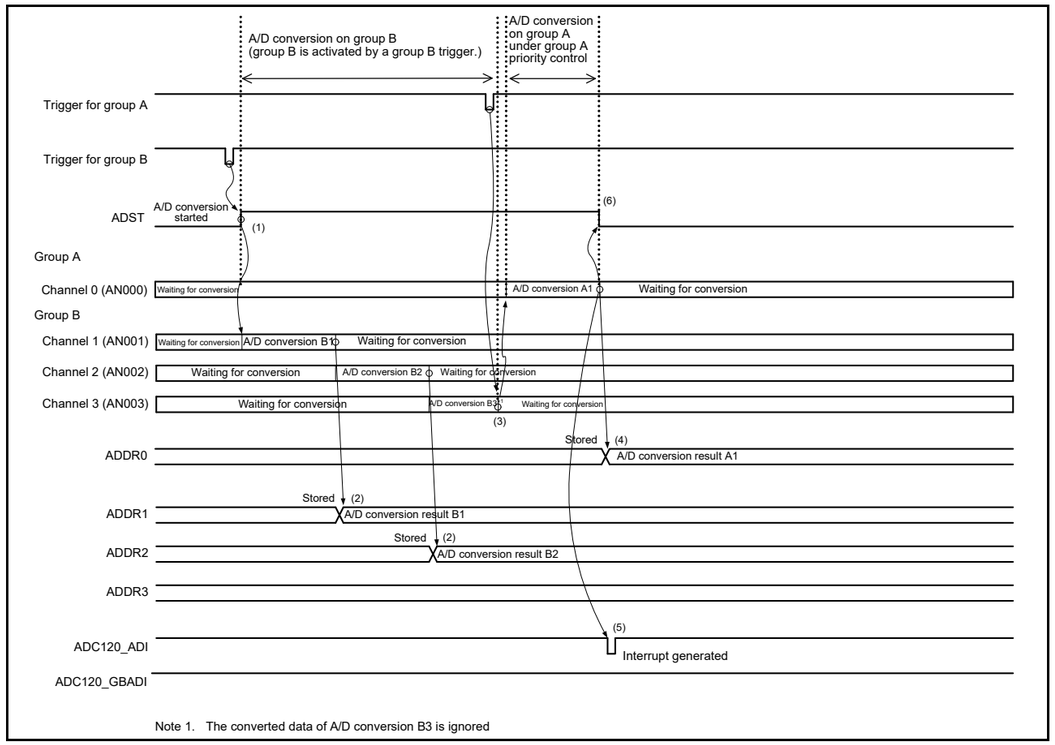
2. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
3. If a group A trigger is input while A/D conversion for group B is in progress, and A/D conversion for group B is discontinued with the ADCSR.ADST bit remaining 1, A/D conversion for the ANn channels selected in the ADANSA0 and ADANSA1 registers starts in order from the channel with the smallest number n.
4. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
5. An ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting).
6. The ADCSR.ADST bit is automatically cleared and ADC12 enters the wait state when A/D conversion is complete.



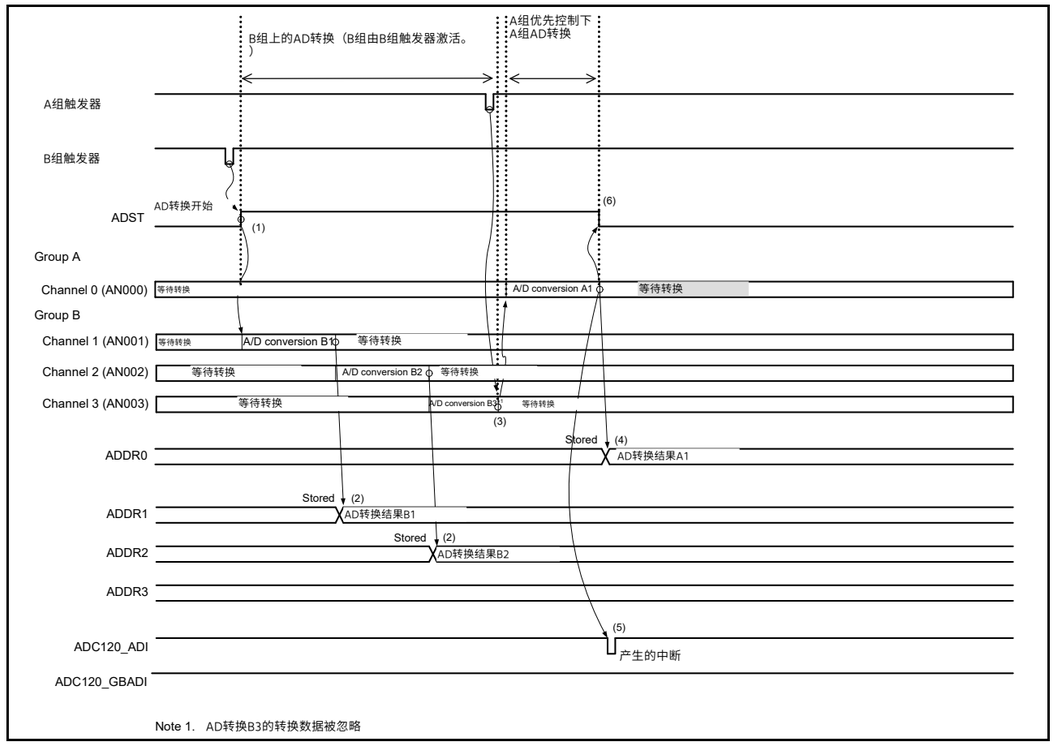
Note 1. The converted data of A/D conversion B3 is ignored

Figure 35.29 Example of operation with group A priority control (4), when ADGSPCR.GBRSCN = 0 and ADGSPCR.GBRP = 0

The following sequence is an example of operation under group A priority control in which channel 0 is selected for group A and channels 1 to 3 are selected for group B (ADGSPCR.GBRP = 1):

1. The ADCSR.ADST bit is set to 1 (A/D conversion start) when ADGSPCR.GBRP is set to 1, and conversion for the ANn channels selected in the ADANSB0 and ADANSB1 registers starts in order from the channel with the smallest number n.
2. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
3. If a group A trigger is input while A/D conversion for group B is in progress, and A/D conversion for group B is discontinued with the ADCSR.ADST bit remaining 1, A/D conversion for the ANn channels selected in the ADANSA0 and ADANSA1 registers starts in order from the channel with the smallest number n.
4. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).

2. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
3. 如果在B组的AD转换正在进行时输入A组触发，并且B组的AD转换中断且ADCSR.ADST位保持为1，则在ADANSA0和ADANSA1寄存器中选择的ANn通道的AD转换按顺序开始从具有最小编号n的通道。
4. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
5. 产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
6. 当AD转换完成时，ADCSR.ADST位自动清零，ADC12进入等待状态。



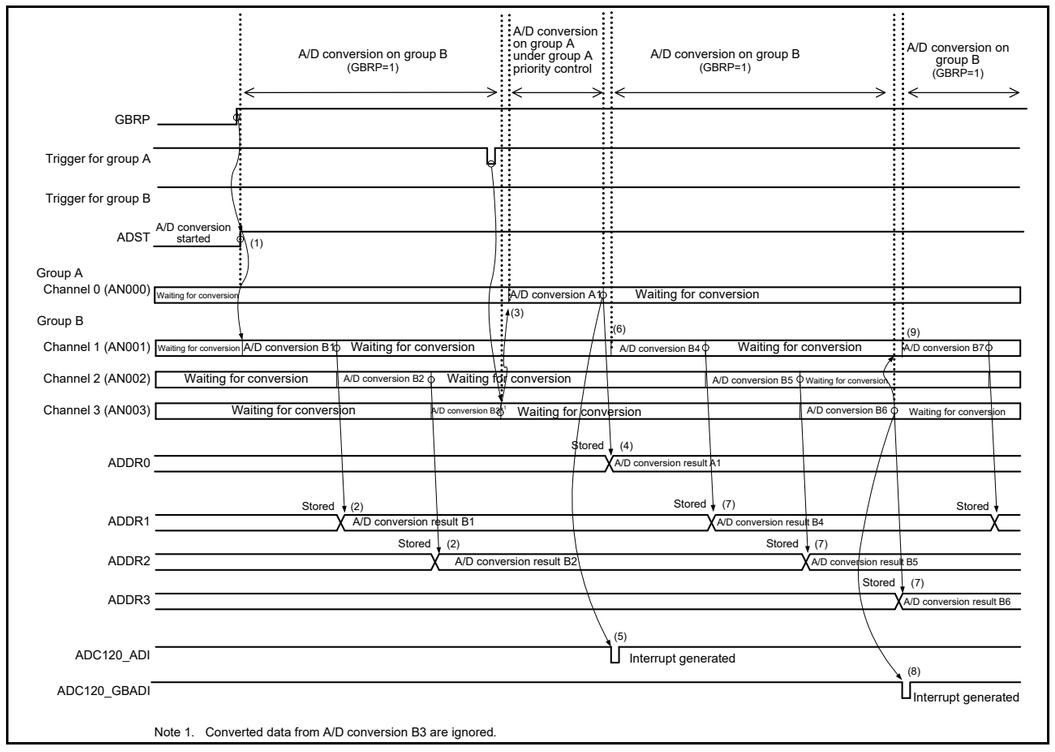
Note 1. AD转换B3的转换数据被忽略

Figure 35.29 使用A组优先级控制(4)的操作示例，当ADGSPCR.GBRSCN=0且ADGSPCR.GBRP = 0

以下序列是A组优先级控制下的操作示例，其中为A组选择通道0，为B组选择通道1到3(ADGSPCR.GBRP=1)：

1. 当ADGSPCR.GBRP设置为1时，ADCSR.ADST位设置为1（AD转换开始），并且ADANSB0和ADANSB1寄存器中选择的ANn通道的转换从编号最小的通道开始按顺序开始。
2. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
3. 如果在B组的AD转换正在进行时输入A组触发，并且B组的AD转换中断且ADCSR.ADST位保持为1，则在ADANSA0和ADANSA1寄存器中选择的ANn通道的AD转换按顺序开始从具有最小编号n的通道。
4. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。

5. An ADC12i_ADI (i = 0, 1) interrupt request is generated (no register setting).
6. A/D conversion for the ANn channels in group B selected in the ADANSB0 and ADANSB1 registers restarts in order from the channel with the smallest number n, with the ADCSR.ADST bit remaining 1.
7. On completion of A/D conversion on a single channel, the result is stored in the associated A/D Data Register y (ADDRy).
8. An ADC12i_GBADI interrupt request is generated if the setting in the ADCSR.GBADIE bit is 1.
9. A/D conversion for the ANn channels selected in the ADANSB0 and ADANSB1 registers starts in order from the channel with the smallest number n. Steps 6. to 9. are repeated as long as the ADGSPCR.GBRP bit remains 1. Clearing of the ADCSR.ADST bit to 0 is prohibited while the ADGSPCR.GBRP bit is set to 1. Follow the procedure shown in Figure 35.40 for clearing the ADCSR.ADST bit operation through software, to force A/D conversion to stop while ADGSPCR.GBRP = 1.



Note 1. Converted data from A/D conversion B3 are ignored.

Figure 35.30 Example of operation with group A priority control (5), when ADGSPCR.GBRP = 1

35.3.5 Compare Function for Windows A and B

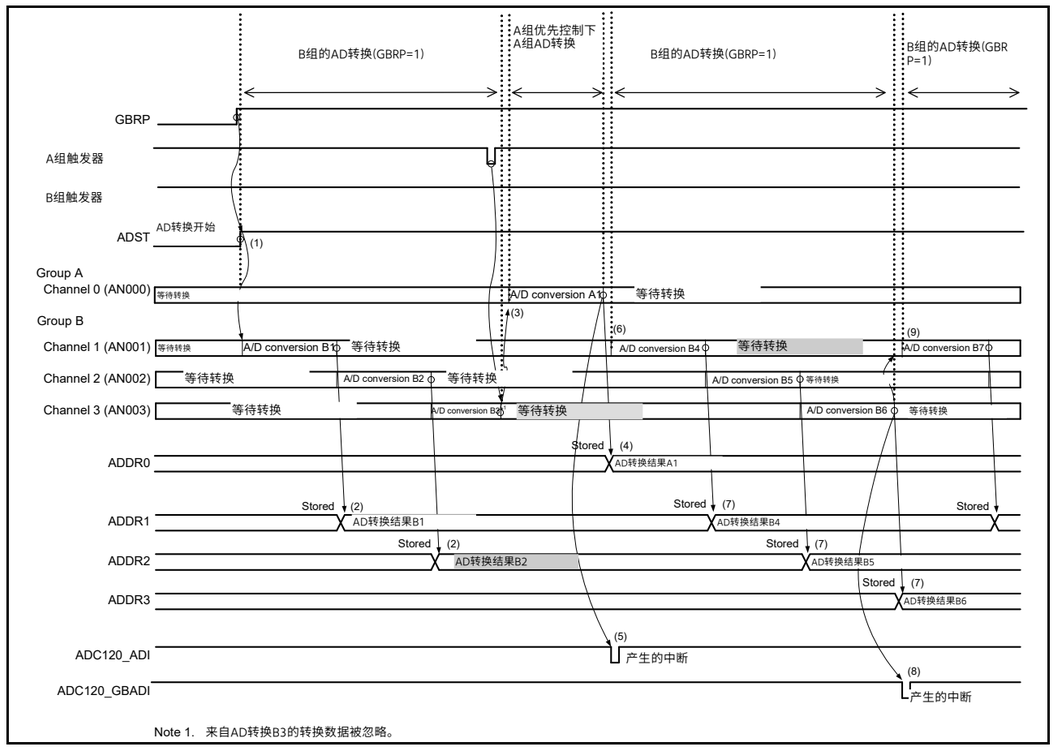
35.3.5.1 Compare function

The compare function compares a reference value with the A/D conversion result. The reference value can be set for window A and window B independently. When the compare function is in use, the self-diagnosis function and double trigger mode cannot be used. The main differences between window A and window B are their different interrupt output signals and the constraint on window B of only one selectable channel.

The following sequence is an example of operation that combines continuous scan mode and the compare function:

1. When the ADCSR.ADST bit is set to 1 (A/D conversion start) by software, a synchronous trigger (ELC) or an asynchronous trigger, A/D conversion starts for the selected channels, temperature sensor, and internal reference voltage.

5. 产生一个ADC12i_ADI(i=0 1)中断请求（无寄存器设置）。
6. ADANSB0和ADANSB1寄存器中选择的B组ANn通道的AD转换从编号n最小的通道开始按顺序重新启动，ADCSR.ADST位保持为1。
7. 在单个通道上完成AD转换后，结果将存储在相关的AD数据寄存器y(ADDRy)中。
8. 如果ADCSR.GBADIE位中的设置为1，则会产生ADC12i_GBADI中断请求。
9. ADANSB0和ADANSB1寄存器中选择的ANn通道的D转换从编号n最小的通道开始按顺序开始。只要ADGSPCR.GBRP位保持为1，就重复步骤6到9。当ADGSPCR.GBRP位设置为1时，禁止将ADCSR.ADST位清除为0。按照图35.40中所示的过程进行清除通过软件对ADCSR.ADST位进行操作，在ADGSPCR.GBRP=1时强制停止AD转换。



Note 1. 来自AD转换B3的转换数据被忽略。

Figure 35.30 当ADGSPCR.GBRP=1时，A组优先级控制(5)的操作示例

35.3.5 比较WindowsA和B的函数

35.3.5.1 比较功能

比较功能将参考值与AD转换结果进行比较。可以分别为窗口A和窗口B设置参考值。使用比较功能时，不能使用自诊断功能和双触发模式。窗口A和窗口B的主要区别在于它们不同的中断输出信号以及对窗口B的限制只有一个可选通道。

以下序列是结合连续扫描模式和比较功能的操作示例：

1. 当ADCSR.ADST位通过软件、同步触发(ELC)或异步触发设置为1（AD转换开始）时，所选通道、温度传感器和内部参考电压的AD转换开始。

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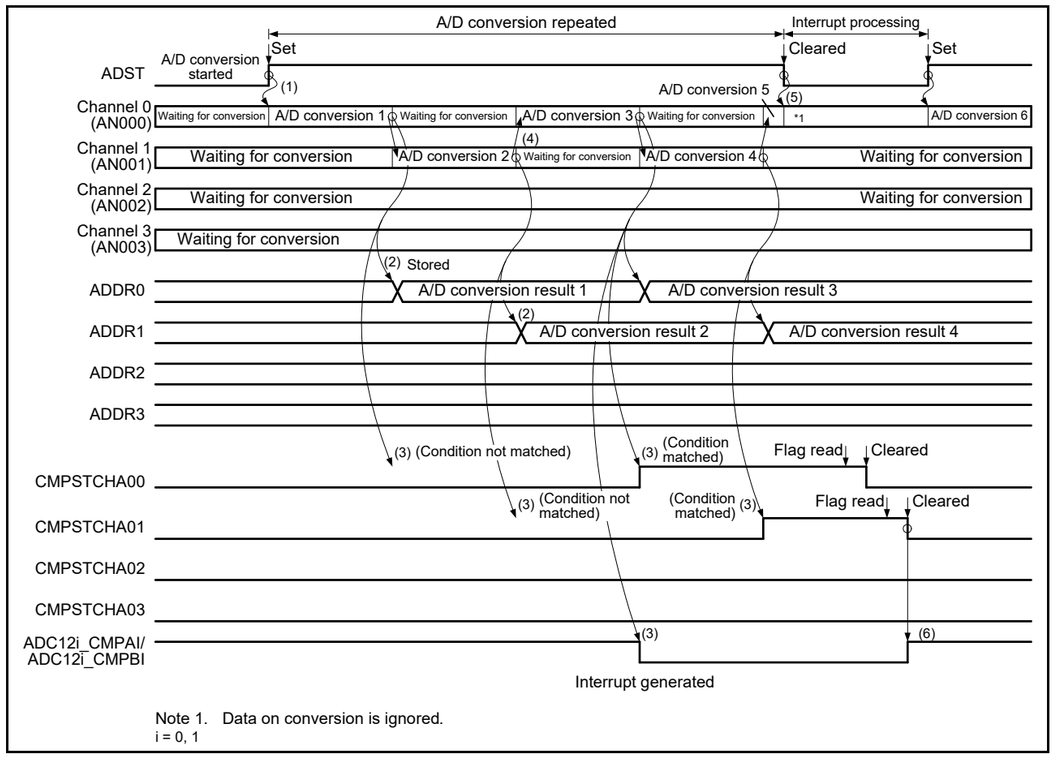
2. On completion of A/D conversion, the A/D conversion result is stored in the associated A/D Data Register y (ADDRy, ADTSDR, or ADOCDR). When ADCMPCR.CMPAE = 1, if bits in the ADCMPANSRy register or the ADCMPANSER register are set for window A, the A/D conversion result is compared with the set ADCMPDR0/1 register value. When ADCMPCR.CMPBE = 1, if bits in the ADCMPBNSR register are set for window B, the A/D conversion result is compared with the ADWINULB/ADWINLLB register setting.
3. As a result of the comparison, when window A meets the condition set in ADCMPLR0/1 or ADCMPLER, the Compare Window A Flag (ADCMPSR0.CMPSTCHA0n, ADCMPSR1.CMPSTCHA1n, ADCMPSER.CMPSTTSA, or ADCMPSER.CMPSTOCA) is set to 1. At this time, if the ADCMPCR.CMPAIE bit is 1, an ADC12i_CMPAI (i = 0, 1) interrupt request is generated. In the same way, when window B meets the condition set in ADCMPBNSR.CMPLB, the Compare Window B Flag (ADCMPBSR.CMPSTB) is set to 1. At this time, if the ADCMPCR.CMPBIE bit is 1, an ADC12i_CMPBI interrupt request is generated.
4. On completion of all selected A/D conversions and comparisons, scan restarts.
5. After the ADC12i_CMPAI and ADC12i_CMPBI interrupts are accepted, the ADCSR.ADST bit is set to 0 (A/D conversion stop) and processing is performed for channels for which the compare flag is set to 1.
6. When all compare flags of window A are cleared, the ADC12i_CMPAI interrupt request is canceled. Similarly, when all compare flags of window B are cleared, the ADC12i_CMPBI interrupt request is reset. To perform comparison again, restart the A/D conversion.



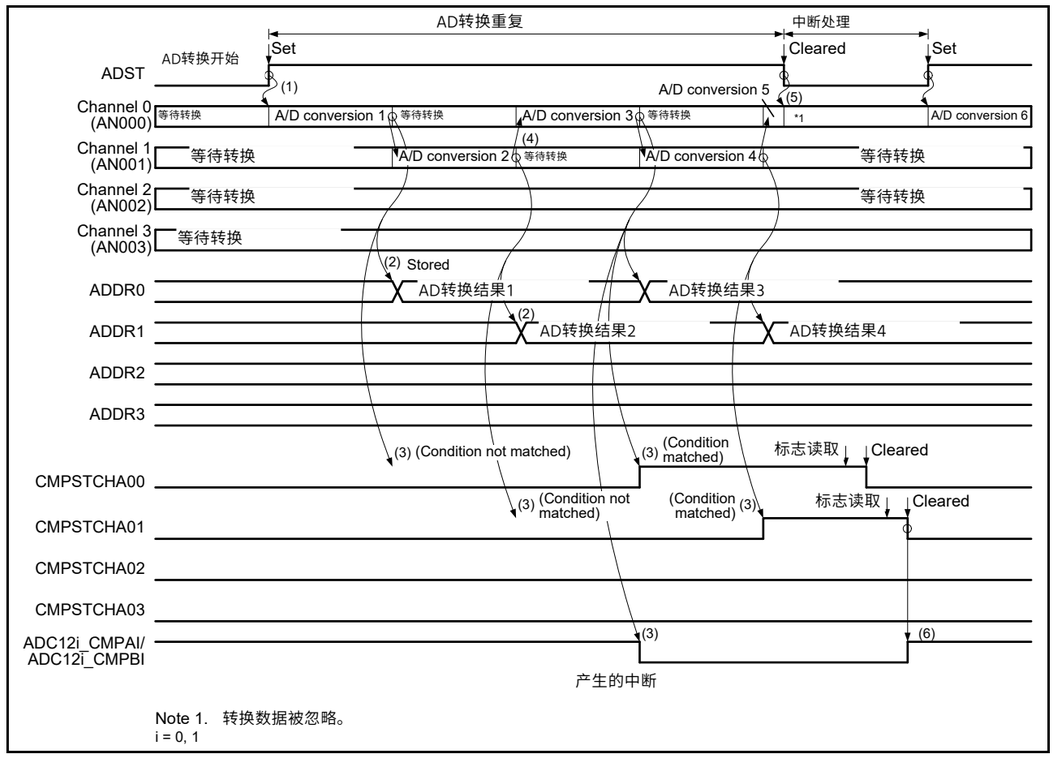
Note 1. Data on conversion is ignored.
i = 0, 1

Figure 35.31 Example of compare function operation, when AN000 to AN003 are compared

35.3.5.2 Event output of compare function

Event output of the compare function specifies the upper reference voltage value for window A and the lower reference voltage value for window B, compares the A/D-converted value of the selected channel with the upper and lower reference voltage values, and then outputs the ADC12i_WCMPM and ADC12i_WCMPUM (i = 0, 1) events based on the event conditions (A OR B, A AND B, A XOR B) and comparison results of window A and window B.

2. 完成AD转换后，AD转换结果存储在相关的AD数据寄存器y（ADDRy、ADTSDR或ADOCDR）中。当ADCMPCR.CMPAE=1时，如果ADCMPANSRy寄存器或ADCMPANSER寄存器中的位为窗口A设置，则AD转换结果与设置的ADCMPDR01寄存器值进行比较。当ADCMPCR.CMPBE=1时，如果ADCMPBNSR寄存器中的位为窗口B设置，则将AD转换结果与ADWINULBADWINLLB寄存器设置进行比较。
3. 作为比较的结果，当窗口A满足ADCMPLR01或ADCMPLER中设置的条件时，比较窗口A标志（ADCMPSR0.CMPSTCHA0n、ADCMPSR1.CMPSTCHA1n、ADCMPSER.CMPSTTSA，或ADCMPSER.CMPSTOCA)设置为1。此时，如果ADCMPCR.CMPAIE位为1，则产生ADC12i_CMPAI(i=0 1)中断请求。同理，当窗口B满足ADCMPBNSR.CMPLB中设置的条件时，比较窗口B标志（ADCMPBSR.CMPSTB）设置为1。此时，如果ADCMPCR.CMPBIE位为1，则产生ADC12i_CMPBI中断请求生成。
4. 完成所有选定的AD转换和比较后，扫描重新开始。
5. 接受ADC12i_CMPAI和ADC12i_CMPBI中断后，ADCSR.ADST位设置为0（AD转换停止），并对比较标志设置为1的通道执行处理。
6. 当窗口A的所有比较标志被清除时，ADC12i_CMPAI中断请求被取消。同样，当窗口B的所有比较标志都被清除时，ADC12i_CMPBI中断请求被复位。要再次进行比较，请重新开始AD转换。



Note 1. 转换数据被忽略。
i = 0, 1

Figure 35.31 比较功能操作示例，当比较AN000和AN003时

35.3.5.2 比较函数的事件输出

比较函数的事件输出指定窗口A的参考电压上限和窗口B的参考电压下限，将所选通道的AD转换值与上下参考电压值进行比较，然后输出ADC12i_WCMPM和ADC12i_WCMPUM(i=0 1)事件基于事件条件（AORB、AANDB、AXORB）和窗口A和窗口B的比较结果。

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If more than one channel is selected for window A, and even one channel in window A meets the comparison condition, the comparison result of window A is met. When using this function, perform A/D conversion in single scan mode. Any channels from AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020 (unit 0), and AN100 to AN102, AN105 to AN107, AN116, AN117 (unit 1), internal reference voltage, and temperature sensor output are selectable for window A.

The following sequence is an example of how to set up and use the event output of the compare function:

1. Confirm that the value in the ADCSR.ADCS bits is 00b (single scan mode).
2. Select the channel for window A in ADCMPANSR0/1 and ADCMPANSER. Set window comparison conditions in the ADCMPLR0/1 and ADCMPLER registers. Set the upper and lower reference values in the ADCMPDR0 and ADCMPDR1 registers.
3. Select the channel and comparison conditions for window B in the ADCMPBNSR register, and set the upper and lower reference values in the ADWINULB and ADWINLLB registers.
4. Set composite conditions for window A/B, window A/B operation enable, and interrupt output enable in ADCMPCR.

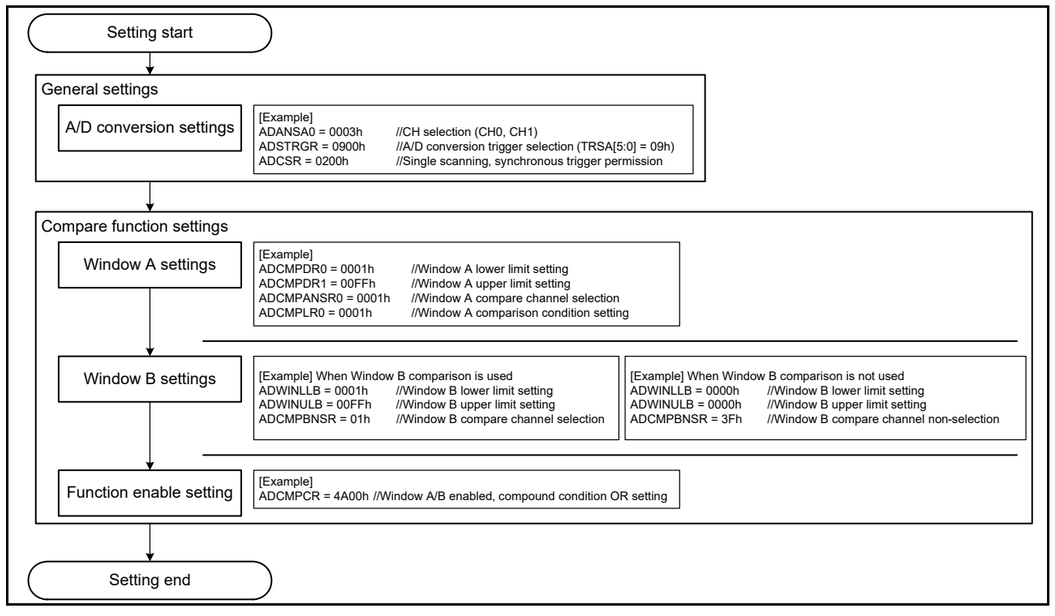

Figure 35.32 Setting example when using the event output of the compare function

Notes on the event output usage when using only window A for the compare function:

- Enable both window A and window B (ADCMPCR.CMPAE = 1, ADCMPCR.CMPBE = 1)
- Set the compound condition of window A and window B to "OR condition" (ADCMPCR.CMPAB[1:0] = 00b)
- Set the compared channel of window B to "Do not select" (ADCMPBNSR.CMPCHB[5:0] = 111111b)
- Set the compare condition of window B to "0 < results < 0 always means mismatch" (ADCMPCR.WCMPE = 1, ADWINLLB.CMPLLB[15:0] = ADWINULB.CMPULB[15:0] = 0000h, and ADCMPBNSR.CMPLB = 1).

Figure 35.33 shows the event output operation example of compare function.

A scan end event (ADC12i_ADI) is output with the same timing of one time single scan completion. A match or mismatch event (ADC12i_WCMPM or ADC12i_WCMPUM) is output delayed by 1 PCLKB depending on ADCMPCR.CMPAB[1:0] settings.

Note: The match and mismatch events are exclusive, so both events are never output simultaneously.

如果为窗口A选择了多个通道，即使窗口A中的一个通道满足比较条件，也满足窗口A的比较结果。使用此功能时，请在单次扫描模式下进行AD转换。从AN000到AN003、AN005到AN007、AN016到AN018、AN020（单元0）和AN100到AN102、AN105到AN107、AN116、AN117（单元1）的任何通道、内部参考电压和温度传感器输出均可用于窗口一个。

以下序列是如何设置和使用比较函数的事件输出的示例：

1. 确认ADCSR.ADCS位中的值为00b（单次扫描模式）。
2. 在ADCMPANSR01和ADCMPANSER中选择窗口A的通道。在ADCMPLR01和ADCMPLER寄存器中设置窗口比较条件。在ADCMPDR0和ADCMPDR1寄存器中设置参考值上限和下限。
3. 在ADCMPBNSR寄存器中选择窗口B的通道和比较条件，并在ADWINULB和ADWINLLB寄存器中设置上下参考值。
4. 设置窗口AB、窗口AB操作使能和中断输出使能的复合条件
ADCMPCR.

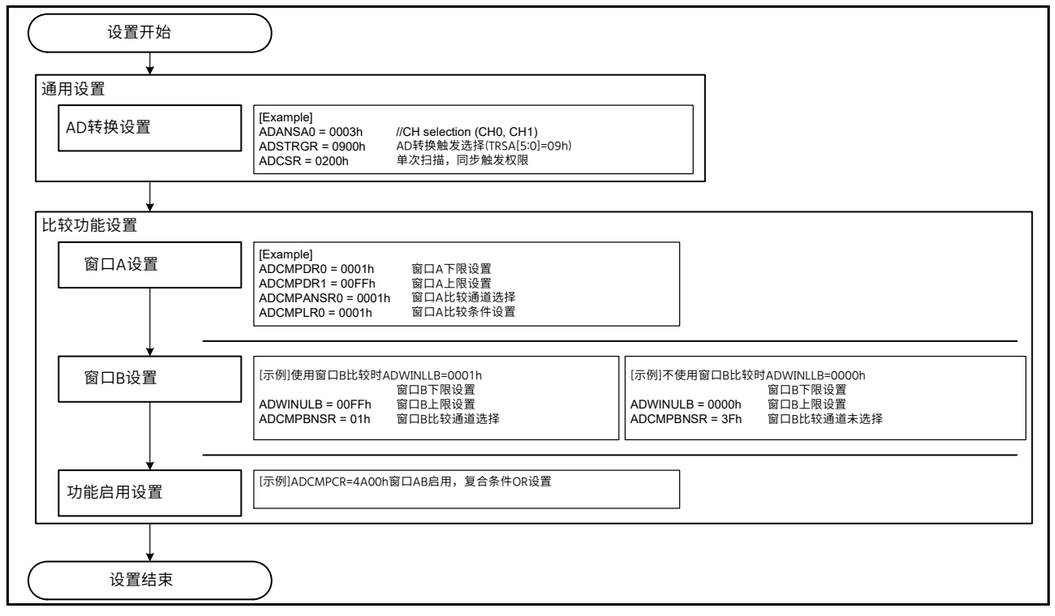

Figure 35.32 使用比较功能的事件输出时的设置示例

仅使用窗口A进行比较功能时的事件输出使用注意事项：

- 启用窗口A和窗口B(ADCMPCR.CMPAE=1 ADCMPCR.CMPBE=1)
- 将窗口A和窗口B的复合条件设置为"或条件"（ADCMPCR.CMPAB[1:0]=00b）
- 将窗口B的比较通道设置为"不选择"（ADCMPBNSR.CMPCHB[5:0]=111111b）
- 将窗口B的比较条件设置为"0<结果<0始终表示不匹配"（ADCMPCR.WCMPE=1，ADWINLLB.CMPLLB[15:0] = ADWINULB.CMPULB[15:0] = 0000h, and ADCMPBNSR.CMPLB = 1).

图35.33显示了比较功能的事件输出操作示例。

扫描结束事件(ADC12i_ADI)以与一次单次扫描完成相同的时序输出。匹配或不匹配事件（ADC12i_WCMPM或ADC12i_WCMPUM）输出延迟1个PCLKB，具体取决于ADCMPCR.CMPAB[1:0]设置。

Note: match和mismatch事件是互斥的，因此这两个事件永远不会同时输出。

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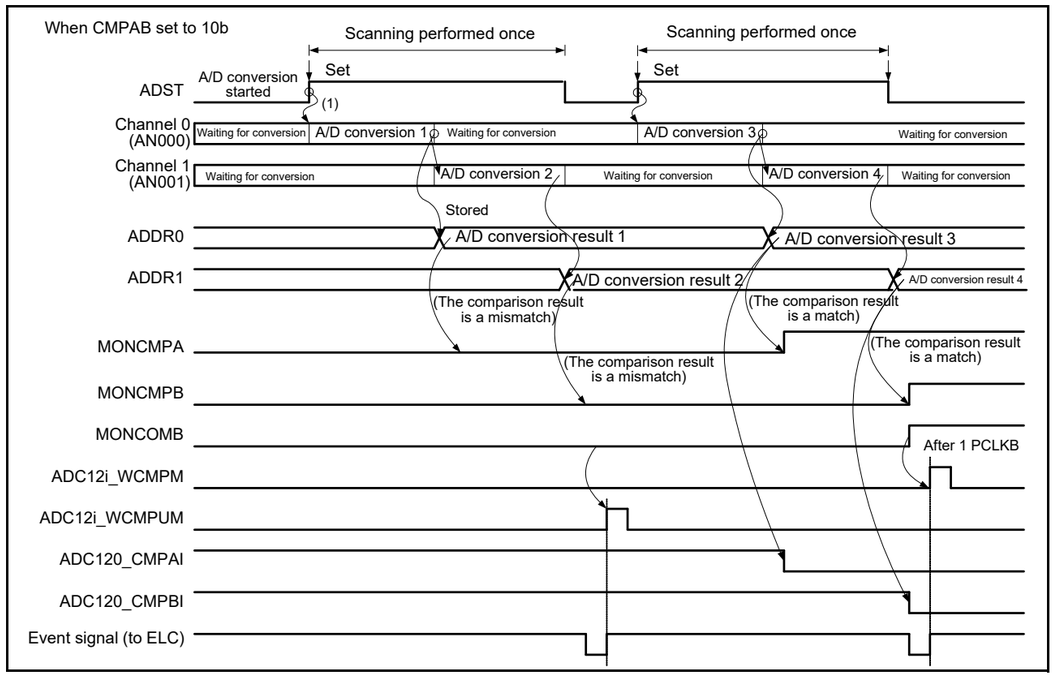


Figure 35.33 Example of the compare function event output when AN000 to AN001 are compared

Note 1. Event output of compare function outputs match/mismatch from the comparison results of window A and window B, based on the ADCMPCR.CMPAB[1:0] settings.

Note 2. The comparison result of window A is the logical addition of the comparison results of the comparison target channels of window A. The comparison results of window A and window B are updated by each A/D conversion, and are kept even when single scan ends. Set ADCMPCR.CMPAE and ADCMPCR.CMPBE to 0 to clear the comparison results to 0.

35.3.5.3 Constraints on the compare function

The following constraints apply for the compare function:

- The compare function cannot be used together with the self-diagnosis function or double trigger mode (the compare function is not available for ADRD, ADDBLDR, ADDBLDRA, and ADDBLDRB)
- Specify single scan mode when using match/mismatch event outputs
- When the temperature sensor output or internal reference voltage is selected for window A, and window B operations are disabled
- When the temperature sensor output or internal reference voltage is selected for window B, and window A operations are disabled
- Setting the same channel for window A and window B is prohibited
- Set the reference voltage values so that the high-potential reference voltage value is equal to or larger than the low-potential reference voltage value.

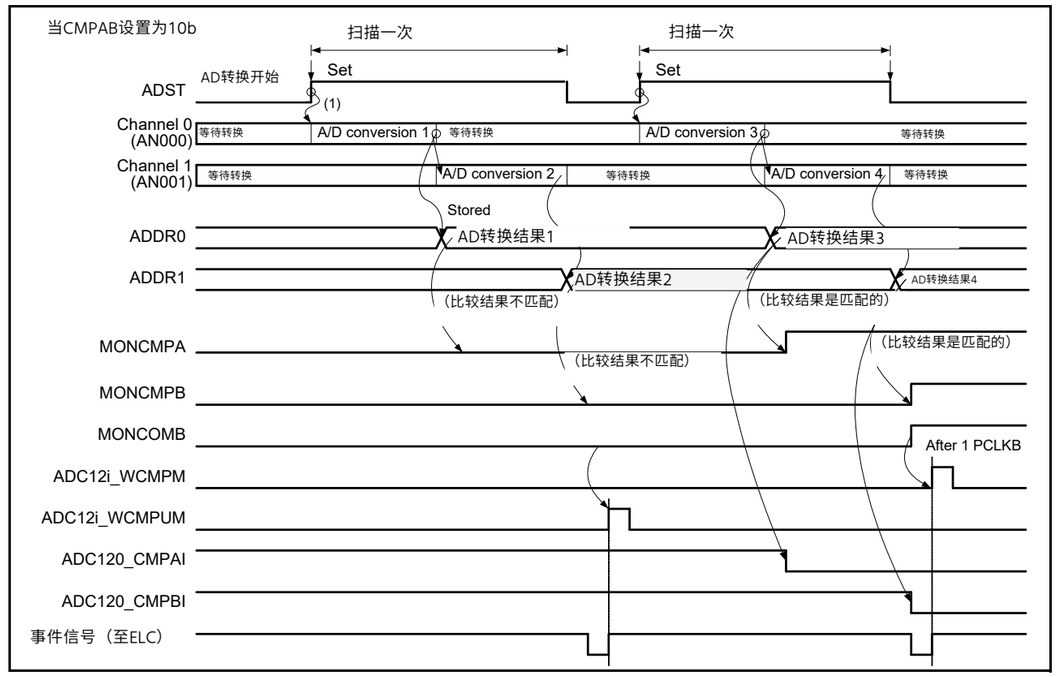


Figure 35.33 比较AN000和AN001时的比较功能事件输出示例

注1.比较函数输出的事件输出matchmismatch来自窗口A和窗口的比较结果
B、基于ADCMPCR.CMPAB[1:0]设置。

注2.窗口A的比较结果是比较对象的比较结果的逻辑相加
窗口A的通道。窗口A和窗口B的比较结果在每次AD转换时更新，即使在单次扫描结束时也保持不变。将ADCMPCR.CMPAE和ADCMPCR.CMPBE设置为0，将比较结果清除为0。

35.3.5.3 比较函数的约束

以下约束适用于比较功能：

- 比较功能不能与自诊断功能或双触发模式一起使用（比较功能不适用于ADRD、ADDBLDR、ADDBLDRA和ADDBLDRB）
- 使用匹配不匹配事件输出时指定单次扫描模式
- 当窗口A选择温度传感器输出或内部参考电压时，窗口B操作被禁用
- 当窗口B选择温度传感器输出或内部参考电压时，窗口A操作被禁用
- 禁止将窗口A和窗口B设置为同一通道
- 设置参考电压值，使高电位参考电压值等于或大于低电位参考电压值。

35.3.6 Analog Input Sampling and Scan Conversion Time

Scan conversion can be activated by a software trigger, a synchronous trigger (ELC), or an asynchronous trigger (ADTRGn). After the start-of-scanning-delay (t_D) elapses, processing by the channel-dedicated sample-and-hold circuits, processing for disconnection detection assistance, and processing of conversion for self-diagnosis all proceed, followed by processing for A/D conversion.

Figure 35.34 shows the scan conversion timing, in which scan conversion is activated by a software trigger or a synchronous trigger (ELC). Figure 35.35 shows the scan conversion timing, in which scan conversion is activated by an asynchronous trigger, ADTRGn. The scan conversion time (t_{SCAN}) includes the start-of-scanning-delay (t_D), channel-dedicated sample-and-hold circuit processing time (t_{SPLSH}),*1 disconnection detection assistance processing time (t_{DIS}),*2 self-diagnosis A/D conversion processing time (t_{DIAG}),*3 A/D conversion processing time (t_{CONV} and t_{DSD}), channel-dedicated sample-and-hold circuit end time (t_{SHED}),*4 and end-of-scanning-delay (t_{ED}).

The A/D conversion processing time (t_{CONV}) consists of the input sampling time (t_{SPL}) and time for conversion by successive approximation (t_{SAM}). The sampling time (t_{SPL}) is used to charge sample-and-hold circuits in the ADC12. If there is not sufficient sampling time because of the high impedance of an analog input signal source, or if the A/D conversion clock (ADCLK) is slow, sampling time can be adjusted using the ADSSTR register.

The time for conversion by successive approximation (t_{SAM}) is 13 ADCLK states with 12-bit accuracy selected, 11 ADCLK states with 10-bit accuracy selected, and 9 ADCLK states with 8-bit accuracy selected.

The scan conversion time (t_{SCAN}) in single scan mode for which the number of selected channels is n can be determined as follows:

$$t_{SCAN} = t_D + t_{SPLSH} + (t_{DIS} \times n) + t_{DIAG} + (t_{CONV} \times n)\ *5 + t_{ED}$$

The scan conversion time for the first cycle in continuous scan mode is t_{SCAN} for single scan minus t_{ED} plus t_{SHED}.

The scan conversion time for the second and subsequent cycles in continuous scan mode is fixed at $t_{SPLSH} + (t_{DIS} \times n) + t_{DIAG} + t_{DSD} + (t_{CONV} \times n)\ *5 + t_{SHED}$.

Note 1. When no channel-dedicated sample-and-hold circuits are used, $t_{SPLSH} = 0$.
Note 2. When disconnection detection assistance is not selected, $t_{DIS} = 0$.
Note 3. When the self-diagnosis function is not used, $t_{DIAG} = 0$, $t_{DSD} = 0$.
Note 4. When no channel-dedicated sample-and-hold circuits are used, $t_{SHED} = 0$, assuming continuous scan mode is active. In single scan mode and group scan mode, t_{SHED} is included in the end-of-scanning-delay (t_{ED}).
Note 5. When input sampling times (t_{SPL}) of all selected channels are the same, this element equals $t_{CONV} \times n$. If each channel has a different sampling time, this element equals that of t_{SPL} and t_{SAM} set to each selected channel.

35.3.6 模拟输入采样和扫描转换时间

扫描转换可以通过软件触发、同步触发(ELC)或异步触发(ADTRGn)来激活。在经过扫描开始延迟(tD)之后，通道专用采样保持电路的处理、断线检测辅助处理、自诊断转换处理全部进行，接着进行AD处理转换。

图35.34显示了扫描转换时序，其中扫描转换由软件触发或同步触发(ELC)激活。图35.35显示了扫描转换时序，其中扫描转换由异步触发器ADTRGn激活。扫描转换时间(tSCAN)包括扫描开始延迟(tD)、通道专用采样保持电路处理时间(tSPLSH)、*1断线检测辅助处理时间(tDIS)、*2自诊断AD转换处理时间(tDIAG)、*3AD转换处理时间(tCONV和tDSD)、通道专用采样保持电路结束时间(tSHED)、*4和扫描结束–延迟（tED）。

AD转换处理时间(tCONV)由输入采样时间(tSPL)和逐次逼近转换时间(tSAM)组成。采样时间(tSPL)用于为ADC12中的采样保持电路充电。如果由于模拟输入信号源的高阻抗而没有足够的采样时间，或者如果AD转换时钟(ADCLK)很慢，可以使用ADSSTR寄存器调整采样时间。

逐次逼近转换时间(tSAM)为13个ADCLK状态，选择12位精度，11
选择了10位精度的ADCLK状态，以及选择了8位精度的9个ADCLK状态。

选择通道数为n的单次扫描模式下的扫描转换时间(tSCAN)可以确定如下：

$$tSCAN=tD+tSPLSH+(tDIS\times n)+tDIAG+(tCONV\times n)*5+tED$$

连续扫描模式下第一个周期的扫描转换时间是单次扫描的tSCAN减去tED加上tSHED。

连续扫描模式中第二个和后续周期的扫描转换时间固定为tSPLSH+(tDIS×n)+tDIAG+tDSD+(tCONV×n)*5+tSHED。

注1.当不使用通道专用采样保持电路时，tSPLSH=0。
注2.未选择断线检测辅助时，tDIS=0。
注3.不使用自诊断功能时，tDIAG=0，tDSD=0。
注4.当不使用通道专用的采样保持电路时，tSHED=0，假设连续扫描模式为积极的。在单扫描模式和组扫描模式中，tSHED包含在扫描结束延迟（tED）中。
注5.当所有选定通道的输入采样时间(tSPL)相同时，该元素等于tCONV×n。如果每个通道具有不同的采样时间，该元素等于为每个选定通道设置的tSPL和tSAM。

Table 35.10 Conversion times during scanning (in numbers of ADCLK and PCLKB cycles)

Parameter			Symbol		Type/conditions: Synchronous trigger*4	Type/conditions: Asynchronous trigger	Type/conditions: Software trigger	Unit
Scan start processing time*1, *2	A/D conversion on group A under group A priority control	Group B is to be stopped. (group A is activated after group B is stopped by an A/D conversion source from group A).	t_D		3 PCLKB + 6 ADCLK 5 PCLKB + 3 ADCLK *5	-	-	Cycles
		Group B is not to be stopped (activation by an A/D conversion source from group A)			2 PCLKB + 4 ADCLK	-	-	
	A/D conversion when self-diagnosis is enabled	A/D conversion for self-diagnosis is to be started			2 PCLKB + 6 ADCLK	4 PCLKB + 6 ADCLK	6 ADCLK	
	All other				2 PCLKB + 4 ADCLK	2 PCLKB + 4 ADCLK	4 ADCLK	
Channel-dedicated sample-and-hold processing time*1	Sampling time		t_{SPLSH}	t_{SH}	Without continuous sampling: setting in ADSHCR.SSTSH[7:0] (initial value = 18h × ADCLK) With continuous sampling: 0			
	Wait time between sampling and A/D conversion			t_W	12			
Disconnection detection assistance processing time			t_{DIS}		Setting in ADNDIS[3:0] (initial value = 0h) × ADCLK			
Self-diagnosis conversion processing time*1	Sampling time		t_{DIAG}	t_{SPL}	Setting in ADSSTR00 (initial value = 0Bh) × ADCLK*3	-	-	
	Time for conversion by successive approximation	12-bit conversion accuracy		t_{SAM}	15 ADCLK	-	-	
		10-bit conversion accuracy			13 ADCLK	-	-	
		8-bit conversion accuracy			11 ADCLK	-	-	
	Wait time between self-diagnosis conversion end and analog channel sampling start			t_{DED}	2 ADCLK			
	Wait time between last channel conversion end and self-diagnosis sampling start in continuous scan mode		t_{DSD}		2 ADCLK			
A/D conversion processing time*1	Sampling time		t_{CONV}	t_{SPL}	Setting in ADSSTRn (n = 00 to 03, 05 to 07, L, T, O) (initial value = 0Bh) × ADCLK + 0.5 ADCLK			
	Time for conversion by successive approximation	12-bit conversion accuracy		t_{SAM}	13 ADCLK			
		10-bit conversion accuracy			11 ADCLK			
		8-bit conversion accuracy			9 ADCLK			
Channel-dedicated sample-and-hold end processing time			t_{SHED}		2 ADCLK			
Scan end processing time*1			t_{ED}		1 PCLKB + 3 ADCLK 2 PCLKB + 3 ADCLK*5			

Note 1. See Figure 35.34 and Figure 35.35 for an illustration of times t_D, t_{SPLSH}, t_{DIAG}, t_{CONV}, and t_{ED}.
Note 2. This is the maximum time required from software writing or trigger input to A/D conversion start.
Note 3. The sampling time setting must satisfy the electrical characteristics.
Note 4. This does not include the time consumed in the path from timer output to trigger input.
Note 5. If ADCLK is faster than PCLKB (PCLKB to ADCLK frequency ratio = 1:2 or 1:4), the scan end processing time changes.

Table 35.10 扫描期间的转换时间（以ADCLK和PCLKB周期数为单位）

Parameter			Symbol		Type/conditions: Synchronous trigger*4	Type/conditions: 异步触发	Type/conditions: 软件触发	Unit
扫描开始处理时间*1、*2	A组优先控制下A组AD转换	B组将被停止。（A组的AD转换源停止B组后激活A组）。	t_D		3 PCLKB + 6 ADCLK 5 PCLKB + 3 ADCLK *5	-	-	Cycles
		不停止B组（由A组的AD转换源激活）			2 PCLKB + 4 ADCLK	-	-	
	启用自诊断时的AD转换	将启动用于自诊断的D转换			2 PCLKB + 6 ADCLK	4 PCLKB + 6 ADCLK	6 ADCLK	
	所有其他				2 PCLKB + 4 ADCLK	2 PCLKB + 4 ADCLK	4 ADCLK	
通道专用采样保持处理时间*1	采样时间		t_{SPLSH}	t_{SH}	没有连续采样：设置 ADSHCR.SSTSH[7:0] (initial value = 18h × ADCLK) 连续采样：0			
	采样和AD转换之间的等待时间			t_W	12			
断线检测辅助处理时间			t_{DIS}		ADNDIS[3:0]中的设置（初始值=0h）×ADCLK			
自诊断转换处理时间*1	采样时间		t_{DIAG}	t_{SPL}	在ADSSTR00中设置（初始值=0Bh）×ADCLK *3	-	-	
	逐次逼近转换时间	12位转换精度		t_{SAM}	15 ADCLK	-	-	
		10位转换精度			13 ADCLK	-	-	
		8位转换精度			11 ADCLK	-	-	
	自诊断转换结束与模拟通道采样开始之间的等待时间			t_{DED}	2 ADCLK			
	连续扫描模式下最后一次通道转换结束和自诊断采样开始之间的等待时间		t_{DSD}		2 ADCLK			
AD转换处理时间*1	采样时间		t_{CONV}	t_{SPL}	ADSSTRn中的设置（n=00至03、05至07、L、T、O）（初始值=0Bh）×ADCLK+0.5ADCLK			
	逐次逼近转换时间	12位转换精度		t_{SAM}	13 ADCLK			
		10位转换精度			11 ADCLK			
		8位转换精度			9 ADCLK			
通道专用的采样保持结束处理时间			t_{SHED}		2 ADCLK			
扫描结束处理时间*1			t_{ED}		1 PCLKB + 3 ADCLK 2 PCLKB + 3 ADCLK*5			

Note 1. 有关时间tD、tSPLSH、tDIAG、tCONV和tED的说明，请参见图35.34和图35.35。
Note 2. 这是从软件写入或触发输入到AD转换开始所需的最长时间。
Note 3. 采样时间设置必须满足电气特性。
Note 4. 这不包括从定时器输出到触发输入的路径中消耗的时间。
Note 5. 如果ADCLK比PCLKB快（PCLKB与ADCLK频率比=1:2或1:4），则扫描结束处理时间会发生变化。

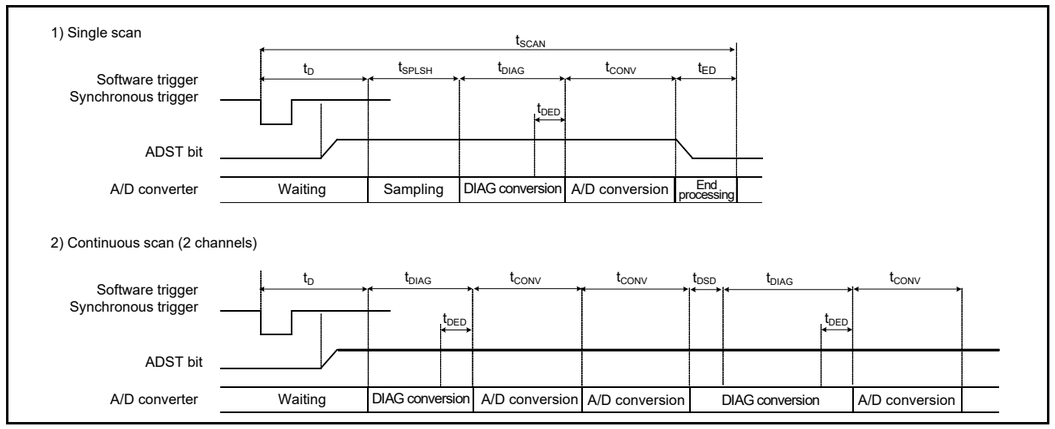


Figure 35.34 Scan conversion timing when activated by software or a synchronous trigger input (ELC)

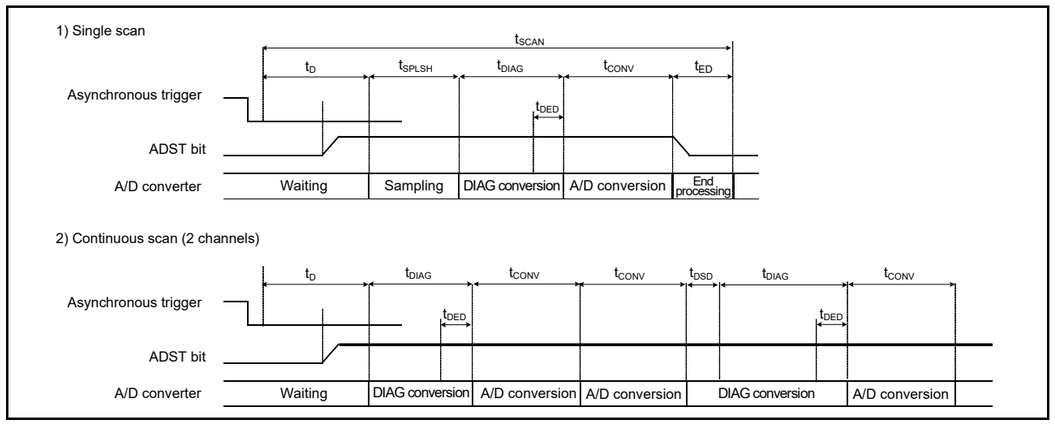


Figure 35.35 Scan conversion timing when activated by an asynchronous trigger input (ADTRG0)

35.3.7 Usage Example of A/D Data Register Automatic Clearing Function

A/D-converted value addition/average mode can be used when A/D conversion of the analog input of the selected channels, temperature sensor output, or internal reference voltage is selected.

Setting the ACE bit in ADCER to 1 automatically clears the data registers (ADDRy, ADRD, ADDBLDR, ADDBLDRA, ADDBLDRB, ADTSDR, and ADOCDR) to 0000h when the data registers are read by the CPU, DTC, or DMAC. This function enables detection of update failures by the data registers.

In the following examples, the function to automatically clear the ADDRy register is enabled and disabled:

- If the ACE bit in ADCER is 0 (automatic clearing disabled), and for some reason, the A/D conversion result (0222h) is not written to the ADDRy register, the ADDRy value retains the old data (0111h). In addition, if this ADDRy value is read into a general-purpose register using an A/D scan end interrupt, the old data (0111h) can be saved in the general-purpose register. When checking whether there is an update failure, it is necessary to frequently save the old data in SRAM or in a general-purpose register.
- If the ACE bit in ADCER is 1 (automatic clearing enabled), when ADDRy = 0111h is read by the CPU, DTC, or DMAC, ADDRy is automatically cleared to 0000h. Next, if the A/D conversion result 0222h cannot be transferred to ADDRy for some reason, the cleared data (0000h) remains as the ADDRy value. If this ADDRy value is read into a general-purpose register using an A/D scan end interrupt at this point, 0000h is saved in the general-purpose register. Occurrence of an ADDRy update failure can be determined by checking that the read data value is 0000h.

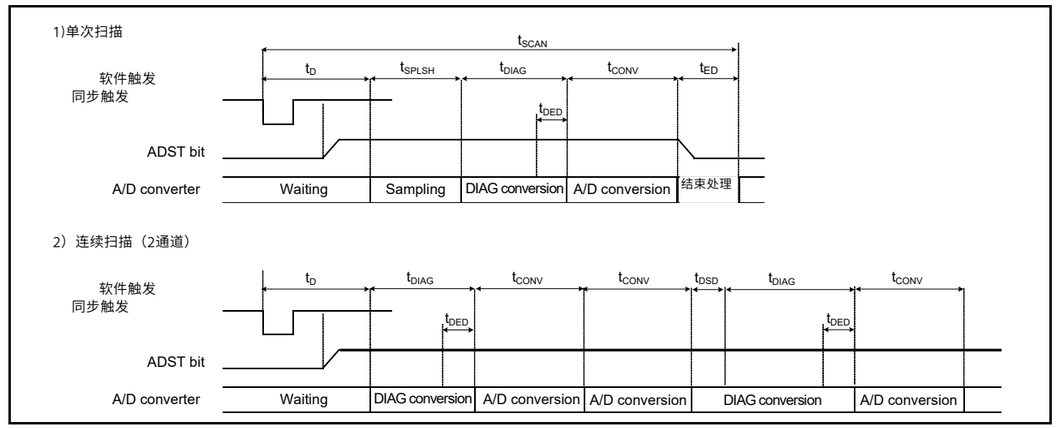


Figure 35.34 由软件或同步触发输入(ELC)激活时的扫描转换时序

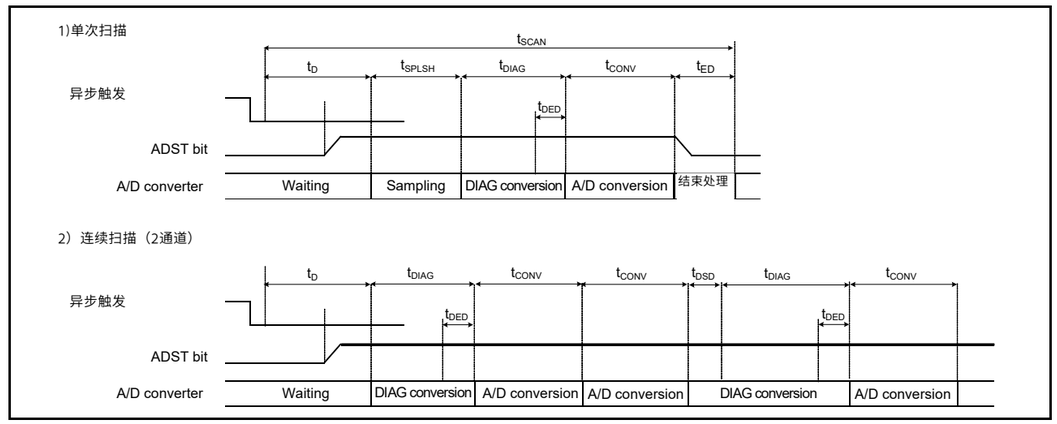


Figure 35.35 由异步触发输入(ADTRG0)激活时的扫描转换时序

35.3.7 AD数据寄存器自动清除功能的使用示例

选择通道的模拟输入、温度传感器输出或内部参考电压的AD转换时，可以使用D转换值加法平均模式。

当CPU、DTC或DMAC读取数据寄存器时，将ADCER中的ACE位设置为1会自动将数据寄存器（ADDRy、ADRD、ADDBLDR、ADDBLDRA、ADDBLDRB、ADTSDR和ADOCDR）清除为0000h。该功能可以通过数据寄存器检测更新失败。

在以下示例中，自动清除ADDRy寄存器的功能被启用和禁用：

- 如果ADCER中的ACE位为0（禁止自动清除），并且由于某种原因，AD转换结果（0222h）没有写入ADDRy寄存器，则ADDRy值保留旧数据（0111h）。此外，如果使用AD扫描结束中断将该ADDRy值读入通用寄存器，则可以将旧数据（0111h）保存在通用寄存器中。在检查是否有更新失败时，需要经常将旧数据保存在SRAM或通用寄存器中。
- 如果ADCER中的ACE位为1（使能自动清除），当ADDRy=0111h时，CPU、DTC或DMAC ADDRy自动清零为0000h。接下来，如果AD转换结果0222h由于某种原因无法传送到ADDRy，则清除的数据(0000h)仍保留为ADDRy值。如果此时使用AD扫描结束中断将该ADDRy值读入通用寄存器，则将0000h保存在通用寄存器中。ADDRy更新失败的发生可以通过检查读取的数据值为0000h来确定。

35.3.8 A/D-Converted Value Addition/Average Mode

In A/D-converted value addition mode, the same channel is A/D-converted 1, 2, 3, 4, or 16*1 consecutive times, and the sum of the converted values is stored in the data register. In A/D-converted value average mode, the same channel is A/D-converted 2 or 4 consecutive times, and the mean of the converted values is stored in the data register. The use of the average of these results can improve the accuracy of A/D conversion, depending on the types of noise components that are present. However, this function cannot always guarantee an improvement in A/D conversion accuracy.

The A/D-converted value addition or average mode can be specified for A/D conversion of the channel select analog input, temperature sensor output, or internal reference voltage.

Note 1. The addition count can be set to 16 only when 12-bit accuracy is selected.

35.3.9 Disconnection Detection Assist Function

This converter incorporates a function that fixes the charge for sampling capacitance to the specified state (VREFH0 or VREFL0 for unit 0, VREFH or VREFL for unit 1) before the start of A/D conversion. This function enables disconnection detection in wiring of analog inputs.

When using the disconnection detection assist function for the channel-dedicated sample-and-hold circuit, select ADSHMSR.SHMD bit to 0 (select disable continuous sampling function).

If any of the following functions are used, the disconnection detection assist function should be disabled:

- Temperature sensor
- Internal reference voltage
- A/D self-diagnosis
- Programmable gain amplifier without bypass enabled.

Figure 35.36 shows the A/D conversion operation when the disconnection detection assist function is used. Figure 35.37 shows an example of disconnection detection when precharge is selected. Figure 35.38 shows an example of disconnection detection when discharge is selected.

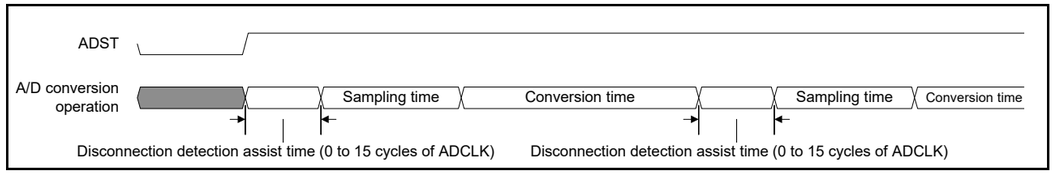


Figure 35.36 A/D conversion operation when the disconnection detection assist function is used

35.3.8 一种D转换的增值平均模式

在AD转换值加法模式下，同一通道连续进行1、2、3、4或16*1次AD转换，转换值的总和存储在数据寄存器中。在AD转换值平均模式下，同一通道连续进行2或4次AD转换，转换值的平均值存储在数据寄存器中。根据存在的噪声成分的类型，使用这些结果的平均值可以提高AD转换的精度。但是，该功能不能始终保证AD转换精度的提高。

可以为通道选择模拟输入、温度传感器输出或内部参考电压的AD转换指定AD转换值加法或平均模式。

注1.只有选择12位精度时，才能将加法计数设置为16。

35.3.9 断线检测辅助功能

该转换器包含一个功能，可将采样电容的电荷固定到指定状态（VREFH0或单元0的VREFL0，单元1的VREFH或VREFL）在AD转换开始之前。此功能可在模拟输入接线中进行断线检测。

使用通道专用采样保持电路的断线检测辅助功能时，选择ADSHMSR.SHMD位为0（选择禁用连续采样功能）。

如果使用以下任一功能，应禁用断线检测辅助功能：

- 温度感应器
- 内部参考电压
- A/D self-diagnosis
- 不启用旁路的可编程增益放大器。

图35.36显示了使用断线检测辅助功能时的AD转换操作。图35.37显示了选择预充电时的断线检测示例。图35.38显示了选择放电时的断线检测示例。

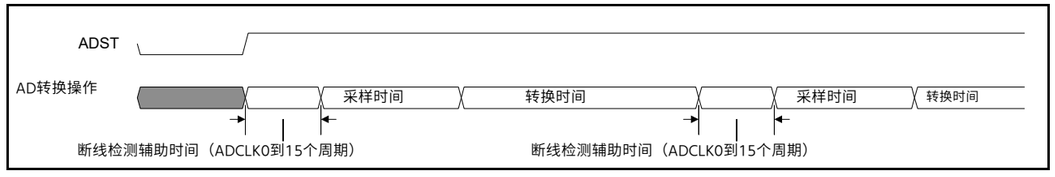
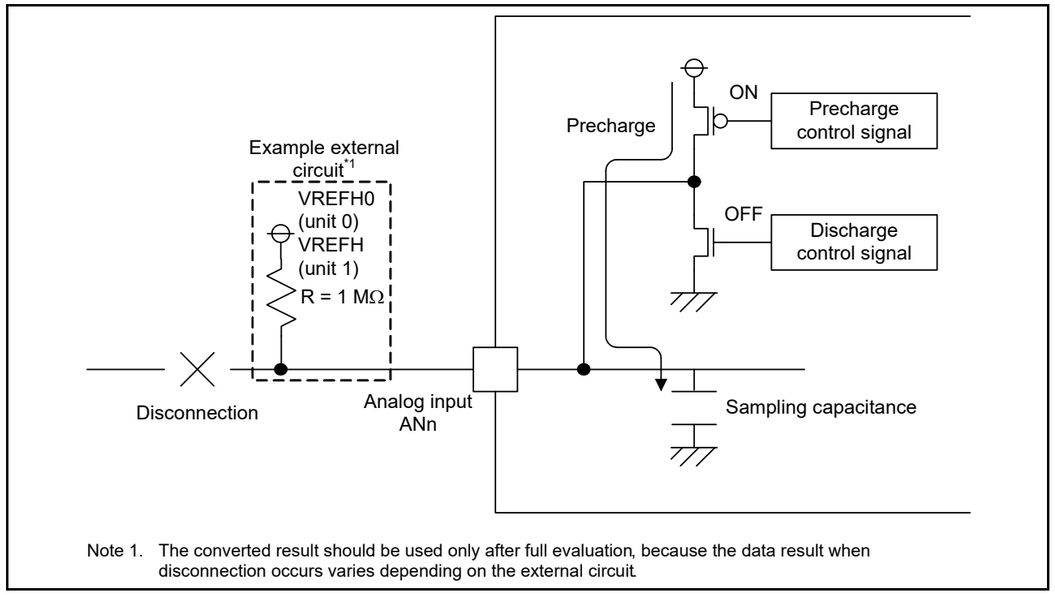
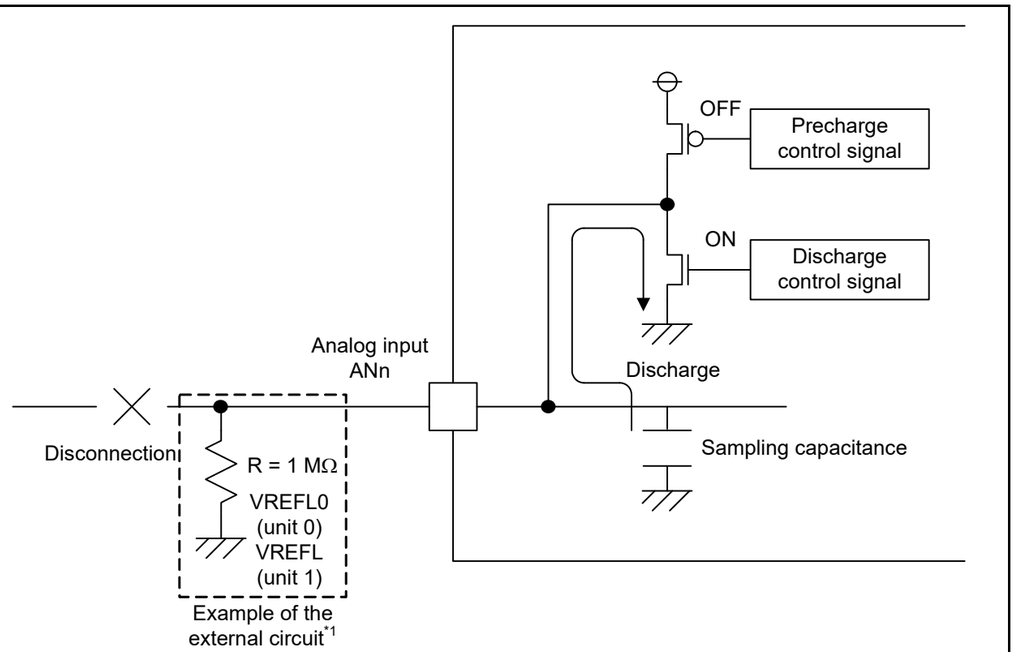


Figure 35.36 使用断线检测辅助功能时的D转换动作



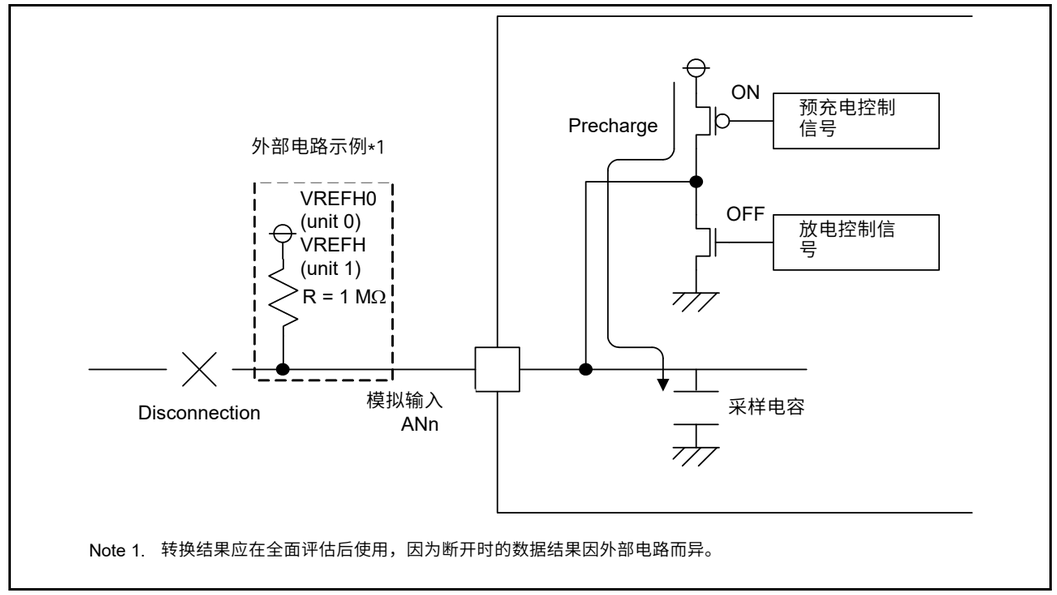
Note 1. The converted result should be used only after full evaluation, because the data result when disconnection occurs varies depending on the external circuit.

Figure 35.37 Example of disconnection detection when precharge is selected



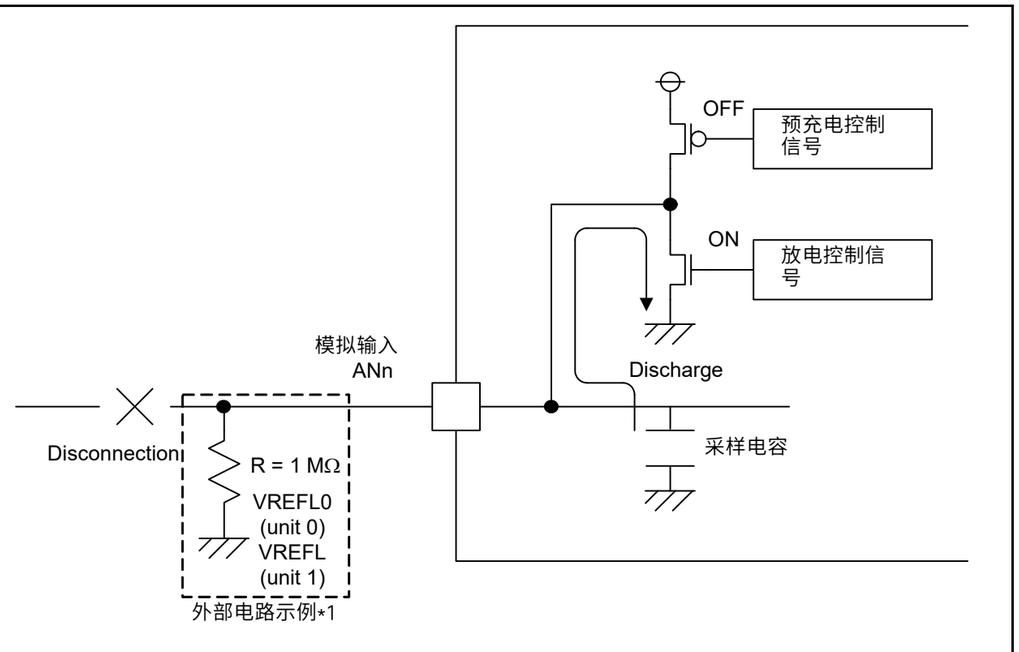
Note 1. The converted result should be used only after full evaluation, because the data result when disconnection occurs varies depending on the external circuit.

Figure 35.38 Example of disconnection detection when discharge is selected



Note 1. 转换结果应在全面评估后使用，因为断开时的数据结果因外部电路而异。

Figure 35.37 选择预充电时的断线检测示例



Note 1. 转换结果应在全面评估后使用，因为断开时的数据结果因外部电路而异。

Figure 35.38 选择放电时的断线检测示例

35.3.10 Starting A/D Conversion with an Asynchronous Trigger

A/D conversion can be started by the input of an asynchronous trigger. To start the A/D conversion by an asynchronous trigger, first set the pin function in the PmnPFS register, next set the A/D Conversion Start Trigger Select bits (ADSTRGR.TRSA[5:0]) to 000000b, then input a high-level signal to the asynchronous trigger (ADTRGn pin). Finally, set both the ADCSR.TRGE and ADCSR.EXTRG bits to 1. Figure 35.39 shows timing of the asynchronous trigger input.

An asynchronous trigger cannot be selected in the A/D Conversion Start Trigger Select bits (ADSTRGR.TRSB[5:0]) for group B in group scan mode. For details on setting the pin function, see section 19, I/O Ports.

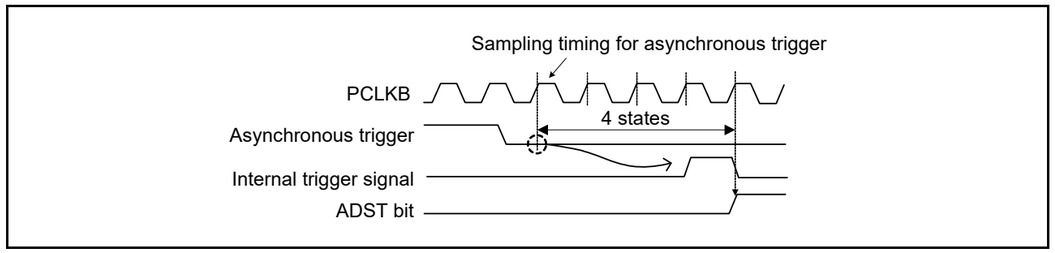


Figure 35.39 Asynchronous trigger input timing

35.3.11 Starting A/D Conversion with a Synchronous Trigger from a Peripheral Module

A/D conversion can be started by a synchronous trigger (ELC). To start the A/D conversion by a synchronous trigger, set the ADCSR.TRGE bit to 1, clear the ADCSR.EXTRG bit to 0, and select the relevant sources in the ADSTRGR.TRSA[5:0] and ADSTRGR.TRSB[5:0] bits.

35.3.12 Programmable Gain Amplifiers

Up to three programmable gain amplifiers (PGAs) can be used in each unit. Select a gain in the ADPGAGS.PnGAIN[3:0] bits (n = 000 to 002) and select an operational amplifier to be used in the ADPGACR.PnSEL bits.

These PGAs accept pseudo-differential inputs. Pins that accept pseudo-differential inputs are PGAVSS000 for AN000 to AN002 (unit 0), PGAVSS100 for AN100 to AN102 (unit 1). To use pseudo-differential inputs, set the pseudo-differential input gain in the ADPGADCR0.PnDG[2:0] bits, enable the pseudo-differential input gain setting in the ADPGADCR0.PnGEN bits, and then select the pseudo-differential input amplifier in the ADPGADCR0.PnDEN bits. The PGA register is selectable as shown in Table 35.11.

Table 35.11 Setting of PGA register and available related functions

Selectable value for each condition	Setting of corresponding register				Related function ✓: available x: unavailable			
	PmnPFS	ADPGACR	ADPGAGS0	ADPGADCR0		ACMPHS*2		
	ASEL*3	PGA P002: bits [11:8] PGA P001: bits [7:4] PGA P000: bit [3:0]	bits [11:8] bits [7:4] bit [3:0]	bits [11:8] bits [7:4] bit [3:0]	Ports*1	IVCMP2	IVCMP3	ADC12
When using ports	0	Leave these bits with initial values			✓	x	x	x
When using ACMPHS or ADC12 (PGA bypass)*4	1	9	0	0	x	✓	x	✓
When using PGA pseudo-differential input disabled	1	Eh	0 to Eh	0	x	✓	✓	✓
When using PGA pseudo-differential input enabled	1	Eh	1, 5, 9, Bh	8 to Bh	x	x	✓	✓

Note 1. Ports: When using input ports.
Note 2. ACMPHS IVCMP2: When using input through the PGA. ACMPHS IVCMP3: When using input of PGA output.
Note 3. For detail on the configuration of PmnPFS registers, see section 19, I/O Ports.
Note 4. Ports and ACMPHS cannot be used at the same time. Ports and ADC12 cannot be used at the same time.

35.3.10 使用异步触发启动AD转换

可以通过输入异步触发器来启动D转换。要通过异步触发启动AD转换，首先在PmnPFS寄存器中设置引脚功能，然后将AD转换启动触发选择位(ADSTRGR.TRSA[5:0])设置为000000b，然后输入高电平信号到异步触发（ADTRGn引脚）。最后，将ADCSR.TRGE和ADCSR.EXTRG位都设置为1。图35.39显示了异步触发输入的时序。

在组扫描模式下，无法在组B的AD转换开始触发选择位(ADSTRGR.TRSB[5:0])中选择异步触发。有关设置引脚功能的详细信息，请参见第19节，IO端口。

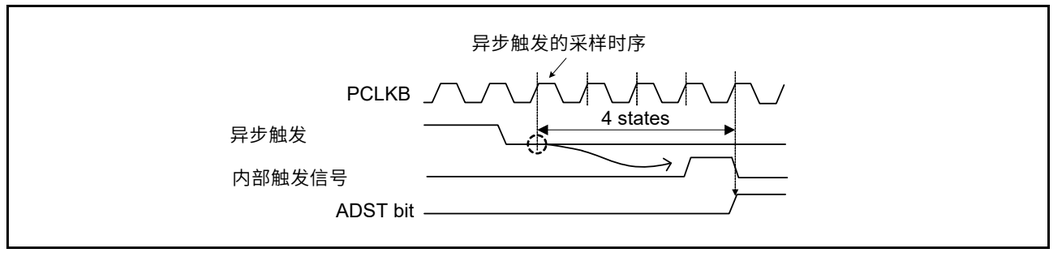


Figure 35.39 异步触发输入时序

35.3.11 使用来自外设模块的同步触发启动AD转换

D转换可以通过同步触发器(ELC)启动。要通过同步触发启动AD转换，请将ADCSR.TRGE位设置为1，将ADCSR.EXTRG位清零，并在ADSTRGR.TRSA[5:0]和ADSTRGR.TRSB[5]中选择相关源：0]位。

35.3.12 可编程增益放大器

每个单元最多可使用三个可编程增益放大器(PGA)。选择增益ADPGAGS.PnGAIN[3:0]位（n=000到002）并选择要在ADPGACR.PnSEL位中使用的运算放大器。

这些PGA接受伪差分输入。接受伪差分输入的引脚是PGAVSS000用于AN000至AN002（单元0），PGAVSS100用于AN100至AN102（单元1）。要使用伪差分输入，请在ADPGADCR0.PnDG[2:0]位中设置伪差分输入增益，在ADPGADCR0.PnGEN位中启用伪差分输入增益设置，然后选择伪差分输入放大器在ADPADCR0.PnDEN位中。

PGA寄存器是可选的，如表35.11所示。

Table 35.11 PGA寄存器的设置和可用的相关功能

每个条件的可选值	对应寄存器的设置				相关功能 ：可用x ：不可用			
	PmnPFS	ADPGACR	ADPGAGS0	ADPGADCR0		ACMPHS*2		
	ASEL*3	PGAP002：位[11:8] PGAP001：位[7:4] PGAP000：位[3:0]	bits [11:8] bits [7:4] bit [3:0]	bits [11:8] bits [7:4] bit [3:0]	Ports*1	IVCMP2	IVCMP3	ADC12
使用端口时	0	将这些位保留为初始值			✓	x	x	x
使用ACMPHS或ADC12（PGA旁路）时*4	1	9	0	0	x	✓	x	✓
使用PGA伪差分输入时禁用	1	Eh	0到呃	0	x	✓	✓	✓
使用PGA伪差分输入时启用	1	Eh	1, 5, 9, Bh	8 to Bh	x	x	✓	✓

Note 1. 端口：使用输入端口时。
Note 2. ACMPHSIVCMP2：通过PGA使用输入时。ACMPHSIVCMP3：使用PGA输出的输入时。
Note 3. 有关PmnPFS寄存器配置的详细信息，请参阅第19节，IO端口。
Note 4. 端口和ACMPHS不能同时使用。端口和ADC12不能同时使用。

Table 35.12 shows the calculation formula for the PGA output voltage.

Table 35.12 PGA output voltage

Mode	PGA output voltage
Single	Gain × Vin
Pseudo-Differential	Gain (Vin - Vs) + 0.5 × AVCC

Vin: AN000 to AN002, AN100 to AN102
Vs: PGAVSS00, PGAVSS001

35.4 Vs: PGAVSS00, PGAVSS001Interrupt Sources and DTC/DMAC Transfer Requests

35.4.1 Interrupt Requests

The ADC12 can send scan end interrupt requests, ADC12i_ADI (i = 0, 1) and ADC12i_GBADI, to the CPU. The ADC12 also generates the ADC12i_CMPAI and ADC12i_CMPBI interrupts to the CPU in response to matches with a comparison condition.

An ADC12i_ADI interrupt is always generated. An ADC12i_GBADI interrupt can be generated by setting the ADCSR.GBADIE bit to 1. Similarly, ADC12i_CMPAI and ADC12i_CMPBI interrupts can be generated by setting the ADCMPCR.CMPAIE and ADCMPCR.CMPBIE bits to 1.

In addition, the DTC or DMAC can be started when an ADC12i_ADI or ADC12i_GBADI interrupt, or ADC12i_WCMPM or ADC12i_WCMPUM event is generated. Using these interrupts or events to allow the DTC or DMAC to read the converted data enables continuous conversion without burdening the software.

For details on the DTC settings, see section 17, Data Transfer Controller (DTC), and for details on the DMAC settings, see section 16, DMA Controller (DMAC).

Table 35.13 describes the interrupt sources and ELC events available for the ADC12.

PGA输出电压的计算公式如表35.12所示。

Table 35.12 PGA输出电压

Mode	PGA输出电压
Single	增益 Vin
Pseudo-Differential	Gain (Vin - Vs) + 0.5 × AVCC

Vin: AN000 to AN002, AN100 to AN102
Vs: PGAVSS00, PGAVSS001

35.4 对比：PGAVSS00、PGAVSS001中断源和DTCDMAC传输请求

35.4.1 中断请求

ADC12可以向CPU发送扫描结束中断请求ADC12i_ADI(i=0 1)和ADC12i_GBADI。这
ADC12还向CPU生成ADC12i_CMPAI和ADC12i_CMPBI中断，以响应与比较条件的匹配。

始终会产生ADC12i_ADI中断。ADC12i_GBADI中断可以通过设置
ADCSR.GBADIE位为1。类似地，ADC12i_CMPAI和ADC12i_CMPBI中断可以通过设置
ADCMPCR.CMPAIE和ADCMPCR.CMPBIE位为1。

此外，当ADC12i_ADI或ADC12i_GBADI中断时，可以启动DTC或DMAC，或者
生成ADC12i_WCMPM或ADC12i_WCMPUM事件。使用这些中断或事件来允许DTC或
读取转换数据的DMAC可以实现连续转换，而不会增加软件负担。

有关DTC设置的详细信息，请参阅第17节，数据传输控制器(DTC)，有关DMAC设置的详细信息，请参阅第16节，DMA控制器(DMAC)。

表35.13描述了ADC12可用的中断源和ELC事件。

Table 35.13 ADC12 events (1 of 2)

✓: Available x: Unavailable

Operation		Interrupt request or ELC event			Inter-rupt re-quest	DTC/ DMAC activa-tion	ELC event re-quest	Function
Scan mode	Double trigger mode	Compare function win-dow A/B	Unit 0	Unit 1				
Single scan mode	Deselected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI generated at the end of single scan
		Selected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI generated at the end of single scan
			ADC120_CMPAI	ADC121_CMPAI	✓	x	x	ADC12i_CMPAI generated on a match comparison condition of window A
			ADC120_CMPBI	ADC121_CMPBI	✓	x	x	ADC12i_CMPBI generated on a match comparison condition of window B
			ADC120_WCMPM	ADC121_WCMPM	x	✓	✓	ADC12i_WCMPM generated on a match condition of the window A/B compare function
			ADC120_WCMPUM	ADC121_WCMPUM	x	✓	✓	ADC12i_WCMPUM generated on a mismatch condition of the window A/B compare function
	Selected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI generated at the end of scans in the even-numbered times
Continuous scan mode	Deselected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI generated at the end of scan of all selected channels
		Selected	ADC120_CMPAI	ADC121_CMPAI	✓	x	x	ADC12i_CMPAI generated on a match comparison condition of window A
			ADC120_CMPBI	ADC121_CMPBI	✓	x	x	ADC12i_CMPBI generated on a match comparison condition of window B

Table 35.13 ADC12事件(1of2)

：可用x：不可用

Operation		中断请求或ELC事件			中断请求	DTC/ DMAC activa-tion	ELC事件请求	Function
扫描模式	双触发模式	比较功能窗口AB	Unit 0	Unit 1				
单次扫描模式	Deselected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI在单次扫描结束时生成
		Selected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI在单次扫描结束时生成
			ADC120_CMPAI	ADC121_CMPAI	✓	x	x	ADC12i_CMPAI在窗口A的匹配比较条件下生成
			ADC120_CMPBI	ADC121_CMPBI	✓	x	x	ADC12i_CMPBI在窗口B的匹配比较条件下生成
			ADC120_WCMPM	ADC121_WCMPM	x	✓	✓	ADC12i_WCMPM在窗口AB比较函数的匹配条件下生成
			ADC120_WCMPUM	ADC121_WCMPUM	x	✓	✓	ADC12i_WCMPUM在窗口AB比较函数的不匹配条件下生成
	Selected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	在偶数次扫描结束时生成ADC12i_ADI
连续扫描模式	Deselected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	在所有选定通道的扫描结束时生成ADC12i_ADI
		Selected	ADC120_CMPAI	ADC121_CMPAI	✓	x	x	ADC12i_CMPAI在窗口A的匹配比较条件下生成
			ADC120_CMPBI	ADC121_CMPBI	✓	x	x	ADC12i_CMPBI在窗口B的匹配比较条件下生成

Table 35.13 ADC12 events (2 of 2)

✓: Available x: Unavailable

Operation		Interrupt request or ELC event			Inter-rupt re-quest	DTC/ DMAC activa-tion	ELC event re-quest	Function
Scan mode	Double trigger mode	Compare function win-dow A/B	Unit 0	Unit 1				
Group scan mode	Deselected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI generated at the end of group A scan
			ADC120_GBADI	ADC121_GBADI	✓	✓	x	ADC12i_GBADI dedicated to group B generated at the end of group B scan
		Selected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI generated at the end of group A scan
			ADC120_GBADI	ADC121_GBADI	✓	✓	x	ADC12i_GBADI dedicated to group B generated at the end of group B scan
			ADC120_CMPAI	ADC121_CMPAI	✓	x	x	ADC12i_CMPAI generated on a match comparison condition of window A
			ADC120_CMPBI	ADC121_CMPBI	✓	x	x	ADC12i_CMPBI generated on a match comparison condition of window B
	Selected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI generated at the end of group A scans in the even-numbered times
			ADC120_GBADI	ADC121_GBADI	✓	✓	x	ADC12i_GBADI dedicated to group B generated at the end of group B scan

Note: i = 0: unit 0, i = 1: unit 1.

Table 35.13 ADC12事件（2个中的2个）

：可用x：不可用

Operation		中断请求或ELC事件			中断请求	DTC/ DMAC activa-tion	ELC事件请求	Function
扫描模式	双触发模式	比较功能窗口AB	Unit 0	Unit 1				
组扫描模式	Deselected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI在A组扫描结束时生成
			ADC120_GBADI	ADC121_GBADI	✓	✓	x	ADC12i_GBADI专用于B组扫描结束时生成的B组
		Selected	ADC120_ADI	ADC121_ADI	✓	✓	✓	ADC12i_ADI在A组扫描结束时生成
			ADC120_GBADI	ADC121_GBADI	✓	✓	x	ADC12i_GBADI专用于B组扫描结束时生成的B组
			ADC120_CMPAI	ADC121_CMPAI	✓	x	x	ADC12i_CMPAI在窗口A的匹配比较条件下生成
			ADC120_CMPBI	ADC121_CMPBI	✓	x	x	ADC12i_CMPBI在窗口B的匹配比较条件下生成
	Selected	Deselected	ADC120_ADI	ADC121_ADI	✓	✓	✓	A组结束时生成的ADC12i_ADI在偶数次扫描
			ADC120_GBADI	ADC121_GBADI	✓	✓	x	ADC12i_GBADI专用于B组扫描结束时生成的B组

Note: i = 0: unit 0, i = 1: unit 1.

35.5 Event Link Function

35.5.1 Event Output to the ELC

The ELC uses an ADC12i_ADI interrupt request signal as an event signal, enabling link operation for the preset module. The ADC12i_GBADI interrupt and ADC12i_CMPAI/ADC12i_CMPBI interrupts cannot be used as event signals. For details, see Table 35.13.

35.5.2 ADC12 Operation through an Event from the ELC

The ADC12 can start A/D conversion by the preset event specified in the ELSRn settings for the ELC as follows:

- Select the ELC_AD00 (unit 0) signal in the ELC.ELSR8 register
- Select the ELC_AD01 (unit 0) signal in the ELC.ELSR9 register
- Select the ELC_AD10 (unit 1) signal in the ELC.ELSR10 register
- Select the ELC_AD11 (unit 1) signal in the ELC.ELSR11 register.

If an ELC_ADi0 or ELC_ADi1 event occurs during A/D conversion, the event is disabled.

35.6 Usage Notes

35.6.1 Constraints on Reading the Data Registers

The following registers must be read in halfword units:

- A/D Data Registers
- A/D Data Duplexing Register
- A/D Data Duplexing Register A
- A/D Data Duplexing Register B
- A/D Temperature Sensor Data Register
- A/D Internal Reference Voltage Register
- A/D Self-Diagnosis Data Register.

If a register is read twice in byte units, that is, the upper byte and lower byte are read separately, the A/D-converted value initially read might not match with the A/D-converted value subsequently read. To prevent this, never read the data registers in byte units.

35.6.2 Constraints on Stopping A/D Conversion

To stop A/D conversion when an asynchronous trigger or a synchronous trigger is selected as the condition for starting A/D conversion, follow the procedure shown in Figure 35.40.

35.5 事件链接功能

35.5.1 事件输出到ELC

ELC使用ADC12i_ADI中断请求信号作为事件信号，为预设模块启用链接操作。
ADC12i_GBADI中断和ADC12i_CMPAIADC12i_CMPBI中断不能用作事件信号。详见表35.13。

35.5.2 ADC12通过来自ELC的事件进行操作

ADC12可以通过ELC的ELSRn设置中指定的预设事件启动AD转换，如下所示：

- 选择ELC.ELSR8寄存器中的ELC_AD00（单元0）信号
- 选择ELC.ELSR9寄存器中的ELC_AD01（单元0）信号
- 选择ELC.ELSR10寄存器中的ELC_AD10（单元1）信号
- 选择ELC.ELSR11寄存器中的ELC_AD11（单元1）信号。

如果在AD转换期间发生ELC_ADi0或ELC_ADi1事件，则该事件被禁用。

35.6 使用说明

35.6.1 读取数据寄存器的限制

以下寄存器必须以半字为单位读取：

- AD数据寄存器
- AD数据双工寄存器
- AD数据双工寄存器A
- AD数据双工寄存器B
- AD温度传感器数据寄存器
- AD内部参考电压寄存器
- AD自诊断数据寄存器。

如果以字节为单位读取寄存器两次，即分别读取高字节和低字节，则最初读取的AD转换值可能与随后读取的AD转换值不匹配。为防止这种情况，切勿以字节为单位读取数据寄存器。

35.6.2 停止AD转换的约束

选择异步触发或同步触发作为启动条件时停止AD转换
AD转换，按照图35.40所示的步骤进行。

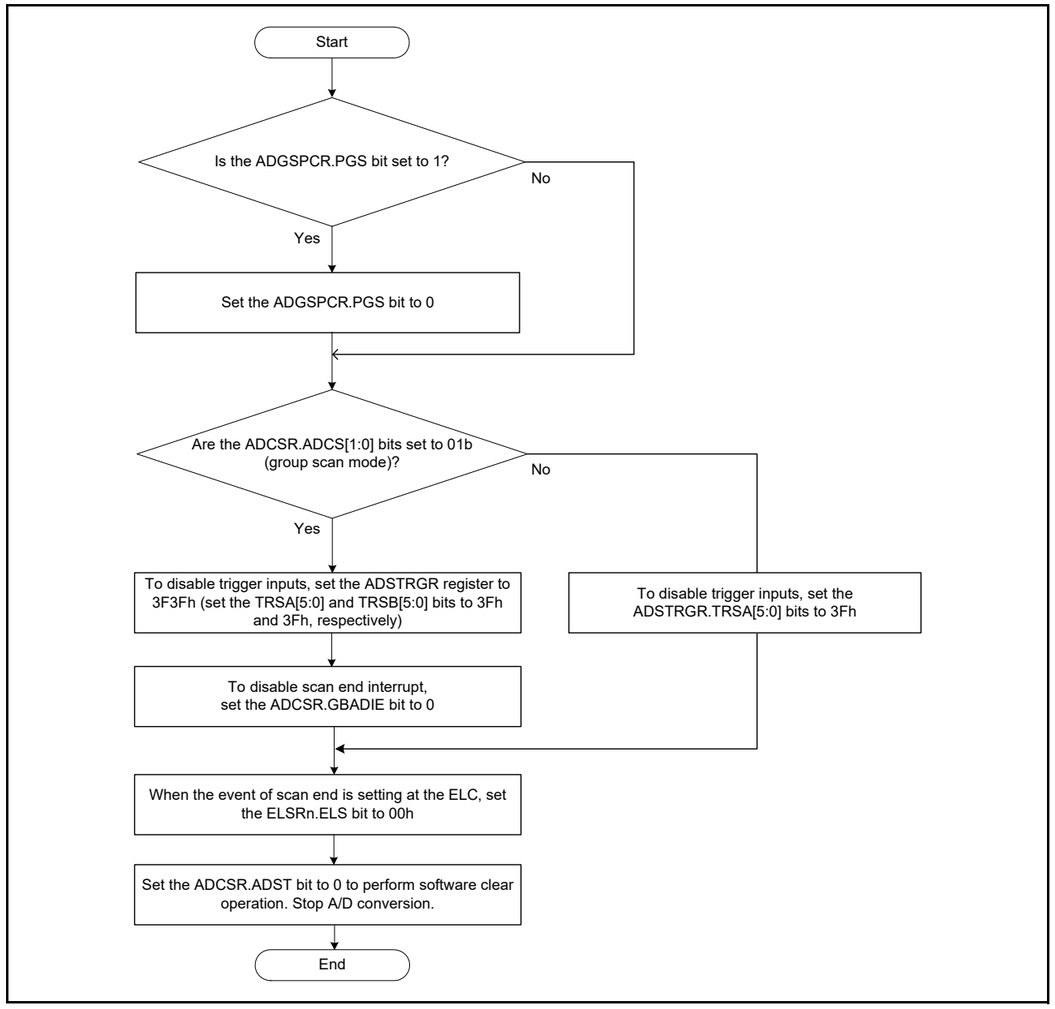


Figure 35.40 Procedure for clearing the ADCSR.ADST bit by software

35.6.3 A/D Conversion Restart and Termination Timing

A maximum of 6 ADCLK cycles is required for the idle analog unit of the ADC12 to restart on setting the ADCSR.ADST bit to 1. A maximum of 2 ADCLK cycles is required for the operating analog unit of the ADC12 to be terminate on setting the ADCSR.ADST bit to 0.

35.6.4 Constraints on Scan End Interrupt Handling

When scanning the same analog input twice using any trigger, the first A/D-converted data is overwritten with the second A/D-converted data if the CPU does not finish reading the A/D-converted data by the time the A/D conversion of the first analog input for the second scan ends after the first scan end interrupt is generated.

35.6.5 Settings for the Module-Stop Function

The Module Stop Control Register can enable or disable ADC12 operation. The ADC12 is initially stopped after reset. Releasing the module-stop state enables access to the registers. After release from the module-stop state, wait for at least 1 µs before starting A/D conversion. For details, see section 11.4, Module-Stop Function.

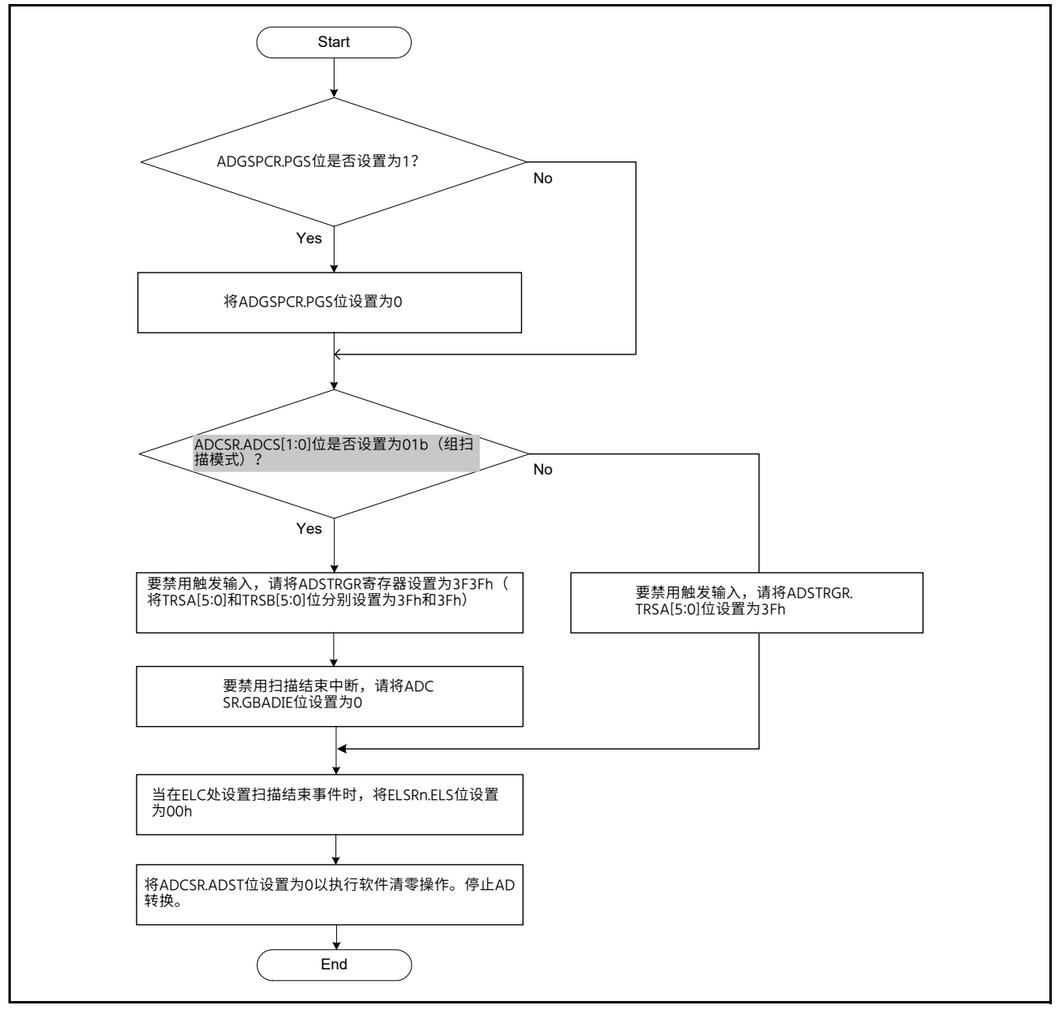


Figure 35.40 通过软件清除ADCSR.ADST位的过程

35.6.3 AD转换重启和终止时序

ADC12的空闲模拟单元最多需要6个ADCLK周期才能在设置时重新启动ADCSR.ADST位为1。ADC12的操作模拟单元最多需要2个ADCLK周期才能在将ADCSR.ADST位设置为0时终止。

35.6.4 扫描结束中断处理的约束

当使用任何触发器扫描相同的模拟输入两次时，如果CPU在第一个AD转换之前没有完成读取AD转换的数据，则第一个AD转换的数据将被第二个AD转换的数据覆盖第二次扫描的模拟输入在第一次扫描结束中断产生后结束。

35.6.5 模块停止功能的设置

模块停止控制寄存器可以启用或禁用ADC12操作。ADC12在复位后最初停止。
释放模块停止状态可以访问寄存器。从模块停止状态释放后，在开始AD转换之前至少等待1微秒。有关详细信息，请参阅第11.4节，模块停止功能。

35.6.6 Notes on Entering the Low Power States

Before entering the module-stop state or Software Standby mode, you must stop A/D conversion. Set the ADCSR.ADST bit to 0 and secure a period of time until the analog unit of the ADC12 stops.

To secure this time, follow the procedure shown in Figure 35.40 for clearing the ADCSR.ADST bit through software. Then, wait for 2 clock cycles of ADCLK before entering the module-stop state or Software Standby mode.

35.6.7 Error in Absolute Accuracy when Disconnection Detection Assistance Is in Use

Using disconnection detection assistance leads to an error in the absolute accuracy of the ADC12. This error arises because an erroneous voltage is input to the analog input pins because of the resistive voltage division between the pull-up or pull-down resistor (Rp) and the resistance of the signal source (Rs). This error in absolute accuracy is calculated from the following formula:

Maximum error in absolute accuracy (LSB) = $(2^{\text{Resolution - 1}}) \times Rs / (Rs + Rp)$, where Resolution = 12, 10, 8

Only use disconnection detection assistance after thorough evaluation.

35.6.8 Available functions and register settings of AN000 to AN002, AN007, AN100 to AN102, and AN107

Table 35.14 shows the available functions and register settings of AN000 to AN002, AN007, AN100 to AN102 and AN107, and Figure 35.41 shows the setting procedure of registers. To use each function, set the register value shown in Table 35.14.

When the PGA is used with pseudo-differential input enabled, a negative voltage can be input for AN000 to AN002 and PGAVSS000 for unit 0, and AN100 to AN102 and PGAVSS100 for unit 1 after setting the registers.

When the PGA is used with pseudo-differential input enabled, all PGA amplifiers in each unit must be set to pseudo-differential input in the ADPGADCR0 register.

When the PGA is used with pseudo-differential input disabled, the associated PGAVSS pin must be connected to AVSS0. When the PGA is not used, the associated PGAVSS can be used as an input port or analog input.

When transitioning to the ADC module-stop state or Software Standby mode from the state of using PGA or sample-and-hold circuit, if the corresponding bit in ADPGACR or ADSHCR register of each ADC12 is set to 0 before transitioning, power consumption can be reduced.

The initial value of the ASEL bit of P003 and P007 is 1. When these pins are not used as an analog function, to reduce the input leakage current, the ASEL bit should be set to 0.

When using a 64-pin product, the P007PFS.ASEL bit should be set to 0.

Table 35.14 Available functions and register setting

Available functions						Register setting				
						P0nPFS*6		PGA		S/H*3
Ports*1	IRQ*2	S/H*3	PGA-S*4	PGA-D*5	ADC12	ASEL	ISEL	ADPGADCR0*7	ADPGACR*8	ADSHCR*9
✓						0	0	x	x	x
	✓					0	1	x	x	x
					✓*10	1	x	0	9h	0
					✓*11	1	x	0*11	0 or 9h	0
		✓			✓	1	x	0	9h	1 (0*13)
		✓	✓		✓	1	x	0	Eh (0h*12)	1 (0*13)
		✓		✓	✓	1	x	1	Eh (0h*12)	1 (0*13)
			✓		✓	1	x	0	Eh (0h*12)	0
				✓	✓	1	x	1	Eh (0h*12)	0

✓: Available
x: Don't care

Note 1. Ports: P000 to P007 can be used as port inputs.

35.6.6 进入低功耗状态的注意事项

在进入模块停止状态或软件待机模式之前，您必须停止AD转换。将ADCSR.ADST位设置为0并确保一段时间，直到ADC12的模拟单元停止。

为确保该时间，请按照图35.40中所示的过程通过软件清除ADCSR.ADST位。
然后，在进入模块停止状态或软件待机模式之前等待ADCLK的2个时钟周期。

35.6.7 使用断线检测辅助时的绝对精度误差

使用断开检测辅助会导致ADC12的绝对精度出现误差。由于上拉或下拉电阻(Rp)与信号源电阻(Rs)之间的电阻分压，导致错误电压输入到模拟输入引脚，因此会出现此错误。该绝对精度误差由以下公式计算得出：

绝对精度的最大误差(LSB)=(2分辨率1)×Rs(Rs+Rp)，其中分辨率=12、10、8

仅在全面评估后使用断线检测辅助。

35.6.8 AN000至AN002、AN007、AN100至AN000的可用功能和寄存器设置 AN102, and AN107

表35.14显示了AN000到AN002、AN007、AN100到AN102和
AN107和图35.41显示了寄存器的设置过程。要使用每个功能，请设置如下所示的寄存器值
Table 35.14.

当PGA在启用伪差分输入的情况下使用时，可以为AN000到AN002输入负电压，并且
设置寄存器后，单元0为PGAVSS000，单元1为AN100到AN102和PGAVSS100。

当PGA在伪差分输入使能的情况下使用时，每个单元中的所有PGA放大器都必须在ADPADCR0寄存器中设置为伪差分输入。

当PGA在伪差分输入禁用的情况下使用时，相关的PGAVSS引脚必须连接到AVSS0。
不使用PGA时，关联的PGAVSS可用作输入端口或模拟输入。

当从使用PGA或采样保持电路的状态转换到ADC模块停止状态或软件待机模式时，如果在转换前将每个ADC12的ADPGACR或ADSHCR寄存器中的相应位设置为0，则可以降低功耗。

P003和P007的ASEL位初始值为1。当这些引脚不用作模拟功能时，为减少输入漏电流，应将ASEL位设置为0。

使用64引脚产品时，P007PFS.ASEL位应设置为0。

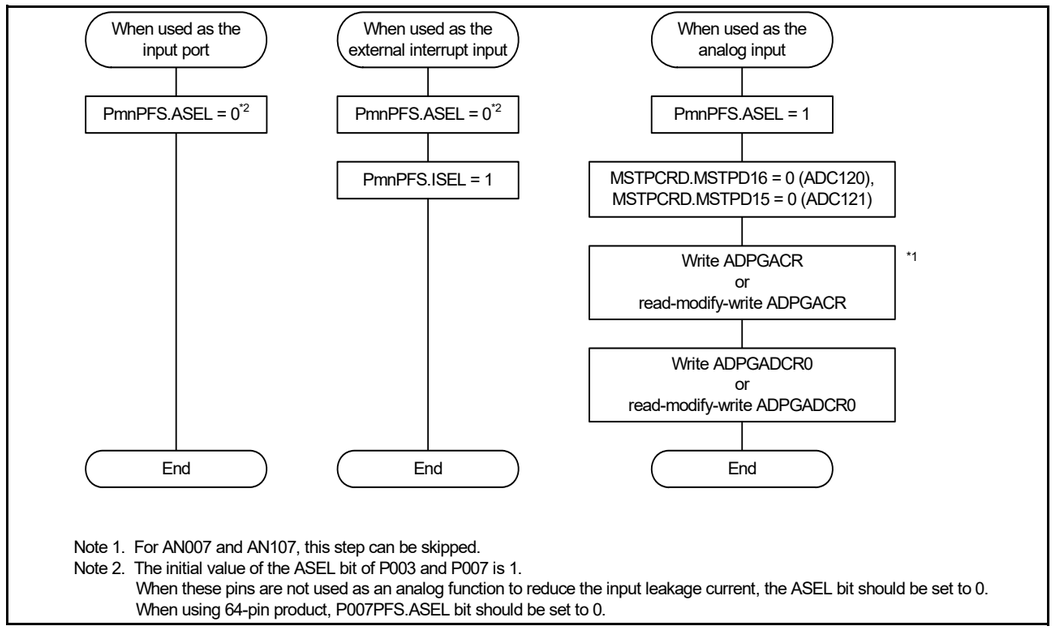
Table 35.14 可用功能和寄存器设置

可用功能						注册设置				
						P0nPFS*6		PGA		S/H*3
Ports*1	IRQ*2	S/H*3	PGA-S*4	PGA-D*5	ADC12	ASEL	ISEL	ADPGADCR0*7	ADPGACR*8	ADSHCR*9
✓						0	0	x	x	x
	✓					0	1	x	x	x
					✓*10	1	x	0	9h	0
					✓*11	1	x	0*11	0 or 9h	0
		✓			✓	1	x	0	9h	1 (0*13)
		✓	✓		✓	1	x	0	Eh (0h*12)	1 (0*13)
		✓		✓	✓	1	x	1	Eh (0h*12)	1 (0*13)
			✓		✓	1	x	0	Eh (0h*12)	0
				✓	✓	1	x	1	Eh (0h*12)	0

:可用x:不关
心

Note 1. 端口：P000至P007可用作端口输入。

Note 2. IRQ: P000 to P002 and P003 to P005 can be used as IRQ pins.
Note 3. S/H: sample-and-hold circuit.
Note 4. PGA-S: When the PGA setting is "pseudo-differential input disabled". Corresponding PGAVSS must be set as ASEL set to 1, and connected to AVSS0.
Note 5. PGA-D: When the PGA setting is "pseudo-differential input enabled". Corresponding PGAVSS must be set as ASEL to 1.
Note 6. P0nPFS: Port 0n Pin Function Select register (n = 00 to 07) corresponding to the analog input pin.
Note 7. Indicates the corresponding ADPGADCR0 register, Pseudo-Differential Input Enable bit (bit [11] or bit [7] or bit [3]).
Note 8. Indicates the corresponding ADPGACR register, Amplifier Control bits (bits [11:8] or bits [7:4] or bits [3:0]).
Note 9. Indicates the corresponding ADSHCR register, Bypass Select bit (bit [10] or bit [9] or bit [8]).
Note 10. When using AN000 to AN002 or AN100 to AN102.
Note 11. When using AN007 or AN107. Set all corresponding bits (bit [11], [7], and [3] in ADPGADCR0) to 0.
Note 12. Power consumption of the PGA can be reduced by setting the corresponding bit in the ADPGACR register to 0 before transitioning to the ADC12 module-stop state or Software Standby mode.
Note 13. Power consumption of the S/H can be reduced by setting the corresponding bit in the ADSHCR register to 0 before transitioning to the ADC12 module-stop state or Software Standby mode.



Note 1. For AN007 and AN107, this step can be skipped.
Note 2. The initial value of the ASEL bit of P003 and P007 is 1.
When these pins are not used as an analog function to reduce the input leakage current, the ASEL bit should be set to 0.
When using 64-pin product, P007PFS.ASEL bit should be set to 0.

Figure 35.41 Setting procedure of registers

35.6.9 Notes on Operating Modes and Status Bits

Initialize or set again individually, if necessary, the voltage values in self-diagnosis, the determination of the first scan or second scan in double-trigger mode, the data buffer pointer, and the status monitor in the compare function.

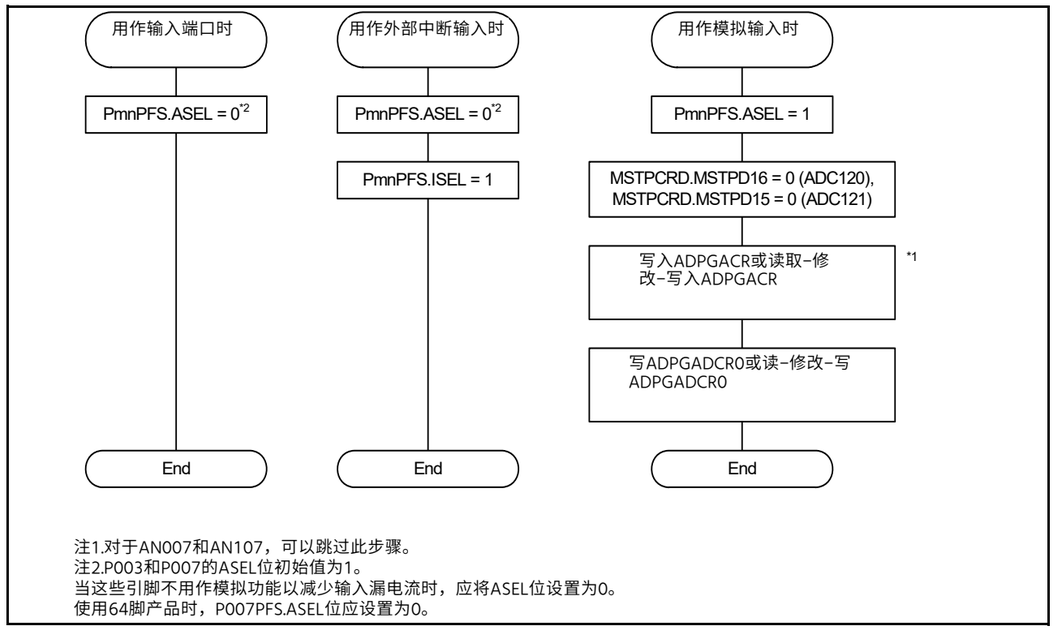
- Select the voltage values in self-diagnosis (ADCER.DIAGVAL[1:0]) after setting ADCER.DIAGLD to 1
- Double trigger mode operates as the first scan after setting ADCSR.DBLE to 1 from 0
- The status monitor bits (MONCMPA, MONCMPB, and MONCOMB) in the compare function are initialized after ADCMPCR.CMPAE and ADCMPCR.CMPBE are set to 0
- The constant sampling function (ADSHMSR.SHMD = 1) is initialized after ADSHMSR.SHMD is set to 0. When the constant sampling function is used (setting ADSHMSR.SHMD = 1) again, wait 1 ADCLK cycle or more.

35.6.10 Notes on Board Design

The board should be designed so that digital circuits and analog circuits are separated from each other as far as possible. In addition, digital circuit signal lines and analog circuit signal lines should not intersect or be placed near each other. If these rules are not followed, noise can occur on analog signals and A/D conversion accuracy is affected. The analog

Note 2. IRQ：P000到P002和P003到P005可用作IRQ引脚。
Note 3. S/H: sample-and-hold circuit.
Note 4. PGA-S：当PGA设置为"伪差分输入禁用"时。对应的PGAVSS必须设置为ASEL设置为1，并连接到AVSS0。

Note 5. PGA-D：当PGA设置为"启用伪差分输入"时。对应的PGAVSS必须设置为ASEL为1。
Note 6. P0nPFS：与模拟输入引脚对应的端口0n引脚功能选择寄存器（n=00至07）。
Note 7. 表示对应的ADPGADCR0寄存器，伪差分输入使能位（位[11]或位[7]或位[3]）。
Note 8. 指示相应的ADPGACR寄存器，放大器控制位（位[11:8]或位[7:4]或位[3:0]）。
Note 9. 表示对应的ADSHCR寄存器，旁路选择位（位[10]或位[9]或位[8]）。
注10.使用AN000至AN002或AN100至AN102时。
注11.使用AN007或AN107时。将所有相应位（ADPGADCR0中的位[11]、[7]和[3]）设置为0。
注12.PGA的功耗可以通过在转换到ADC12模块停止状态或软件待机模式之前将ADPGACR寄存器中的相应位设置为0来降低。注13.在转换到ADC12模块停止状态或软件待机模式之前，可以通过将ADSHCR寄存器中的相应位设置为0来降低SH的功耗。



注1.对于AN007和AN107，可以跳过此步骤。
注2.P003和P007的ASEL位初始值为1。
当这些引脚不用作模拟功能以减少输入漏电流时，应将ASEL位设置为0。
使用64脚产品时，P007PFS.ASEL位应设置为0。

Figure 35.41 寄存器的设置步骤

35.6.9 操作模式和状态位注意事项

必要时单独初始化或重新设置自诊断中的电压值、双触发模式下第一次扫描或第二次扫描的确定、数据缓冲区指针和比较功能中的状态监视器。

- 设置ADCER.DIAGLD为1后，选择自诊断中的电压值（ADCER.DIAGVAL[1:0]）
- 双触发模式在将ADCSR.DBLE从0设置为1后作为第一次扫描运行
- 比较函数中的状态监控位（MONCMPA、MONCMPB和MONCOMB）在之后初始化ADCMPCR.CMPAE和ADCMPCR.CMPBE设置为0
- 恒定采样功能（ADSHMSR.SHMD=1）在ADSHMSR.SHMD设置为0后初始化。当再次使用恒定采样功能（设置ADSHMSR.SHMD=1）时，等待1个ADCLK周期或更长时间。

35.6.10 电路板设计注意事项

电路板的设计应使数字电路和模拟电路尽可能分开。此外，数字电路信号线和模拟电路信号线不应交叉或靠近。如果不遵守这些规则，模拟信号上可能会出现噪声，影响AD转换精度。模拟

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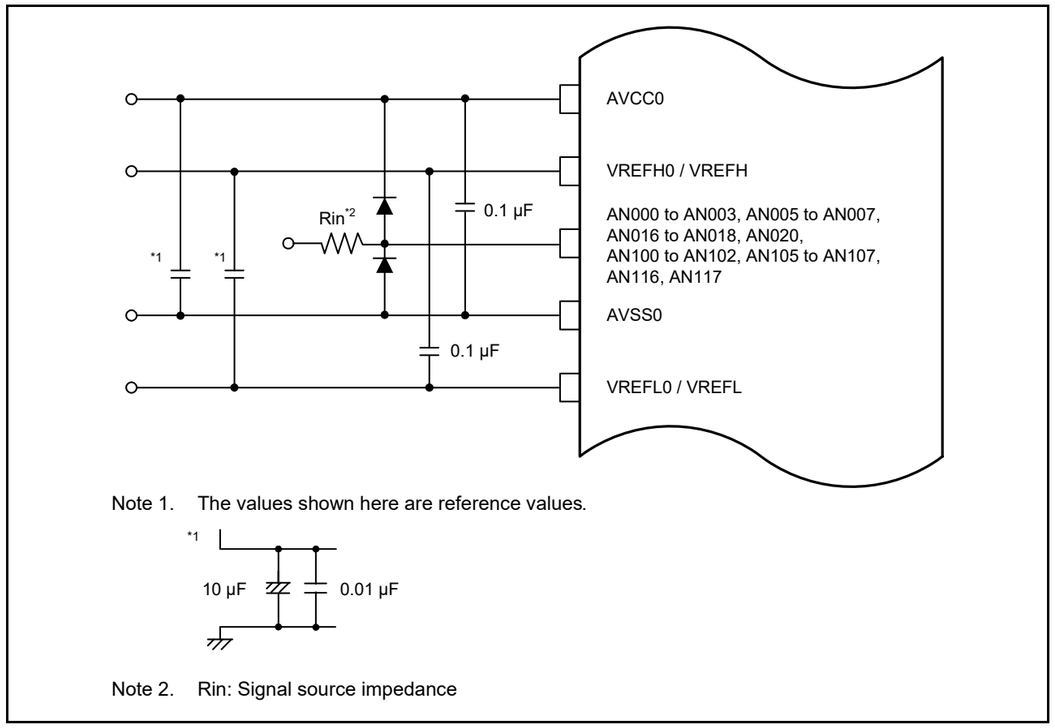
input pins (AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020, AN100 to AN102, AN105 to AN107, AN116, AN117), reference power supply pin (VREFH0/VREFH), reference ground pin (VREFL0/VREFL), and analog power supply (AVCC0) should be separated from digital circuits using the analog ground (AVSS0). The analog ground (AVSS0) should be connected to a stable digital ground (VSS) on the board (single-point ground plane connection).

35.6.11 Constraints on Noise Prevention

To prevent the analog input pins (AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020, AN100 to AN102, AN105 to AN107, AN116, AN117) from being destroyed by abnormal voltage such as excessive surges, insert a capacitor between AVCC0 and AVSS0, between VREFH0 and VREFL0, and between VREFH and VREFL, and connect a protection circuit to protect the analog input pins (AN000 to AN003, AN005 to AN007, AN016 to AN018, AN020, AN100 to AN102, AN105 to AN107, AN116, AN117) as shown Figure 35.42.



Note 1. The values shown here are reference values.

Note 2. Rin: Signal source impedance

Figure 35.42 Example protection circuit for analog inputs

35.6.12 Port Settings when Using the ADC12 Input

When using the high-precision channels, do not use PORT 0 as a digital output port. Renesas also recommends not using the digital output that is also used as the A/D analog input, if normal precision channels are used. If the digital output that is also used as the A/D analog input is used for output signals, perform A/D conversion several times, eliminate the maximum and minimum values, and obtain the average of the other results.

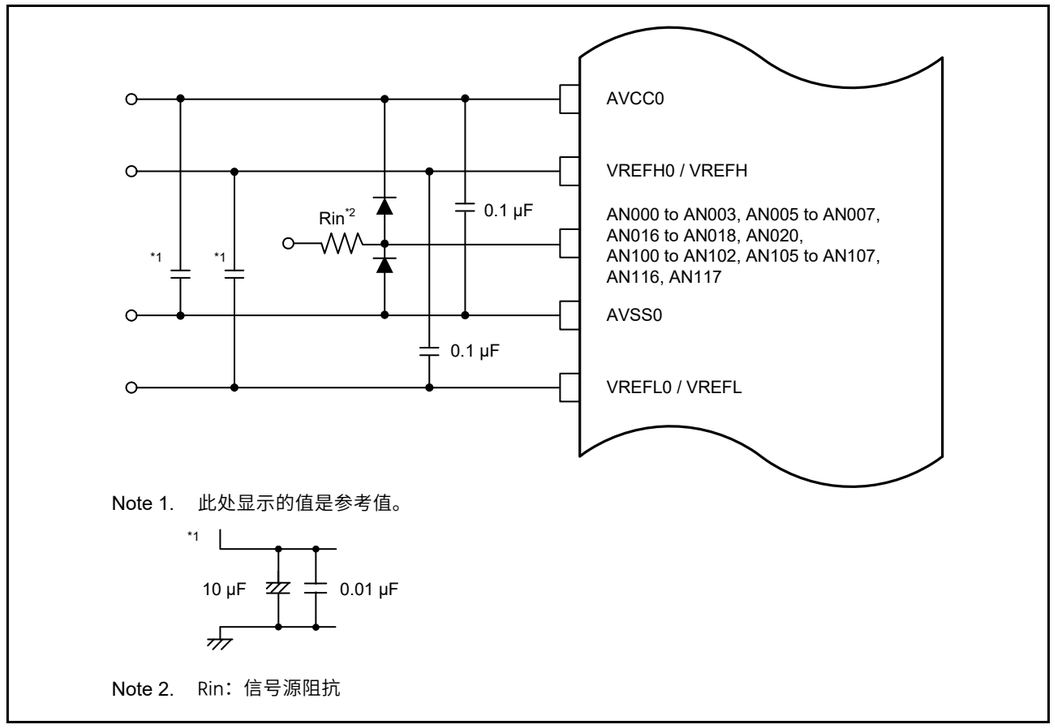
35.6.13 Relationship between ADC12 Units 0 and 1 and the ACMPHS

For the A/D conversion targets in Table 35.15, unit 0 and 1 cannot perform A/D conversion at the same time.

输入引脚（AN000至AN003、AN005至AN007、AN016至AN018、AN020、AN100至AN102、AN105至AN107、AN116、AN117）、参考电源引脚（VREFH0VREFH）、参考接地引脚（VREFL0VREFL）和模拟电源电源(AVCC0)应使用模拟地(AVSS0)与数字电路分开。模拟接地(AVSS0)应连接到板上的稳定数字接地(VSS)（单点接地层连接）。

35.6.11 防止噪音的限制

为了防止模拟输入引脚（AN000到AN003、AN005到AN007、AN016到AN018、AN020、AN100到AN102、AN105至AN107、AN116、AN117)以免被过大浪涌等异常电压破坏，在AVCC0和AVSS0之间、VREFH0和VREFL0之间以及VREFH和VREFL之间插入一个电容器，并连接一个保护电路以保护模拟输入引脚(AN000到AN003、AN005到AN007、AN016到AN018、AN020、AN100到AN102、AN105到AN107、AN116、AN117），如图35.42所示。



Note 1. 此处显示的值是参考值。

Note 2. Rin：信号源阻抗

Figure 35.42 模拟输入保护电路示例

35.6.12 使用ADC12输入时的端口设置

使用高精度通道时，请勿将PORT0用作数字输出端口。如果使用普通精密通道，瑞萨还建议不要使用也用作AD模拟输入的数字输出。如果将同时用作AD模拟输入的数字输出用于输出信号，则进行几次AD转换，消除最大值和最小值，取其他结果的平均值。

35.6.13 ADC12单元0和1与ACMPHS之间的关系

对于表35.15中的AD转换目标，单元0和单元1不能同时进行AD转换。

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Table 35.15 A/D conversion targets that are mutually exclusive with each other

A/D conversion target	
Unit 0	**Unit 1**
Temperature sensor	
Internal reference voltage	
AN005/DA0	AN105/DA0
AN006/DA1	AN106/DA1

The A/D conversion targets in Table 35.16 should not be selected as ACMPHS input during A/D conversion, because these pins are multiplexed with the ADC12 and ACMPHS.

Table 35.16 A/D conversion targets that are mutually exclusive with ACMPHS

A/D conversion target		
Unit 0	**Unit 1**	**ACMPHS**
AN000	-	ACMPHS0.IVCMP2
AN001	-	ACMPHS1.IVCMP2
AN002	-	ACMPHS2.IVCMP2
PGA P000 output	-	ACMPHS0.IVCMP3
PGA P001 output	-	ACMPHS1.IVCMP3
PGA P002 output	-	ACMPHS2.IVCMP3
AN005/DA0	-	ACMPHS0 to ACMPHS5.IVREF3
AN006/DA1	-	ACMPHS0 to ACMPHS5.IVCMP1
AN016	-	ACMPHS0 to ACMPHS5.IVREF0
AN017	-	ACMPHS0 to ACMPHS5.IVCMP0
Internal reference voltage	-	ACMPHS0 to ACMPHS5.IVREF2
-	AN100	ACMPHS3.IVCMP2
-	AN101	ACMPHS4.IVCMP2
-	AN102	ACMPHS5.IVCMP2
-	PGA P000 output	ACMPHS3.IVCMP3
-	PGA P001 output	ACMPHS4.IVCMP3
-	PGA P002 output	ACMPHS5.IVCMP3
-	AN105/DA0	ACMPHS3 to ACMPHS5.IVREF3
-	AN106/DA1	ACMPHS3 to ACMPHS5.IVCMP1
-	AN116	ACMPHS0 to ACMPHS5.IVREF1
-	Internal reference voltage	ACMPHS0 to ACMPHS5.IVREF2

Table 35.15 相互排斥的AD转换目标

AD转换目标	
Unit 0	**Unit 1**
温度感应器	
内部参考电压	
AN005/DA0	AN105/DA0
AN006/DA1	AN106/DA1

在AD转换期间，不应选择表35.16中的AD转换目标作为ACMPHS输入，因为这些引脚与ADC12和ACMPHS复用。

Table 35.16 与ACMPHS互斥的D转换目标

AD转换目标		
Unit 0	**Unit 1**	**ACMPHS**
AN000	-	ACMPHS0.IVCMP2
AN001	-	ACMPHS1.IVCMP2
AN002	-	ACMPHS2.IVCMP2
PGAP000输出	-	ACMPHS0.IVCMP3
PGAP001输出	-	ACMPHS1.IVCMP3
PGAP002输出	-	ACMPHS2.IVCMP3
AN005/DA0	-	ACMPHS0 to ACMPHS5.IVREF3
AN006/DA1	-	ACMPHS0 to ACMPHS5.IVCMP1
AN016	-	ACMPHS0 to ACMPHS5.IVREF0
AN017	-	ACMPHS0 to ACMPHS5.IVCMP0
内部参考电压	-	ACMPHS0 to ACMPHS5.IVREF2
-	AN100	ACMPHS3.IVCMP2
-	AN101	ACMPHS4.IVCMP2
-	AN102	ACMPHS5.IVCMP2
-	PGAP000输出	ACMPHS3.IVCMP3
-	PGAP001输出	ACMPHS4.IVCMP3
-	PGAP002输出	ACMPHS5.IVCMP3
-	AN105/DA0	ACMPHS3 to ACMPHS5.IVREF3
-	AN106/DA1	ACMPHS3 to ACMPHS5.IVCMP1
-	AN116	ACMPHS0 to ACMPHS5.IVREF1
-	内部参考电压	ACMPHS0 to ACMPHS5.IVREF2

RA生态工作室

36. 12-Bit D/A Converter (DAC12)

36.1 Overview

The MCU provides a 12-bit D/A Converter (DAC12) with an output amplifier.

Table 36.1 lists the DAC12 specifications, Figure 36.1 shows a block diagram, and Table 36.2 lists the I/O pins.

Table 36.1 DAC12 specifications

Parameter	Specifications
Resolution	12 bits
Output channels	2 channels
Interference reduction between analog modules	Methods provided to minimize interference between D/A and A/D conversion: • D/A converted data update timing is controlled by the ADC12 synchronous D/A conversion enable input signal from the ADC12 (unit 1) • Degradation of A/D conversion accuracy caused by interference is reduced by controlling the DAC12 inrush current generation timing with the enable signal
Module-stop function	Module-stop state can be set to reduce power consumption
Event link function (input)	DA0 and DA1 conversion can be started when an event signal is input
D/A output amplifier control function	Controls whether the output amplifier (for both amplifier-through and amplifier-bias controls) is used

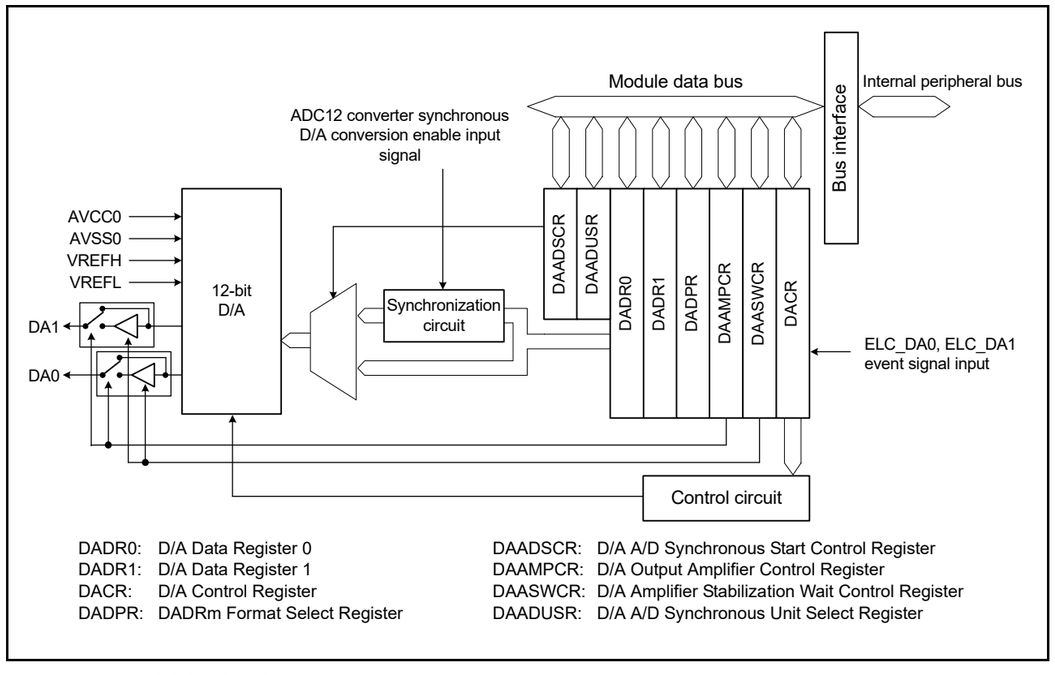


Figure 36.1 DAC12 block diagram

Table 36.2 DAC12 I/O pins (1 of 2)

Pin name	I/O	Function
AVCC0	Input	Analog power supply pin for ADC12, DAC12, and comparator. Connect to VCC when these modules are not used.

RA生态工作室

36. 12-Bit D/A Converter (DAC12)

36.1 Overview

MCU提供带输出放大器的12位DA转换器(DAC12)。

表36.1列出了DAC12规格，图36.1显示了框图，表36.2列出了IO引脚。

Table 36.1 DAC12 specifications

Parameter	Specifications
Resolution	12 bits
输出通道	2 channels
减少模拟模块之间的干扰	提供的用于将DA和AD转换之间的干扰降至最低的方法： DA转换数据更新时序由来自ADC12（单元1）的ADC12同步DA转换启用输入信号控制 通过控制DAC12可以减少由干扰引起的AD转换精度下降使用使能信号的浪涌电流产生时序
Module-stop function	可设置模块停止状态以降低功耗
事件链接功能（输入）	输入事件信号时可启动DA0和DA1转换
DA输出放大器控制功能	控制是否使用输出放大器（用于放大器直通和放大器偏置控制）

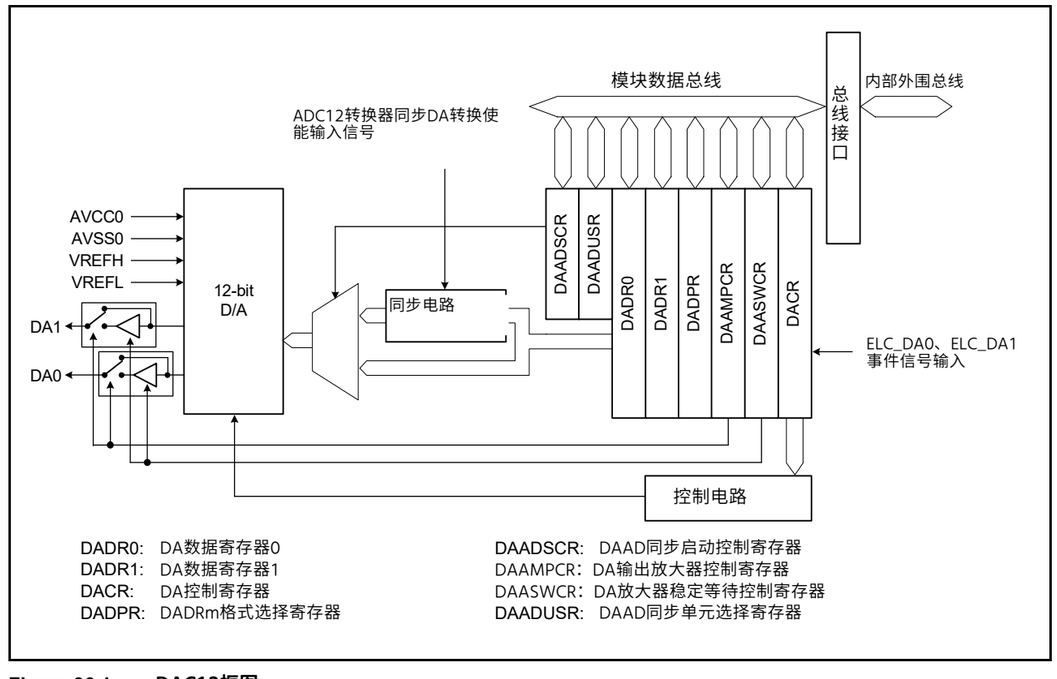


Figure 36.1 DAC12框图

Table 36.2 DAC12IO引脚（2个中的1个）

引脚名称	I/O	Function
AVCC0	Input	ADC12、DAC12和比较器的模拟电源引脚。 不使用这些模块时连接到VCC。

Table 36.2 DAC12 I/O pins (2 of 2)

Pin name	I/O	Function
AVSS0	Input	Analog ground pin for ADC12, DAC12, and comparator. Connect to VSS when these modules are not used.
VREFH	Input	Analog reference top voltage supply pin for the ADC12 (unit 1) and the DAC12
VREFL	Input	Analog reference ground pin for the ADC12 (unit 1) and the DAC12
DA0	Output	Channel 0 analog output pin
DA1	Output	Channel 1 analog output pin

36.2 Register Descriptions

36.2.1 D/A Data Register m (DADRm) (m = 0, 1)

Address(es): DAC12.DADR0 4005 E000h, DAC12.DADR1 4005 E002h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DADRm registers are 16-bit read/write registers that store data for D/A conversion. When an analog output is enabled, the values in DADRm are converted and output to the analog output pins.

12-bit data can be formatted as left- or right-justified in the DADPR.DPSEL bit setting. In right-justified format (DADPR.DPSEL = 0), the lower 12 bits, [11:0], are valid. In left-justified format (DADPR.DPSEL = 1), the upper 12 bits, [15:4], are valid.

For information on using the output amplifier, see section 36.6.5, Initialization Procedure with the Output Amplifier.

36.2.2 D/A Control Register (DACR)

Address(es): DAC12.DACR 4005 E004h

	b7	b6	b5	b4	b3	b2	b1	b0
	DAOE1	DAOE0	DAE	—	—	—	—	—
Value after reset:	0	0	0	1	1	1	1	1

Bit	Symbol	Bit name	Description	R/W
b4 to b0	—	Reserved	These bits are read as 1. The write value should be 1.	R/W
b5	DAE	D/A Enable*1	0: Control D/A conversion of channels 0 and 1 individually 1: Control D/A conversion of channels 0 and 1 collectively.	R/W
b6	DAOE0	D/A Output Enable 0	0: Disable analog output of channel 0 (DA0) 1: Enable D/A conversion of channel 0 (DA0).	R/W
b7	DAOE1	D/A Output Enable 1	0: Disable analog output of channel 1 (DA1) 1: Enable D/A conversion of channel 1 (DA1).	R/W

Note 1. This bit controls D/A conversion in combination with the DAOEi bit (i = 0, 1), which controls the output of the conversion results. For details, see Table 36.3.

Table 36.2 DAC12IO引脚（2个中的2个）

引脚名称	I/O	Function
AVSS0	Input	ADC12、DAC12和比较器的模拟接地引脚。 不使用这些模块时连接到VSS。
VREFH	Input	ADC12（单元1）和DAC12的模拟参考最高电压电源引脚
VREFL	Input	ADC12（单元1）和DAC12的模拟参考接地引脚
DA0	Output	通道0模拟输出引脚
DA1	Output	通道1模拟输出引脚

36.2 注册说明

36.2.1 DA数据寄存器m(DADRm)(m=0 1)

Address(es): DAC12.DADR0 4005 E000h, DAC12.DADR1 4005 E002h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DADRm寄存器是16位读写寄存器，用于存储用于DA转换的数据。当启用模拟输出时，DADRm中的值将被转换并输出到模拟输出引脚。

在DADPR.DPSEL位设置中，12位数据可以被格式化为左对齐或右对齐。在右对齐格式(DADPR.DPSEL=0)中，低12位[11:0]有效。在左对齐格式(DADPR.DPSEL=1)中，高12位[15:4]有效。

有关使用输出放大器的信息，请参阅第36.6.5节，使用输出放大器的初始化过程。

36.2.2 DA控制寄存器(DACR)

Address(es): DAC12.DACR 4005 E004h

	b7	b6	b5	b4	b3	b2	b1	b0
	DAOE1	DAOE0	DAE	—	—	—	—	—
重置后的值：	0	0	0	1	1	1	1	1

Bit	Symbol	位名称	Description	R/W
b4 to b0	—	Reserved	这些位被读取为1。写入值应为1。	R/W
b5	DAE	D/A Enable*1	0：分别控制通道0和1的DA转换1：控制通道0和1的DA转换。	R/W
b6	DAOE0	DA输出使能0	0：禁用通道0（DA0）的模拟输出1：启用通道0（DA0）的DA转换。	R/W
b7	DAOE1	DA输出使能1	0：禁用通道1（DA1）的模拟输出1：启用通道1（DA1）的DA转换。	R/W

Note 1. 该位与DAOEi位(i=0 1)一起控制DA转换，DAOEi位控制转换结果的输出。
详见表36.3。

Table 36.3 D/A conversion controls

b5	b7	b6	
DAE	DAOE1	DAOE0	Description
0	0	0	Disable D/A conversion and analog output pins (DA0, DA1)*1
		1	• Enable D/A conversion of channel 0 and disable D/A conversion of channel 1 • Enable analog output of channel 0 (DA0) and disable analog output of channel 1 (DA1)*1.
	1	0	• Disable D/A conversion of channel 0 and enable D/A conversion of channel 1 • Disable analog output of channel 0 (DA0)*1 and enable analog output of channel 1 (DA1).
		1	• Enable D/A conversion of channels 0 and 1 • Enable analog output of channels 0 and 1 (DA0, DA1).
1	x	x	• Enable D/A conversion of channels 0 and 1 • Collective enable analog output of channels 0 and 1 (DA0, DA1).

x: Don't care

Note 1. When analog output is disabled, the analog output signal is placed in the Hi-Z state.

Only set this register while the ADC12 is halted when the DAADSCR.DAADST bit is 1 (interference prevention between D/A and A/D conversion is enabled). Only set DACR while the ADCSR.ADST bit is 0 and after selecting the software trigger, for the ADC12 trigger to securely stop the ADC12. This MCU only supports ADC12 unit 1.

DAE bit (D/A Enable)

The DAE bit controls D/A conversion, amplifier operation, and analog output in combination with the DAOEi bit (i = 0, 1) and the DAMMPCR.DAAMPi bit (i = 0, 1). See Table 36.4.

When interference prevention between D/A and A/D conversions is enabled (DAADSCR.DAADST = 1), set the ADCSR.ADST bit of the ADC12 to 0. Then, select the software trigger for the ADC12 trigger to securely stop the ADC12.

DAOEi bit (D/A Output Enable i)

The DAOEi bit (i = 0, 1) controls D/A conversion, amplifier operation, and analog output in combination with the DAE bit and DAMMPCR.DAAMPi bit (i = 0, 1). See Table 36.4.

When both the DAOEi (i = 0, 1) and DAE bits are 0, D/A conversion of channel i (i = 0, 1) is not processed, and no conversion result is output.

When interference prevention between D/A and A/D conversions is enabled (DAADSCR.DAADST = 1), set the DAOEi bit while the ADCSR.ADST bit of the ADC12 is 0. Then, select the software trigger for the ADC12 trigger to securely stop the ADC12.

The event link function can be used to set the DAOEi bit to 1. The DAOE0 bit is set to 1 when the event specified in the ELSR12 register of the ELC (ELC_DA0 event) occurs, and output of the D/A conversion results starts. The DAOE1 bit is set to 1 when the event specified in the ELSR13 register of the ELC (ELC_DA1 event) occurs, and output of the D/A conversion results starts.

Table 36.4 D/A conversion and analog output control (1 of 2)

DACR		DAAMPCR			
DAE	DAOEi	DAAMPi	Channel i operation	Amplifier operation of channel i	Analog output of channel i
0	0	0	Stop	Stop	Hi-Z
		1	Stop	Stop	Hi-Z
	1	0	Run	Stop	Amplifier-through
		1	Run	Run	Amplifier output

Table 36.3 DA转换控制

b5	b7	b6	
DAE	DAOE1	DAOE0	Description
0	0	0	禁用DA转换和模拟输出引脚（DA0、DA1）*1
		1	启用通道0的DA转换并禁用通道1的DA转换 启用通道0(DA0)的模拟输出并禁用通道1(DA1)*1的模拟输出。
	1	0	禁用通道0的DA转换并启用通道1的DA转换 禁用通道0(DA0)*1的模拟输出并启用通道1(DA1)的模拟输出。
		1	启用通道0和1的DA转换 启用通道0和1（DA0、DA1）的模拟输出。
1	x	x	启用通道0和1的DA转换 共同启用通道0和1（DA0、DA1）的模拟输出。

x: Don't care

Note 1. 禁用模拟输出时，模拟输出信号置于Hi-Z状态。

仅当DAADSCR.DAADST位为1（启用DA和AD转换之间的干扰防止）时ADC12停止时设置该寄存器。只有在ADCSR.ADST位为0且选择软件触发后设置DACR，ADC12触发才能安全停止ADC12。此MCU仅支持ADC12单元1。

DAE位（DA启用）

DAE位与DAOEi位(i=0 1)和DAMMPCR.DAAMPi位(i=0 1)一起控制DA转换、放大器操作和模拟输出。见表36.4。

当启用DA和AD转换之间的干扰防止(DAADSCR.DAADST=1)时，设置ADC12的ADCSR.ADST位为0。然后，选择ADC12触发的软件触发以安全停止ADC12。

DAOEi位（DA输出使能i）

DAOEi位(i=0 1)与DAE位和DAMMPCR.DAAMPi位(i=0 1)一起控制DA转换、放大器操作和模拟输出。见表36.4。

当DAOEi(i=0 1)和DAE位均为0时，通道i(i=0 1)的DA转换不进行处理，不输出转换结果。

当DA和AD转换之间的干扰防止启用时（DAADSCR.DAADST=1），在ADC12的ADCSR.ADST位为0时设置DAOEi位。然后，选择ADC12触发的软件触发以安全停止ADC12。

事件链接功能可用于将DAOEi位设置为1。当ELC的ELSR12寄存器中指定的事件（ELC_DA0事件）发生时，DAOE0位设置为1，并开始输出DA转换结果。当发生ELC的ELSR13寄存器中指定的事件（ELC_DA1事件）时，DAOE1位设置为1，并开始输出DA转换结果。

Table 36.4 DA转换和模拟输出控制(1of2)

DACR		DAAMPCR			
DAE	DAOEi	DAAMPi	通道i操作	通道i的放大器操作	通道i的模拟输出
0	0	0	Stop	Stop	Hi-Z
		1	Stop	Stop	Hi-Z
	1	0	Run	Stop	Amplifier-through
		1	Run	Run	放大器输出

Table 36.4 D/A conversion and analog output control (2 of 2)

DACR		DAAMPCR			
DAE	DAOEi	DAAMPi	Channel i operation	Amplifier operation of channel i	Analog output of channel i
1	0	0	Run	Stop	Amplifier-through
		1	Run	Run	Amplifier output
	1	0	Run	Stop	Amplifier-through
		1	Run	Run	Amplifier output

i = 0, 1

36.2.3 DADRm Format Select Register (DADPR)

Address(es): DAC12.DADPR 4005 E005h

	b7	b6	b5	b4	b3	b2	b1	b0
	DPSEL	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b6 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	DPSEL	DADRm Format Select	0: Right-justified format 1: Left-justified format.	R/W

36.2.4 D/A A/D Synchronous Start Control Register (DAADSCR)

Address(es): DAC12.DAADSCR 4005 E006h

	b7	b6	b5	b4	b3	b2	b1	b0
	DAADST	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b6 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	DAADST	D/A A/D Synchronous Conversion	0: Do not synchronize DAC12 operation with ADC12 (unit 1) operation (disable interference prevention between D/A and A/D conversion) 1: Synchronize DAC12 operation with ADC12 (unit 1) operation (enable interference prevention between D/A and A/D conversion).	R/W

To minimize interference between D/A and A/D conversion, the DAADSCR register enables synchronization of the start timing of D/A conversion with the ADC12 synchronous D/A conversion enable input signal.

Note: This MCU only supports ADC12 unit 1.

Only set this register while the ADC12 is halted, that is, while the ADCSR.ADST bit is 0 after selecting the software trigger as the ADC12 trigger.

Select unit 1 as the target ADC12 unit before setting the DAADST bit to 1. Set bit [1] in the DAADUSR register to 1 to select unit 1.

DAADST bit (D/A A/D Synchronous Conversion)

Setting the DAADST bit to 0 allows the DADRm register value to be converted into analog data at any time. Setting the DAADST bit to 1 allows synchronous D/A conversion with the ADC12 synchronous D/A conversion enable input signal from the ADC12. With this bit set, D/A conversion does not start until the ADC12 completes A/D conversion, even if the

Table 36.4 DA转换和模拟输出控制(2of2)

DACR		DAAMPCR			
DAE	DAOEi	DAAMPi	通道i操作	通道i的放大器操作	通道i的模拟输出
1	0	0	Run	Stop	Amplifier-through
		1	Run	Run	放大器输出
	1	0	Run	Stop	Amplifier-through
		1	Run	Run	放大器输出

i = 0, 1

36.2.3 DADRm格式选择寄存器(DADPR)

Address(es): DAC12.DADPR 4005 E005h

	b7	b6	b5	b4	b3	b2	b1	b0
	DPSEL	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b6 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	DPSEL	DADRm格式选择	0: Right-justified format 1: Left-justified format.	R/W

36.2.4 DAAD同步启动控制寄存器(DAADSCR)

Address(es): DAC12.DAADSCR 4005 E006h

	b7	b6	b5	b4	b3	b2	b1	b0
	DAADST	—	—	—	—	—	—	—
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b6 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	DAADST	D/A A/D Synchronous Conversion	0：不将DAC12操作与ADC12（单元1）操作同步（禁用DA和AD转换之间的防干扰）1：将DAC12操作与ADC12（单元1）操作同步（启用DA和AD转换之间的防干扰）。	R/W

为了尽量减少DA和AD转换之间的干扰，DAADSCR寄存器使DA转换的开始时序与ADC12同步DA转换使能输入信号同步。

Note: 此MCU仅支持ADC12单元1。

仅在ADC12停止时设置该寄存器，即选择软件触发作为ADC12触发后ADCSR.ADST位为0。

在将DAADST位设置为1之前选择单元1作为目标ADC12单元。将DAADUSR寄存器中的位[1]设置为1以选择单元1。

DAADST位（DAAD同步转换）

将DAADST位设置为0可以随时将DADRm寄存器值转换为模拟数据。将DAADST位设置为1允许使用来自ADC12的ADC12同步DA转换使能输入信号进行同步DA转换。设置该位后，直到ADC12完成AD转换，DA转换才会开始，即使

DADRm register value is changed.

Set this bit while the ADCSR.ADST bit is set to 0. Then, select the software trigger for the ADC12 trigger to securely stop the ADC12. Set bit [1] in the DAADUSR register to 1 before setting the DAADST bit to 1.

The event link function cannot be used when the DAADST bit is set to 1. Stop the event link function by setting the ELSR12 and ELSR13 registers of the ELC. The setting of the DAADST bit is shared by channels 0 and 1 of the DAC12.

36.2.5 D/A Output Amplifier Control Register (DAAMPCR)

Address(es): DAC12.DAAMPCR 4005 E008h

	b7	b6	b5	b4	b3	b2	b1	b0
	DAAMP1	DAAMP0	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b5 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	DAAMP0	Amplifier Control 0	0: Do not use channel 0 output amplifier 1: Use channel 0 output amplifier.	R/W
b7	DAAMP1	Amplifier Control 1	0: Do not use channel 1 output amplifier 1: Use channel 1 output amplifier.	R/W

The DAAMPCR register selects D/A output with or without using the amplifier.

DAAMP0 bit (Amplifier Control 0)

When the DAAMP0 bit is 0, analog values are output for D/A output of channel 0 without using the amplifier. When the DAAMP0 bit is 1, analog values are output for D/A output of channel 0 through the amplifier.

When both the DAE and DAOE0 bits are 0, the amplifier is not used regardless of the setting of the DAAMP0 bit. See Table 36.4 for details.

DAAMP1 bit (Amplifier Control 1)

When the DAAMP1 bit is 0, analog values are output for D/A output of channel 1 without using the amplifier. When the DAAMP1 bit is 1, analog values are output for D/A output of channel 1 through the amplifier.

When both the DAE and DAOE1 bits are 0, the amplifier is not used regardless of the setting of the DAAMP1 bit. See Table 36.4 for details.

36.2.6 D/A Amplifier Stabilization Wait Control Register (DAASWCR)

Address(es): DAC12.DAASWCR 4005 E01Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	DAASW1	DAASW0	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b5 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b6	DAASW0	D/A Amplifier Stabilization Wait 0	0: Amplifier stabilization wait off (output) for channel 0 1: Amplifier stabilization wait on (Hi-Z) for channel 0.	R/W
b7	DAASW1	D/A Amplifier Stabilization Wait 1	0: Amplifier stabilization wait off (output) for channel 1 1: Amplifier stabilization wait on (Hi-Z) for channel 1.	R/W

The DAASWCR register controls D/A output with the output amplifier. This register is used in the initialization

DADRm寄存器值被更改。

在ADCSR.ADST位设置为0时设置该位。然后，选择ADC12触发的软件触发以安全地停止ADC12。在将DAADST位设置为1之前，将DAADUSR寄存器中的位[1]设置为1。

当DAADST位设置为1时，不能使用事件链接功能。通过设置ELC的ELSR12和ELSR13寄存器。DAADST位的设置由DAC12的通道0和1共享。

36.2.5 DA输出放大器控制寄存器(DAAMPCR)

Address(es): DAC12.DAAMPCR 4005 E008h

	b7	b6	b5	b4	b3	b2	b1	b0
	DAAMP1	DAAMP0	—	—	—	—	—	—
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b5 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	DAAMP0	放大器控制0	0：不使用通道0输出放大器1：使用通道0输出放大器。	R/W
b7	DAAMP1	放大器控制1	0：不使用通道1输出放大器1：使用通道1输出放大器。	R/W

DAAMPCR寄存器选择使用或不使用放大器的DA输出。

DAAMP0位（放大器控制0）

当DAAMP0位为0时，模拟值输出通道0的DA输出，而不使用放大器。当。。。的时候DAAMP0位为1，模拟值通过放大器输出通道0的DA输出。

当DAE和DAOE0位都为0时，无论DAAMP0位的设置如何，都不会使用放大器。看详细信息见表36.4。

DAAMP1位（放大器控制1）

当DAAMP1位为0时，模拟值输出通道1的DA输出，而不使用放大器。当。。。的时候DAAMP1位为1，模拟值通过放大器输出到通道1的DA输出。

当DAE和DAOE1位都为0时，无论DAAMP1位的设置如何，都不会使用放大器。看详细信息见表36.4。

36.2.6 DA放大器稳定等待控制寄存器(DAASWCR)

Address(es): DAC12.DAASWCR 4005 E01Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	DAASW1	DAASW0	—	—	—	—	—	—
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b5 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b6	DAASW0	DA放大器稳定等待0	0：通道0的放大器稳定等待关闭（输出）1：通道0的放大器稳定等待打开（Hi-Z）。	R/W
b7	DAASW1	DA放大器稳定等待1	0：通道1的放大器稳定等待关闭（输出）1：通道1的放大器稳定等待打开（Hi-Z）。	R/W

DAASWCR寄存器通过输出放大器控制DA输出。该寄存器用于初始化

procedure to wait for stabilization of the D/A output amplifier. Each bit in DAASWCR should be set to 1 when both the DAE and the DAOEi (i = 0, 1) bits in the DACR register are 0. See section 36.6.5, Initialization Procedure with the Output Amplifier.

DAASW0 bit (D/A Amplifier Stabilization Wait 0)

Set the DAASW0 bit to 1 in the initialization procedure to wait for the stabilization of the D/A channel 0 output amplifier. When DAASW0 is set to 1, D/A conversion operates, but the conversion result of D/A is not output from channel 0. When the DAASW0 bit is 0, the stabilization wait time stops, and the D/A conversion result of channel 0 is output through the output amplifier.

DAASW1 bit (D/A Amplifier Stabilization Wait 1)

Set the DAASW1 bit to 1 in the initialization procedure to wait for the stabilization of the D/A channel 1 output amplifier. When DAASW1 is set to 1, D/A conversion operates, but the conversion result of D/A is not output from channel 1. When the DAASW1 bit is 0, the stabilization wait time stops, and the D/A conversion result of channel 1 is output through the output amplifier.

36.2.7 D/A A/D Synchronous Unit Select Register (DAADUSR)

Address(es): DAC12.DAADUSR 4005 F0C0h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	AMADSEL1	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	—	Reserved	This bit is read as 0. The write value should be 0.	R/W
b1	AMADSEL1	A/D Unit 1 Select	0: Do not select unit 1 1: Select unit 1.	R/W
b7 to b2	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The DAADUSR register selects the target ADC12 unit for D/A and A/D synchronous conversions. Set bit [1] to 1 to select unit 1 as the target synchronous unit for the MCU. When setting the DAADSCR.DAADST bit to 1 for synchronous conversions, select the target unit in this register in advance.

Only set the DAADUSR register while the ADCSR.ADST bit of the ADC12 is 0 and the DAADSCR.DAADST bit is set to 0.

36.3 Operation

DAC12 includes D/A conversion circuits for two channels, each of which can operate independently. When the DAOEn bit (n = 0, 1) in DACR is set to 1, DAC12 is enabled and the conversion result is output.

The following example shows D/A conversion on channel 0. Figure 36.2 shows the timing of this operation.

To process D/A conversion on channel 0:

1. Set the data for D/A conversion in the DADPR.DPSEL bit and the DADR0 register.
2. Set the DACR.DAOE0 bit to 1 to start D/A conversion. The conversion result is output from the analog output pin DA0 after the conversion time tDCONV elapses. The conversion result continues to be output until DADR0 is written to again or the DAOE0 bit is set to 0. The output value (reference) is expressed by the following formula:

$$\frac{\text{Setting in DADRm}}{4096} \times \text{VREFH}$$

3. To start another conversion, write another value to DADR0. The conversion result is output after the conversion time t_{DCONV} elapses.
When the DAADSCR.DAADST bit is 1 (interference reduction between D/A and A/D conversion is enabled), a

程序等待DA输出放大器稳定。当DACR寄存器中的DAE和DAOEi(i=0 1)位都为0时，DAASWCR中的每个位都应设置为1。请参见第36.6.5节，使用
输出放大器。

DAASW0位（DA放大器稳定等待0）

在初始化过程中将DAASW0位设置为1，以等待DA通道0输出放大器稳定。当DAASW0设置为1时，DA转换进行，但DA的转换结果不从通道0输出。当DAASW0位为0时，稳定等待时间停止，通过输出输出通道0的DA转换结果放大器。

DAASW1位（DA放大器稳定等待1）

在初始化过程中将DAASW1位设置为1，以等待DA通道1输出放大器稳定。当DAASW1设置为1时，DA转换进行，但DA的转换结果不从通道1输出。当DAASW1位为0时，稳定等待时间停止，通道1的DA转换结果通过输出输出放大器。

36.2.7 DAAD同步单元选择寄存器(DAADUSR)

Address(es): DAC12.DAADUSR 4005 F0C0h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	AMADSEL1	—
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	—	Reserved	该位读取为0。写入值应为0。	R/W
b1	AMADSEL1	AD单元1选择	0：不选择单元11： 选择单元1。	R/W
b7 to b2	—	Reserved	这些位被读取为0。写入值应为0。	R/W

DAADUSR寄存器为DA和AD同步转换选择目标ADC12单元。将位[1]设置为1以选择单元1作为MCU的目标同步单元。将DAADSCR.DAADST位设置为1以进行同步转换时，请预先在该寄存器中选择目标单位。

仅当ADC12的ADCSR.ADST位为0且DAADSCR.DAADST位设置为0时才设置DAADUSR寄存器。

36.3 Operation

DAC12包含两个通道的DA转换电路，每个通道都可以独立工作。当DACR中的DAOEn位(n=0 1)设置为1时，DAC12使能并输出转换结果。

以下示例显示通道0上的DA转换。图36.2显示了此操作的时序。

在通道0上处理DA转换：

1. 在DADPR.DPSEL位和DADR0寄存器中设置用于DA转换的数据。
2. 将DACR.DAOE0位设置为1以启动DA转换。转换结果从模拟输出引脚输出
转换时间tDCONV过后的DA0。转换结果继续输出，直到再次写入DADR0或将DAOE0位设置为0。输出值（参考值）由以下公式表示：

$$\frac{\text{DADRm4096中的设置}}{} \times \text{VREFH}$$

3. 要开始另一次转换，请将另一个值写入DADR0。在经过转换时间tDCONV后输出转换结果。当DAADSCR.DAADST位为1（启用DA和AD转换之间的干扰降低）时，a

maximum of one A/D conversion time is required for D/A conversion to start. When ADCLK is faster than the peripheral clock, a longer time period might be required.

4. To disable analog output, set the DAOE0 bit to 0.

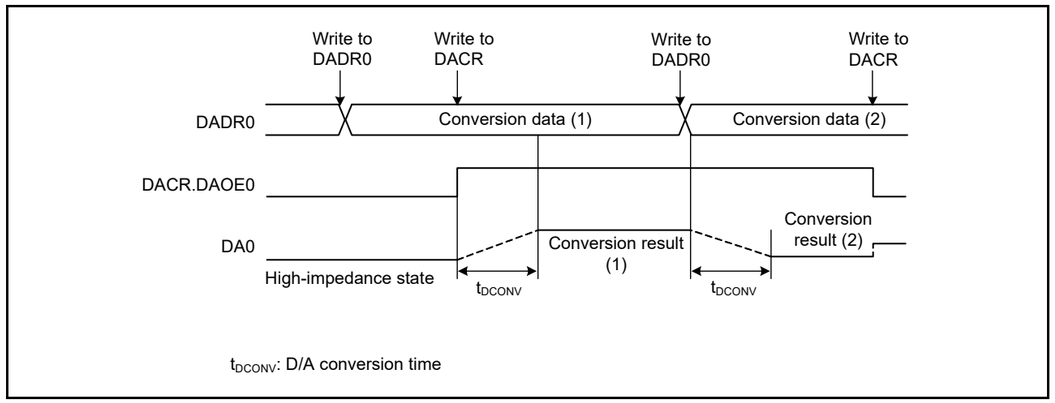


Figure 36.2 Example of DAC12 operation

36.3.1 Reducing Interference between D/A and A/D Conversion

When D/A conversion starts, the DAC12 generates inrush current. Because the DAC12 and ADC12 share the same analog power supply, the generated inrush current can interfere with ADC12 operation.

While the DAADSCR.DAADST bit is 1, even if the DADRm register data is changed during ADC12 operation, D/A conversion does not start immediately but starts synchronously with A/D conversion completion. A maximum of one A/D conversion time is required for the DADRm register data update to be reflected as the D/A conversion circuit input. Before reflection, the DADRm register value does not correspond to the analog output value.

When this function is enabled, it is not possibles to check through software whether the DADRm register value was D/A converted. When the DADRm register data is changed while the ADC12 is halted, D/A conversion starts in 1 PCLKB cycle, even if DAADSCR.DAADST is 1.

The following sequence provides an example of channel 0 D/A conversion, in which the DAC12 operates synchronously with the ADC12.

To perform D/A conversion on channel 0 in synchronization with the ADC12:

1. Confirm that the ADC12 is halted and set the DAADUSR.AMADSEL1 bit to 1.
2. Confirm that the ADC12 is halted and set the DAADSCR.DAADST bit to 1.
3. Confirm that the ADC12 is halted and set the DACR.DAOE0 bit to 1.
4. Set the DADR0 register. If ADCLK is faster than the peripheral clock, a period longer than one A/D conversion time might be required.

- If the 12-bit A/D conversion is halted (ADCSR.ADST bit = 0) when the DADR0 register is modified, D/A conversion starts in 1 PCLKB cycle
- If the 12-bit A/D conversion is in progress (ADCSR.ADST bit = 1) when the DADR0 register is modified, D/A conversion starts on A/D conversion completion. If the DADR0 register is modified twice during A/D conversion, the first update might not be converted.

DA转换开始最多需要一个AD转换时间。当ADCLK比外设时钟快时，可能需要更长的时间周期。

4. 要禁用模拟输出，请将DAOE0位设置为0。

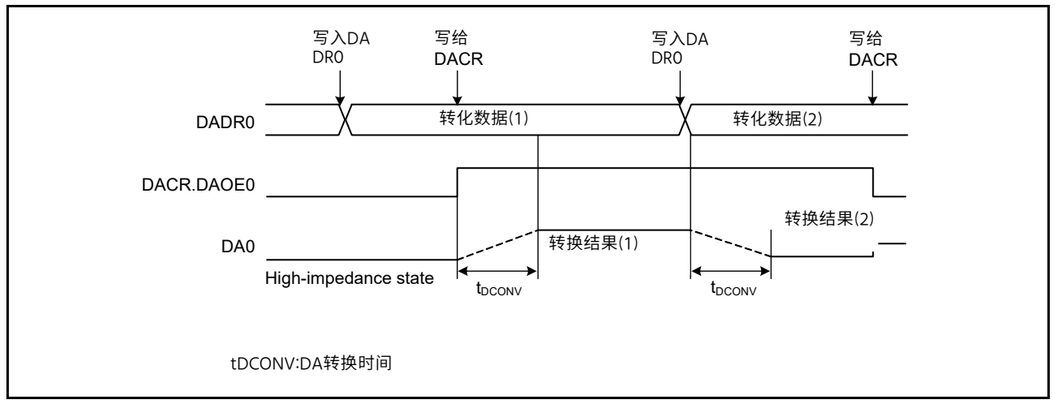


Figure 36.2 DAC12操作示例

36.3.1 减少DA和AD转换之间的干扰

当DA转换开始时，DAC12会产生浪涌电流。由于DAC12和ADC12共用同一个模拟电源，产生的浪涌电流会干扰ADC12的运行。

当DAADSCR.DAADST位为1时，即使在ADC12操作期间更改DADRm寄存器数据，DA转换也不会立即开始，而是与AD转换完成同步开始。DADRm寄存器数据更新最多需要一个AD转换时间才能反映为DA转换电路输入。

反射前，DADRm寄存器值与模拟输出值不对应。

当此功能使能时，无法通过软件检查DADRm寄存器值是否经过DA转换。如果在ADC12停止时更改DADRm寄存器数据，即使DAADSCR.DAADST为1，DA转换也会在1个PCLKB周期内开始。

以下序列提供了通道0DA转换的示例，其中DAC12与ADC12同步运行。

与ADC12同步在通道0上执行DA转换：

1. 确认ADC12已停止并将DAADUSR.AMADSEL1位设置为1。
2. 确认ADC12已停止并将DAADSCR.DAADST位设置为1。
3. 确认ADC12已停止并将DACR.DAOE0位设置为1。
4. 设置DADR0寄存器。如果ADCLK比外设时钟快，则可能需要比一个AD转换时间更长的周期。

- 如果在修改DADR0寄存器时停止12位AD转换（ADCSR.ADST位=0），则DA转换在1个PCLKB周期内开始
- 如果修改DADR0寄存器时12位AD转换正在进行（ADCSR.ADST位=1），则DA转换在AD转换完成时开始。如果在AD转换期间DADR0寄存器被修改两次，第一次更新可能不会被转换。

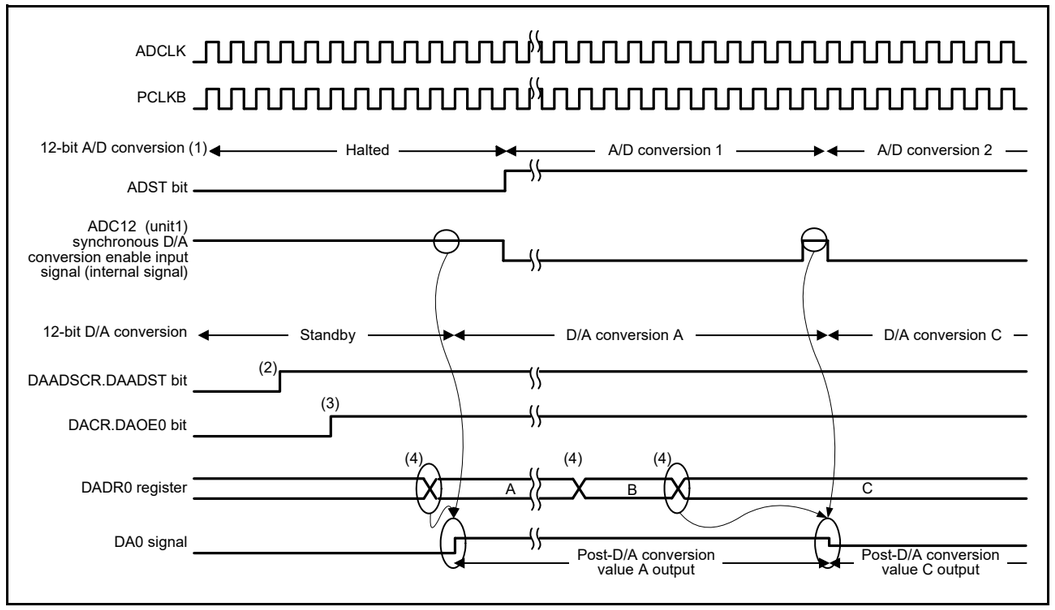


Figure 36.3 Example of conversion when the DAC12 is synchronized with the ADC12

When ADCLK is faster than PCLKB, the DAC12 might not be able to capture an ADC12 synchronous D/A conversion enable input signal during the 1 ADCLK cycle that is output between A/D conversion 1 and A/D conversion 2, as shown in Figure 36.4. In this case, post-D/A conversion value A is continuously output as the DA0 signal.

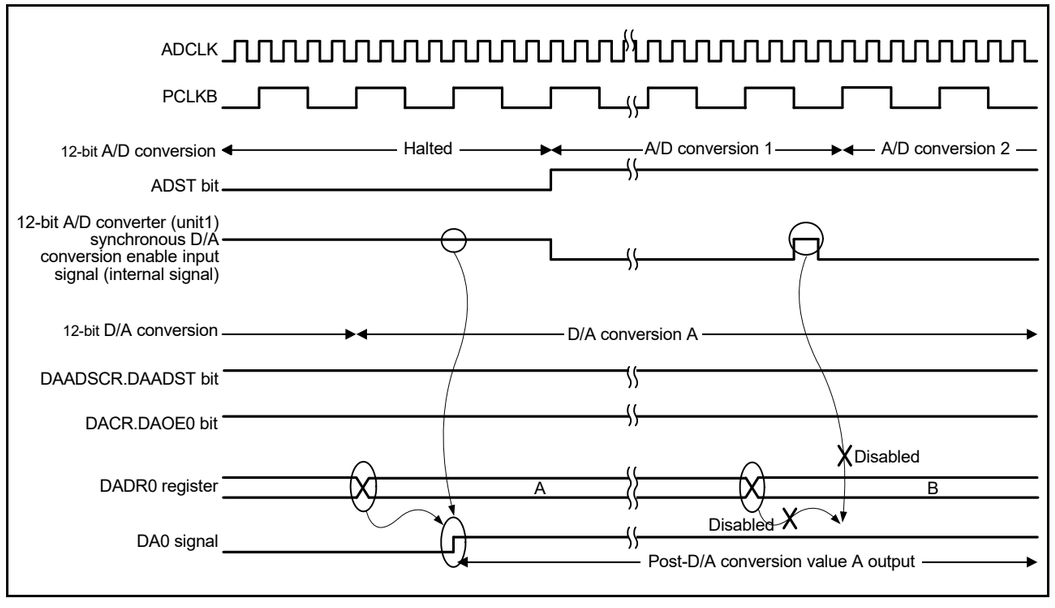


Figure 36.4 Example when the DAC12 cannot capture the synchronous D/A conversion enable input signal from the ADC12 (unit 1)

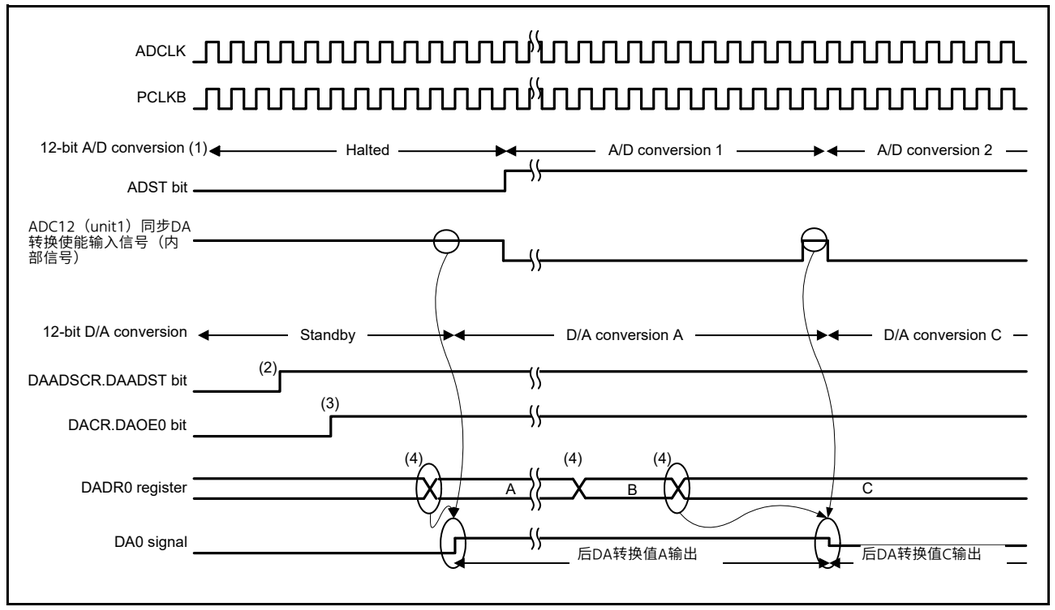


Figure 36.3 DAC12与ADC12同步时的转换示例

当ADCLK快于PCLKB时，DAC12可能无法在AD转换1和AD转换2之间输出的1个ADCLK周期内捕获ADC12同步DA转换使能输入信号，如图36.4所示。在这种情况下，后DA转换值A作为DA0信号连续输出。

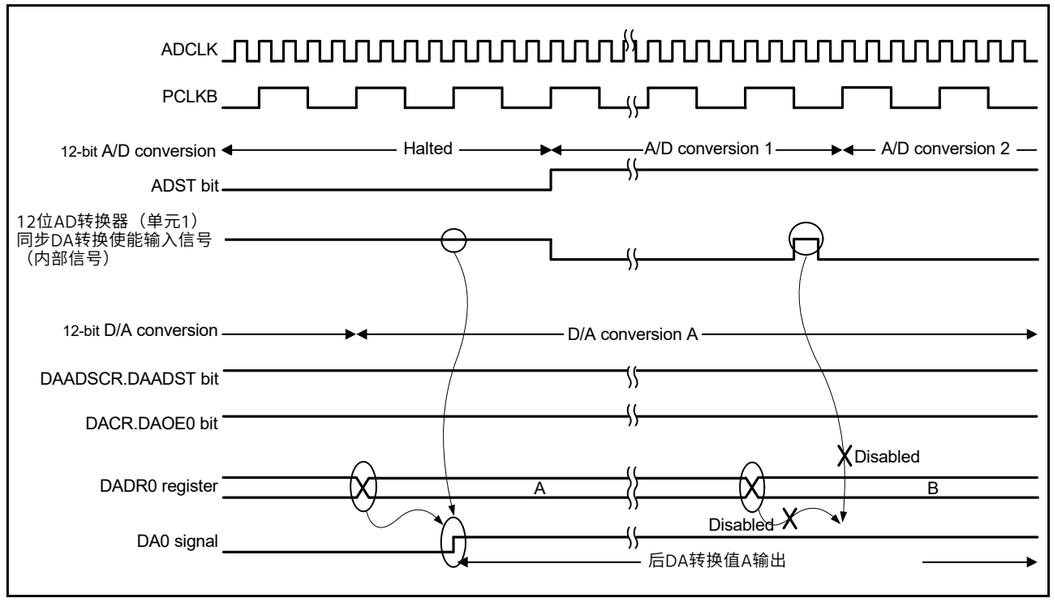


Figure 36.4 DAC12无法捕获来自ADC12（单元1）的同步DA转换使能输入信号时的示例

36.4 Event Link Operation Setting Procedure

This section describes the procedures used in event link operation.

36.4.1 DA0 Event Link Operation Setting Procedure

To set up DA0 event link operation:

1. Set the DADPR.DPSEL bit and the data for D/A conversion in the DADR0 register.
2. Set the ELC_DA0 event signal to be linked to each peripheral module in the ELSR12 register.
3. Set the ELCR.ELCON bit to 1. This enables event link operation for all modules with the event link function selected.
4. Set the event output source module to activate the event link. After the event is output from the module, the DACR.DAOE0 bit is set to 1, and D/A conversion starts on channel 0.
5. Set the ELSR12.ELS[8:0] bits to 000h to stop event link operation on DAC12 channel 0. All event link operation is stopped when the ELCR.ELCON bit is set to 0.

36.4.2 DA1 Event Link Operation Setting Procedure

To set up DA1 event link operation:

1. Set the DADPR.DPSEL bit and set the data for D/A conversion in the DADR1 register.
2. Set the ELC_DA1 event signal to be linked to each peripheral module in the ELSR13 register.
3. Set the ELCR.ELCON bit to 1. This enables the event link operation for all modules with the event link function selected.
4. Set the event output source module to activate the event link. After the event is output from the module, the DACR.DAOE1 bit is set to 1, and D/A conversion starts on channel 1.
5. Set the ELSR13.ELS[8:0] bits to 000h to stop event link operation on DAC12 channel 1. All event link operation is stopped when the ELCR.ELCON bit is set to 0.

36.5 Usage Notes on Event Link Operation

- When the event link function is used, do not use the amplifier output function.
- When the event link function is used, set the DACR.DAE bit to 0.
- When the event specified for the ELC_DA0 event signal is generated while a write to the DACR.DAOE0 bit is performed, the write cycle is stopped, and the generated event takes precedence in setting the bit to 1.
- When the event specified for the ELC_DA1 event signal is generated while a write to the DACR.DAOE1 bit is performed, the write cycle is stopped, and the generated event takes precedence in setting the bit to 1.
- Use of the event link function is prohibited when the DAADSCR.DAADST bit is set to 1 to reduce interference between D/A and A/D conversions.

36.6 Usage Notes

36.6.1 Settings for the Module-Stop Function

The Module Stop Control Register can enable or disable DAC12 operation. The DAC12 is initially stopped after reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

36.6.2 DAC12 Operation in the Module-Stop State

When the MCU enters the module-stop state with D/A conversion enabled, the D/A outputs is saved, and the analog power supply current is the same as during D/A conversion. To reduce the analog power supply current in the module-stop state, disable D/A conversion by setting the DACR.DAOE1, DAOE0, and DAE bits to 0.

36.4 事件链接操作设置步骤

本节介绍事件链接操作中使用的过程。

36.4.1 DA0事件链接操作设置步骤

设置DA0事件链接操作：

1. 在DADR0寄存器中设置DADPR.DPSEL位和用于DA转换的数据。
2. 将ELC_DA0事件信号设置为链接到ELSR12寄存器中的每个外围模块。
3. 将ELCR.ELCON位设置为1。这将为所有选择了事件链接功能的模块启用事件链接操作。
4. 设置事件输出源模块以激活事件链接。事件从模块输出后，DACR.DAOE0位设置为1，DA转换从通道0开始。
5. 将ELSR12.ELS[8:0]位设置为000h以停止DAC12通道0上的事件链接操作。当ELCR.ELCON位设置为0时，将停止所有事件链接操作。

36.4.2 DA1事件链接操作设置步骤

设置DA1事件链接操作：

1. 设置DADPR.DPSEL位并在DADR1寄存器中设置用于DA转换的数据。
2. 设置ELC_DA1事件信号链接到ELSR13寄存器中的每个外围模块。
3. 将ELCR.ELCON位设置为1。这将为所有选择了事件链接功能的模块启用事件链接操作。
4. 设置事件输出源模块以激活事件链接。事件从模块输出后，DACR.DAOE1位设置为1，DA转换从通道1开始。
5. 将ELSR13.ELS[8:0]位设置为000h以停止DAC12通道1上的事件链接操作。当ELCR.ELCON位设置为0时，将停止所有事件链接操作。

36.5 事件链接操作使用说明

- 使用事件链接功能时，请勿使用放大器输出功能。
- 使用事件链接功能时，将DACR.DAE位设置为0。
- 如果在执行对DACR.DAOE0位的写入时生成了为ELC_DA0事件信号指定的事件，则写入周期停止，并且生成的事件优先将该位设置为1。
- 如果在执行对DACR.DAOE1位的写入时生成了为ELC_DA1事件信号指定的事件，则写入周期停止，并且生成的事件优先将该位设置为1。
- 当DAADSCR.DAADST位设置为1以减少DA和AD转换之间的干扰时，禁止使用事件链接功能。

36.6 使用说明

36.6.1 模块停止功能的设置

模块停止控制寄存器可以启用或禁用DAC12操作。DAC12在复位后最初停止。
释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

36.6.2 DAC12在模块停止状态下的操作

当单片机进入模组停止状态并开启数模转换时，数模输出被保存，模拟电源电流与数模转换时相同。要降低模块停止状态下的模拟电源电流，请通过将DACR.DAOE1、DAOE0和DAE位设置为0来禁用DA转换。

36.6.3 DAC12 Operation in Software Standby Mode

When the MCU enters Software Standby mode with D/A conversion enabled, the D/A outputs are saved, and the analog power supply current is the same as during D/A conversion. To reduce the analog power supply current in Software Standby mode, disable D/A conversion by setting the DACR.DAOE1, DAOE0, and DAE bits to 0.

36.6.4 Restriction on Entering Deep Software Standby Mode

When the MCU enters Deep Software Standby mode with D/A conversion enabled, the outputs of DAC12 are placed in a high impedance state.

36.6.5 Initialization Procedure with the Output Amplifier

Use the following initialization procedures with the output amplifier. The example shows the case for channel 0.

To initialize the DAC12 with the output amplifier:

1. Write 000h to the DADR0 register.
2. Set the DAASWCR.DAASW0 bit to 1.
3. Set the DAAMPCR.DAAMP0 bit to 1.
4. Set the DACR.DAE bit or the DACR.DAOE0 bit to 1 to start operation of the amplifier.
5. Set the DAASWCR.DAASW0 bit to 0 after waiting for the duration of D/A conversion time t_{CONV}.
6. Write the value to be converted in the DADR0 register.

While the amplifier is running, setting the DACR.DAE and DACR.DAOE0 bits to 0 allows the amplifier to stop operation. To use the amplifier again, repeat steps 1. to 6.

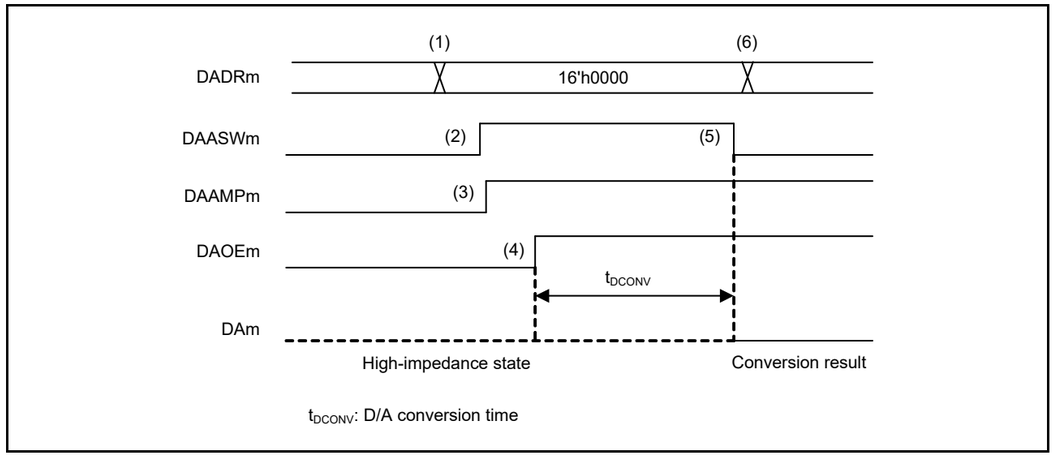


Figure 36.5 Example of the initial flow with the output amplifier in DAC12

36.6.6 Restriction on Usage when Interference Reduction between D/A and A/D Conversion is Enabled

When the DAADSCR.DAADST bit is 1, enabling interference prevention between D/A and A/D conversion, do not place the ADC12 in the module-stop state. Doing so can halt D/A conversion in addition to A/D conversion.

36.6.3 DAC12在软件待机模式下的操作

当MCU进入软件待机模式并启用DA转换时，DA输出被保存，模拟电源电流与DA转换期间相同。要降低软件待机模式下的模拟电源电流，请通过将DACR.DAOE1、DAOE0和DAE位设置为0来禁用DA转换。

36.6.4 进入深度软件待机模式的限制

当MCU进入深度软件待机模式并启用DA转换时，DAC12的输出置于高阻抗状态。

36.6.5 输出放大器的初始化程序

对输出放大器使用以下初始化程序。该示例显示了通道0的情况。

使用输出放大器初始化DAC12：

1. 将000h写入DADR0寄存器。
2. 将DAASWCR.DAASW0位设置为1。
3. 将DAAMPCR.DAAMP0位设置为1。
4. 将DACR.DAE位或DACR.DAOE0位设置为1以启动放大器的操作。
5. 在等待DA转换时间tCONV的持续时间后，将DAASWCR.DAASW0位设置为0。
6. 将要转换的值写入DADR0寄存器。

在放大器运行时，将DACR.DAE和DACR.DAOE0位设置为0可使放大器停止运行。要再次使用放大器，请重复步骤1.至6。

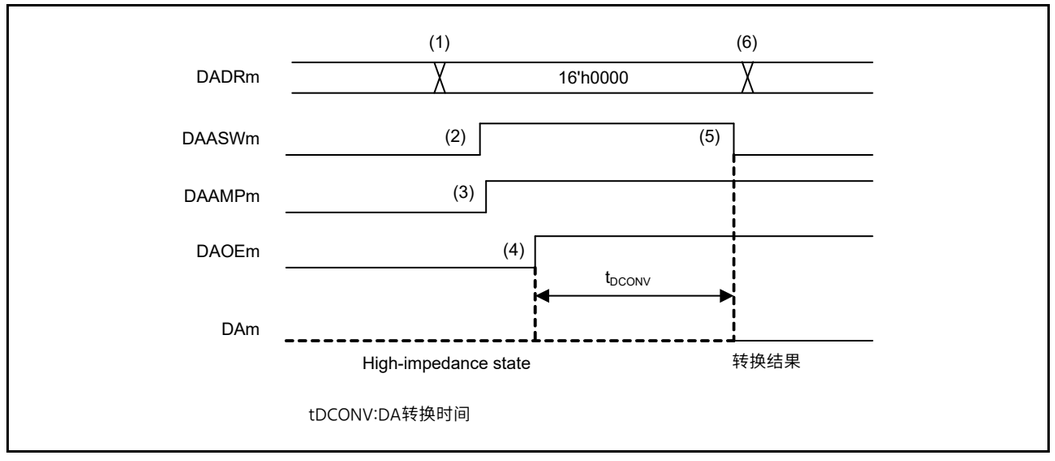


Figure 36.5 DAC12中输出放大器的初始流程示例

36.6.6 DA和AD之间减少干扰时的使用限制 转换已启用

当DAADSCR.DAADST位为1时，使能DA和AD转换之间的干扰防止，不要将ADC12置于模块停止状态。除了AD转换之外，这样做还可以停止DA转换。

37. Temperature Sensor (TSN)

37.1 Overview

The on-chip temperature sensor determines and monitors the die temperature for reliable operation of the device. The sensor outputs a voltage directly proportional to the die temperature, and the relationship between the die temperature and the output voltage is fairly linear. The output voltage is provided to the ADC12 for conversion and can also be used by the end application.

Table 37.1 lists the temperature sensor specifications and Figure 37.1 shows a block diagram.

Table 37.1 Temperature sensor specifications

Parameter	Specifications
Temperature sensor voltage output	Temperature sensor outputs a voltage to the 12-Bit A/D Converter (ADC12)
Module-stop function	Module-stop state can be set to reduce power consumption
Temperature Sensor Calibration Data	Reference data measured for each chip at factory shipment is stored

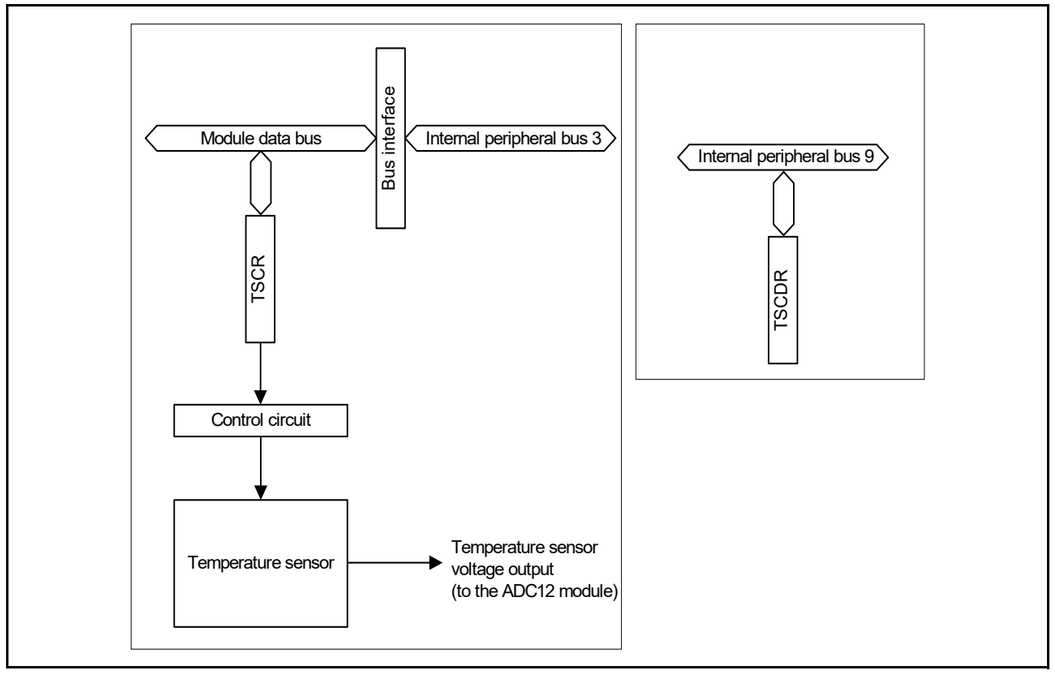


Figure 37.1 Temperature sensor block diagram

37. 温度传感器(TSN)

37.1 Overview

片上温度传感器确定并监控芯片温度，以确保器件可靠运行。传感器输出与管芯温度成正比的电压，管芯温度与输出电压之间的关系相当线性。输出电压提供给ADC12进行转换，也可供最终应用使用。

表37.1列出了温度传感器规格，图37.1显示了框图。

Table 37.1 温度传感器规格

Parameter	Specifications
温度传感器电压输出	温度传感器向12位模数转换器(ADC12)输出电压
Module-stop function	可设置模块停止状态以降低功耗
温度传感器校准数据	存储在出厂时为每个芯片测量的参考数据

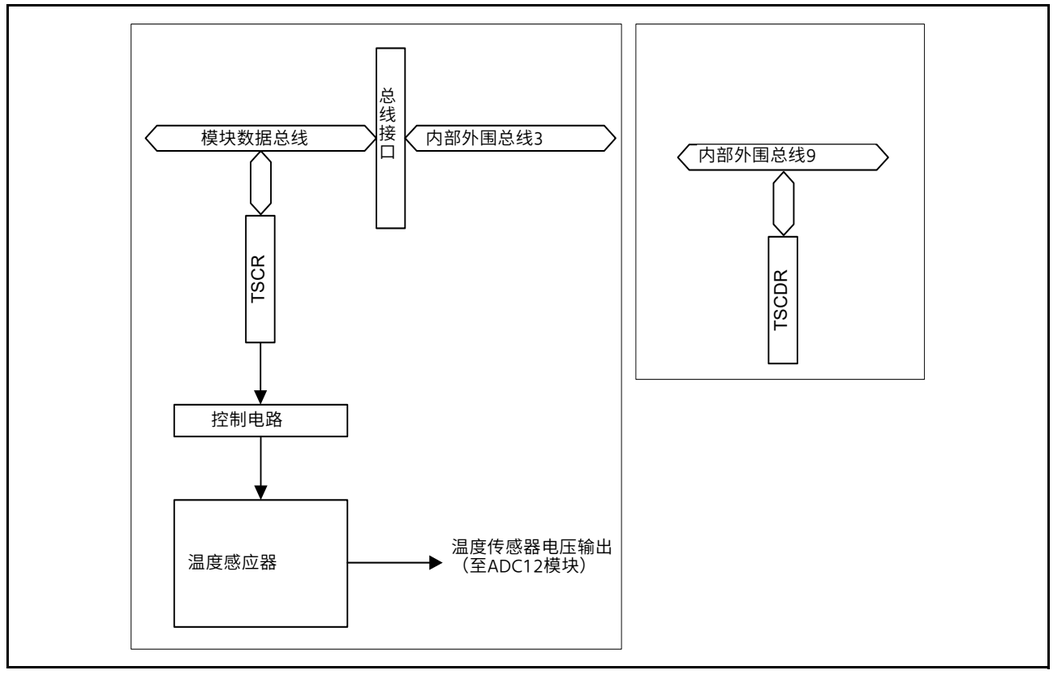


Figure 37.1 温度传感器框图

37.2 Register Descriptions

37.2.1 Temperature Sensor Control Register (TSCR)

Address(es): TSN.TSCR 4005 D000h

	b7	b6	b5	b4	b3	b2	b1	b0
	TSEN	—	—	TSOE	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b4	TSOE	Temperature Sensor Output Enable	0: Disable output from the temperature sensor to the ADC12 1: Enable output from the temperature sensor to the ADC12.	R/W
b6, b5	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	TSEN	Temperature Sensor Enable	0: Stop the temperature sensor 1: Start the temperature sensor.	R/W

The timing constraints shown in Figure 37.3 apply to the settings of the TSCR register.

37.2.2 Temperature Sensor Calibration Data Register (TSCDR)

Address(es): TSD.TSCDR 407F B17Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—												
Value after reset:	0	0	0	0	Unique value for each chip											

The TSCDR register stores temperature sensor calibration data measured for each MCU at factory shipment.

Temperature sensor calibration data is a digital value obtained using the 12-bit A/D converter unit 0 to convert the voltage output by the temperature sensor under the condition $T_a = T_j = 127°C$ and AVCC0 = 3.3 V.

The TSCDR register is a 32-bit read-only register and should be read in 32-bit units.

37.3 Using the Temperature Sensor

The temperature sensor outputs a voltage that varies with the temperature. This voltage is converted to a digital value by the ADC12. To obtain the die temperature, convert this value into the temperature.

37.3.1 Preparation for Using the Temperature Sensor

The temperature (T) is proportional to the sensor voltage output (Vs), so temperature is calculated with the following formula:

T = (Vs - V1) / slope + T1

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when temperature is measured (V)

T1: Temperature experimentally measured at one point (°C)

V1: Voltage output by the temperature sensor when T1 is measured (V)

37.2 注册说明

37.2.1 温度传感器控制寄存器(TSCR)

Address(es): TSN.TSCR 4005 D000h

	b7	b6	b5	b4	b3	b2	b1	b0
	TSEN	—	—	TSOE	—	—	—	—
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b4	TSOE	温度传感器输出使能	0：禁用从温度传感器到ADC12的输出1：启用从温度传感器到ADC12的输出。	R/W
b6, b5	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	TSEN	温度传感器启用	0：停止温度传感器1：启动温度传感器。	R/W

图37.3所示的时序约束适用于TSCR寄存器的设置。

37.2.2 温度传感器校准数据寄存器(TSCDR)

Address(es): TSD.TSCDR 407F B17Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—												
重置后的值：	0	0	0	0	每个芯片的独特价值											

TSCDR寄存器存储在出厂时为每个MCU测量的温度传感器校准数据。

温度传感器校准数据是在Ta=Tj=127°C和AVCC0=3.3V条件下，使用12位AD转换器单元0对温度传感器输出的电压进行转换得到的数字值。

TSCDR寄存器是一个32位只读寄存器，应该以32位为单位读取。

37.3 使用温度传感器

温度传感器输出随温度变化的电压。该电压由ADC12转换为数字值。要获得芯片温度，请将该值转换为温度。

37.3.1 使用温度传感器的准备工作

温度(T)与传感器电压输出(Vs)成正比，因此使用以下公式计算温度：

T = (Vs - V1) / slope + T1

T:测量温度(°C)

Vs：测量温度时温度传感器输出的电压（V）

T1：在某一点实验测量的温度(°C)

V1：测量T1时温度传感器输出的电压（V）

T2: Temperature experimentally measured at a second point (°C)

V2: Voltage output by the temperature sensor when T2 is measured (V)

Slope: Temperature gradient of the temperature sensor (V /°C), slope = (V2 - V1) / (T2 - T1)

Characteristics vary between sensors. Therefore, Renesas recommends measuring two different sample temperatures as follows:

1. Use the ADC12 to measure the voltage V1 output by the temperature sensor at temperature T1.
2. Use the ADC12 to measure the voltage V2 output by the temperature sensor at a different temperature T2. Obtain the temperature gradient (slope = (V2 - V1) / (T2 - T1)) from these results.
3. Subsequently, obtain temperatures by substituting the slope into the formula for the temperature characteristic (T = (Vs - V1) / slope + T1).

If you are using the temperature slope given in Table 43.32 of section 43, Electrical Characteristics, use the ADC12 converter unit 0 to measure the voltage V1 output by the temperature sensor at temperature T1, then calculate the temperature characteristic using the following formula:

T = (Vs - V1) / slope + T1

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when the temperature is measured (V)

T1: Sample temperature measurement at first point (°C)

V1: Voltage output by the temperature sensor when T1 is measured (V)

Slope: Temperature slope given in Table 43.32 ÷ 1000 (V / °C)

In this MCU, the TSCDR register stores the temperature value (CAL127) of the temperature sensor measured under the condition $T_a = T_j = 127°C$ and AVCC0 = 3.3 V. By using this value as the sample measurement result at the first point, you can omit the preparation before using the temperature sensor.

V1 is calculated from CAL127 as follows:

V1 = 3.3 × CAL127 / 4096 [V]

Using this value, the measured temperature can be calculated according to the following formula:

T = (Vs - V1) / slope + 127 [°C]

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when the temperature is measured (V)

V1: Voltage output by the temperature sensor when $T_a = T_j = 127°C$ and AVCC0 = 3.3 V (V)

Slope: Temperature slope given in Table 43.32 ÷ 1000 (V / °C)

37.3.2 Procedure for Using the Temperature Sensor

Figure 37.2 shows the procedure for using the temperature sensor. For the procedure to configure the ADC12, see section 35, 12-Bit A/D Converter (ADC12).

T2：在第二点实验测量的温度(°C)

V2：测量T2时温度传感器输出的电压（V）

斜率：温度传感器的温度梯度（V°C），斜率=（V2V1）（T2T1）

特性因传感器而异。因此，瑞萨推荐测量两种不同的样品温度，如下所示：

1. 使用ADC12测量温度传感器在温度T1时输出的电压V1。
2. 使用ADC12测量温度传感器在不同温度T2下输出的电压V2。从这些结果中获得温度梯度（斜率=(V2V1)(T2T1)）。
3. 随后，通过将斜率代入温度特性公式(T=(VsV1)斜率+T1)来获得温度。

如果您使用第43节"电气特性"的表43.32中给出的温度斜率，请使用ADC12转换器单元0测量温度传感器在温度T1下输出的电压V1，然后使用以下公式计算温度特性：

T = (Vs - V1) / slope + T1

T:测量温度(°C)

Vs：测温时温度传感器输出的电压（V）

T1：第一点的样品温度测量(°C)

V1：测量T1时温度传感器输出的电压（V）

斜率：表43.32中给出的温度斜率÷1000(V°C)

在此MCU中，TSCDR寄存器存储在条件Ta=Tj=127°C和AVCC0=3.3V下测量的温度传感器的温度值(CAL127)。将此值用作第一点的样本测量结果，您可以省略使用温度传感器前的准备工作。

V1从CAL127计算如下：

V1 = 3.3 × CAL127 / 4096 [V]

使用该值，可根据以下公式计算测得的温度：

T = (Vs - V1) / slope + 127 [°C]

T:测量温度(°C)

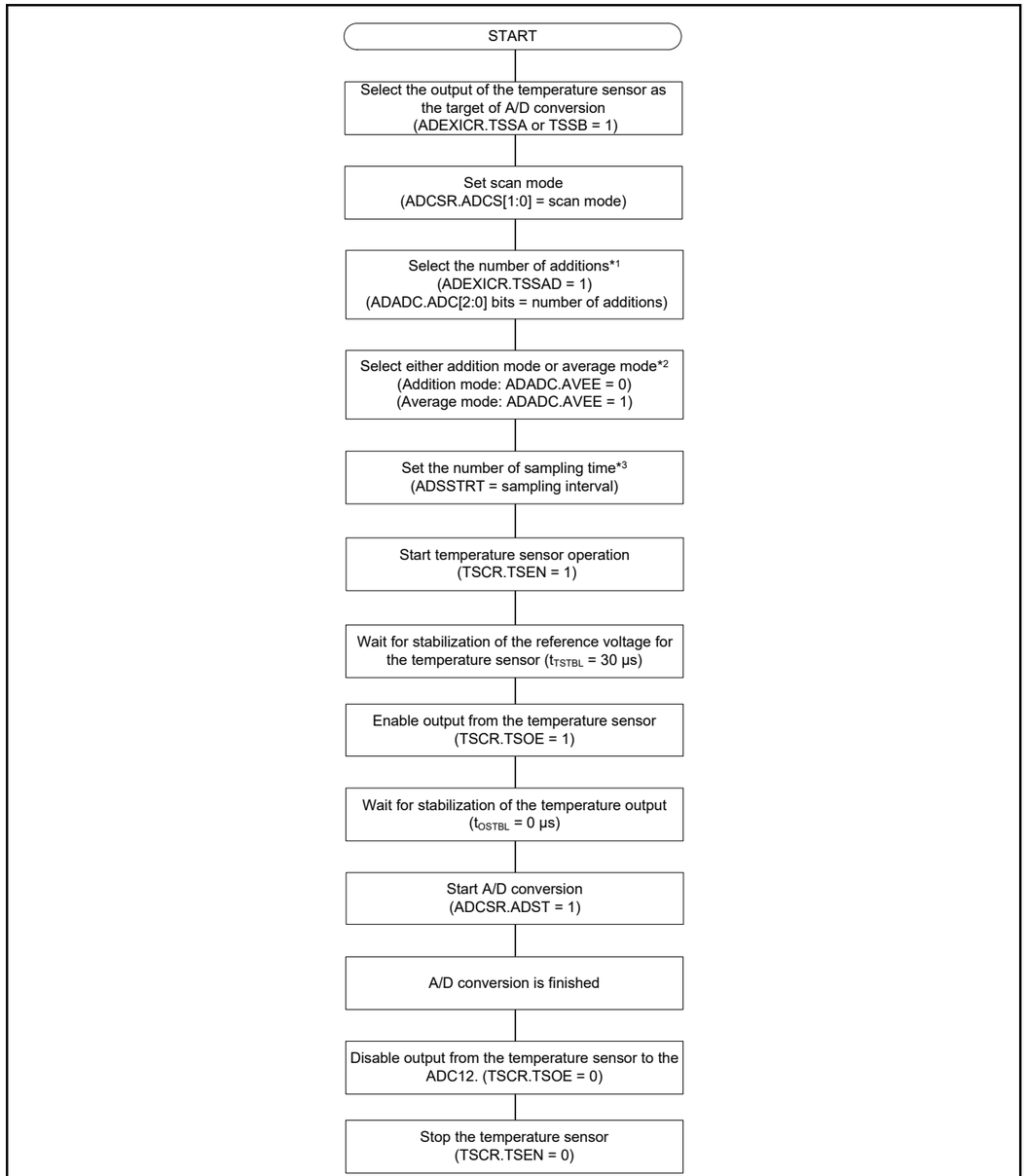
Vs：测温时温度传感器输出的电压（V）

V1：温度传感器在Ta=Tj=127°C和AVCC0=3.3V(V)时输出的电压

斜率：表43.32中给出的温度斜率÷1000(V°C)

37.3.2 使用温度传感器的步骤

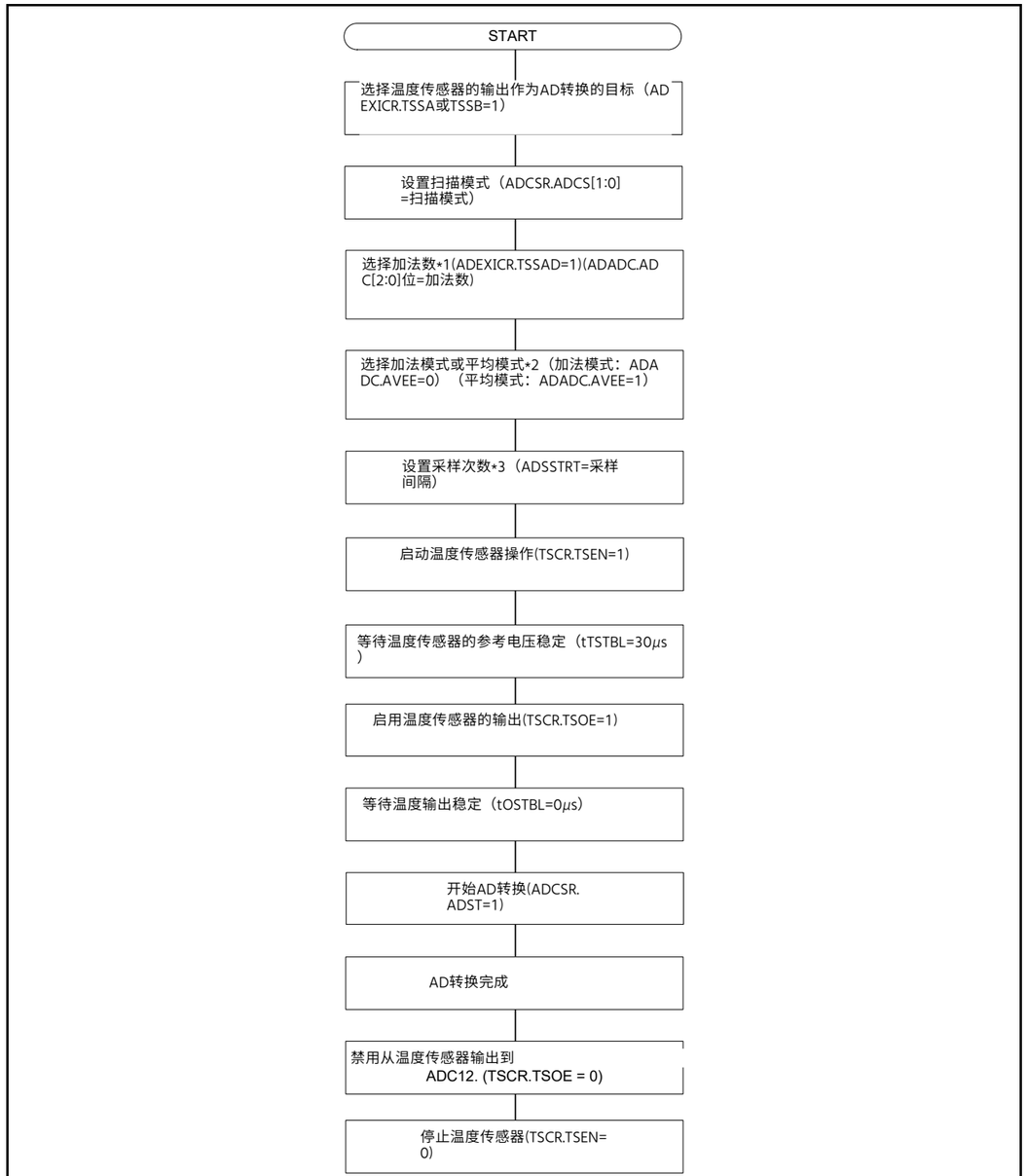
图37.2显示了使用温度传感器的过程。有关配置ADC12的过程，请参阅第35节，12位AD转换器(ADC12)。



Note 1. The ADADC.ADC[2:0] setting is limited to some values in average mode. For details on the available ADADC.ADC[2:0] settings in average mode, see section 35.2.10, A/D-Converted Value Addition/Average Count Select Register (ADADC).
Note 2. This setting is not required if addition/average mode is not set.
Note 3. Set the sampling time to more than the value described in section 43.6, TSN Characteristics.

Figure 37.2 Procedure for using the temperature sensor

Figure 37.3 shows the timing from the start of temperature sensor operation until the completion of A/D conversion when the ADC12 is in single scan mode (the conversion target is the temperature sensor output only). The times shown in the figure are described in Table 37.2.



Note 1. ADADC.ADC[2:0]设置仅限于平均模式下的某些值。有关平均模式下可用ADADC.ADC[2:0]设置的详细信息，请参阅第35.2.10节，AD转换值加法平均计数选择寄存器(ADADC)。
Note 2. 如果未设置加法平均模式，则不需要此设置。
Note 3. 将采样时间设置为大于第43.6节，TSN特性中描述的值。

Figure 37.2 温度传感器的使用步骤

图37.3显示了当ADC12处于单次扫描模式（转换目标仅为温度传感器输出）时，从温度传感器操作开始到AD转换完成的时序。图中显示的时间在表37.2中描述。

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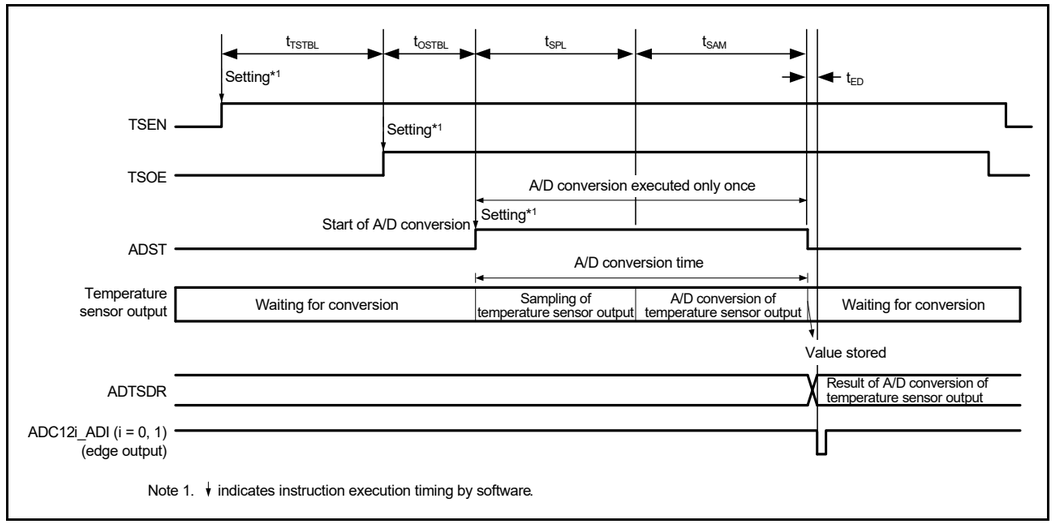


Figure 37.3 Timing from start of temperature sensor operation until completion of A/D conversion

Table 37.2 Time until completion of A/D conversion after start of temperature sensor operation

Parameter	Symbol	Time
Wait time for temperature sensor reference voltage stabilization	t_{TSTBL}	30 µs (min)
Wait time for temperature sensor output stabilization	t_{OSTBL}	0 µs (min)
ADC12 input sampling time	t_{SPL}	ADSSTRT setting × ADCLK cycles
A/D conversion time	t_{SAM}	See Table 35.10, Conversion times during scanning (in numbers of ADCLK and PCLKB cycles)
Scan conversion end delay	t_{ED}	

37.4 Usage Notes

37.4.1 Settings for the Module-Stop Function

The Module Stop Control Register D (MSTPCRD) can enable or disable temperature sensor operation. The temperature sensor is initially stopped after reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

37.4.2 Constraints

It is prohibited to use both channels of the ADC12 simultaneously for temperature sensor measurement.

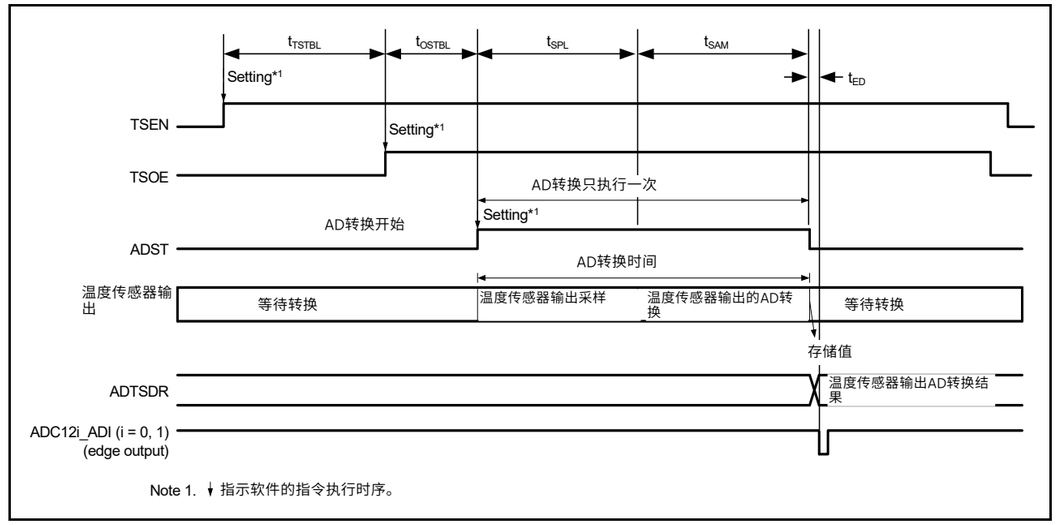


Figure 37.3 从温度传感器操作开始到AD转换完成的时间

Table 37.2 温度传感器动作开始后到AD转换完成的时间

Parameter	Symbol	Time
温度传感器参考电压稳定的等待时间	t_{TSTBL}	30 µs (min)
温度传感器输出稳定的等待时间	t_{OSTBL}	0 µs (min)
ADC12输入采样时间	t_{SPL}	ADSTRT设置×ADCLK周期
AD转换时间	t_{SAM}	请参见表35.10，扫描期间的转换时间（以ADCLK和PCLKB周期数为单位）
扫描转换结束延迟	t_{ED}	

37.4 使用说明

37.4.1 模块停止功能的设置

模块停止控制寄存器D(MSTPCRD)可以启用或禁用温度传感器操作。温度传感器在复位后最初停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

37.4.2 Constraints

禁止同时使用ADC12的两个通道进行温度传感器测量。

38. High-Speed Analog Comparator (ACMPHS)

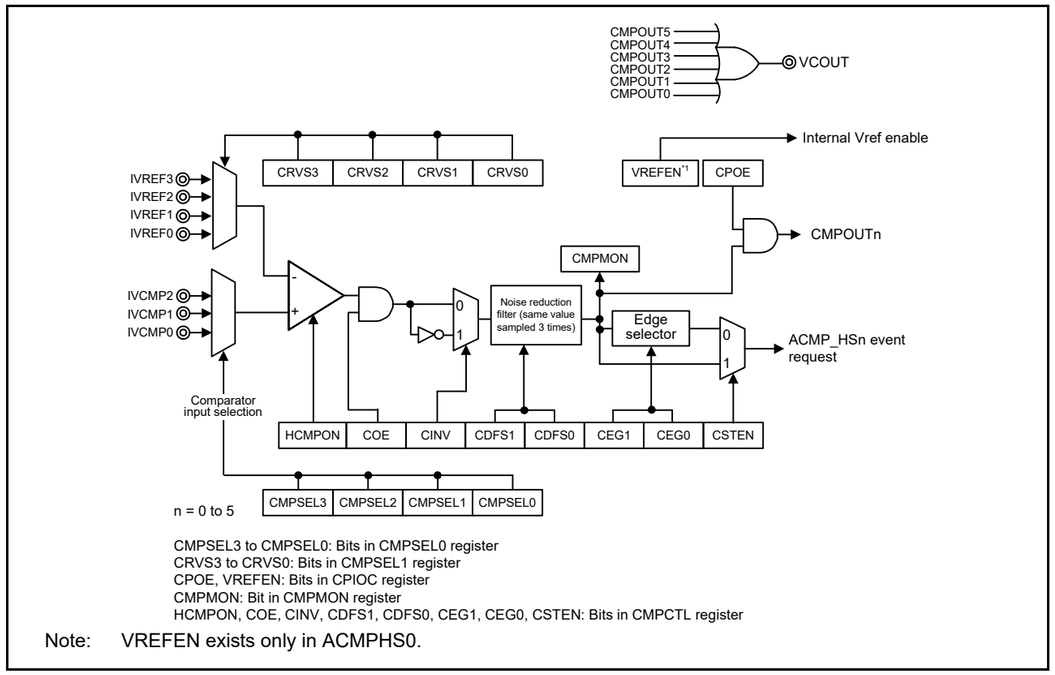
38.1 Overview

The High-Speed Analog Comparator (ACMPHS) compares a test voltage with a reference voltage and provides a digital output based on the result of conversion. Both the test voltage and the reference voltage can be provided to the ACMPHS from internal sources (D/A converter output and internal reference voltage) and an external source (with or without an internal PGA). Such flexibility is useful in applications that require go/no-go comparisons to be performed between analog signals without necessarily requiring A/D conversion.

Table 38.1 lists the ACMPHS specifications, Figure 38.1 shows a block diagram, and Table 38.2 shows the input source configuration of the ACMPHS.

Table 38.1 ACMPHS 0 to 5 specifications

Parameter	Specifications
Number of channels	6 channels: ACMPHS 0 to ACMPHS 5
Analog input voltage	• Output from internal PGA • Output from internal D/A converter • Input from internal A/D converter input pin (one selectable).
Reference voltage	• Internal reference voltage (Vref) • Output from internal D/A converter • Input from internal A/D converter input pin (one selectable).
ACMPHS output	• Comparison result • Generation of ELC event output • Monitor output from register.
Interrupt request signal	• Interrupt request generated on valid edge detection from comparison result • Rising edge, falling edge, or both edges can be selected.
Digital filter function	• One of three sampling frequencies can be selected • Not using the filter function can be selected.



Note: VREFEN exists only in ACMPHS0.

Figure 38.1 ACMPHS block diagram

38. 高速模拟比较器(ACMPHS)

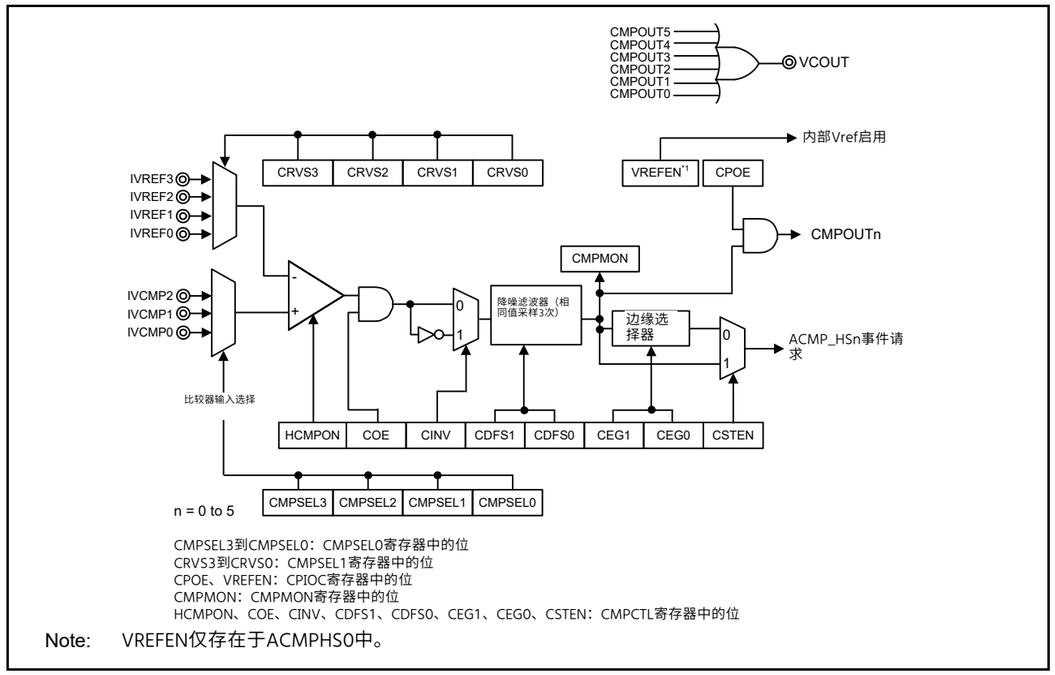
38.1 Overview

高速模拟比较器(ACMPHS)将测试电压与参考电压进行比较，并根据转换结果提供数字输出。测试电压和参考电压都可以从内部源（DA转换器输出和内部参考电压）和外部源（带或不带内部PGA）提供给ACMPHS。这种灵活性在需要在模拟信号之间执行go-no-go比较而不一定需要AD转换的应用中很有用。

表38.1列出了ACMPHS规范，图38.1显示了框图，表38.2显示了ACMPHS的输入源配置。

Table 38.1 ACMPHS0到5规格

Parameter	Specifications
通道数	6 channels: ACMPHS 0 to ACMPHS 5
模拟输入电压	来自内部PGA的输出 来自内部DA转换器的输出 来自内部AD转换器输入引脚的输入（一个可选）。
参考电压	内部参考电压(Vref) 来自内部DA转换器的输出 从内部AD转换器输入引脚输入（一个可选）。
ACMPHS output	比较结果 生成ELC事件输出 监控寄存器的输出。
中断请求信号	从比较结果中检测到有效边沿时产生中断请求 可以选择上升沿、下降沿或两个沿。
数字滤波功能	可以选择三个采样频率之一。 可以选择不使用过滤器功能。



Note: VREFEN仅存在于ACMPHS0中。

Figure 38.1 ACMPHS框图

Table 38.2 Input source configuration of the ACMPHS

Comparator	Reference voltage input source				Analog voltage input source				Optput pin
	IVREF3	IVREF2	IVREF1	IVREF0	IVCMP3	IVCMP2	IVCMP1	IVCMP0	
ACMPHS0	DA0*1	Vref*2	AN116	AN016	PGA0 output*6	AN000*3,*6	DA1*4	AN017	VCOUT*5
ACMPHS1	DA0*1	Vref*2	AN116	AN016	PGA1 output*6	AN001*3,*6	DA1*4	AN017	
ACMPHS2	DA0*1	Vref*2	AN116	AN016	PGA2 output*6	AN002*3,*6	DA1*4	AN017	
ACMPHS3	DA0*1	Vref*2	AN116	AN016	PGA3 output*6	AN100*3,*6	DA1*4	AN017	
ACMPHS4	DA0*1	Vref*2	AN116	AN016	PGA4 output*6	AN101*3,*6	DA1*4	AN017	
ACMPHS5	DA0*1	Vref*2	AN116	AN016	PGA5 output*6	AN102*3,*6	DA1*4	AN017	

Note 1. When D/A converter 0 output is not used, the signal can be used as AN005/AN105 analog input.
Note 2. Internal voltage reference.
Note 3. Because input is through PGA, the corresponding module-stop bit, MSTPCRD.MSTPD16 (unit 0) or MSTPCRD.MSTPD15 (unit 1) should be set to 0.
Note 4. When D/A converter 1 output is not used, the signal can be used as AN006/AN106 analog input.
Note 5. ACMPHS0 to ACMPHS5 compare outputs are bundled with the VCOUT pin.
Note 6. Setting of ADC12 is required. For details, see section 35.6.8, Available functions and register settings of AN000 to AN002, AN007, AN100 to AN102, and AN107.

38.2 Register Descriptions

38.2.1 Comparator Control Register (CMPCTL)

Address(es): ACMPHS0.CMPCTL 4008 5000h,ACMPHS1.CMPCTL 4008 5100h, ACMPHS2.CMPCTL 4008 5200h, ACMPHS3.CMPCTL 4008 5300h, ACMPHS4.CMPCTL 4008 5400h, ACMPHS5.CMPCTL 4008 5500h

	b7	b6	b5	b4	b3	b2	b1	b0
	HCMPON	CDFS[1:0]		CEG1	CEG0	CSTEN	COE	CINV
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CINV	Comparator Output Polarity Selection*2, *3	0: Do not invert comparator output 1: Invert comparator output.	R/W
b1	COE	Comparator Output Enable	0: Disable comparator output (output signal is low level) 1: Enable comparator output.	R/W
b2	CSTEN	Interrupt Select*1	0: Output through the edge selector 1: Output directly.	R/W
b4, b3	CEG1/CEG0	Selection of Valid Edge (Edge Selector)	b4 b3 0 0: Do not detect edge 0 1: Detect rising edge 1 0: Detect falling edge 1 1: Detect both edges.	R/W
b6, b5	CDFS[1:0]	Noise Filter Selection*1, *2, *3, *4	b6 b5 0 0: Do not use noise filter. 0 1: Use noise filter sampling frequency of PCLKB/2^3 1 0: Use noise filter sampling frequency of PCLKB/2^4 1 1: Use noise filter sampling frequency of PCLKB/2^5.	R/W
b7	HCMPON	Comparator Operation Control*5	0: Stop operation (comparator outputs a low-level signal) 1: Enable operation (enables input to the comparator pins).	R/W

Note 1. Set the CSTEN bit to 1 and the CDFS[1:0] bits to 00b if the ACMPHS interrupt causes the release of Software Standby or Snooze modes. CTSEN is supported only by the ACMPHS0. ACMPHSn.CMPCTL.CTESN (n = 1 to 5) must be set to 0.
Note 2. Disable the ACMPHS output (COE = 0) before changing the CDFS[1:0] and CINV bits.
Note 3. If the CDFS[1:0] and CINV bits are changed, an ACMPHS interrupt request and an ELC event might be generated. Before changing these bits, set the ELSRn register to 0 (the ACMPHS output is not linked). After changing these bits, clear the IR flag in the IELSRn register to 0 to clear the interrupt status.
Note 4. If the CDFS[1:0] bits are changed from 00b (noise filter not used) to a value other than 00b (noise filter used), perform sampling

Table 38.2 ACMPHS的输入源配置

Comparator	参考电压输入源				模拟电压输入源				Optput pin
	IVREF3	IVREF2	IVREF1	IVREF0	IVCMP3	IVCMP2	IVCMP1	IVCMP0	
ACMPHS0	DA0*1	Vref*2	AN116	AN016	PGA0 output*6	AN000*3,*6	DA1*4	AN017	VCOUT*5
ACMPHS1	DA0*1	Vref*2	AN116	AN016	PGA1 output*6	AN001*3,*6	DA1*4	AN017	
ACMPHS2	DA0*1	Vref*2	AN116	AN016	PGA2 output*6	AN002*3,*6	DA1*4	AN017	
ACMPHS3	DA0*1	Vref*2	AN116	AN016	PGA3 output*6	AN100*3,*6	DA1*4	AN017	
ACMPHS4	DA0*1	Vref*2	AN116	AN016	PGA4 output*6	AN101*3,*6	DA1*4	AN017	
ACMPHS5	DA0*1	Vref*2	AN116	AN016	PGA5 output*6	AN102*3,*6	DA1*4	AN017	

Note 1. 当不使用DA转换器0输出时，该信号可用作AN005AN105模拟输入。
Note 2. 内部参考电压。
Note 3. 因为通过PGA输入，所以相应的模块停止位MSTPCRD.MSTPD16（单元0）或MSTPCRD.MSTPD15（单元1）应设置为0。
Note 4. 当不使用DA转换器1输出时，该信号可用作AN006AN106模拟输入。
Note 5. ACMPHS0到ACMPHS5比较输出与VCOUT引脚捆绑在一起。
Note 6. 需要设置ADC12。有关详细信息，请参阅第35.6.8节，AN000到AN002的可用功能和寄存器设置，AN007、AN100至AN102和AN107。

38.2 注册说明

38.2.1 比较器控制寄存器(CMPCTL)

Address(es): ACMPHS0.CMPCTL 4008 5000h,ACMPHS1.CMPCTL 4008 5100h, ACMPHS2.CMPCTL 4008 5200h, ACMPHS3.CMPCTL 4008 5300h, ACMPHS4.CMPCTL 4008 5400h, ACMPHS5.CMPCTL 4008 5500h

	b7	b6	b5	b4	b3	b2	b1	b0
	HCMPON	CDFS[1:0]		CEG1	CEG0	CSTEN	COE	CINV
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CINV	比较器输出极性 Selection*2, *3	0：不反转比较器输出1：反转比较器输出。	R/W
b1	COE	比较器输出使能	0：禁止比较器输出（输出信号为低电平）1：使能比较器输出。	R/W
b2	CSTEN	Interrupt Select*1	0：通过边沿选择器输出1：直接输出。	R/W
b4, b3	CEG1/CEG0	有效边的选择（边 Selector)	b4b300：不检测边沿01：检测上升沿10：检测下降沿11：检测两个边沿。	R/W
b6, b5	CDFS[1:0]	噪声滤波器选择*1、*2、*3、*4	b6b500：不使用噪声滤波器。01：使用PCLKB231的噪声滤波器采样频率0：使用PCLKB241的噪声滤波器采样频率1：使用PCLKB25的噪声滤波器采样频率。	R/W
b7	HCMPON	比较器操作控制*5	0：停止操作（比较器输出低电平信号）1：使能操作（使能输入到比较器引脚）。	R/W

Note 1. 如果ACMPHS中断导致软件待机或贪睡模式。只有ACMPHS0支持CTSEN。ACMPHSn.CMPCTL.CTESN（n=1到5）必须设置为0。
Note 2. 在更改CDFS[1:0]和CINV位之前禁用ACMPHS输出(COE=0)。
Note 3. 如果CDFS[1:0]和CINV位发生变化，可能会产生ACMPHS中断请求和ELC事件。在更改这些位之前，将ELSRn寄存器设置为0（ACMPHS输出未链接）。更改这些位后，将IELSRn寄存器中的IR标志清零以清除中断状态。
Note 4. 如果CDFS[1:0]位从00b（未使用噪声滤波器）更改为00b（使用噪声滤波器）以外的值，则执行采样

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four times and update the filter output, then use the ACMPHS interrupt request or the ELC event.

Note 5. A stabilization wait time is required to permit ACMPHS operation after enabling it (HCMPON = 1). The operation stabilization wait time for ACMPHS modules 0 to 5 is 300 ns.

The CMPCTL register controls the ACMPHS operation, enables or disables the ACMPHS output, selects the noise filter, selects the valid edge of the interrupt signal, and selects the interrupt. A reset clears this register to 00h.

38.2.2 Comparator Input Select Register (CMPSEL0)

Address(es): ACMPHS0.CMPSEL0 4008 5004h, ACMPHS1.CMPSEL0 4008 5104h, ACMPHS2.CMPSEL0 4008 5204h, ACMPHS3.CMPSEL0 4008 5304h, ACMPHS4.CMPSEL0 4008 5404h, ACMPHS5.CMPSEL0 4008 5504h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	CMPSEL[3:0]			
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	CMPSEL[3:0]	Comparator Input Selection*1	b3 b0 0 0 0 0: Do not input 0 0 0 1: Select IVCMP0*2 0 0 1 0: Select IVCMP1*2 0 1 0 0: Select IVCMP2*2 1 0 0 0: Select IVCMP3*2. Other settings are prohibited.	R/W
b7 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. Use the following procedure to change the CMPSEL[3:0] bits. Writing a value other than 0000 0000b while the value of the CMPSEL0 register is not 0000 0000b is invalid. Writing 1 to two or more bits is also invalid. In both cases, the previous value is retained.
To change the CMPSEL[3:0] bits:
1. Set the CMPCTL.COE bit to 0.
2. Set the CMPSEL0 register to 0000 0000b.
3. Set a new value in the CMPSEL[3:0] bits, with 1 set in only one of the bits.
4. Wait for the input switching stabilization wait time (200 ns).
5. Set the CMPCTL.COE bit to 1.
6. Clear the IR flag in the IELSRn register to clear the interrupt status.

Note 2. For details, see Table 38.2.

38.2.3 Comparator Reference Voltage Select Register (CMPSEL1)

Address(es): ACMPHS0.CMPSEL1 4008 5008h, ACMPHS1.CMPSEL1 4008 5108h, ACMPHS2.CMPSEL1 4008 5208h, ACMPHS3.CMPSEL1 4008 5308h, ACMPHS4.CMPSEL1 4008 5408h, ACMPHS5.CMPSEL1 4008 5508h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	CRVS[3:0]			
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b3 to b0	CRVS[3:0]	Reference Voltage Selection*1	b3 b0 0 0 0 0: Do not input 0 0 0 1: Select IVREF0*2 0 0 1 0: Select IVREF1*2 0 1 0 0: Select IVREF2*2 1 0 0 0: Select IVREF3*2. Other settings are prohibited.	R/W
b7 to b4	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

Note 1. Use the following procedure to change the CRVS[3:0] bits. Writing a value other than 0000 0000b while the value of the CMPSEL1 register is not 0000 0000b is invalid. Writing 1 to two or more bits is also invalid. In both cases, the previous value is

四次更新滤波器输出，然后使用ACMPHS中断请求或ELC事件。

Note 5. 在启用ACMPHS后，需要一个稳定等待时间来允许其运行(HCMPON=1)。ACMPHS模块0到5的操作稳定等待时间为300ns。

CMPCTL寄存器控制ACMPHS操作，使能或禁用ACMPHS输出，选择噪声滤波器，选择中断信号的有效边沿，选择中断。复位将该寄存器清除为00h。

38.2.2 比较器输入选择寄存器(CMPSEL0)

Address(es): ACMPHS0.CMPSEL0 4008 5004h, ACMPHS1.CMPSEL0 4008 5104h, ACMPHS2.CMPSEL0 4008 5204h, ACMPHS3.CMPSEL0 4008 5304h, ACMPHS4.CMPSEL0 4008 5404h, ACMPHS5.CMPSEL0 4008 5504h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	CMPSEL[3:0]			
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	CMPSEL[3:0]	比较器输入选择*1	b3b00000：不输入0001：选择IVCMP0*20010：选择IVCMP1*20100：选择IVCMP2*21000：选择IVCMP3*2。禁止其他设置。	R/W
b7 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 使用以下程序更改CMPSEL[3:0]位。写入00000000b以外的值，而CMPSEL0寄存器不是00000000b无效。将1写入两位或更多位也是无效的。在这两种情况下，都会保留先前的值。要更改CMPSEL[3:0]位：1.将CMPCTL.COE位设置为0。2.将CMPSEL0寄存器设置为00000000b。3.在CMPSEL[3:0]位中设置一个新值，其中一个位设置为1。4.等待输入切换稳定等待时间（200ns）。5.将CMPCTL.COE位设置为1。6.清除IELSRn寄存器中的IR标志以清除中断状态。

Note 2. 详见表38.2。

38.2.3 比较器参考电压选择寄存器(CMPSEL1)

Address(es): ACMPHS0.CMPSEL1 4008 5008h, ACMPHS1.CMPSEL1 4008 5108h, ACMPHS2.CMPSEL1 4008 5208h, ACMPHS3.CMPSEL1 4008 5308h, ACMPHS4.CMPSEL1 4008 5408h, ACMPHS5.CMPSEL1 4008 5508h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	CRVS[3:0]			
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b3 to b0	CRVS[3:0]	参考电压选择*1	b3b00000：不输入0001：选择IVREF0*20010：选择IVREF1*20100：选择IVREF2*21000：选择IVREF3*2。禁止其他设置。	R/W
b7 to b4	—	Reserved	这些位被读取为0。写入值应为0。	R/W

Note 1. 使用以下过程更改CRVS[3:0]位。写入00000000b以外的值，而CMPSEL1寄存器不是00000000b无效。将1写入两位或更多位也是无效的。在这两种情况下，先前的值都是

retained.
To change the CRVS[3:0] bits:
1. Set the CMPCTL.COE bit to 0.
2. Set the CMPSEL1 register to 0000 0000b.
3. Set a new value to the CRVS[3:0] bits, with 1 set in only one of the bits.
4. Wait for the input switching stabilization wait time (200 ns)
5. Set the CMPCTL.COE bit to 1.
6. Clear the IR flag in the IELSRn register to clear the interrupt status.

Note 2. For details, see Table 38.2.

38.2.4 Comparator Output Monitor Register (CMPMON)

Address(es): ACMPHS0.CMPMON 4008 500Ch, ACMPHS1.CMPMON 4008 510Ch, ACMPHS2.CMPMON 4008 520Ch, ACMPHS3.CMPMON 4008 530Ch, ACMPHS4.CMPMON 4008 540Ch, ACMPHS5.CMPMON 4008 550Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CMPMON
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CMPMON	Comparator Output Monitor*1	0: Comparator output is low 1: Comparator output is high.	R
b7 to b1	—	Reserved	These bits are read as 0.	R

Note 1. When ACMPHS operation is enabled (HCMPON = COE = 1) but the noise filter is not in use (CDFS[1:0] = 00b), design the software application so that the CMPMON bit is read twice and the values are only used after the two consecutive values match.

38.2.5 Comparator Output Control Register (CPIOC)

Address(es): ACMPHS0.CPIOC 4008 5010h, ACMPHS1.CPIOC 4008 5110h, ACMPHS2.CPIOC 4008 5210h, ACMPHS3.CPIOC 4008 5310h, ACMPHS4.CPIOC 4008 5410h, ACMPHS5.CPIOC 4008 5510h

	b7	b6	b5	b4	b3	b2	b1	b0
	VREFEN	—	—	—	—	—	—	CPOE
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	CPOE	Comparator Output Selection	0: Disable VCOUT pin output of the comparator (output signal is low) 1: Enable VCOUT pin output of the comparator.	R/W
b6 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W
b7	VREFEN	Internal Vref Enable*1	0: Disable internal Vref 1: Enable internal Vref.	R/W

Note 1. For ACMPHS modules 0 to 5, VREFEN exists only in ACMPHS0.CPIOC. When using the internal Vref in COMP0 to COMP5, set the VREFEN bit in ACMPHS0.CPIOC to 1. Bit [7] in ACMPHS1.CPIOC to ACMPHS5.CPIOC registers should be 0 regardless of whether or not the internal Vref is used.

38.3 Operation

The ACMPHS compares a reference voltage to an analog input voltage. Operation is not guaranteed when the values of registers are changed during ACMPHS operation. Table 38.3 shows the procedure for setting the registers associated with ACMPHS.

保留。要更改CRVS[3:0]位：1.将CMPCTL.COE位设置为0。2.将CMPSEL1寄存器设置为00000000b。3.为CRVS[3:0]位设置一个新值，其中一个位设置为1。4.等待输入切换稳定等待时间（200ns）5.将CMPCTL.COE位设置为1。6.清除IELSRn寄存器中的IR标志以清除中断状态。

Note 2. 详见表38.2。

38.2.4 比较器输出监控寄存器(CMPMON)

Address(es): ACMPHS0.CMPMON 4008 500Ch, ACMPHS1.CMPMON 4008 510Ch, ACMPHS2.CMPMON 4008 520Ch, ACMPHS3.CMPMON 4008 530Ch, ACMPHS4.CMPMON 4008 540Ch, ACMPHS5.CMPMON 4008 550Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	CMPMON
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CMPMON	比较器输出监视器*1	0：比较器输出低1：比较器输出高。	R
b7 to b1	—	Reserved	这些位读为0。	R

Note 1. 当启用ACMPHS操作(HCMPON=COE=1)但未使用噪声滤波器(CDFS[1:0]=00b)时，设计软件应用程序，以便读取CMPMON位两次并且仅在之后使用这些值两个连续的值匹配。

38.2.5 比较器输出控制寄存器(CPIOC)

Address(es): ACMPHS0.CPIOC 4008 5010h, ACMPHS1.CPIOC 4008 5110h, ACMPHS2.CPIOC 4008 5210h, ACMPHS3.CPIOC 4008 5310h, ACMPHS4.CPIOC 4008 5410h, ACMPHS5.CPIOC 4008 5510h

	b7	b6	b5	b4	b3	b2	b1	b0
	VREFEN	—	—	—	—	—	—	CPOE
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	CPOE	比较器输出选择	0：禁止比较器的VCOUT引脚输出（输出信号为低电平）1：使能比较器的VCOUT引脚输出。	R/W
b6 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W
b7	VREFEN	Internal Vref Enable*1	0：禁用内部Vref1：启用内部Vref。	R/W

Note 1. 对于ACMPHS模块0到5，VREFEN仅存在于ACMPHS0.CPIOC中。当使用COMP0至COMP5的内部Vref时，将ACMPHS0.CPIOC中的VREFEN位设置为1。无论是否使用内部Vref，ACMPHS1.CPIOC至ACMPHS5.CPIOC寄存器中的位[7]都应为0。

38.3 Operation

ACMPHS将参考电压与模拟输入电压进行比较。如果在ACMPHS操作期间更改寄存器的值，则无法保证操作。表38.3显示了设置与ACMPHS相关的寄存器的过程。

Table 38.3 Procedure for setting registers associated with ACMPHSn (n = 0 to 5)

Step	Register	Bit	Setting
1	Associated MSTPCRD register	MSTPD28 to MSTPD23	0: Input clock supply.
2	Associated Pin Function Control Register (PFS)	ASEL	1: Select the function of pins IVREF and IVCMP.
3	ACMPHS0.CPIOC	VREFEN	1: When using the internal Vref.
4	Associated D/A converter		When using the D/A converter, select in the register
5	CMPSEL0, CMPSEL1	CMPSEL0 to CMPSEL3, CRVS0 to CRVS3	Select the ACMPHSn input, with 1 set in only one of the bits
6	CMPCTL	CDFS[1:0], CEG1, CEG0, and CINV	Set up ACMPHSn control
		HCMPON	1: Enable ACMPHSn operation.
7	Waiting for the ACMPHS stabilization time (minimum 300 ns).		
8	CMPCTL	COE	1: Enable ACMPHSn output.
9	CPIOC	CPOE	Set the VCOUT output
	Associated Port mn Pin Function Select register (PmnPFS)	PSEL, PMR	Select the VCOUT port function
10	IELSRn	IR, IELS[8:0]	When using an interrupt, select the interrupt status flag and the ICU event link*1
11	ELSRn	ELS[8:0]	When using an ELC, select the event link*2
12	Operation started		
13	CMPCTL	COE	0: When changing IVREF or IVCMP, to disable ACMPHSn output.
14	CMPSEL1	CRVS0 to CRVS3	Change the CMPSEL1 bits as follows: 1. Set bits CMPSEL1 to 0000 0000b. 2. Set a new value to the CMPSEL1 bits, with 1 set in only one of the bits.
	CMPSEL0	CMPSEL0 to CMPSEL3	Change the CMPSEL0 bits as follows: 1. Set bits CMPSEL0 to 0000 0000b. 2. Set a new value to the CMPSEL0 bits, with 1 set in only one of the bits.
15	Waiting for the ACMPHS switching stabilization time (minimum 200 ns)		
16	CMPCTL	COE	1: Enable ACMPHSn output.
17	Operation restarted		

Note 1. After ACMPHSn is set, an unnecessary interrupt might occur until operation becomes stable, so initialize the interrupt flag.
Note 2. After ACMPHSn is set, an unnecessary interrupt might occur until operation becomes stable, so initialize the event link select.

Figure 38.2 shows an example of ACMPHS operation. The VCOUT output becomes 1 when the analog input voltage is higher than the ACMPHS reference input voltage, and the VCOUT output becomes 0 when the analog input voltage is lower than the reference voltage. When the ACMPHS output changes, an interrupt request and an ELC event are output.

Table 38.3 设置与ACMPHSn相关的寄存器的过程（n=0到5）

Step	Register	Bit	Setting
1	相关的MSTPCRD寄存器	MSTPD28 to MSTPD23	0：输入时钟电源。
2	相关引脚功能控制 Register (PFS)	ASEL	1：选择引脚IVREF和IVCMP的功能。
3	ACMPHS0.CPIOC	VREFEN	1：使用内部Vref时。
4	相关数模转换器		使用DA转换器时，在寄存器中选择
5	CMPSEL0, CMPSEL1	CMPSEL0 to CMPSEL3, CRVS0 to CRVS3	选择ACMPHSn输入，仅其中一位设置为1
6	CMPCTL	CDFS[1:0], CEG1, CEG0, and CINV	设置ACMPHSn控制
		HCMPON	1：使能ACMPHSn操作。
7	等待ACMPHS稳定时间（最少300ns）。		
8	CMPCTL	COE	1：使能ACMPHSn输出。
9	CPIOC	CPOE	设置VCOUT输出
	关联端口mn引脚功能 选择寄存器(PmnPFS)	PSEL, PMR	选择VCOUT端口功能
10	IELSRn	IR, IELS[8:0]	使用中断时，选择中断状态标志和ICU事件链接*1
11	ELSRn	ELS[8:0]	使用ELC时，请选择活动链接*2
12	操作开始		
13	CMPCTL	COE	0：改变IVREF或IVCMP时，禁用ACMPHSn输出。
14	CMPSEL1	CRVS0 to CRVS3	如下更改CMPSEL1位：1.将CMPSEL1位设置为00000000b。2.为CMPSEL1位设置一个新值，其中一个位设置为1。
	CMPSEL0	CMPSEL0 to CMPSEL3	如下更改CMPSEL0位：1.将CMPSEL0位设置为00000000b。2.为CMPSEL0位设置一个新值，其中一个位设置为1。
15	等待ACMPHS开关稳定时间（最少200ns）		
16	CMPCTL	COE	1：使能ACMPHSn输出。
17	操作重新开始		

Note 1. 设置ACMPHSn后，可能会发生不必要的中断，直到运行稳定为止，因此请初始化中断标志。
Note 2. 设置ACMPHSn后，在操作稳定之前可能会发生不必要的中断，因此初始化事件链接选择。

图38.2显示了ACMPHS操作的示例。当模拟输入电压高于ACMPHS参考输入电压时，VCOUT输出变为1，当模拟输入电压低于参考电压时，VCOUT输出变为0。当ACMPHS输出改变时，会输出一个中断请求和一个ELC事件。

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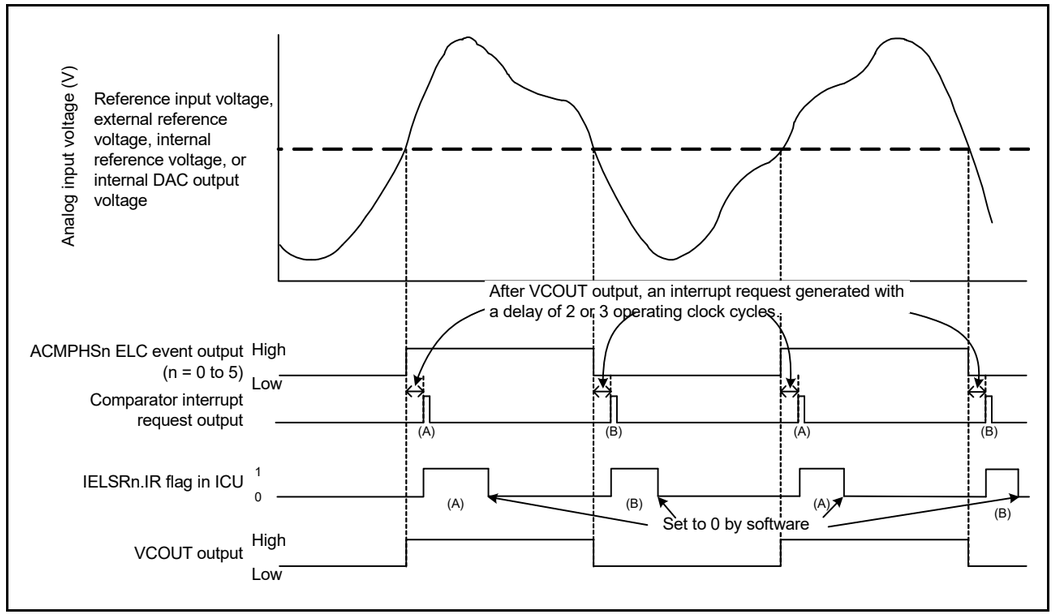

Figure 38.2 ACMPHS operation example

Figure 38.2 applies when CPOE = 1 (pin output enabled), CDFS[1:0] = 00b (filter not used), and CEG1 = CEG0 = 1 (both-edge detection selected). When CINV = 0, CEG0 = 1, and CEG1 = 0 (rising-edge detection selected for non-inversion output signal from the ACMPHS), the IELSR.IR flag changes as shown by (A) only. When CINV = 0, CEG0 = 0, and CEG1 = 1 (falling-edge detection selected for non-inversion output signal from the ACMPHS), the IR flag changes as shown by (B) only. When CPOE = 1, VCOUT directly outputs the ELC event output.

38.4 Noise Filter

The ACMPHS contains a noise filter. The sampling clock can be selected in the CMPCTL.CDFS[1:0] bits. The ACMPHS signal is sampled every sampling clock, and if the same value is sampled three times, the noise filter output at the next sampling clock cycle is used as the ACMPHS output.

Figure 38.3 shows the configuration of the noise filter and edge detector, and Figure 38.4 shows an example of the noise filter and interrupt operation.

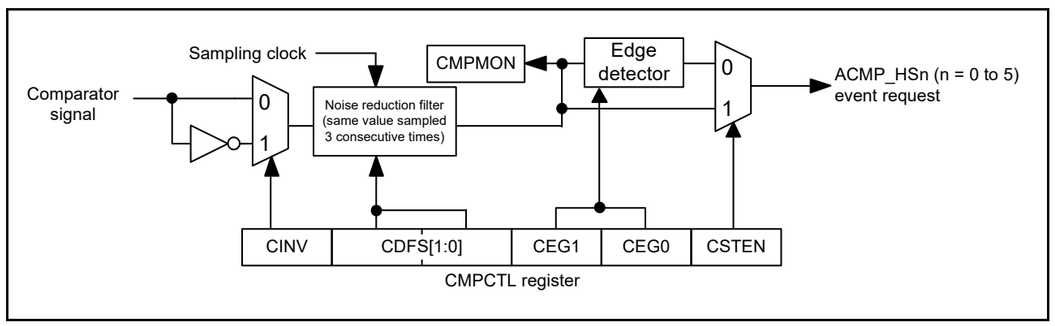

Figure 38.3 Noise filter and edge detection configuration

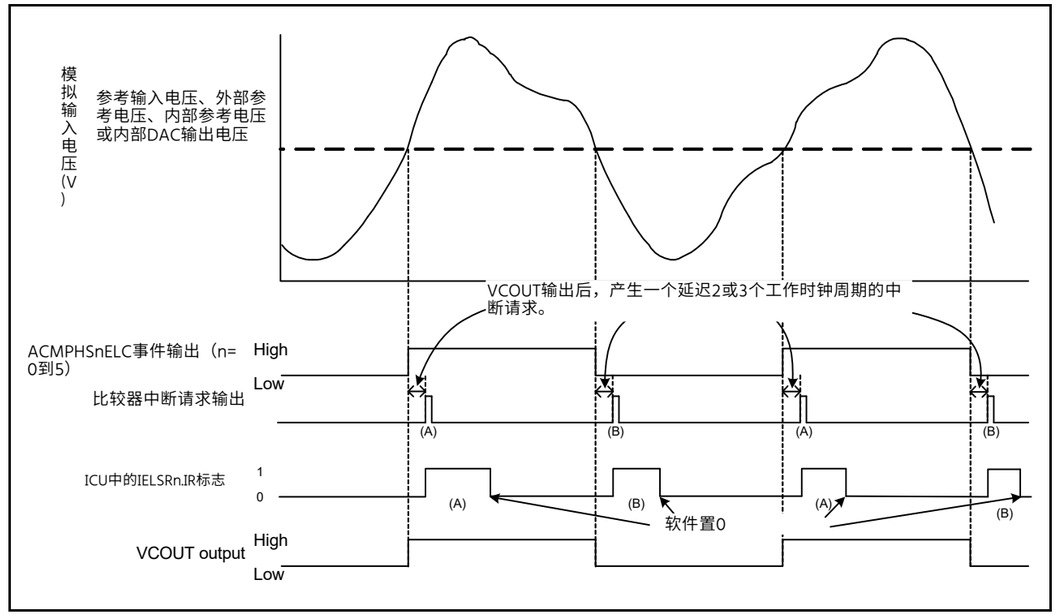

Figure 38.2 ACMPHS操作示例

图38.2适用于CPOE=1（使能引脚输出）、CDFS[1:0]=00b（未使用滤波器）和CEG1=CEG0=1（选择双沿检测）时。当CINV=0、CEG0=1和CEG1=0（为来自ACMPHS的同相输出信号选择上升沿检测）时，IELSR.IR标志仅如(A)所示变化。当CINV=0、CEG0=0和CEG1=1（为来自ACMPHS的非反相输出信号选择下降沿检测）时，IR标志仅如(B)所示变化。当CPOE=1时，VCOUT直接输出ELC事件输出。

38.4 噪声过滤器

ACMPHS包含一个噪声滤波器。可以在CMPCTL.CDFS[1:0]位中选择采样时钟。这
每个采样时钟对ACMPHS信号进行采样，如果采样3次相同的值，则将下一个采样时钟周期的噪声滤波器输出作为ACMPHS输出。

图38.3显示了噪声滤波器和边缘检测器的配置，图38.4显示了噪声滤波器和中断操作的示例。

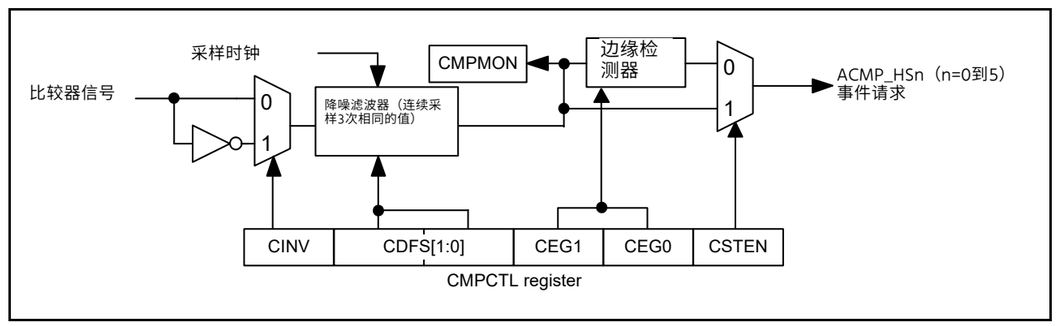

Figure 38.3 噪声过滤器和边缘检测配置

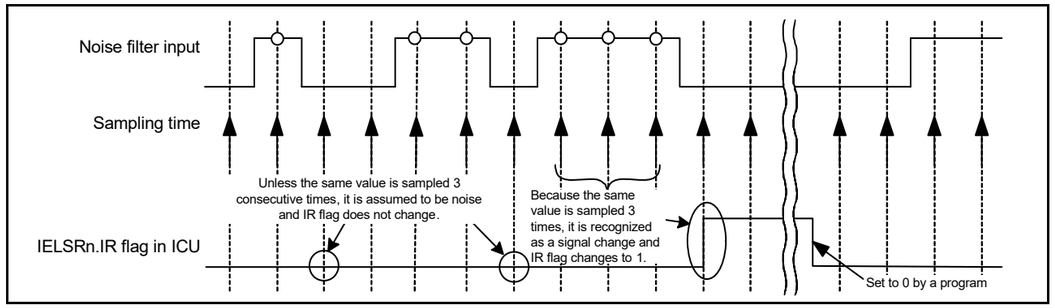

Figure 38.4 Noise filter and interrupt operation example

The operation example in Figure 38.4 applies when the CMPCTL.CDFS[1:0] bits are 01b, 10b, or 11b (noise filter used).

38.5 ACMPHS Interrupts

The ACMPHS generates six interrupt requests from sources ACMPHS0 to ACMPHS5. To use an ACMPHS interrupt, select it in the IELSR register in the Interrupt Controller Unit (ICU). Select the interrupt request in the CMPCTL.CSTEN bit, either through the edge selector, or not.

When using the ACMPHS interrupt through the edge selector, set at least one of the CMPCTL.CEG0 and CMPCTL.CEG1 bits to 1 (a value other than 00b for no edge selection). In most cases, set the CMPCTL.CSTEN bit to 0 (output through the edge selector). Set this bit to 1 only to release Software Standby mode or Snooze mode.

To use the ACMPHS interrupt in Software Standby mode or Snooze mode, set the CMPCTL.CSTEN bit to 1 (direct output), set the CMPCTL.CDFS[1:0] bits to 00b (digital noise filter not used), and set CMPCTL.CINV as follows:

- When detecting compare result 1 to 0, set CMPCTL.CINV to 0 (comparator output not inverted)
- When detecting compare result 0 to 1, set CMPCTL.CINV to 1 (comparator output inverted).

An ACMPHS0 interrupt request can be used to release Software Standby mode or Snooze mode. ACMPHS1 to ACMPHS5 cannot be used. For details on the register settings related to ACMPHS interrupt requests, see section 38.2.1, Comparator Control Register (CMPCTL).

38.6 ACMPHS Output to the Event Link Controller (ELC)

The ELC uses the ACMPHS interrupt request signal as an ELC event signal, enabling link operation for the preset module. To use the ACMPHS ELC event, select it in the ELSRn register in the ELC. When using the ELC event request, set the CMPCTL.CSTEN bit to 0 (output through the edge selector). Also, set at least one of the CMPCTL.CEG0 and CMPCTL.CEG1 bits to 1 (a value other than 00b for no edge selection).

38.7 ACMPHS Pin Output

The comparison result from the ACMPHS can be output to external pins. Use the CMPCTL.CINV and CPIOC.CPOE bits to set the output polarity (non-inverted or inverted output) and enable or disable output. To output the ACMPHS comparison result to the VCOUT output pin, set the associated Port mn Pin Function Select register (PmnPFS) in the I/O register.

38.8 Usage Notes

38.8.1 Settings for the Module-Stop Function

The Module Stop Control Register can enable or disable ACMPHS operation. The ACMPHS is initially stopped after reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

38.8.2 Relationship with the ADC12

Restrictions apply on the simultaneous use of the ACMPHS analog input and ADC12 analog input. For details, see section 35, Relationship between ADC12 Units 0 and 1 and the ACMPHS.

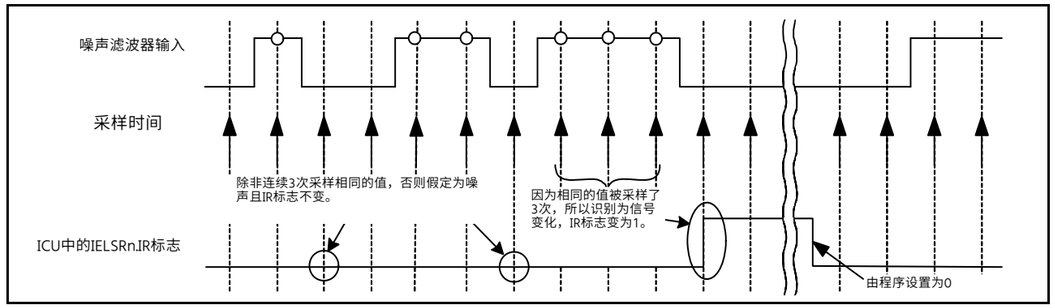

Figure 38.4 噪声滤波器和中断操作示例

图38.4中的操作示例适用于CMPCTL.CDFS[1:0]位为01b、10b或11b（使用噪声滤波器）时。

38.5 ACMPHS Interrupts

ACMPHS从源ACMPHS0到ACMPHS5产生六个中断请求。要使用ACMPHS中断，请在中断控制器单元(ICU)的IELSR寄存器中选择它。通过边沿选择器选择CMPCTL.CSTEN位中的中断请求，或者不选择。

通过边沿选择器使用ACMPHS中断时，至少设置CMPCTL.CEG0和CMPCTL.CEG1位为1（00b以外的值，用于无边沿选择）。在大多数情况下，将CMPCTL.CSTEN位设置为0（通过边沿选择器输出）。将此位设置为1仅用于释放软件待机模式或贪睡模式。

要在软件待机模式或贪睡模式下使用ACMPHS中断，请将CMPCTL.CSTEN位设置为1（直接输出），将CMPCTL.CDFS[1:0]位设置为00b（未使用数字噪声滤波器），并将CMPCTL设置为.CINV如下：

- 检测比较结果1到0时，将CMPCTL.CINV设置为0（比较器输出不反转）
- 当检测到比较结果0到1时，将CMPCTL.CINV设置为1（比较器输出反转）。

ACMPHS0中断请求可用于释放软件待机模式或贪睡模式。ACMPHS1至不能使用ACMPHS5。有关与ACMPHS中断请求相关的寄存器设置的详细信息，请参见第38.2.1节，比较器控制寄存器(CMPCTL)。

38.6 ACMPHS输出到事件链接控制器(ELC)

ELC使用ACMPHS中断请求信号作为ELC事件信号，为预设模块启用链接操作。要使用ACMPHSELC事件，请在ELC的ELSRn寄存器中选择它。使用ELC事件请求时，将CMPCTL.CSTEN位设置为0（通过边沿选择器输出）。此外，将CMPCTL.CEG0和CMPCTL.CEG1位中的至少一个设置为1（不选择边沿时为00b以外的值）。

38.7 ACMPHS引脚输出

ACMPHS的比较结果可以输出到外部引脚。使用CMPCTL.CINV和CPIOC.CPOE位设置输出极性（非反相或反相输出）并启用或禁用输出。要将ACMPHS比较结果输出到VCOUT输出引脚，请在IO寄存器中设置相关的端口mn引脚功能选择寄存器(PmnPFS)。

38.8 使用说明

38.8.1 模块停止功能的设置

模块停止控制寄存器可以启用或禁用ACMPHS操作。ACMPHS在复位后最初停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

38.8.2 与ADC12的关系

同时使用ACMPHS模拟输入和ADC12模拟输入有限制。有关详细信息，请参阅第35节，ADC12单元0和1与ACMPHS之间的关系。

39. Data Operation Circuit (DOC)

39.1 Overview

The Data Operation Circuit (DOC) compares, adds, and subtracts 16-bit data. When a selected condition applies, 16-bit data is compared and an interrupt can be generated.

Table 39.1 lists the DOC specifications, and Figure 39.1 shows a block diagram.

Table 39.1 DOC specifications

Parameter	Specifications
Data operation function	16-bit data comparison, addition, and subtraction
Module-stop function	Module-stop state can be set to reduce power consumption
Interrupts and event link function (DOC_DOPCI)	An interrupt is generated on the following conditions: • Compared values either match or mismatch • The result of data addition is greater than FFFFh • The result of data subtraction is less than 0000h.

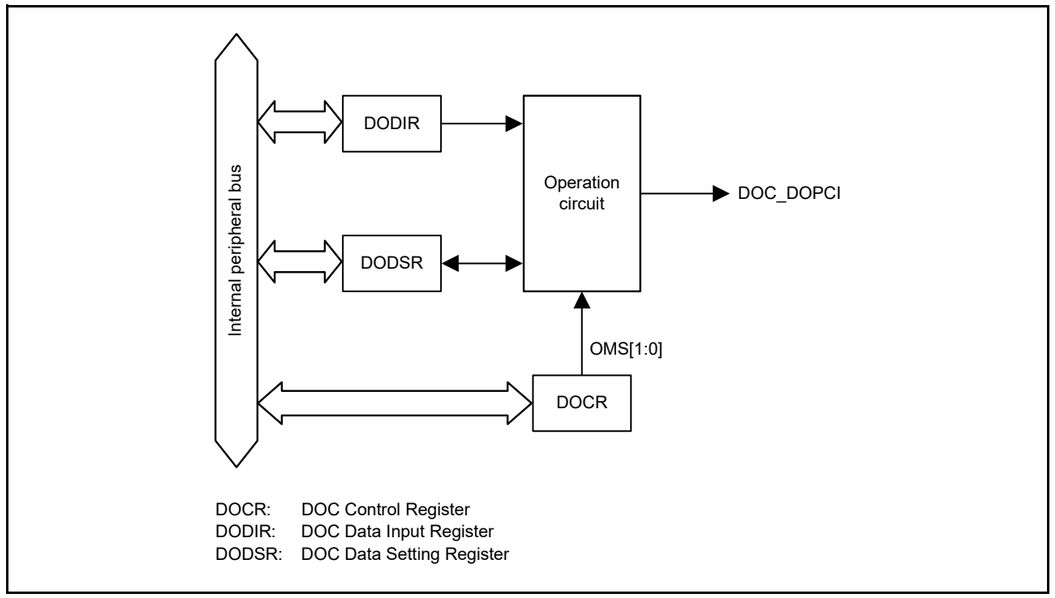

Figure 39.1 DOC block diagram

39. 数据运算电路(DOC)

39.1 Overview

数据运算电路(DOC)对16位数据进行比较、加法和减法。当适用选定条件时，比较16位数据并可以生成中断。

表39.1列出了DOC规范，图39.1显示了框图。

Table 39.1 文档规范

Parameter	Specifications
数据运算功能	16位数据比较、加法和减法
Module-stop function	可设置模块停止状态以降低功耗
中断和事件链接功能（DOC_DOPCI）	在以下情况下会产生中断： 比较值匹配或不匹配 数据加法的结果大于FFFFh 数据减法的结果小于0000h。

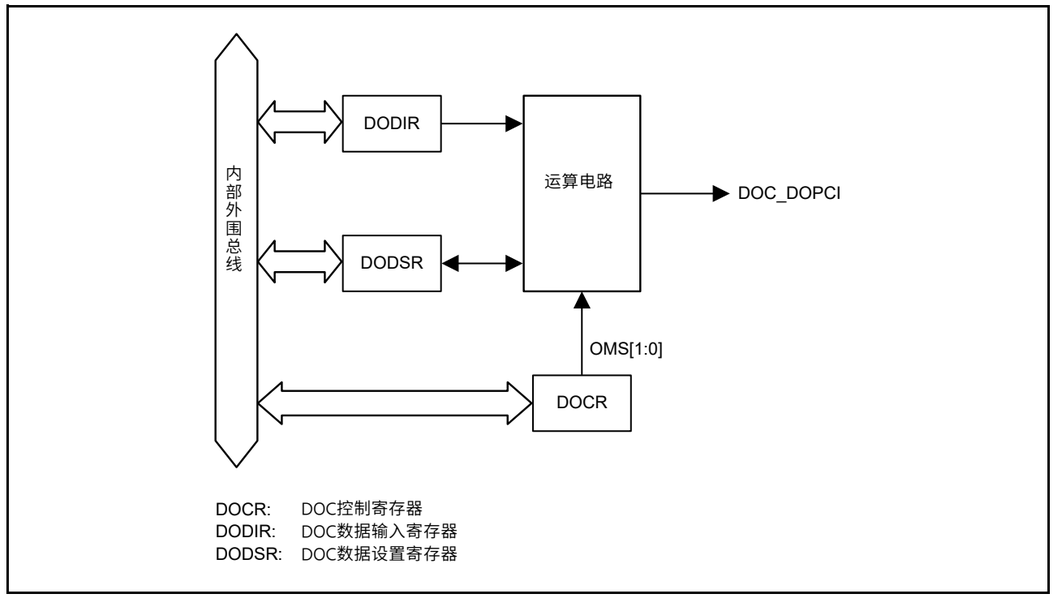

Figure 39.1 文档框图

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39.2 Register Descriptions

39.2.1 DOC Control Register (DOCR)

Address(es): DOC.DOCR 4005 4100h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	DOPCFCL	DOPCF	—	—	DCSEL	OMS[1:0]	
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b1, b0	OMS[1:0]	Operating Mode Select	b1 b0 0 0: Data comparison mode 0 1: Data addition mode 1 0: Data subtraction mode 1 1: Setting prohibited.	R/W
b2	DCSEL*1	Detection Condition Select	0: Set DOPCF when data mismatch is detected 1: Set DOPCF when data match is detected.	R/W
b4, b3	—	Reserved	There bits are read as 0. The write value should be 0.	R/W
b5	DOPCF	Data Operation Circuit Flag	Indicates the result of an operation	R
b6	DOPCFCL	DOPCF Clear	0: Save DOPCF flag state 1: Clear DOPCF flag.	R/W
b7	—	Reserved	This bit is read as 0. The write value should be 0.	R/W

Note 1. Only valid when data comparison mode is selected.

OMS[1:0] bits (Operating Mode Select)

The OMS[1:0] bits select the operating mode of the DOC.

DCSEL bit (Detection Condition Select)

The DCSEL bit selects the detection condition in data comparison mode. This bit is only valid when data comparison mode is selected.

DOPCF flag (Data Operation Circuit Flag)

The DOPCF flag indicates the result of an operation.

[Setting conditions]

- The condition selected in the DCSEL bit is met
- A data addition result is greater than FFFFh
- A data subtraction result is less than 0000h.

[Clearing condition]

- Writing 1 to the DOPCFCL bit.

DOPCFCL bit (DOPCF Clear)

Setting the DOPCFCL bit to 1 clears the DOPCF flag. This bit is read as 0.

39.2 注册说明

39.2.1 DOC控制寄存器(DOCR)

Address(es): DOC.DOCR 4005 4100h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	DOPCFCL	DOPCF	—	—	DCSEL	OMS[1:0]	
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b1, b0	OMS[1:0]	操作模式选择	b1b000：数据比较模式01： 数据加法模式10：数据减法 模式11：禁止设置。	R/W
b2	DCSEL*1	检测条件选择	0：检测到数据不匹配时置位DOPCF1：检测到 数据匹配时置位DOPCF。	R/W
b4, b3	—	Reserved	有位被读取为0。写入值应为0。	R/W
b5	DOPCF	数据运算电路标志	表示操作的结果	R
b6	DOPCFCL	DOPCF Clear	0：保存DOPCF标志状态1 ：清除DOPCF标志。	R/W
b7	—	Reserved	该位读取为0。写入值应为0。	R/W

Note 1. 仅在选择数据比较模式时有效。

OMS[1:0]位（操作模式选择）

OMS[1:0]位选择DOC的工作模式。

DCSEL位（检测条件选择）

DCSEL位选择数据比较模式下的检测条件。该位仅在选择数据比较模式时有效。

DOPCF标志（数据操作电路标志）

DOPCF标志指示操作的结果。

[Setting conditions]

- 满足在DCSEL位中选择的条件
- 数据相加结果大于FFFFh
- 数据减法结果小于0000h。

[Clearing condition]

- 将1写入DOPCFCL位。

DOPCFCL位（DOPCF清除）

将DOPCFCL位设置为1会清除DOPCF标志。该位读为0。

39.2.2 DOC Data Input Register (DODIR)

Address(es): DOC.DODIR 4005 4102h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DODIR is a 16-bit read/write register that stores 16-bit data used in all operations.

39.2.3 DOC Data Setting Register (DODSR)

Address(es): DOC.DODSR 4005 4104h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DODSR is a 16-bit read/write register that stores 16-bit data used as a reference in data comparison mode. This register also stores the results of operations in data addition and subtraction modes.

39.3 Operation

39.3.1 Data Comparison Mode

Figure 39.2 shows an example DOC operation in data comparison mode. The following sequence is an example of operation when DCSEL is set to 0 (data mismatch is detected as a result of data comparison):

1. Write 00b to the DOCR.OMS[1:0] bits to select data comparison mode.
2. Set 16-bit reference data in DODSR.
3. Write 16-bit data for comparison to DODIR.
4. Continue writing 16-bit data until all data to be compared is written to DODIR.
5. If a value written to DODIR does not match that in DODSR,*1 the DOCR.DOPCF flag is set to 1.

Note 1. When DOCR.DCSEL = 0

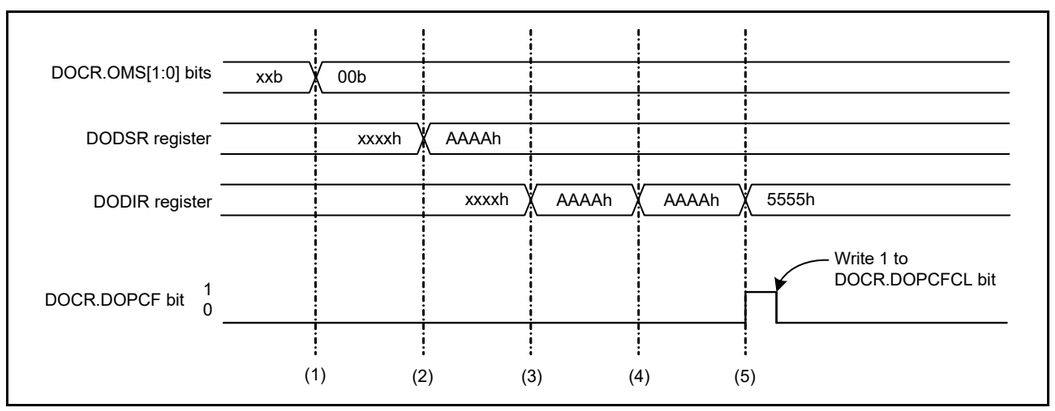

Figure 39.2 Example of operation in data comparison mode

39.2.2 DOC数据输入寄存器(DODIR)

Address(es): DOC.DODIR 4005 4102h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DODIR是一个16位读写寄存器，用于存储所有操作中使用的16位数据。

39.2.3 DOC数据设置寄存器(DODSR)

Address(es): DOC.DODSR 4005 4104h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
重置后的值：	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DODSR是一个16位读写寄存器，用于存储16位数据，在数据比较模式下用作参考。该寄存器还存储数据加法和减法模式下的运算结果。

39.3 Operation

39.3.1 数据比较模式

图39.2显示了数据比较模式下的示例DOC操作。以下序列是DCSEL设置为0时的操作示例（通过数据比较检测到数据不匹配）：

1. 将00b写入DOCR.OMS[1:0]位以选择数据比较模式。
2. 在DODSR中设置16位参考数据。
3. 写入16位数据以与DODIR进行比较。
4. 继续写入16位数据，直到所有要比较的数据都写入DODIR。
5. 如果写入DODIR的值与DODSR中的值不匹配，*1DOCR.DOPCF标志设置为1。

注1.当DOCR.DCSEL=0时

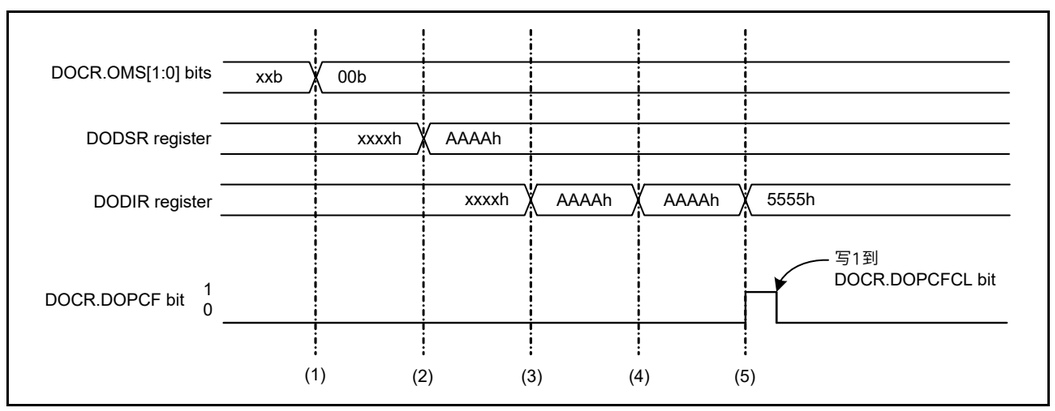

Figure 39.2 数据比较模式的操作示例

39.3.2 Data Addition Mode

Figure 39.3 shows an example for DOC operation in data addition mode. The steps are as follows:

1. Write 01b to the DOCR.OMS[1:0] bits to select data addition mode.
2. Set 16-bit data in the DODSR register as the initial value.
3. Write 16-bit data to be added to the DODIR register. The result of the operation is stored in DODSR.
4. Continue writing 16-bit data until all data to be added is written to DODIR.
5. If the result of an operation is greater than FFFFh, the DOCR.DOPCF flag is set to 1.

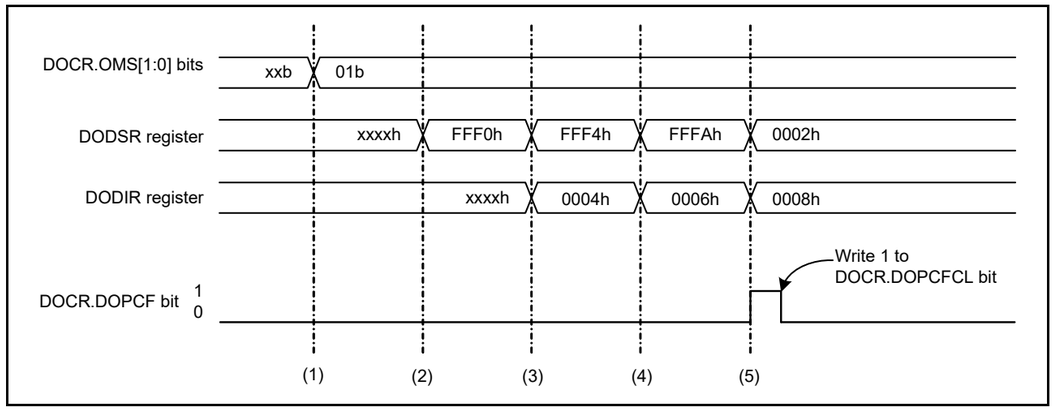

Figure 39.3 Example of operation in data addition mode

39.3.3 Data Subtraction Mode

Figure 39.4 shows an example for DOC operation in data subtraction mode. The steps are as follows:

1. Write 10b to the DOCR.OMS[1:0] bits to select data subtraction mode.
2. Set 16-bit data as the initial value in the DODSR register.
3. Write 16-bit data to be subtracted to the DODIR register. The result of the operation is stored in DODSR.
4. Continue writing 16-bit data to DODIR until all data for subtraction is written.
5. If the result of an operation is less than 0000h, the DOCR.DOPCF flag is set to 1.

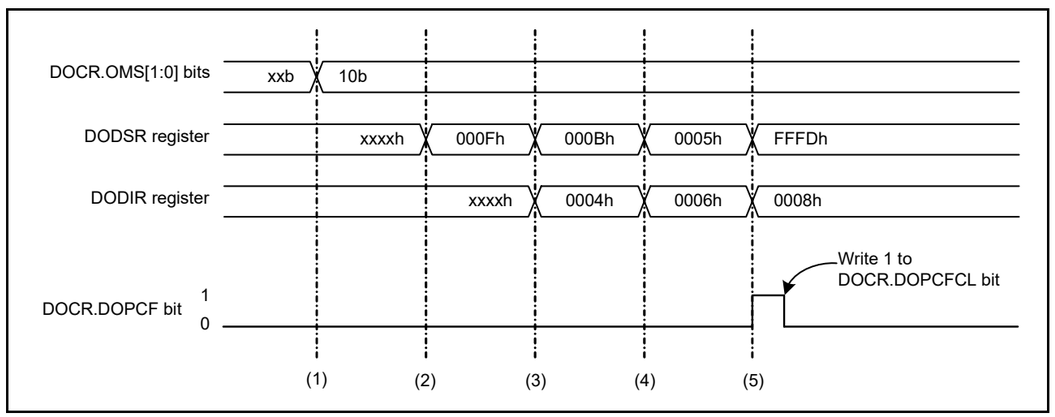

Figure 39.4 Example of operation in data subtraction mode

39.3.2 数据加法模式

图39.3显示了数据添加模式下的DOC操作示例。步骤如下：

1. 将01b写入DOCR.OMS[1:0]位以选择数据添加模式。
2. 将DODSR寄存器中的16位数据设置为初始值。
3. 写入要添加到DODIR寄存器的16位数据。操作结果存储在DODSR中。
4. 继续写入16位数据，直到所有要添加的数据都写入DODIR。
5. 如果运算结果大于FFFFh，则DOCR.DOPCF标志设置为1。

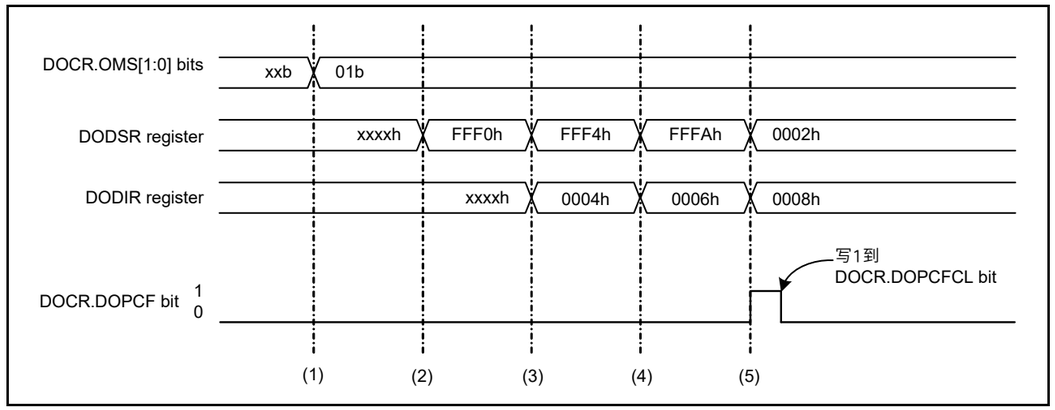

Figure 39.3 数据添加模式中的操作示例

39.3.3 数据减法模式

图39.4显示了数据减法模式下的DOC操作示例。步骤如下：

1. 将10b写入DOCR.OMS[1:0]位以选择数据减法模式。
2. 在DODSR寄存器中设置16位数据作为初始值。
3. 将要减去的16位数据写入DODIR寄存器。操作结果存储在DODSR中。
4. 继续向DODIR写入16位数据，直到写入所有减法数据。
5. 如果运算结果小于0000h，则DOCR.DOPCF标志设置为1。

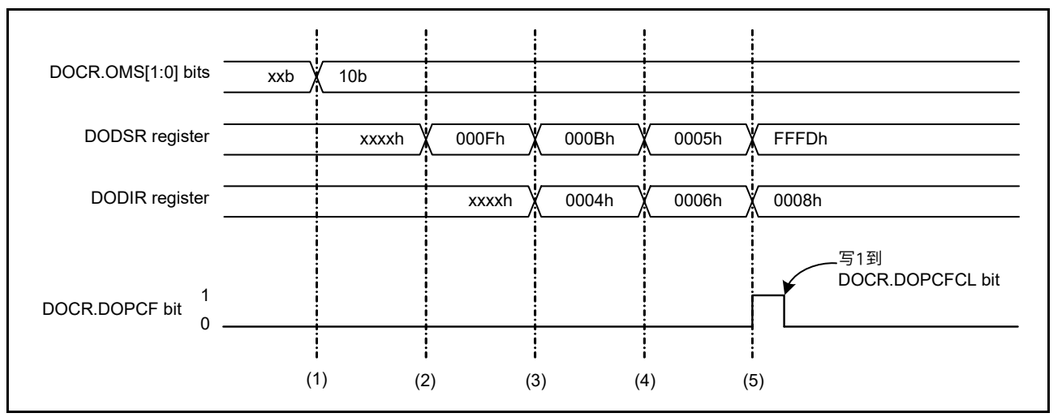

Figure 39.4 数据减法模式下的操作示例

39.4 Interrupt Request and Output to the Event Link Controller (ELC)

The DOC outputs an event signal for the ELC under the following conditions:

- The compared values either match or mismatch
- The data addition result is greater than FFFFh
- The data subtraction result is less than 0000h.

This signal can be used to initiate operations by other modules selected in advance and can also be used as an interrupt request. When an event signal is generated, the Data Operation Circuit Flag (DOCR.DOPCF) is set to 1.

39.5 Usage Notes

39.5.1 Settings for the Module-Stop State

The Module Stop Control Register C (MSTPCRC) can enable or disable DOC operation. The DOC is initially stopped after reset. Releasing the module-stop state enables access to the registers. For details, see section 11, Low Power Modes.

39.4 中断请求和输出到事件链接控制器(ELC)

DOC在以下条件下为ELC输出事件信号：

- 比较的值匹配或不匹配
- 数据相加结果大于FFFFh
- 数据减法结果小于0000h。

该信号可用于启动其他预先选择的模块的操作，也可用作中断请求。产生事件信号时，数据操作电路标志(DOCR.DOPCF)设置为1。

39.5 使用说明

39.5.1 模块停止状态的设置

模块停止控制寄存器C(MSTPCRC)可以启用或禁用DOC操作。DOC在复位后最初停止。释放模块停止状态可以访问寄存器。有关详细信息，请参阅第11节，低功耗模式。

RA生态工作室

40. SRAM

40.1 Overview

The MCU provides on-chip high-speed SRAM modules with parity-bit checking.

Table 40.1 lists the SRAM specifications.

Table 40.1 SRAM specifications

Parameter	SRAMHS specifications
SRAM capacity	SRAMHS: 64 KB
SRAM address	SRAMHS: 1FFE 0000h to 1FFE FFFFh
Access*1	Access to the SRAMHS is always a no wait state
Data retention	Not available in Deep Software Standby mode
Module-stop function	Module-stop state can be set to reduce power consumption
Parity	Even-parity (data: 8 bits, parity: 1 bit)
Error checking	Even-parity error check

Note 1. For details, see section 40.3.4, Access Cycles.

40.2 Register Descriptions

40.2.1 SRAM Parity Error Operation After Detection Register (PARIOAD)

Address(es): SRAM.PARIOAD 4000 2000h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	OAD
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	OAD	Operation after Detection	1: Reset 0: Non-maskable interrupt.	R/W
b7 to b1	—	Reserved	These bits are read as 0. The write value should be 0.	R/W

The PARIOAD register controls the operation on detection of a parity error. The SRAM Protection Register (SRAMPRCR) protects this register against writes. Always set the SRAMPRCR bit in SRAMPRCR to enabled before writing to this register. Do not write to the PARIOAD register while accessing the SRAM.

OAD bit (Operation after Detection)

The OAD bit specifies the generation of either a reset or a non-maskable interrupt when a parity error is detected.

40. SRAM

40.1 Overview

MCU提供带有奇偶校验位检查的片上高速SRAM模块。

表40.1列出了SRAM规格。

Table 40.1 SRAM specifications

Parameter	SRAMHS specifications
SRAM capacity	SRAMHS: 64 KB
SRAM address	SRAMHS: 1FFE 0000h to 1FFE FFFFh
Access*1	访问SRAMHS始终是无等待状态
数据保留	在深度软件待机模式下不可用
Module-stop function	可设置模块停止状态以降低功耗
Parity	Even-parity (data: 8 bits, parity: 1 bit)
错误检查	偶校验错误检查

Note 1. 有关详细信息，请参阅第40.3.4节，访问周期。

40.2 注册说明

40.2.1 检测寄存器后的SRAM奇偶校验错误操作(PARIOAD)

Address(es): SRAM.PARIOAD 4000 2000h

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	OAD
重置后的值：	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	OAD	检测后的操作	1：复位0：不可屏蔽中断 。	R/W
b7 to b1	—	Reserved	这些位被读取为0。写入值应为0。	R/W

PARIOAD寄存器控制检测奇偶校验错误时的操作。SRAM保护寄存器(SRAMPRCR)保护该寄存器不被写入。在写入该寄存器之前，始终将SRAMPRCR中的SRAMPRCR位设置为启用。访问SRAM时不要写入PARIOAD寄存器。

OAD位（检测后操作）

OAD位指定在检测到奇偶校验错误时产生复位或不可屏蔽中断。

40.2.2 SRAM Protection Register (SRAMPRCR)

Address(es): SRAM.SRAMPRCR 4000 2004h

	b7	b6	b5	b4	b3	b2	b1	b0
	KW[6:0]							SRAMPRCR
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	SRAMPRCR	Register Write Control	0: Disable writes to protected registers 1: Enable writes to protected registers.	R/W
b7 to b1	KW[6:0]	Write Key Code	These bits enable or disable writes to the SRAMPRCR bit	R/W

SRAMPRCR bit (Register Write Control)

The SRAMPRCR bit controls the write mode of the PARIOAD registers. When this bit is set to 1, writing to the PARIOAD registers is enabled. When you write to this bit, write 78h to the KW[6:0] bits simultaneously.

KW[6:0] bits (Write Key Code)

The KW[6:0] bits enable or disable writes to the SRAMPRCR bit. When you write to the SRAMPRCR bit, write 78h to the KW[6:0] bits simultaneously. When a value other than 78h is written to KW[6:0], the SRAMPRCR bit is not updated. The KW[6:0] bits are always read as 00h.

40.3 Operation

40.3.1 Low-Power Functions

Power consumption can be reduced by setting the Module Stop Control Register A (MSTPCRA) to stop the supply of the clock signal to the SRAM. The control bits for each module are as follows:

- Setting the MSTPA5 bit in MSTPCRA to 1 stops the supply of the clock signal to SRAMHS.

Stopping the clock signal supply places the SRAM in the module-stop state. The SRAM operates after a reset.

The SRAM is not accessible in the module-stop state. Do not transition to the module-stop state while accessing the SRAM. Access to the SRAM in the module-stop state is prohibited. If access is attempted, correct operation is not guaranteed. For details on the MSTPCRA register, see section 11, Low Power Modes.

40.3.2 Parity Calculation Function

The IEC60730 standard requires the checking of SRAM data. When data is written, a parity bit is added to every 8-bit data in the SRAM which has a 32-bit data width, and when data is read, the parity is checked. When a parity error occurs, a parity-error notification is generated. This function can also be used to trigger a reset. The specification for SRAMHS is even parity.

Parity error notification can be specified as a non-maskable interrupt or a reset in the OAD bit in the PARIOAD register. When the OAD bit in the PARIOAD register is set to 1, a parity error is output to the reset function. When the OAD bit is set to 0, a parity error is output to the ICU as a non-maskable interrupt.

Parity errors often occur because of noise. To confirm whether the cause of the parity error is noise or corruption, see the parity check flows in Figure 40.1 and Figure 40.2.

40.2.2 SRAM保护寄存器(SRAMPRCR)

Address(es): SRAM.SRAMPRCR 4000 2004h

	b7	b6	b5	b4	b3	b2	b1	b0
	KW[6:0]							SRAMPRCR
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	SRAMPRCR	寄存器写控制	0：禁止写入受保护寄存器1：允许写入受保护寄存器。	R/W
b7 to b1	KW[6:0]	编写关键代码	这些位启用或禁用对SRAMPRCR位的写入	R/W

SRAMPRCR位（寄存器写控制）

SRAMPRCR位控制PARIOAD寄存器的写模式。当该位设置为1时，写入启用PARIOAD寄存器。写入该位时，同时将78h写入KW[6:0]位。

KW[6:0]位（写入密钥代码）

KW[6:0]位启用或禁用对SRAMPRCR位的写入。写入SRAMPRCR位时，同时将78h写入KW[6:0]位。当78h以外的值写入KW[6:0]时，SRAMPRCR位不会更新。KW[6:0]位总是读为00h。

40.3 Operation

40.3.1 Low-Power Functions

通过设置模块停止控制寄存器A(MSTPCRA)以停止向SRAM提供时钟信号，可以降低功耗。每个模块的控制位如下：

- 将MSPCRA中的MSTPA5位设置为1会停止向SRAMHS提供时钟信号。

停止时钟信号供应会将SRAM置于模块停止状态。SRAM在复位后运行。

SRAM在模块停止状态下不可访问。访问时不要转换到模块停止状态SRAM。禁止在模块停止状态下访问SRAM。如果尝试访问，则无法保证正确操作。有关MSTPCRA寄存器的详细信息，请参见第11节，低功耗模式。

40.3.2 奇偶校验计算功能

IEC60730标准要求检查SRAM数据。写入数据时，对32位数据宽度的SRAM中的每8位数据添加一个奇偶校验位，读取数据时检查奇偶校验位。当发生奇偶校验错误时，会生成奇偶校验错误通知。此功能也可用于触发复位。SRAMHS的规格是偶数奇偶校验。

奇偶校验错误通知可以在PARIOAD寄存器的OAD位中指定为不可屏蔽中断或复位。当PARIOAD寄存器中的OAD位设置为1时，将向复位功能输出奇偶校验错误。当OAD位设置为0时，奇偶校验错误作为不可屏蔽中断输出到ICU。

奇偶校验错误经常因噪声而发生。要确认奇偶校验错误的原因是噪声还是损坏，请参见图40.1和图40.2中的奇偶校验流程。

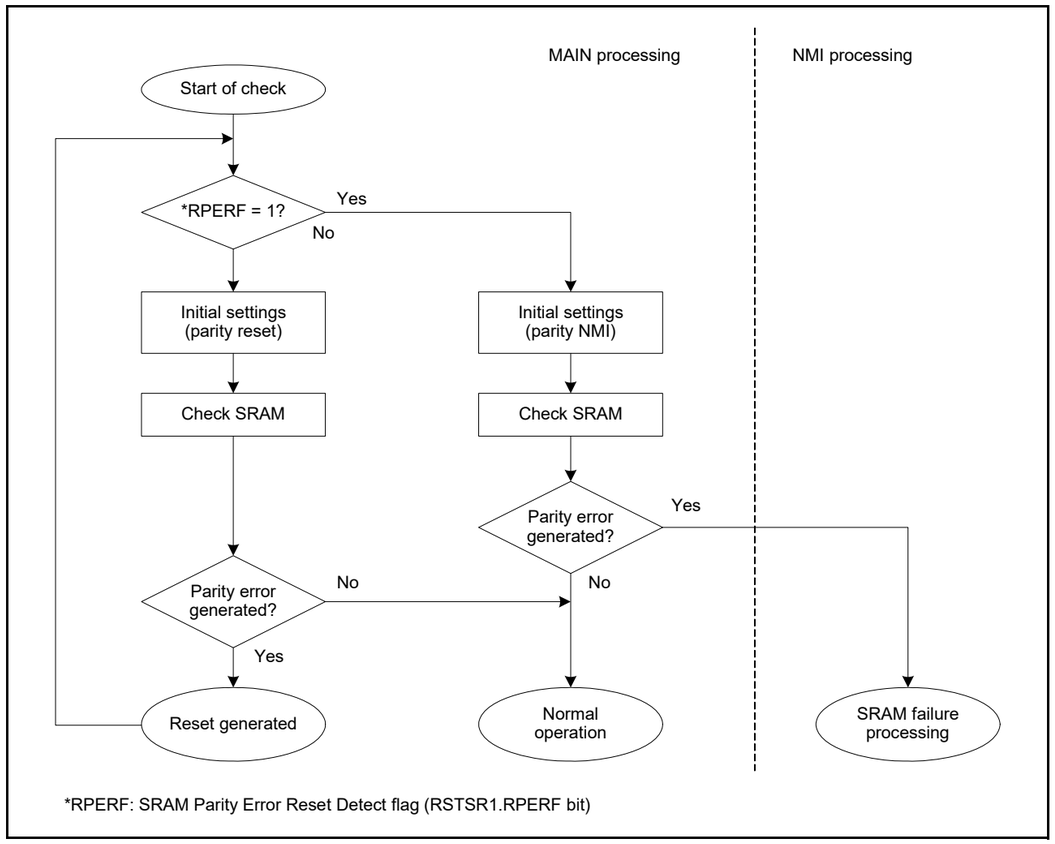

Figure 40.1 Flow of SRAM parity check when SRAM parity reset is enabled

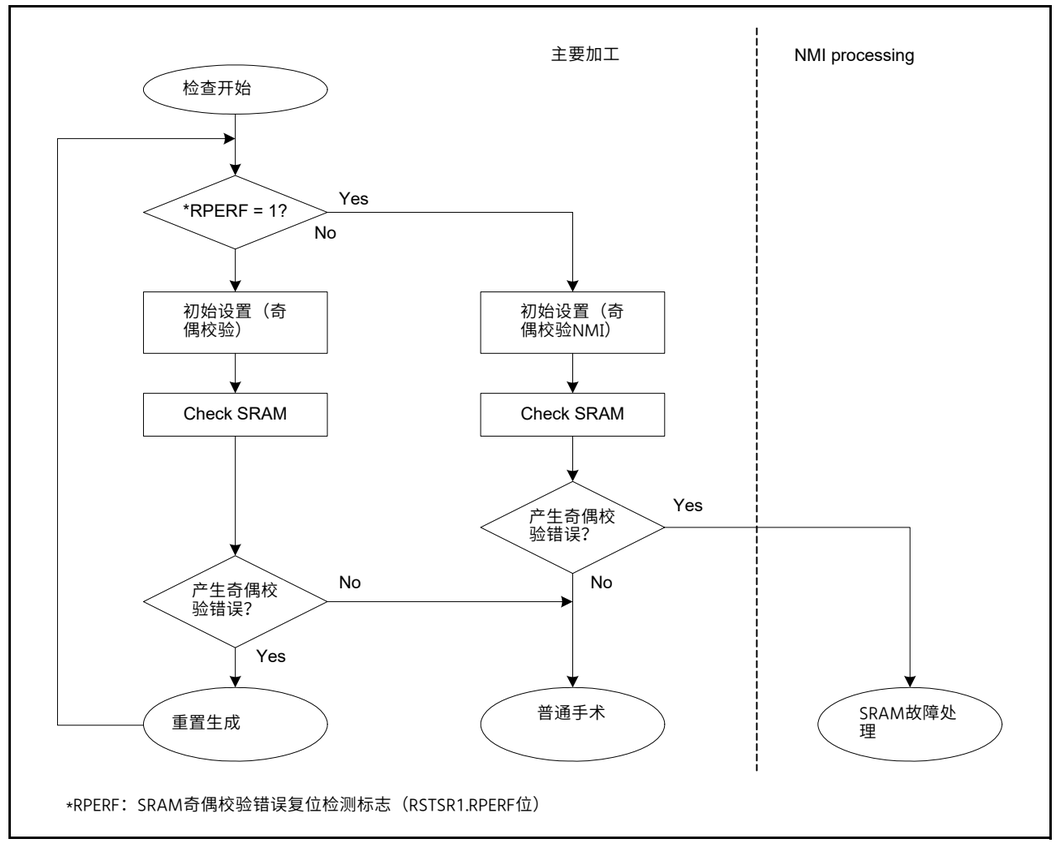

Figure 40.1 启用SRAM奇偶校验复位时的SRAM奇偶校验流程

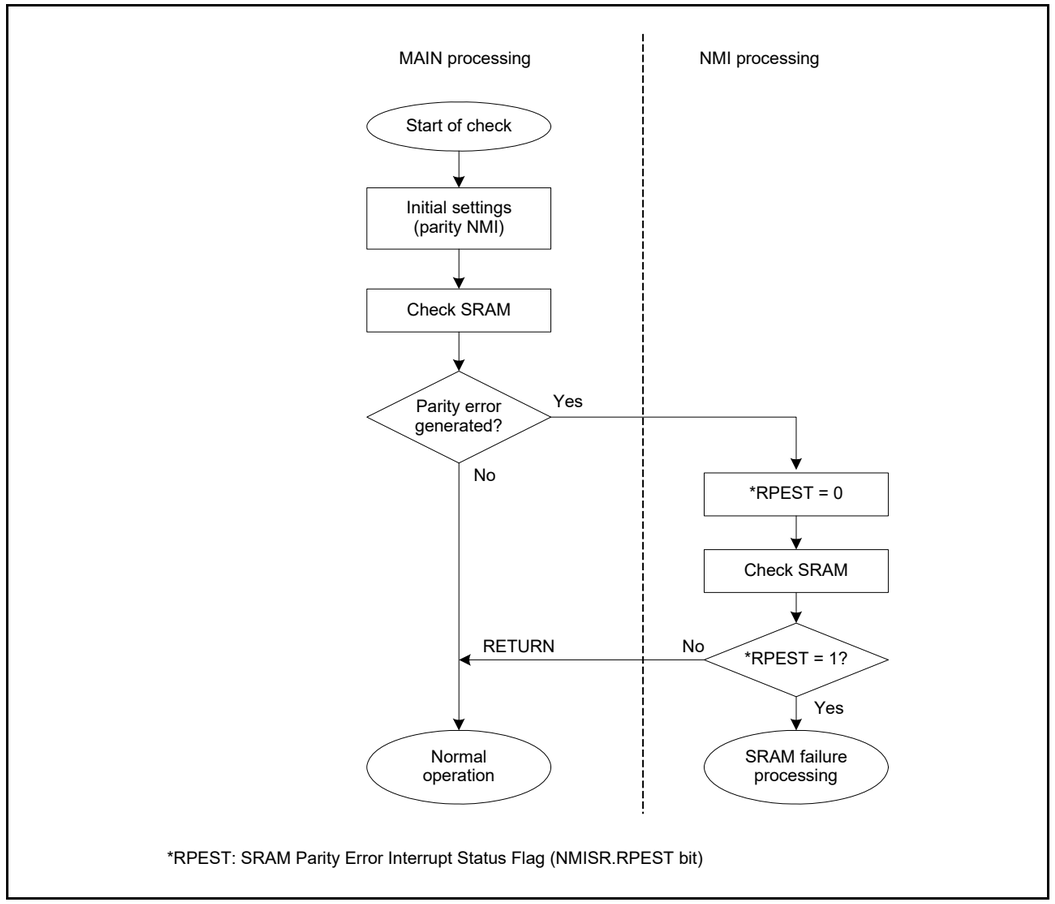

Figure 40.2 Flow of SRAM parity check when SRAM parity interrupt is enabled

40.3.3 SRAM Error Sources

An SRAM error source is a parity error and can generate either a non-maskable interrupt or a reset, as selected with the OAD bit in the PARIOAD register.

Table 40.2 SRAM error sources

Interrupt source	DTC activation	DMAC activation
Parity error (SRAMHS)	Not possible	Not possible

40.3.4 Access Cycles

Table 40.3 SRAMHS (parity area 1FFE 0000h to 1FFE FFFFh)

Read (cycles)		Write (cycles)	
Word access	Halfword/byte access	Word access	Halfword/byte access
2		2	

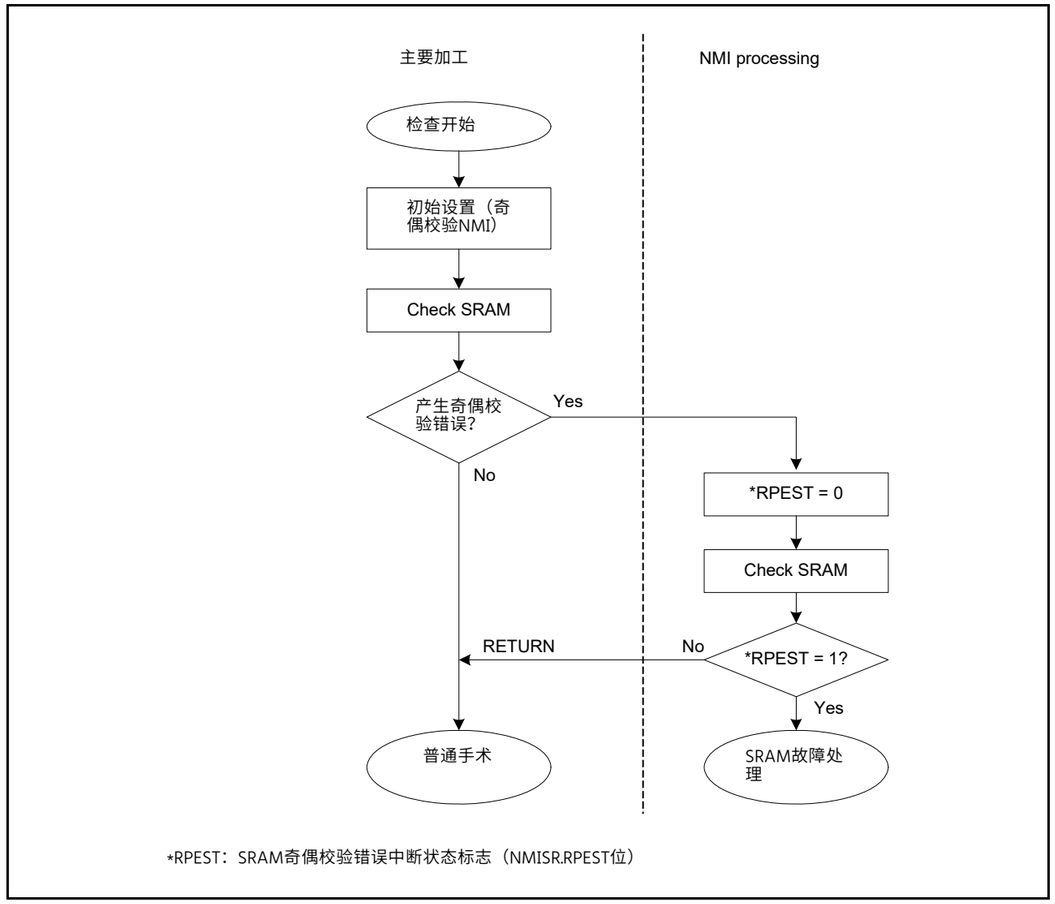

Figure 40.2 启用SRAM奇偶校验中断时的SRAM奇偶校验流程

40.3.3 SRAM错误源

SRAM错误源是奇偶校验错误，可以生成不可屏蔽中断或复位，由PARIOAD寄存器中的OAD位。

Table 40.2 SRAM错误源

中断源	DTC activation	DMAC activation
奇偶校验错误(SRAMHS)	不可能	不可能

40.3.4 访问周期

Table 40.3 SRAMHS（奇偶校验区1FFE0000h至1FFEFFFFh）

Read (cycles)		Write (cycles)	
字访问	Halfword/byte access	字访问	Halfword/byte access
2		2	

40.4 Usage Notes

40.4.1 Instruction Fetch from SRAM Area

When using the SRAMHS to operate a program, initialize the SRAM area so that the CPU can correctly prefetch data. If the CPU prefetches data from an SRAM area that is not initialized, a parity error might occur. Initialize the additional 12-byte area from the end address of a program with a 4-byte boundary. Renesas recommends using the NOP instruction for data initialization.

40.4.2 Store Buffer of SRAM

For fast access between the SRAM and CPU, a store buffer is used. When a load instruction is executed from the same address after a store instruction to the SRAM, the load instruction might read data from the buffer instead of data from the SRAM. To read data on the SRAM correctly, use either of the following procedures:

- After writing to the SRAM (address = A), use the NOP instruction, then read the SRAM (address = A)
- After writing to the SRAM (address = A), read data from an area other than SRAM (address = A), then read the SRAM (address = A).

40.4 使用说明

40.4.1 从SRAM区域取指令

使用SRAMHS操作程序时，初始化SRAM区域，以便CPU可以正确预取数据。如果CPU从未初始化的SRAM区域预取数据，则可能发生奇偶校验错误。用4字节边界从程序的结束地址初始化额外的12字节区域。瑞萨推荐使用NOP指令进行数据初始化。

40.4.2 SRAM的存储缓冲区

为了在SRAM和CPU之间进行快速访问，使用了存储缓冲区。当在对SRAM执行存储指令之后从同一地址执行加载指令时，加载指令可能会从缓冲区读取数据，而不是从SRAM读取数据。要正确读取SRAM上的数据，请使用以下任一过程：

- 写入SRAM（地址=A）后，使用NOP指令，然后读取SRAM（地址=A）
- 写入SRAM（地址=A）后，从SRAM（地址=A）以外的区域读取数据，然后读取SRAM (address = A).

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41. Flash Memory

41.1 Overview

The MCU provides up to 512-KB code flash memory and 8-KB data flash memory. The Flash Control Unit (FCU) controls the programming and erasure of the flash memory. The Flash Application Command Interface (FACI) controls the FCU in accordance with the specified FACI commands.

Table 41.1 lists the specifications of the code flash memory and data flash memory, and Figure 41.1 shows a block diagram of the related modules. Figure 41.2 shows the configuration of the code flash memory, and Figure 41.3 shows the configuration of the data flash memory.

Table 41.1 Code flash memory and data flash memory specifications

Parameter	Code flash memory	Data flash memory
Memory capacity	• Up to 512 KB of user area	8 KB of data area
Read cycle	• 80 MHz < ICLK frequency ≤ 120 MHz Cache hit: 1 cycle Cache miss: 3 cycles • 40 MHz < ICLK frequency ≤ 80 MHz Cache hit: 1 cycle Cache miss: 2 cycles • ICLK frequency ≤ 40 MHz Cache hit: 1 cycle Cache miss: 1 cycle.	A read operation takes 7 FCLK cycles in words or bytes (FCLK frequency is up to 60 MHz)
Value after erasure	FFh	Undefined
Programming/erasing methods	• Programming and erasure of code and data flash memory through the FACI commands specified in the FACI command issuing area (407E 0000h) • Programming by dedicated flash-memory programmer transfer through a serial interface (serial programming) • Programming of flash memory by user program (self-programming)	
Security function	Protection against illicit tampering or reading of data in flash memory	
Protection	Protection against erroneous overwriting of flash memory	
Background operations (BGOs)	• Code flash memory can be read during data flash memory programming • Data flash memory can be read during code flash memory programming	
Units of programming and erasure	• 128-byte units for programming in user area • Block units for erasure in user area	• 4/8/16-byte units for programming in data area • 64/128/256-byte units for erasure in data area
Other functions	Interrupts accepted during self-programming	
	An expansion area of flash memory (option bytes) can be set in the initial MCU settings	
On-board programming (four types)	Programming in serial programming mode (SCI boot mode): • Asynchronous serial interface (SCI9) used • Transfer rate adjusted automatically. Programming in on-chip debug mode: • JTAG or SWD interface used • Dedicated hardware not required. Programming by a routine for code and data flash memory programming within the user program: • Allows code and data flash memory programming without resetting the system.	

41. 闪存

41.1 Overview

MCU提供高达512-KB的代码闪存和8-KB的数据闪存。闪存控制单元(FCU)控制闪存的编程和擦除。Flash应用命令接口(FACI)根据指定的FACI命令控制FCU。

表41.1列出了代码闪存和数据闪存的规格，图41.1给出了相关模块的框图。图41.2显示了代码闪存的配置，图41.3显示了数据闪存的配置。

Table 41.1 代码闪存和数据闪存规格

Parameter	代码闪存	数据闪存
内存容量	高达512KB的用户区	8KB数据区
读周期	80MHz<ICLK频率≤120MHz高速缓存命中：1个周期 缓存未命中：3个周期 40MHz<ICLK频率≤80MHz缓存命中：1个周期 缓存未命中：2个周期 ICLK频率≤40MHz缓存命中：1个周期 缓存未命中：1个周期。	读取操作需要7个FCLK周期（以字或字节为单位）（FCLK频率高达60MHz）
擦除后的值	FFh	Undefined
Programming/erasing methods	通过FACI命令发出区域(407E0000h)中指定的FACI命令对代码和数据闪存进行编程和擦除（自编程）	
安全功能	防止非法篡改或读取闪存中的数据	
Protection	防止错误覆盖闪存	
后台操作(BGO)	在数据闪存编程期间可以读取代码闪存 在代码闪存编程期间可以读取数据闪存	
编程和擦除单元	128字节单元，用于用户区中的编程 块单元，用于用户区中的擦除	48个16字节单元，用于数据区中的编程 64128256字节单元，用于数据区中的擦除
其他功能	自编程期间接受的中断	
	可在初始MCU设置中设置闪存的扩展区域（选项字节）	
On-board programming (four types)	在串行编程模式（SCI引导模式）下编程： 使用异步串行接口(SCI9) 自动调整传输速率。 在片上调试模式下编程： 使用JTAG或SWD接口 不需要专用硬件。 通过用户程序中的代码和数据闪存编程例程进行编程： 允许在不重置系统的情况下对代码和数据闪存进行编程。	

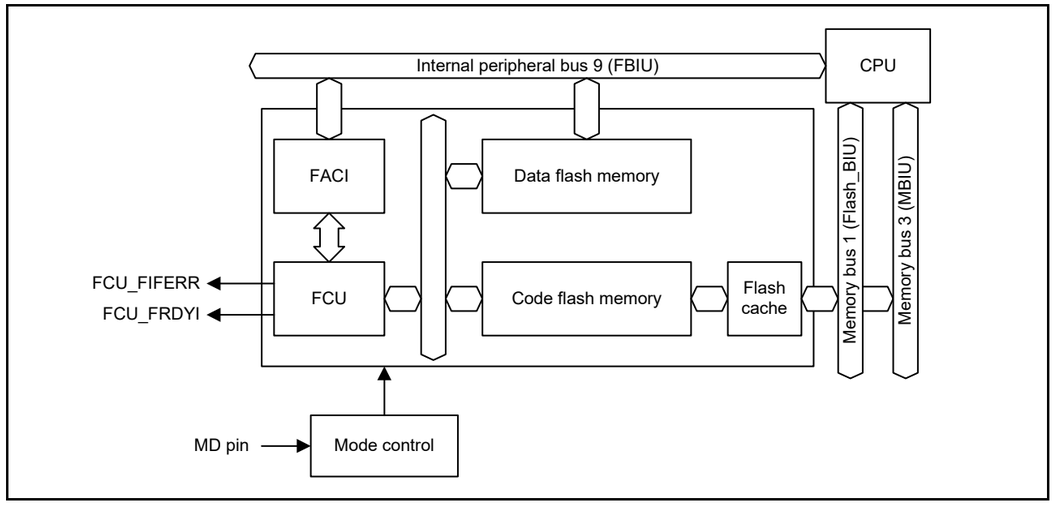

Figure 41.1 Flash memory-related modules block diagram

41.2 Memory Structure

Figure 41.2 shows the mapping of the code flash memory, and Table 41.2 shows the read and programming/erasure addresses of the code flash memory. The user space of the code flash memory is divided into 8- and 32-KB blocks, which serve as the units of erasure. The user area is available for storing the user program.

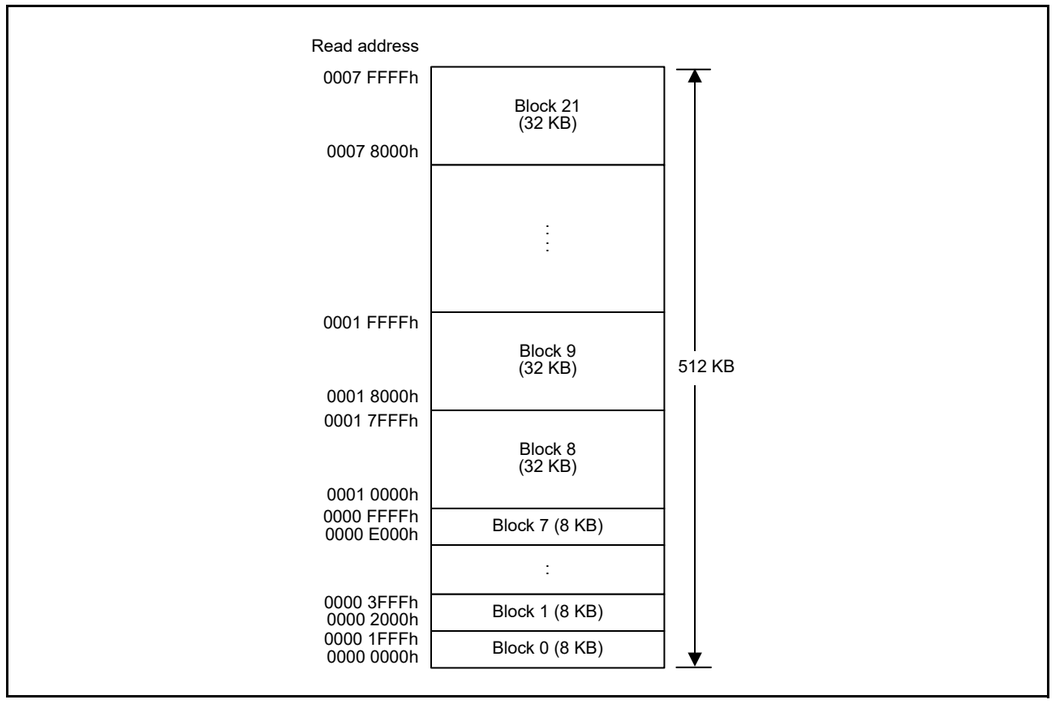

Figure 41.2 Mapping of the code flash memory

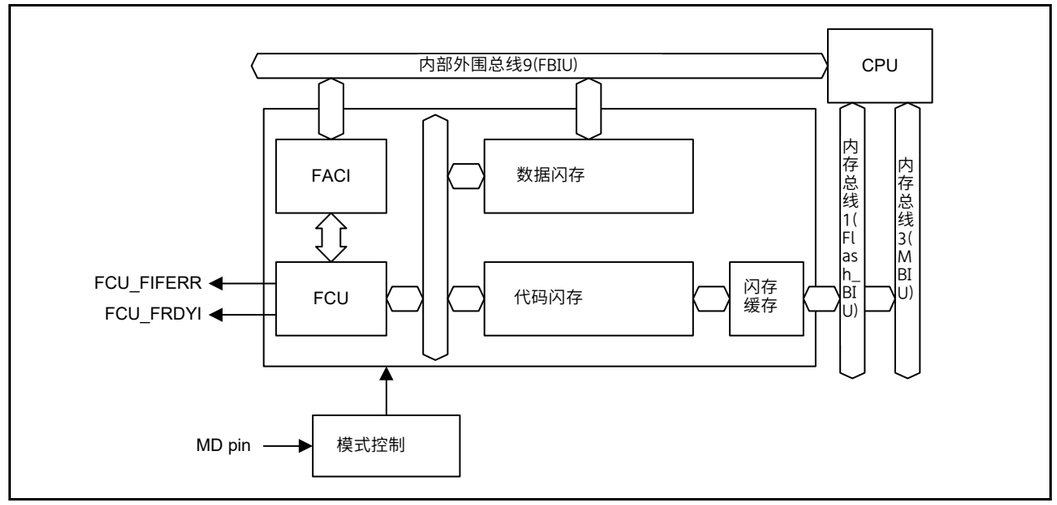

Figure 41.1 闪存相关模块框图

41.2 内存结构

图41.2显示了代码闪存的映射，表41.2显示了代码闪存的读取和编程擦除地址。代码闪存的用户空间分为8KB和32KB块，作为擦除单位。用户区可用于存储用户程序。

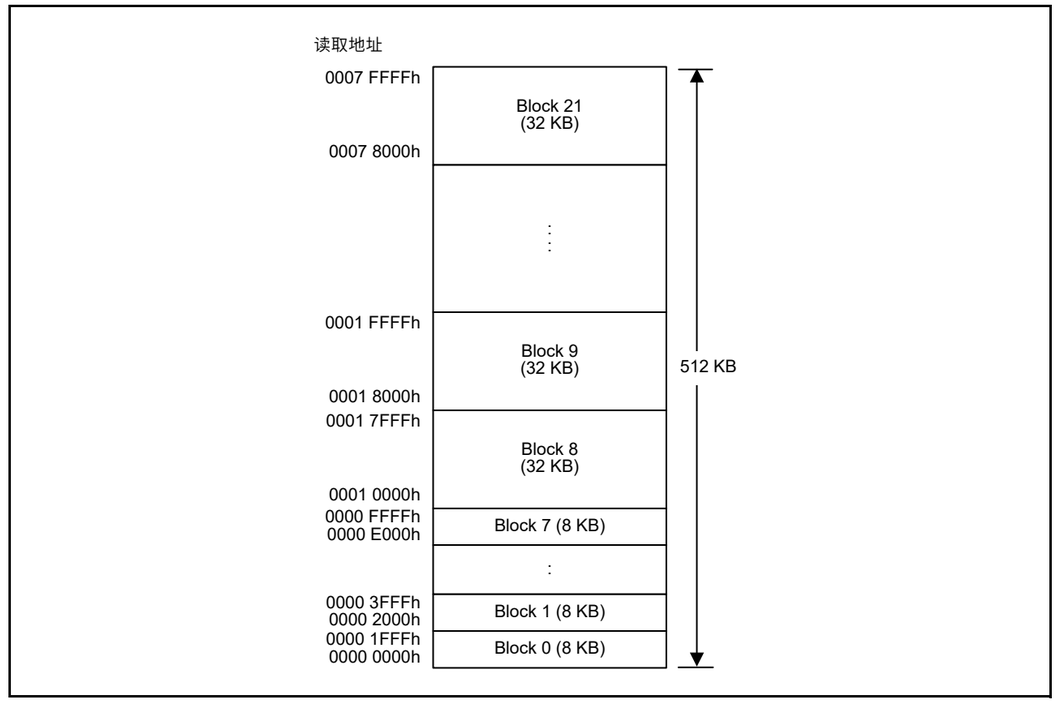

Figure 41.2 代码闪存的映射

Table 41.2 Read and P/E addresses of the code flash memory

Size of code flash memory	Read address	P/E address	Number of blocks
512 KB	0000 0000h to 0007 FFFFh	0000 0000h to 0007 FFFFh	0 to 21
256 KB	0000 0000h to 0003 FFFFh	0000 0000h to 0003 FFFFh	0 to 13

The data area of the data flash memory is divided into 64-byte blocks, with each being a unit for erasure. Figure 41.3 shows the mapping of the data flash memory.

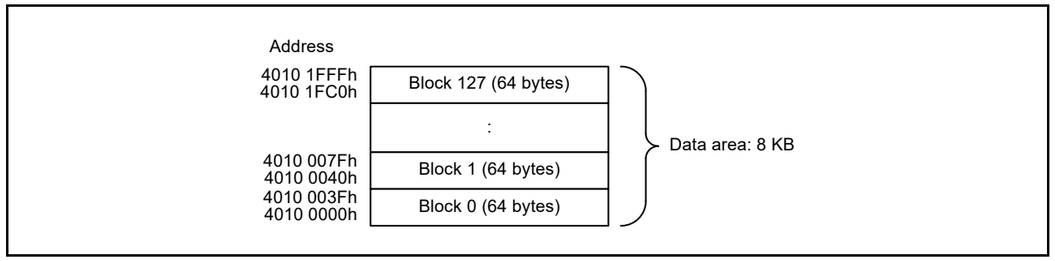

Figure 41.3 Mapping of the data flash memory

41.3 Flash Cache

41.3.1 Overview

The flash cache (FCACHE) speeds up read access from the bus master to the flash memory. The FCACHE includes:

- FCACHE1, for CPU instruction fetches
- FCACHE2, for CPU operand access and DMA
- FLPF, for the prefetch access in CPU instruction fetches.

Table 41.3 Flash cache overview

Parameter	Flash cache 1 (FCACHE1)	Flash cache 2 (FCACHE2)	Prefetch buffer (FLPF)
Cache target region	0000 0000h - 0007 FFFFh	0000 0000h - 0007 FFFFh	0000 0000h - 0007 FFFFh
Target bus master	CPU instruction fetch	CPU operand access and access from other than CPU	FLPF
Capacity	256 bytes	16 bytes	32 bytes
Associativity	• 8-way set associative • 128 bits/entry (128-bit aligned data) • 2 entries/way	• Fully associative • 128 bits/entry (128-bit aligned data) • 1 entry for FCACHE2	• Fully associative • 128 bits/entry (128-bit aligned data) • 2 entries
Access cycles	• Cache hit: 0 wait • Cache miss: Number of waits set in Flash Wait Cycle Register	• Cache hit: 0 wait • Cache miss: Number of waits set in Flash Wait Cycle Register	• Cache hit: 0 wait • Cache miss: Number of waits set in Flash Wait Cycle Register

Table 41.2 代码闪存的读取和PE地址

代码闪存大小	读取地址	P/E address	块数
512 KB	0000 0000h to 0007 FFFFh	0000 0000h to 0007 FFFFh	0 to 21
256 KB	0000 0000h to 0003 FFFFh	0000 0000h to 0003 FFFFh	0 to 13

数据闪存的数据区被划分为64个字节的块，每个块为一个擦除单元。图41.3显示了数据闪存的映射。

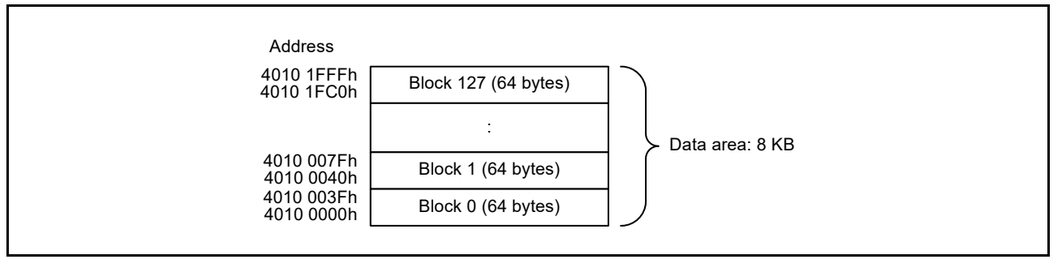

Figure 41.3 数据闪存的映射

41.3 闪存缓存

41.3.1 Overview

闪存高速缓存(FCACHE)加快了从总线主机到闪存的读取访问。FCACHE包括：

- FCACHE1，用于CPU指令取指
- FCACHE2，用于CPU操作数访问和DMA
- FLPF，用于CPU取指中的预取访问。

Table 41.3 闪存缓存概述

Parameter	闪存缓存1(FCACHE1)	闪存缓存2(FCACHE2)	Prefetch buffer (FLPF)
缓存目标区域	0000 0000h - 0007 FFFFh	0000 0000h - 0007 FFFFh	0000 0000h - 0007 FFFFh
目标总线主机	CPU指令获取	CPU操作数访问和非CPU访问	FLPF
Capacity	256 bytes	16 bytes	32 bytes
Associativity	8路组关联 128位条目（128位对齐数据） 2项方式	完全关联 128位条目（128位对齐数据） FCACHE2的1个条目	完全关联 128位条目（128位对齐数据） 2个条目
访问周期	缓存命中：0次等待 缓存未命中Flash等待周期寄存器中设置的等待数	缓存命中：0次等待 缓存未命中Flash等待周期寄存器中设置的等待数	缓存命中：0次等待 缓存未命中：Flash等待周期寄存器中设置的等待数

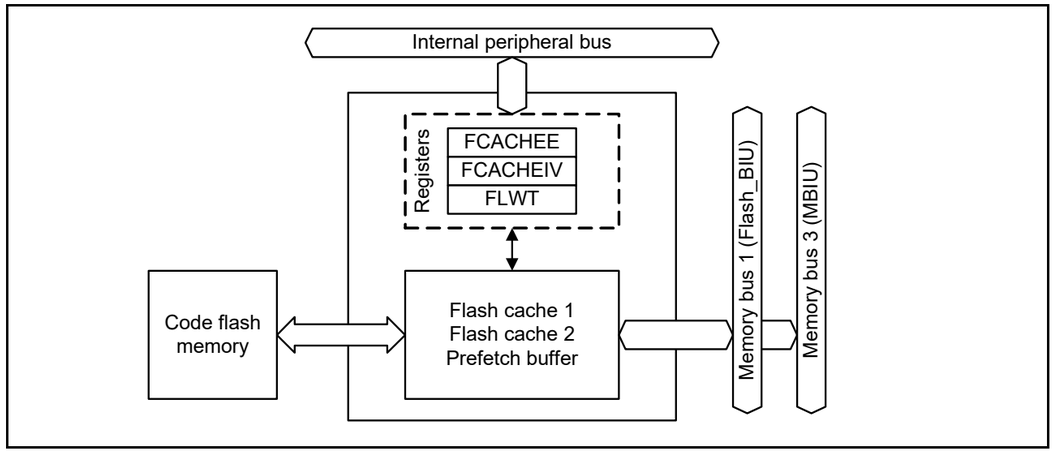

Figure 41.4 FCACHE block diagram

41.3.2 Register Descriptions

41.3.2.1 Flash Cache Enable Register (FCACHEE)

Address(es): FCACHE.FCACHEE 4001 C100h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	FCACHEEN
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	FCACHEEN	FCACHE Enable	0: Disable FCACHE 1: Enable FCACHE.	R/W
b15 to b1	—	Reserved	These bits are read as 0.	R

The FCACHEE.FCACHEEN bit enables or disables the flash cache function for FCACHE1, FCACHE2, and FLPF. This bit does not affect FCACHEIV.FCACHEIV. When FCACHE is enabled, the HPROT[3] bit setting determines whether it is cacheable or non-cacheable. See section 14.5 for details on HPROT[3].

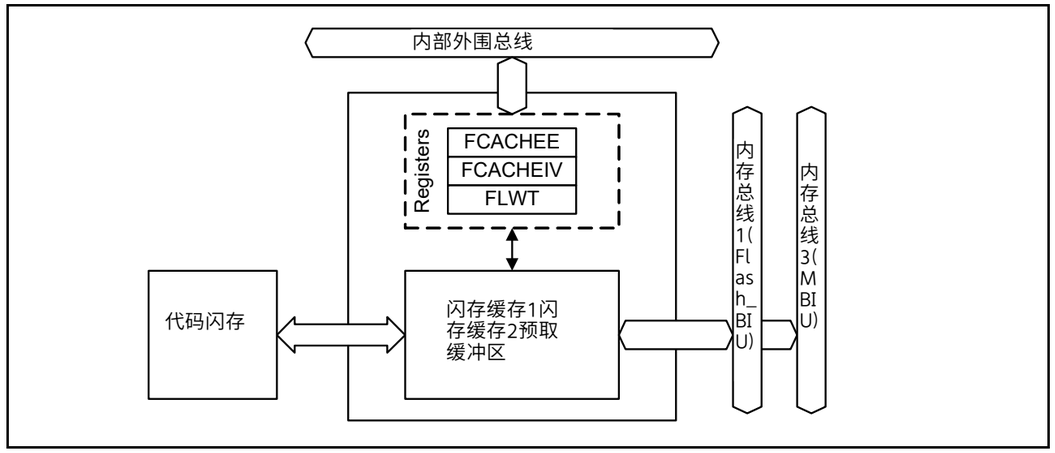

Figure 41.4 FCACHE框图

41.3.2 注册说明

41.3.2.1 闪存缓存启用寄存器(FCACHEE)

Address(es): FCACHE.FCACHEE 4001 C100h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	FCACHEEN
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	FCACHEEN	FCACHE Enable	0：禁用FCACHE1： 启用FCACHE。	R/W
b15 to b1	—	Reserved	这些位读为0。	R

FCACHEE.FCACHEEN位启用或禁用FCACHE1、FCACHE2和FLPF的闪存缓存功能。该位不影响FCACHEIV.FCACHEIV。当启用FCACHE时，HPROT[3]位设置确定它是可缓存的还是不可缓存的。有关HPROT[3]的详细信息，请参见第14.5节。

41.3.2.2 Flash Cache Invalidate Register (FCACHEIV)

Address(es): FCACHE.FCACHEIV 4001 C104h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	FCACHEIV
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b0	FCACHEIV	Flash Cache Invalidate	• Reads: 0: Do not invalidate 1: Invalidate. • Writes: When write value is 1, FCACHE is invalidated. When write value is 0, this setting is ignored.	R/W
b15 to b1	—	Reserved	These bits are read as 0	R

When 1 is written to the FCACHEIV.FCACHEIV bit, the flash cache data in FCACHE1, FCACHE2, and FLPF is invalidated.

41.3.2.3 Flash Wait Cycle Register (FLWT)

Address(es): FCACHE.FLWT 4001 C11Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	FLWT[2:0]		
Value after reset:	0	0	0	0	0	0	0	0

Bit	Symbol	Bit name	Description	R/W
b2 to b0	FLWT[2:0]*1	Flash Wait Cycle	b2 b0 0 0 0: 0 wait (ICLK ≤ 40 MHz) 0 0 1: 1 wait (40 MHz < ICLK ≤ 80 MHz) 0 1 0: 2 waits (80 MHz < ICLK ≤ 120 MHz). Other settings are reserved.	R/W
b15 to b3	—	Reserved	These bits are read as 0.	R

Note 1. Settings other than 000b are prohibited in the Subosc-speed mode.

The Flash Wait Cycle Register (FLWT) sets the access wait count for the flash memory. For faster clock frequencies, set FLWT.FLWT before changing the clock frequency. For slower clock frequencies, set FLWT.FLWT after changing the clock frequency.

41.4 Operation

Use the FCACHEE register to set up and enable flash operation. To set up the flash cache and prepare to rewrite the flash memory:

1. Disable the flash cache by resetting FCACHEE.FCACHEEN.*1
2. Invalidate the flash cache by setting FCACHEIV.FCACHEIV.
3. Check that FCACHEIV.FCACHEIV is 0.
4. Enable the flash cache by setting FCACHEE.FCACHEEN.

Note 1. It is not necessary to disable the flash cache on the first setup after reset.

41.3.2.2 闪存缓存无效寄存器(FCACHEIV)

Address(es): FCACHE.FCACHEIV 4001 C104h

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	FCACHEIV
重置后的值:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b0	FCACHEIV	闪存缓存失效	读取：0：不无效1：无效。 写入：当写入值为1时，CACHE无效。当写入值为0时，忽略此设置。	R/W
b15 to b1	—	Reserved	这些位被读为0	R

当FCACHEIV.FCACHEIV位写入1时，FCACHE1、FCACHE2和FLPF中的闪存缓存数据无效。

41.3.2.3 闪存等待周期寄存器(FLWT)

Address(es): FCACHE.FLWT 4001 C11Ch

	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—	—	FLWT[2:0]		
重置后的值:	0	0	0	0	0	0	0	0

Bit	Symbol	位名称	Description	R/W
b2 to b0	FLWT[2:0]*1	闪存等待周期	b2b0000：0等待（ICLK≤40MHz）001：1等待（40MHz<ICLK≤80MHz）010：2等待（80MHz<ICLK≤120MHz）。保留其他设置。	R/W
b15 to b3	—	Reserved	这些位读为0。	R

Note 1. 在Subosc-speed模式中禁止设置000b以外的设置。

闪存等待周期寄存器(FLWT)设置闪存的访问等待计数。对于更快的时钟频率，设置更改时钟频率之前的FLWT.FLWT。对于较慢的时钟频率，请在更改时钟频率后设置FLWT.FLWT。

41.4 Operation

使用FCACHEE寄存器设置和启用闪存操作。设置闪存缓存并准备重写闪存：

1. 通过重置FCACHEE.FCACHEEN禁用闪存缓存。*1
2. 通过设置FCACHEIV.FCACHEIV使闪存缓存无效。
3. 检查FCACHEIV.FCACHEIV是否为0。
4. 通过设置FCACHEE.FCACHEEN启用闪存缓存。

注1.复位后第一次设置时无需禁用闪存缓存。

41.4.1 Notice to use Flash Cache

When accessing the flash cache from the CPU, Arm® MPU should also be set to cacheable.

See the *ARM®v7-M Architecture Reference Manual* and the *ARM® Cortex®-M4 Devices Generic User Guide*.

41.5 Operating Modes Associated with the Flash Memory

Figure 41.5 shows a diagram of the mode transitions associated with the flash memory. For information on setting up the modes, see section 3, Operating Modes.

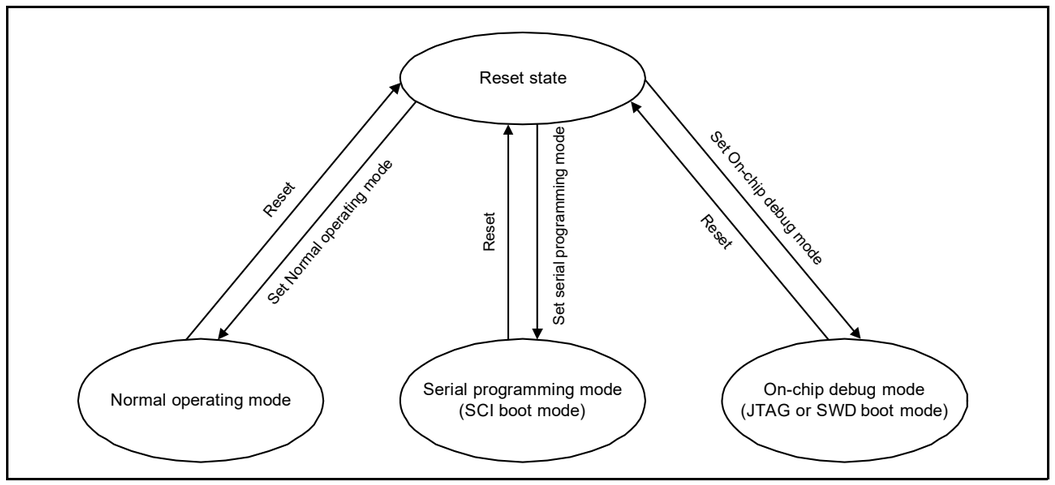

Figure 41.5 Mode transitions associated with flash memory

The flash memory areas where programming and erasure are permitted and where the boot program executes at a reset, differ with the mode. Table 41.4 shows the differences between the modes.

Table 41.4 Difference between modes

Parameter	Normal operating mode	Serial programming mode (SCI boot mode)	On-chip debug mode (JTAG or SWD boot mode)
Programmable and erasable areas	• Code flash memory • Data flash memory	• Code flash memory • Data flash memory	• Code flash memory • Data flash memory
Erasure in block units	Possible	Possible	Possible
Boot program at a reset	User area program	Embedded program for serial programming	Depends on debug command

41.5.1 ID Code Protection

The ID code protection function prohibits programming and on-chip debugging. When ID code protection is enabled, the device validates or invalidates the ID code sent from the host by comparing it with the ID code stored in the flash memory. Programming and on-chip debugging are enabled only when the two match.

The ID code in flash memory consists of four 32-bit words. ID code bits [127] and [126] determine whether ID code protection is enabled and the authentication method to use with the host.

Table 41.5 shows how the ID code determines the authentication method.

41.4.1 使用FlashCache的注意事项

从CPU访问闪存缓存时，Arm®MPU也应设置为可缓存。

请参阅ARM®v7-M架构参考手册和ARM®Cortex®-M4设备通用用户指南。

41.5 与闪存相关的操作模式

图41.5显示了与闪存相关的模式转换图。有关设置模式的信息，请参阅第3节，操作模式。

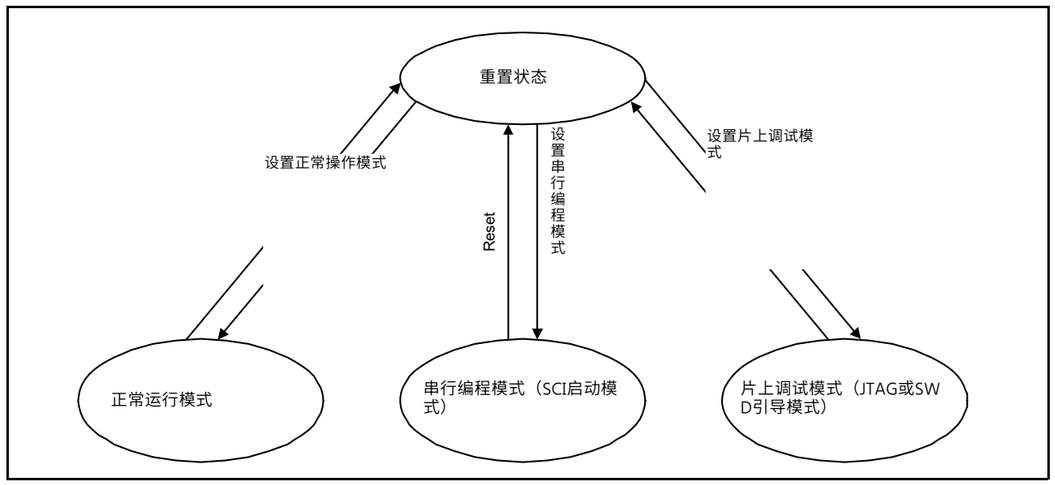

Figure 41.5 与闪存相关的模式转换

允许编程和擦除以及在复位时执行引导程序的闪存区域因模式而异。表41.4显示了这些模式之间的差异。

Table 41.4 模式之间的差异

Parameter	正常运行模式	串行编程模式（SCI启动模式）	片上调试模式（JTAG或SWD引导模式）
可编程和可擦除区域	代码闪存 数据闪存	代码闪存 数据闪存	代码闪存 数据闪存
以块为单位擦除	Possible	Possible	Possible
复位时的引导程序	用户区程序	用于串行编程的嵌入式程序	取决于调试命令

41.5.1 ID码保护

ID码保护功能禁止编程和片上调试。启用ID代码保护时，设备通过将主机发送的ID代码与存储在闪存中的ID代码进行比较来使该ID代码有效或无效。编程和片上调试仅在两者匹配时才启用。

闪存中的ID代码由四个32位字组成。ID代码位[127]和[126]确定是否启用ID代码保护以及与主机一起使用的身份验证方法。

表41.5显示了ID代码如何确定身份验证方法。

Table 41.5 Specifications for ID code protection

Operating mode on boot up	ID code	State of protection	Operations on connection with the programmer or on-chip debugger
Serial programming mode (SCI boot mode) On-chip debug mode (JTAG/SWD boot mode)	FFh, …, FFh (All bytes are FFh)	Protection disabled	ID code validation is not performed, the ID code always matches, and connection to the programmer or the on-chip debugger is permitted.
	Bit [127] = 1, bit [126] = 1, and at least one of the 16 bytes is not FFh	Protection enabled	Matching ID code: Authentication ends and connection to the programmer or on-chip debugger is permitted. Mismatching ID code: Additional transition to the ID code protection waiting state. When the ID code sent from the programmer or the on-chip debugger is ALeRASE in ASCII code (414C_6552_4153_45FF_FFFF_FFFF_FFFF_FFFFh), the contents of the user flash (code and data) area and configuration area are erased. However, forced erasure is not performed when the AWS.FSPR*1 bit is 0.
	Bit [127] = 1 and bit [126] = 0	Protection enabled	Matching ID code: Authentication ends and connection to the programmer or the on-chip debugger is permitted. Mismatching ID code: Additional transition to the ID code protection waiting state.
	Bit [127] = 0	Protection enabled	ID code validation is not performed, the ID code is always mismatching, and connection to the programmer or the on-chip debugger is prohibited.

Note 1. For details on the AWS.FSPR bit, see section 7.2.3, Access Window Setting Register (AWS).

41.6 Overview of Functions

By using a dedicated flash-memory programmer to program the on-chip flash memory through a serial interface (serial programming) or JTAG/SWD interface (on-chip debug mode), the device can be programmed before or after it is mounted on the target system. Additionally, security functions to prohibit overwriting of the user program written to the on-chip flash memory are incorporated to prevent tampering by third parties.

Programming by the user program (self-programming) is available for applications that might require updating after system manufacturing or shipment. Protection features for safely overwriting the flash memory area are also provided. Additionally, interrupt processing during self-programming is supported so that the programming can proceed while processing external communications and other functions. Table 41.6 lists the programming methods and the associated operating modes.

Table 41.6 Programming methods (1 of 2)

Programming method	Functional overview	Operating mode
Serial programming	A dedicated flash-memory programmer connected through the SCI interface enables on-board programming of the flash memory after the device is mounted on the target system.	Serial programming mode
	A dedicated flash-memory programmer connected through the SCI interface and a dedicated programming adapter board allow off-board programming of the flash memory, before it is mounted on the target system.	

Table 41.5 ID码保护规范

启动时的操作模式	身份证号码	保护状态	与编程器或片上调试器连接的操作
串行编程模式（SCI启动模式） 片上调试模式（JTAGSWD启动模式）	FFh … FFh（所有字节均为FFh）	保护已禁用	不执行ID代码验证，ID代码始终匹配，并且允许连接到编程器或片上调试器。
	位[127]=1，位[126]=1，16个字节中至少有一个不是FFh	启用保护	匹配ID代码：验证结束并允许连接到编程器或片上调试器。不匹配的ID代码：额外转换到ID代码保护等待状态。 当编程器或片上调试器发送的ID码为ASCII码的ALeRASE（414C_6552_4153_45FF_FFFF_FFFF_FFFF_FFFFh）时，用户闪存（代码和数据）区和配置区的内容被擦除。但是，当AWS.FSPR*1位为0时，不执行强制擦除。
	位[127]=1和位[126]=0	启用保护	匹配ID代码：验证结束，允许连接到编程器或片上调试器。不匹配的ID代码：向 ID码保护等待状态。
	Bit [127] = 0	启用保护	不执行ID代码验证，ID代码总是不匹配，并且禁止连接到编程器或片上调试器。

Note 1. 有关AWS.FSPR位的详细信息，请参阅第7.2.3节，访问窗口设置寄存器(AWS)。

41.6 功能概述

通过使用专用闪存编程器通过串行接口（串行编程）或JTAGSWD接口（片上调试模式）对片上闪存进行编程，可以在器件安装到目标之前或之后对其进行编程系统。此外，还集成了禁止覆盖写入片上闪存的用户程序的安全功能，以防止第三方篡改。

用户程序编程（自编程）可用于在系统制造或发货后可能需要更新的应用程序。还提供了用于安全覆盖闪存区域的保护功能。此外，支持自编程期间的中断处理，以便在处理外部通信和其他功能的同时进行编程。表41.6列出了编程方法和相关的操作模式。

Table 41.6 编程方法(1of2)

编程方法	功能概览	操作模式
串行编程	通过SCI接口连接的专用闪存编程器可在器件安装到目标系统后对闪存进行板载编程。	串行编程模式
	通过SCI接口连接的专用闪存编程器和专用编程适配器板允许在将闪存安装到目标系统之前对其进行板外编程。	

Table 41.6 Programming methods (2 of 2)

Programming method	Functional overview	Operating mode
Self-programming	A user program written to memory in advance of serial programming execution can also program the flash memory. The background operation capability makes it possible to fetch instructions or otherwise read data from the code flash memory while the data flash memory is programmed. As a result, a program resident in the code flash memory can program the data flash memory. For background operations that are not possible, instructions in the code flash memory cannot be fetched and data cannot be accessed while the code flash memory is being programmed by self-programming. In such cases, a program for programming from the internal SRAM must be transferred in advance and executed.	Normal operating mode
JTAG or SWD programming	A dedicated flash-memory programmer or an on-chip debugger connected through JTAG or SWD enables on-board programming of the flash memory after the device is mounted on the target system.	On-chip debug mode
	A dedicated flash-memory programmer or an on-chip debugger connected through JTAG or SWD and a dedicated programming adapter board allow off-board programming of the flash memory, for example, programming of the device, before it is mounted on the target system.	

Table 41.7 lists the functions of the on-chip flash memory.

Use serial programmer commands for serial programming. For self-programming, use the FACI commands to read the on-chip flash memory or run the user program.

Table 41.7 Basic functions

Function	Functional overview	Availability	
		Serial programming	Self-programming
Blank check	Checks a specified block to ensure that writing to it has not already proceeded. Results of reading from data flash memory to which nothing is written after erasure are not guaranteed, so use blank checking to confirm that writing to memory has not proceeded after erasure.	Not supported	Supported (data flash programming only)
Block erasure	Erases the memory contents in the specified block	Supported	Supported
Programming	Writes to the specified address	Supported	Supported
Read	Reads data programmed in the flash memory	Supported	Not supported (read by user program is possible)
ID code check	Compares the ID code sent by the host with the code stored in the ROM. If the two match, the FCU enters the wait state for programming and erasure commands from the host.	Supported	Not supported (ID authentication is not performed)
Security configuration	Configures the security function for serial programming	Supported with conditions (only allows switching from enabled to disabled)	Supported with conditions (only allows switching from enabled to disabled)
Protection configuration	Configures the access window for flash area protection in the code flash memory	Supported	Supported

The on-chip flash memory supports the ID code security function. Authentication of ID codes is a security function for use with serial programming and with JTAG or SWD programming. Table 41.8 lists the security functions supported by the on-chip flash memory, and Table 41.9 lists the available operations and security settings.

Table 41.8 Security functions

Function	Description
ID authentication	The result of ID authentication can be used to control the connection of a serial programmer for serial programming

Table 41.6 编程方法（2之2）

编程方法	功能概览	操作模式
Self-programming	在串行编程执行之前写入存储器的用户程序也可以对闪存进行编程。后台操作能力使得在对数据闪存进行编程时，可以从代码闪存中获取指令或以其他方式读取数据。结果，驻留在代码闪存中的程序可以对数据闪存进行编程。对于无法进行的后台操作，在通过自编程对代码闪存进行编程时，无法获取代码闪存中的指令并且无法访问数据。在这种情况下，必须提前传输并执行内部SRAM的编程程序。	正常运行模式
JTAG或SWD编程	通过JTAG或SWD连接的专用闪存编程器或片上调试器可在器件安装到目标系统后对闪存进行板载编程。	片上调试模式
	专用闪存编程器或通过JTAG或SWD连接的片上调试器和专用编程适配器板允许对闪存进行板外编程，例如，在将器件安装到目标系统之前对其进行编程。	

表41.7列出了片上闪存的功能。

使用串行编程器命令进行串行编程。对于自编程，使用FACI命令读取片上闪存或运行用户程序。

Table 41.7 基本功能

Function	功能概览	Availability	
		串行编程	Self-programming
空白支票	检查指定的块以确保尚未对其进行写入。无法保证从擦除后没有写入任何内容的数据闪存中读取的结果，因此使用空白检查来确认擦除后没有继续写入内存。	不支持	支持（仅数据闪存编程）
块擦除	擦除指定块中的内存内容	Supported	Supported
Programming	写入指定地址	Supported	Supported
Read	读取闪存中编程的数据	Supported	不支持（可由用户程序读取）
识别码检查	将主机发送的ID代码与存储在ROM中的代码进行比较。如果两者匹配，则FCU进入等待状态，等待来自主机的编程和擦除命令。	Supported	不支持（不进行身份验证）
安全配置	配置串行编程的安全功能	有条件支持（只允许从启用切换到禁用）	有条件支持（只允许从启用切换到禁用）
保护配置	配置代码闪存中闪存区域保护的访问窗口	Supported	Supported

片上闪存支持ID码安全功能。ID代码验证是一种安全功能，可用于串行编程和JTAG或SWD编程。表41.8列出了片上闪存支持的安全功能，表41.9列出了可用的操作和安全设置。

Table 41.8 安全功能

Function	Description
身份认证	ID认证的结果可以用来控制串口编程器的连接进行串口编程

Table 41.9 Available operations and security settings

Function	All security settings and erasure, programming, and read operations		Constraints on the security setting configuration
	Serial programming and on-chip debug mode	Self-programming mode	Self-programming mode
ID authentication	When ID codes do not match: • Block erasure commands: Not supported • Programming commands: Not supported • Read commands: Not supported • Security configuration commands: Not supported • Protection configuration commands: Not supported. When ID codes match: • Block erasure commands: Supported • Programming commands: Supported • Read commands: Supported • Security configuration commands: Supported • Protection configuration commands: Supported.	• ID authentication is not performed • Blank check: Supported • Block erasure: Supported • Programming: Supported • Security configuration: Supported • Protection configuration: Supported.	ID authentication is not performed

41.6.1 Configuration Area Bit Map

The bits used for ID authentication, startup area select, access window protection, and security configuration functions are mapped in Figure 41.6. The boot program must use these bits as hexadecimal data.

Base R-address: 0100 A100h
P/E-address: 0000 A100h

offset	Bit +31	+30	+29	+28	+27	+26	+25	+24	+23	+22	+21	+20	+19	+18	+17	+16	+15	+14	+13	+12	+11	+10	+ 9	+ 8	+ 7	+ 6	+ 5	+ 4	+ 3	+ 2	+ 1	+ 0
00BCh																																
:																																
0080h																																
007Ch																																
0078h																																
0074h																																
0070h																																
006Ch																																
0068h																																
0064h	BTFLG					FAWE[10:0]											FSPR				FAWS[10:0]											
0060h																																
005Ch	ID[127:96]																															
0058h	ID[95:64]																															
0054h	ID[63:32]																															
0050h	ID[31:0]																															
004Ch																																
0048h																																
0044h																																
0040h																																

Figure 41.6 Configuration area bit map

41.6.2 Startup Area Select

The startup area select function allows the boot program to be safely updated. The startup area is 8 KB of space located in the user area. The FACI controls the address of the startup area based on the Startup Area Select flag (AWS.BTFLG) that is located in the configuration area. The startup area can be locked by the AWS.FSPR*1 bit.

Note 1. For the AWS.FSPR bit, see section 7.2.3, Access Window Setting Register (AWS).

Table 41.9 可用的操作和安全设置

Function	所有安全设置和擦除、编程和读取操作		安全设置配置的约束
	串行编程和片上调试模式	Self-programming mode	Self-programming mode
身份认证	当ID代码不匹配时： 块擦除命令：不支持 编程命令 不执行ID身份验证 空白检查：不支持 读取命令：不支持 安全配置命令：不支持：支持 块擦除：支持 编程：保护配置命令：不支持。当ID代码匹配时： 块擦除 支持 安全配置：支持 保护配命令：支持 编程命令：支持 读取命令：支持 安全置：支持。 置命令：支持 保护配置命令：支持。		不进行身份验证

41.6.1 配置区位图

用于身份验证、启动区域选择、访问窗口保护和安全配置功能的位映射在图41.6中。引导程序必须使用这些位作为十六进制数据。

Base R-address: 0100 A100h
P/E-address: 0000 A100h

offset	Bit +31	+30	+29	+28	+27	+26	+25	+24	+23	+22	+21	+20	+19	+18	+17	+16	+15	+14	+13	+12	+11	+10	+ 9	+ 8	+ 7	+ 6	+ 5	+ 4	+ 3	+ 2	+ 1	+ 0
00BCh																																
:																																
0080h																																
007Ch																																
0078h																																
0074h																																
0070h																																
006Ch																																
0068h																																
0064h	BTFLG					FAWE[10:0]											FSPR				FAWS[10:0]											
0060h																																
005Ch	ID[127:96]																															
0058h	ID[95:64]																															
0054h	ID[63:32]																															
0050h	ID[31:0]																															
004Ch																																
0048h																																
0044h																																
0040h																																

Figure 41.6 配置区位图

41.6.2 启动区域选择

启动区域选择功能允许安全更新引导程序。启动区是位于用户区的8KB空间。FACI根据位于配置区域中的启动区域选择标志(AWS.BTFLG)控制启动区域的地址。启动区域可以通过AWS.FSPR*1位锁定。

注1.关于AWS.FSPR位，请参见第7.2.3节，访问窗口设置寄存器(AWS)。

Figure 41.7 shows an overview of the startup program protection.

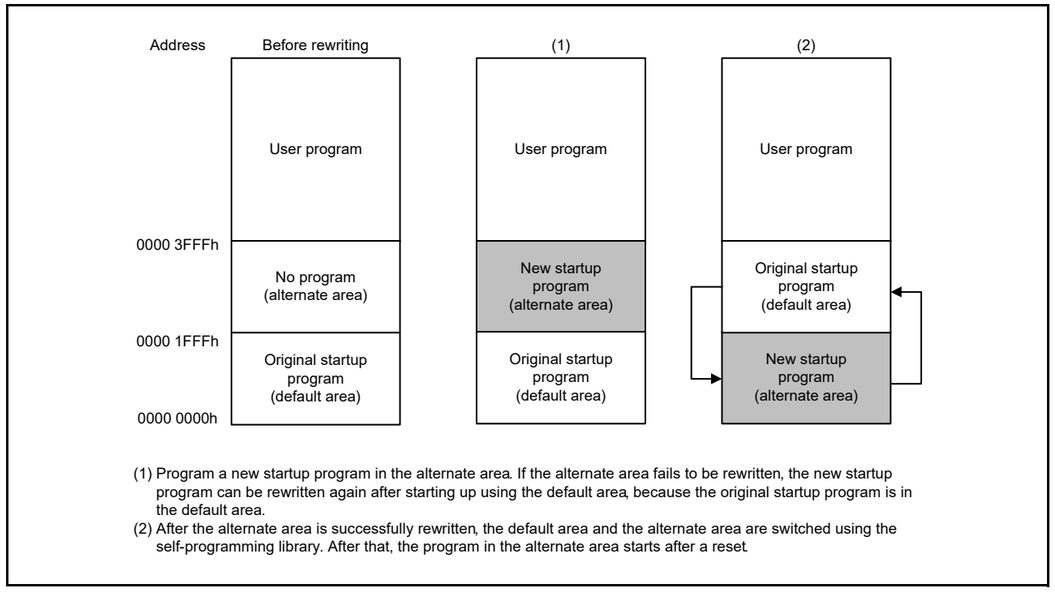

Figure 41.7 Overview of startup program protection

41.6.3 Protection by Access Window

Issuing the program or block erase command to a flash memory area outside of the access window results in the command-locked state. The access window is only valid in the user area of the code flash memory. The access window provides protection in self-programming, serial programming, and on-chip debug modes.

The access window is specified in both the AWS.FAWS[10:0] and AWS.FAWE[10:0] bits*1.

Setting of the FAWS[10:0] and the FAWE[10:0] bits in various conditions is described as follows:

- FAWE[10:0] = FAWS[10:0]: The P/E command can execute anywhere in the user area of the code flash memory
- FAWE[10:0] > FAWS[10:0]: The P/E command can only execute in the window from the block pointed to by the FAWS[10:0] bits to one block lower than the one pointed to by the FAWE bits
- FAWE[10:0] < FAWS[10:0]: The P/E command cannot execute anywhere in the user area of the code flash memory.

Note 1. For information on the AWS.FAWS[10:0] and AWS.FAWE[10:0] bits, see section 7.2.3, Access Window Setting Register (AWS).

图41.7显示了启动程序保护的概述。

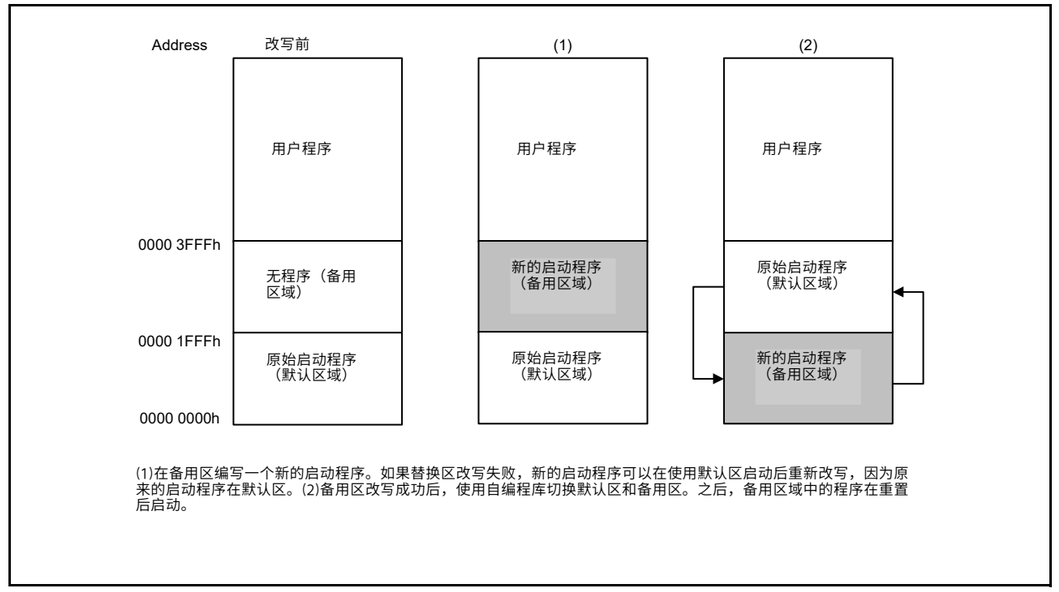

Figure 41.7 启动程序保护概述

41.6.3 通过访问窗口保护

向访问窗口之外的闪存区域发出程序或块擦除命令会导致命令锁定状态。访问窗口仅在代码闪存的用户区有效。访问窗口在自编程、串行编程和片上调试模式下提供保护。

访问窗口在AWS.FAWS[10:0]和AWS.FAWE[10:0]位*1中指定。

各种条件下FAWS[10:0]和FAWE[10:0]位的设置说明如下：

- FAWE[10:0]=FAWS[10:0]：PE命令可以在代码闪存用户区的任何地方执行
- FAWE[10:0]>FAWS[10:0]：PE命令只能在窗口中执行
  FAWS[10:0]位比FAWE位指向的块低一个块
- FAWE[10:0]<FAWS[10:0]：PE命令不能在代码闪存用户区的任何地方执行。

注1.有关AWS.FAWS[10:0]和AWS.FAWE[10:0]位的信息，请参阅第7.2.3节，访问窗口设置 Register (AWS).

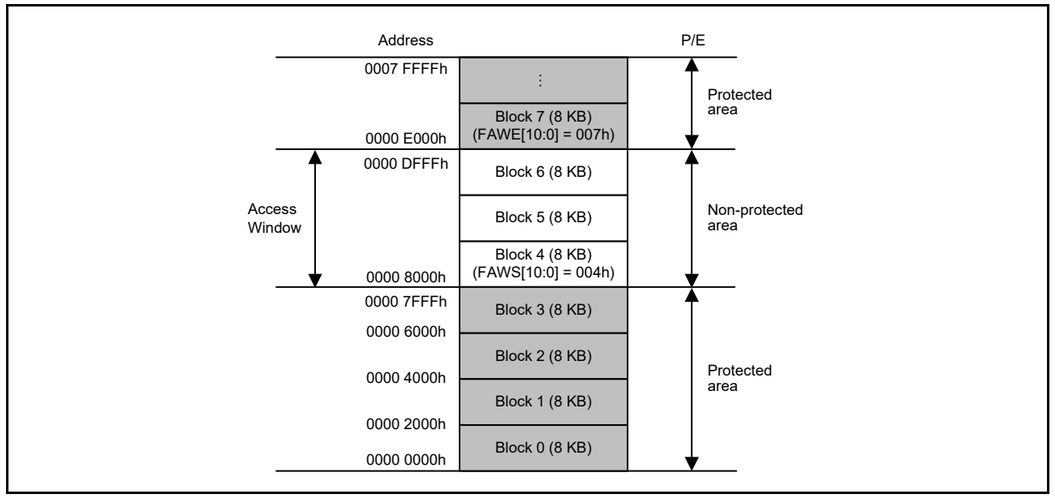

Figure 41.8 Start block address (FAWS) and end block address (FAWE) of access window when the access window only includes the 8-KB block size

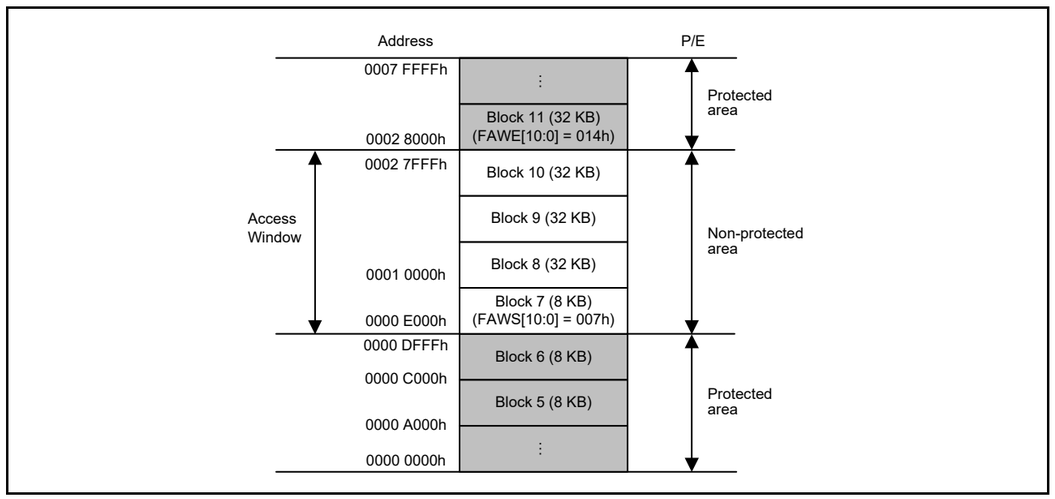

Figure 41.9 Start block address (FAWS) and end block address (FAWE) of access window when the access window includes 8-KB and 32-KB block sizes

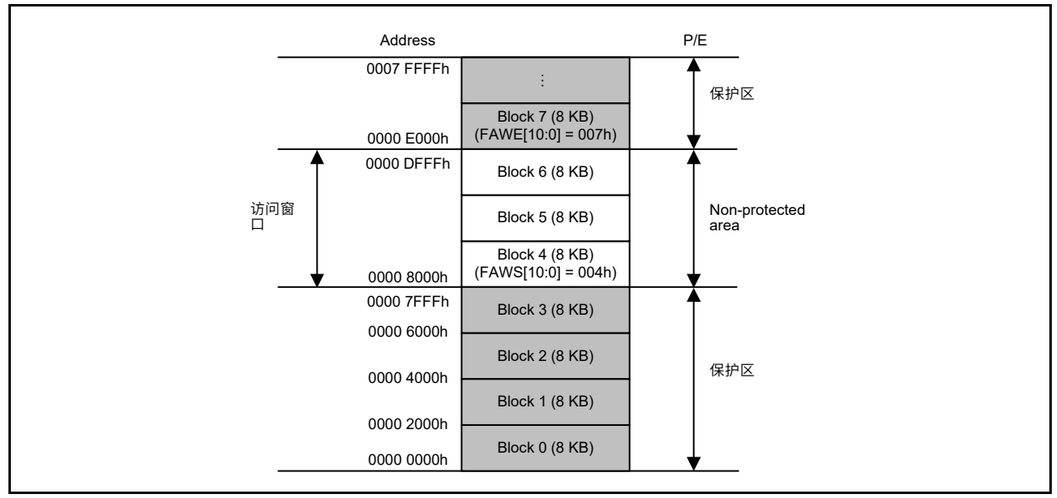

Figure 41.8 当访问窗口仅包含8-KB块大小时访问窗口的起始块地址(FAWS)和结束块地址(FAWE)

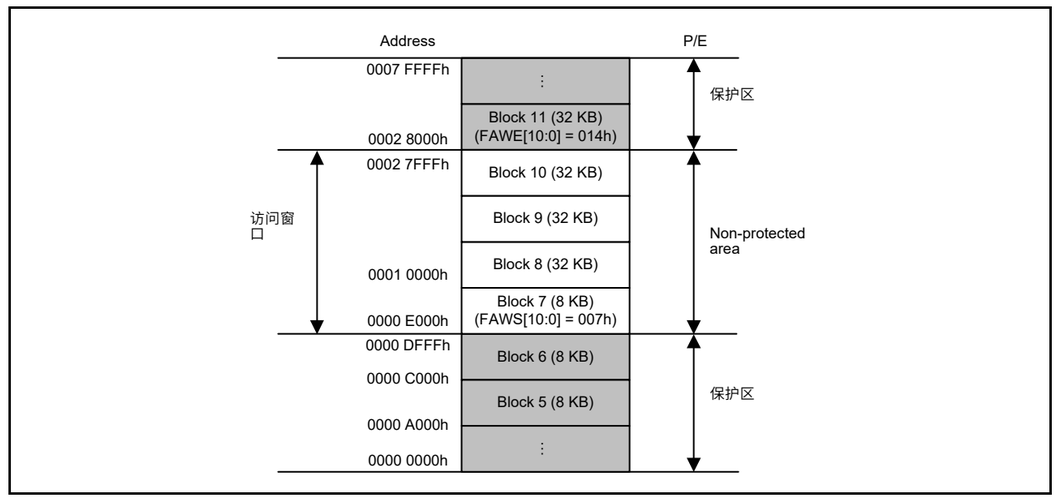

Figure 41.9 当访问窗口包括8-KB和32-KB块大小时访问窗口的起始块地址(FAWS)和结束块地址(FAWE)

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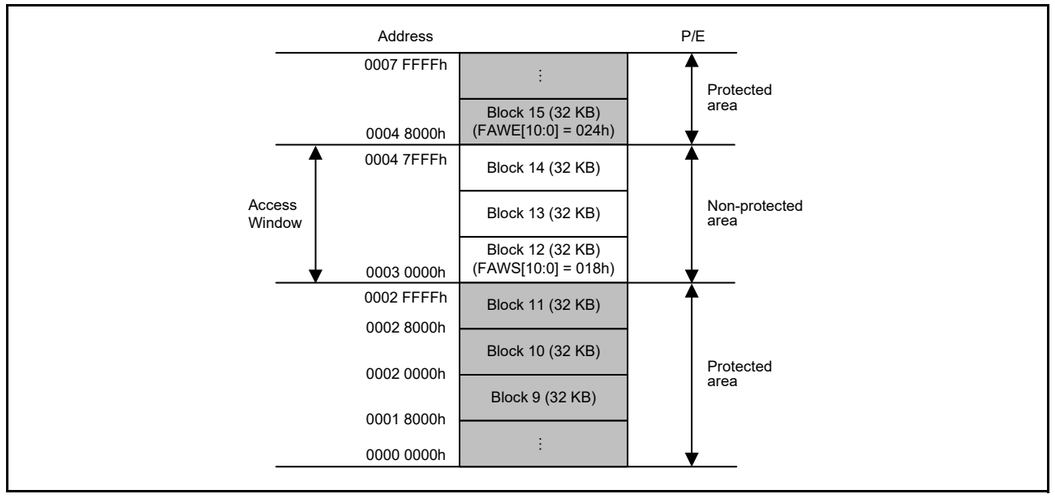

Figure 41.10 Start block address (FAWS) and end block address (FAWE) of access window when the access window only includes the 32-KB block size

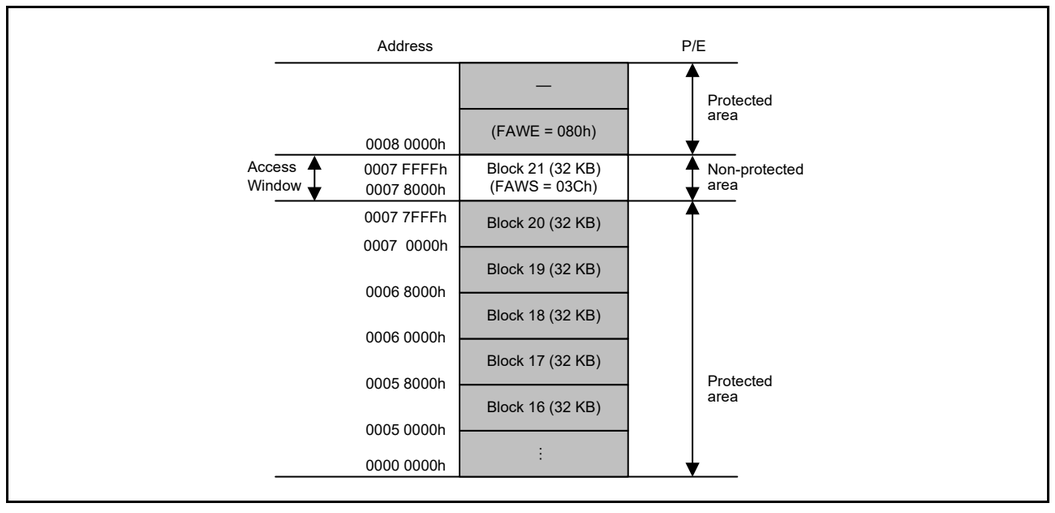

Figure 41.11 Start block address (FAWS) and end block address (FAWE) of access window when the access window only includes the final block

41.7 Programming Commands

The FACI controls the FCU in accordance with the specified FACI commands.

41.8 Suspend Operation

Reading from the code or data flash memory is not possible during programming or erasure when the address ranges do not satisfy the conditions for background operation. When a P/E suspend command is issued to suspend the programming or erasure of the code or data flash memory, reading from memory is enabled. One suspend command mode is available for programming and two suspend command modes are available for erasure (suspension priority mode and erasure priority mode). The P/E resume command is available for resuming suspended programming or erasure.

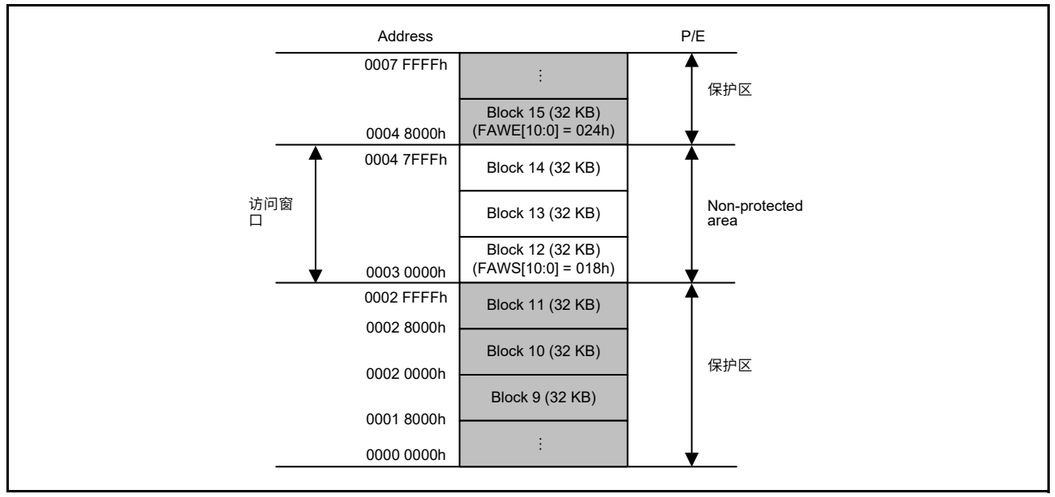

Figure 41.10 当访问窗口仅包含32−KB块大小时访问窗口的起始块地址(FAWS)和结束块地址(FAWE)

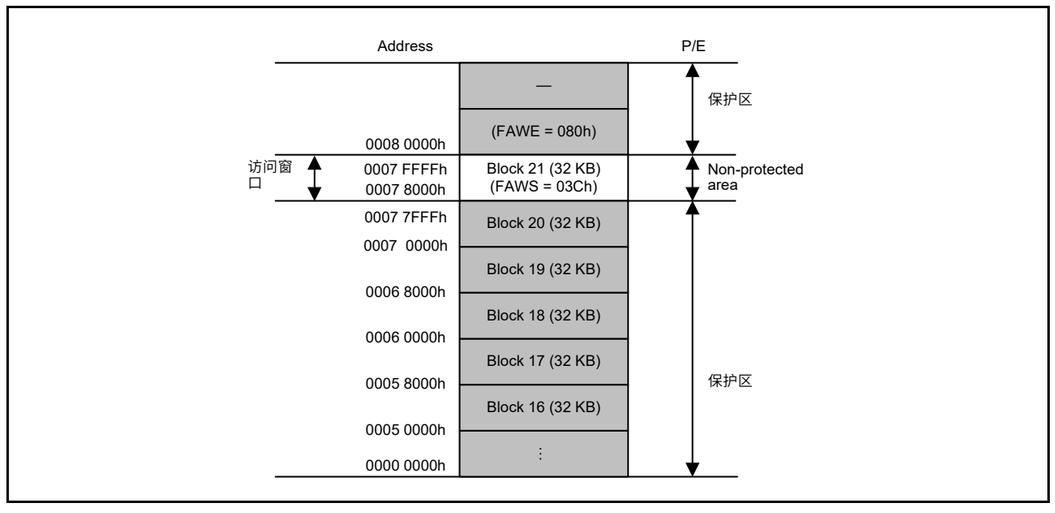

Figure 41.11 访问窗口只包含最终块时访问窗口的起始块地址（FAWS）和结束块地址（FAWE）

41.7 编程命令

FACI根据指定的FACI命令控制FCU。

41.8 暂停操作

当地址范围不满足后台操作条件时，在编程或擦除期间无法读取代码或数据闪存。当发出PE暂停命令以暂停代码或数据闪存的编程或擦除时，将启用从存储器读取。一种挂起命令模式可用于编程，两种挂起命令模式可用于擦除（挂起优先模式和擦除优先模式）。PEresume命令可用于恢复暂停的编程或擦除。

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41.9 Protection

The types of protection provided include:

- Software protection
- Error protection
- Boot program protection.

41.10 Serial Programming Mode

The serial programming mode includes boot mode with SCI9.

Table 41.10 lists the I/O pins of the flash memory-related modules.

Table 41.10 I/O pins of flash memory-related modules

Pin name	I/O	Applicable modes	Function
MD	Input	SCI boot mode (serial programming mode)	Selection of operating mode
P110/RXD9	Input	SCI boot mode	For host communication, to receive data through SCI
P109/TXD9	Output		For host communication, to transmit data through SCI

41.10.1 SCI Boot Mode

In boot mode, the host sends control commands and data for programming, and the code and data flash memory area are programmed or erased accordingly. An on-chip SCI handles transfer between the host and the MCU in asynchronous mode. Tools for transmission of control commands and the data for programming must be prepared in the host.

When the MCU is activated in boot mode, the embedded program for serial programming is executed. This program automatically adjusts the bit rate of the SCI and controls programming and erasure by receiving control commands from the host.

Figure 41.12 shows the system configuration for operation in boot mode.

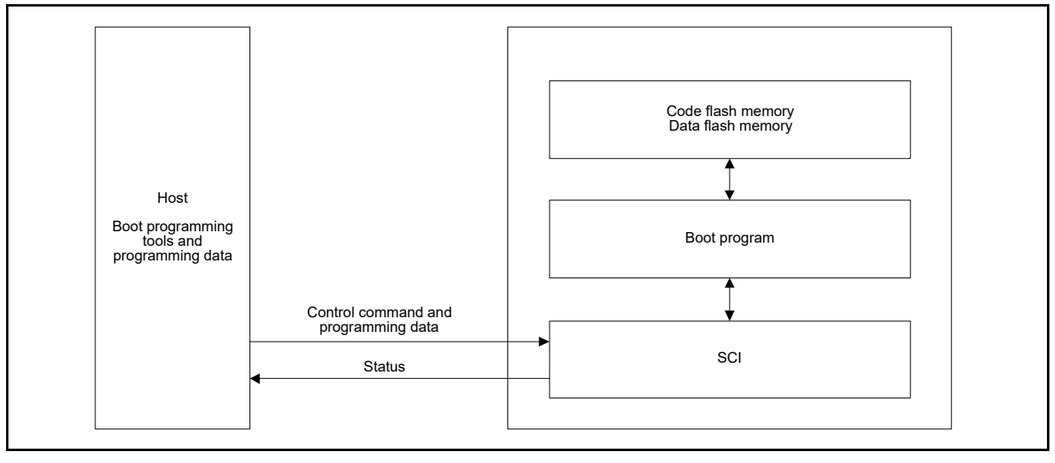

Figure 41.12 System configuration in SCI boot mode

41.11 Using a Serial Programmer

A dedicated flash memory programmer can be used to program the flash memory in serial programming mode.

41.9 Protection

提供的保护类型包括：

- 软件保护
- 错误保护
- 引导程序保护。

41.10 串行编程模式

串行编程模式包括带有SCI9的引导模式。

表41.10列出了闪存相关模块的IO引脚。

Table 41.10 闪存相关模块的IO管脚

引脚名称	I/O	适用模式	Function
MD	Input	SCI启动模式（串行编程模式）	操作模式的选择
P110/RXD9	Input	SCI开机模式	用于主机通信，通过SCI接收数据
P109/TXD9	Output		用于主机通信，通过SCI传输数据

41.10.1 SCI启动模式

在引导模式下，主机发送控制命令和数据进行编程，代码和数据闪存区域被相应地编程或擦除。片上SCI以异步模式处理主机和MCU之间的传输。主机中必须准备好用于传输控制命令和编程数据的工具。

当MCU在引导模式下激活时，将执行用于串行编程的嵌入式程序。该程序通过接收来自主机的控制命令自动调整SCI的比特率并控制编程和擦除。

图41.12显示了在引导模式下运行的系统配置。

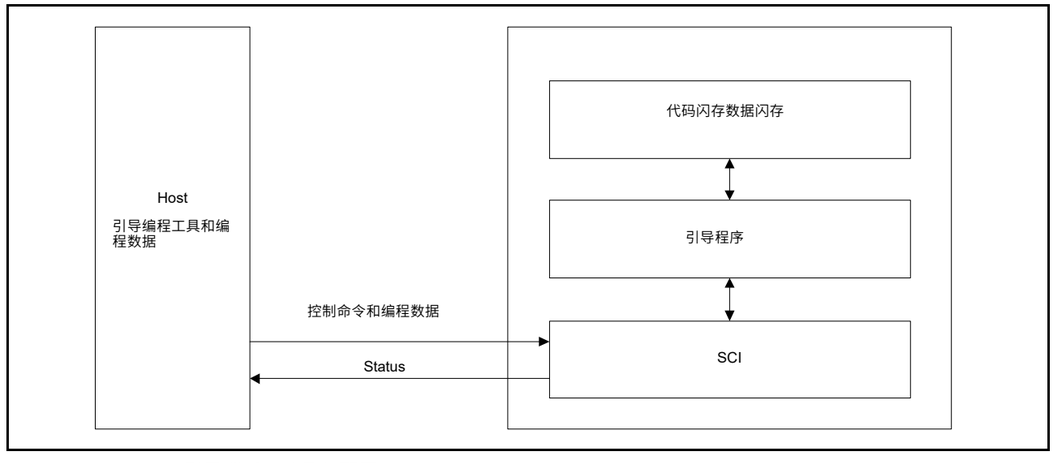

Figure 41.12 SCI引导模式下的系统配置

41.11 使用串行编程器

可以使用专用的闪存编程器在串行编程模式下对闪存进行编程。

41.11.1 Serial Programming

The MCU is mounted on the system board for serial programming. A connector to the board allows programming by the flash memory programmer.

41.11.2 Programming Environments

Figure 41.13 shows the environments recommended by Renesas for programming the flash memory of the MCU with data.

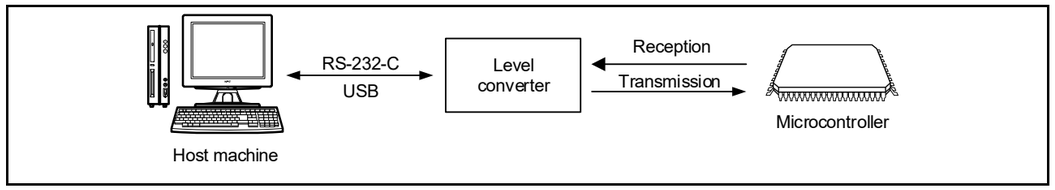

Figure 41.13 Environments for writing programs to the flash memory

41.12 Self-Programming

41.12.1 Overview

The MCU supports programming of the flash memory by the user program. The programming commands can be used with user programs for writing to the code and data flash memory. This enables upgrading of user programs and overwriting of constant data fields.

The background operation facility makes it possible to execute a program from the code flash memory to program the data flash memory under the conditions shown in Table 41.11. This program can also be copied in advance to and executed from the internal SRAM. When executing from the internal SRAM, this program can also program the code flash memory area.

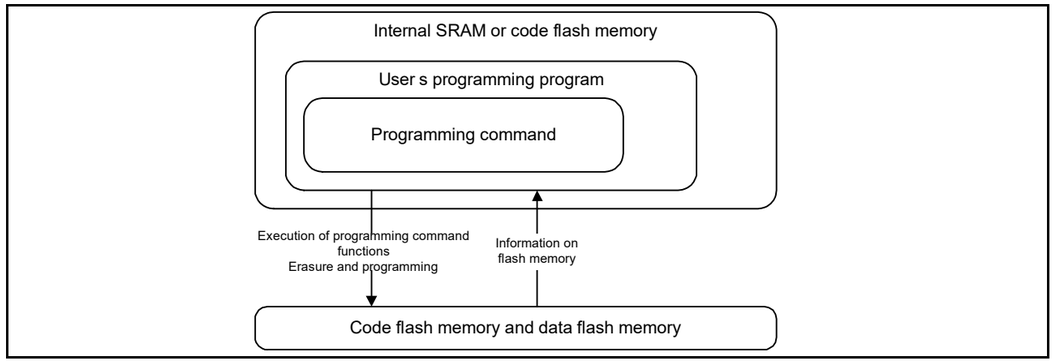

Figure 41.14 Schematic view of self-programming

41.12.2 Background Operation

Background operation can be used when a combination of the flash memory for writing and reading is as listed in Table 41.11.

Table 41.11 Conditions under which background operation is available

Product	Writable range	Readable range
All products	Data flash memory	Code flash memory
	Code flash memory	Data flash memory

41.11.1 串行编程

MCU安装在系统板上，用于串行编程。板上的连接器允许闪存编程器进行编程。

41.11.2 编程环境

图41.13显示了瑞萨推荐的使用数据对MCU闪存进行编程的环境。

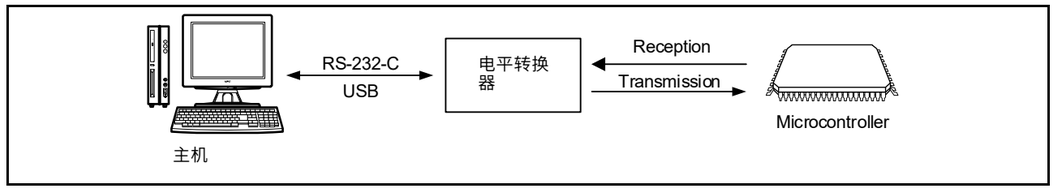

Figure 41.13 将程序写入闪存的环境

41.12 Self-Programming

41.12.1 Overview

MCU支持通过用户程序对闪存进行编程。编程命令可与用户程序一起用于写入代码和数据闪存。这使得用户程序的升级和常量数据字段的覆盖成为可能。

后台操作工具可以在表41.11所示的条件下从代码闪存执行程序以对数据闪存进行编程。该程序也可以预先复制到内部SRAM中并从内部SRAM中执行。当从内部SRAM执行时，该程序还可以对代码闪存区域进行编程。

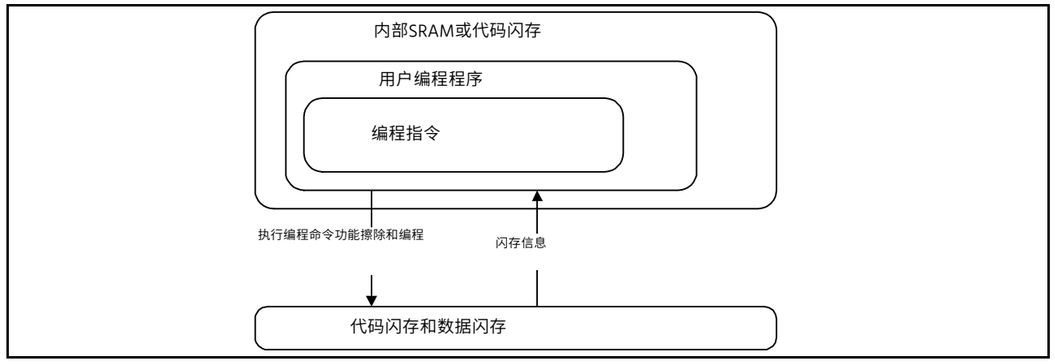

Figure 41.14 自编程示意图

41.12.2 后台操作

当用于写入和读取的闪存组合如表41.11中所列时，可以使用后台操作。

Table 41.11 后台操作可用的条件

Product	Writable range	可读范围
所有产品	数据闪存	代码闪存
	代码闪存	数据闪存

41.13 Reading the Flash Memory

41.13.1 Reading the Code Flash Memory

No special settings are required to read the code flash memory in Normal mode. Data can be read by accessing addresses in the code flash memory. When reading code flash memory that was erased but not yet reprogrammed, such as code flash memory in the non-programmed state, all bits are read as 1s.

41.13.2 Reading the Data Flash Memory

No special settings are required to read the data flash memory in Normal mode. Data can be read by accessing addresses in the data flash memory. Values read from data flash memory that was erased but not yet reprogrammed, such as data flash memory in the non-programmed state, are undefined. Use the blank check function to confirm that an area is in the non-programmed state.

41.14 Usage Notes

41.14.1 Reading Areas where Programming or Erasure was Interrupted

When programming or erasure of an area of flash memory is interrupted, the data stored in the area becomes undefined. To avoid reading undefined data, which can be a source of faulty operation, do not fetch instructions or read data from areas where programming or erasure was interrupted.

41.14.2 Restrictions on Additional Writes

Other than the configuration area, no other area can be written to twice. After a write to a flash memory area is complete, erase the area before attempting to overwrite data in that area. The configuration area can be overwritten.

41.14.3 Reset during Programming and Erasure

If inputting a reset from the RES pin, release the reset after a reset input time of at least t_{RESW} (see section 43.3.3, Reset Timing) within the range of the operating voltage defined in the electrical characteristics.

41.14.4 Allocation of Vectors for Interrupts and Other Exceptions during Programming and Erasure

Generation of an interrupt or other exception during programming or erasure might lead to fetching of the vector from the code flash memory. If the vector allocation does not satisfy the conditions for using background operation, set the address for vector fetching to an address that is not in the code flash memory.

41.14.5 Restrictions during Programming and Erasure

During programming and erasure, do not:

- Permit the operating voltage from the power supply to go beyond the allowed range
- Change the frequency of the peripheral clock.

41.14.6 Abnormal Termination of Programming and Erasure

When programming or erasure ends abnormally because of the generation of a reset by the RES pin, the programming or erasure state of the flash memory with undefined data cannot be verified or checked. For the area where programming or erasure ends abnormally, the blank check function cannot determine whether the area was erased successfully. Erase the area again to ensure that the corresponding area is completely erased before use.

41.13 读取闪存

41.13.1 读取代码闪存

在正常模式下读取代码闪存不需要特殊设置。可以通过访问代码闪存中的地址来读取数据。当读取已擦除但尚未重新编程的代码闪存时，例如处于未编程状态的代码闪存，所有位都被读取为1。

41.13.2 读取数据闪存

在正常模式下读取数据闪存不需要特殊设置。可以通过访问数据闪存中的地址来读取数据。从已擦除但尚未重新编程的数据闪存（例如处于未编程状态的数据闪存）读取的值是未定义的。使用空白检查功能确认某个区域处于非编程状态。

41.14 使用说明

41.14.1 编程或擦除被中断的阅读区域

当闪存区域的编程或擦除被中断时，存储在该区域中的数据变得不确定。
为避免读取可能导致错误操作的未定义数据，请勿从编程或擦除中断的区域获取指令或读取数据。

41.14.2 额外写入的限制

除配置区域外，其他区域不能写入两次。对闪存区域的写入完成后，请先擦除该区域，然后再尝试覆盖该区域中的数据。配置区域可以被覆盖。

41.14.3 在编程和擦除期间复位

如果从RES引脚输入复位，请在至少tRESW的复位输入时间后释放复位（参见第43.3.3节，复位时序)在电气特性中定义的工作电压范围内。

41.14.4 在编程和擦除期间为中断和其他异常分配向量

在编程或擦除期间产生中断或其他异常可能会导致从代码闪存中获取向量。如果向量分配不满足使用后台操作的条件，则将取向量的地址设置为不在代码闪存中的地址。

41.14.5 编程和擦除期间的限制

在编程和擦除期间，不要：

- 允许来自电源的工作电压超出允许范围
- 改变外设时钟的频率。

41.14.6 烧写异常终止和擦除

当由于RES引脚产生复位而导致编程或擦除异常结束时，无法验证或检查具有未定义数据的闪存的编程或擦除状态。对于编程或擦除异常结束的区域，空白检查功能无法确定该区域是否擦除成功。再次擦除该区域，以确保在使用前将相应区域完全擦除。

42. Internal Voltage Regulator

42.1 Overview

The MCU includes a linear regulator (LDO) that supplies voltage to the internal circuits and memory, except for I/O and analog.

42.2 Operation

Table 42.1 lists the LDO mode pin settings, and Figure 42.1 shows the LDO mode settings. In LDO mode, the internal voltage is generated from VCC.

Table 42.1 LDO mode pin settings

Pin	Description
All VCC pins	• Connect each pin to the system power supply • Connect each pin to VSS through a 0.1-µF multilayer ceramic capacitor. Place the capacitor close to the pin.
VCL and VCL0 pins	Connect each pin to VSS through a 0.1-µF multilayer ceramic capacitor. Place the capacitor close to the pin.

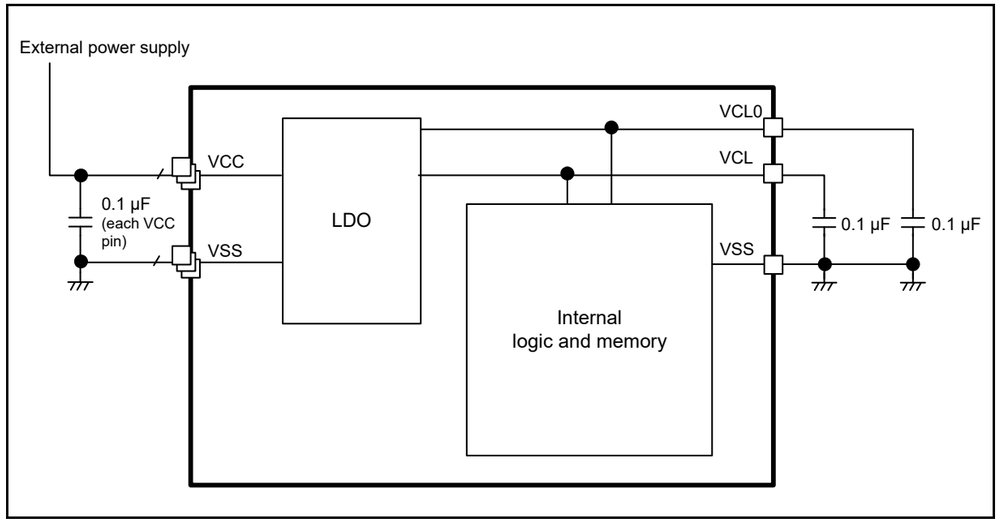

Figure 42.1 LDO mode settings

42. 内部稳压器

42.1 Overview

MCU包含一个线性稳压器(LDO)，可为内部电路和存储器（IO和模拟除外）提供电压。

42.2 Operation

表42.1列出了LDO模式引脚设置，图42.1显示了LDO模式设置。在LDO模式下，内部电压由VCC产生。

Table 42.1 LDO模式引脚设置

Pin	Description
所有VCC引脚	将每个引脚连接到系统电源 通过一个0.1µF多层陶瓷电容器将每个引脚连接到VSS。将电容器靠近引脚放置。
VCL和VCL0引脚	通过一个0.1µF多层陶瓷电容器将每个引脚连接到VSS。将电容器靠近引脚放置。

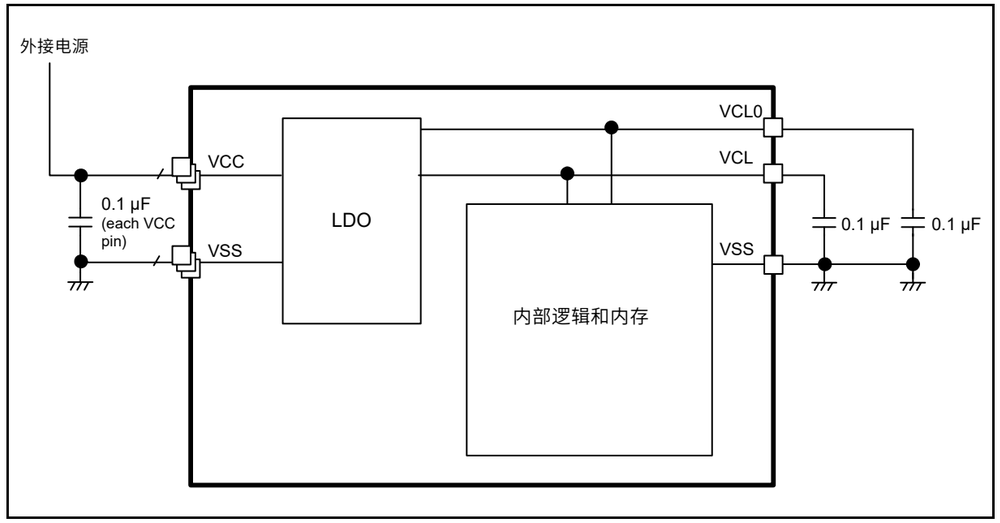

Figure 42.1 LDO模式设置

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43. Electrical Characteristics

Unless otherwise specified, the electrical characteristics of the MCU are defined under the following conditions:

- VCC = AVCC0 = 2.7 to 3.6 V
- 2.7 ≤ VREFH0/VREFH ≤ AVCC0
- VSS = AVSS0 = VREFL0/VREFL= 0 V
- $T_a = T_{opr}$.

Figure 43.1 shows the timing conditions.

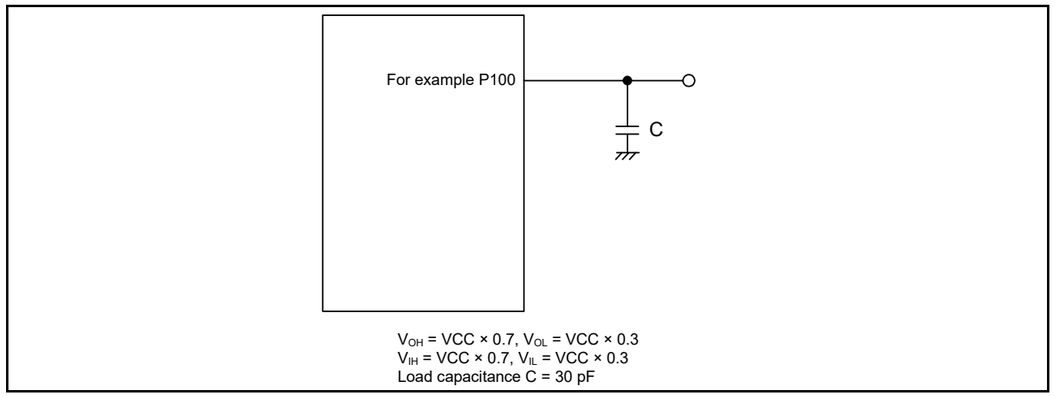

Figure 43.1 Input or output timing measurement conditions

The measurement conditions for the timing specification of each peripheral are recommended for the best peripheral operation. However, make sure to adjust the driving abilities of each pin to meet the conditions of your system.

Each function pin used for the same function must select the same drive ability. If the I/O drive ability of each function pin is mixed, the A/C specification of each function is not guaranteed.

43.1 Absolute Maximum Ratings

Table 43.1 Absolute maximum ratings

Parameter	Symbol	Value	Unit
Power supply voltage	VCC	-0.3 to +4.0	V
Input voltage (except for 5 V-tolerant ports*1)	V_{in}	-0.3 to VCC + 0.3	V
Input voltage (5 V-tolerant ports*1)	V_{in}	-0.3 to + VCC + 4.0 (max. 5.8)	V
Reference power supply voltage	VREFH/VREFH0	-0.3 to AVCC0 + 0.3	V
Analog power supply voltage	AVCC0 *2	-0.3 to +4.0	V
Analog input voltage (except for P000 to P007)	V_{AN}	-0.3 to AVCC0 + 0.3	V
Analog input voltage (P000 to P007) when PGA pseudo-differential input is disabled	V_{AN}	-0.3 to AVCC0 + 0.3	V
Analog input voltage (P000 to P002, P004 to P006) when PGA pseudo-differential input is enabled	V_{AN}	-1.3 to AVCC0 + 0.3	V
Analog input voltage (P003, P007) when PGA pseudo-differential input is enabled	V_{AN}	-0.8 to AVCC0 + 0.3	V
Operating temperature*3, *4	T_{opr}	-40 to +105	°C
Storage temperature	T_{stg}	-55 to +125	°C

Caution: Permanent damage to the MCU might result if absolute maximum ratings are exceeded.

Note 1. Ports P205, P206, P400, P401, P407 to P415, and P708 are 5 V tolerant.
Note 2. Connect AVCC0 to VCC.

43. 电气特性

除非另有规定，MCU的电气特性在以下条件下定义：

- VCC = AVCC0 = 2.7 to 3.6 V
- 2.7 ≤ VREFH0/VREFH ≤ AVCC0
- VSS = AVSS0 = VREFL0/VREFL= 0 V
- $T_a = T_{opr}$.

图43.1显示了时序条件。

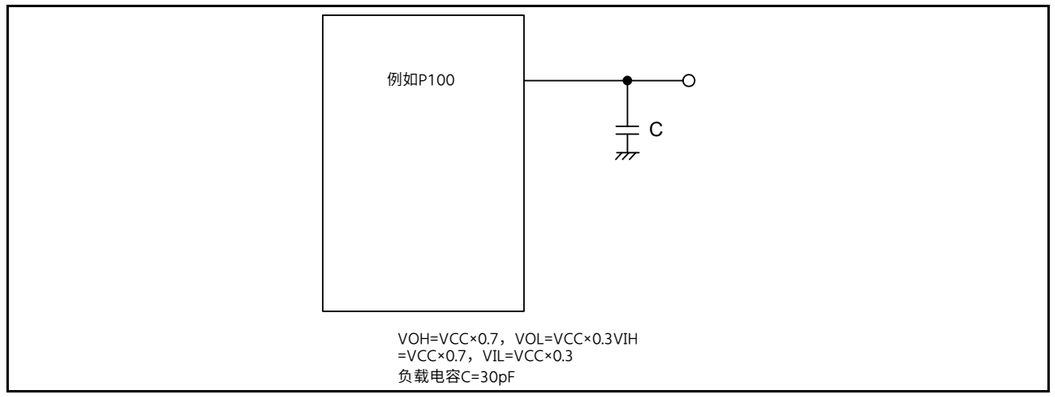

Figure 43.1 输入或输出定时测量条件

推荐每个外设时序规范的测量条件，以实现最佳外设操作。但是，请确保调整每个引脚的驱动能力以满足您系统的条件。

用于相同功能的每个功能引脚必须选择相同的驱动能力。如果各功能管脚的IO驱动能力混用，则无法保证各功能的AC规格。

43.1 绝对最大额定值

Table 43.1 绝对最大额定值

Parameter	Symbol	Value	Unit
电源电压	VCC	-0.3 to +4.0	V
输入电压（除了5V容限端口*1）	V_{in}	-0.3 to VCC + 0.3	V
输入电压（5V容限端口*1）	V_{in}	-0.3 to + VCC + 4.0 (max. 5.8)	V
参考电源电压	VREFH/VREFH0	-0.3 to AVCC0 + 0.3	V
模拟电源电压	AVCC0 *2	-0.3 to +4.0	V
模拟输入电压（P000至P007除外）	V_{AN}	-0.3 to AVCC0 + 0.3	V
PGA伪差分输入禁用时的模拟输入电压（P000至P007）	V_{AN}	-0.3 to AVCC0 + 0.3	V
启用PGA伪差分输入时的模拟输入电压（P000至P002、P004至P006）	V_{AN}	-1.3 to AVCC0 + 0.3	V
PGA伪差分输入启用时的模拟输入电压(P003 P007)	V_{AN}	-0.8 to AVCC0 + 0.3	V
Operating temperature*3, *4	T_{opr}	-40 to +105	°C
贮存温度	T_{stg}	-55 to +125	°C

Caution: 如果超过绝对最大额定值，可能会对MCU造成永久性损坏。

Note 1. 端口P205、P206、P400、P401、P407至P415和P708可承受5V电压。
Note 2. 将AVCC0连接到VCC。

Note 3. See section 43.2.1, T_j/T_a Definition.
Note 4. Contact Renesas Electronics sales office for information on derating operation when Ta = +85°C to +105°C. Derating is the systematic reduction of load for improved reliability.

Table 43.2 Recommended operating conditions

Parameter	Symbol	Min	Typ	Max	Unit
Power supply voltages	VCC	2.7	-	3.6	V
	VSS	-	0	-	V
Analog power supply voltages	AVCC0*1	-	VCC	-	V
	AVSS0	-	0	-	V

Note 1. Connect AVCC0 to VCC. When the A/D converter, the D/A converter, or the comparator are not in use, do not leave the AVCC0, VREFH/VREFH0, AVSS0, and VREFL/VREFL0 pins open. Connect the AVCC0 and VREFH/VREFH0 pins to VCC, and the AVSS0 and VREFL/VREFL0 pins to VSS, respectively.

43.2 DC Characteristics

43.2.1 T_j/T_a Definition

Table 43.3 DC characteristics
Conditions: Products with operating temperature (T_a) -40 to +105°C.

Parameter		Symbol	Typ	Max	Unit	Test conditions
Permissible junction temperature	100-pin LQFP 64-pin LQFP	T_j	-	125	°C	High-speed mode Low-speed mode Subosc-speed mode.

Note: Make sure that $T_j = T_a + \theta ja \times$ total power consumption (W),
where total power consumption = $(VCC - V_{OH}) \times \Sigma I_{OH} + V_{OL} \times \Sigma I_{OL} + I_{CC}max \times VCC$.

43.2.2 I/O V_{IH}, V_{IL}

Table 43.4 I/O V_{IH}, V_{IL} (1 of 2)

Parameter			Symbol	Min	Typ	Max	Unit
Input voltage (except for Schmitt trigger input pins)	Peripheral function pin	EXTAL(external clock input), SPI (except RSPCK)	V_{IH}	VCC × 0.8	-	-	V
			V_{IL}	-	-	VCC × 0.2	
		IIC (SMBus)*1	V_{IH}	2.1	-	-	
			V_{IL}	-	-	0.8	
		IIC (SMBus)*2	V_{IH}	2.1	-	VCC + 3.6 (max 5.8)	
			V_{IL}	-	-	0.8	
Schmitt trigger input voltage		IIC (except for SMBus)*1	V_{IH}	VCC × 0.7	-	-	
			V_{IL}	-	-	VCC × 0.3	
			ΔV_T	VCC × 0.05	-	-	
		IIC (except for SMBus)*2	V_{IH}	VCC × 0.7	-	VCC + 3.6 (max 5.8)	
			V_{IL}	-	-	VCC × 0.3	
			ΔV_T	VCC × 0.05	-	-	
		5 V-tolerant ports*3, *7	V_{IH}	VCC × 0.8	-	VCC + 3.6 (max 5.8)	
			V_{IL}	-	-	VCC × 0.2	
			ΔV_T	VCC × 0.05	-	-	

Note 3. 参见第43.2.1节，TjTa定义。
Note 4. 有关Ta=+85°C至+105°C时降额操作的信息，请联系瑞萨电子销售办事处。降额是系统地减少负载以提高可靠性。

Table 43.2 推荐工作条件

Parameter	Symbol	Min	Typ	Max	Unit
电源电压	VCC	2.7	-	3.6	V
	VSS	-	0	-	V
模拟电源电压	AVCC0*1	-	VCC	-	V
	AVSS0	-	0	-	V

Note 1. 将AVCC0连接到VCC。不使用AD转换器、DA转换器或比较器时，请勿离开AVCC0、VREFHVREFH0、AVSS0和VREFLVREFL0引脚打开。将AVCC0和VREFHVREFH0引脚分别连接到VCC，将AVSS0和VREFLVREFL0引脚分别连接到VSS。

43.2 DC Characteristics

43.2.1 T_j/T_a Definition

Table 43.3 DC characteristics
条件：工作温度(Ta)-40至+105°C的产品。

Parameter		Symbol	Typ	Max	Unit	测试条件
允许结温	100-pin LQFP 64-pin LQFP	T_j	-	125	°C	High-speed mode Low-speed mode Subosc-speed mode.

Note: 确保Tj=Ta+θja×总功耗(W)，其中总功耗=(VCCVOH)×ΣIOH+VOL×ΣIOL+ICCmax×VCC。

43.2.2 I O V I H

Table 43.4 IOVIH VIL(1of2)

Parameter			Symbol	Min	Typ	Max	Unit
输入电压（施密特触发器输入引脚除外）	外设功能引脚	EXTAL（外部时钟输入），SPI（除RSPCK)	V_{IH}	VCC × 0.8	-	-	V
			V_{IL}	-	-	VCC × 0.2	
		IIC (SMBus)*1	V_{IH}	2.1	-	-	
			V_{IL}	-	-	0.8	
		IIC (SMBus)*2	V_{IH}	2.1	-	VCC + 3.6 (max 5.8)	
			V_{IL}	-	-	0.8	
施密特触发器输入电压		IIC (except for SMBus)*1	V_{IH}	VCC × 0.7	-	-	
			V_{IL}	-	-	VCC × 0.3	
			ΔV_T	VCC × 0.05	-	-	
		IIC (except for SMBus)*2	V_{IH}	VCC × 0.7	-	VCC + 3.6 (max 5.8)	
			V_{IL}	-	-	VCC × 0.3	
			ΔV_T	VCC × 0.05	-	-	
		5 V-tolerant ports*3, *7	V_{IH}	VCC × 0.8	-	VCC + 3.6 (max 5.8)	
			V_{IL}	-	-	VCC × 0.2	
			ΔV_T	VCC × 0.05	-	-	

Table 43.4 I/O V_{IH}, V_{IL} (2 of 2)

Parameter			Symbol	Min	Typ	Max	Unit
Schmitt trigger input voltage	Peripheral function pin	P402/AGTIO0,1 P403/AGTIO0,1	V_{IH}	VCC × 0.8	-	VCC + 0.3	V
			V_{IL}	-	-	VCC × 0.2	
			ΔV_T	VCC × 0.05	-	-	
		Other input pins*4	V_{IH}	VCC × 0.8	-	-	
			V_{IL}	-	-	VCC × 0.2	
			ΔV_T	VCC × 0.05	-	-	
	Ports	5 V-tolerant ports*5, *7	V_{IH}	VCC × 0.8	-	VCC + 3.6 (max 5.8)	
			V_{IL}	-	-	VCC × 0.2	
		Other input pins*6	V_{IH}	VCC × 0.8	-	-	
			V_{IL}	-	-	VCC × 0.2	

Note 1. SCL1_B, SDA1_B (total 2 pins).
Note 2. SCL0_A, SDA0_A, SCL0_B, SDA0_B, SCL1_A, SDA1_A (total 6 pins).
Note 3. RES and peripheral function pins associated with P205, P206, P400, P401, P407 to P415, P708 (total 15 pins).
Note 4. All input pins except for the peripheral function pins already described in the table.
Note 5. P205, P206, P400, P401, P407 to P415, P708 (total 14 pins).
Note 6. All input pins except for the ports already described in the table.
Note 7. When VCC is less than 2.7 V, the input voltage of 5 V-tolerant ports should be less than 3.6 V, otherwise breakdown may occur because 5 V-tolerant ports are electrically controlled so as not to violate the breakdown voltage.

43.2.3 I/O I_{OH}, I_{OL}

Table 43.5 I/O I_{OH}, I_{OL} (1 of 2)

Parameter			Symbol	Min	Typ	Max	Unit
Permissible output current (average value per pin)	Ports P008, P201	-	I_{OH}	-	-	-2.0	mA
			I_{OL}	-	-	2.0	mA
	Ports P014, P015	-	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
	Ports P205, P206, P407 to P415, P602, P708 (total 13 pins)	Low drive*1	I_{OH}	-	-	-2.0	mA
			I_{OL}	-	-	2.0	mA
		Middle drive*2	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
		High drive*3	I_{OH}	-	-	-20	mA
			I_{OL}	-	-	20	mA
	Other output pins*4	Low drive*1	I_{OH}	-	-	-2.0	mA
			I_{OL}	-	-	2.0	mA
		Middle drive*2	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
		High drive*3	I_{OH}	-	-	-16	mA
			I_{OL}	-	-	16	mA

Table 43.4 IOVIH VIL(2of2)

Parameter			Symbol	Min	Typ	Max	Unit
施密特触发器输入电压	外设功能引脚	P402/AGTIO0,1 P403/AGTIO0,1	V_{IH}	VCC × 0.8	-	VCC + 0.3	V
			V_{IL}	-	-	VCC × 0.2	
			ΔV_T	VCC × 0.05	-	-	
		其他输入引脚*4	V_{IH}	VCC × 0.8	-	-	
			V_{IL}	-	-	VCC × 0.2	
			ΔV_T	VCC × 0.05	-	-	
	Ports	5 V-tolerant ports*5, *7	V_{IH}	VCC × 0.8	-	VCC + 3.6 (max 5.8)	
			V_{IL}	-	-	VCC × 0.2	
		其他输入引脚*6	V_{IH}	VCC × 0.8	-	-	
			V_{IL}	-	-	VCC × 0.2	

Note 1. SCL1_B, SDA1_B (total 2 pins).
Note 2. SCL0_A, SDA0_A, SCL0_B, SDA0_B, SCL1_A, SDA1_A (total 6 pins).
Note 3. RES和与P205、P206、P400、P401、P407到P415、P708相关的外围功能引脚（共15个引脚）。
Note 4. 除表中已描述的外围功能引脚外的所有输入引脚。
Note 5. P205, P206, P400, P401, P407 to P415, P708 (total 14 pins).
Note 6. 除表中已描述的端口外的所有输入引脚。
Note 7. 当VCC小于2.7V时，耐5V端口的输入电压应小于3.6V，否则可能发生击穿，因为5V耐压端口是电控的，不会违反击穿电压。

43.2.3 我爱我哦

Table 43.5 IOIOH IOL(1of2)

Parameter			Symbol	Min	Typ	Max	Unit
允许输出电流（每个引脚的平均值）	Ports P008, P201	-	I_{OH}	-	-	-2.0	mA
			I_{OL}	-	-	2.0	mA
	Ports P014, P015	-	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
	端口P205、P206、P407至P415、P602, P708 (total 13 pins)	Low drive*1	I_{OH}	-	-	-2.0	mA
			I_{OL}	-	-	2.0	mA
		Middle drive*2	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
		High drive*3	I_{OH}	-	-	-20	mA
			I_{OL}	-	-	20	mA
	其他输出引脚*4	Low drive*1	I_{OH}	-	-	-2.0	mA
			I_{OL}	-	-	2.0	mA
		Middle drive*2	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
		High drive*3	I_{OH}	-	-	-16	mA
			I_{OL}	-	-	16	mA

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Table 43.5 I/O I_{OH}, I_{OL} (2 of 2)

Parameter			Symbol	Min	Typ	Max	Unit
Permissible output current (max value per pin)	Ports P008, P201	-	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
	Ports P014, P015	-	I_{OH}	-	-	-8.0	mA
			I_{OL}	-	-	8.0	mA
	Ports P205, P206, P407 to P415, P602, P708 (total 13 pins)	Low drive*1	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
		Middle drive*2	I_{OH}	-	-	-8.0	mA
			I_{OL}	-	-	8.0	mA
		High drive*3	I_{OH}	-	-	-40	mA
			I_{OL}	-	-	40	mA
	Other output pins*4	Low drive*1	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
		Middle drive*2	I_{OH}	-	-	-8.0	mA
			I_{OL}	-	-	8.0	mA
		High drive*3	I_{OH}	-	-	-32	mA
			I_{OL}	-	-	32	mA
Permissible output current (max value of total of all pins)	Maximum of all output pins		ΣI_{OH} (max)	-	-	-80	mA
			ΣI_{OL} (max)	-	-	80	mA

Caution: To protect the reliability of the MCU, the output current values should not exceed the values in this table. The average output current indicates the average value of current measured during 100 µs.

Note 1. This is the value when low driving ability is selected in the Port Drive Capability bit in the PmnPFS register. The selected driving ability is retained in Deep Software Standby mode.
Note 2. This is the value when middle driving ability is selected in the Port Drive Capability bit in the PmnPFS register. The selected driving ability is retained in Deep Software Standby mode.
Note 3. This is the value when high driving ability is selected in the Port Drive Capability bit in the PmnPFS register. The selected driving ability is retained in Deep Software Standby mode.
Note 4. Except for P000 to P007, P200, which are input ports.

43.2.4 I/O V_{OH}, V_{OL}, and Other Characteristics

Table 43.6 I/O V_{OH}, V_{OL}, and other characteristics (1 of 2)

Parameter			Symbol	Min	Typ	Max	Unit	Test conditions
Output voltage	IIC		V_{OL}	-	-	0.4	V	I_{OL} = 3.0 mA
			V_{OL}	-	-	0.6		I_{OL} = 6.0 mA
	IIC*1		V_{OL}	-	-	0.4		I_{OL} = 15.0 mA (ICFER.FMPE = 1)
			V_{OL}	-	0.4	-		I_{OL} = 20.0 mA (ICFER.FMPE = 1)
	Ports P205, P206, P407 to P415, P602, P708 (total of 13 pins)*2		V_{OH}	VCC - 1.0	-	-		I_{OH} = -20 mA VCC = 3.3 V
			V_{OL}	-	-	1.0		I_{OL} = 20 mA VCC = 3.3 V
	Other output pins		V_{OH}	VCC - 0.5	-	-		I_{OH} = -1.0 mA
			V_{OL}	-	-	0.5		I_{OL} = 1.0 mA
Input leakage current	RES		$\lvert I_{in} \rvert$	-	-	5.0	µA	V_{in} = 0 V V_{in} = 5.5 V
	Ports P000 to P002, P004 to P006, P200			-	-	1.0		V_{in} = 0 V V_{in} = VCC
	Ports P003, P007	Before initialization*3		-	-	45.0		V_{in} = 0 V V_{in} = VCC
		After initialization*4		-	-	1.0		V_{in} = 0 V V_{in} = VCC

Table 43.5 IOIOH IOL(2/2)

Parameter			Symbol	Min	Typ	Max	Unit
允许输出电流（每个引脚的最大值）	Ports P008, P201	-	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
	Ports P014, P015	-	I_{OH}	-	-	-8.0	mA
			I_{OL}	-	-	8.0	mA
	端口P205、P206、P407至P415、P602, P708 (total 13 pins)	Low drive*1	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
		Middle drive*2	I_{OH}	-	-	-8.0	mA
			I_{OL}	-	-	8.0	mA
		High drive*3	I_{OH}	-	-	-40	mA
			I_{OL}	-	-	40	mA
	其他输出引脚*4	Low drive*1	I_{OH}	-	-	-4.0	mA
			I_{OL}	-	-	4.0	mA
		Middle drive*2	I_{OH}	-	-	-8.0	mA
			I_{OL}	-	-	8.0	mA
		High drive*3	I_{OH}	-	-	-32	mA
			I_{OL}	-	-	32	mA
允许输出电流（所有引脚总和的最大值）	所有输出引脚的最大值		ΣI_{OH} (max)	-	-	-80	mA
			ΣI_{OL} (max)	-	-	80	mA

Caution: 为保护单片机的可靠性，输出电流值不应超过此表中的值。平均输出电流是指在100µs内测得的电流平均值。

Note 1. 这是在PmnPFS寄存器的端口驱动能力位中选择低驱动能力时的值。在深度软件待机模式下会保留所选的驾驶能力。
Note 2. 这是在PmnPFS寄存器的端口驱动能力位中选择中等驱动能力时的值。在深度软件待机模式下会保留所选的驾驶能力。
Note 3. 这是在PmnPFS寄存器的端口驱动能力位中选择高驱动能力时的值。在深度软件待机模式下会保留所选的驾驶能力。
Note 4. 除了P000至P007、P200为输入端口。

43.2.4 IOVOH VOL和其他特性

Table 43.6 IOVOH、VOL和其他特征(1of2)

Parameter			Symbol	Min	Typ	Max	Unit	测试条件
输出电压	IIC		V_{OL}	-	-	0.4	V	我OL=3.0毫安
			V_{OL}	-	-	0.6		我OL=6.0毫安
	IIC*1		V_{OL}	-	-	0.4		IOL=15.0mA(ICFER.FMPE=1)
			V_{OL}	-	0.4	-		IOL=20.0mA(ICFER.FMPE=1)
	端口P205、P206、P407至P415、P602、P708（共13针）*2		V_{OH}	VCC - 1.0	-	-		我OH=-20毫安VCC=3.3V
			V_{OL}	-	-	1.0		我OL=20毫安VCC=3.3V
	其他输出引脚		V_{OH}	VCC - 0.5	-	-		IOH=-1.0毫安
			V_{OL}	-	-	0.5		我OL=1.0毫安
输入漏电流	RES		$\lvert I_{in} \rvert$	-	-	5.0	µA	V_{in} = 0 V V_{in} = 5.5 V
	端口P000至P002、P004至P006、P200			-	-	1.0		V_{in} = 0 V V_{in} = VCC
	Ports P003, P007	Before initialization*3		-	-	45.0		V_{in} = 0 V V_{in} = VCC
		After initialization*4		-	-	1.0		V_{in} = 0 V V_{in} = VCC

Table 43.6 I/O V_{OH}, V_{OL}, and other characteristics (2 of 2)

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
Three-state leakage current (off state)	5 V-tolerant ports	$\|I_{TSI}\|$	-	-	5.0	μA	V_{in} = 0 V V_{in} = 5.5 V
	Other ports (except for ports P000 to P007, P200)		-	-	1.0		V_{in} = 0 V V_{in} = VCC
Input pull-up MOS current	Ports P0 to P7 (except for ports P000 to P007)	I_p	-300	-	-10	μA	VCC = 2.7 to 3.6 V V_{in} = 0 V
Input capacitance	Ports P003, P007, P014, P015, P400, P401	C_{in}	-	-	16	pF	Vbias = 0 V Vamp = 20 mV f = 1 MHz T_a = 25°C
	Other input pins		-	-	8		

Note 1. SCL0_A, SDA0_A (total 2 pins).
Note 2. This is the value when high driving ability is selected in the Port Drive Capability bit in the PmnPFS register.
The selected driving ability is retained in Deep Software Standby mode.
Note 3. P0nPFS.ASEL(n = 3 or 7) = 1
Note 4. P0nPFS.ASEL(n = 3 or 7) = 0

43.2.5 Operating and Standby Current

Table 43.7 Operating and standby current (1 of 2)

Parameter				Symbol	Min	Typ	Max	Unit	Test conditions
Supply current*1	High-speed mode	Maximum*2		I_{CC}*3	-	-	87	mA	ICLK = 120 MHz PCLKA = 120 MHz PCLKB = 60 MHz PCLKC = 60 MHz PCLKD = 120 MHz FCLK = 60 MHz
		CoreMark®*5			-	17	-		
		Normal mode	All peripheral clocks enabled, while (1) code executing from flash*4		-	24	-		
			All peripheral clocks disabled, while (1) code executing from flash*5, *6		-	12	-		
		Sleep mode*5, *6			-	9	33.5		
		Increase during BGO operation	Data flash P/E		-	6	-		
			Code flash P/E		-	8	-		
	Low-speed mode*5				-	1.2	-		ICLK = 1 MHz
	Subosc-speed mode*5				-	1.0	-		ICLK = 32.768 kHz
	Software Standby mode				-	1.3	13		Ta ≤ 85°C
					-	1.3	21		Ta ≤ 105°C
	Deep Software Standby mode	DPSBYCR.DEEPCUT[1:0] = 00b*8			-	28	65	μA	Ta ≤ 85°C
					-	28	93		Ta ≤ 105°C
		DPSBYCR.DEEPCUT[1:0] = 01b*8			-	11.6	28		Ta ≤ 85°C
					-	11.6	32		Ta ≤ 105°C
		DPSBYCR.DEEPCUT[1:0] = 11b*8			-	4.9	21		Ta ≤ 85°C
					-	4.9	26		Ta ≤ 105°C
		Increase when the AGT is operating	When the low-speed on-chip oscillator (LOCO) is in use		-	4.4	-		-
			When a crystal oscillator for low clock loads is in use		-	1.0	-		-
			When a crystal oscillator for standard clock loads is in use		-	1.4	-		-
Analog power supply current	During 12-bit A/D conversion			AI_{CC}	-	0.8	1.1	mA	-
	During 12-bit A/D conversion with S/H amp				-	2.3	3.3	mA	-
	PGA (1ch)				-	1	3	mA	-
	ACMPHS (1 unit)				-	100	150	μA	-
	Temperature sensor				-	0.1	0.2	mA	-
	During D/A conversion (per unit)		Without AMP output		-	0.1	0.2	mA	-
			With AMP output		-	0.6	1.1	mA	-
	Waiting for A/D, D/A conversion (all units)				-	0.9	1.6	mA	-
	ADC12, DAC12 in standby modes (all units)*7				-	2	8	μA	-

Table 43.6 IOVOH、VOL和其他特征(2of2)

Parameter		Symbol	Min	Typ	Max	Unit	测试条件
三态漏电流（关闭状态）	5 V-tolerant ports	$\|I_{TSI}\|$	-	-	5.0	μA	V_{in} = 0 V V_{in} = 5.5 V
	其他端口（端口P000至P007、P200除外）		-	-	1.0		V_{in} = 0 V V_{in} = VCC
输入上拉MOS电流	端口P0至P7（端口除外P000 to P007）	I_p	-300	-	-10	μA	VCC = 2.7 to 3.6 V V_{in} = 0 V
输入电容	Ports P003, P007, P014, P015, P400, P401	C_{in}	-	-	16	pF	Vbias = 0 V Vamp = 20 mV f = 1 MHz T_a = 25°C
	其他输入引脚		-	-	8		

Note 1. SCL0_A, SDA0_A (total 2 pins).
Note 2. 这是在PmnPFS寄存器的端口驱动能力位中选择高驱动能力时的值。
在深度软件待机模式下会保留所选的驾驶能力。
Note 3. P0nPFS.ASEL(n = 3 or 7) = 1
Note 4. P0nPFS.ASEL(n = 3 or 7) = 0

43.2.5 工作和待机电流

Table 43.7 工作和待机电流(1of2)

Parameter				Symbol	Min	Typ	Max	Unit	测试条件
供电电流*1	High-speed mode	Maximum*2		I_{CC}*3	-	-	87	mA	ICLK = 120 MHz PCLKA = 120 MHz PCLKB = 60 MHz PCLKC = 60 MHz PCLKD = 120 MHz FCLK = 60 MHz
		CoreMark®*5			-	17	-		
		正常模式	启用所有外设时钟，同时(1)代码从闪存执行*4		-	24	-		
			禁用所有外设时钟，同时(1)代码从闪存执行*5、*6		-	12	-		
		Sleep mode*5, *6			-	9	33.5		
		BGO运行期间增加	数据闪存PE		-	6	-		
			代码闪存PE		-	8	-		
	Low-speed mode*5				-	1.2	-		ICLK = 1 MHz
	Subosc-speed mode*5				-	1.0	-		ICLK = 32.768 kHz
	软件待机模式				-	1.3	13		Ta ≤ 85°C
					-	1.3	21		Ta ≤ 105°C
	深度软件待机模式	DPSBYCR.DEEPCUT[1:0] = 00b*8			-	28	65	μA	Ta ≤ 85°C
					-	28	93		Ta ≤ 105°C
		DPSBYCR.DEEPCUT[1:0] = 01b*8			-	11.6	28		Ta ≤ 85°C
					-	11.6	32		Ta ≤ 105°C
		DPSBYCR.DEEPCUT[1:0] = 11b*8			-	4.9	21		Ta ≤ 85°C
					-	4.9	26		Ta ≤ 105°C
		AGT运行时增加	使用低速片上振荡器(LOCO)时		-	4.4	-		-
			当使用用于低时钟负载的晶体振荡器时		-	1.0	-		-
			当使用标准时钟负载的晶体振荡器时		-	1.4	-		-
模拟电源电流	在12位AD转换期间			AI_{CC}	-	0.8	1.1	mA	-
	在使用SHamp进行12位AD转换期间				-	2.3	3.3	mA	-
	PGA (1ch)				-	1	3	mA	-
	ACMPHS (1 unit)				-	100	150	μA	-
	温度感应器				-	0.1	0.2	mA	-
	DA转换期间（每单位）		无AMP输出		-	0.1	0.2	mA	-
			带AMP输出		-	0.6	1.1	mA	-
	等待AD、DA转换（所有单位）				-	0.9	1.6	mA	-
	ADC12、DAC12处于待机模式（所有单元）*7				-	2	8	μA	-

Table 43.7 Operating and standby current (2 of 2)

Parameter			Symbol	Min	Typ	Max	Unit	Test conditions
Reference power supply current (VREFH0)	During 12-bit A/D conversion (unit 0)		AI_{REFH0}	-	70	120	µA	-
	Waiting for 12-bit A/D conversion (unit 0)			-	0.07	0.5	µA	-
	ADC12 in standby modes (unit 0)			-	0.07	0.5	µA	-
Reference power supply current (VREFH)	During 12-bit A/D conversion (unit 1)		AI_{REFH}	-	70	120	µA	-
	During D/A conversion (per unit)	Without AMP output		-	0.1	0.4	mA	-
		With AMP ouput		-	0.1	0.4	mA	-
	Waiting for 12-bit A/D (unit 1), D/A (all units) conversion			-	0.07	0.8	µA	-
	ADC12 unit 1 in standby modes			-	0.07	0.8	µA	-

Note 1. Supply current values are with all output pins unloaded and all input pull-up MOS transistors in the off state.
Note 2. Measured with clocks supplied to the peripheral functions. This does not include the BGO operation.
Note 3. I_{CC} depends on f (ICLK) as follows. (ICLK:PCLKA:PCLKB:PCLKC:PCLKD = 2:2:1:1:2)
I_{CC} Max. = 0.53 x f + 23 (maximum operation in High-speed mode)
I_{CC} Typ. = 0.08 x f + 2.4 (normal operation in High-speed mode)
I_{CC} Typ. = 0.1 x f + 1.1 (Low-speed mode)
I_{CC} Max. = 0.09 x f + 23 (Sleep mode).
Note 4. This does not include the BGO operation.
Note 5. Supply of the clock signal to peripherals is stopped in this state. This does not include the BGO operation.
Note 6. FCLK, PCLKA, PCLKB, PCLKC, and PCLKD are set to divided by 64 (3.75 MHz).
Note 7. When the MCU is in Software Standby mode or the MSTPCRD.MSTPD16 (12-bit A/D Converter 0 Module Stop bit) and MSTPCRD.MSTPD15 (12-bit A/D Converter 1 Module Stop bit) are in the module-stop state.
See section 35.6.8, Available functions and register settings of AN000 to AN002, AN007, AN100 to AN102, and AN107.
Note 8. For more information on the DBSBYCR register, see section 11.2.11, Deep Software Standby Control Register (DPSBYCR).

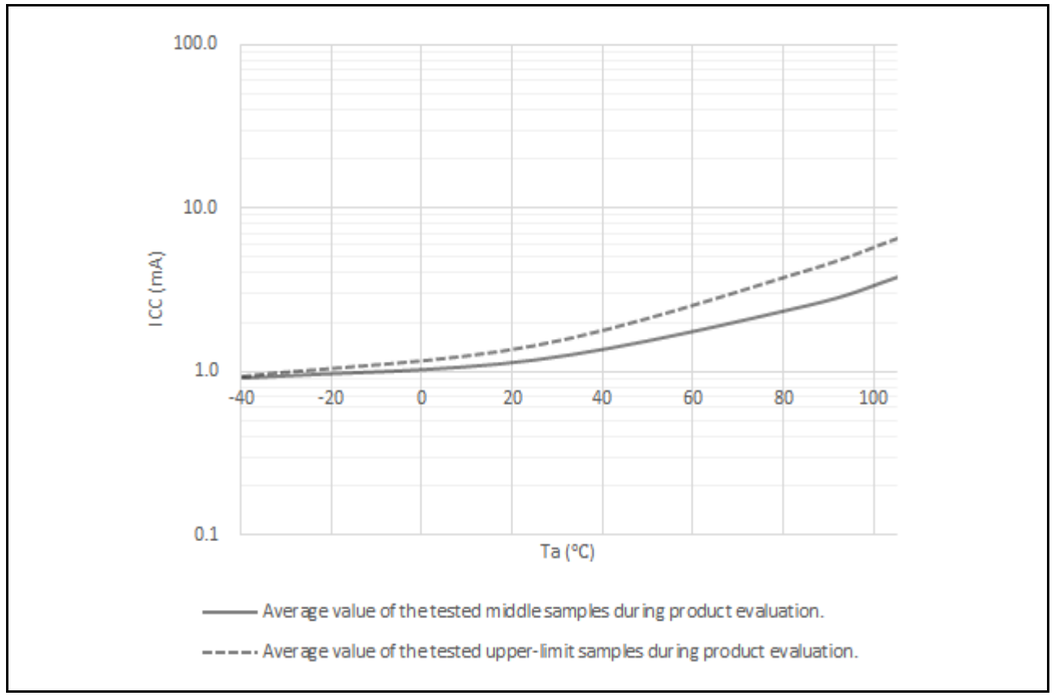


Figure 43.2 Temperature dependency in Software Standby mode (reference data)

Table 43.7 工作和待机电流(2of2)

Parameter			Symbol	Min	Typ	Max	Unit	测试条件
参考电源电流(VREFH0)	在12位AD转换期间（单元0）		AI_{REFH0}	-	70	120	µA	-
	等待12位AD转换（单元0）			-	0.07	0.5	µA	-
	ADC12处于待机模式（单元0）			-	0.07	0.5	µA	-
参考电源电流(VREFH)	在12位AD转换期间（单元1）		AI_{REFH}	-	70	120	µA	-
	DA转换期间（每单位）	无AMP输出		-	0.1	0.4	mA	-
		带AMP输出		-	0.1	0.4	mA	-
	等待12位AD（单元1）、DA（所有单元）转换			-	0.07	0.8	µA	-
	ADC12单元1处于待机模式			-	0.07	0.8	µA	-

Note 1. 电源电流值是在所有输出引脚空载且所有输入上拉MOS晶体管处于关闭状态的情况下。
Note 2. 使用提供给外围功能的时钟进行测量。这不包括BGO操作。
Note 3. ICC取决于f(ICLK)如下。（ICLK:PCLKA:PCLKB:PCLKC:PCLKD=2:2:1:1:2）
我CC最大。=0.53xf+23（高速模式下的最大操作）
我CC典型。=0.08xf+2.4（高速模式下的正常操作）
I_{CC} Typ. = 0.1 x f + 1.1 (Low-speed mode)
I_{CC} Max. = 0.09 x f + 23 (Sleep mode).
Note 4. 这不包括BGO操作。
Note 5. 在该状态下停止向外围设备提供时钟信号。这不包括BGO操作。
Note 6. FCLK、PCLKA、PCLKB、PCLKC和PCLKD设置为除以64(3.75MHz)。
Note 7. 当MCU处于软件待机模式或MSTPCRD.MSTPD16（12位AD转换器0模块停止位）和MSTPCRD.MSTPD15（12位AD转换器1模块停止位）处于模块停止状态时。
请参见第35.6.8节，AN000至AN002、AN007、AN100至AN102和AN107的可用功能和寄存器设置。
Note 8. 有关DBSBYCR寄存器的更多信息，请参见第11.2.11节，深度软件待机控制寄存器(DPSBYCR)。

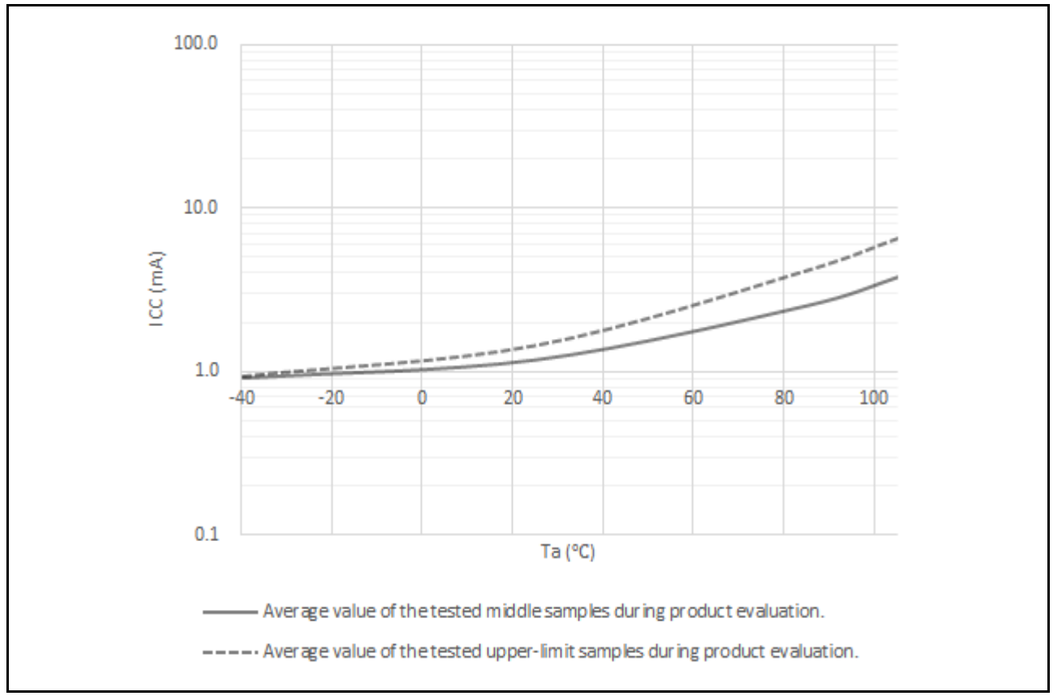


Figure 43.2 软件待机模式下的温度依赖性（参考数据）

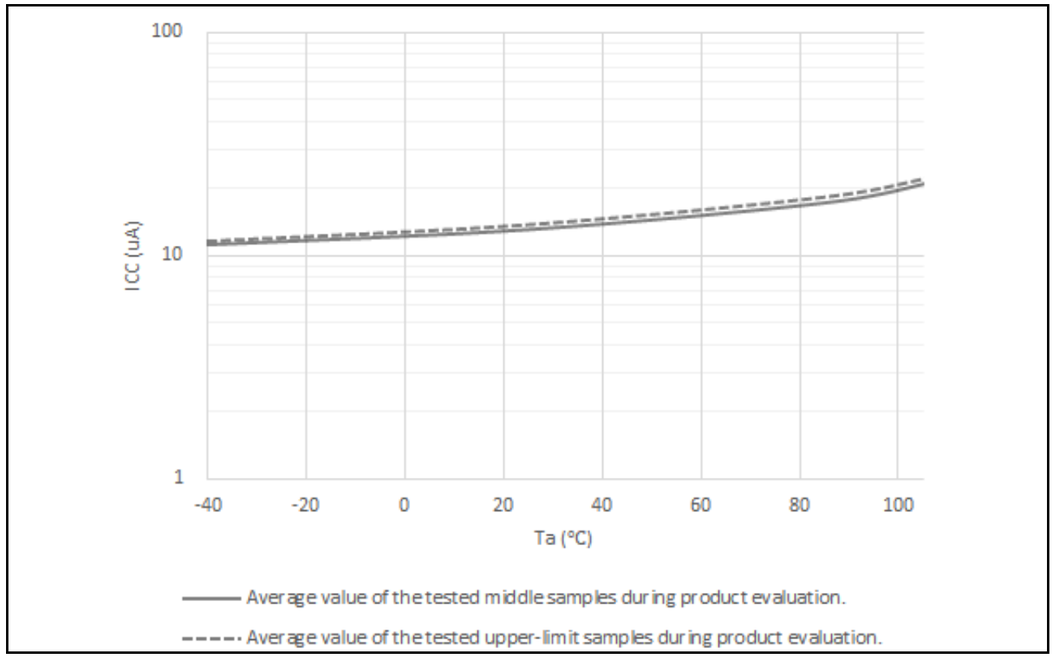


Figure 43.3 Temperature dependency in Deep Software Standby mode, power-on reset circuit low power function disabled (reference data)

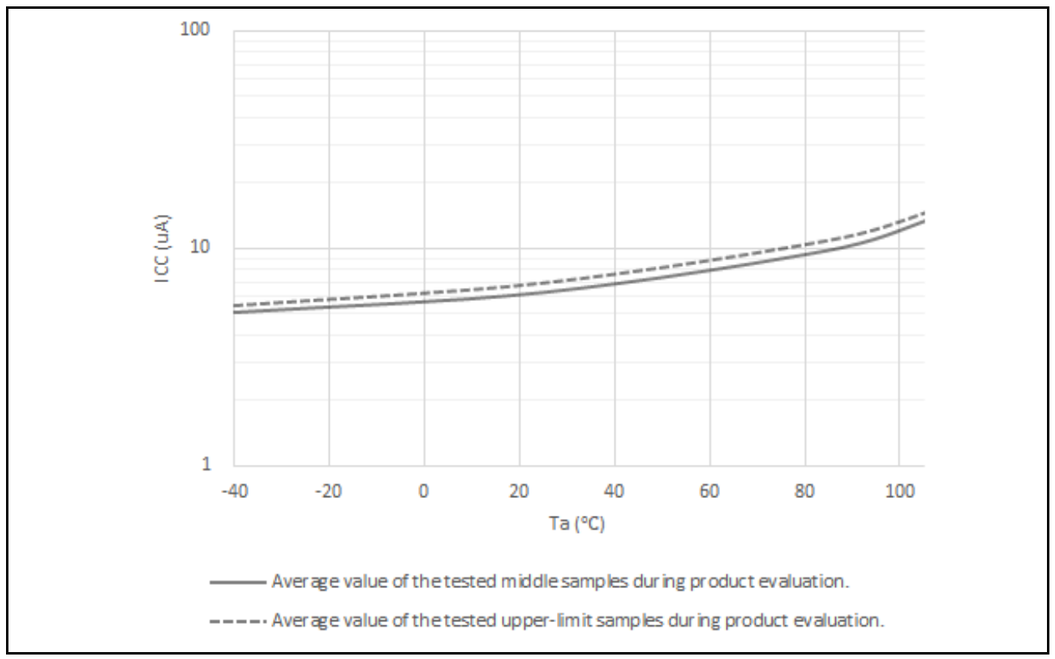


Figure 43.4 Temperature dependency in Deep Software Standby mode, power-on reset circuit low power function enabled (reference data)

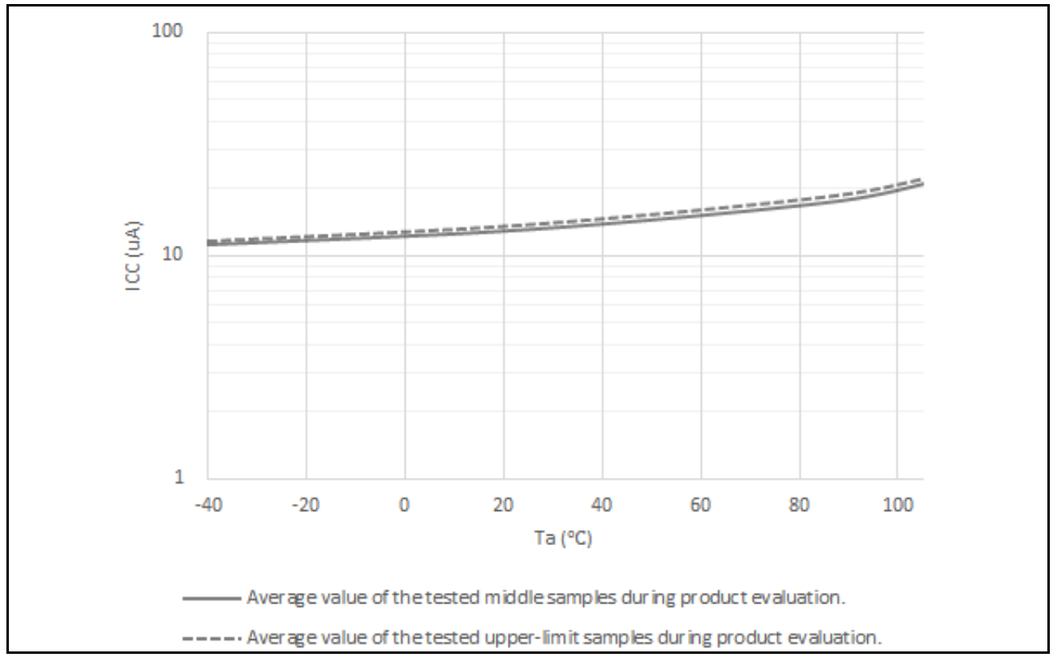


Figure 43.3 深度软件待机模式下的温度依赖性，上电复位电路低功耗功能禁用（参考数据）

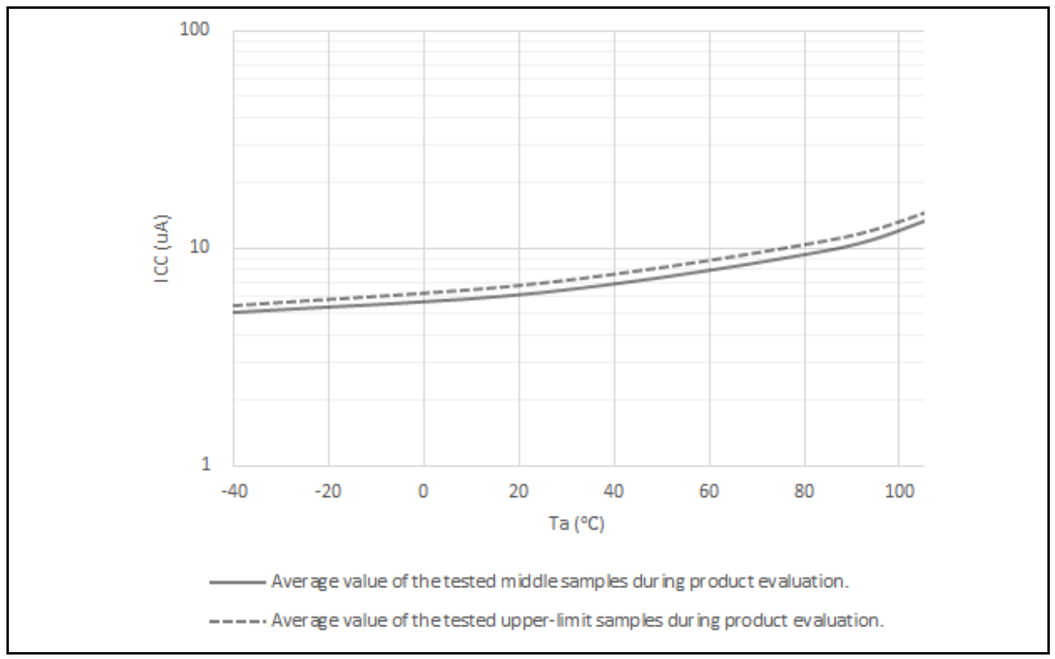


Figure 43.4 深度软件待机模式下的温度依赖性，启用上电复位电路低功耗功能（参考数据）

43.2.6 VCC Rise and Fall Gradient and Ripple Frequency

Table 43.8 Rising gradient characteristics

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
VCC rising gradient	Voltage monitor 0 reset disabled at startup	SrVCC	0.0084	-	20	ms/V	-
	Voltage monitor 0 reset enabled at startup		0.0084	-	-		-
	SCI boot mode*1		0.0084	-	20		-

Note 1. At boot mode, the reset from voltage monitor 0 is disabled regardless of the value of the OFS1.LVDAS bit.

Table 43.9 Rise and fall gradient and ripple frequency characteristics

The ripple voltage must meet the allowable ripple frequency $f_{r(VCC)}$ within the range between the VCC upper limit (3.6 V) and lower limit (2.7 V). When the VCC change exceeds VCC ±10%, the allowable voltage change rising and falling gradient dt/dVCC must be met.

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
Allowable ripple frequency	$f_{r(VCC)}$	-	-	10	kHz	Figure 43.5 $V_{r(VCC)} \leq VCC \times 0.2$
		-	-	1	MHz	Figure 43.5 $V_{r(VCC)} \leq VCC \times 0.08$
		-	-	10	MHz	Figure 43.5 $V_{r(VCC)} \leq VCC \times 0.06$
Allowable voltage change rising and falling gradient	dt/dVCC	1.0	-	-	ms/V	When VCC change exceeds VCC ±10%

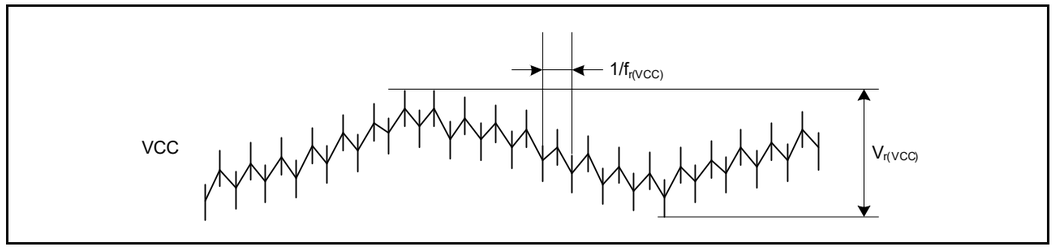


Figure 43.5 Ripple waveform

43.3 AC Characteristics

43.3.1 Frequency

Table 43.10 Operation frequency value in high-speed mode

Parameter		Symbol	Min	Typ	Max	Unit
Operation frequency	System clock (ICLK*2)	f	-	-	120	MHz
	Peripheral module clock (PCLKA)*2		-	-	120	
	Peripheral module clock (PCLKB)*2		-	-	60	
	Peripheral module clock (PCLKC)*2		-*3	-	60	
	Peripheral module clock (PCLKD)*2		-	-	120	
	Flash interface clock (FCLK)*2		-*1	-	60	

Note 1. FCLK must run at a frequency of at least 4 MHz when programming or erasing the flash memory.
Note 2. See section 9, Clock Generation Circuit for the relationship between the ICLK, PCLKA, PCLKB, PCLKC, PCLKD, and FCLK frequencies.
Note 3. When the ADC12 is used, the PCLKC frequency must be at least 1 MHz.

43.2.6 VCC上升和下降梯度和纹波频率

Table 43.8 上升梯度特性

Parameter		Symbol	Min	Typ	Max	Unit	测试条件
VCC上升梯度	启动时禁用电压监视器0复位	SrVCC	0.0084	-	20	ms/V	-
	启动时启用电压监视器0复位		0.0084	-	-		-
	SCI开机模式*1		0.0084	-	20		-

Note 1. 在引导模式下，无论OFS1.LVDAS位的值如何，都禁止从电压监视器0进行的复位。

Table 43.9 升降梯度和纹波频率特性

纹波电压必须在VCC上限(3.6V)和下限(2.7V)之间的范围内满足允许的纹波频率fr(VCC)。当VCC变化超过VCC±10%时，必须满足允许的电压变化上升和下降梯度dtdVCC。

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
允许纹波频率	$f_{r(VCC)}$	-	-	10	kHz	Figure 43.5 $V_{r(VCC)} \leq VCC \times 0.2$
		-	-	1	MHz	Figure 43.5 $V_{r(VCC)} \leq VCC \times 0.08$
		-	-	10	MHz	Figure 43.5 $V_{r(VCC)} \leq VCC \times 0.06$
允许电压变化上升下降梯度	dt/dVCC	1.0	-	-	ms/V	当VCC变化超过VCC±10%

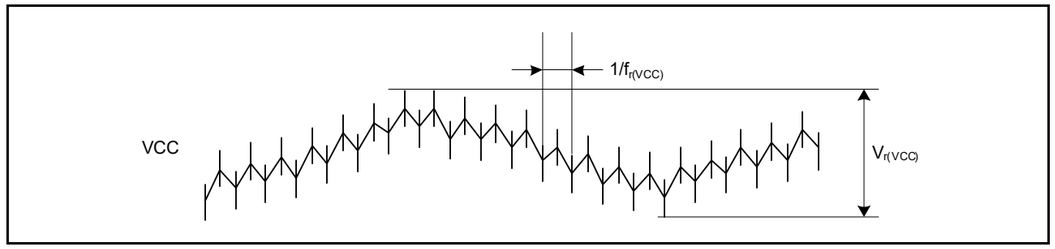


Figure 43.5 纹波波形

43.3 交流特性

43.3.1 Frequency

Table 43.10 高速模式下的运行频率值

Parameter		Symbol	Min	Typ	Max	Unit
运行频率	系统时钟(ICLK*2)	f	-	-	120	MHz
	外设模块时钟(PCLKA)*2		-	-	120	
	外设模块时钟(PCLKB)*2		-	-	60	
	外设模块时钟(PCLKC)*2		-*3	-	60	
	外设模块时钟(PCLKD)*2		-	-	120	
	闪存接口时钟(FCLK)*2		-*1	-	60	

Note 1. 在对闪存进行编程或擦除时，FCLK必须以至少4MHz的频率运行。
Note 2. 有关ICLK、PCLKA、PCLKB、PCLKC、PCLKD和FCLK频率之间的关系，请参见第9节，时钟生成电路。
Note 3. 使用ADC12时，PCLKC频率必须至少为1MHz。

RA生态工作

Table 43.11 Operation frequency value in low-speed mode

Parameter		Symbol	Min	Typ	Max	Unit
Operation frequency	System clock (ICLK)*2	f	-	-	1	MHz
	Peripheral module clock (PCLKA)*2		-	-	1	
	Peripheral module clock (PCLKB)*2		-	-	1	
	Peripheral module clock (PCLKC)*2,*3		-*3	-	1	
	Peripheral module clock (PCLKD)*2		-	-	1	
	Flash interface clock (FCLK)*1, *2		-	-	1	

Note 1. Programming or erasing the flash memory is disabled in Low-speed mode.
Note 2. See section 9, Clock Generation Circuit for the relationship between the ICLK, PCLKA, PCLKB, PCLKC, PCLKD, and FCLK frequencies.
Note 3. When the ADC12 is used, the PCLKC frequency must be set to at least 1 MHz.

Table 43.12 Operation frequency value in Subosc-speed mode

Parameter		Symbol	Min	Typ	Max	Unit
Operation frequency	System clock (ICLK)*2	f	29.4	-	36.1	kHz
	Peripheral module clock (PCLKA)*2		-	-	36.1	
	Peripheral module clock (PCLKB)*2		-	-	36.1	
	Peripheral module clock (PCLKC)*2,*3		-	-	36.1	
	Peripheral module clock (PCLKD)*2		-	-	36.1	
	Flash interface clock (FCLK)*1, *2		29.4	-	36.1	

Note 1. Programming or erasing the flash memory is disabled in Subosc-speed mode.
Note 2. See section 9, Clock Generation Circuit for the relationship between the ICLK, PCLKA, PCLKB, PCLKC, PCLKD, and FCLK frequencies.
Note 3. The ADC12 cannot be used.

43.3.2 Clock Timing

Table 43.13 Clock timing except for sub-clock oscillator (1 of 2)

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
EXTAL external clock input cycle time	t_{EXcyc}	41.66	-	-	ns	Figure 43.6
EXTAL external clock input high pulse width	t_{EXH}	15.83	-	-	ns	
EXTAL external clock input low pulse width	t_{EXL}	15.83	-	-	ns	
EXTAL external clock rise time	t_{EXr}	-	-	5.0	ns	
EXTAL external clock fall time	t_{EXf}	-	-	5.0	ns	
Main clock oscillator frequency	f_{MAIN}	8	-	24	MHz	-
Main clock oscillation stabilization wait time (crystal) *1	$t_{MAINOSCWT}$	-	-	-*1	ms	Figure 43.7
LOCO clock oscillation frequency	f_{LOCO}	29.4912	32.768	36.0448	kHz	-
LOCO clock oscillation stabilization wait time	t_{LOCOWT}	-	-	60.4	µs	Figure 43.8
ILOCO clock oscillation frequency	f_{ILOCO}	13.5	15	16.5	kHz	-
MOCO clock oscillation frequency	F_{MOCO}	6.8	8	9.2	MHz	-
MOCO clock oscillation stabilization wait time	t_{MOCOWT}	-	-	15.0	µs	-

Table 43.11 低速模式下的运行频率值

Parameter		Symbol	Min	Typ	Max	Unit
运行频率	系统时钟(ICLK)*2	f	-	-	1	MHz
	外设模块时钟(PCLKA)*2		-	-	1	
	外设模块时钟(PCLKB)*2		-	-	1	
	外设模块时钟(PCLKC)*2 *3		-*3	-	1	
	外设模块时钟(PCLKD)*2		-	-	1	
	Flash接口时钟(FCLK)*1 *2		-	-	1	

Note 1. 编程或擦除闪存在低速模式下被禁用。
Note 2. 有关ICLK、PCLKA、PCLKB、PCLKC、PCLKD和FCLK频率之间的关系，请参见第9节，时钟生成电路。
Note 3. 使用ADC12时，PCLKC频率必须设置为至少1MHz。

Table 43.12 Subosc-speed模式下的运行频率值

Parameter		Symbol	Min	Typ	Max	Unit
运行频率	系统时钟(ICLK)*2	f	29.4	-	36.1	kHz
	外设模块时钟(PCLKA)*2		-	-	36.1	
	外设模块时钟(PCLKB)*2		-	-	36.1	
	外设模块时钟(PCLKC)*2 *3		-	-	36.1	
	外设模块时钟(PCLKD)*2		-	-	36.1	
	Flash接口时钟(FCLK)*1 *2		29.4	-	36.1	

Note 1. 在Subosc速度模式下，禁止对闪存进行编程或擦除。
Note 2. 有关ICLK、PCLKA、PCLKB、PCLKC、PCLKD和FCLK频率之间的关系，请参见第9节，时钟生成电路。
Note 3. ADC12不能使用。

43.3.2 时钟时序

Table 43.13 除副时钟振荡器外的时钟时序（2个中的1个）

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
EXTAL外部时钟输入周期时间	t_{EXcyc}	41.66	-	-	ns	Figure 43.6
EXTAL外部时钟输入高脉冲宽度	t_{EXH}	15.83	-	-	ns	
EXTAL外部时钟输入低脉冲宽度	t_{EXL}	15.83	-	-	ns	
EXTAL外部时钟上升时间	t_{EXr}	-	-	5.0	ns	
EXTAL外部时钟下降时间	t_{EXf}	-	-	5.0	ns	
主时钟振荡器频率	f_{MAIN}	8	-	24	MHz	-
主时钟振荡稳定等待时间（晶振）*1	$t_{MAINOSCWT}$	-	-	-*1	ms	Figure 43.7
LOCO时钟振荡频率	f_{LOCO}	29.4912	32.768	36.0448	kHz	-
LOCO时钟振荡稳定等待时间	t_{LOCOWT}	-	-	60.4	µs	Figure 43.8
ILOCO时钟振荡频率	f_{ILOCO}	13.5	15	16.5	kHz	-
MOCO时钟振荡频率	F_{MOCO}	6.8	8	9.2	MHz	-
MOCO时钟振荡稳定等待时间	t_{MOCOWT}	-	-	15.0	µs	-

Table 43.13 Clock timing except for sub-clock oscillator (2 of 2)

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
HOCO clock oscillator oscillation frequency	Without FLL	f_{HOCO16}	15.78	16	16.22	MHz	-20 ≤ Ta ≤ 105°C
		f_{HOCO18}	17.75	18	18.25		
		f_{HOCO20}	19.72	20	20.28		
		f_{HOCO16}	15.71	16	16.29		-40 ≤ Ta ≤ -20°C
		f_{HOCO18}	17.68	18	18.32		
		f_{HOCO20}	19.64	20	20.36		
	With FLL	f_{HOCO16}	15.955	16	16.045		-40 ≤ Ta ≤ 105°C Sub-clock frequency accuracy is ±50 ppm.
		f_{HOCO18}	17.949	18	18.051		
		f_{HOCO20}	19.944	20	20.056		
HOCO clock oscillation stabilization wait time*2		t_{HOCOWT}	-	-	64.7	μs	-
FLL stabilization wait time		t_{FLLWT}	-	-	1.8	ms	-
PLL clock frequency		f_{PLL}	120	-	240	MHz	-
PLL clock oscillation stabilization wait time		t_{PLLWT}	-	-	174.9	μs	Figure 43.9

Note 1. When setting up the main clock oscillator, ask the oscillator manufacturer for an oscillation evaluation, and use the results as the recommended oscillation stabilization time. Set the MOSCWTCR register to a value equal to or greater than the recommended value.
After changing the setting in the MOSCCR.MOSTP bit to start main clock operation, read the OSCSF.MOSCSF flag to confirm that it is 1, and then start using the main clock oscillator.

Note 2. This is the time from release from reset state until the HOCO oscillation frequency (fHOCO) reaches the range for guaranteed operation.

Table 43.14 Clock timing for the sub-clock oscillator

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
Sub-clock frequency	f_{SUB}	-	32.768	-	kHz	-
Sub-clock oscillation stabilization wait time	$t_{SUBOSCWT}$	-	-	-*1	s	Figure 43.10

Note 1. When setting up the sub-clock oscillator, ask the oscillator manufacturer for an oscillation evaluation and use the results as the recommended oscillation stabilization time.
After changing the setting in the SOSCCR.SOSTP bit to start sub-clock operation, only start using the sub-clock oscillator after the sub-clock oscillation stabilization time elapses with an adequate margin. A value that is two times the value shown is recommended.

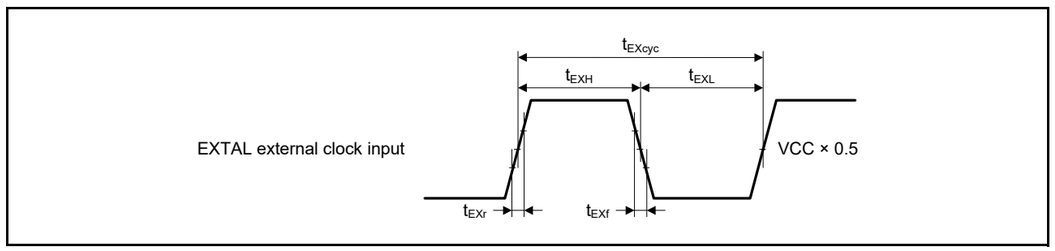


Figure 43.6 EXTAL external clock input timing

Table 43.13 除副时钟振荡器外的时钟时序(2of2)

Parameter		Symbol	Min	Typ	Max	Unit	测试条件
HOCO时钟振荡器振荡频率	Without FLL	f_{HOCO16}	15.78	16	16.22	MHz	-20 ≤ Ta ≤ 105°C
		f_{HOCO18}	17.75	18	18.25		
		f_{HOCO20}	19.72	20	20.28		
		f_{HOCO16}	15.71	16	16.29		-40 ≤ Ta ≤ -20°C
		f_{HOCO18}	17.68	18	18.32		
		f_{HOCO20}	19.64	20	20.36		
	With FLL	f_{HOCO16}	15.955	16	16.045		−40≤Ta≤105°C副时钟频率精度为±50ppm。
		f_{HOCO18}	17.949	18	18.051		
		f_{HOCO20}	19.944	20	20.056		
HOCO时钟振荡稳定等待时间*2		t_{HOCOWT}	-	-	64.7	μs	-
FLL稳定等待时间		t_{FLLWT}	-	-	1.8	ms	-
锁相环时钟频率		f_{PLL}	120	-	240	MHz	-
PLL时钟振荡稳定等待时间		t_{PLLWT}	-	-	174.9	μs	Figure 43.9

Note 1. 设置主时钟振荡器时，请向振荡器制造商索取振荡评估，并将结果作为推荐的振荡稳定时间。将MOSCWTCR寄存器设置为等于或大于推荐值的值。更改MOSCCR.MOSTP位的设置以启动主时钟操作后，读取OSCSF.MOSCSF标志以确认其为1，然后开始使用主时钟振荡器。

Note 2. 这是从复位状态释放到HOCO振荡频率(fHOCO)达到保证工作范围的时间。

Table 43.14 副时钟振荡器的时钟时序

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
Sub-clock frequency	f_{SUB}	-	32.768	-	kHz	-
副时钟振荡稳定等待时间	$t_{SUBOSCWT}$	-	-	-*1	s	Figure 43.10

Note 1. 设置副时钟振荡器时，请向振荡器制造商索取振荡评估，并将结果作为推荐的振荡稳定时间。更改SOSCCR.SOSTP位的设置以启动副时钟操作后，只有在副时钟振荡稳定时间过去并留有足够余量后才开始使用副时钟振荡器。建议使用两倍于显示值的值。

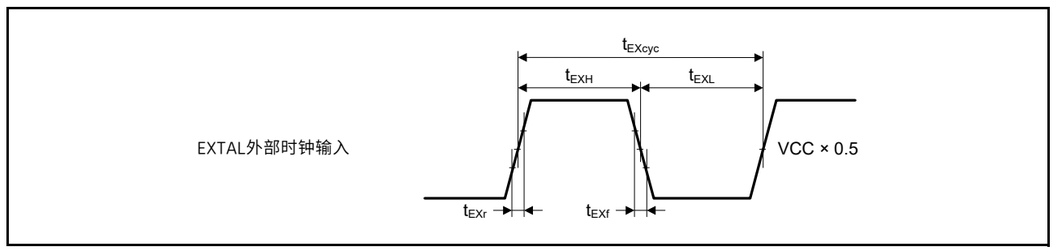


Figure 43.6 EXTAL外部时钟输入时序

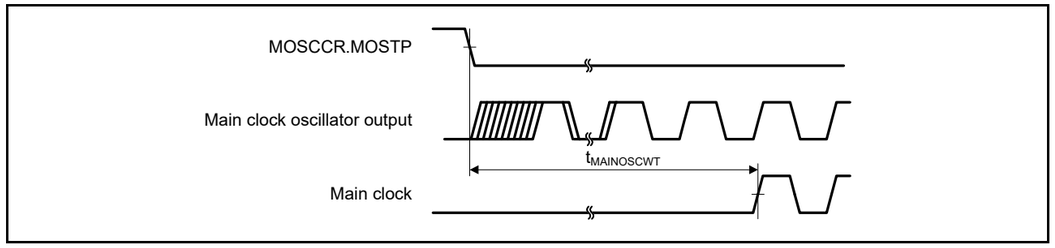


Figure 43.7 Main clock oscillation start timing

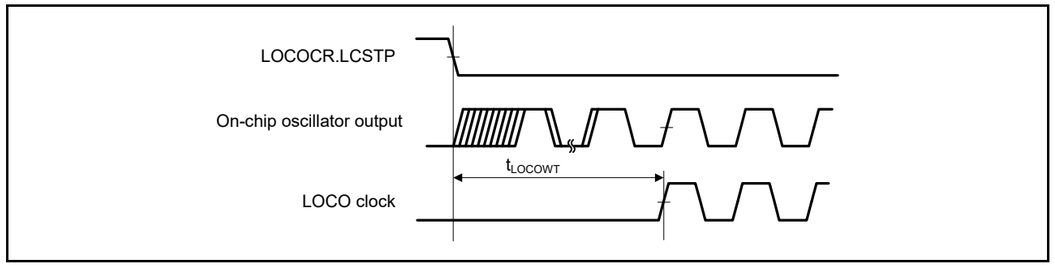


Figure 43.8 LOCO clock oscillation start timing

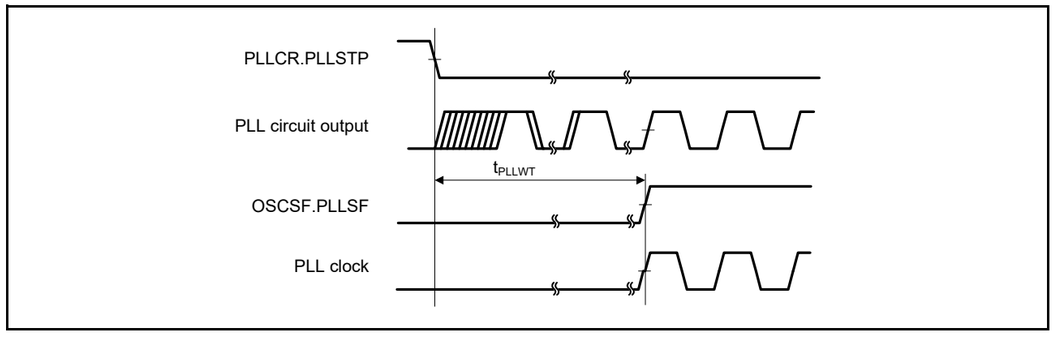


Figure 43.9 PLL clock oscillation start timing

Note: Only operate the PLL after the main clock oscillation has stabilized.

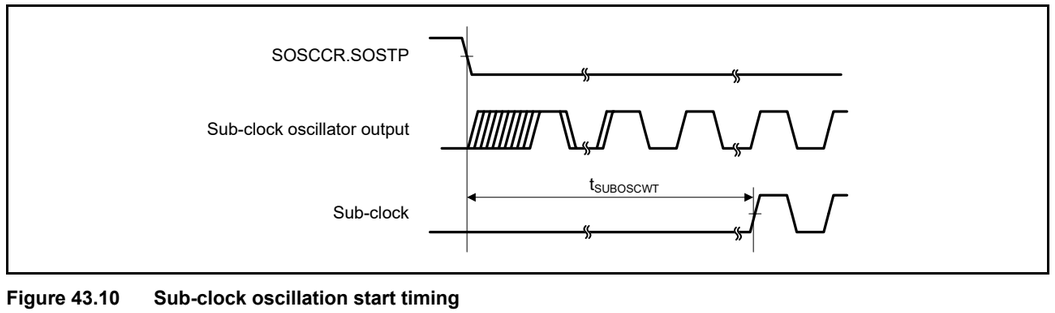


Figure 43.10 Sub-clock oscillation start timing

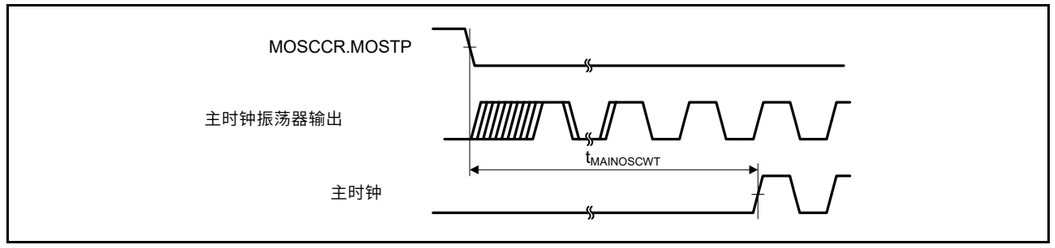


Figure 43.7 主时钟振荡开始时序

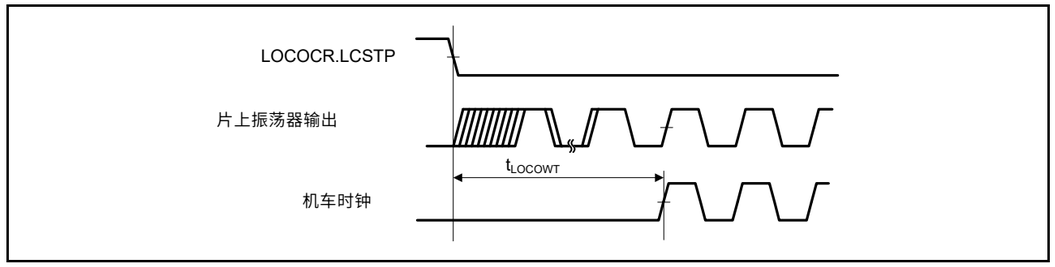


Figure 43.8 LOCO时钟振荡开始时序

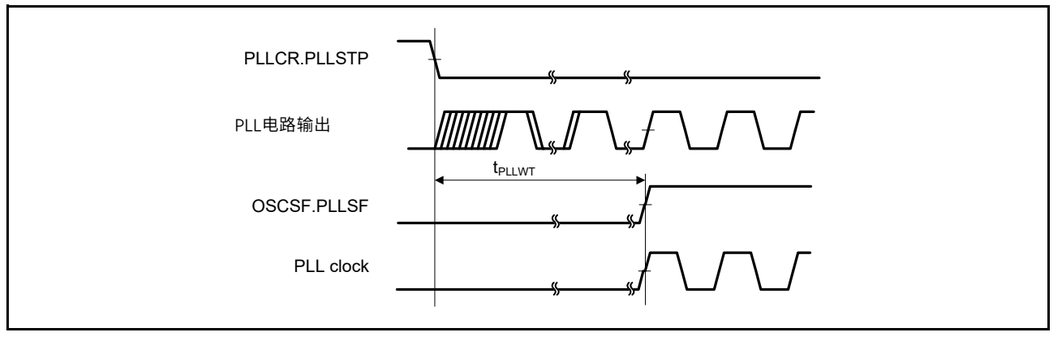


Figure 43.9 PLL时钟振荡开始时序

Note: 仅在主时钟振荡稳定后操作PLL。

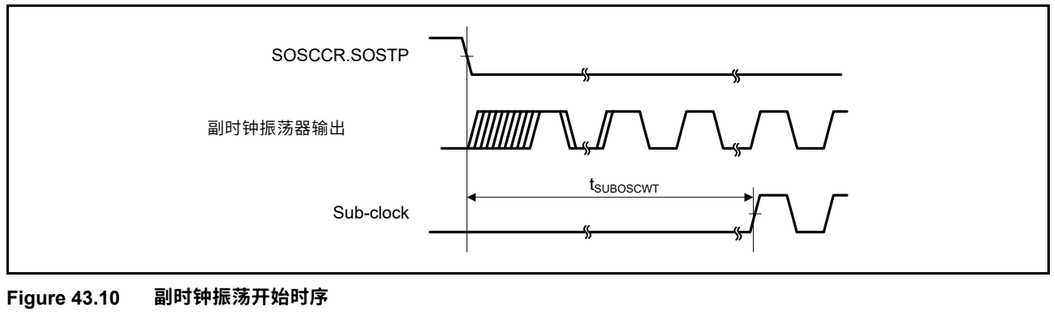


Figure 43.10 副时钟振荡开始时序

43.3.3 Reset Timing

Table 43.15 Reset timing

Parameter		Symbol	Min	Typ	Max	Unit	Test conditions
RES pulse width	Power-on	t_{RESWP}	1	-	-	ms	Figure 43.11
	Deep Software Standby mode	t_{RESWD}	0.6	-	-	ms	Figure 43.12
	Software Standby mode, Subosc-speed mode	t_{RESWS}	0.3	-	-	ms	
	All other	t_{RESW}	200	-	-	µs	
Wait time after RES cancellation		t_{RESWT}	-	29	32	µs	Figure 43.11
Wait time after internal reset cancellation (IWDT reset, WDT reset, software reset, SRAM parity error reset, bus master MPU error reset, bus slave MPU error reset, stack pointer error reset)		t_{RESW2}	-	320	390	µs	-

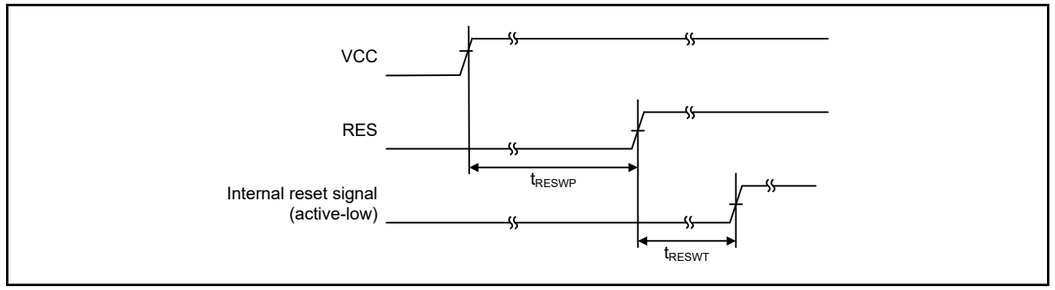


Figure 43.11 Power-on reset timing

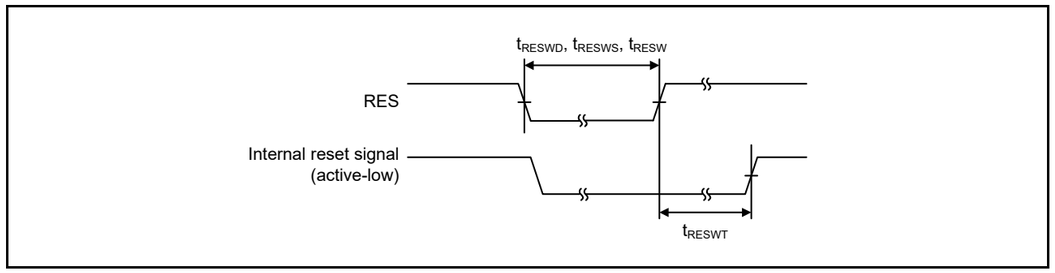


Figure 43.12 Reset input timing

43.3.3 重置时间

Table 43.15 重置时间

Parameter		Symbol	Min	Typ	Max	Unit	测试条件
RES脉冲宽度	Power-on	t_{RESWP}	1	-	-	ms	Figure 43.11
	深度软件待机模式	t_{RESWD}	0.6	-	-	ms	Figure 43.12
	软件待机模式，Subosc速度模式	t_{RESWS}	0.3	-	-	ms	
	所有其他	t_{RESW}	200	-	-	µs	
RES取消后的等待时间		t_{RESWT}	-	29	32	µs	Figure 43.11
内部复位取消后的等待时间（IWDT复位、WDT复位、软件复位、SRAM奇偶校验错误复位、总线主MPU错误复位、总线从MPU错误复位、堆栈指针错误复位）		t_{RESW2}	-	320	390	µs	-

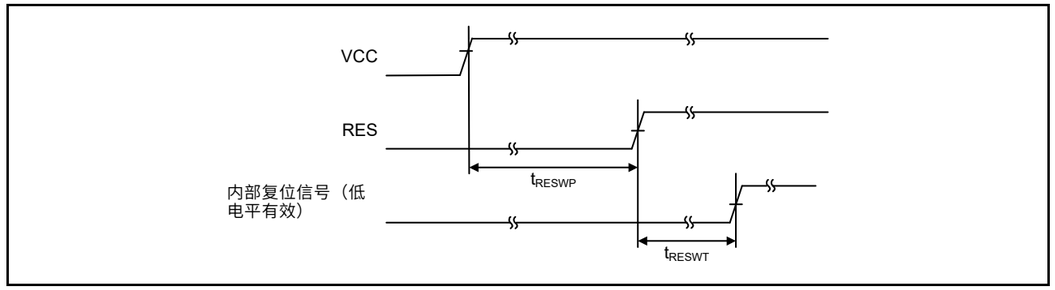


Figure 43.11 上电复位时序

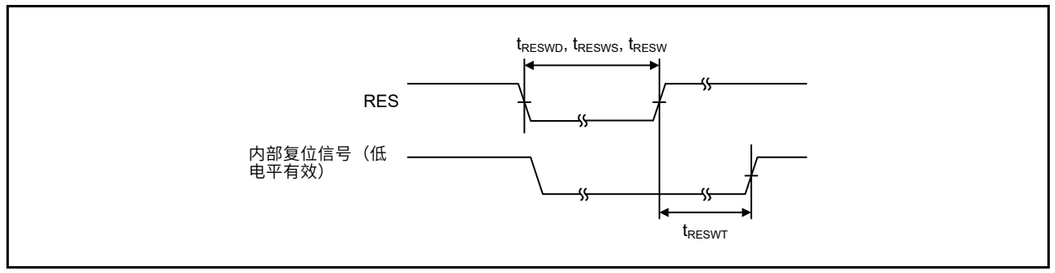


Figure 43.12 复位输入时序

43.3.4 Wakeup Timing

Table 43.16 Timing of recovery from low power modes

Parameter			Symbol	Min	Typ	Max	Unit	Test conditions
Recovery time from Software Standby mode*1	Crystal resonator connected to main clock oscillator	System clock source is main clock oscillator*2	t_{SBYMC}	-	2.4*9	2.8*9	ms	Figure 43.13 The division ratio of all oscillators is 1.
		System clock source is PLL with main clock oscillator*3	t_{SBYPC}	-	2.7*9	3.2*9	ms	
	External clock input to main clock oscillator	System clock source is main clock oscillator*4	t_{SBYEX}	-	230*9	280*9	µs	
		System clock source is PLL with main clock oscillator*5	t_{SBYPE}	-	570*9	700*9	µs	
	System clock source is sub-clock oscillator*8		t_{SBYSC}	-	1.2*9	1.3*9	ms	
	System clock source is LOCO*8		t_{SBYLO}	-	1.2*9	1.4*9	ms	
	System clock source is HOCO*6		t_{SBYHO}	-	240*9, *10	300 *9, *10	µs	
	System clock source is MOCO*7		t_{SBYMO}	-	220*9	300*9	µs	
Recovery time from Deep Software Standby mode			t_{DSBY}	-	0.65	1.0	ms	Figure 43.14
Wait time after cancellation of Deep Software Standby mode			t_{DSBYWT}	34	-	35	t_{cyc}	
Recovery time from Software Standby mode to Snooze mode	High-speed mode when system clock source is HOCO (20 MHz)		t_{SNZ}	-	35*9, *10	70 *9, *10	µs	Figure 43.15
	High-speed mode when system clock source is MOCO (8 MHz)		t_{SNZ}	-	11*9	14*9	µs	

Note 1. The recovery time is determined by the system clock source. When multiple oscillators are active, the recovery time can be determined with the following equation:
Total recovery time = recovery time for an oscillator as the system clock source + the longest oscillation stabilization time of any oscillators requiring longer stabilization times than the system clock source + 2 LOCO cycles (when LOCO is operating) + 3 SOSC cycles (when Subosc is oscillating and MSTPC0 = 0 (CAC module stop)).

Note 2. When the frequency of the crystal is 24 MHz (Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 05h). For other settings (MOSCWTCR is set to Xh), the recovery time can be determined with the following equation:
t_{SBYMC} (MOSCWTCR = Xh) = t_{SBYMC} (MOSCWTCR = 05h) + ($t_{MAINOSCWT}$ (MOSCWTCR = Xh) - $t_{MAINOSCWT}$ (MOSCWTCR = 05h))

Note 3. When the frequency of PLL is 240 MHz (Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 05h). For other settings (MOSCWTCR is set to Xh), the recovery time can be determined with the following equation:
t_{SBYMC} (MOSCWTCR = Xh) = t_{SBYMC} (MOSCWTCR = 05h) + ($t_{MAINOSCWT}$ (MOSCWTCR = Xh) - $t_{MAINOSCWT}$ (MOSCWTCR = 05h))

Note 4. When the frequency of the external clock is 24 MHz (Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 00h). For other settings (MOSCWTCR is set to Xh), the recovery time can be determined with the following equation:
t_{SBYMC} (MOSCWTCR = Xh) = t_{SBYMC} (MOSCWTCR = 00h) + ($t_{MAINOSCWT}$ (MOSCWTCR = Xh) - $t_{MAINOSCWT}$ (MOSCWTCR = 00h))

Note 5. When the frequency of PLL is 240 MHz (Main Clock Oscillator Wait Control Register (MOSCWTCR) is set to 00h). For other settings (MOSCWTCR is set to Xh), the recovery time can be determined with the following equation:
t_{SBYMC} (MOSCWTCR = Xh) = t_{SBYMC} (MOSCWTCR = 00h) + ($t_{MAINOSCWT}$ (MOSCWTCR = Xh) - $t_{MAINOSCWT}$ (MOSCWTCR = 00h))

Note 6. The HOCO frequency is 20 MHz.

Note 7. The MOCO frequency is 8 MHz.

Note 8. In Subosc-speed mode, the sub-clock oscillator or LOCO continues oscillating in Software Standby mode.

Note 9. When the SNZCR.RXDREQEN bit is set to 0, the following time is added as the power supply recovery time:
STCONR.STCON[1:0] = 00b:16 µs (typical), 34 µs (maximum)
STCONR.STCON[1:0] = 11b:16 µs (typical), 104 µs (maximum).

Note 10. When the SNZCR.RXDREQEN bit is set to 0, 16 µs (typical) or 18 µs (maximum) is added as the HOCO wait time.

43.3.4 唤醒时间

Table 43.16 从低功耗模式恢复的时间

Parameter			Symbol	Min	Typ	Max	Unit	测试条件
从软件待机模式恢复时间*1	连接到主时钟振荡器的晶体谐振器	系统时钟源为主时钟振荡器*2	t_{SBYMC}	-	2.4*9	2.8*9	ms	图43.13所有振荡器的分频比为1。
		系统时钟源是带有主时钟振荡器的PLL*3	t_{SBYPC}	-	2.7*9	3.2*9	ms	
	主时钟振荡器的外部时钟输入	系统时钟源为主时钟振荡器*4	t_{SBYEX}	-	230*9	280*9	µs	
		系统时钟源是带有主时钟振荡器*5的PLL	t_{SBYPE}	-	570*9	700*9	µs	
	系统时钟源为副时钟振荡器*8		t_{SBYSC}	-	1.2*9	1.3*9	ms	
	系统时钟源为LOCO*8		t_{SBYLO}	-	1.2*9	1.4*9	ms	
	系统时钟源为HOCO*6		t_{SBYHO}	-	240*9, *10	300 *9, *10	µs	
	系统时钟源为MOCO*7		t_{SBYMO}	-	220*9	300*9	µs	
从深度软件待机模式恢复时间			t_{DSBY}	-	0.65	1.0	ms	Figure 43.14
取消深度软件待机模式后的等待时间			t_{DSBYWT}	34	-	35	t_{cyc}	
从软件待机模式恢复到	系统时钟源为HOCO(20MHz)时的高速模式		t_{SNZ}	-	35*9, *10	70 *9, *10	µs	Figure 43.15
贪睡模式	系统时钟源为MOCO(8MHz)时的高速模式		t_{SNZ}	-	11*9	14*9	µs	

Note 1. 恢复时间由系统时钟源决定。当多个振荡器处于活动状态时，恢复时间可以通过以下公式确定：总恢复时间=振荡器作为系统时钟源的恢复时间+任何需要比系统时钟源更长稳定时间的振荡器的最长振荡稳定时间+2个LOCO周期（当LOCO运行时）+3个SOSC周期（当Subosc正在振荡且MSTPC0=0（CAC模块停止）时）。

Note 2. 当晶振频率为24MHz时（主时钟振荡器等待控制寄存器（MOSCWTCR）设置为05h）。对于其他设置（MOSCWTCR设置为Xh），可以使用以下公式确定恢复时间：tSBYMC(MOSCWTCR=Xh)=tSBYMC(MOSCWTCR=05h)+(tMAINOSCWT(MOSCWTCR=Xh)tMAINOSCWT(MOSCWTCR=05h))

Note 3. 当PLL的频率为240MHz时（主时钟振荡器等待控制寄存器（MOSCWTCR）设置为05h）。对于其他设置（MOSCWTCR设置为Xh），可以使用以下公式确定恢复时间：tSBYMC(MOSCWTCR=Xh)=tSBYMC(MOSCWTCR=05h)+(tMAINOSCWT(MOSCWTCR=Xh)tMAINOSCWT(MOSCWTCR=05h))

Note 4. 当外部时钟频率为24MHz时（主时钟振荡器等待控制寄存器（MOSCWTCR）设置为00h）。对于其他设置（MOSCWTCR设置为Xh），可以使用以下公式确定恢复时间：tSBYMC(MOSCWTCR=Xh)=tSBYMC(MOSCWTCR=00h)+(tMAINOSCWT(MOSCWTCR=Xh)tMAINOSCWT(MOSCWTCR=00h))

Note 5. 当PLL的频率为240MHz时（主时钟振荡器等待控制寄存器（MOSCWTCR）设置为00h）。对于其他设置（MOSCWTCR设置为Xh），可以使用以下公式确定恢复时间：tSBYMC(MOSCWTCR=Xh)=tSBYMC(MOSCWTCR=00h)+(tMAINOSCWT(MOSCWTCR=Xh)tMAINOSCWT(MOSCWTCR=00h))

Note 6. HOCO频率为20MHz。

Note 7. MOCO频率为8MHz。

Note 8. 在Subosc速度模式下，副时钟振荡器或LOCO在软件待机模式下继续振荡。

Note 9. 当SNZCR.RXDREQEN位设置为0时，添加以下时间作为电源恢复时间：
STCONR.STCON[1:0] = 00b:16 µs (typical), 34 µs (maximum)
STCONR.STCON[1:0] = 11b:16 µs (typical), 104 µs (maximum).

注10.当SNZCR.RXDREQEN位设置为0时，添加16µs（典型值）或18µs（最大值）作为HOCO等待时间。

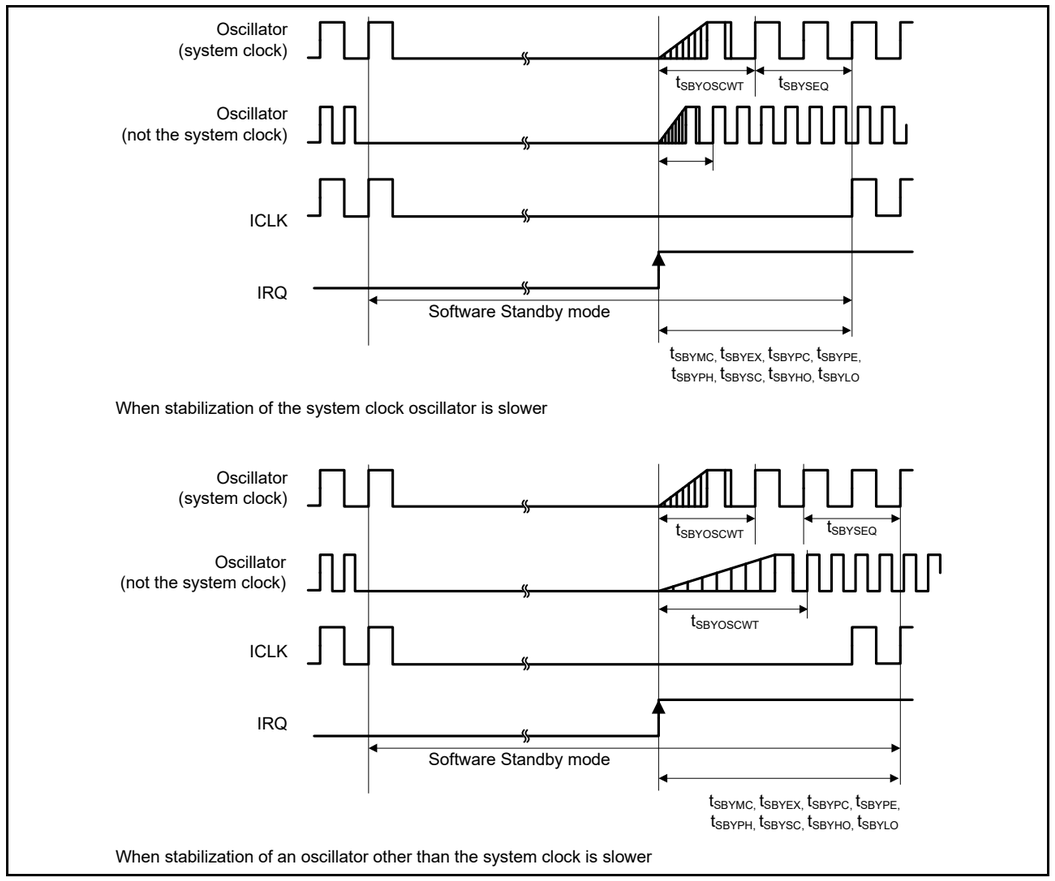


Figure 43.13 Software Standby mode cancellation timing

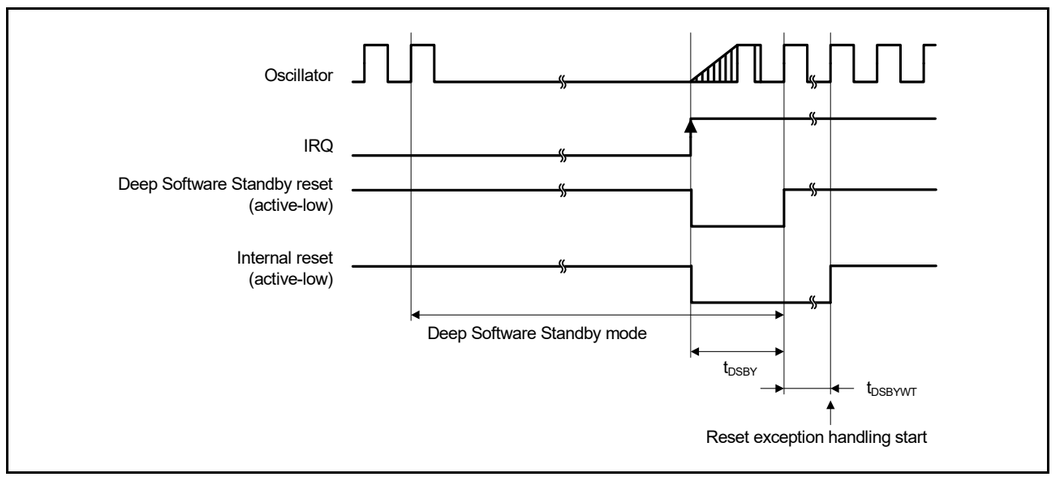


Figure 43.14 Deep Software Standby mode cancellation timing

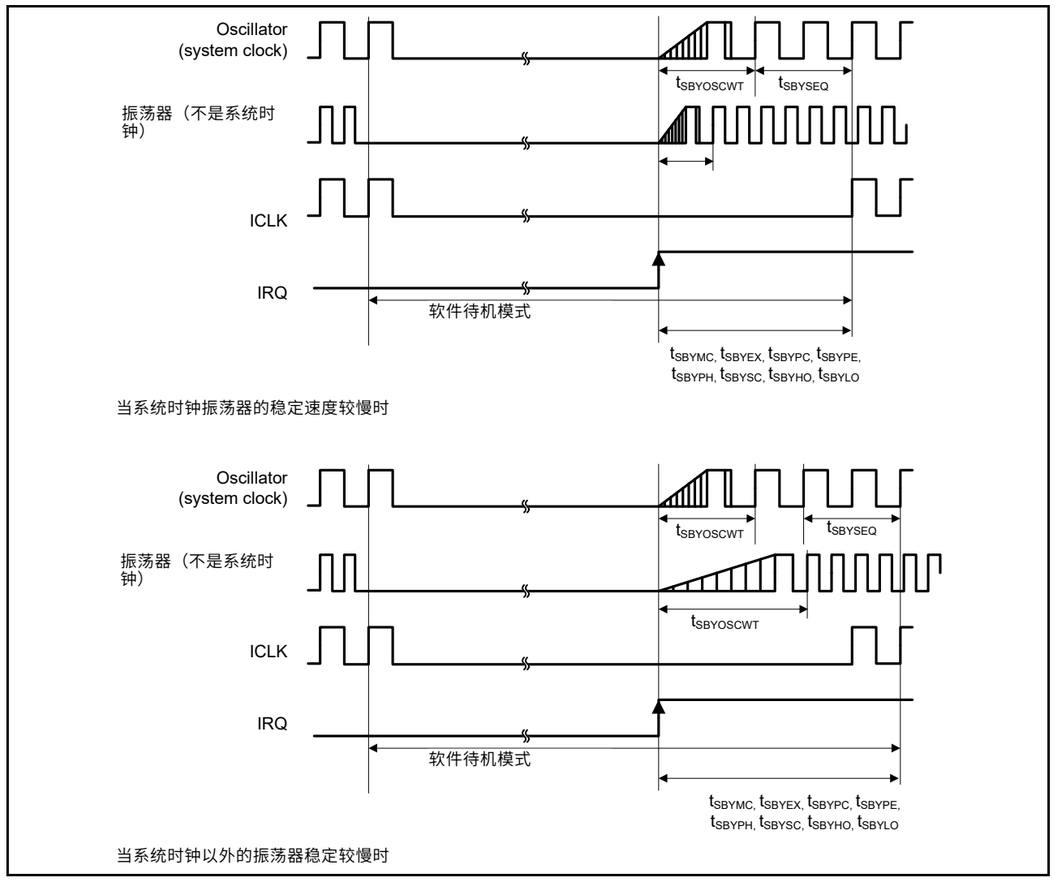


Figure 43.13 软件待机模式取消时序

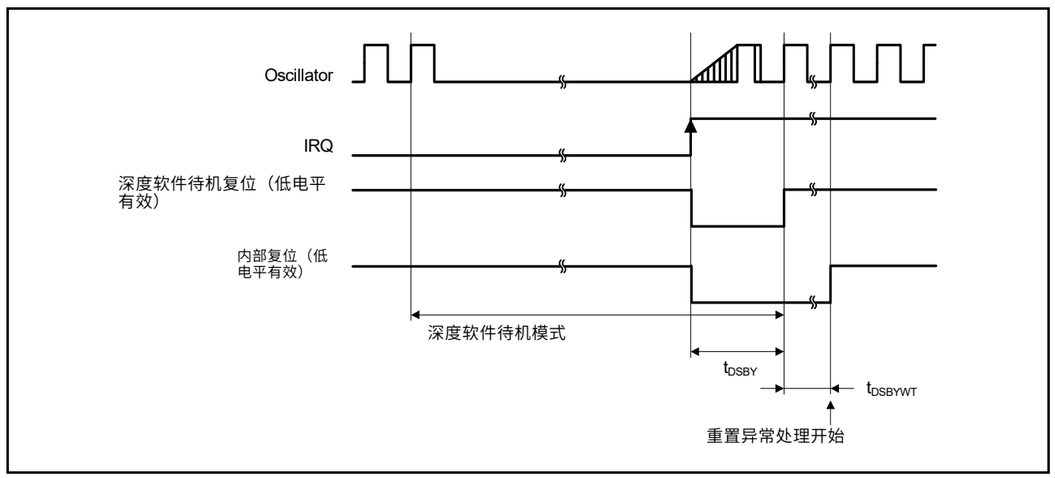
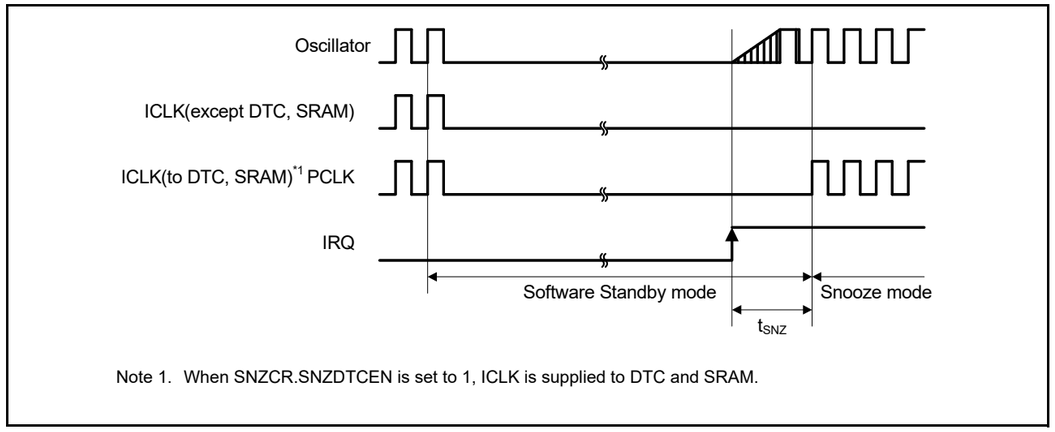


Figure 43.14 深度软件待机模式取消时序



Note 1. When SNZCR.SNZDTCEN is set to 1, ICLK is supplied to DTC and SRAM.

Figure 43.15 Recovery timing from Software Standby mode to Snooze mode

43.3.5 NMI and IRQ Noise Filter

Table 43.17 NMI and IRQ noise filter

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions	
NMI pulse width	t_{NMIW}	200	-	-	ns	NMI digital filter disabled	$t_{Pcyc} \times 2 \leq 200$ ns
		$t_{Pcyc} \times 2$*1	-	-			$t_{Pcyc} \times 2 > 200$ ns
		200	-	-		NMI digital filter enabled	$t_{NMICK} \times 3 \leq 200$ ns
		$t_{NMICK} \times 3.5$*2	-	-			$t_{NMICK} \times 3 > 200$ ns
IRQ pulse width	t_{IRQW}	200	-	-	ns	IRQ digital filter disabled	$t_{Pcyc} \times 2 \leq 200$ ns
		$t_{Pcyc} \times 2$*1	-	-			$t_{Pcyc} \times 2 > 200$ ns
		200	-	-		IRQ digital filter enabled	$t_{IRQCK} \times 3 \leq 200$ ns
		$t_{IRQCK} \times 3.5$*3	-	-			$t_{IRQCK} \times 3 > 200$ ns

Note: 200 ns minimum in Software Standby mode.
Note: If the clock source is switched, add 4 clock cycles of the switched source.
Note 1. t_{Pcyc} indicates the PCLKB cycle.
Note 2. t_{NMICK} indicates the cycle of the NMI digital filter sampling clock.
Note 3. t_{IRQCK} indicates the cycle of the IRQi digital filter sampling clock.

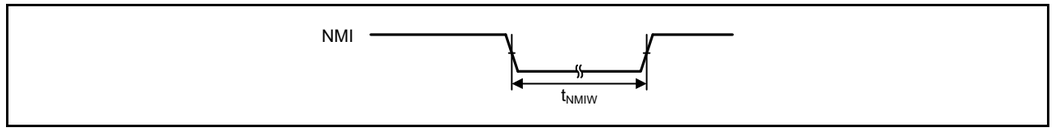


Figure 43.16 NMI interrupt input timing

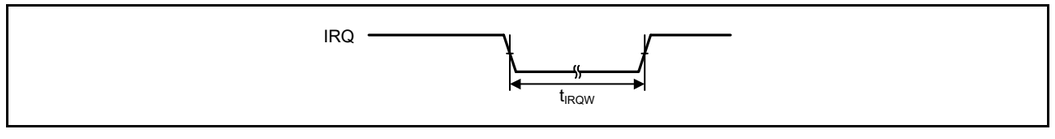
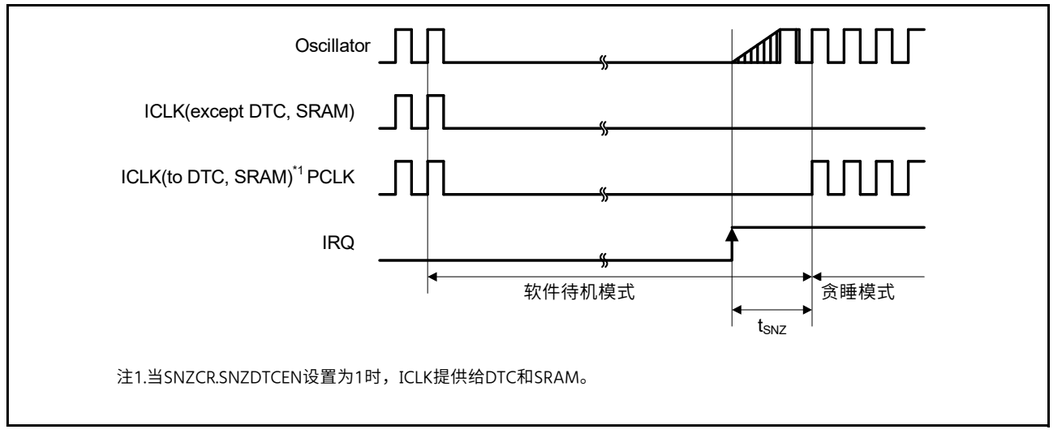


Figure 43.17 IRQ interrupt input timing



注1.当SNZCR.SNZDTCEN设置为1时，ICLK提供给DTC和SRAM。

Figure 43.15 从软件待机模式到贪睡模式的恢复时间

43.3.5 NMI和IRQ噪声滤波器

Table 43.17 NMI和IRQ噪声滤波器

Parameter	Symbol	Min	Typ	Max	Unit	测试条件	
NMI脉冲宽度	t_{NMIW}	200	-	-	ns	NMI数字滤波器禁用	$t_{Pcyc} \times 2 \leq 200$ ns
		$t_{Pcyc} \times 2$*1	-	-			$t_{Pcyc} \times 2 > 200$ ns
		200	-	-		启用NMI数字滤波器	$t_{NMICK} \times 3 \leq 200$ ns
		$t_{NMICK} \times 3.5$*2	-	-			$t_{NMICK} \times 3 > 200$ ns
IRQ脉冲宽度	t_{IRQW}	200	-	-	ns	IRQ数字滤波器禁用	$t_{Pcyc} \times 2 \leq 200$ ns
		$t_{Pcyc} \times 2$*1	-	-			$t_{Pcyc} \times 2 > 200$ ns
		200	-	-		启用IRQ数字滤波器	$t_{IRQCK} \times 3 \leq 200$ ns
		$t_{IRQCK} \times 3.5$*3	-	-			$t_{IRQCK} \times 3 > 200$ ns

Note: 软件待机模式下最少200ns。
Note: 如果时钟源切换，则增加切换源的4个时钟周期。
Note 1. tPcyc表示PCLKB周期。
Note 2. tNMICK表示NMI数字滤波器采样时钟的周期。
Note 3. tIRQCK表示IRQi数字滤波器采样时钟的周期。

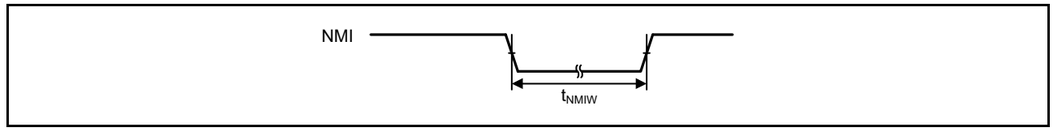


Figure 43.16 NMI中断输入时序

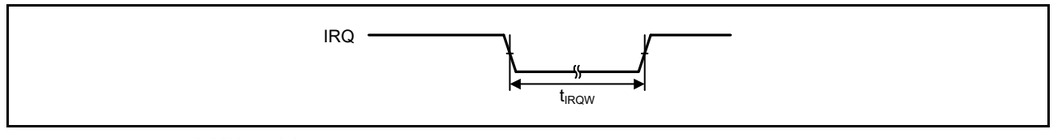


Figure 43.17 IRQ中断输入时序

43.3.6 I/O Ports, POEG, GPT32, AGT, KINT, and ADC12 Trigger Timing

Table 43.18 I/O ports, POEG, GPT32, AGT, KINT, and ADC12 trigger timing
GPT32 conditions: High drive output is selected in the Port Drive Capability bit in the PmnPFS register.
AGT conditions: Middle drive output is selected in the Port Drive Capability bit in the PmnPFS register.

Parameter			Symbol	Min	Max	Unit	Test conditions
I/O ports	Input data pulse width		t_{PRW}	1.5	-	t_{Pcyc}	Figure 43.18
POEG	POEG input trigger pulse width		t_{POEW}	3	-	t_{Pcyc}	Figure 43.19
GPT32	Input capture pulse width	Single edge	t_{GTICW}	1.5	-	t_{PDcyc}	Figure 43.20
		Dual edge		2.5	-		
	GTIOCxY output skew (x = 0 to 7, Y= A or B)	Middle drive buffer	t_{GTISK}*1	-	4	ns	Figure 43.21
		High drive buffer		-	4		
	GTIOCxY output skew (x = 8 to 12, Y = A or B)	Middle drive buffer		-	4		
		High drive buffer		-	4		
	GTIOCxY output skew (x = 0 to 12, Y = A or B)	Middle drive buffer		-	6		
		High drive buffer		-	6		
	OPS output skew GTOUUP, GTOULO, GTOVUP, GTOVLO, GTOWUP, GTOWLO		t_{GTOSK}	-	5	ns	Figure 43.22
GPT (PWM Delay Generation Circuit)	GTIOCxY_Z output skew (x = 0 to 3, Y = A or B, Z = A)		t_{HRSK}*2	-	2.0	ns	Figure 43.23
AGT	AGTIO, AGTEE input cycle		t_{ACYC}*3	100	-	ns	Figure 43.24
	AGTIO, AGTEE input high width, low width		t_{ACKWH}, t_{ACKWL}	40	-	ns	
	AGTIO, AGTO, AGTOA, AGTOB output cycle		t_{ACYC2}	62.5	-	ns	
ADC12	ADC12 trigger input pulse width		t_{TRGW}	1.5	-	t_{Pcyc}	Figure 43.25
KINT	KRn(n = 00 to 07) pulse width		t_{KR}	250	-	ns	Figure 43.26

Note: t_{Pcyc}: PCLKB cycle, t_{PDcyc}: PCLKD cycle.
Note 1. This skew applies when the same driver I/O is used. If the I/O of the middle and high drivers is mixed, operation is not guaranteed.
Note 2. The load is 30 pF.
Note 3. Constraints on input cycle:
When not switching the source clock: $t_{Pcyc} \times 2 < t_{ACYC}$ should be satisfied.
When switching the source clock: $t_{Pcyc} \times 6 < t_{ACYC}$ should be satisfied.

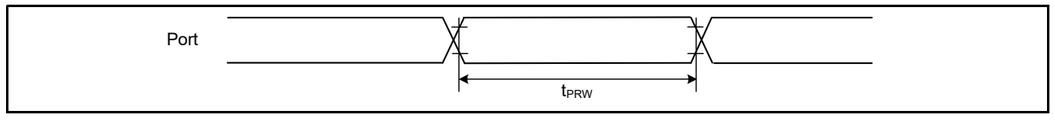


Figure 43.18 I/O ports input timing

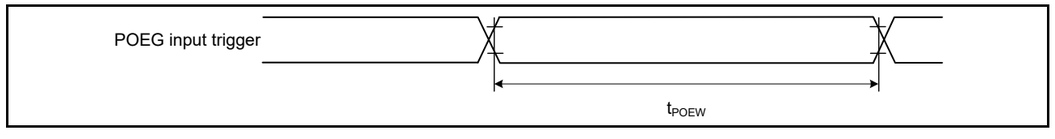


Figure 43.19 POEG input trigger timing

43.3.6 IO端口、POEG、GPT32、AGT、KINT和ADC12触发时序

Table 43.18 IO端口、POEG、GPT32、AGT、KINT和ADC12触发时序
GPT32条件：在PmnPFS寄存器的端口驱动能力位中选择高驱动输出。AGT条件：在PmnPFS寄存器的端口驱动能力位中选择中间驱动输出。

Parameter			Symbol	Min	Max	Unit	测试条件
I/O ports	输入数据脉冲宽度		t_{PRW}	1.5	-	t_{Pcyc}	Figure 43.18
POEG	POEG输入触发脉冲宽度		t_{POEW}	3	-	t_{Pcyc}	Figure 43.19
GPT32	输入捕捉脉冲宽度	单边	t_{GTICW}	1.5	-	t_{PDcyc}	Figure 43.20
		双刃		2.5	-		
	GTIOCxY输出偏移（x=0到7，Y=A或B）	中间驱动缓冲器	t_{GTISK}*1	-	4	ns	Figure 43.21
		高驱动缓冲器		-	4		
	GTIOCxY输出偏差（x=8到12，Y=A或B）	中间驱动缓冲器		-	4		
		高驱动缓冲器		-	4		
	GTIOCxY输出偏移（x=0到12，Y=A或B）	中间驱动缓冲器		-	6		
		高驱动缓冲器		-	6		
	OPS输出偏差 GTOUUP, GTOULO, GTOVUP, GTOVLO, GTOWUP, GTOWLO		t_{GTOSK}	-	5	ns	Figure 43.22
GPT（PWM延迟生成 Circuit)	GTIOCxY_Z输出偏移（x=0到3，Y=A或B，Z=A）		t_{HRSK}*2	-	2.0	ns	Figure 43.23
AGT	AGTIO、AGTEE输入周期		t_{ACYC}*3	100	-	ns	Figure 43.24
	AGTIO、AGTEE输入高宽、低宽		t_{ACKWH}, t_{ACKWL}	40	-	ns	
	AGTIO、AGTO、AGTOA、AGTOB输出周期		t_{ACYC2}	62.5	-	ns	
ADC12	ADC12触发输入脉冲宽度		t_{TRGW}	1.5	-	t_{Pcyc}	Figure 43.25
KINT	KRn(n=00到07)脉冲宽度		t_{KR}	250	-	ns	Figure 43.26

Note: t_{Pcyc}: PCLKB cycle, t_{PDcyc}: PCLKD cycle.
Note 1. 当使用相同的驱动程序IO时，此偏差适用。如果中高驱动器的IO混合使用，则无法保证运行。
Note 2. 负载为30pF。
Note 3. 输入周期的约束：
不切换源时钟时：tPcyc×2<tACYC应满足。
切换源时钟时：tPcyc×6<tACYC应满足。

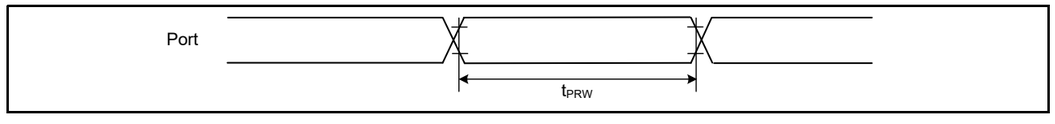


Figure 43.18 IO端口输入时序

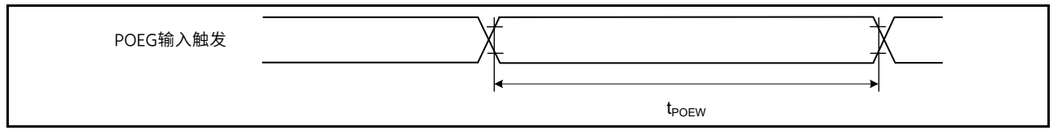


Figure 43.19 POEG输入触发时序

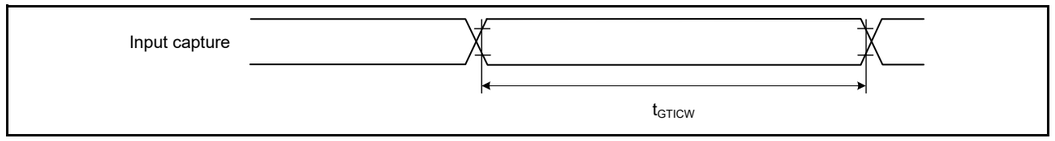


Figure 43.20 GPT32 input capture timing

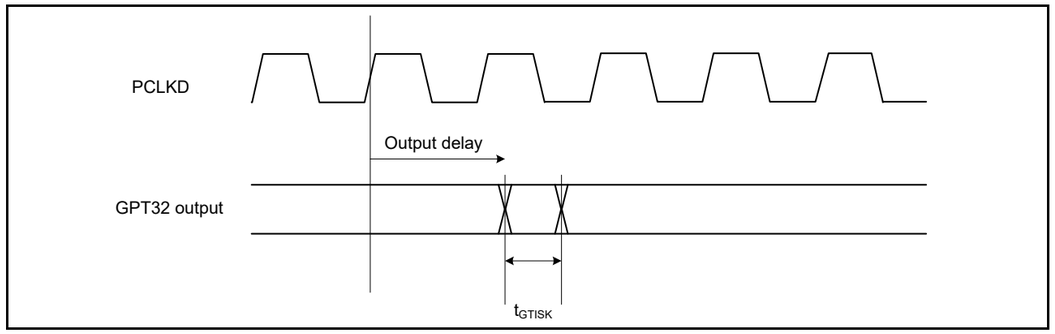


Figure 43.21 GPT32 output delay skew

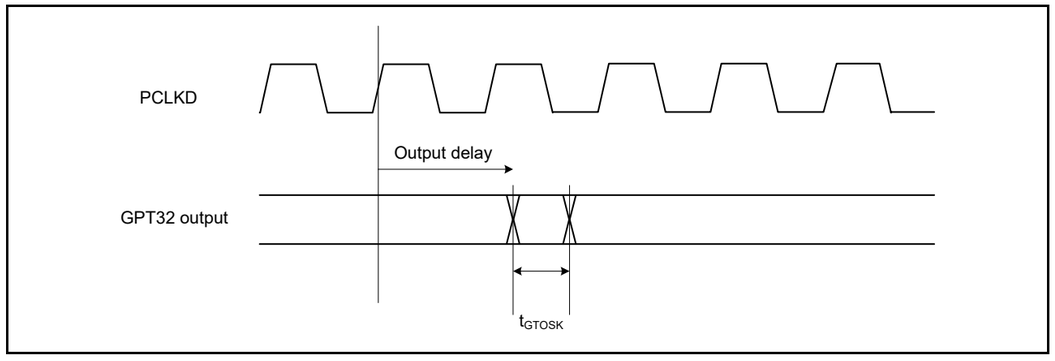


Figure 43.22 GPT32 output delay skew for OPS

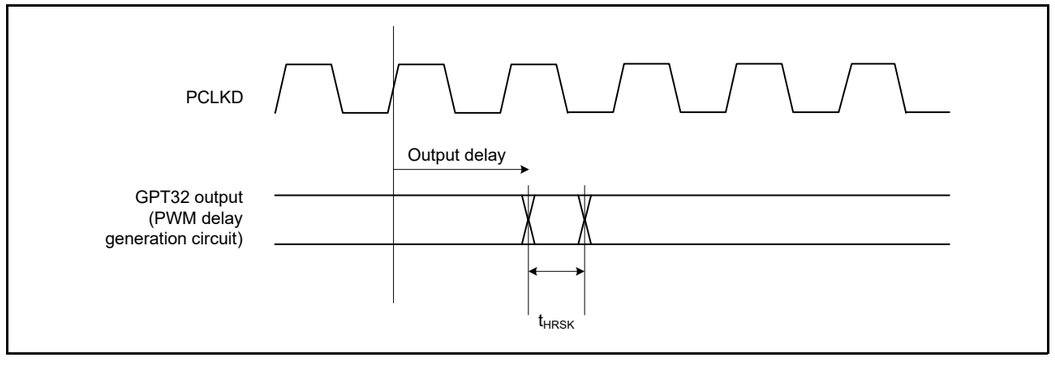


Figure 43.23 GPT32 (PWM delay generation circuit) output delay skew

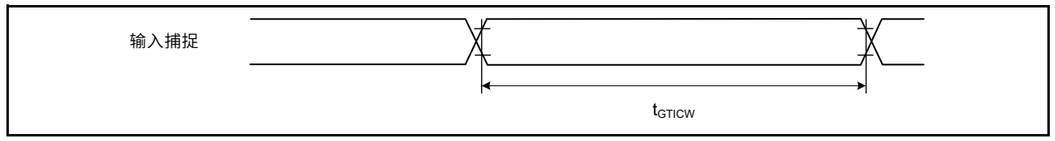


Figure 43.20 GPT32输入捕捉时序

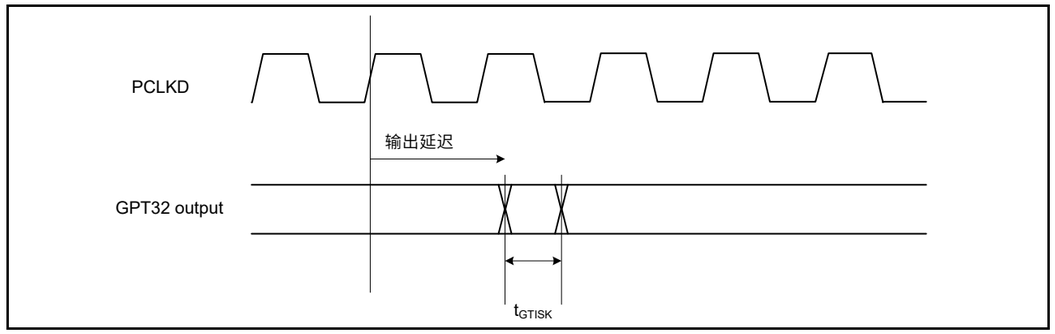


Figure 43.21 GPT32输出延迟偏移

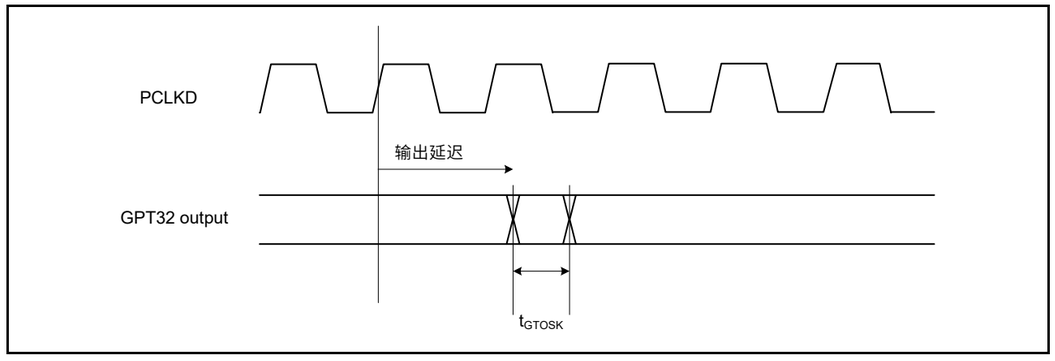


Figure 43.22 用于OPS的GPT32输出延迟偏移

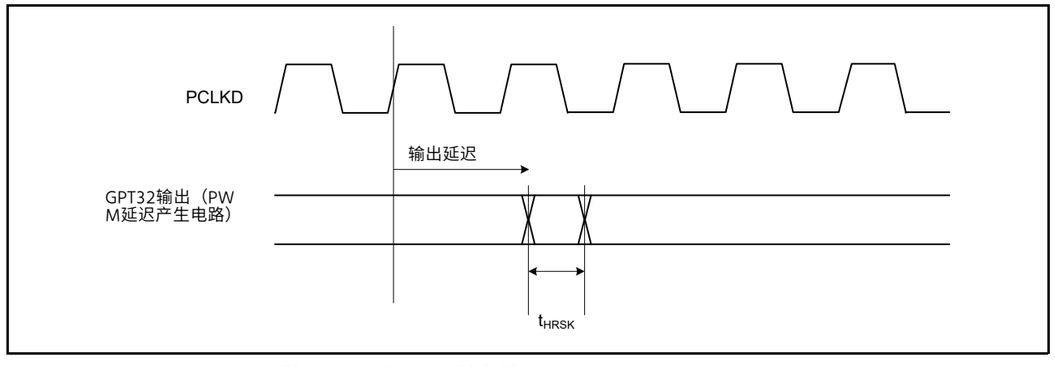


Figure 43.23 GPT32（PWM延迟产生电路）输出延迟歪斜

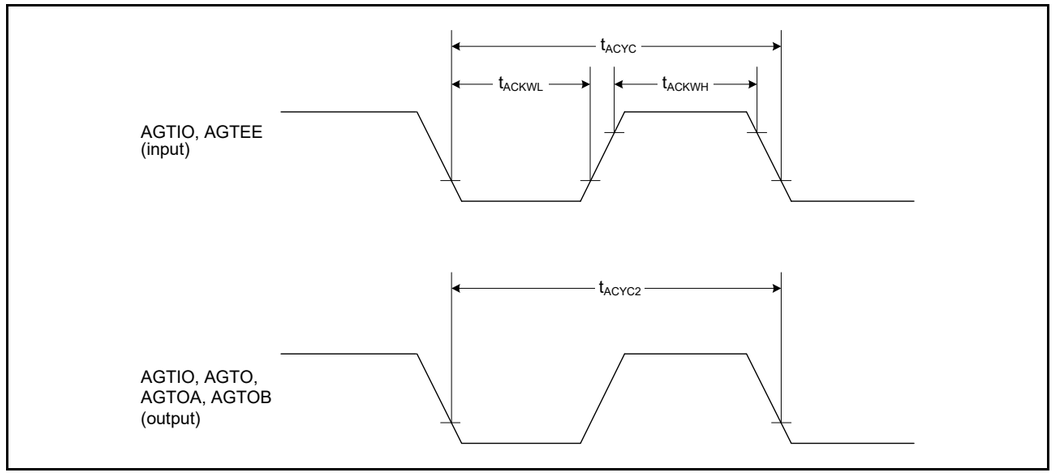


Figure 43.24 AGT input/output timing

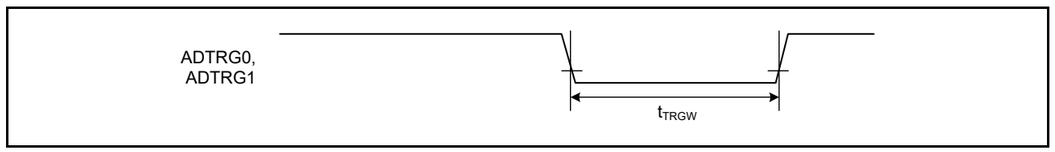


Figure 43.25 ADC12 trigger input timing

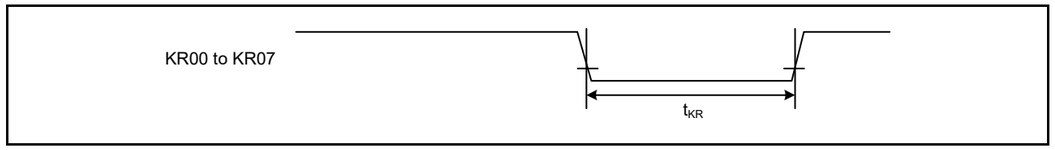


Figure 43.26 Key interrupt input timing

43.3.7 PWM Delay Generation Circuit Timing

Table 43.19 PWM Delay Generation Circuit timing

Parameter	Min	Typ	Max	Unit	Test conditions
Operation frequency	80	-	120	MHz	-
Resolution	-	260	-	ps	PCLKD = 120 MHz
DNL*1	-	±2.0	-	LSB	-

Note 1. This value normalizes the differences between lines in 1-LSB resolution.

43.3.8 CAC Timing

Table 43.20 CAC timing

Parameter			Symbol	Min	Typ	Max	Unit	Test conditions
CAC	CACREF input pulse width	$t_{PBcyc} \le t_{cac}$*2	t_{CACREF}	$4.5 \times t_{cac} + 3 \times t_{PBcyc}$	-	-	ns	-
		$t_{PBcyc} > t_{cac}$*2		$5 \times t_{cac} + 6.5 \times t_{PBcyc}$	-	-	ns	

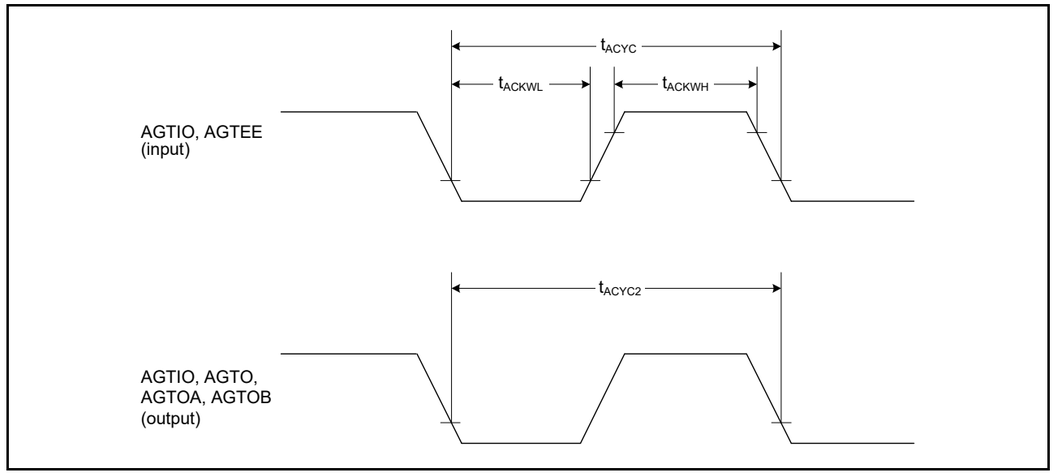


Figure 43.24 AGT input/output timing

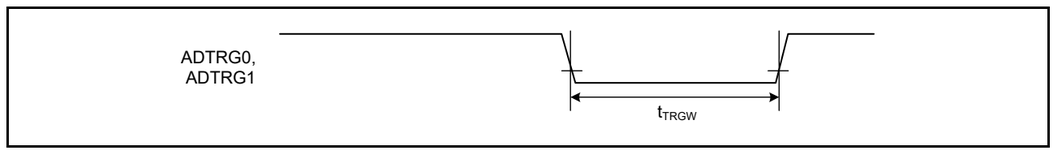


Figure 43.25 ADC12触发输入时序

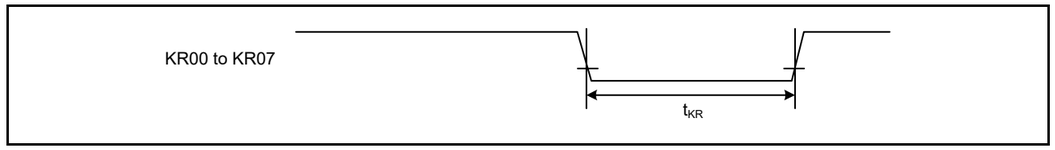


Figure 43.26 按键中断输入时序

43.3.7 PWM延迟产生电路时序

Table 43.19 PWM延迟产生电路时序

Parameter	Min	Typ	Max	Unit	测试条件
运行频率	80	-	120	MHz	-
Resolution	-	260	-	ps	PCLKD = 120 MHz
DNL*1	-	±2.0	-	LSB	-

Note 1. 此值标准化1-LSB分辨率中的行之间的差异。

43.3.8 CAC时序

Table 43.20 CAC计时

Parameter			Symbol	Min	Typ	Max	Unit	测试条件
CAC	CACREF输入脉冲宽度	$t_{PBcyc} \le t_{cac}$*2	t_{CACREF}	$4.5 \times t_{cac} + 3 \times t_{PBcyc}$	-	-	ns	-
		$t_{PBcyc} > t_{cac}$*2		$5 \times t_{cac} + 6.5 \times t_{PBcyc}$	-	-	ns	

Note 1. t_{PBcyc}: PCLKB cycle.
Note 2. t_{cac}: CAC count clock source cycle.

43.3.9 SCI Timing

Table 43.21 SCI timing (1)
Conditions: High drive output is selected in the Port Drive Capability bit in the PmnPFS register for the following pins: SCK0 to SCK4, SCK8, SCK9.
For other pins, middle drive output is selected in the Port Drive Capability bit in the PmnPFS register.

Parameter			Symbol	Min	Max	Unit*1	Test conditions
SCI	Input clock cycle	Asynchronous	t_{Scyc}	4	-	t_{Pcyc}	Figure 43.27
		Clock synchronous		6	-		
	Input clock pulse width		t_{SCKW}	0.4	0.6	t_{Scyc}	
	Input clock rise time		t_{SCKr}	-	5	ns	
	Input clock fall time		t_{SCKf}	-	5	ns	
	Output clock cycle	Asynchronous	t_{Scyc}	6	-	t_{Pcyc}	
		Clock synchronous		4	-		
	Output clock pulse width		t_{SCKW}	0.4	0.6	t_{Scyc}	
	Output clock rise time		t_{SCKr}	-	5	ns	
	Output clock fall time		t_{SCKf}	-	5	ns	
	Transmit data delay	Clock synchronous	t_{TXD}	-	25	ns	Figure 43.28
	Receive data setup time	Clock synchronous	t_{RXS}	15	-	ns	
	Receive data hold time	Clock synchronous	t_{RXH}	5	-	ns	

Note 1. t_{Pcyc}: PCLKA cycle.

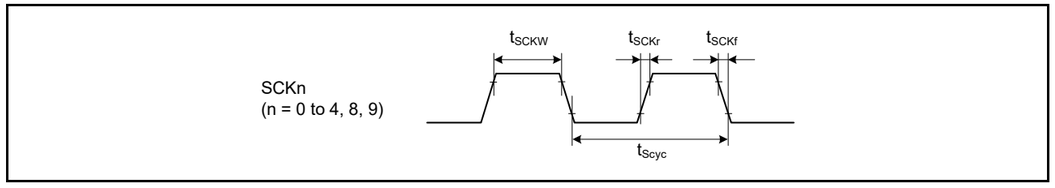


Figure 43.27 SCK clock input/output timing

Note 1. t_{PBcyc}: PCLKB cycle.
Note 2. tcac:CAC计数时钟源周期。

43.3.9 SCI时序

Table 43.21 SCI时序（1）
条件：在PmnPFS寄存器的端口驱动能力位中为以下引脚选择高驱动输出：SCK0至SCK4，SCK8, SCK9.
对于其他引脚，在PmnPFS寄存器的端口驱动能力位中选择中间驱动输出。

Parameter			Symbol	Min	Max	Unit*1	测试条件
SCI	输入时钟周期	Asynchronous	t_{Scyc}	4	-	t_{Pcyc}	Figure 43.27
		时钟同步		6	-		
	输入时钟脉冲宽度		t_{SCKW}	0.4	0.6	t_{Scyc}	
	输入时钟上升时间		t_{SCKr}	-	5	ns	
	输入时钟下降时间		t_{SCKf}	-	5	ns	
	输出时钟周期	Asynchronous	t_{Scyc}	6	-	t_{Pcyc}	
		时钟同步		4	-		
	输出时钟脉冲宽度		t_{SCKW}	0.4	0.6	t_{Scyc}	
	输出时钟上升时间		t_{SCKr}	-	5	ns	
	输出时钟下降时间		t_{SCKf}	-	5	ns	
	传输数据延迟	时钟同步	t_{TXD}	-	25	ns	Figure 43.28
	接收数据建立时间	时钟同步	t_{RXS}	15	-	ns	
	接收数据保持时间	时钟同步	t_{RXH}	5	-	ns	

Note 1. t_{Pcyc}: PCLKA cycle.

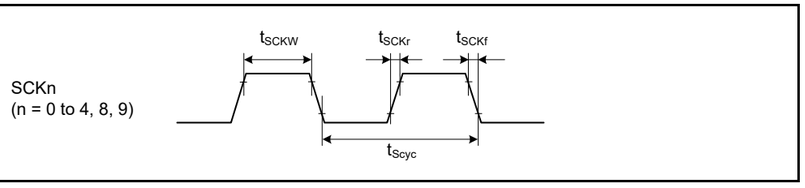


Figure 43.27 SCK时钟输入输出时序

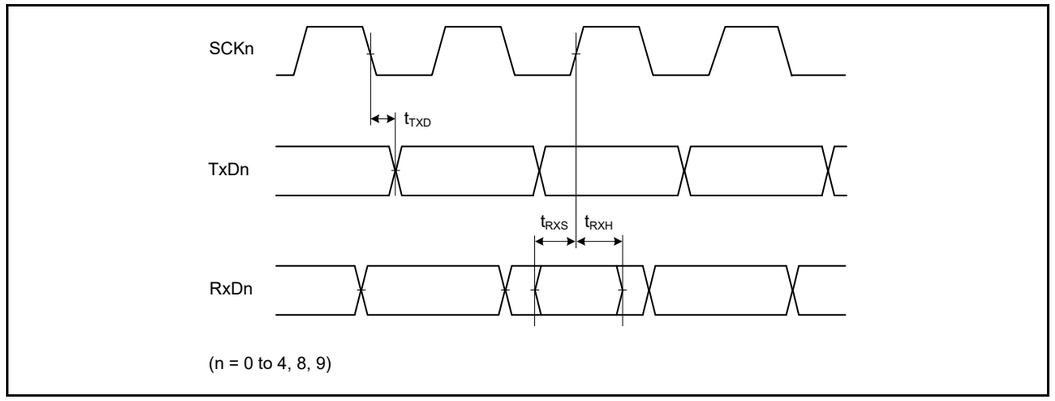


Figure 43.28 SCI input/output timing in clock synchronous mode

Table 43.22 SCI timing (2)
Conditions: High drive output is selected in the Port Drive Capability bit in the PmnPFS register for the following pins: SCK0 to SCK4, SCK8, SCK9.
For other pins, middle drive output is selected in the Port Drive Capability bit in the PmnPFS register.

Parameter		Symbol	Min	Max	Unit	Test conditions
Simple SPI	SCK clock cycle output (master)	t_{SPcyc}	4 (PCLKA ≤ 60 MHz) 8 (PCLKA > 60 MHz)	65536	t_{Pcyc}	Figure 43.29
	SCK clock cycle input (slave)	-	6 (PCLKA ≤ 60 MHz) 12 (PCLKA > 60 MHz)	65536		
	SCK clock high pulse width	t_{SPCKWH}	0.4	0.6	t_{SPcyc}	
	SCK clock low pulse width	t_{SPCKWL}	0.4	0.6	t_{SPcyc}	
	SCK clock rise and fall time	t_{SPCKr}, t_{SPCKf}	-	20	ns	
	Data input setup time	t_{SU}	33.3	-	ns	Figure 43.30 to Figure 43.33
	Data input hold time	t_H	33.3	-	ns	
	SS input setup time	t_{LEAD}	1	-	t_{SPcyc}	
	SS input hold time	t_{LAG}	1	-	t_{SPcyc}	
	Data output delay	t_{OD}	-	33.3	ns	
	Data output hold time	t_{OH}	-10	-	ns	
	Data rise and fall time	t_{Dr}, t_{Df}	-	16.6	ns	
	SS input rise and fall time	t_{SSLr}, t_{SSLf}	-	16.6	ns	
	Slave access time	t_{SA}	-	4 (PCLKA ≤ 60 MHz) 8 (PCLKA > 60 MHz)	t_{Pcyc}	Figure 43.33
	Slave output release time	t_{REL}	-	5 (PCLKA ≤ 60 MHz) 10 (PCLKA > 60 MHz)	t_{Pcyc}	

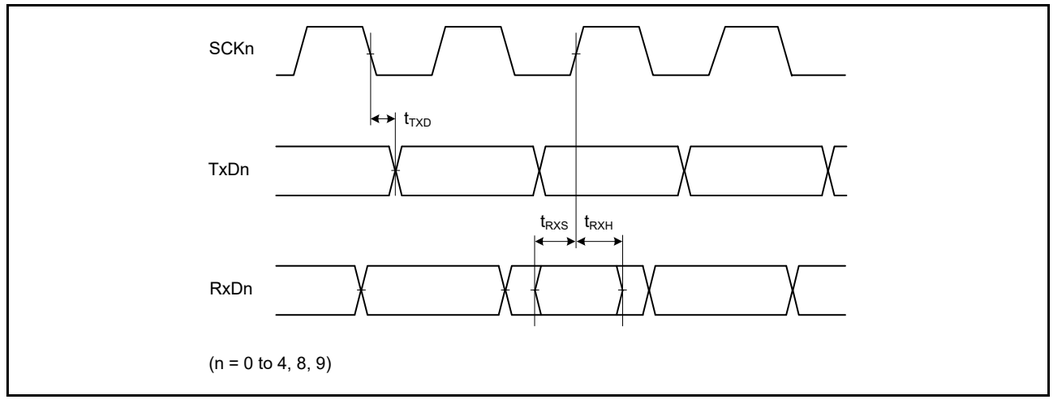


Figure 43.28 时钟同步模式下的SCI输入输出时序

Table 43.22 SCI时序（2）
条件：在PmnPFS寄存器的端口驱动能力位中为以下引脚选择高驱动输出：SCK0至SCK4，SCK8, SCK9.
对于其他引脚，在PmnPFS寄存器的端口驱动能力位中选择中间驱动输出。

Parameter		Symbol	Min	Max	Unit	测试条件
Simple SPI	SCK时钟周期输出（主机）	t_{SPcyc}	4 (PCLKA ≤ 60 MHz) 8 (PCLKA > 60 MHz)	65536	t_{Pcyc}	Figure 43.29
	SCK时钟周期输入（从机）	-	6 (PCLKA ≤ 60 MHz) 12 (PCLKA > 60 MHz)	65536		
	SCK时钟高脉冲宽度	t_{SPCKWH}	0.4	0.6	t_{SPcyc}	
	SCK时钟低脉冲宽度	t_{SPCKWL}	0.4	0.6	t_{SPcyc}	
	SCK时钟上升和下降时间	t_{SPCKr}, t_{SPCKf}	-	20	ns	
	数据输入建立时间	t_{SU}	33.3	-	ns	图43.30至Figure 43.33
	数据输入保持时间	t_H	33.3	-	ns	
	SS输入建立时间	t_{LEAD}	1	-	t_{SPcyc}	
	SS输入保持时间	t_{LAG}	1	-	t_{SPcyc}	
	数据输出延迟	t_{OD}	-	33.3	ns	
	数据输出保持时间	t_{OH}	-10	-	ns	
	数据上升和下降时间	t_{Dr}, t_{Df}	-	16.6	ns	
	SS输入上升和下降时间	t_{SSLr}, t_{SSLf}	-	16.6	ns	
	从站访问时间	t_{SA}	-	4 (PCLKA ≤ 60 MHz) 8 (PCLKA > 60 MHz)	t_{Pcyc}	Figure 43.33
	从机输出释放时间	t_{REL}	-	5 (PCLKA ≤ 60 MHz) 10 (PCLKA > 60 MHz)	t_{Pcyc}	

RA生态工作室

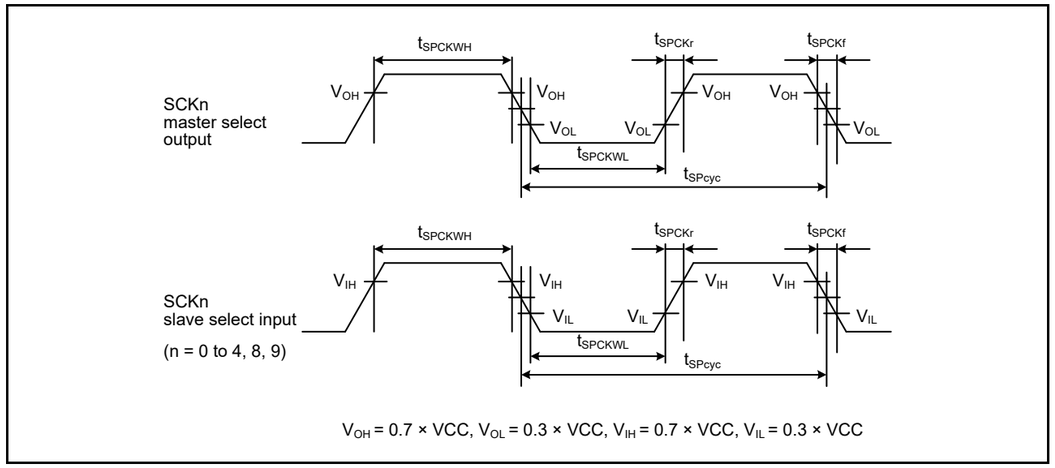


Figure 43.29 SCI simple SPI mode clock timing

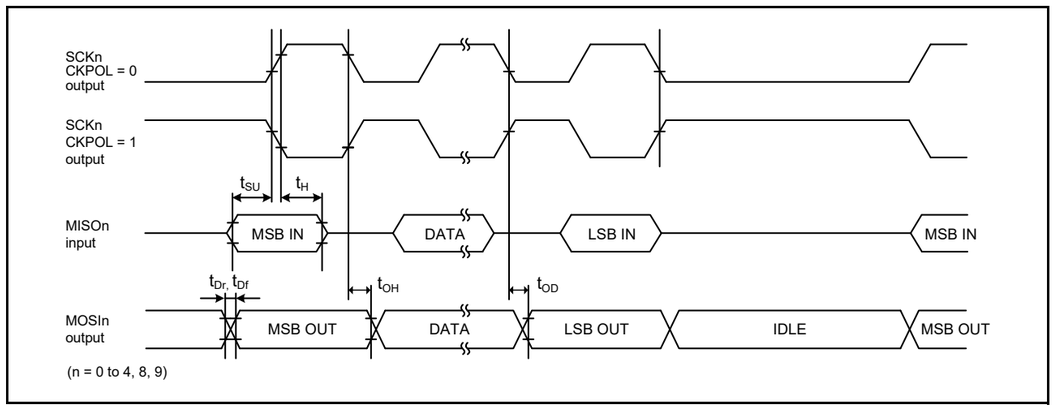


Figure 43.30 SCI simple SPI mode timing for master when CKPH = 1

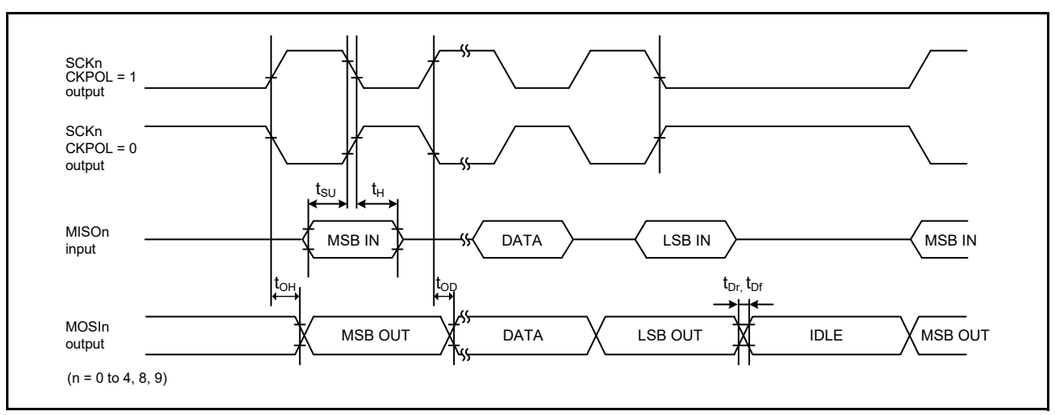


Figure 43.31 SCI simple SPI mode timing for master when CKPH = 0

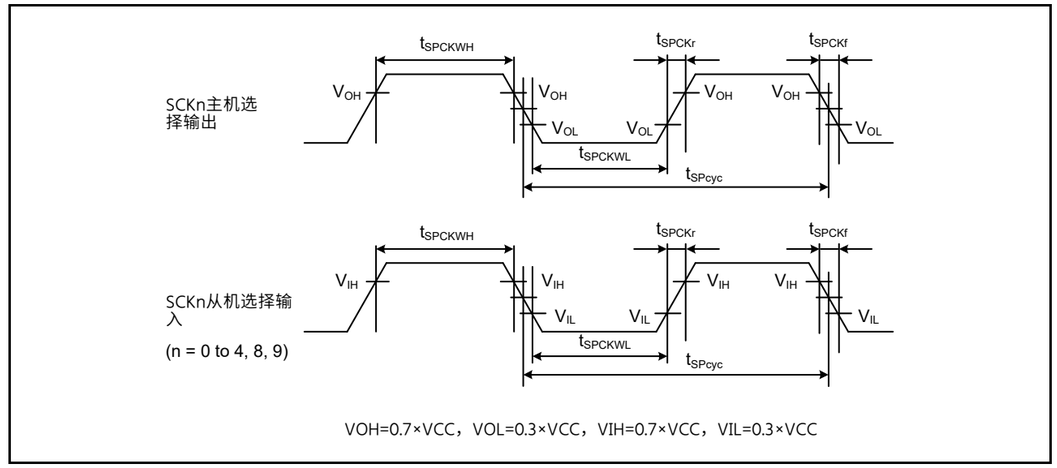


Figure 43.29 SCI简单SPI模式时钟时序

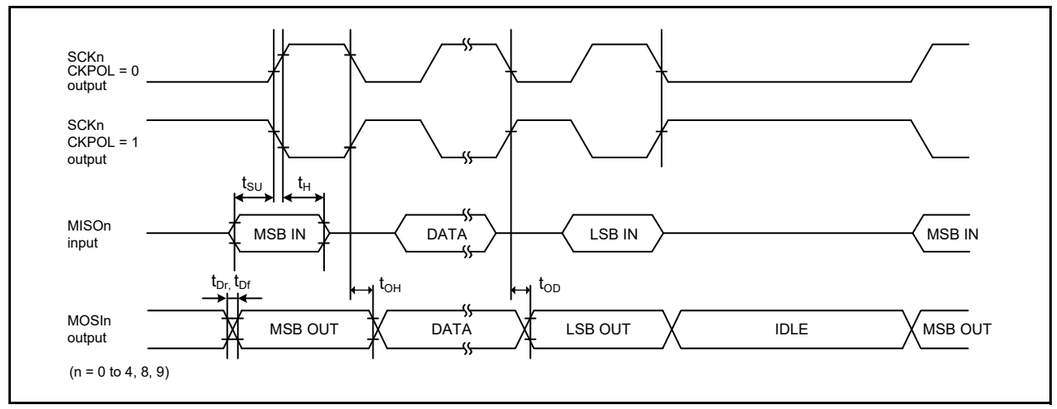


Figure 43.30 CKPH=1时主机的SCI简单SPI模式时序

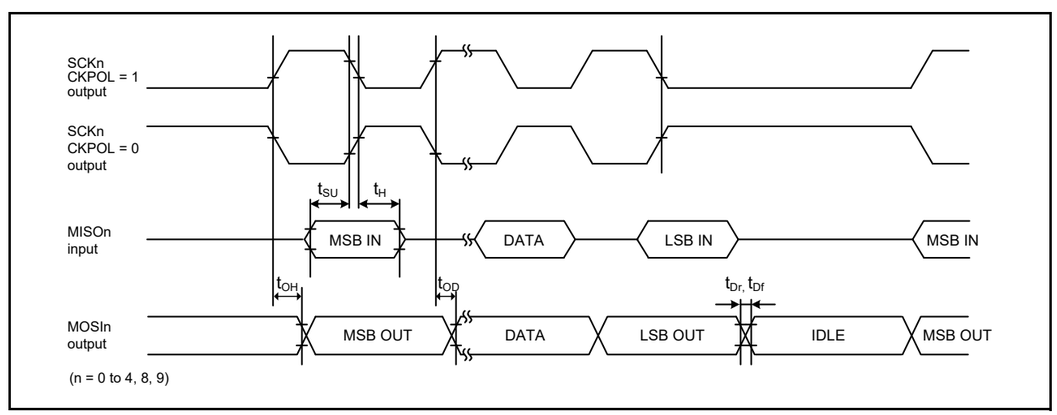


Figure 43.31 CKPH=0时主机的SCI简单SPI模式时序

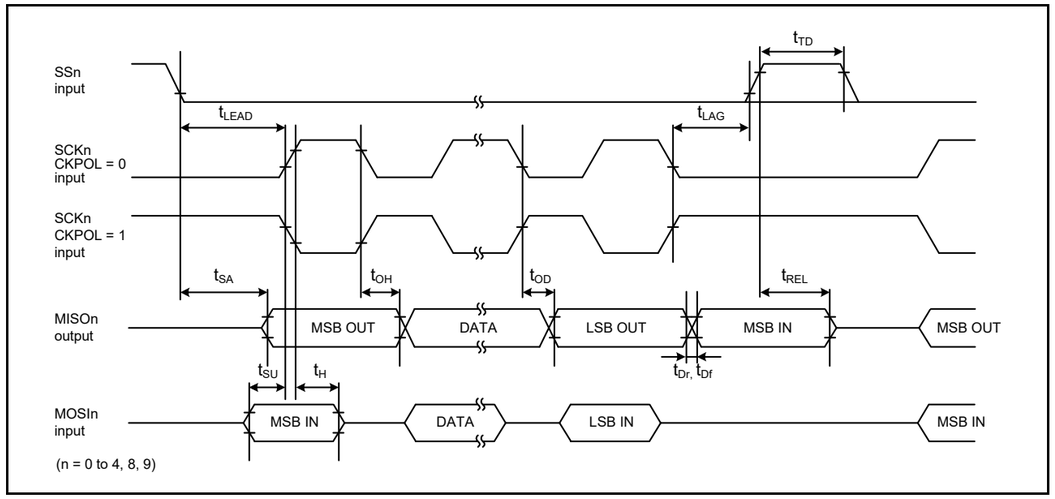


Figure 43.32 SCI simple SPI mode timing for slave when CKPH = 1

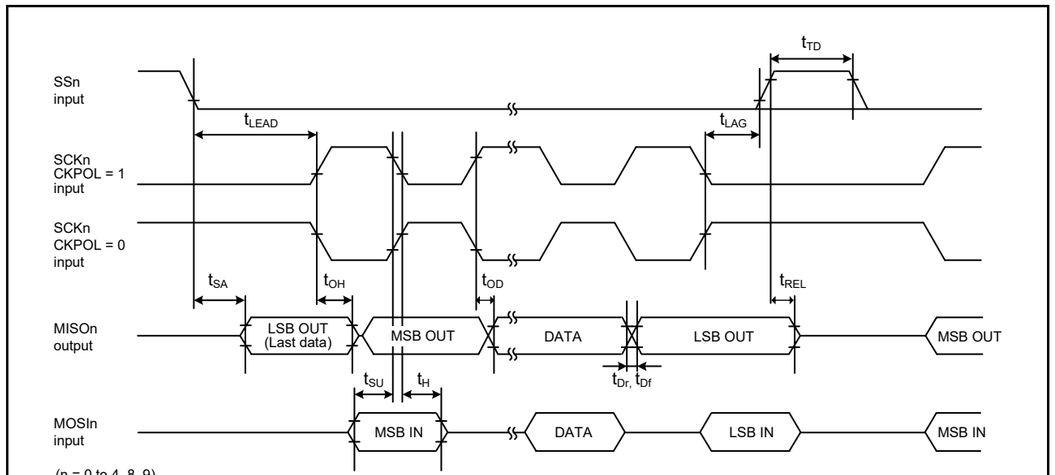


Figure 43.33 SCI simple SPI mode timing for slave when CKPH = 0

Table 43.23 SCI timing (3) (1 of 2)
Conditions: Middle drive output is selected in the Port Drive Capability bit in the PmnPFS register.

Parameter		Symbol	Min	Max	Unit	Test conditions
Simple IIC (Standard mode)	SDA input rise time	t_{Sr}	-	1000	ns	Figure 43.34
	SDA input fall time	t_{Sf}	-	300	ns	
	SDA input spike pulse removal time	t_{SP}	0	4 × t_{IICcyc}	ns	
	Data input setup time	t_{SDAS}	250	-	ns	
	Data input hold time	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b*1	-	400	pF	

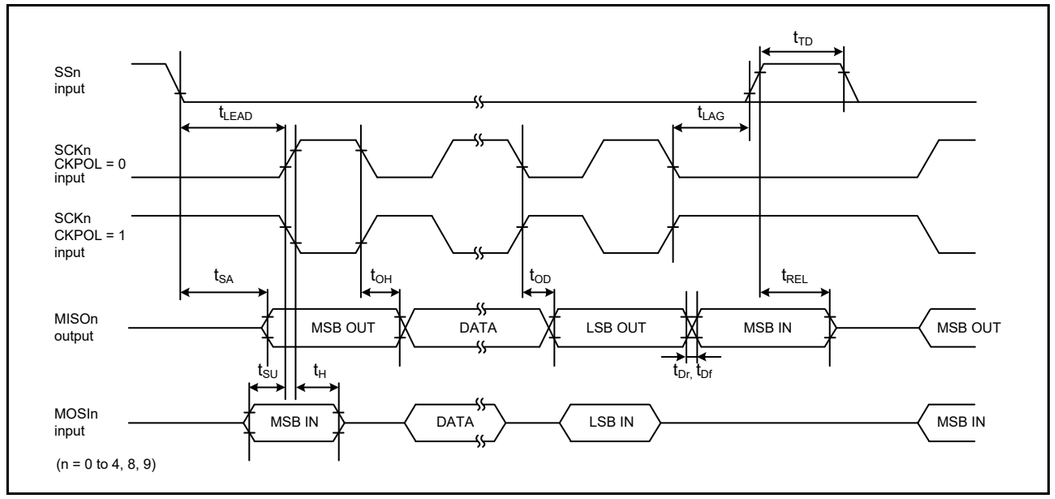


Figure 43.32 CKPH=1时从机的SCI简单SPI模式时序

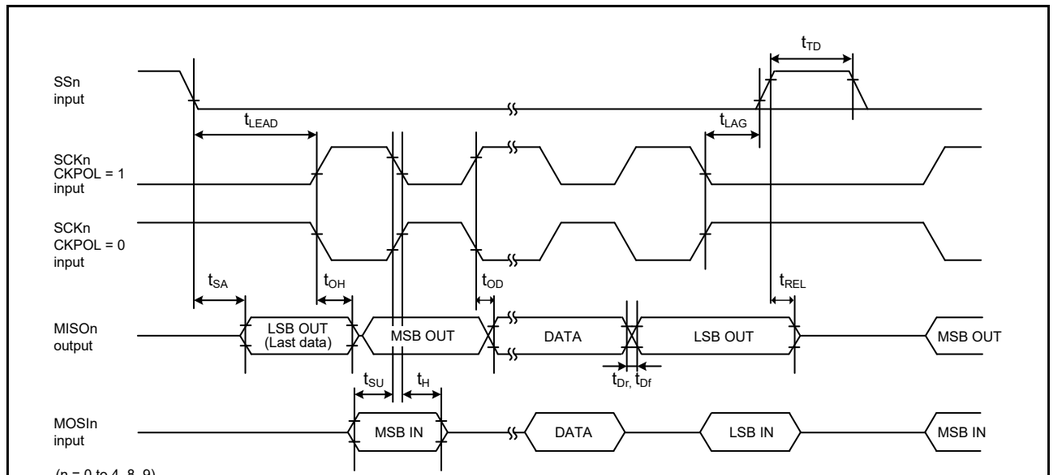


Figure 43.33 CKPH=0时从机的SCI简单SPI模式时序

Table 43.23 SCI计时(3)(1of2)
条件：在PmnPFS寄存器的端口驱动能力位中选择中间驱动输出。

Parameter		Symbol	Min	Max	Unit	测试条件
Simple IIC (Standard mode)	SDA输入上升时间	t_{Sr}	-	1000	ns	Figure 43.34
	SDA输入下降时间	t_{Sf}	-	300	ns	
	SDA输入尖峰脉冲去除时间	t_{SP}	0	4 × t_{IICcyc}	ns	
	数据输入建立时间	t_{SDAS}	250	-	ns	
	数据输入保持时间	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b*1	-	400	pF	

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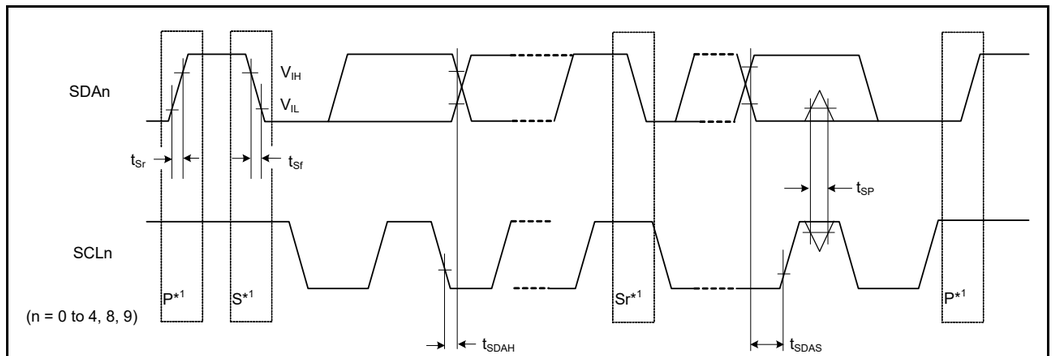
Table 43.23 SCI timing (3) (2 of 2)
Conditions: Middle drive output is selected in the Port Drive Capability bit in the PmnPFS register.

Parameter		Symbol	Min	Max	Unit	Test conditions
Simple IIC (Fast mode)	SDA input rise time	t_{Sr}	-	300	ns	Figure 43.34
	SDA input fall time	t_{Sf}	-	300	ns	
	SDA input spike pulse removal time	t_{SP}	0	4 × t_{IICcyc}	ns	
	Data input setup time	t_{SDAS}	100	-	ns	
	Data input hold time	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b*1	-	400	pF	

Note: t_{IICcyc}: IIC internal reference clock (IICφ) cycle.
Note 1. Cb indicates the total capacity of the bus line.



Note 1. S, P, and Sr indicate the following:
S: Start condition
P: Stop condition
Sr: Restart condition

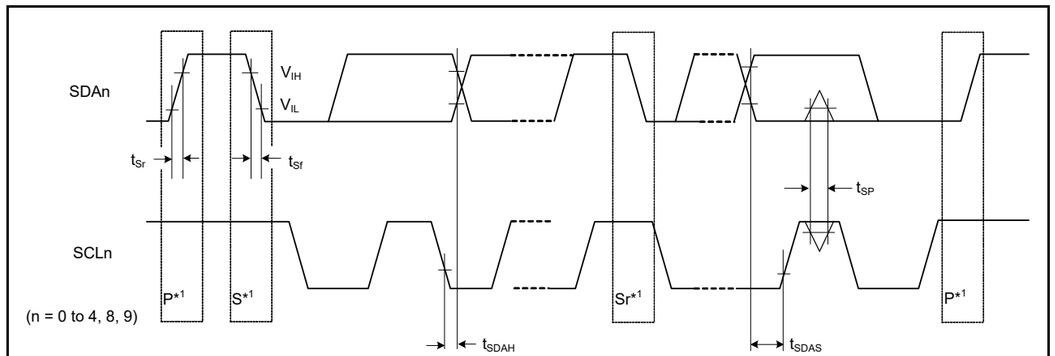
Test conditions:
V_{IH} = VCC × 0.7, V_{IL} = VCC × 0.3
V_{OL} = 0.6 V, I_{OL} = 6 mA

Figure 43.34 SCI simple IIC mode timing

Table 43.23 SCI计时(3)(2of2)
条件：在PmnPFS寄存器的端口驱动能力位中选择中间驱动输出。

Parameter		Symbol	Min	Max	Unit	测试条件
Simple IIC (Fast mode)	SDA输入上升时间	t_{Sr}	-	300	ns	Figure 43.34
	SDA输入下降时间	t_{Sf}	-	300	ns	
	SDA输入尖峰脉冲去除时间	t_{SP}	0	4 × t_{IICcyc}	ns	
	数据输入建立时间	t_{SDAS}	100	-	ns	
	数据输入保持时间	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b*1	-	400	pF	

Note: tIICcyc:IIC内部参考时钟(IICφ)周期。
Note 1. Cb表示公交线路的总容量。



Note 1. S、P和Sr表示以下内容：
S：开始条件P：
停止条件
Sr：重启条件

Test conditions:
VIH=VCC×0.7，VIL=VCC×0.3
VOL=0.6V，IOL=6mA

Figure 43.34 SCI简单IIC模式时序

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43.3.10 SPI Timing

Table 43.24 SPI timing

Conditions:
For RSPCKA and RSPCKB pins, high drive output is selected with the Port Drive Capability bit in the PmnPFS register.
For other pins, middle drive output is selected in the Port Drive Capability bit in the PmnPFS register.

Parameter			Symbol	Min	Max	Unit*1	Test conditions*2
SPI	RSPCK clock cycle	Master	t_{SPcyc}	2 (PCLKA ≤ 60 MHz) 4 (PCLKA > 60 MHz)	4096	t_{Pcyc}	Figure 43.35 C = 30 pF
		Slave		4	4096		
	RSPCK clock high pulse width	Master	t_{SPCKWH}	(t_{SPcyc} - t_{SPCKr} - t_{SPCKf}) / 2 - 3	-	ns	
		Slave		2 × t_{Pcyc}	-		
	RSPCK clock low pulse width	Master	t_{SPCKWL}	(t_{SPcyc} - t_{SPCKr} - t_{SPCKf}) / 2 - 3	-	ns	
		Slave		2 × t_{Pcyc}	-		
	RSPCK clock rise and fall time	Master	t_{SPCKr}, t_{SPCKf}	-	5	ns	
		Slave		-	1	µs	
	Data input setup time	Master	t_{SU}	4	-	ns	Figure 43.36 to Figure 43.41 C = 30 pF
		Slave		5	-		
	Data input hold time	Master (PCLKA division ratio set to 1/2)	t_{HF}	0	-	ns	
		Master (PCLKA division ratio set to a value other than 1/2)	t_H	t_{Pcyc}	-		
		Slave	t_H	20	-		
	SSL setup time	Master	t_{LEAD}	N × t_{SPcyc} - 10*3	N × t_{SPcyc} + 100*3	ns	
		Slave		6 x t_{Pcyc}	-	ns	
	SSL hold time	Master	t_{LAG}	N × t_{SPcyc} - 10 *4	N × t_{SPcyc} + 100*4	ns	
		Slave		6 x t_{Pcyc}	-	ns	
	Data output delay	Master	t_{OD}	-	6.3	ns	
		Slave		-	20		
	Data output hold time	Master	t_{OH}	0	-	ns	
		Slave		0	-		
	Successive transmission delay	Master	t_{TD}	t_{SPcyc} + 2 × t_{Pcyc}	8 × t_{SPcyc} + 2 × t_{Pcyc}	ns	
		Slave		6 × t_{Pcyc}			
	MOSI and MISO rise and fall time	Output	t_{Dr}, t_{Df}	-	5	ns	
		Input		-	1	µs	
	SSL rise and fall time	Output	t_{SSLr}, t_{SSLf}	-	5	ns	
		Input		-	1	µs	
	Slave access time		t_{SA}	-	2 x t_{Pcyc} + 28	ns	Figure 43.40 and Figure 43.41 C = 30pF
	Slave output release time		t_{REL}	-	2 x t_{Pcyc} + 28		

Note 1. t_{Pcyc}: PCLKA cycle.

43.3.10 SPI时序

Table 43.24 SPI时序

Conditions:
对于RSPCKA和RSPCKB引脚，通过PmnPFS寄存器中的端口驱动能力位选择高驱动输出。
对于其他引脚，在PmnPFS寄存器的端口驱动能力位中选择中间驱动输出。

Parameter			Symbol	Min	Max	Unit*1	Test conditions*2
SPI	RSPCK时钟周期	Master	t_{SPcyc}	2 (PCLKA ≤ 60 MHz) 4 (PCLKA > 60 MHz)	4096	t_{Pcyc}	Figure 43.35 C = 30 pF
		Slave		4	4096		
	RSPCK时钟高脉冲宽度	Master	t_{SPCKWH}	(t_{SPcyc} - t_{SPCKr} - t_{SPCKf}) / 2 - 3	-	ns	
		Slave		2 × t_{Pcyc}	-		
	RSPCK时钟低脉冲宽度	Master	t_{SPCKWL}	(t_{SPcyc} - t_{SPCKr} - t_{SPCKf}) / 2 - 3	-	ns	
		Slave		2 × t_{Pcyc}	-		
	RSPCK时钟上升和下降时间	Master	t_{SPCKr}, t_{SPCKf}	-	5	ns	
		Slave		-	1	µs	
	数据输入建立时间	Master	t_{SU}	4	-	ns	图43.36至 Figure 43.41 C = 30 pF
		Slave		5	-		
	数据输入保持时间	主控（PCLKA分频比设置为12）	t_{HF}	0	-	ns	
		主控（PCLKA分频比设置为12以外的值）	t_H	t_{Pcyc}	-		
		Slave	t_H	20	-		
	SSL设置时间	Master	t_{LEAD}	N × t_{SPcyc} - 10*3	N × t_{SPcyc} + 100*3	ns	
		Slave		6 x t_{Pcyc}	-	ns	
	SSL保持时间	Master	t_{LAG}	N × t_{SPcyc} - 10 *4	N × t_{SPcyc} + 100*4	ns	
		Slave		6 x t_{Pcyc}	-	ns	
	数据输出延迟	Master	t_{OD}	-	6.3	ns	
		Slave		-	20		
	数据输出保持时间	Master	t_{OH}	0	-	ns	
		Slave		0	-		
	连续传输延迟	Master	t_{TD}	t_{SPcyc} + 2 × t_{Pcyc}	8 × t_{SPcyc} + 2 × t_{Pcyc}	ns	
		Slave		6 × t_{Pcyc}			
	MOSI和MISO上升和下降时间	Output	t_{Dr}, t_{Df}	-	5	ns	
		Input		-	1	µs	
	SSL上升和下降时间	Output	t_{SSLr}, t_{SSLf}	-	5	ns	
		Input		-	1	µs	
	从站访问时间		t_{SA}	-	2 x t_{Pcyc} + 28	ns	图43.40和 Figure 43.41 C = 30pF
	从机输出释放时间		t_{REL}	-	2 x t_{Pcyc} + 28		

Note 1. t_{Pcyc}: PCLKA cycle.

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Note 2. Must use pins that have a letter appended to their name, for instance "_A", "_B", to indicate group membership. For the SPI interface, the AC portion of the electrical characteristics is measured for each group.
Note 3. N is set to an integer from 1 to 8 by the SPCKD register.
Note 4. N is set to an integer from 1 to 8 by the SSLND register.

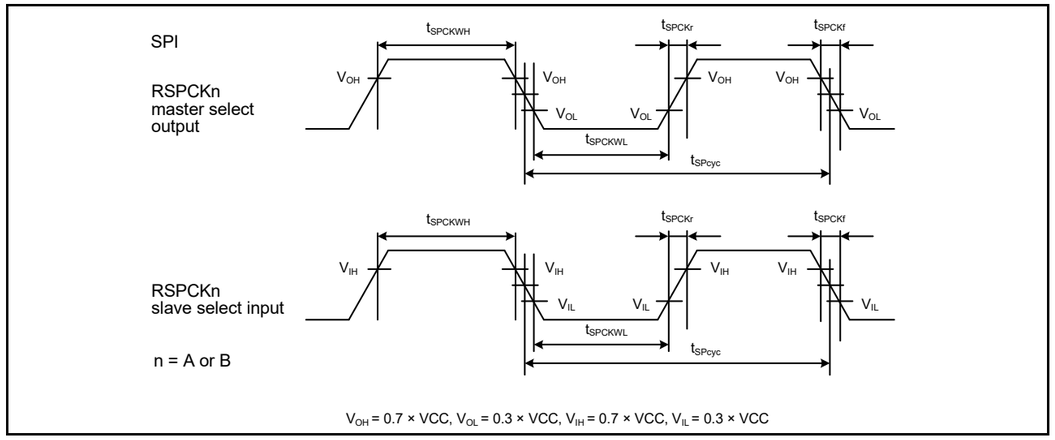

Figure 43.35 SPI clock timing

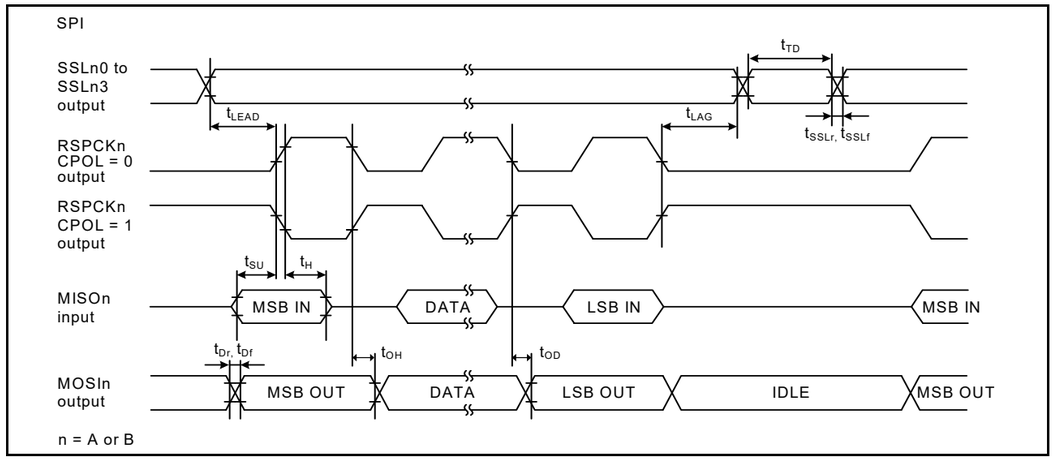

Figure 43.36 SPI timing for master when CPHA = 0

Note 2. 必须使用名称后附有字母的引脚，例如"_A"、"_B"，以表示组成员身份。对于SPI接口，测量每组的电气特性的交流部分。

Note 3. N由SPCKD寄存器设置为从1到8的整数。
Note 4. N由SSLND寄存器设置为从1到8的整数。

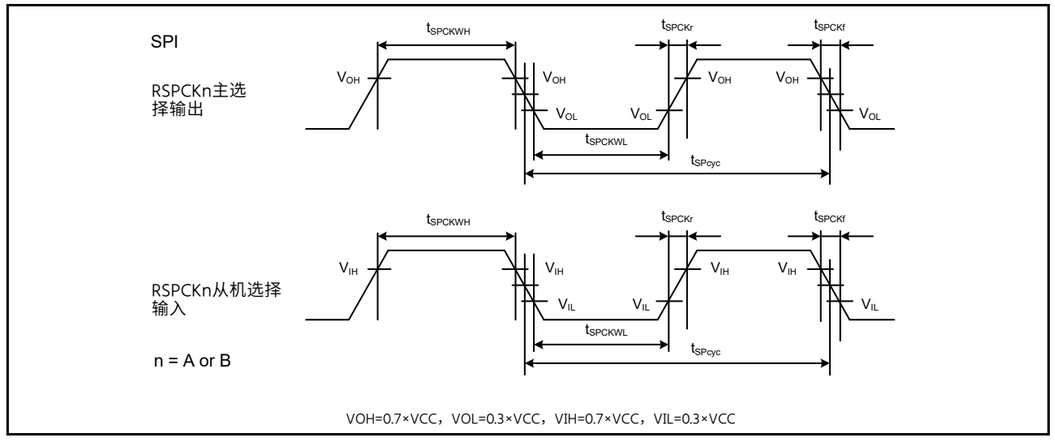

Figure 43.35 SPI时钟时序

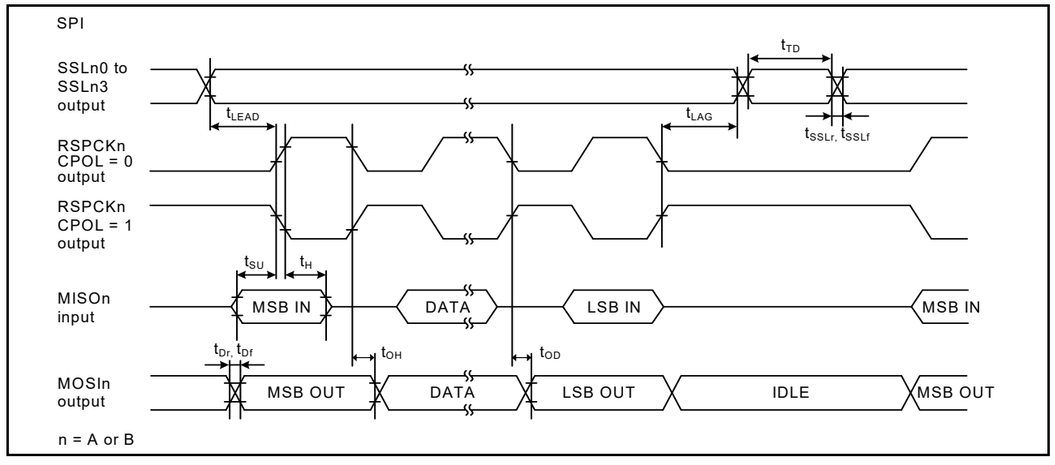

Figure 43.36 CPHA=0时主机的SPI时序

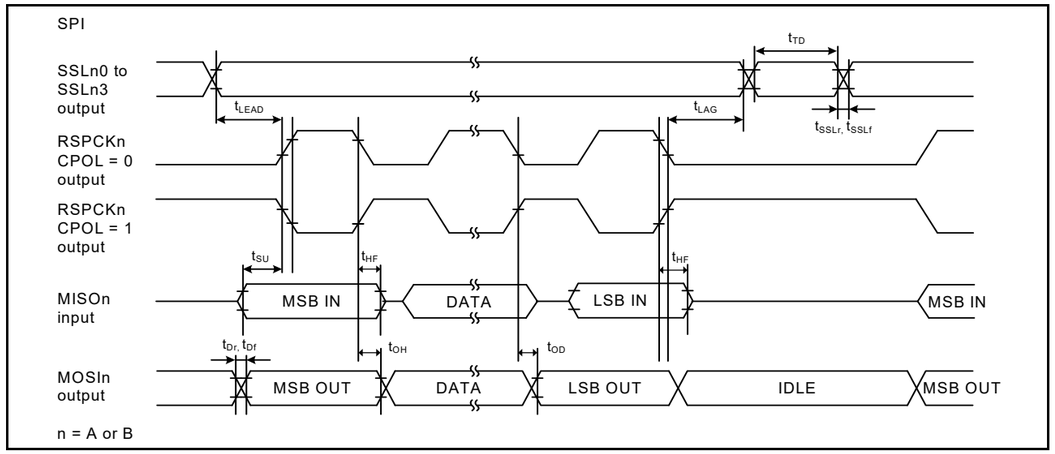

Figure 43.37 SPI timing for master when CPHA = 0 and the bit rate is set to PCLKA/2

Figure 43.38 SPI timing for master when CPHA = 1

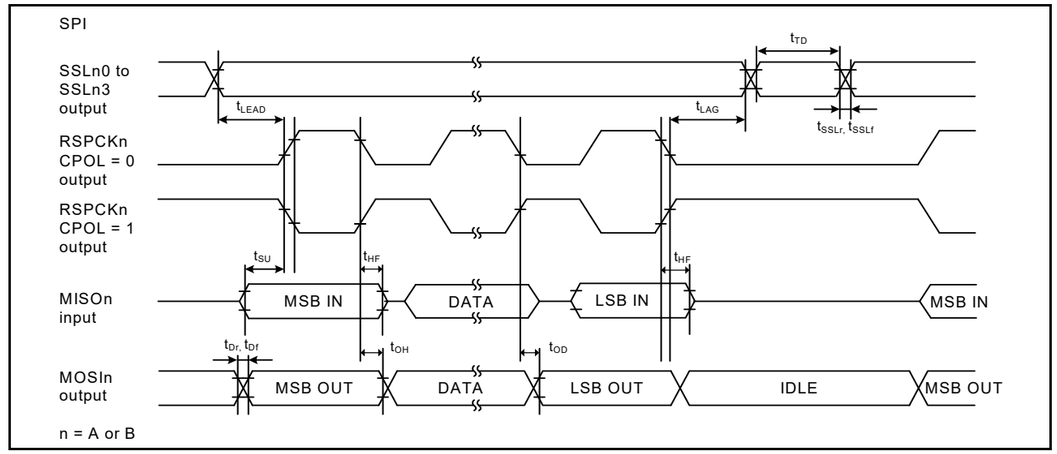

Figure 43.37 当CPHA=0且比特率设置为PCLKA2时主设备的SPI时序

Figure 43.38 CPHA=1时主机的SPI时序

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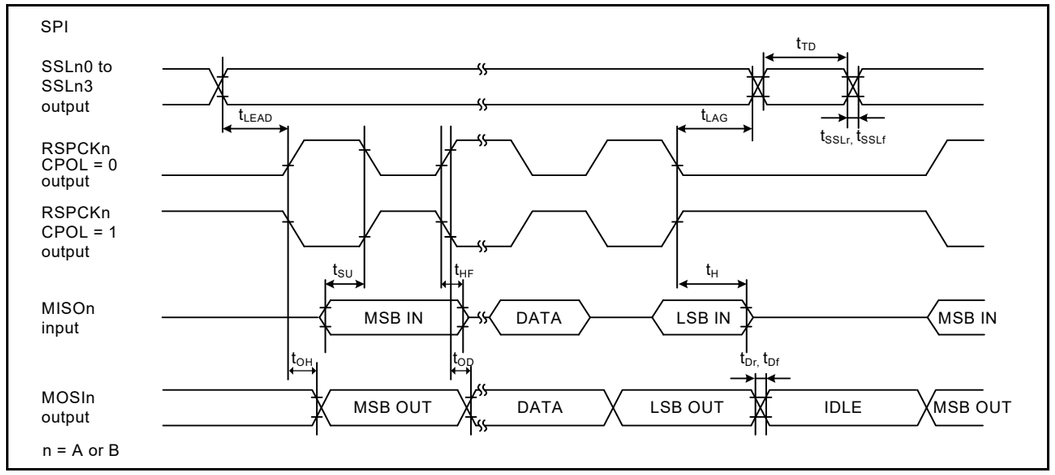

Figure 43.39 RSPI timing for master when CPHA = 1 and the bit rate is set to PCLKA/2

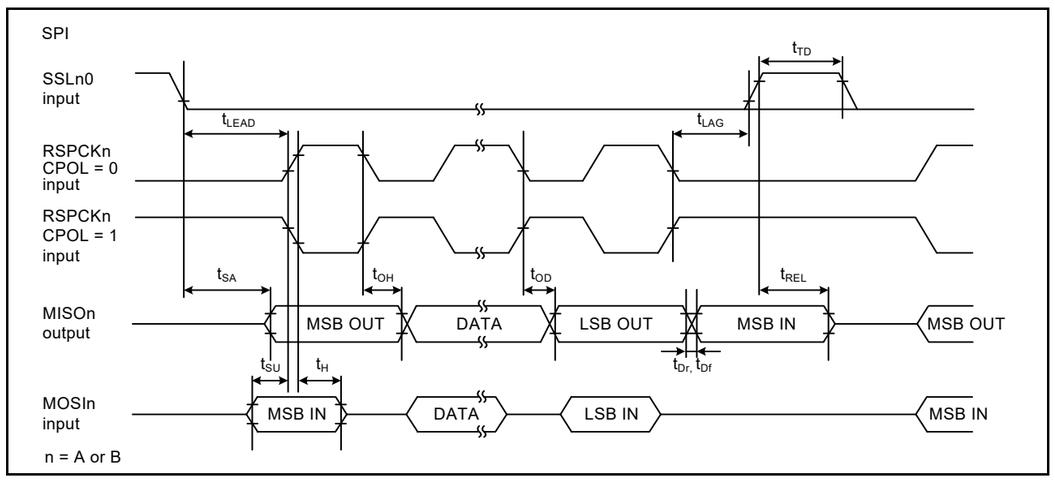

Figure 43.40 SPI timing for slave when CPHA = 0

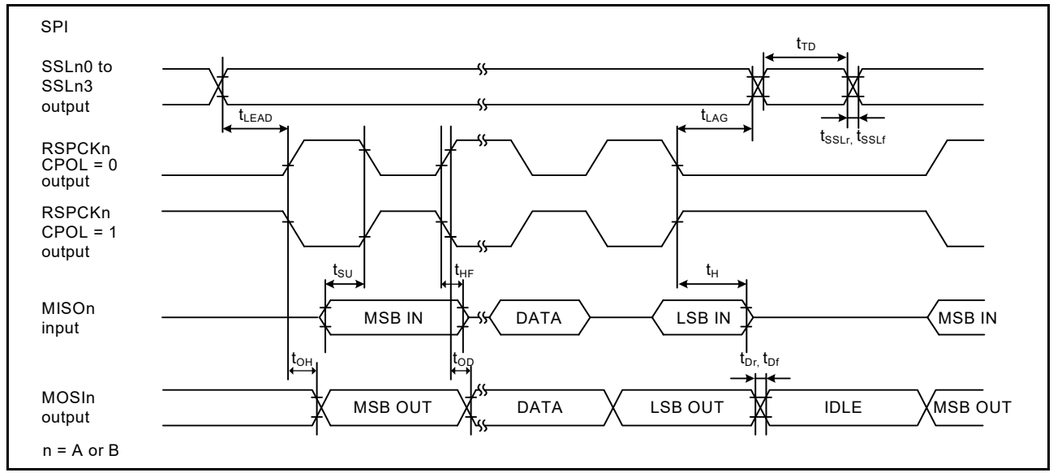

Figure 43.39 当CPHA=1且比特率设置为PCLKA2时，主机的RSPI时序

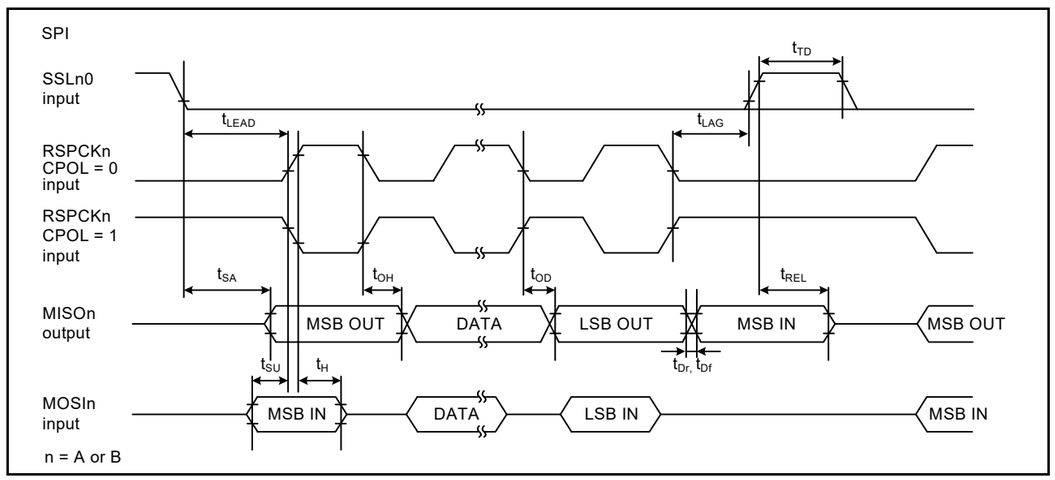

Figure 43.40 CPHA=0时从机的SPI时序

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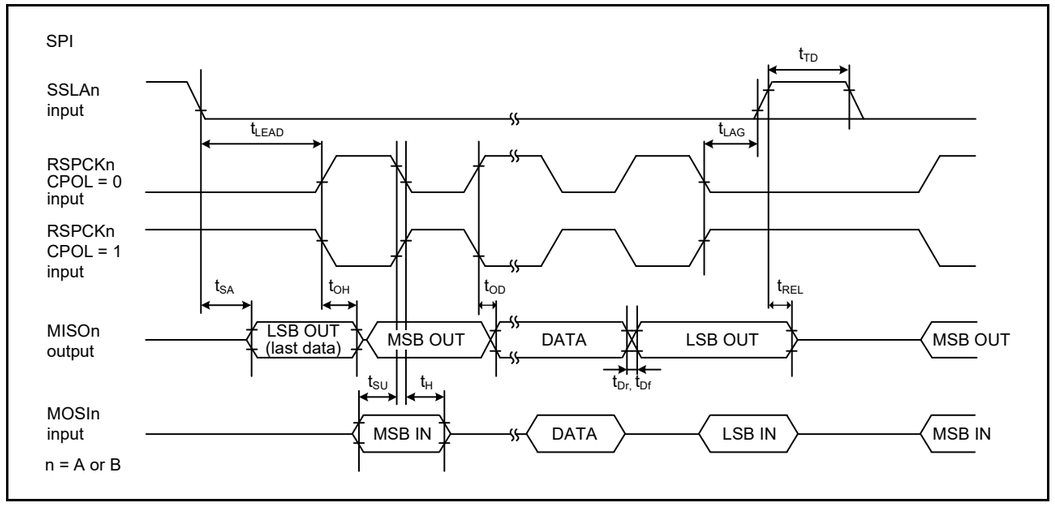

Figure 43.41 SPI timing for slave when CPHA = 1

43.3.11 IIC Timing

Table 43.25 IIC timing (1) (1 of 2)
(1) Conditions: Middle drive output is selected in the Port Drive Capability bit in the PmnPFS register for the following pins: SDA0_B, SCL0_B, SDA1_A, SCL1_A, SDA1_B, SCL1_B.
(2) The following pins do not require setting: SCL0_A, SDA0_A.
(3) Use pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the IIC interface, the AC portion of the electrical characteristics is measured for each group.

Parameter		Symbol	Min*1	Max	Unit	Test conditions*3
IIC (Standard mode, SMBus) ICFER.FMPE = 0	SCL input cycle time	t_{SCL}	6 (12) × t_{IICcyc} + 1300	-	ns	Figure 43.42
	SCL input high pulse width	t_{SCLH}	3 (6) × t_{IICcyc} + 300	-	ns	
	SCL input low pulse width	t_{SCLL}	3 (6) × t_{IICcyc} + 300	-	ns	
	SCL, SDA input rise time	t_{Sr}	-	1000	ns	
	SCL, SDA input fall time	t_{Sf}	-	300	ns	
	SCL, SDA input spike pulse removal time	t_{SP}	0	1 (4) × t_{IICcyc}	ns	
	SDA input bus free time when wakeup function is disabled	t_{BUF}	3 (6) × t_{IICcyc} + 300	-	ns	
	SDA input bus free time when wakeup function is enabled	t_{BUF}	3 (6) × t_{IICcyc} + 4 × t_{Pcyc} + 300	-	ns	
	START condition input hold time when wakeup function is disabled	t_{STAH}	t_{IICcyc} + 300	-	ns	
	START condition input hold time when wakeup function is enabled	t_{STAH}	1 (5) × t_{IICcyc} + t_{Pcyc} + 300	-	ns	
	Repeated START condition input setup time	t_{STAS}	1000	-	ns	
	STOP condition input setup time	t_{STOS}	1000	-	ns	
	Data input setup time	t_{SDAS}	t_{IICcyc} + 50	-	ns	
	Data input hold time	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b	-	400	pF	

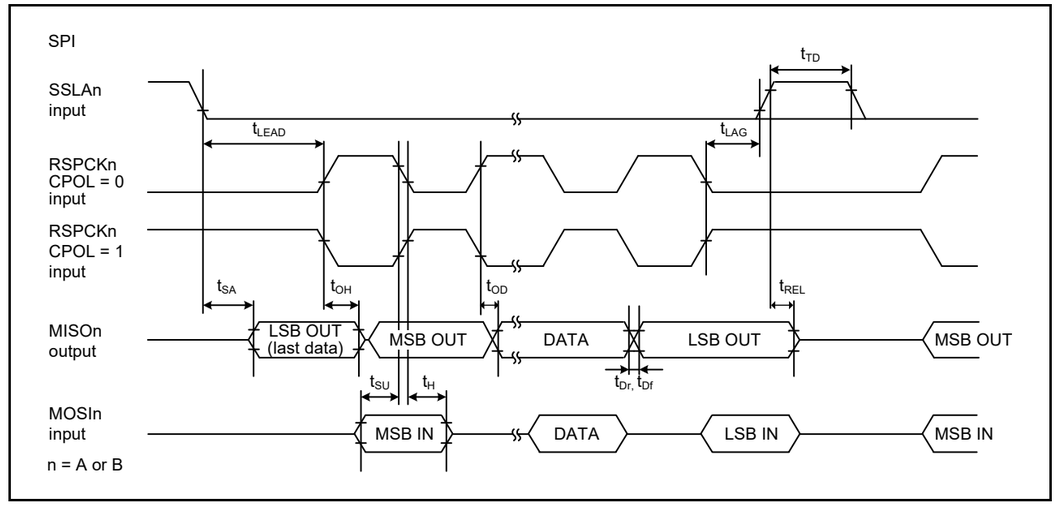

Figure 43.41 CPHA=1时从机的SPI时序

43.3.11 IIC Timing

表43.25IIC时序(1)(1of2)(1)条件：在PmnPFS寄存器的端口驱动能力位中为以下引脚选择中间驱动输出：SDA0_B、SCL0_B、SDA1_A、SCL1_A、SDA1_B、SCL1_B。(2)以下引脚不需要设置：SCL0_A、SDA0_A。(3)使用名称后附有字母的图钉，例如"_A"或"_B"，表示组成员身份。对于IIC接口，测量每组的电气特性的交流部分。

Parameter		Symbol	Min*1	Max	Unit	Test conditions*3
IIC (Standard mode, SMBus) ICFER.FMPE = 0	SCL输入周期时间	t_{SCL}	6 (12) × t_{IICcyc} + 1300	-	ns	Figure 43.42
	SCL输入高脉冲宽度	t_{SCLH}	3 (6) × t_{IICcyc} + 300	-	ns	
	SCL输入低脉冲宽度	t_{SCLL}	3 (6) × t_{IICcyc} + 300	-	ns	
	SCL、SDA输入上升时间	t_{Sr}	-	1000	ns	
	SCL、SDA输入下降时间	t_{Sf}	-	300	ns	
	SCL、SDA输入尖峰脉冲去除时间	t_{SP}	0	1 (4) × t_{IICcyc}	ns	
	禁用唤醒功能时的SDA输入总线空闲时间	t_{BUF}	3 (6) × t_{IICcyc} + 300	-	ns	
	唤醒功能启用时SDA输入总线空闲时间	t_{BUF}	3 (6) × t_{IICcyc} + 4 × t_{Pcyc} + 300	-	ns	
	禁用唤醒功能时的START条件输入保持时间	t_{STAH}	t_{IICcyc} + 300	-	ns	
	启用唤醒功能时的START条件输入保持时间	t_{STAH}	1 (5) × t_{IICcyc} + t_{Pcyc} + 300	-	ns	
	重复启动条件输入建立时间	t_{STAS}	1000	-	ns	
	STOP条件输入建立时间	t_{STOS}	1000	-	ns	
	数据输入建立时间	t_{SDAS}	t_{IICcyc} + 50	-	ns	
	数据输入保持时间	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b	-	400	pF	

Table 43.25 IIC timing (1) (2 of 2)

(1) Conditions: Middle drive output is selected in the Port Drive Capability bit in the PmnPFS register for the following pins: SDA0_B, SCL0_B, SDA1_A, SCL1_A, SDA1_B, SCL1_B.
(2) The following pins do not require setting: SCL0_A, SDA0_A.
(3) Use pins that have a letter appended to their names, for instance "_A" or "_B", to indicate group membership. For the IIC interface, the AC portion of the electrical characteristics is measured for each group.

Parameter		Symbol	Min*1	Max	Unit	Test conditions*3
IIC (Fast mode)	SCL input cycle time	t_{SCL}	6 (12) × t_{IICcyc} + 600	-	ns	Figure 43.42
	SCL input high pulse width	t_{SCLH}	3 (6) × t_{IICcyc} + 300	-	ns	
	SCL input low pulse width	t_{SCLL}	3 (6) × t_{IICcyc} + 300	-	ns	
	SCL, SDA input rise time	t_{Sr}	20 × (external pullup voltage/5.5V)*2	300	ns	
	SCL, SDA input fall time	t_{Sf}	20 × (external pullup voltage/5.5V)*2	300	ns	
	SCL, SDA input spike pulse removal time	t_{SP}	0	1 (4) × t_{IICcyc}	ns	
	SDA input bus free time when wakeup function is disabled	t_{BUF}	3 (6) × t_{IICcyc} + 300	-	ns	
	SDA input bus free time when wakeup function is enabled	t_{BUF}	3 (6) × t_{IICcyc} + 4 × t_{Pcyc} + 300	-	ns	
	START condition input hold time when wakeup function is disabled	t_{STAH}	t_{IICcyc} + 300	-	ns	
	START condition input hold time when wakeup function is enabled	t_{STAH}	1 (5) × t_{IICcyc} + t_{Pcyc} + 300	-	ns	
	Repeated START condition input setup time	t_{STAS}	300	-	ns	
	STOP condition input setup time	t_{STOS}	300	-	ns	
	Data input setup time	t_{SDAS}	t_{IICcyc} + 50	-	ns	
	Data input hold time	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b	-	400	pF	

Note: t_{IICcyc}: IIC internal reference clock (IICφ) cycle, t_{Pcyc}: PCLKB cycle.
Note 1. Values in parentheses apply when ICMR3.NF[1:0] is set to 11b while the digital filter is enabled with ICFER.NFE set to 1.
Note 2. Only supported for SCL0_A, SDA0_A.
Note 3. Must use pins that have a letter appended to their name, for instance "_A", "_B", to indicate group membership. For the IIC interface, the AC portion of the electrical characteristics is measured for each group.

表43.25IIC时序(1)(2of2)(1)条件：在PmnPFS寄存器的端口驱动能力位中为以下引脚选择中间驱动输出：SDA0_B、SCL0_B、SDA1_A、SCL1_A、SDA1_B、SCL1_B。(2)以下引脚不需要设置：SCL0_A、SDA0_A。(3)使用名称后附有字母的图钉，例如"_A"或"_B"，表示组成员身份。对于IIC接口，测量每组的电气特性的交流部分。

Parameter		Symbol	Min*1	Max	Unit	Test conditions*3
IIC (Fast mode)	SCL输入周期时间	t_{SCL}	6 (12) × t_{IICcyc} + 600	-	ns	Figure 43.42
	SCL输入高脉冲宽度	t_{SCLH}	3 (6) × t_{IICcyc} + 300	-	ns	
	SCL输入低脉冲宽度	t_{SCLL}	3 (6) × t_{IICcyc} + 300	-	ns	
	SCL、SDA输入上升时间	t_{Sr}	20 × (external pullup voltage/5.5V)*2	300	ns	
	SCL、SDA输入下降时间	t_{Sf}	20 × (external pullup voltage/5.5V)*2	300	ns	
	SCL、SDA输入尖峰脉冲去除时间	t_{SP}	0	1 (4) × t_{IICcyc}	ns	
	禁用唤醒功能时的SDA输入总线空闲时间	t_{BUF}	3 (6) × t_{IICcyc} + 300	-	ns	
	唤醒功能启用时SDA输入总线空闲时间	t_{BUF}	3 (6) × t_{IICcyc} + 4 × t_{Pcyc} + 300	-	ns	
	禁用唤醒功能时的START条件输入保持时间	t_{STAH}	t_{IICcyc} + 300	-	ns	
	启用唤醒功能时的START条件输入保持时间	t_{STAH}	1 (5) × t_{IICcyc} + t_{Pcyc} + 300	-	ns	
	重复启动条件输入建立时间	t_{STAS}	300	-	ns	
	STOP条件输入建立时间	t_{STOS}	300	-	ns	
	数据输入建立时间	t_{SDAS}	t_{IICcyc} + 50	-	ns	
	数据输入保持时间	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b	-	400	pF	

Note: tIICcyc：IIC内部参考时钟(IICφ)周期，tPcyc：PCLKB周期。
Note 1. 当ICMR3.NF[1:0]设置为11b且数字滤波器启用且ICFER.NFE设置为1时，括号中的值适用。
Note 2. 仅支持SCL0_A、SDA0_A。
Note 3. 必须使用名称后附有字母的引脚，例如"_A"、"_B"，以表示组成员身份。对于IIC接口，测量每组的电气特性的交流部分。

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Table 43.26 IIC timing (2)
Setting of the SCL0_A, SDA0_A pins is not required with the Port Drive Capability bit in the PmnPFS register.

Parameter		Symbol	Min*1,*2	Max	Unit	Test conditions
IIC (Fast mode+) ICFER.FMPE = 1	SCL input cycle time	t_{SCL}	6 (12) × t_{IICcyc} + 240	-	ns	Figure 43.42
	SCL input high pulse width	t_{SCLH}	3 (6) × t_{IICcyc} + 120	-	ns	
	SCL input low pulse width	t_{SCLL}	3 (6) × t_{IICcyc} + 120	-	ns	
	SCL, SDA input rise time	t_{Sr}	-	120	ns	
	SCL, SDA input fall time	t_{Sf}	-	120	ns	
	SCL, SDA input spike pulse removal time	t_{SP}	0	1 (4) × t_{IICcyc}	ns	
	SDA input bus free time when wakeup function is disabled	t_{BUF}	3 (6) × t_{IICcyc} + 120	-	ns	
	SDA input bus free time when wakeup function is enabled	t_{BUF}	3 (6) × t_{IICcyc} + 4 × t_{Pcyc} + 120	-	ns	
	Start condition input hold time when wakeup function is disabled	t_{STAH}	t_{IICcyc} + 120	-	ns	
	START condition input hold time when wakeup function is enabled	t_{STAH}	1 (5) × t_{IICcyc} + t_{Pcyc} + 120	-	ns	
	Restart condition input setup time	t_{STAS}	120	-	ns	
	Stop condition input setup time	t_{STOS}	120	-	ns	
	Data input setup time	t_{SDAS}	t_{IICcyc} + 30	-	ns	
	Data input hold time	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b	-	550	pF	

Note: t_{IICcyc}: IIC internal reference clock (IICφ) cycle, t_{Pcyc}: PCLKB cycle.
Note 1. Values in parentheses apply when ICMR3.NF[1:0] is set to 11b while the digital filter is enabled with ICFER.NFE set to 1.
Note 2. Cb indicates the total capacity of the bus line.

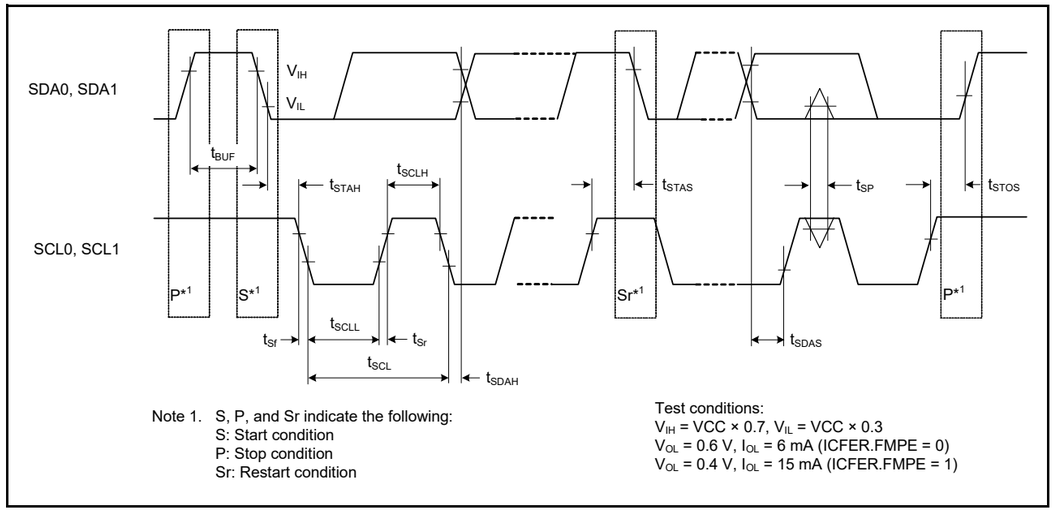

Figure 43.42 I²C bus interface input/output timing

Table 43.26 IIC timing (2)
PmnPFS寄存器中的端口驱动能力位不需要设置SCL0_A、SDA0_A引脚。

Parameter		Symbol	Min*1,*2	Max	Unit	测试条件
IIC (Fast mode+) ICFER.FMPE = 1	SCL输入周期时间	t_{SCL}	6 (12) × t_{IICcyc} + 240	-	ns	Figure 43.42
	SCL输入高脉冲宽度	t_{SCLH}	3 (6) × t_{IICcyc} + 120	-	ns	
	SCL输入低脉冲宽度	t_{SCLL}	3 (6) × t_{IICcyc} + 120	-	ns	
	SCL、SDA输入上升时间	t_{Sr}	-	120	ns	
	SCL、SDA输入下降时间	t_{Sf}	-	120	ns	
	SCL、SDA输入尖峰脉冲去除时间	t_{SP}	0	1 (4) × t_{IICcyc}	ns	
	禁用唤醒功能时的SDA输入总线空闲时间	t_{BUF}	3 (6) × t_{IICcyc} + 120	-	ns	
	唤醒功能启用时SDA输入总线空闲时间	t_{BUF}	3 (6) × t_{IICcyc} + 4 × t_{Pcyc} + 120	-	ns	
	禁用唤醒功能时的启动条件输入保持时间	t_{STAH}	t_{IICcyc} + 120	-	ns	
	启用唤醒功能时的START条件输入保持时间	t_{STAH}	1 (5) × t_{IICcyc} + t_{Pcyc} + 120	-	ns	
	重启条件输入建立时间	t_{STAS}	120	-	ns	
	停止条件输入建立时间	t_{STOS}	120	-	ns	
	数据输入建立时间	t_{SDAS}	t_{IICcyc} + 30	-	ns	
	数据输入保持时间	t_{SDAH}	0	-	ns	
	SCL, SDA capacitive load	C_b	-	550	pF	

Note: tIICcyc：IIC内部参考时钟(IICφ)周期，tPcyc：PCLKB周期。
Note 1. 当ICMR3.NF[1:0]设置为11b且数字滤波器启用且ICFER.NFE设置为1时，括号中的值适用。
Note 2. Cb表示公交线路的总容量。

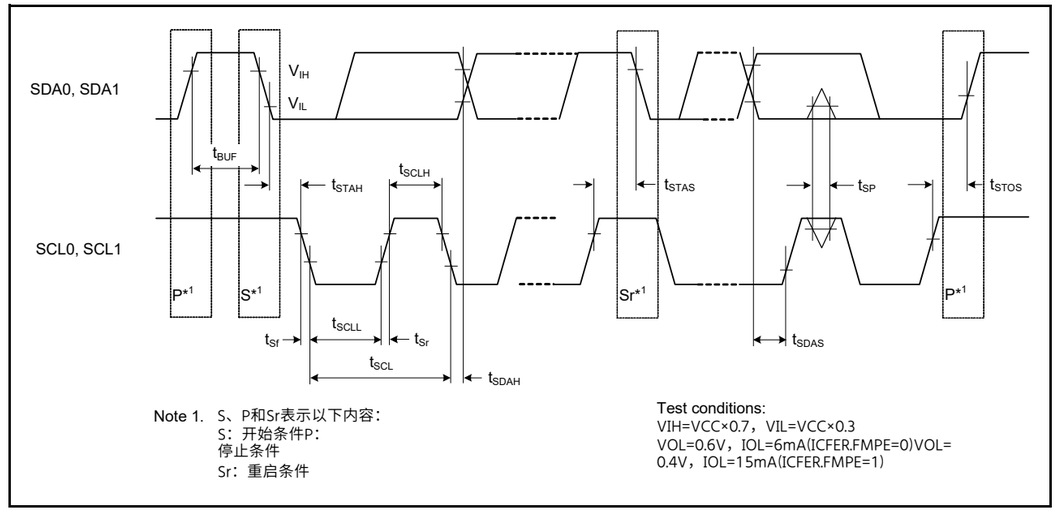

Figure 43.42 I2C总线接口输入输出时序

43.4 ADC12 Characteristics

Table 43.27 A/D conversion characteristics for unit 0 (1 of 2)
Conditions: PCLKC = 1 to 60 MHz

Parameter			Min	Typ	Max	Unit	Test conditions
Frequency			1	-	60	MHz	-
Analog input capacitance			-	-	30	pF	-
Quantization error			-	±0.5	-	LSB	-
Resolution			-	-	12	Bits	-
Channel-dedicated sample-and-hold circuits in use*3 (AN000 to AN002)	Conversion time*1 (operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	1.06 (0.4 + 0.25)*2	-	-	µs	• Sampling of channel-dedicated sample-and-hold circuits in 24 states • Sampling in 15 states
	Offset error		-	±1.5	±3.5	LSB	AN000 to AN002 = 0.25 V
	Full-scale error		-	±1.5	±3.5	LSB	AN000 to AN002 = VREFH0- 0.25 V
	Absolute accuracy		-	±2.5	±5.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±1.0	±2.0	LSB	-
	INL integral nonlinearity error		-	±1.5	±3.0	LSB	-
	Holding characteristics of sample-and hold circuits		-	-	20	µs	-
	Dynamic range		0.25	-	VREFH0 - 0.25	V	-
Channel-dedicated sample-and-hold circuits not in use (AN000 to AN002)	Conversion time*1 (operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	0.48 (0.267)*2	-	-	µs	Sampling in 16 states
	Offset error		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	Absolute accuracy		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL integral nonlinearity error		-	±1.0	±2.5	LSB	-
High-precision channels (AN003, AN005, AN006)	Conversion time*1 (operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	0.48 (0.267)*2	-	-	µs	Sampling in 16 states
		Max. = 400 Ω	0.40 (0.183)*2	-	-	µs	Sampling in 11 states VCC = AVCC0 = 3.0 to 3.6 V 3.0 V ≤ VREFH0 ≤ AVCC0
	Offset error		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	Absolute accuracy		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL integral nonlinearity error		-	±1.0	±2.5	LSB	-
High-precision channels (AN007)	Conversion time*1 (operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	0.75 (0.533)*2	-	-	µs	Sampling in 32 states
	Offset error		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	Absolute accuracy		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL integral nonlinearity error		-	±1.0	±2.5	LSB	-

43.4 ADC12 Characteristics

Table 43.27 单元0(1of2)的AD转换特性
Conditions: PCLKC = 1 to 60 MHz

Parameter			Min	Typ	Max	Unit	测试条件
Frequency			1	-	60	MHz	-
模拟输入电容			-	-	30	pF	-
量化误差			-	±0.5	-	LSB	-
Resolution			-	-	12	Bits	-
使用中的通道专用采样保持电路*3（AN000至AN002）	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	1.06 (0.4 + 0.25)*2	-	-	µs	通道采样 24种状态的专用采样保持电路 15种状态的采样
	偏移误差		-	±1.5	±3.5	LSB	AN000 to AN002 = 0.25 V
	Full-scale error		-	±1.5	±3.5	LSB	AN000 to AN002 = VREFH0- 0.25 V
	绝对精度		-	±2.5	±5.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±1.0	±2.0	LSB	-
	INL积分非线性误差		-	±1.5	±3.0	LSB	-
	采样保持电路的保持特性		-	-	20	µs	-
	动态范围		0.25	-	VREFH0 - 0.25	V	-
未使用通道专用采样保持电路（AN000至AN002）	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	0.48 (0.267)*2	-	-	µs	在16个州进行抽样
	偏移误差		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	绝对精度		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL积分非线性误差		-	±1.0	±2.5	LSB	-
High-precision channels (AN003, AN005, AN006)	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	0.48 (0.267)*2	-	-	µs	在16个州进行抽样
		Max. = 400 Ω	0.40 (0.183)*2	-	-	µs	在11个州进行抽样 VCC = AVCC0 = 3.0 to 3.6 V 3.0 V ≤ VREFH0 ≤ AVCC0
	偏移误差		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	绝对精度		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL积分非线性误差		-	±1.0	±2.5	LSB	-
High-precision channels (AN007)	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	0.75 (0.533)*2	-	-	µs	在32个州进行抽样
	偏移误差		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	绝对精度		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL积分非线性误差		-	±1.0	±2.5	LSB	-

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Table 43.27 A/D conversion characteristics for unit 0 (2 of 2)
Conditions: PCLKC = 1 to 60 MHz

Parameter			Min	Typ	Max	Unit	Test conditions
Normal-precision channels (AN016 to AN018, AN020)	Conversion time*1 (Operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	0.88 (0.667)*2	-	-	µs	Sampling in 40 states
	Offset error		-	±1.0	±5.5	LSB	-
	Full-scale error		-	±1.0	±5.5	LSB	-
	Absolute accuracy		-	±2.0	±7.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±4.5	LSB	-
	INL integral nonlinearity error		-	±1.0	±5.5	LSB	-

Note: These specification values apply when there is no access to the external bus during A/D conversion. If access occurs during A/D conversion, the values might not fall within the indicated ranges.
The use of ports 0 as digital outputs is not allowed when the 12-bit A/D converter is used.
The characteristics apply when AVCC0, AVSS0, VREFH0, VREFH, VREFL0, VREFL, and 12-bit A/D converter input voltage are stable.
Note 1. The conversion time includes the sampling and comparison times. The number of sampling states is indicated for the test conditions.
Note 2. Values in parentheses indicate the sampling time.
Note 3. When simultaneously using channel-dedicated sample-and-hold circuits in unit 0 and unit 1, see Table 43.29.

Table 43.28 A/D conversion characteristics for unit 1 (1 of 2)
Conditions: PCLKC = 1 to 60 MHz

Parameter			Min	Typ	Max	Unit	Test conditions
Frequency			1	-	60	MHz	-
Analog input capacitance			-	-	30	pF	-
Quantization error			-	±0.5	-	LSB	-
Resolution			-	-	12	Bits	-
Channel-dedicated sample-and-hold circuits in use*3 (AN100 to AN102)	Conversion time*1 (operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	1.06 (0.4 + 0.25)*2	-	-	µs	• Sampling of channel-dedicated sample-and-hold circuits in 24 states • Sampling in 15 states
	Offset error		-	±1.5	±3.5	LSB	AN100 to AN102 = 0.25 V
	Full-scale error		-	±1.5	±3.5	LSB	AN100 to AN102 = VREFH - 0.25 V
	Absolute accuracy		-	±2.5	±5.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±1.0	±2.0	LSB	-
	INL integral nonlinearity error		-	±1.5	±3.0	LSB	-
	Holding characteristics of sample-and hold circuits		-	-	20	µs	-
	Dynamic range		0.25	-	VREFH - 0.25	V	-
Channel-dedicated sample-and-hold circuits not in use (AN100 to AN102)	Conversion time*1 (Operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	0.48 (0.267)*2	-	-	µs	Sampling in 16 states
	Offset error		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	Absolute accuracy		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL integral nonlinearity error		-	±1.0	±2.5	LSB	-

Table 43.27 单元0(2of2)的AD转换特性
Conditions: PCLKC = 1 to 60 MHz

Parameter			Min	Typ	Max	Unit	测试条件
普通精度通道（AN016至AN018、AN020）	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	0.88 (0.667)*2	-	-	µs	在40个州进行抽样
	偏移误差		-	±1.0	±5.5	LSB	-
	Full-scale error		-	±1.0	±5.5	LSB	-
	绝对精度		-	±2.0	±7.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±4.5	LSB	-
	INL积分非线性误差		-	±1.0	±5.5	LSB	-

Note: 这些规范值适用于在AD转换期间无法访问外部总线的情况。如果访问发生在AD转换，值可能不在指定范围内。
使用12位AD转换器时，不允许将端口0用作数字输出。
这些特性适用于AVCC0、AVSS0、VREFH0、VREFH、VREFL0、VREFL和12位AD转换器输入电压稳定时。

Note 1. 转换时间包括采样时间和比较时间。针对测试条件指示采样状态的数量。

Note 2. 括号中的值表示采样时间。
Note 3. 在单元0和单元1中同时使用通道专用的采样保持电路时，请参见表43.29。

Table 43.28 单元1的AD转换特性（2个中的1个）
Conditions: PCLKC = 1 to 60 MHz

Parameter			Min	Typ	Max	Unit	测试条件
Frequency			1	-	60	MHz	-
模拟输入电容			-	-	30	pF	-
量化误差			-	±0.5	-	LSB	-
Resolution			-	-	12	Bits	-
使用中的通道专用采样保持电路*3（AN100至AN102）	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	1.06 (0.4 + 0.25)*2	-	-	µs	通道采样 24种状态的专用采样保持电路 15种状态的采样
	偏移误差		-	±1.5	±3.5	LSB	AN100 to AN102 = 0.25 V
	Full-scale error		-	±1.5	±3.5	LSB	AN100 to AN102 = VREFH - 0.25 V
	绝对精度		-	±2.5	±5.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±1.0	±2.0	LSB	-
	INL积分非线性误差		-	±1.5	±3.0	LSB	-
	采样保持电路的保持特性		-	-	20	µs	-
	动态范围		0.25	-	VREFH - 0.25	V	-
未使用通道专用采样保持电路（AN100至AN102）	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	0.48 (0.267)*2	-	-	µs	在16个州进行抽样
	偏移误差		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	绝对精度		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL积分非线性误差		-	±1.0	±2.5	LSB	-

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Table 43.28 A/D conversion characteristics for unit 1 (2 of 2)
Conditions: PCLKC = 1 to 60 MHz

Parameter			Min	Typ	Max	Unit	Test conditions
High-precision channels (AN105, AN106)	Conversion time*1 (Operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	0.48 (0.267)*2	-	-	µs	Sampling in 16 states
		Max. = 400 Ω	0.40 (0.183)*2	-	-	µs	Sampling in 11 states VCC = AVCC0 = 3.0 to 3.6 V 3.0 V ≤ VREFH ≤ AVCC0
	Offset error		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	Absolute accuracy		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL integral nonlinearity error		-	±1.0	±2.5	LSB	-
High-precision channels (AN107)	Conversion time*1 (Operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	0.75 (0.533)*2	-	-	µs	Sampling in 32 states
	Offset error		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	Absolute accuracy		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL integral nonlinearity error		-	±1.0	±2.5	LSB	-
Normal-precision channels (AN116, AN117)	Conversion time*1 (Operation at PCLKC = 60 MHz)	Permissible signal source impedance Max. = 1 kΩ	0.88 (0.667)*2	-	-	µs	Sampling in 40 states
	Offset error		-	±1.0	±5.5	LSB	-
	Full-scale error		-	±1.0	±5.5	LSB	-
	Absolute accuracy		-	±2.0	±7.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±4.5	LSB	-
	INL integral nonlinearity error		-	±1.0	±5.5	LSB	-

Note: These specification values apply when there is no access to the external bus during A/D conversion. If access occurs during A/D conversion, the values might not fall within the indicated ranges.
The use of ports 0 as digital outputs is not allowed when the 12-bit A/D converter is used.
The characteristics apply when AVCC0, AVSS0, VREFH0, VREFH, VREFL0, VREFL, and 12-bit A/D converter input voltage are stable.
Note 1. The conversion time includes the sampling and comparison times. The number of sampling states is indicated for the test conditions.
Note 2. Values in parentheses indicate the sampling time.
Note 3. When simultaneously using channel-dedicated sample-and-hold circuits in unit 0 and unit 1, see Table 43.29.

Table 43.29 A/D conversion characteristics for simultaneous use of channel-dedicated sample-and-hold circuits in unit 0 and unit 1
Conditions: PCLKC = 30/60 MHz

Parameter		Min	Typ	Max	Test conditions
Channel-dedicated sample-and-hold circuits in use with continious sampling function enabled (AN000 to AN002)	Offset error	-	±1.5	±5.0	• PCLKC = 60 MHz • Sampling in 15 states
	Full-scale error	-	±2.5	±5.0	
	Absolute accuracy	-	±4.0	±8.0	
Channel-dedicated sample-and-hold circuits in use with continious sampling function enabled (AN100 to AN102)	Offset error	-	±1.5	±5.0	
	Full-scale error	-	±2.5	±5.0	
	Absolute accuracy	-	±4.0	±8.0	
Channel-dedicated sample-and-hold circuits in use with continious sampling function enabled (AN000 to AN002)	Offset error	-	±1.5	±3.5	• PCLKC = 30 MHz • Sampling in 7 states
	Full-scale error	-	±1.5	±3.5	
	Absolute accuracy	-	±3.0	+4.5/-6.5	
Channel-dedicated sample-and-hold circuits in use with continious sampling function enabled (AN100 to AN102)	Offset error	-	±1.5	±3.5	
	Full-scale error	-	±1.5	±3.5	
	Absolute accuracy	-	±3.0	+4.5/-6.5	

Table 43.28 单元1的AD转换特性（2个中的2个）
Conditions: PCLKC = 1 to 60 MHz

Parameter			Min	Typ	Max	Unit	测试条件
High-precision channels (AN105, AN106)	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	0.48 (0.267)*2	-	-	µs	在16个州进行抽样
		Max. = 400 Ω	0.40 (0.183)*2	-	-	µs	在11个州进行抽样 VCC = AVCC0 = 3.0 to 3.6 V 3.0 V ≤ VREFH ≤ AVCC0
	偏移误差		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	绝对精度		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL积分非线性误差		-	±1.0	±2.5	LSB	-
High-precision channels (AN107)	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	0.75 (0.533)*2	-	-	µs	在32个州进行抽样
	偏移误差		-	±1.0	±2.5	LSB	-
	Full-scale error		-	±1.0	±2.5	LSB	-
	绝对精度		-	±2.0	±4.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±1.5	LSB	-
	INL积分非线性误差		-	±1.0	±2.5	LSB	-
Normal-precision channels (AN116, AN117)	转换时间*1（在PCLKC=60MHz下运行）	允许的信号源阻抗 Max.=1kΩ	0.88 (0.667)*2	-	-	µs	在40个州进行抽样
	偏移误差		-	±1.0	±5.5	LSB	-
	Full-scale error		-	±1.0	±5.5	LSB	-
	绝对精度		-	±2.0	±7.5	LSB	-
	DNL pseudo-differential nonlinearity error		-	±0.5	±4.5	LSB	-
	INL积分非线性误差		-	±1.0	±5.5	LSB	-

Note: 这些规范值适用于在AD转换期间无法访问外部总线的情况。如果访问发生在AD转换，值可能不在指定范围内。
使用12位AD转换器时，不允许将端口0用作数字输出。
这些特性适用于AVCC0、AVSS0、VREFH0、VREFH、VREFL0、VREFL和12位AD转换器输入电压稳定时。

Note 1. 转换时间包括采样时间和比较时间。针对测试条件指示采样状态的数量。

Note 2. 括号中的值表示采样时间。
Note 3. 在单元0和单元1中同时使用通道专用的采样保持电路时，请参见表43.29。

表43.29在单元0和单元1中同时使用通道专用采样和保持电路的AD转换特性条件：PCLKC=3060MHz

Parameter		Min	Typ	Max	测试条件
启用连续采样功能的通道专用采样保持电路（AN000至AN002）	偏移误差	-	±1.5	±5.0	PCLKC=60MHz 15种状态采样
	Full-scale error	-	±2.5	±5.0	
	绝对精度	-	±4.0	±8.0	
启用连续采样功能的通道专用采样保持电路（AN100至AN102）	偏移误差	-	±1.5	±5.0	
	Full-scale error	-	±2.5	±5.0	
	绝对精度	-	±4.0	±8.0	
启用连续采样功能的通道专用采样保持电路（AN000至AN002）	偏移误差	-	±1.5	±3.5	PCLKC=30MHz 7种状态采样
	Full-scale error	-	±1.5	±3.5	
	绝对精度	-	±3.0	+4.5/-6.5	
启用连续采样功能的通道专用采样保持电路（AN100至AN102）	偏移误差	-	±1.5	±3.5	
	Full-scale error	-	±1.5	±3.5	
	绝对精度	-	±3.0	+4.5/-6.5	

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Note: When simultaneously using channel-dedicated sample-and-hold circuits in unit 0 and unit 1, setting the ADSHMSR.SHMD bit to 1 is recommended.

Table 43.30 A/D internal reference voltage characteristics

Parameter	Min	Typ	Max	Unit	Test conditions
A/D internal reference voltage	1.13	1.18	1.23	V	-
Sampling time	4.15	-	-	µs	-

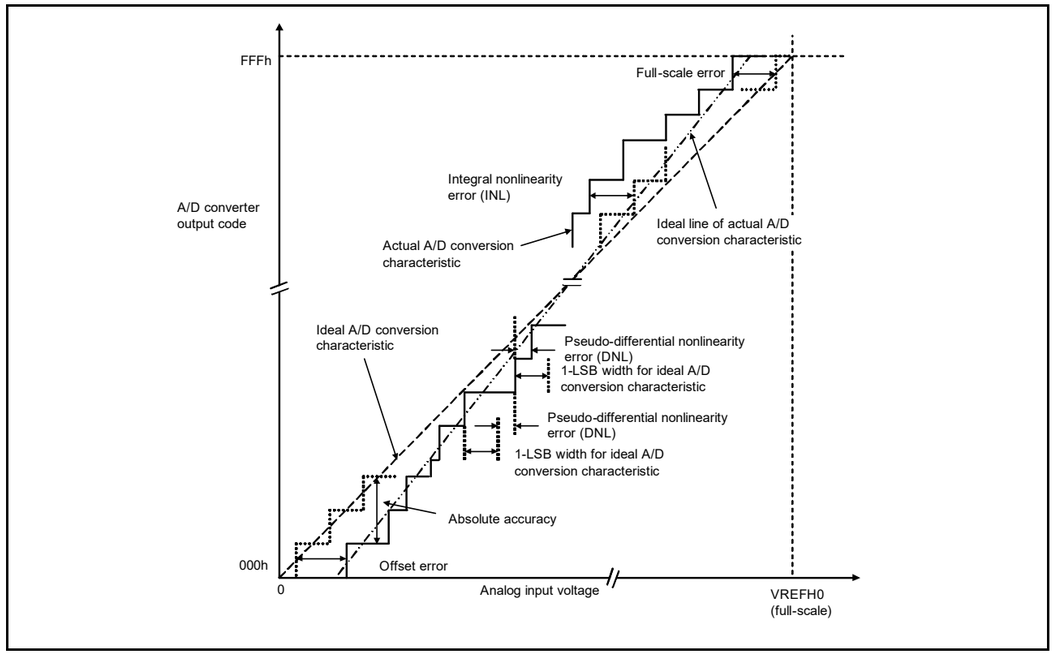

Figure 43.43 Illustration of ADC12 characteristic terms

Absolute accuracy

Absolute accuracy is the difference between output code based on the theoretical A/D conversion characteristics, and the actual A/D conversion result. When measuring absolute accuracy, the voltage at the midpoint of the width of the analog input voltage (1-LSB width), which can meet the expectation of outputting an equal code based on the theoretical A/D conversion characteristics, is used as the analog input voltage. For example, if 12-bit resolution is used and the reference voltage VREFH0 is 3.072 V, then the 1-LSB width becomes 0.75 mV, and 0 mV, 0.75 mV, and 1.5 mV are used as the analog input voltages. If the analog input voltage is 6 mV, an absolute accuracy of ±5 LSB means that the actual A/D conversion result is in the range of 003h to 00Dh, though an output code of 008h can be expected from the theoretical A/D conversion characteristics.

Integral nonlinearity error (INL)

Integral nonlinearity error is the maximum deviation between the ideal line when the measured offset and full-scale errors are zeroed, and the actual output code.

Pseudo-differential nonlinearity error (DNL)

Pseudo-differential nonlinearity error is the difference between the 1-LSB width based on the ideal A/D conversion characteristics and the width of the actual output code.

Offset error

Offset error is the difference between the transition point of the ideal first output code and the actual first output code.

Note: 在单元0和单元1中同时使用通道专用采样保持电路时，建议将ADSHMSR.SHMD位设置为1。

Table 43.30 AD内部参考电压特性

Parameter	Min	Typ	Max	Unit	测试条件
AD内部参考电压	1.13	1.18	1.23	V	-
采样时间	4.15	-	-	µs	-

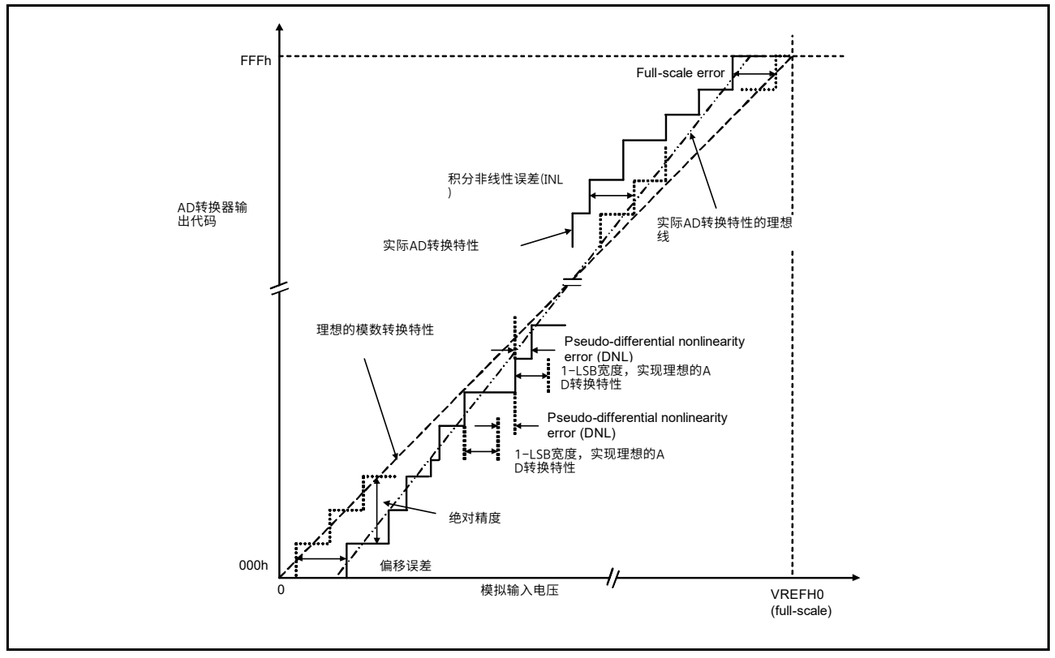

Figure 43.43 ADC12特征项说明

绝对精度

绝对精度是基于理论AD转换特性的输出代码与实际AD转换结果之间的差异。测量绝对精度时，将模拟输入电压宽度（1-LSB宽度）的中点电压作为模拟输入电压，该电压在理论上可以满足输出等码的期望。.例如，如果使用12位分辨率且参考电压VREFH0为3.072V，则1-LSB宽度变为0.75mV，并且使用0mV、0.75mV和1.5mV作为模拟输入电压。如果模拟输入电压为6mV，±5LSB的绝对精度意味着实际的AD转换结果在003h到00Dh的范围内，尽管从理论上的AD转换特性可以预期输出码为008h。

积分非线性误差(INL)

积分非线性误差是测量的偏移和满量程误差为零时的理想线与实际输出代码之间的最大偏差。

Pseudo-differential nonlinearity error (DNL)

伪微分非线性误差是基于理想AD转换特性的1-LSB宽度与实际输出码的宽度之差。

偏移误差

偏移误差是理想的第一个输出代码的转换点与实际的第一个输出代码之间的差异。

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Full-scale error

Full-scale error is the difference between the transition point of the ideal last output code and the actual last output code.

43.5 DAC12 Characteristics

Table 43.31 D/A conversion characteristics

Parameter	Min	Typ	Max	Unit	Test conditions
Resolution	-	-	12	Bits	-
Without output amplifier					
Absolute accuracy	-	-	±24	LSB	Resistive load 2 MΩ
INL	-	±2.0	±8.0	LSB	Resistive load 2 MΩ
DNL	-	±1.0	±2.0	LSB	-
Output impedance	-	8.5	-	kΩ	-
Conversion time	-	-	3.0	µs	Resistive load 2 MΩ, Capacitive load 20 pF
Output voltage range	0	-	VREFH	V	-
With output amplifier					
INL	-	±2.0	±4.0	LSB	-
DNL	-	±1.0	±2.0	LSB	-
Conversion time	-	-	4.0	µs	-
Resistive load	5	-	-	kΩ	-
Capacitive load	-	-	50	pF	-
Output voltage range	0.2	-	VREFH - 0.2	V	-

43.6 TSN Characteristics

Table 43.32 TSN characteristics

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
Relative accuracy	-	-	±1.0	-	°C	-
Temperature slope	-	-	4.0	-	mV/°C	-
Output voltage (at 25°C)	-	-	1.24	-	V	-
Temperature sensor start time	t_{START}	-	-	30	µs	-
Sampling time	-	4.15	-	-	µs	-

43.7 OSC Stop Detect Characteristics

Table 43.33 Oscillation stop detection circuit characteristics

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
Detection time	t_{dr}	-	-	1	ms	Figure 43.44

Full-scale error

满量程误差是理想的最后输出代码的转换点与实际的最后输出代码之间的差异。

43.5 DAC12 Characteristics

Table 43.31 DA转换特性

Parameter	Min	Typ	Max	Unit	测试条件
Resolution	-	-	12	Bits	-
无输出放大器					
绝对精度	-	-	±24	LSB	阻性负载2MΩ
INL	-	±2.0	±8.0	LSB	阻性负载2MΩ
DNL	-	±1.0	±2.0	LSB	-
输出阻抗	-	8.5	-	kΩ	-
转换时间	-	-	3.0	µs	电阻负载2MΩ，电容负载20pF
输出电压范围	0	-	VREFH	V	-
带输出放大器					
INL	-	±2.0	±4.0	LSB	-
DNL	-	±1.0	±2.0	LSB	-
转换时间	-	-	4.0	µs	-
阻性负载	5	-	-	kΩ	-
Capacitive load	-	-	50	pF	-
输出电压范围	0.2	-	VREFH - 0.2	V	-

43.6 TSN Characteristics

Table 43.32 TSN characteristics

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
相对精度	-	-	±1.0	-	°C	-
温度斜率	-	-	4.0	-	mV/°C	-
输出电压（25°C时）	-	-	1.24	-	V	-
温度传感器启动时间	t_{START}	-	-	30	µs	-
采样时间	-	4.15	-	-	µs	-

43.7 OSC停止检测特性

Table 43.33 振荡停止检测电路特性

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
检测时间	t_{dr}	-	-	1	ms	Figure 43.44

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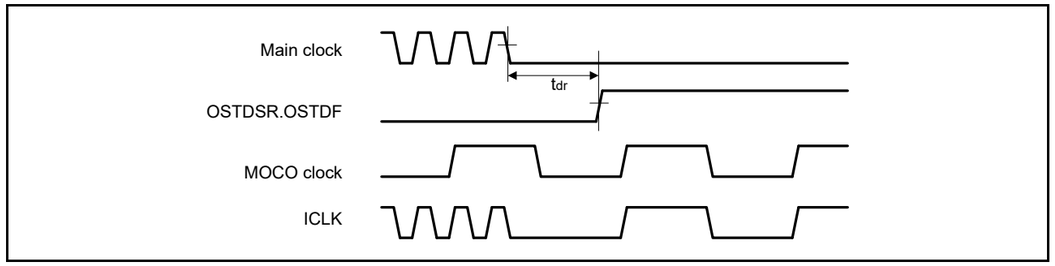

Figure 43.44 Oscillation stop detection timing

43.8 POR and LVD Characteristics

Table 43.34 Power-on reset circuit and voltage detection circuit characteristics

Parameter			Symbol	Min	Typ	Max	Unit	Test conditions
Voltage detection level	Power-on reset (POR)	DPSBYCR.DEEPCUT[1:0] = 00b or 01b	V_{POR}	2.5	2.6	2.7	V	Figure 43.45
		DPSBYCR.DEEPCUT[1:0] = 11b		1.8	2.25	2.7		
	Voltage detection circuit (LVD0)		V_{det0_1}	2.84	2.94	3.04		Figure 43.46
			V_{det0_2}	2.77	2.87	2.97		
			V_{det0_3}	2.70	2.80	2.90		
	Voltage detection circuit (LVD1)		V_{det1_1}	2.89	2.99	3.09		Figure 43.47
			V_{det1_2}	2.82	2.92	3.02		
			V_{det1_3}	2.75	2.85	2.95		
	Voltage detection circuit (LVD2)		V_{det2_1}	2.89	2.99	3.09		Figure 43.48
			V_{det2_2}	2.82	2.92	3.02		
			V_{det2_3}	2.75	2.85	2.95		
Internal reset time	Power-on reset time		t_{POR}	-	4.5	-	ms	Figure 43.45
	LVD0 reset time		t_{LVD0}	-	0.51	-		Figure 43.46
	LVD1 reset time		t_{LVD1}	-	0.38	-		Figure 43.47
	LVD2 reset time		t_{LVD2}	-	0.38	-		Figure 43.48
Minimum VCC down time*1			t_{VOFF}	200	-	-	µs	Figure 43.45, Figure 43.46
Response delay			t_{det}	-	-	200	µs	Figure 43.45 to Figure 43.48
LVD operation stabilization time (after LVD is enabled)			$t_{d(E-A)}$	-	-	10	µs	Figure 43.47, Figure 43.48
Hysteresis width (LVD1 and LVD2)			V_{LVH}	-	70	-	mV	

Note 1. The minimum VCC down time indicates the time when VCC is below the minimum value of voltage detection levels V_{POR}, V_{det1}, and V_{det2} for POR and LVD.

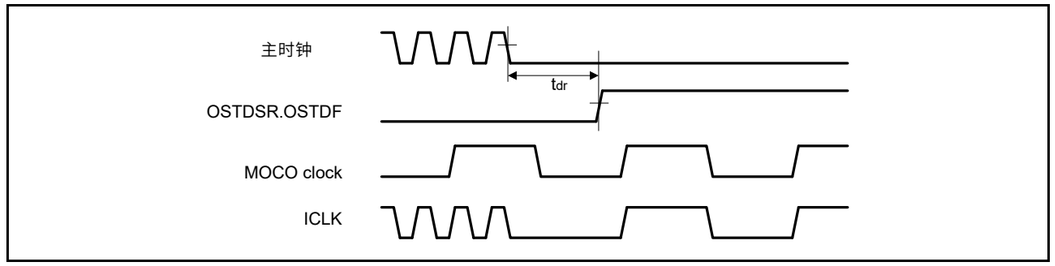

Figure 43.44 振荡停止检测时机

43.8 POR和LVD特性

Table 43.34 上电复位电路及电压检测电路特性

Parameter			Symbol	Min	Typ	Max	Unit	测试条件
电压检测电平	Power-on reset (POR)	DPSBYCR.DEEPCUT[1:0] = 00b or 01b	V_{POR}	2.5	2.6	2.7	V	Figure 43.45
		DPSBYCR.DEEPCUT[1:0] = 11b		1.8	2.25	2.7		
	电压检测电路（LVD0）		V_{det0_1}	2.84	2.94	3.04		Figure 43.46
			V_{det0_2}	2.77	2.87	2.97		
			V_{det0_3}	2.70	2.80	2.90		
	电压检测电路（LVD1）		V_{det1_1}	2.89	2.99	3.09		Figure 43.47
			V_{det1_2}	2.82	2.92	3.02		
			V_{det1_3}	2.75	2.85	2.95		
	电压检测电路（LVD2）		V_{det2_1}	2.89	2.99	3.09		Figure 43.48
			V_{det2_2}	2.82	2.92	3.02		
			V_{det2_3}	2.75	2.85	2.95		
内部复位时间	上电复位时间		t_{POR}	-	4.5	-	ms	Figure 43.45
	LVD0复位时间		t_{LVD0}	-	0.51	-		Figure 43.46
	LVD1复位时间		t_{LVD1}	-	0.38	-		Figure 43.47
	LVD2复位时间		t_{LVD2}	-	0.38	-		Figure 43.48
最短VCC停机时间*1			t_{VOFF}	200	-	-	µs	Figure 43.45, Figure 43.46
响应延迟			t_{det}	-	-	200	µs	图43.45至图43.48
LVD操作稳定时间（启用LVD后）			$t_{d(E-A)}$	-	-	10	µs	Figure 43.47, Figure 43.48
迟滞宽度（LVD1和LVD2）			V_{LVH}	-	70	-	mV	

Note 1. 最小VCC停机时间表示VCC低于电压检测电平VPOR的最小值的时间，Vdet1和Vdet2用于POR和LVD。

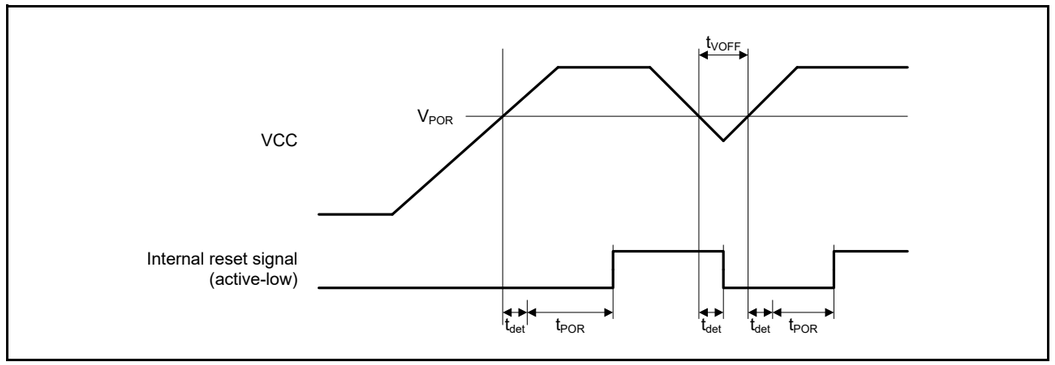

Figure 43.45 Power-on reset timing

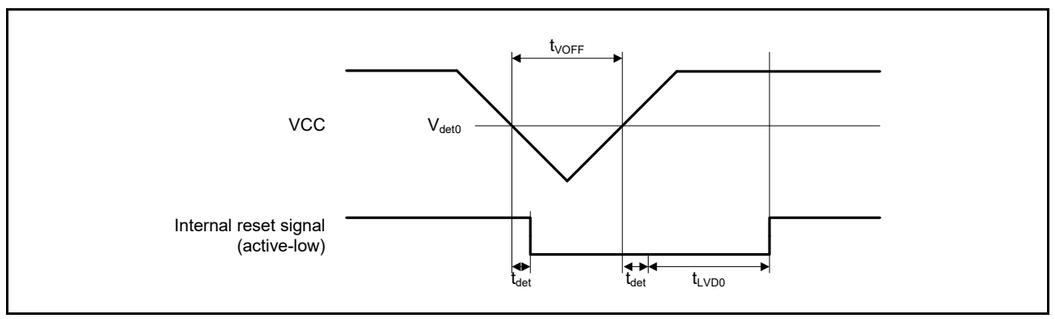

Figure 43.46 Voltage detection circuit timing (V_{det0})

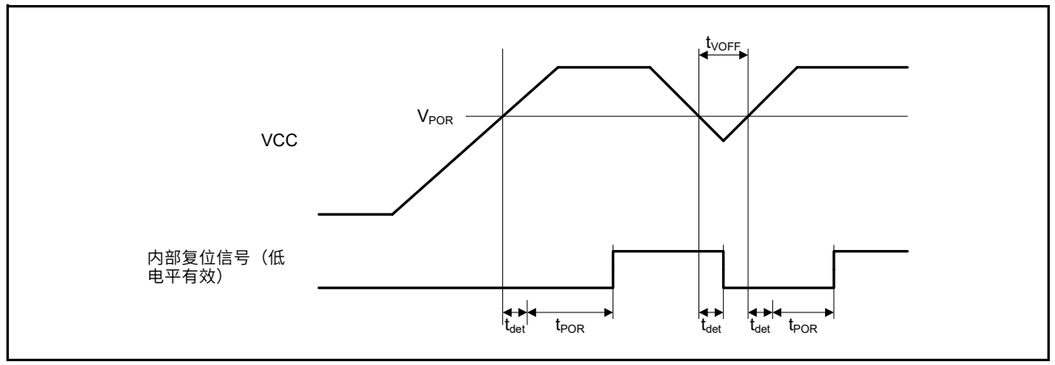

Figure 43.45 上电复位时序

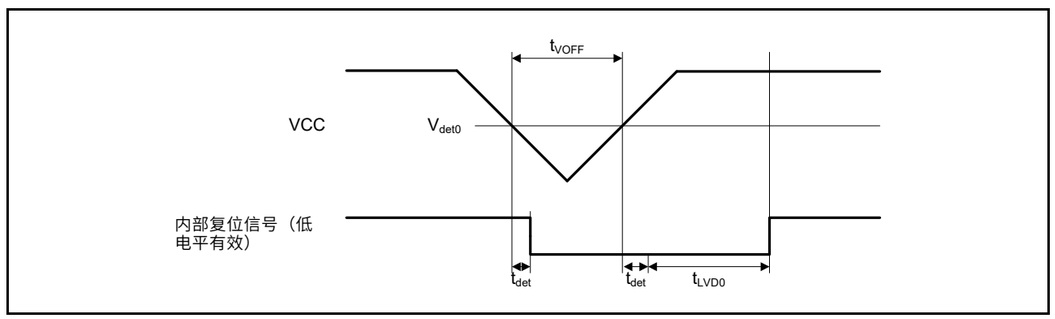

Figure 43.46 电压检测电路时序（Vdet0）

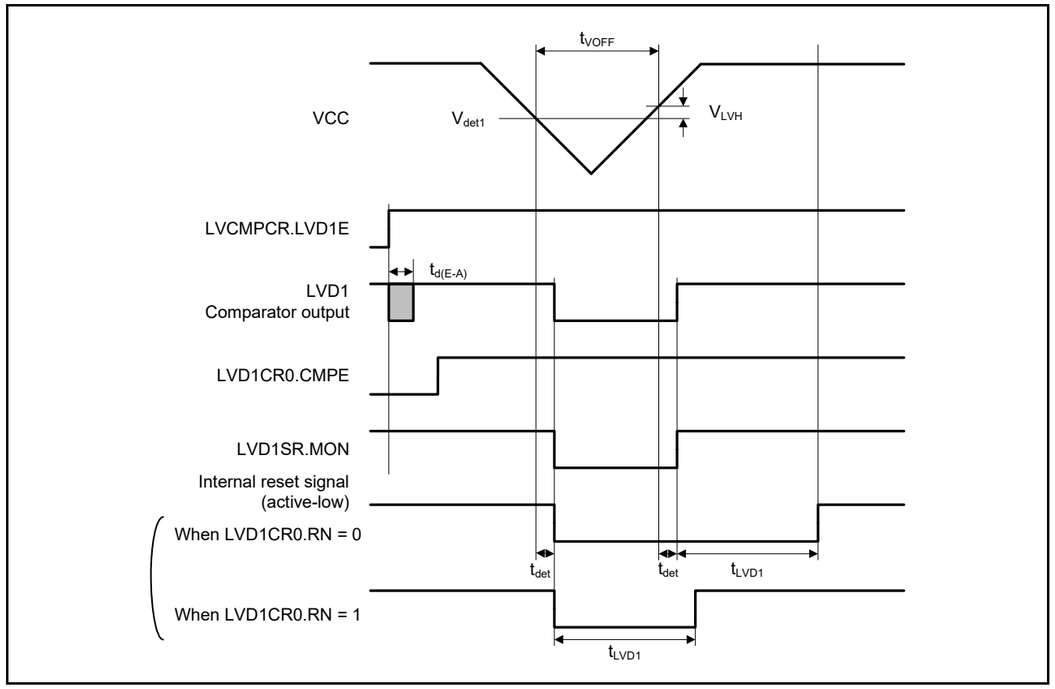

Figure 43.47 Voltage detection circuit timing (V_{det1})

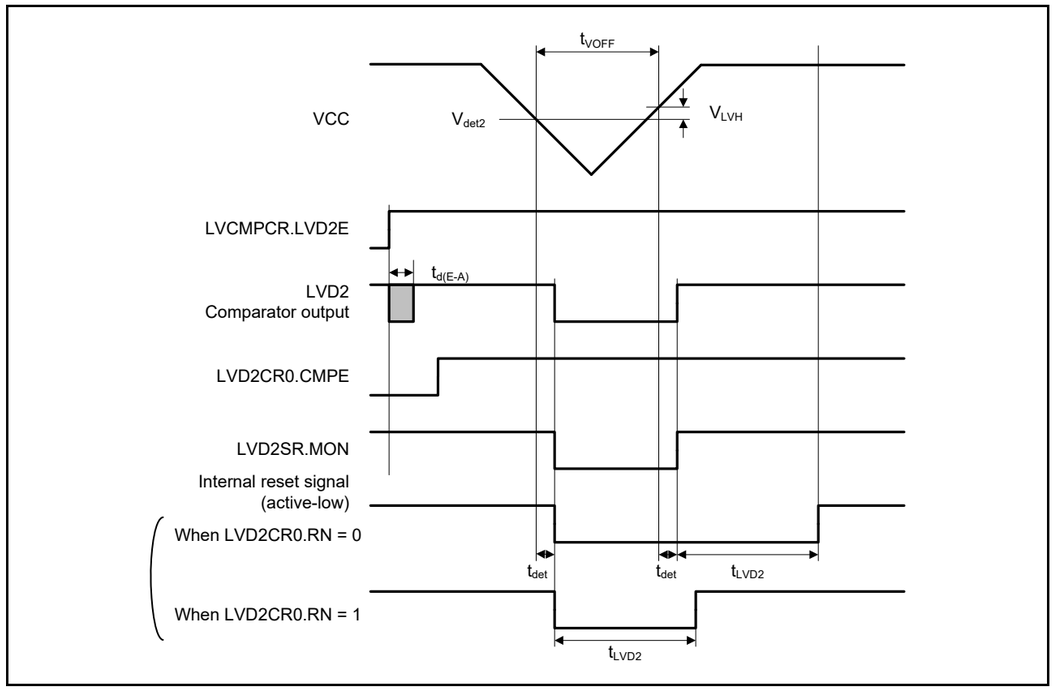

Figure 43.48 Voltage detection circuit timing (V_{det2})

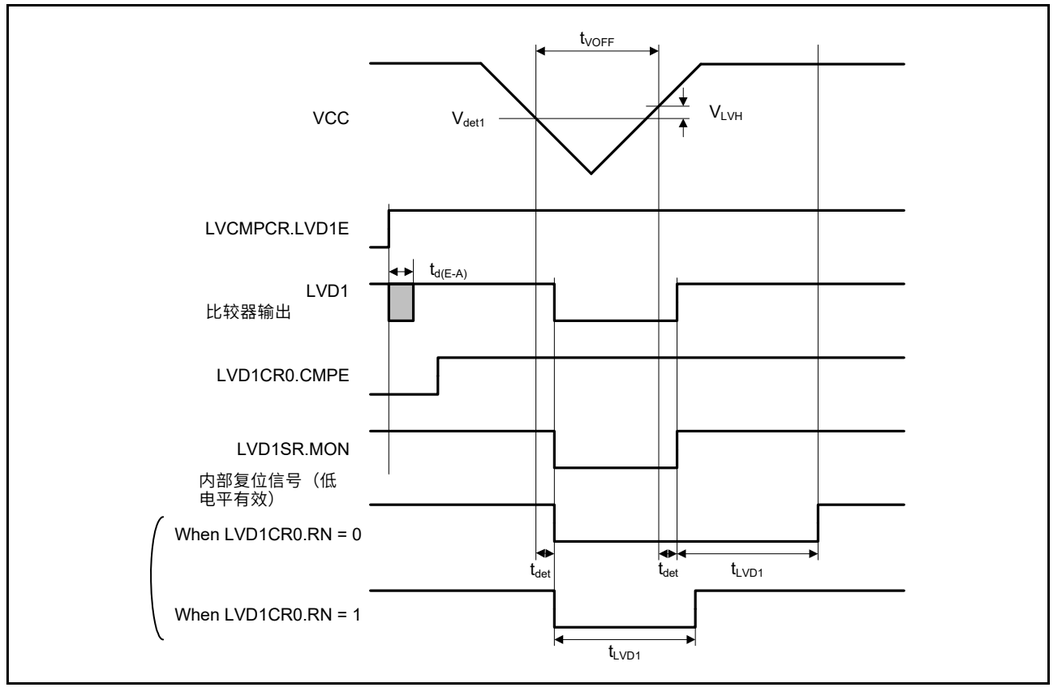

Figure 43.47 电压检测电路时序（Vdet1）

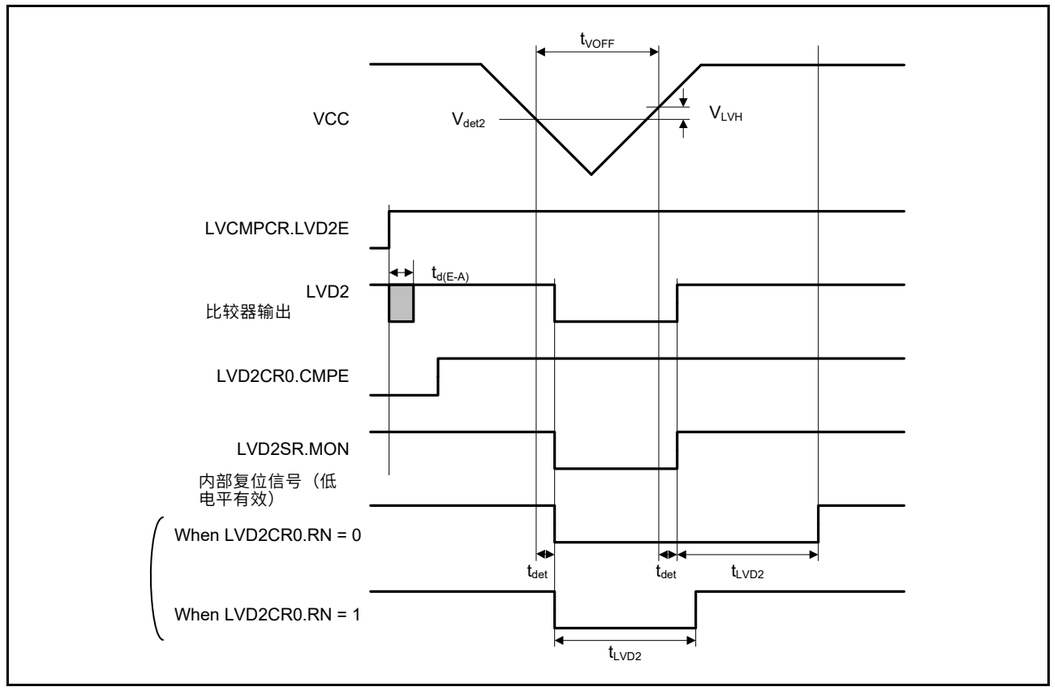

Figure 43.48 电压检测电路时序（Vdet2）

43.9 ACMPHS Characteristics

Table 43.35 ACMPHS characteristics

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
Reference voltage range	VREF	0	-	AVCC0	V	-
Input voltage range	VI	0	-	AVCC0	V	-
Output delay*1	Td	-	50	100	ns	VI = VREF ± 100 mV
Internal reference voltage	Vref	1.13	1.18	1.23	V	-

Note 1. This value is the internal propagation delay.

43.10 PGA Characteristics

Table 43.36 PGA characteristics in single mode

Parameter	Symbol	Min	Typ	Max	Unit
PGAVSS input voltage range	PGAVSS	0	-	0	V
	AIN0 (G = 2.000)	0.050 × AVCC0	-	0.45 × AVCC0	V
	AIN1 (G = 2.500)	0.047 × AVCC0	-	0.360 × AVCC0	V
	AIN2 (G = 2.667)	0.046 × AVCC0	-	0.337 × AVCC0	V
	AIN3 (G = 2.857)	0.046 × AVCC0	-	0.32 × AVCC0	V
	AIN4 (G = 3.077)	0.045 × AVCC0	-	0.292 × AVCC0	V
	AIN5 (G = 3.333)	0.044 × AVCC0	-	0.265 × AVCC0	V
	AIN6 (G = 3.636)	0.042 × AVCC0	-	0.247 × AVCC0	V
	AIN7 (G = 4.000)	0.040 × AVCC0	-	0.212 × AVCC0	V
	AIN8 (G = 4.444)	0.036 × AVCC0	-	0.191 × AVCC0	V
	AIN9 (G = 5.000)	0.033 × AVCC0	-	0.17 × AVCC0	V
	AIN10 (G = 5.714)	0.031 × AVCC0	-	0.148 × AVCC0	V
	AIN11 (G = 6.667)	0.029 × AVCC0	-	0.127 × AVCC0	V
	AIN12 (G = 8.000)	0.027 × AVCC0	-	0.09 × AVCC0	V
	AIN13 (G = 10.000)	0.025 × AVCC0	-	0.08 × AVCC0	V
	AIN14 (G = 13.333)	0.023 × AVCC0	-	0.06 × AVCC0	V
Gain error	Gerr0 (G = 2.000)	-1.0	-	1.0	%
	Gerr1 (G = 2.500)	-1.0	-	1.0	%
	Gerr2 (G = 2.667)	-1.0	-	1.0	%
	Gerr3 (G = 2.857)	-1.0	-	1.0	%
	Gerr4 (G = 3.077)	-1.0	-	1.0	%
	Gerr5 (G = 3.333)	-1.5	-	1.5	%
	Gerr6 (G = 3.636)	-1.5	-	1.5	%
	Gerr7 (G = 4.000)	-1.5	-	1.5	%
	Gerr8 (G = 4.444)	-2.0	-	2.0	%
	Gerr9 (G = 5.000)	-2.0	-	2.0	%
	Gerr10 (G = 5.714)	-2.0	-	2.0	%
	Gerr11 (G = 6.667)	-2.0	-	2.0	%
	Gerr12 (G = 8.000)	-2.0	-	2.0	%
	Gerr13 (G = 10.000)	-2.0	-	2.0	%
	Gerr14 (G = 13.333)	-2.0	-	2.0	%
Offset error	Voff	-8	-	8	mV

43.9 ACMPHS Characteristics

Table 43.35 ACMPHS characteristics

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
参考电压范围	VREF	0	-	AVCC0	V	-
输入电压范围	VI	0	-	AVCC0	V	-
Output delay*1	Td	-	50	100	ns	VI = VREF ± 100 mV
内部参考电压	Vref	1.13	1.18	1.23	V	-

Note 1. 该值是内部传播延迟。

43.10 PGA特性

Table 43.36 单模PGA特性

Parameter	Symbol	Min	Typ	Max	Unit
PGAVSS输入电压范围	PGAVSS	0	-	0	V
	AIN0 (G = 2.000)	0.050 × AVCC0	-	0.45 × AVCC0	V
	AIN1 (G = 2.500)	0.047 × AVCC0	-	0.360 × AVCC0	V
	AIN2 (G = 2.667)	0.046 × AVCC0	-	0.337 × AVCC0	V
	AIN3 (G = 2.857)	0.046 × AVCC0	-	0.32 × AVCC0	V
	AIN4 (G = 3.077)	0.045 × AVCC0	-	0.292 × AVCC0	V
	AIN5 (G = 3.333)	0.044 × AVCC0	-	0.265 × AVCC0	V
	AIN6 (G = 3.636)	0.042 × AVCC0	-	0.247 × AVCC0	V
	AIN7 (G = 4.000)	0.040 × AVCC0	-	0.212 × AVCC0	V
	AIN8 (G = 4.444)	0.036 × AVCC0	-	0.191 × AVCC0	V
	AIN9 (G = 5.000)	0.033 × AVCC0	-	0.17 × AVCC0	V
	AIN10 (G = 5.714)	0.031 × AVCC0	-	0.148 × AVCC0	V
	AIN11 (G = 6.667)	0.029 × AVCC0	-	0.127 × AVCC0	V
	AIN12 (G = 8.000)	0.027 × AVCC0	-	0.09 × AVCC0	V
	AIN13 (G = 10.000)	0.025 × AVCC0	-	0.08 × AVCC0	V
	AIN14 (G = 13.333)	0.023 × AVCC0	-	0.06 × AVCC0	V
增益误差	Gerr0 (G = 2.000)	-1.0	-	1.0	%
	Gerr1 (G = 2.500)	-1.0	-	1.0	%
	Gerr2 (G = 2.667)	-1.0	-	1.0	%
	Gerr3 (G = 2.857)	-1.0	-	1.0	%
	Gerr4 (G = 3.077)	-1.0	-	1.0	%
	Gerr5 (G = 3.333)	-1.5	-	1.5	%
	Gerr6 (G = 3.636)	-1.5	-	1.5	%
	Gerr7 (G = 4.000)	-1.5	-	1.5	%
	Gerr8 (G = 4.444)	-2.0	-	2.0	%
	Gerr9 (G = 5.000)	-2.0	-	2.0	%
	Gerr10 (G = 5.714)	-2.0	-	2.0	%
	Gerr11 (G = 6.667)	-2.0	-	2.0	%
	Gerr12 (G = 8.000)	-2.0	-	2.0	%
	Gerr13 (G = 10.000)	-2.0	-	2.0	%
	Gerr14 (G = 13.333)	-2.0	-	2.0	%
偏移误差	Voff	-8	-	8	mV

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Table 43.37 PGA characteristics in pseudo-differential mode

Parameter		Symbol	Min	Typ	Max	Unit
PGAVSS input voltage range		PGAVSS	-0.5	-	0.3	V
Pseudo-differential input voltage range	G = 1.500	AIN-PGAVSS	-0.5	-	0.5	V
	G = 2.333		-0.4	-	0.4	V
	G = 4.000		-0.2	-	0.2	V
	G = 5.667		-0.15	-	0.15	V
Gain error	G = 1.500	Gerr	-1.0	-	1.0	%
	G = 2.333		-1.0	-	1.0	
	G = 4.000		-1.0	-	1.0	
	G = 5.667		-1.0	-	1.0	

43.11 Flash Memory Characteristics

43.11.1 Code Flash Memory Characteristics

Table 43.38 Code flash memory characteristics
Conditions: Program or erase: FCLK = 4 to 60 MHz
Read: FCLK ≤ 60 MHz

Parameter		Symbol	FCLK = 4 MHz			20 MHz ≤ FCLK ≤ 60 MHz			Unit	Test conditions
			Min	Typ	Max	Min	Typ	Max		
Programming time N_{PEC} ≤ 100 times	128-byte	t_{P128}	-	0.75	13.2	-	0.34	6.0	ms	
	8-KB	t_{P8K}	-	49	176	-	22	80	ms	
	32-KB	t_{P32K}	-	194	704	-	88	320	ms	
Programming time N_{PEC} > 100 times	128-byte	t_{P128}	-	0.91	15.8	-	0.41	7.2	ms	
	8-KB	t_{P8K}	-	60	212	-	27	96	ms	
	32-KB	t_{P32K}	-	234	848	-	106	384	ms	
Erasure time N_{PEC} ≤ 100 times	8-KB	t_{E8K}	-	78	216	-	43	120	ms	
	32-KB	t_{E32K}	-	283	864	-	157	480	ms	
Erasure time N_{PEC} > 100 times	8-KB	t_{E8K}	-	94	260	-	52	144	ms	
	32-KB	t_{E32K}	-	341	1040	-	189	576	ms	
Reprogramming/erasure cycle*4		N_{PEC}	10000*1	-	-	10000*1	-	-	Times	
Suspend delay during programming		t_{SPD}	-	-	264	-	-	120	µs	
First suspend delay during erasure in suspend priority mode		t_{SESD1}	-	-	216	-	-	120	µs	
Second suspend delay during erasure in suspend priority mode		t_{SESD2}	-	-	1.7	-	-	1.7	ms	
Suspend delay during erasure in erasure priority mode		t_{SEED}	-	-	1.7	-	-	1.7	ms	
Forced stop command		t_{FD}	-	-	32	-	-	20	µs	
Data hold time*2		t_{DRP}	10*2, *3	-	-	10*2, *3	-	-	Years	
			30*2, *3	-	-	30*2, *3	-	-		Ta = +85°C

Note 1. This is the minimum number of times to guarantee all the characteristics after reprogramming. The guaranteed range is from 1 to the minimum value.
Note 2. This indicates the minimum value of the characteristic when reprogramming is performed within the specified range.
Note 3. This result is obtained from reliability testing.
Note 4. The reprogram/erase cycle is the number of erasures for each block. When the reprogram/erase cycle is n times (n = 10000), erasing can be performed n times for each block. For example, when 128-byte programming is performed 64 times for different addresses in 8-KB blocks, and then the entire block is erased, the reprogram/erase cycle is counted as one. However, programming the same address several times as one erasure is not enabled. Overwriting is prohibited.

Table 43.37 伪差分模式下的PGA特性

Parameter		Symbol	Min	Typ	Max	Unit
PGAVSS输入电压范围		PGAVSS	-0.5	-	0.3	V
伪差分输入电压范围	G = 1.500	AIN-PGAVSS	-0.5	-	0.5	V
	G = 2.333		-0.4	-	0.4	V
	G = 4.000		-0.2	-	0.2	V
	G = 5.667		-0.15	-	0.15	V
增益误差	G = 1.500	Gerr	-1.0	-	1.0	%
	G = 2.333		-1.0	-	1.0	
	G = 4.000		-1.0	-	1.0	
	G = 5.667		-1.0	-	1.0	

43.11 闪存特性

43.11.1 代码闪存特性

Table 43.38 代码闪存特性
条件：编程或擦除：FCLK=4至60MHz
Read: FCLK ≤ 60 MHz

Parameter		Symbol	FCLK = 4 MHz			20 MHz ≤ FCLK ≤ 60 MHz			Unit	测试条件
			Min	Typ	Max	Min	Typ	Max		
编程时间NPEC 100次	128-byte	t_{P128}	-	0.75	13.2	-	0.34	6.0	ms	
	8-KB	t_{P8K}	-	49	176	-	22	80	ms	
	32-KB	t_{P32K}	-	194	704	-	88	320	ms	
编程时间NPEC>100次	128-byte	t_{P128}	-	0.91	15.8	-	0.41	7.2	ms	
	8-KB	t_{P8K}	-	60	212	-	27	96	ms	
	32-KB	t_{P32K}	-	234	848	-	106	384	ms	
擦除时间 NPEC 100次	8-KB	t_{E8K}	-	78	216	-	43	120	ms	
	32-KB	t_{E32K}	-	283	864	-	157	480	ms	
擦除时间 NPEC>100次	8-KB	t_{E8K}	-	94	260	-	52	144	ms	
	32-KB	t_{E32K}	-	341	1040	-	189	576	ms	
Reprogramming/erasure cycle*4		N_{PEC}	10000*1	-	-	10000*1	-	-	Times	
编程期间暂停延迟		t_{SPD}	-	-	264	-	-	120	µs	
挂起优先模式下擦除期间的第一个挂起延迟		t_{SESD1}	-	-	216	-	-	120	µs	
挂起优先模式下擦除期间的第二挂起延迟		t_{SESD2}	-	-	1.7	-	-	1.7	ms	
擦除优先模式下擦除期间的挂起延迟		t_{SEED}	-	-	1.7	-	-	1.7	ms	
强制停止命令		t_{FD}	-	-	32	-	-	20	µs	
数据保持时间*2		t_{DRP}	10*2, *3	-	-	10*2, *3	-	-	Years	
			30*2, *3	-	-	30*2, *3	-	-		Ta = +85°C

Note 1. 这是重新编程后保证所有特性的最少次数。保证范围是从1到最小值。
Note 2. 这表示在指定范围内执行重新编程时特性的最小值。
Note 3. 这个结果是从可靠性测试中获得的。
Note 4. 重新编程擦除周期是每个块的擦除次数。当重新编程擦除周期为n次（n=10000）时，可以对每个块执行n次擦除。例如，当对8KB块中的不同地址执行64次128字节编程，然后擦除整个块时，重新编程擦除周期计为1。但是，不能将同一地址多次编程为一次擦除。禁止覆盖。

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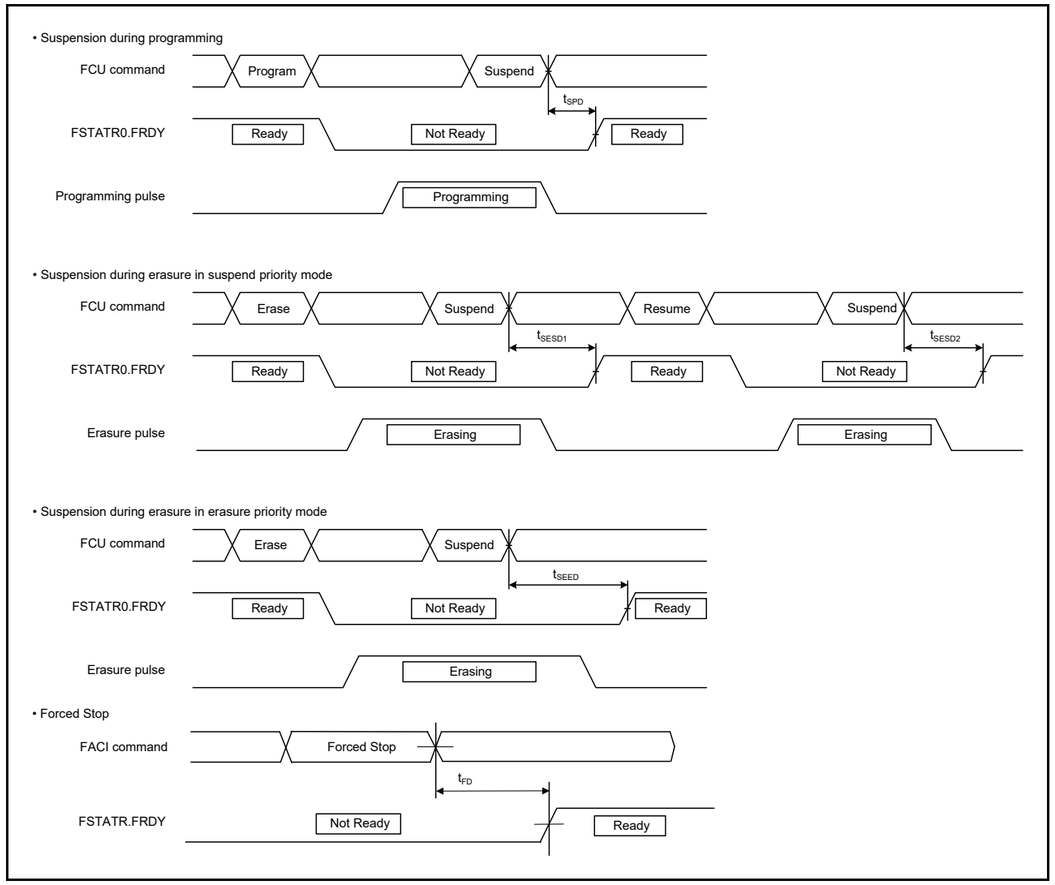

Figure 43.49 Suspension and forced stop timing for flash memory programming and erasure

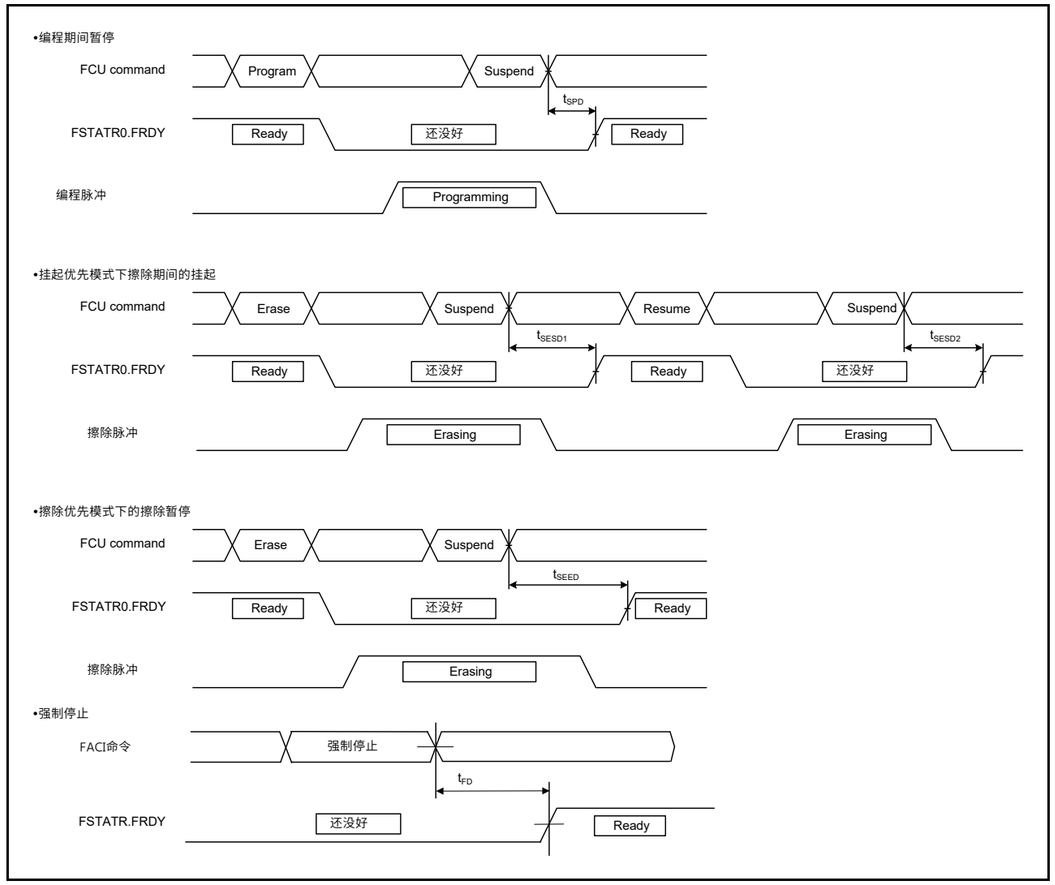

Figure 43.49 闪存编程和擦除的暂停和强制停止时序

43.11.2 Data Flash Memory Characteristics

Table 43.39 Data flash memory characteristics
Conditions: Program or erase: FCLK = 4 to 60 MHz
Read: FCLK ≤ 60 MHz

Parameter		Symbol	FCLK = 4 MHz			20 MHz ≤ FCLK ≤ 60 MHz			Unit	Test conditions
			Min	Typ	Max	Min	Typ	Max		
Programming time	4-byte	t_{DP4}	-	0.36	3.8	-	0.16	1.7	ms	
	8-byte	t_{DP8}	-	0.38	4.0	-	0.17	1.8		
	16-byte	t_{DP16}	-	0.42	4.5	-	0.19	2.0		
Erasure time	64-byte	t_{DE64}	-	3.1	18	-	1.7	10	ms	
	128-byte	t_{DE128}	-	4.7	27	-	2.6	15		
	256-byte	t_{DE256}	-	8.9	50	-	4.9	28		
Blank check time	4-byte	t_{DBC4}	-	-	84	-	-	30	µs	
Reprogramming/erasure cycle*1		N_{DPEC}	125000*2	-	-	125000*2	-	-	-	
Suspend delay during programming	4-byte	t_{DSPD}	-	-	264	-	-	120	µs	
	8-byte		-	-	264	-	-	120		
	16-byte		-	-	264	-	-	120		
First suspend delay during erasure in suspend priority mode	64-byte	t_{DSESD1}	-	-	216	-	-	120	µs	
	128-byte		-	-	216	-	-	120		
	256-byte		-	-	216	-	-	120		
Second suspend delay during erasure in suspend priority mode	64-byte	t_{DSESD2}	-	-	300	-	-	300	µs	
	128-byte		-	-	390	-	-	390		
	256-byte		-	-	570	-	-	570		
Suspend delay during erasing in erasure priority mode	64-byte	t_{DSEED}	-	-	300	-	-	300	µs	
	128-byte		-	-	390	-	-	390		
	256-byte		-	-	570	-	-	570		
Forced stop command		t_{FD}	-	-	32	-	-	20	µs	
Data hold time*3		t_{DRP}	10*3,*4	-	-	10*3,*4	-	-	Year	
			30*3,*4	-	-	30*3,*4	-	-		Ta = +85°C

Note 1. The reprogram/erase cycle is the number of erasures for each block. When the reprogram/erase cycle is n times (n = 125000), erasing can be performed n times for each block. For example, when 4-byte programming is performed 16 times for different addresses in 64-byte blocks, and then the entire block is erased, the reprogram/erase cycle is counted as one. However, programming the same address several times as one erasure is not enabled. Overwriting is prohibited.
Note 2. This is the minimum number of times to guarantee all the characteristics after reprogramming. The guaranteed range is from 1 to the minimum value.
Note 3. This indicates the minimum value of the characteristic when reprogramming is performed within the specified range.
Note 4. This result is obtained from reliability testing.

43.12 Boundary Scan

Table 43.40 Boundary scan characteristics (1 of 2)

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
TCK clock cycle time	t_{TCKcyc}	100	-	-	ns	Figure 43.50
TCK clock high pulse width	t_{TCKH}	45	-	-	ns	
TCK clock low pulse width	t_{TCKL}	45	-	-	ns	
TCK clock rise time	t_{TCKr}	-	-	5	ns	
TCK clock fall time	t_{TCKf}	-	-	5	ns	

43.11.2 数据闪存特性

Table 43.39 数据闪存特性
条件：编程或擦除：FCLK=4至60MHz
Read: FCLK ≤ 60 MHz

Parameter		Symbol	FCLK = 4 MHz			20 MHz ≤ FCLK ≤ 60 MHz			Unit	测试条件
			Min	Typ	Max	Min	Typ	Max		
编程时间	4-byte	t_{DP4}	-	0.36	3.8	-	0.16	1.7	ms	
	8-byte	t_{DP8}	-	0.38	4.0	-	0.17	1.8		
	16-byte	t_{DP16}	-	0.42	4.5	-	0.19	2.0		
擦除时间	64-byte	t_{DE64}	-	3.1	18	-	1.7	10	ms	
	128-byte	t_{DE128}	-	4.7	27	-	2.6	15		
	256-byte	t_{DE256}	-	8.9	50	-	4.9	28		
空白检查时间	4-byte	t_{DBC4}	-	-	84	-	-	30	µs	
Reprogramming/erasure cycle*1		N_{DPEC}	125000*2	-	-	125000*2	-	-	-	
编程期间暂停延迟	4-byte	t_{DSPD}	-	-	264	-	-	120	µs	
	8-byte		-	-	264	-	-	120		
	16-byte		-	-	264	-	-	120		
挂起优先模式下擦除期间的第一个挂起延迟	64-byte	t_{DSESD1}	-	-	216	-	-	120	µs	
	128-byte		-	-	216	-	-	120		
	256-byte		-	-	216	-	-	120		
挂起优先模式下擦除期间的第二挂起延迟	64-byte	t_{DSESD2}	-	-	300	-	-	300	µs	
	128-byte		-	-	390	-	-	390		
	256-byte		-	-	570	-	-	570		
在擦除优先模式下擦除期间暂停延迟	64-byte	t_{DSEED}	-	-	300	-	-	300	µs	
	128-byte		-	-	390	-	-	390		
	256-byte		-	-	570	-	-	570		
强制停止命令		t_{FD}	-	-	32	-	-	20	µs	
数据保持时间*3		t_{DRP}	10*3,*4	-	-	10*3,*4	-	-	Year	
			30*3,*4	-	-	30*3,*4	-	-		Ta = +85°C

Note 1. 重新编程擦除周期是每个块的擦除次数。当重新编程擦除周期为n次（n=125000）时，每个块可以执行n次擦除。例如，当对64字节块中的不同地址执行16次4字节编程，然后擦除整个块时，重新编程擦除周期计为1。但是，不能将同一地址多次编程为一次擦除。禁止覆盖。

Note 2. 这是重新编程后保证所有特性的最少次数。保证范围是从1到最小值。

Note 3. 这表示在指定范围内执行重新编程时特性的最小值。
Note 4. 这个结果是从可靠性测试中获得的。

43.12 边界扫描

Table 43.40 边界扫描特征(1of2)

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
TCK时钟周期时间	t_{TCKcyc}	100	-	-	ns	Figure 43.50
TCK时钟高脉冲宽度	t_{TCKH}	45	-	-	ns	
TCK时钟低脉冲宽度	t_{TCKL}	45	-	-	ns	
TCK时钟上升时间	t_{TCKr}	-	-	5	ns	
TCK时钟下降时间	t_{TCKf}	-	-	5	ns	

Table 43.40 Boundary scan characteristics (2 of 2)

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
TMS setup time	t_{TMSS}	20	-	-	ns	Figure 43.51
TMS hold time	t_{TMSH}	20	-	-	ns	
TDI setup time	t_{TDIS}	20	-	-	ns	
TDI hold time	t_{TDIH}	20	-	-	ns	
TDO data delay	t_{TDOD}	-	-	40	ns	
Boundary scan circuit startup time*1	T_{BSSTUP}	t_{RESWP}	-	-	-	Figure 43.52

Note 1. Boundary scan does not function until the power-on reset becomes negative.

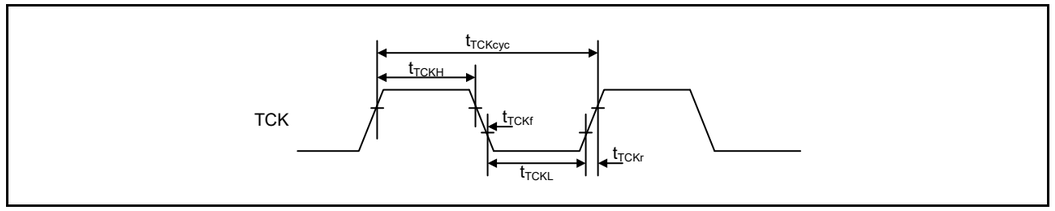

Figure 43.50 Boundary scan TCK timing

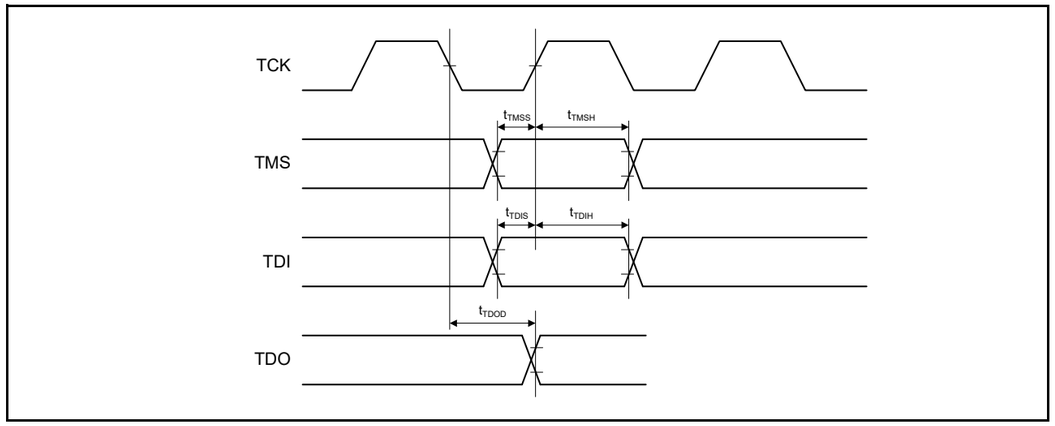

Figure 43.51 Boundary scan input/output timing

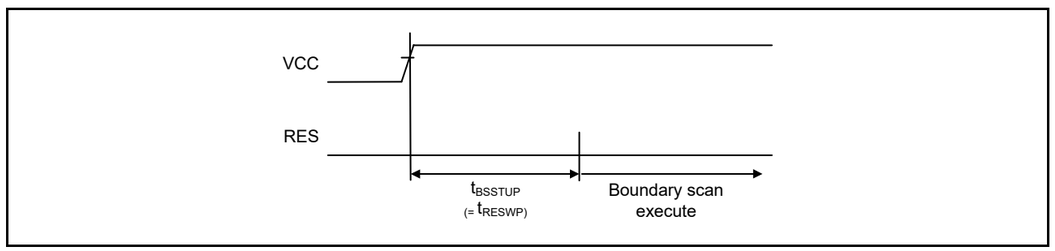

Figure 43.52 Boundary scan circuit startup timing

Table 43.40 边界扫描特征(2of2)

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
TMS设置时间	t_{TMSS}	20	-	-	ns	Figure 43.51
TMS保持时间	t_{TMSH}	20	-	-	ns	
TDI建立时间	t_{TDIS}	20	-	-	ns	
TDI保持时间	t_{TDIH}	20	-	-	ns	
TDO数据延迟	t_{TDOD}	-	-	40	ns	
边界扫描电路启动时间*1	T_{BSSTUP}	t_{RESWP}	-	-	-	Figure 43.52

Note 1. 在上电复位变为负值之前，边界扫描不起作用。

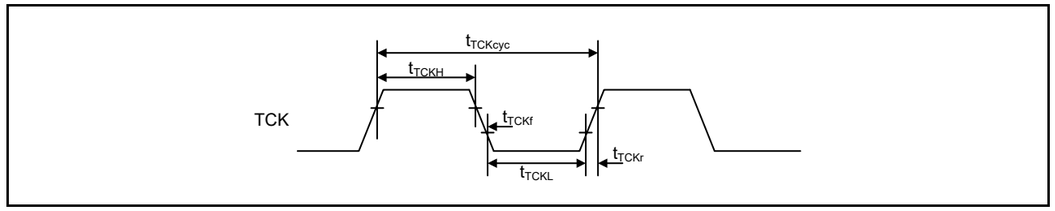

Figure 43.50 边界扫描TCK时序

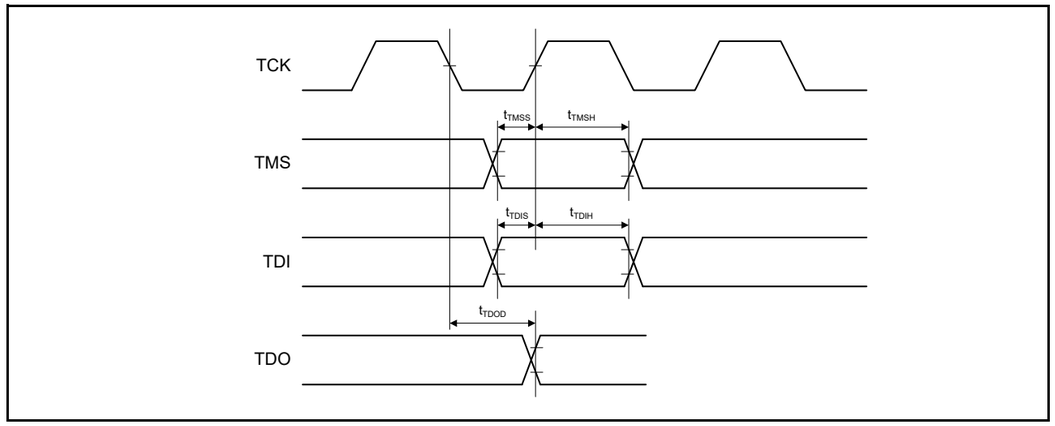

Figure 43.51 边界扫描输入输出时序

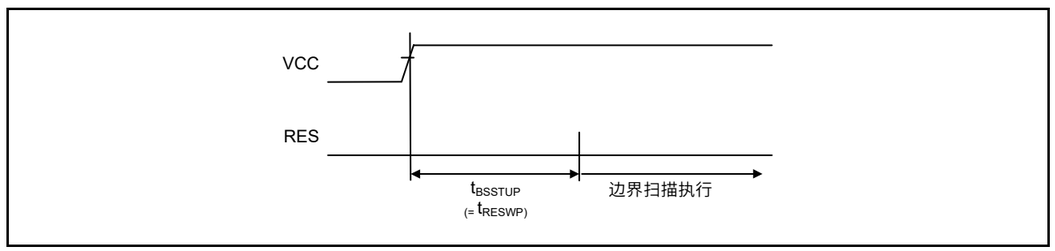

Figure 43.52 边界扫描电路启动时序

43.13 Joint Test Action Group (JTAG)

Table 43.41 JTAG

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
TCK clock cycle time	t_{TCKcyc}	40	-	-	ns	Figure 43.50
TCK clock high pulse width	t_{TCKH}	15	-	-	ns	
TCK clock low pulse width	t_{TCKL}	15	-	-	ns	
TCK clock rise time	t_{TCKr}	-	-	5	ns	
TCK clock fall time	t_{TCKf}	-	-	5	ns	
TMS setup time	t_{TMSS}	8	-	-	ns	Figure 43.51
TMS hold time	t_{TMSH}	8	-	-	ns	
TDI setup time	t_{TDIS}	8	-	-	ns	
TDI hold time	t_{TDIH}	8	-	-	ns	
TDO data delay time	t_{TDOD}	-	-	20	ns	

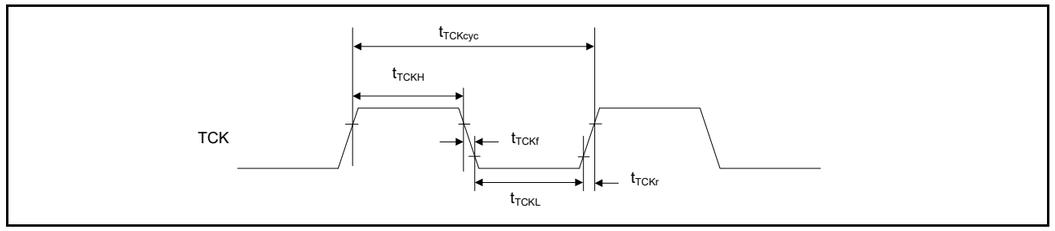

Figure 43.53 JTAG TCK timing

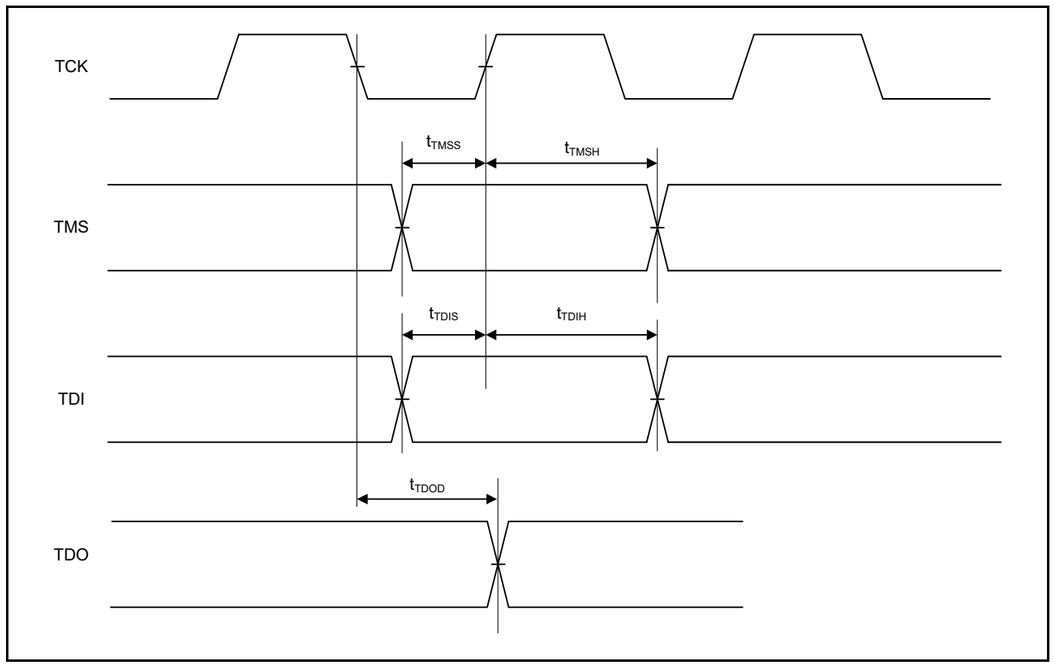

Figure 43.54 JTAG input/output timing

43.13 联合测试行动组(JTAG)

Table 43.41 JTAG

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
TCK时钟周期时间	t_{TCKcyc}	40	-	-	ns	Figure 43.50
TCK时钟高脉冲宽度	t_{TCKH}	15	-	-	ns	
TCK时钟低脉冲宽度	t_{TCKL}	15	-	-	ns	
TCK时钟上升时间	t_{TCKr}	-	-	5	ns	
TCK时钟下降时间	t_{TCKf}	-	-	5	ns	
TMS设置时间	t_{TMSS}	8	-	-	ns	Figure 43.51
TMS保持时间	t_{TMSH}	8	-	-	ns	
TDI建立时间	t_{TDIS}	8	-	-	ns	
TDI保持时间	t_{TDIH}	8	-	-	ns	
TDO数据延迟时间	t_{TDOD}	-	-	20	ns	

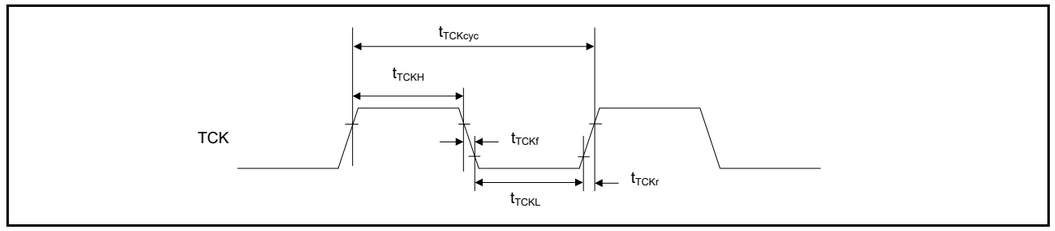

Figure 43.53 JTAG TCK timing

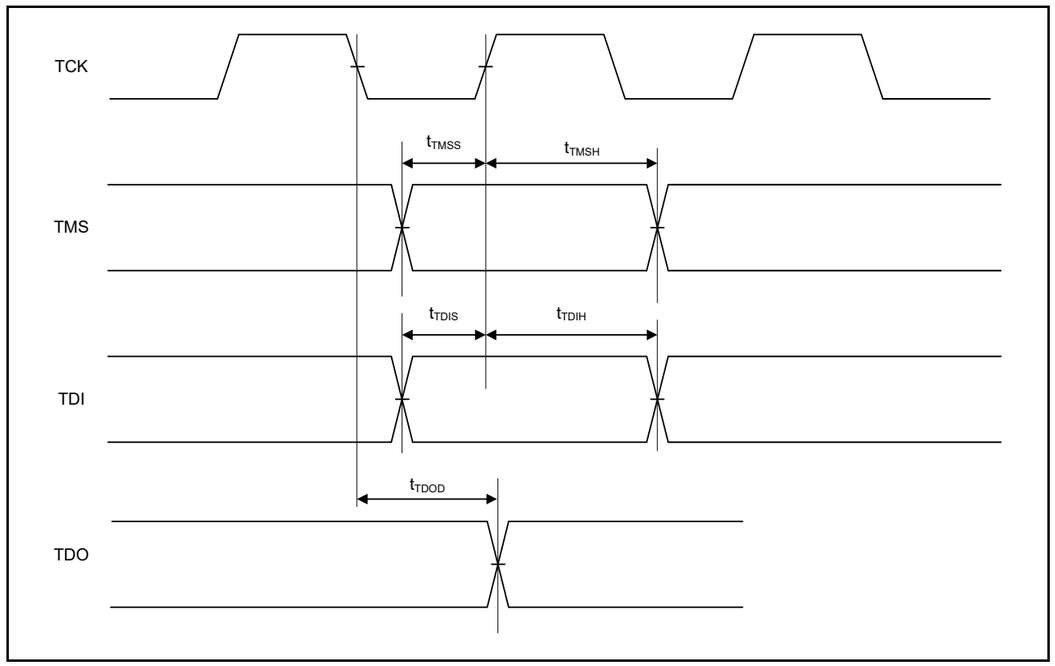

Figure 43.54 JTAG input/output timing

43.14 Serial Wire Debug (SWD)

Table 43.42 SWD

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
SWCLK clock cycle time	$t_{SWCKcyc}$	40	-	-	ns	Figure 43.55
SWCLK clock high pulse width	t_{SWCKH}	15	-	-	ns	
SWCLK clock low pulse width	t_{SWCKL}	15	-	-	ns	
SWCLK clock rise time	t_{SWCKr}	-	-	5	ns	
SWCLK clock fall time	t_{SWCKf}	-	-	5	ns	
SWDIO setup time	t_{SWDS}	8	-	-	ns	Figure 43.56
SWDIO hold time	t_{SWDH}	8	-	-	ns	
SWDIO data delay time	t_{SWDD}	2	-	28	ns	

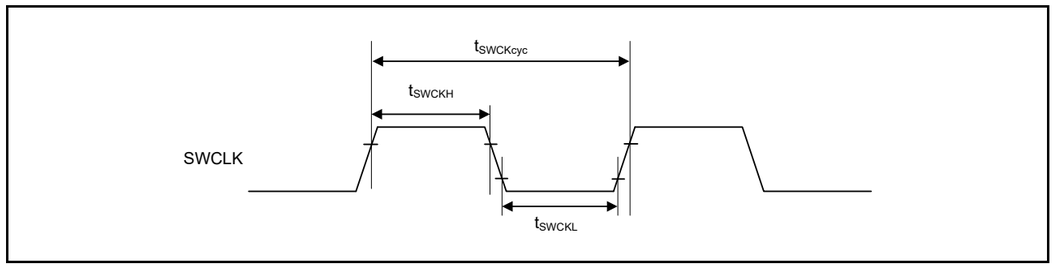

Figure 43.55 SWD SWCLK timing

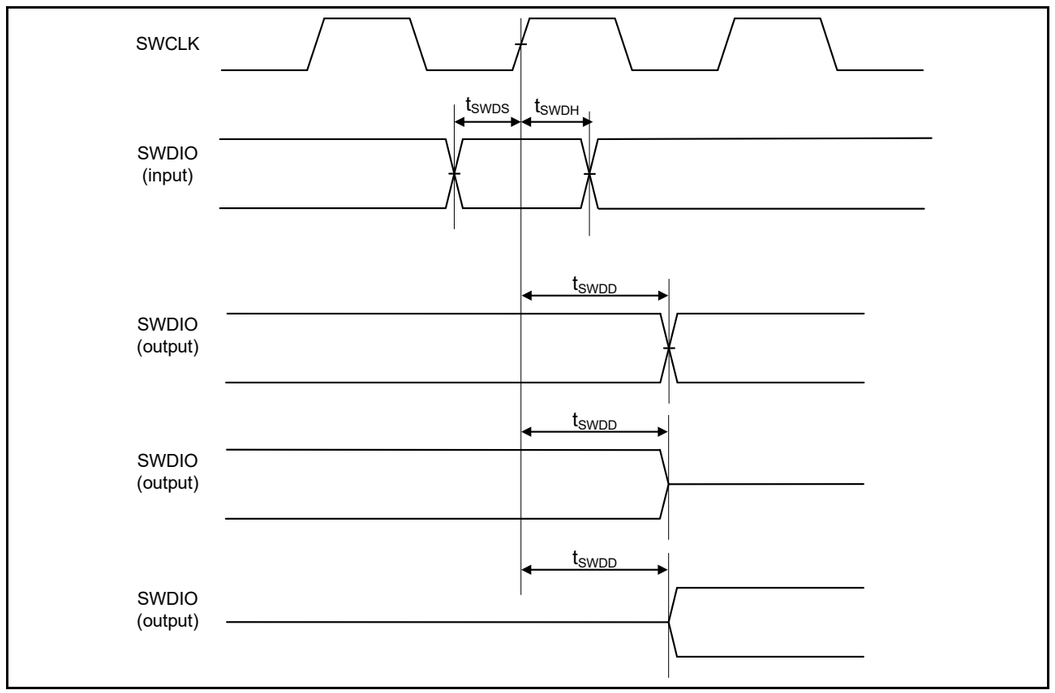

Figure 43.56 SWD input/output timing

43.14 串行线调试(SWD)

Table 43.42 SWD

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
SWCLK时钟周期时间	$t_{SWCKcyc}$	40	-	-	ns	Figure 43.55
SWCLK时钟高脉冲宽度	t_{SWCKH}	15	-	-	ns	
SWCLK时钟低脉冲宽度	t_{SWCKL}	15	-	-	ns	
SWCLK时钟上升时间	t_{SWCKr}	-	-	5	ns	
SWCLK时钟下降时间	t_{SWCKf}	-	-	5	ns	
SWDIO设置时间	t_{SWDS}	8	-	-	ns	Figure 43.56
SWDIO保持时间	t_{SWDH}	8	-	-	ns	
SWDIO数据延迟时间	t_{SWDD}	2	-	28	ns	

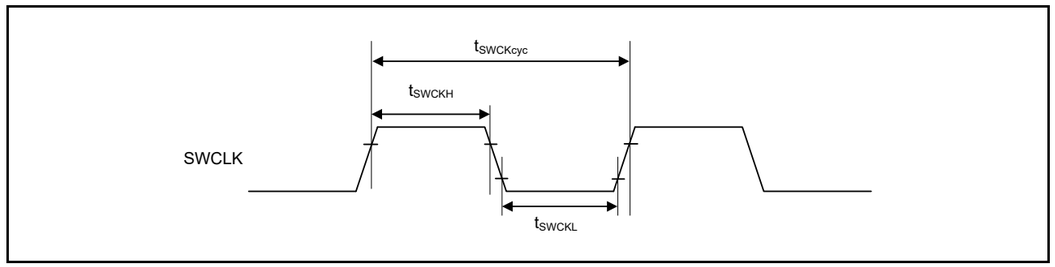

Figure 43.55 SWD SWCLK timing

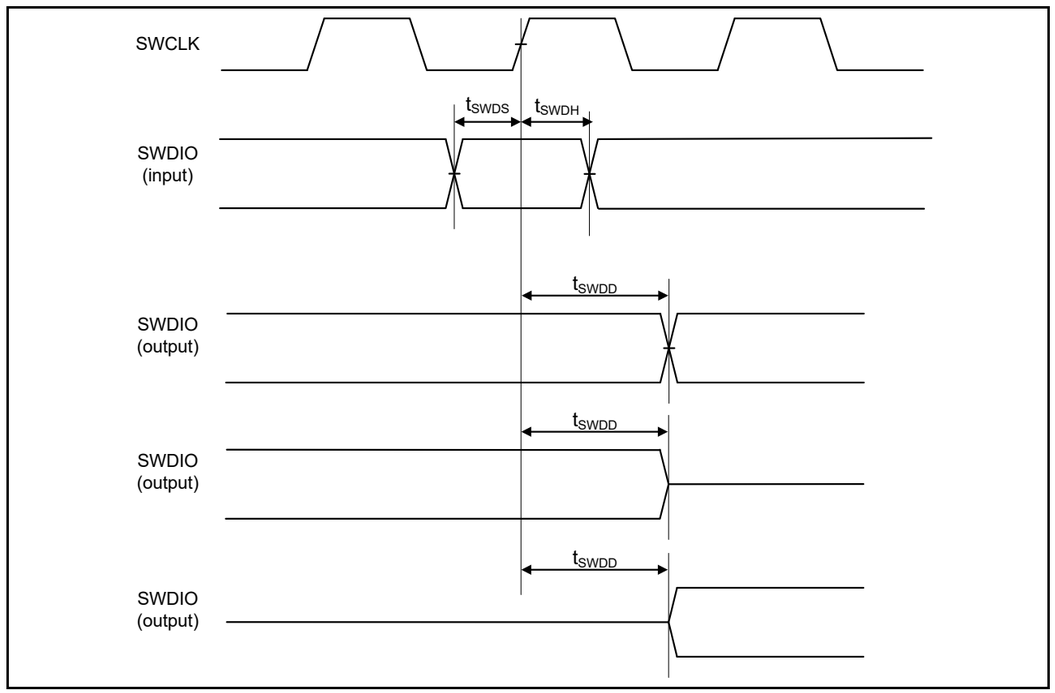

Figure 43.56 SWD input/output timing

43.15 Embedded Trace Macro Interface (ETM)

Table 43.43 ETM
Conditions: High drive output is selected in the Port Drive Capability bit in the PmnPFS register.

Parameter	Symbol	Min	Typ	Max	Unit	Test conditions
TCLK clock cycle time	$t_{TCLKcyc}$	33.3	-	-	ns	Figure 43.57
TCLK clock high pulse width	t_{TCLKH}	13.6	-	-	ns	
TCLK clock low pulse width	t_{TCLKL}	13.6	-	-	ns	
TCLK clock rise time	t_{TCLKr}	-	-	3	ns	
TCLK clock fall time	t_{TCLKf}	-	-	3	ns	
TDATA[3:0] output setup time	t_{TRDS}	3.5	-	-	ns	Figure 43.58
TDATA[3:0] output hold time	t_{TRDH}	2.5	-	-	ns	

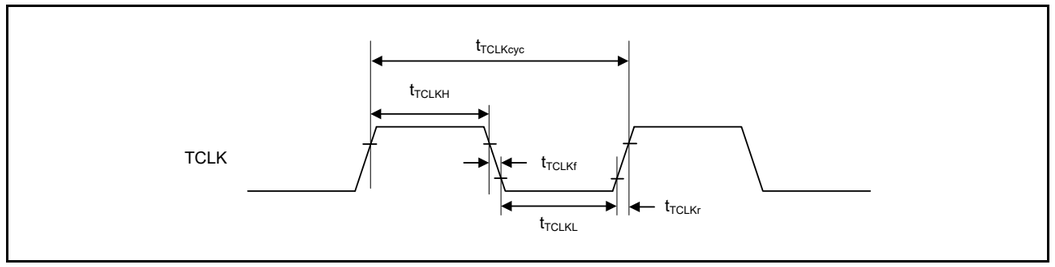

Figure 43.57 ETM TCLK timing

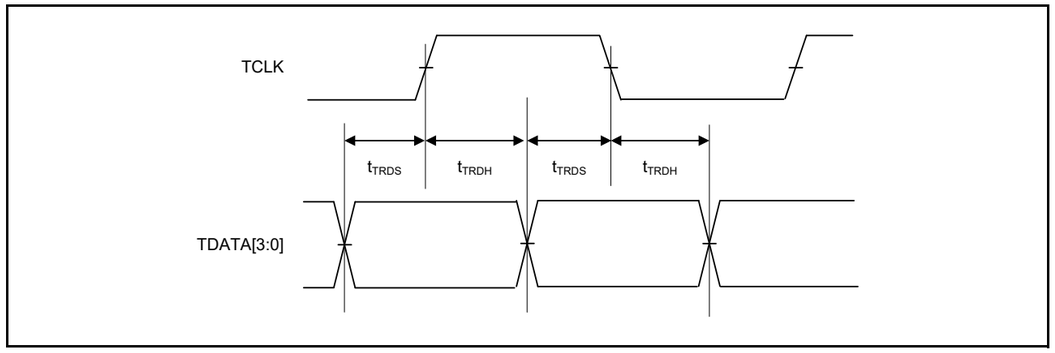

Figure 43.58 ETM output timing

43.15 嵌入式跟踪宏接口(ETM)

Table 43.43 ETM
条件：在PmnPFS寄存器的端口驱动能力位中选择高驱动输出。

Parameter	Symbol	Min	Typ	Max	Unit	测试条件
TCLK时钟周期时间	$t_{TCLKcyc}$	33.3	-	-	ns	Figure 43.57
TCLK时钟高脉冲宽度	t_{TCLKH}	13.6	-	-	ns	
TCLK时钟低脉冲宽度	t_{TCLKL}	13.6	-	-	ns	
TCLK时钟上升时间	t_{TCLKr}	-	-	3	ns	
TCLK时钟下降时间	t_{TCLKf}	-	-	3	ns	
TDATA[3:0]输出建立时间	t_{TRDS}	3.5	-	-	ns	Figure 43.58
TDATA[3:0]输出保持时间	t_{TRDH}	2.5	-	-	ns	

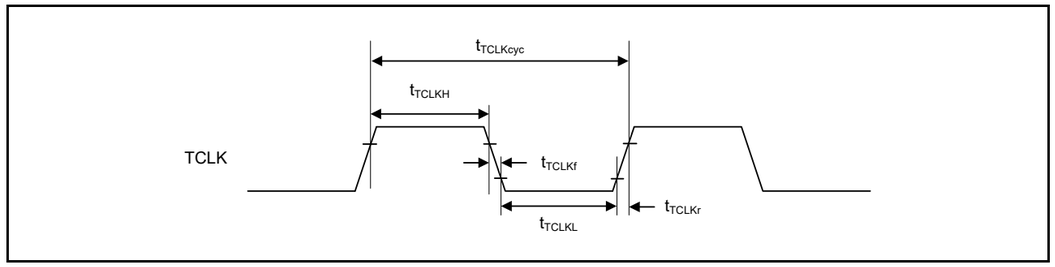

Figure 43.57 ETM TCLK timing

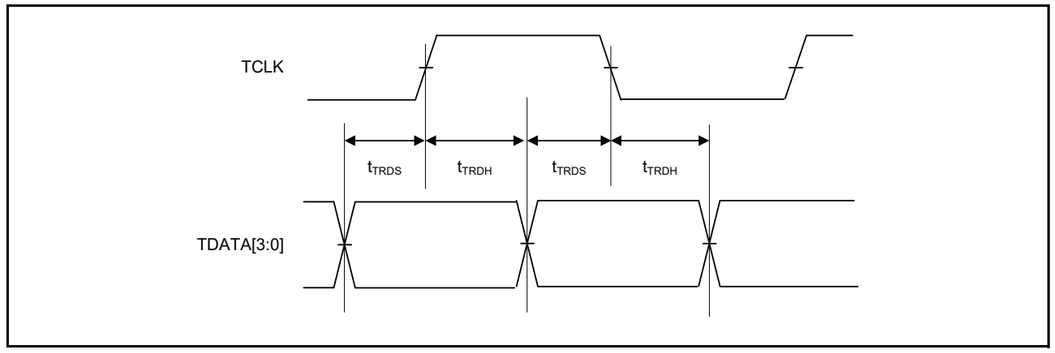

Figure 43.58 ETM输出时序

Appendix 1. Port States in Each Processing Mode

Table 1.1 Port states in each processing state (1 of 3)

Port name	Reset	Software Standby mode		Deep SoftwareStandby mode	After Deep Software Standby mode is canceled (return to startup mode)	
		OPE = 0	OPE = 1		IOKEEP = 0	IOKEEP = 1*1
P000/IRQ6-DS, P001/IRQ7-DS, P002/IRQ8-DS	Hi-Z	Hi-Z*2		Keep-O*3	Hi-Z	Keep
P003	Hi-Z	Hi-Z		Keep	Hi-Z	Keep
P004/IRQ9-DS, P005/IRQ10-DS, P006/IRQ11-DS	Hi-Z	Hi-Z*2		Keep-O*3	Hi-Z	Keep
P007	Hi-Z	Hi-Z		Keep	Hi-Z	Keep
P008/IRQ12-DS	Hi-Z	Keep-O*2		Keep-O*3	Hi-Z	Keep
P014/DA0	Hi-Z	[DA0 output (DAOE0 = 1)] D/A output retained [All other (DAOE0 = 0)] Keep-O		Keep	Hi-Z	Keep
P015/IRQ13/DA1	Hi-Z	[DA1 output (DAOE1 = 1)] D/A output retained [All other (DAOE1 = 0)] Keep-O*2		Keep	Hi-Z	Keep
P100/D00[A00/D00]/KR00/ AGTIO0/RXD0/IRQ2	Hi-Z	[D00 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P101/D01[A01/D01]/KR01/IRQ1	Hi-Z	[D01 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P102/D02[A02/D02]/KR02	Hi-Z	[D02 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P103/D03[A03/D03]/KR03	Hi-Z	[D03 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P104/D04[A04/D04]/KR04/IRQ1	Hi-Z	[D04 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P105/D05[A05/D05]/KR05/IRQ0	Hi-Z	[D05 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P106/D06[A06/D06]/KR06	Hi-Z	[D06 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P107/D07[A07/D07]/KR07	Hi-Z	[D07 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P108/TMS	Pull-up	Keep-O		Keep	Pull-up	Keep
P109/TDO/CLKOUT	TDO output	[CLKOUT selected] CLKOUT output [All other] Keep-O		[TDO output] TDO output retained [All other] Keep	[TDO output] TDO output retained [All other] Hi-Z	[TDO output] TDO output retained [All other] Keep
P110/IRQ3/TDI/VCOUT	Pull-up	[ACMPHS selected] VCOUT output [All other] Keep-O*2		Keep	Pull-up	Keep
P111/A05/IRQ4	Hi-Z	[A05 output] Hi-Z [All other] Keep-O*2	[A05 output] Address output retained [All other] Keep-O*2	Keep	Hi-Z	Keep
P112/A04	Hi-Z	[A04 output] Hi-Z [All other] Keep-O	[A04 output] Address output retained [All other] Keep-O	Keep	Hi-Z	Keep

附录1.每种处理模式下的端口状态

Table 1.1 每个处理状态中的端口状态（3个中的1个）

端口名称	Reset	软件待机模式		深度软件待机模式	取消深度软件待机模式后（返回启动模式）	
		OPE = 0	OPE = 1		IOKEEP = 0	IOKEEP = 1*1
P000/IRQ6-DS, P001/IRQ7-DS, P002/IRQ8-DS	Hi-Z	Hi-Z*2		Keep-O*3	Hi-Z	Keep
P003	Hi-Z	Hi-Z		Keep	Hi-Z	Keep
P004/IRQ9-DS, P005/IRQ10-DS, P006/IRQ11-DS	Hi-Z	Hi-Z*2		Keep-O*3	Hi-Z	Keep
P007	Hi-Z	Hi-Z		Keep	Hi-Z	Keep
P008/IRQ12-DS	Hi-Z	Keep-O*2		Keep-O*3	Hi-Z	Keep
P014/DA0	Hi-Z	[DA0输出(DAOE0=1)]DA 输出保留[所有其他(DAOE 0=0)]保持-O		Keep	Hi-Z	Keep
P015/IRQ13/DA1	Hi-Z	[DA1输出(DAOE1=1)]DA 输出保持[所有其他(DAOE 1=0)]Keep-O*2		Keep	Hi-Z	Keep
P100/D00[A00/D00]/KR00/ AGTIO0/RXD0/IRQ2	Hi-Z	[D00 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P101/D01[A01/D01]/KR01/IRQ1	Hi-Z	[D01 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P102/D02[A02/D02]/KR02	Hi-Z	[D02 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P103/D03[A03/D03]/KR03	Hi-Z	[D03 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P104/D04[A04/D04]/KR04/IRQ1	Hi-Z	[D04 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P105/D05[A05/D05]/KR05/IRQ0	Hi-Z	[D05 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P106/D06[A06/D06]/KR06	Hi-Z	[D06 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P107/D07[A07/D07]/KR07	Hi-Z	[D07 output] Hi-Z [All other] Keep-O*2		Keep	Hi-Z	Keep
P108/TMS	Pull-up	Keep-O		Keep	Pull-up	Keep
P109/TDO/CLKOUT	TDO输出	[CLKOUT selected] CLKOUT output [All other] Keep-O		[TDO输出]TDO输出 保留[所有其他]保留	[TDO输出]TDO输出 保留[所有其他]Hi-Z	[TDO输出]TDO输出 保留[所有其他]保留
P110/IRQ3/TDI/VCOUT	Pull-up	[ACMPHS selected] VCOUT output [All other] Keep-O*2		Keep	Pull-up	Keep
P111/A05/IRQ4	Hi-Z	[A05 output] Hi-Z [All other] Keep-O*2	[A05输出]地址输出保持 [所有其他]Keep-O*2	Keep	Hi-Z	Keep
P112/A04	Hi-Z	[A04 output] Hi-Z [All other] Keep-O	[A04输出]地址输出保留 [所有其他]Keep-O	Keep	Hi-Z	Keep

Table 1.1 Port states in each processing state (2 of 3)

Port name	Reset	Software Standby mode		Deep SoftwareStandby mode	After Deep Software Standby mode is canceled (return to startup mode)	
		OPE = 0	OPE = 1		IOKEEP = 0	IOKEEP = 1*1
P113/A03	Hi-Z	[A03 output] Hi-Z [All other] Keep-O	[A03 output] Address output retained [All other] Keep-O	Keep	Hi-Z	Keep
P114/A02	Hi-Z	[A02 output] Hi-Z [All other] Keep-O	[A02 output] Address output retained [All other] Keep-O	Keep	Hi-Z	Keep
P115/A01	Hi-Z	[A01 output] Hi-Z [All other] Keep-O	[A01 output] Address output retained [All other] Keep-O	Keep	Hi-Z	Keep
P200/NMI	Hi-Z	Hi-Z		Keep	Hi-Z	Keep
P201	Pull-up	Keep-O		Keep	Pull-up	Keep
P205/CLKOUT/IRQ1-DS	Hi-Z	[CLKOUT selected] CLKOUT output [All other] Keep-O*2	[CLKOUT selected] CLKOUT output [All other] Keep-O*2	Keep-O*3	Hi-Z	Keep
P206/WAIT/IRQ0-DS	Hi-Z	Keep-O*2		Keep-O*3	Hi-Z	Keep
P207	Hi-Z	Keep-O	Keep-O	Keep	Hi-Z	Keep
P208/CS4	Hi-Z	[CS4 output] Hi-Z [All other] Keep-O	[CS4 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P209/CS5	Hi-Z	[CS5 output] Hi-Z [All other] Keep-O	[CS5 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P210/CS6	Hi-Z	[CS6 output] Hi-Z [All other] Keep-O	[CS6 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P211/CS7	Hi-Z	[CS7 output] Hi-Z [All other] Keep-O	[CS7 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P212/IRQ3/EXTAL, P213/IRQ2/XTAL	Hi-Z	Keep-O*2		Keep	Hi-Z	Keep
P214	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P300/TCK	Pull-up	Keep-O		Keep	Pull-up	Keep
P301/A06/AGTIO0/IRQ6	Hi-Z	[A06 output] Hi-Z [All other] Keep-O*2	[A06 output] Address output retained [All other] Keep-O*2	Keep	Hi-Z	Keep
P302/A07/IRQ5	Hi-Z	[A07 output] Hi-Z [All other] Keep-O*2	[A07 output] Address output retained [All other] Keep-O*2	Keep	Hi-Z	Keep
P303/A08	Hi-Z	[A08 output] Hi-Z [All other] Keep-O	[A08 output] Address output retained [All other] Keep-O	Keep	Hi-Z	Keep
P304/A09/IRQ9	Hi-Z	[A09 output] Hi-Z [All other] Keep-O*2	[A09 output] Address output retained [All other] Keep-O*2	Keep	Hi-Z	Keep
P305/A10/IRQ8	Hi-Z	[A10 output] Hi-Z [All other] Keep-O*2	[A10 output] Address output retained [All other] Keep-O*2	Keep	Hi-Z	Keep
P306/A11	Hi-Z	[A11 output] Hi-Z [All other] Keep-O	[A11 output] Address output retained [All other] Keep-O	Keep	Hi-Z	Keep
P307/A12	Hi-Z	[A12 output] Hi-Z [All other] Keep-O	[A12 output] Address output retained [All other] Keep-O	Keep	Hi-Z	Keep
P400/AGTIO1/SCL0_A/IRQ0	Hi-Z	Keep-O*2		Keep	Hi-Z	Keep

Table 1.1 每个处理状态中的端口状态（2个，共3个）

端口名称	Reset	软件待机模式		深度软件待机模式	取消深度软件待机模式后（返回启动模式）	
		OPE = 0	OPE = 1		IOKEEP = 0	IOKEEP = 1*1
P113/A03	Hi-Z	[A03 output] Hi-Z [All other] Keep-O	[A03输出]地址输出保留 [所有其他]Keep-O	Keep	Hi-Z	Keep
P114/A02	Hi-Z	[A02 output] Hi-Z [All other] Keep-O	[A02输出]地址输出保留 [所有其他]Keep-O	Keep	Hi-Z	Keep
P115/A01	Hi-Z	[A01 output] Hi-Z [All other] Keep-O	[A01输出]地址输出保留 [所有其他]Keep-O	Keep	Hi-Z	Keep
P200/NMI	Hi-Z	Hi-Z		Keep	Hi-Z	Keep
P201	Pull-up	Keep-O		Keep	Pull-up	Keep
P205/CLKOUT/IRQ1-DS	Hi-Z	[CLKOUT selected] CLKOUT output [All other] Keep-O*2	[CLKOUT selected] CLKOUT output [All other] Keep-O*2	Keep-O*3	Hi-Z	Keep
P206/WAIT/IRQ0-DS	Hi-Z	Keep-O*2		Keep-O*3	Hi-Z	Keep
P207	Hi-Z	Keep-O	Keep-O	Keep	Hi-Z	Keep
P208/CS4	Hi-Z	[CS4 output] Hi-Z [All other] Keep-O	[CS4 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P209/CS5	Hi-Z	[CS5 output] Hi-Z [All other] Keep-O	[CS5 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P210/CS6	Hi-Z	[CS6 output] Hi-Z [All other] Keep-O	[CS6 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P211/CS7	Hi-Z	[CS7 output] Hi-Z [All other] Keep-O	[CS7 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P212/IRQ3/EXTAL, P213/IRQ2/XTAL	Hi-Z	Keep-O*2		Keep	Hi-Z	Keep
P214	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P300/TCK	Pull-up	Keep-O		Keep	Pull-up	Keep
P301/A06/AGTIO0/IRQ6	Hi-Z	[A06 output] Hi-Z [All other] Keep-O*2	[A06输出]地址输出保持 [所有其他]Keep-O+2	Keep	Hi-Z	Keep
P302/A07/IRQ5	Hi-Z	[A07 output] Hi-Z [All other] Keep-O*2	[A07输出]地址输出保持 [所有其他]Keep-O+2	Keep	Hi-Z	Keep
P303/A08	Hi-Z	[A08 output] Hi-Z [All other] Keep-O	[A08输出]地址输出保留 [所有其他]Keep-O	Keep	Hi-Z	Keep
P304/A09/IRQ9	Hi-Z	[A09 output] Hi-Z [All other] Keep-O*2	[A09输出]地址输出保持 [所有其他]Keep-O+2	Keep	Hi-Z	Keep
P305/A10/IRQ8	Hi-Z	[A10 output] Hi-Z [All other] Keep-O*2	[A10输出]地址输出保持 [所有其他]Keep-O+2	Keep	Hi-Z	Keep
P306/A11	Hi-Z	[A11 output] Hi-Z [All other] Keep-O	[A11输出]地址输出保留 [所有其他]Keep-O	Keep	Hi-Z	Keep
P307/A12	Hi-Z	[A12 output] Hi-Z [All other] Keep-O	[A12输出]地址输出保留 [所有其他]Keep-O	Keep	Hi-Z	Keep
P400/AGTIO1/SCL0_A/IRQ0	Hi-Z	Keep-O*2		Keep	Hi-Z	Keep

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Table 1.1 Port states in each processing state (3 of 3)

Port name	Reset	Software Standby mode		Deep SoftwareStandby mode	After Deep Software Standby mode is canceled (return to startup mode)	
		OPE = 0	OPE = 1		IOKEEP = 0	IOKEEP = 1*1
P401/SDA0_A/IRQ5-DS, P402/IRQ4-DS/AGTIO0/ AGTIO1, P403/AGTIO0/AGTIO1, P404	Hi-Z	Keep-O		Keep-O*3	Hi-Z	Keep
P405, P406	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P407/AGTIO0/SDA0_B	Hi-Z	Keep-O		Keep-O*3	Hi-Z	Keep
P408/SCL0_B/IRQ7, P409/IRQ6, P410/RXD0/IRQ5, P411/IRQ4	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P412, P413	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P414/IRQ9, P415/IRQ8	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P500	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P501/IRQ11, P502/IRQ12	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P503	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P504/ALE	Hi-Z	[ALE output] Hi-Z [All other] Keep-O	[ALE output] L [All other] Keep-O	Keep	Hi-Z	Keep
P508	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P600/RD/CLKOUT	Hi-Z	[RD output] Hi-Z [CLKOUT selected] CLKOUT output [All other] Keep-O	[RD output] H [CLKOUT selected] CLKOUT output [All other] Keep-O	Keep	Hi-Z	Keep
P601/WR0	Hi-Z	[WR0 output] Hi-Z [All other] Keep-O	[WR0 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P602	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P608/A00	Hi-Z	[A00 output] Hi-Z [All other] Keep-O	[A00 output] Address output retained [All other] Keep-O	Keep	Hi-Z	Keep
P708/IRQ11	Hi-Z	Keep-O		Keep	Hi-Z	Keep

H: High-level
L: Low-level
Hi-Z: High-impedance
Keep-O: Output pins retain their previous values. Input pins go to high-impedance.
Keep: Pin states are retained during periods in Software Standby mode.

Note 1. Retains the I/O port state until the DPSBYCR.IOKEEP bit is set to 0.
Note 2. Input is enabled if the pin is specified as the Software Standby canceling source while it is used as an external interrupt pin.
Note 3. Input is enabled if the pin is specified as the Deep Software Standby canceling source.
Note 4. Input is enabled while the pin is used as an input.

Table 1.1 每个处理状态中的端口状态（3个中的3个）

端口名称	Reset	软件待机模式		深度软件待机模式	取消深度软件待机模式后（返回启动模式）	
		OPE = 0	OPE = 1		IOKEEP = 0	IOKEEP = 1*1
P401/SDA0_A/IRQ5-DS, P402/IRQ4-DS/AGTIO0/ AGTIO1, P403/AGTIO0/AGTIO1, P404	Hi-Z	Keep-O		Keep-O*3	Hi-Z	Keep
P405, P406	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P407/AGTIO0/SDA0_B	Hi-Z	Keep-O		Keep-O*3	Hi-Z	Keep
P408/SCL0_B/IRQ7, P409/IRQ6, P410/RXD0/IRQ5, P411/IRQ4	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P412, P413	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P414/IRQ9, P415/IRQ8	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P500	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P501/IRQ11, P502/IRQ12	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P503	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P504/ALE	Hi-Z	[ALE output] Hi-Z [All other] Keep-O	[ALE output] L [All other] Keep-O	Keep	Hi-Z	Keep
P508	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P600/RD/CLKOUT	Hi-Z	[RD output] Hi-Z [CLKOUT selected] CLKOUT output [All other] Keep-O	[RD output] H [CLKOUT selected] CLKOUT output [All other] Keep-O	Keep	Hi-Z	Keep
P601/WR0	Hi-Z	[WR0 output] Hi-Z [All other] Keep-O	[WR0 output] H [All other] Keep-O	Keep	Hi-Z	Keep
P602	Hi-Z	Keep-O		Keep	Hi-Z	Keep
P608/A00	Hi-Z	[A00 output] Hi-Z [All other] Keep-O	[A00输出]地址输出保留 [所有其他]Keep-O	Keep	Hi-Z	Keep
P708/IRQ11	Hi-Z	Keep-O		Keep	Hi-Z	Keep

H: High-level
L: Low-level
Hi-Z: High-impedance
Keep-O：输出引脚保留其先前的值。输入引脚变为高阻抗。
保持：在软件待机模式期间保持引脚状态。

Note 1. 保持IO端口状态，直到DPSBYCR.IOKEEP位设置为0。
Note 2. 如果引脚被指定为软件待机取消源，同时它被用作外部中断引脚，则输入被启用。
Note 3. 如果将引脚指定为深度软件待机取消源，则启用输入。
Note 4. 当引脚用作输入时，输入被启用。

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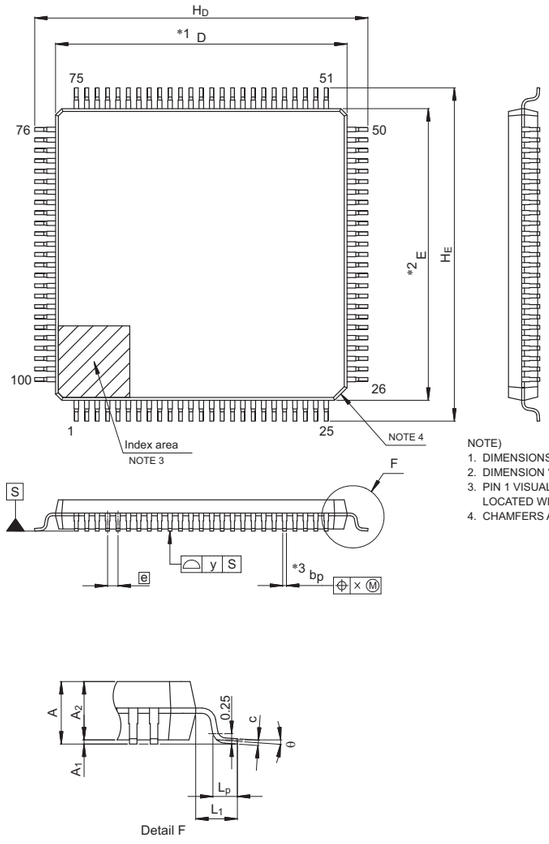
Appendix 2.Package Dimensions

Information on the latest version of the package dimensions or mountings is shown in "Packages" on the Renesas Electronics Corporation website.

JEITA Package Code	RENESAS Code	Previous Code	MASS (Typ) [g]
P-LFQFP100-14x14-0.50	PLQP0100KB-B	—	0.6

Unit: mm



NOTE)
1. DIMENSIONS "*1" AND "*2" DO NOT INCLUDE MOLD FLASH.
2. DIMENSION "*3" DOES NOT INCLUDE TRIM OFFSET.
3. PIN 1 VISUAL INDEX FEATURE MAY VARY, BUT MUST BE LOCATED WITHIN THE HATCHED AREA.
4. CHAMFERS AT CORNERS ARE OPTIONAL, SIZE MAY VARY.

Reference Symbol	Dimensions in millimeters		
	Min	Nom	Max
D	13.9	14.0	14.1
E	13.9	14.0	14.1
A_2	—	1.4	—
H_D	15.8	16.0	16.2
H_E	15.8	16.0	16.2
A	—	—	1.7
A_1	0.05	—	0.15
b_p	0.15	0.20	0.27
c	0.09	—	0.20
θ	0°	3.5°	8°
e	—	0.5	—
x	—	—	0.08
y	—	—	0.08
L_p	0.45	0.6	0.75
L_1	—	1.0	—

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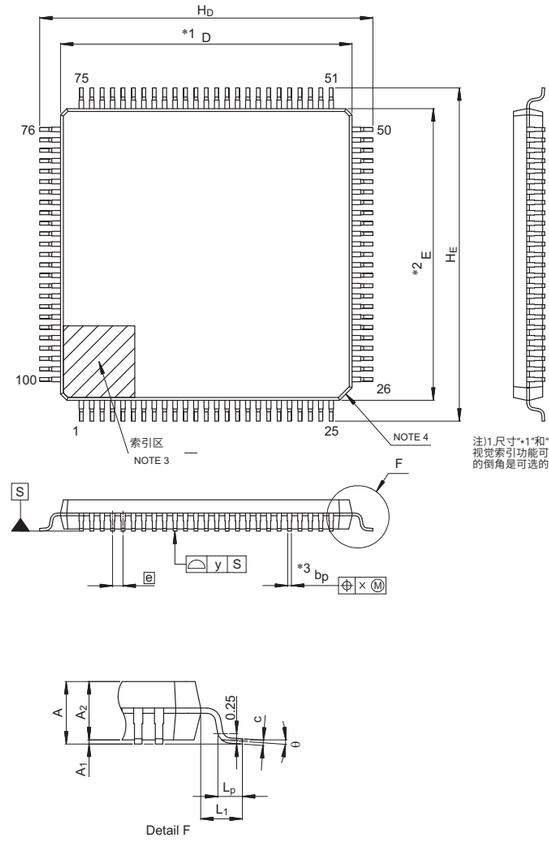
Figure 2.1 100-pin LQFP

附录2.包装尺寸

最新版本的封装尺寸或安装信息显示在瑞萨电子的"封装"中
电子公司网站。

JEITA包装代码	RENESAS Code	以前的代码	MASS (Typ) [g]
P-LFQFP100-14x14-0.50	PLQP0100KB-B	—	0.6

Unit: mm



注)1.尺寸"*1"和"*2"不包括毛边。2.尺寸"*3"不包括微调偏移。3.PIN1视觉索引功能可能会有所不同，但必须位于阴影区域内。4.拐角处的倒角是可选的，尺寸可能会有所不同。

参考符号	尺寸以毫米为单位		
	Min	Nom	Max
D	13.9	14.0	14.1
E	13.9	14.0	14.1
A_2	—	1.4	—
H_D	15.8	16.0	16.2
H_E	15.8	16.0	16.2
A	—	—	1.7
A_1	0.05	—	0.15
b_p	0.15	0.20	0.27
c	0.09	—	0.20
θ	0°	3.5°	8°
e	—	0.5	—
x	—	—	0.08
y	—	—	0.08
L_p	0.45	0.6	0.75
L_1	—	1.0	—

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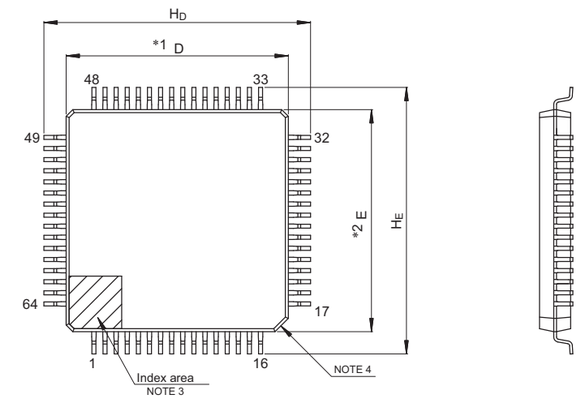
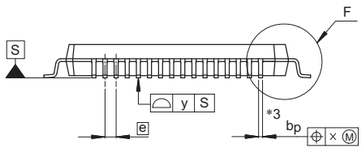
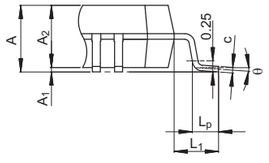
Figure 2.1 100-pin LQFP

JEITA Package Code	RENESAS Code	Previous Code	MASS (Typ) [g]
P-LFQFP64-10x10-0.50	PLQP0064KB-C	—	0.3

Unit: mm







Detail F

NOTE)
1. DIMENSIONS "*1" AND "*2" DO NOT INCLUDE MOLD FLASH.
2. DIMENSION "*3" DOES NOT INCLUDE TRIM OFFSET.
3. PIN 1 VISUAL INDEX FEATURE MAY VARY, BUT MUST BE LOCATED WITHIN THE HATCHED AREA.
4. CHAMFERS AT CORNERS ARE OPTIONAL, SIZE MAY VARY.

Reference Symbol	Dimensions in millimeters		
	Min	Nom	Max
D	9.9	10.0	10.1
E	9.9	10.0	10.1
A_2	—	1.4	—
H_D	11.8	12.0	12.2
H_E	11.8	12.0	12.2
A	—	—	1.7
A_1	0.05	—	0.15
b_p	0.15	0.20	0.27
c	0.09	—	0.20
θ	0°	3.5°	8°
e	—	0.5	—
x	—	—	0.08
y	—	—	0.08
L_p	0.45	0.6	0.75
L_1	—	1.0	—

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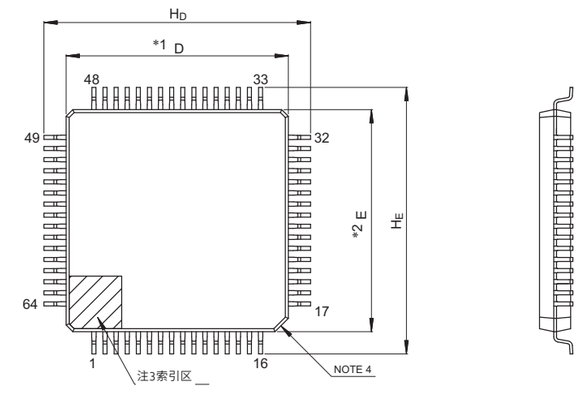
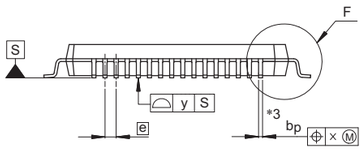
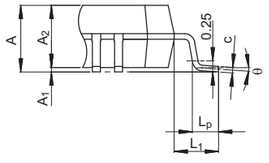
Figure 2.2 64-pin LQFP

JEITA包装代码	RENESAS Code	以前的代码	MASS (Typ) [g]
P-LFQFP64-10x10-0.50	PLQP0064KB-C	—	0.3

Unit: mm







Detail F

注)1.尺寸"*1"和"*2"不包括毛边。2.尺寸"*3"不包括微调偏移。3.PIN1视觉索引功能可能会有所不同，但必须位于阴影区域内。4.拐角处的倒角是可选的，尺寸可能会有所不同。

参考符号	尺寸以毫米为单位		
	Min	Nom	Max
D	9.9	10.0	10.1
E	9.9	10.0	10.1
A_2	—	1.4	—
H_D	11.8	12.0	12.2
H_E	11.8	12.0	12.2
A	—	—	1.7
A_1	0.05	—	0.15
b_p	0.15	0.20	0.27
c	0.09	—	0.20
θ	0°	3.5°	8°
e	—	0.5	—
x	—	—	0.08
y	—	—	0.08
L_p	0.45	0.6	0.75
L_1	—	1.0	—

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Figure 2.2 64-pin LQFP

Appendix 3. I/O Registers

This appendix describes I/O register addresses, access cycles, and reset values by function.

3.1 Peripheral Base Addresses

This section provides the base addresses for peripherals described in this manual.

Table 3.1 shows the name, description, and the base address of each peripheral.

Table 3.1 Peripheral base address (1 of 2)

Name	Description	Base address
MMPU	Bus Master MPU	0x40000000
SMPU	Bus Slave MPU	0x40000C00
SPMON	CPU Stack Pointer Monitor	0x40000D00
MMF	Memory Mirror Function	0x40001000
SRAM	SRAM Control	0x40002000
BUS	BUS Control	0x40003000
DMAC0	Direct Memory Access Controller 0	0x40005000
DMAC1	Direct Memory Access Controller 1	0x40005040
DMAC2	Direct Memory Access Controller 2	0x40005080
DMAC3	Direct Memory Access Controller 3	0x400050C0
DMAC4	Direct Memory Access Controller 4	0x40005100
DMAC5	Direct Memory Access Controller 5	0x40005140
DMAC6	Direct Memory Access Controller 6	0x40005180
DMAC7	Direct Memory Access Controller 7	0x400051C0
DMA	DMAC Module Activation	0x40005200
DTC	Data Transfer Controller	0x40005400
ICU	Interrupt Controller	0x40006000
DBG	Debug Function	0x4001B000
FCACHE	Flash Cache	0x4001C000
SYSTEM	System Control	0x4001E000
PORT0	Port 0 Control Registers	0x40040000
PORT1	Port 1 Control Registers	0x40040020
PORT2	Port 2 Control Registers	0x40040040
PORT3	Port 3 Control Registers	0x40040060
PORT4	Port 4 Control Registers	0x40040080
PORT5	Port 5 Control Registers	0x400400A0
PORT6	Port 6 Control Registers	0x400400C0
PORT7	Port 7 Control Registers	0x400400E0
PFS	Pmn Pin Function Control Register	0x40040800
PMISC	Miscellaneous Port Control Register	0x40040D00
ELC	Event Link Controller	0x40041000
POEG	Port Output Enable Module for GPT	0x40042000
INIT	Register to be initialized after reset release	0x40044000
WDT	Watchdog Timer	0x40044200
IWDT	Independent Watchdog Timer	0x40044400
CAC	Clock Frequency Accuracy Measurement Circuit	0x40044600
MSTP	Module Stop Control B, C, D	0x40047000
CAN0	CAN0 Module	0x40050000

附录3.IO寄存器

本附录按功能描述了IO寄存器地址、访问周期和复位值。

3.1 外设基地址

本节提供本手册中描述的外设的基地址。

表3.1显示了每个外设的名称、描述和基地址。

Table 3.1 外设基地址(1of2)

Name	Description	基址
MMPU	总线主控MPU	0x40000000
SMPU	总线从MPU	0x40000C00
SPMON	CPU堆栈指针监视器	0x40000D00
MMF	内存镜像功能	0x40001000
SRAM	SRAM Control	0x40002000
BUS	总线控制	0x40003000
DMAC0	直接内存访问控制器0	0x40005000
DMAC1	直接内存访问控制器1	0x40005040
DMAC2	直接内存访问控制器2	0x40005080
DMAC3	直接内存访问控制器3	0x400050C0
DMAC4	直接内存访问控制器4	0x40005100
DMAC5	直接内存访问控制器5	0x40005140
DMAC6	直接内存访问控制器6	0x40005180
DMAC7	直接内存访问控制器7	0x400051C0
DMA	DMAC模块激活	0x40005200
DTC	数据传输控制器	0x40005400
ICU	中断控制器	0x40006000
DBG	调试功能	0x4001B000
FCACHE	闪存缓存	0x4001C000
SYSTEM	系统控制	0x4001E000
PORT0	端口0控制寄存器	0x40040000
PORT1	端口1控制寄存器	0x40040020
PORT2	端口2控制寄存器	0x40040040
PORT3	端口3控制寄存器	0x40040060
PORT4	端口4控制寄存器	0x40040080
PORT5	端口5控制寄存器	0x400400A0
PORT6	端口6控制寄存器	0x400400C0
PORT7	端口7控制寄存器	0x400400E0
PFS	Pmn引脚功能控制寄存器	0x40040800
PMISC	杂项端口控制寄存器	0x40040D00
ELC	事件链接控制器	0x40041000
POEG	GPT端口输出使能模块	0x40042000
INIT	复位释放后要初始化的寄存器	0x40044000
WDT	看门狗定时器	0x40044200
IWDT	独立看门狗定时器	0x40044400
CAC	时钟频率精度测量电路	0x40044600
MSTP	模块停止控制B、C、D	0x40047000
CAN0	CAN0 Module	0x40050000

RA生态工作室

Table 3.1 Peripheral base address (2 of 2)

Name	Description	Base address
IIC0	Inter-Integrated Circuit 0	0x40053000
IIC1	Inter-Integrated Circuit 1	0x40053100
DOC	Data Operation Circuit	0x40054100
ADC120	12-bit A/D Converter 0	0x4005C000
ADC121	12-bit A/D Converter 1	0x4005C200
TSN	Temperature Sensor	0x4005D000
DAC12	12-bit D/A Converter	0x4005E000
SCI0	Serial Communication Interface 0	0x40070000
SCI1	Serial Communication Interface 1	0x40070020
SCI2	Serial Communication Interface 2	0x40070040
SCI3	Serial Communication Interface 3	0x40070060
SCI4	Serial Communication Interface 4	0x40070080
SCI8	Serial Communication Interface 8	0x40070100
SCI9	Serial Communication Interface 9	0x40070120
IRDA	Infrared Data Association	0x40070F00
SPI0	Serial Peripheral Interface 0	0x40072000
SPI1	Serial Peripheral Interface 1	0x40072100
CRC	CRC Calculator	0x40074000
GPT32EH0	General PWM Timer 0 (32-bit Enhanced High Resolution)	0x40078000
GPT32EH1	General PWM Timer 1 (32-bit Enhanced High Resolution)	0x40078100
GPT32EH2	General PWM Timer 2 (32-bit Enhanced High Resolution)	0x40078200
GPT32EH3	General PWM Timer 3 (32-bit Enhanced High Resolution)	0x40078300
GPT32E4	General PWM Timer 4 (32-bit Enhanced)	0x40078400
GPT32E5	General PWM Timer 5 (32-bit Enhanced)	0x40078500
GPT32E6	General PWM Timer 6 (32-bit Enhanced)	0x40078600
GPT32E7	General PWM Timer 7 (32-bit Enhanced)	0x40078700
GPT328	General PWM Timer 8	0x40078800
GPT329	General PWM Timer 9	0x40078900
GPT3210	General PWM Timer 10	0x40078A00
GPT3211	General PWM Timer 11	0x40078B00
GPT3212	General PWM Timer 12	0x40078C00
GPT_OPS	Output Phase Switching Controller	0x40078FF0
GPT_ODC	PWM Delay Generation Circuit	0x4007B000
KINT	Key Interrupt Function	0x40080000
AGT0	Low Power Asynchronous General-purpose Timer 0	0x40084000
AGT1	Low Power Asynchronous General-purpose Timer 1	0x40084100
ACMPHS0	High-Speed Analog Comparator 0	0x40085000
ACMPHS1	High-Speed Analog Comparator 1	0x40085100
ACMPHS2	High-Speed Analog Comparator 2	0x40085200
ACMPHS3	High-Speed Analog Comparator 3	0x40085300
ACMPHS4	High-Speed Analog Comparator 4	0x40085400
ACMPHS5	High-Speed Analog Comparator 5	0x40085500
TSD	Temperature Sensor Data	0x407FB17C

Name = Peripheral name
Description = Peripheral functionality
Base address = Lowest reserved address or address used by the peripheral

Table 3.1 外设基地址（2个中的2个）

Name	Description	基址
IIC0	Inter-Integrated Circuit 0	0x40053000
IIC1	Inter-Integrated Circuit 1	0x40053100
DOC	数据运算电路	0x40054100
ADC120	12-bit A/D Converter 0	0x4005C000
ADC121	12-bit A/D Converter 1	0x4005C200
TSN	温度感应器	0x4005D000
DAC12	12-bit D/A Converter	0x4005E000
SCI0	串行通讯接口0	0x40070000
SCI1	串行通讯接口1	0x40070020
SCI2	串行通讯接口2	0x40070040
SCI3	串行通讯接口3	0x40070060
SCI4	串行通讯接口4	0x40070080
SCI8	串行通讯接口8	0x40070100
SCI9	串行通讯接口9	0x40070120
IRDA	红外数据协会	0x40070F00
SPI0	串行外设接口0	0x40072000
SPI1	串行外设接口1	0x40072100
CRC	CRC Calculator	0x40074000
GPT32EH0	通用PWM定时器0（32位增强型高分辨率）	0x40078000
GPT32EH1	通用PWM定时器1（32位增强型高分辨率）	0x40078100
GPT32EH2	通用PWM定时器2（32位增强型高分辨率）	0x40078200
GPT32EH3	通用PWM定时器3（32位增强型高分辨率）	0x40078300
GPT32E4	通用PWM定时器4（32位增强型）	0x40078400
GPT32E5	通用PWM定时器5（32位增强型）	0x40078500
GPT32E6	通用PWM定时器6（32位增强型）	0x40078600
GPT32E7	通用PWM定时器7（32位增强型）	0x40078700
GPT328	通用PWM定时器8	0x40078800
GPT329	通用PWM定时器9	0x40078900
GPT3210	通用PWM定时器10	0x40078A00
GPT3211	通用PWM定时器11	0x40078B00
GPT3212	通用PWM定时器12	0x40078C00
GPT_OPS	输出相位切换控制器	0x40078FF0
GPT_ODC	PWM延迟产生电路	0x4007B000
KINT	按键中断功能	0x40080000
AGT0	低功耗异步通用定时器0	0x40084000
AGT1	低功耗异步通用定时器1	0x40084100
ACMPHS0	高速模拟比较器0	0x40085000
ACMPHS1	高速模拟比较器1	0x40085100
ACMPHS2	高速模拟比较器2	0x40085200
ACMPHS3	高速模拟比较器3	0x40085300
ACMPHS4	高速模拟比较器4	0x40085400
ACMPHS5	高速模拟比较器5	0x40085500
TSD	温度传感器数据	0x407FB17C

名称=外设名称
描述=外围功能
基地址=外设使用的最低保留地址或地址

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3.2 Access Cycles

This section provides access cycle information for the I/O registers described in this manual.

The following information applies to Table 3.2:

- Registers are grouped by associated module
- The number of access cycles indicates the number of cycles based on the specified reference clock
- In the internal I/O area, reserved addresses that are not allocated to registers must not be accessed, otherwise operations cannot be guaranteed
- The number of I/O access cycles depends on bus cycles of the internal peripheral bus, divided clock synchronization cycles, and wait cycles of each module. Divided clock synchronization cycles differ depending on the frequency ratio between ICLK and PCLK.
- When the frequency of ICLK is equal to that of PCLK, the number of divided clock synchronization cycles is always constant.
- When the frequency of ICLK is greater than that of PCLK, at least 1 PCLK cycle is added to the number of divided clock synchronization cycles.

Note: This applies to the number of cycles when access from the CPU does not conflict with the instruction fetching to the external memory or bus access from other bus master such as DMAC or DTC.

Table 3.2 shows the access cycles for the I/O registers.

Table 3.2 Access cycles for I/O registers (1 of 2)

Peripherals	Address		Number of access cycles				Cycle unit	Related function
			ICLK = PCLK		ICLK > PCLK*1			
	From	To	Read	Write	Read	Write		
MMPU, SMPU, SPMON, MMF, SRAM, BUS, DMACn, DMA, DTC, ICU, DBG, FCACHE	4000 0000h	4001 CFFFh	4				ICLK	Memory Protection Unit, Memory Mirror Function, SRAM, Buses, DMA Controller Data Transfer Controller, Interrupt Controller, CPU, Flash Memory
SYSTEM	4001 E000h	4001 E3FFh	5				ICLK	Low Power Modes, Resets, Low Voltage Detection, Clock Generation Circuit, Register Write Protection
SYSTEM	4001 E400h	4001 E6FFh	9		5 to 8		PCLKB	Low Power Modes, Resets, Low Voltage Detection, AGT Input Control
PORTn, PFS, PMISC, ELC, POEG, INIT, WDT, IWDT, CAC, MSTP	4004 0000h	4004 7FFFh	3		2 to 3		PCLKB	I/O Ports, Event Link Controller, Port Output Enable for GPT, Register to be initialized after reset release, Watchdog Timer, Independent Watchdog Timer, Clock Frequency Accuracy Measurement Circuit, Module Stop Control
CANn, IICn, DOC, ADC12n, TSN, DAC12	4004 E000h	4005 FFFFh	3		2 to 3		PCLKB	Controller Area Network Module, I2C Bus Interface, Data Operation Circuit, 12-Bit A/D Converter, Temperature Sensor, 12-Bit D/A Converter
SCIn	4007 0000h	4007 0EFFh	3*2		2 to 3*2		PCLKA	Serial Communications Interface

3.2 访问周期

本节提供本手册中描述的IO寄存器的访问周期信息。

以下信息适用于表3.2：

- 寄存器按相关模块分组
- 访问周期数表示基于指定参考时钟的周期数
- 在内部IO区，不能访问未分配给寄存器的保留地址，否则无法保证操作
- IO访问周期数取决于内部外设总线的总线周期、分频时钟同步周期和每个模块的等待周期。分频时钟同步周期取决于ICLK和PCLK之间的频率比。
- 当ICLK的频率等于PCLK的频率时，分频时钟同步周期的数量始终是恒定的。
- 当ICLK的频率大于PCLK的频率时，分频时钟同步周期数至少增加1个PCLK周期。

Note: 这适用于当来自CPU的访问与从外部存储器获取指令或来自其他总线主控器（例如DMAC或DTC）的总线访问不冲突时的周期数。

表3.2显示了IO寄存器的访问周期。

Table 3.2 IO寄存器的访问周期(1of2)

Peripherals	Address		访问周期数				循环单元	相关功能
			ICLK = PCLK		ICLK > PCLK*1			
	From	To	Read	Write	Read	Write		
MMPU, SMPU, SPMON, MMF, SRAM, BUS, DMACn, DMA, DTC, ICU, DBG, FCACHE	4000 0000h	4001 CFFFh	4				ICLK	内存保护单元、内存镜像功能、SRAM、总线、DMA控制器数据传输 控制器，中断 控制器、CPU、闪存 Memory
SYSTEM	4001 E000h	4001 E3FFh	5				ICLK	低功耗模式，复位，低电压检测、时钟生成电路、寄存器写保护
SYSTEM	4001 E400h	4001 E6FFh	9		5 to 8		PCLKB	低功耗模式、复位、低电压检测、AGT 输入控制
PORTn, PFS, PMISC, ELC, POEG、初始化、WDT、IWDT、CAC、MSTP	4004 0000h	4004 7FFFh	3		2 to 3		PCLKB	IO端口，事件链接控制器、GPT端口输出使能、复位释放后要初始化的寄存器、看门狗定时器、独立看门狗定时器、时钟频率精度测量 电路、模块停止控制
CANn、IICn、DOC、ADC12n, TSN, DAC12	4004 E000h	4005 FFFFh	3		2 to 3		PCLKB	控制器局域网模块、I2C总线接口、数据运算电路、12位AD转换器、 温度传感器，12位 D/A Converter
SCIn	4007 0000h	4007 0EFFh	3*2		2 to 3*2		PCLKA	串行通信 Interface

Table 3.2 Access cycles for I/O registers (2 of 2)

Peripherals	Address From	Address To	Number of access cycles: ICLK = PCLK Read	ICLK = PCLK Write	ICLK > PCLK*1 Read	ICLK > PCLK*1 Write	Cycle unit	Related function
IRDA	4007 0F00h	4007 0FFFh	3		2 to 3		PCLKA	IrDA Interface
SPI0, SPI1	4007 2000h	4007 2FFFh	3*3		2 to 3*3		PCLKA	Serial Peripheral Interface
CRC	4007 4000h	4007 4FFFh	3		2 to 3		PCLKA	CRC Calculator
GPT32EHi, GPT32Ej, GPT32k, GPT_OPS	4007 8000h	4007 8FFFh	5	3	4 to 5	2 to 3	PCLKA	General PWM Timer
			2		1 to 2			
GPT_ODC	4007 B000h	4007 BFFFh	2		1 to 2		PCLKA	PWM Delay Generation Circuit
KINT	4008 0000h	4008 1FFFh	2		1 to 2		PCLKB	Key interrupt Function
AGTn	4008 4000h	4008 4FFFh	5	3	4 to 5	2 to 3	PCLKB	Asynchronous General Purpose Timer
ACMPHSn	4008 5000h	4008 5FFFh	2		1 to 2		PCLKB	High-Speed Analog Comparator
TSD	407FB17Ch	407FB17Ch	2	-	2	-	ICLK	Temperature Sensor

Note 1. If the number of PCLK cycles is non-integer (for example 1.5), the minimum value is without the decimal point, and the maximum value is rounded up to the decimal point. For example, 1.5 to 2. 5 is 1 to 3.

Note 2. When accessing a 16-bit register (FTDRHL, FRDRHL, FCR, FDR, LSR, and CDR), access is 2 cycles more than the value shown in Table 3.2. When accessing an 8-bit register (FTDRH, FTDRL, FRDRH, and FRDRL), the access cycles are as shown in Table 3.2.

Note 3. When accessing the 32-bit register (SPDR), access is 2 cycles more than the value in Table 3.2. When accessing an 8-bit or 16-bit register (SPDR_HA), the access cycles are as shown in Table 3.2.

3.3 Register Descriptions

This section provides information associated with registers described in this manual.

Table 3.3 shows a list of registers including address offsets, address sizes, access rights, and reset values.

Table 3.3 Register description (1 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
MMPU	-	-	-	MMPUCTLA	Bus Master MPU Control Register	0x000	16	read-write	0x0000	0xFFFF
				MMPUPTA	Group A Protection of Register	0x102	16	read-write	0x0000	0xFFFF
	32	0x010	0-31	MMPUACA%s	Group A Region %s Access Control Register	0x200	16	read-write	0x0000	0xFFFF
	32	0x010	0-31	MMPUSA%s	Group A Region %s Start Address Register	0x204	32	read-write	0x0000 0000	0x00000 003
	32	0x010	0-31	MMPUEA%s	Group A Region %s End Address Register	0x208	32	read-write	0x0000 0003	0x00000 003
SMPU	-	-	-	SMPUCTL	Slave MPU Control Register	0x00	16	read-write	0x0000	0xFFFF
				SMPUMBIU	Access Control Register for MBIU	0x10	16	read-write	0x2000	0xFFFF
				SMPUFBIU	Access Control Register for FBIU	0x14	16	read-write	0x0000	0xFFFF
	3	0x4	0,2,6	SMPUP%sBIU	Access Control Register for P%sBIU	0x20	16	read-write	0x0000	0xFFFF

Table 3.2 IO寄存器的访问周期(2of2)

Peripherals	Address From	Address To	访问周期数: ICLK = PCLK Read	ICLK = PCLK Write	ICLK > PCLK*1 Read	ICLK > PCLK*1 Write	循环单元	相关功能
IRDA	4007 0F00h	4007 0FFFh	3		2 to 3		PCLKA	IrDA Interface
SPI0, SPI1	4007 2000h	4007 2FFFh	3*3		2 to 3*3		PCLKA	串行外设接口
CRC	4007 4000h	4007 4FFFh	3		2 to 3		PCLKA	CRC Calculator
GPT32EHi, GPT32Ej, GPT32k, GPT_OPS	4007 8000h	4007 8FFFh	5	3	4 to 5	2 to 3	PCLKA	通用PWM定时器
			2		1 to 2			
GPT_ODC	4007 B000h	4007 BFFFh	2		1 to 2		PCLKA	PWM延迟生成 Circuit
KINT	4008 0000h	4008 1FFFh	2		1 to 2		PCLKB	按键中断功能
AGTn	4008 4000h	4008 4FFFh	5	3	4 to 5	2 to 3	PCLKB	异步通用 目的定时器
ACMPHSn	4008 5000h	4008 5FFFh	2		1 to 2		PCLKB	High-Speed Analog Comparator
TSD	407FB17Ch	407FB17Ch	2	-	2	-	ICLK	温度感应器

注1.如果PCLK周期数为非整数（例如1.5），则最小值不带小数点，最大值四舍五入到小数点。例如，1.5到2。5是1到3。
注2.访问16位寄存器（FTDRHL、FRDRHL、FCR、FDR、LSR和CDR）时，访问时间比表3.2中显示的值多2个周期.访问8位寄存器（FTDRH、FTDRL、FRRDH和FRDRL）时，访问周期如表3.2所示。注3.访问32位寄存器(SPDR)时，访问比表3.2中的值多2个周期。访问8位或16位寄存器（SPDR_HA）时，访问周期如表3.2所示。

3.3 注册说明

本节提供与本手册中描述的寄存器相关的信息。

表3.3显示了寄存器列表，包括地址偏移、地址大小、访问权限和复位值。

Table 3.3 寄存器描述（25个中的1个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
MMPU	-	-	-	MMPUCTLA	总线主控MPU控制寄存器	0x000	16	读写	0x0000	0xFFFF
				MMPUPTA	A组保护 Register	0x102	16	读写	0x0000	0xFFFF
	32	0x010	0-31	MMPUACA%s	A组地区%s 访问控制寄存器	0x200	16	读写	0x0000	0xFFFF
	32	0x010	0-31	MMPUSA%s	A组地区%s 起始地址寄存器	0x204	32	读写	0x0000 0000	0x00000 003
	32	0x010	0-31	MMPUEA%s	A组地区%s结束 地址寄存器	0x208	32	读写	0x0000 0003	0x00000 003
SMPU	-	-	-	SMPUCTL	从MPU控制 Register	0x00	16	读写	0x0000	0xFFFF
				SMPUMBIU	MBIU的访问控制寄存器	0x10	16	读写	0x2000	0xFFFF
				SMPUFBIU	FBIU访问控制寄存器	0x14	16	读写	0x0000	0xFFFF
	3	0x4	0,2,6	SMPUP%sBIU	P%sBIU的访问控制寄存器	0x20	16	读写	0x0000	0xFFFF

Table 3.3 Register description (2 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
SPMON	-	-	-	MSPMPUOAD	Stack Pointer Monitor Operation After Detection Register	0x00	16	read-write	0x0000	0xFFFF
				MSPMPUCTL	Stack Pointer Monitor Access Control Register	0x04	16	read-write	0x0000	0xFEFF
				MSPMPUPT	Stack Pointer Monitor Protection Register	0x06	16	read-write	0x0000	0xFFFF
				MSPMPUSA	Main Stack Pointer Monitor Start Address Register	0x08	32	read-write	0x0000 0000	0x00000 003
				MSPMPUEA	Main Stack Pointer Monitor End Address Register	0x0C	32	read-write	0x0000 0003	0x00000 003
				PSPMPUOAD	Stack Pointer Monitor Operation After Detection Register	0x10	16	read-write	0x0000	0xFFFF
				PSPMPUCTL	Stack Pointer Monitor Access Control Register	0x14	16	read-write	0x0000	0xFEFF
				PSPMPUPT	Stack Pointer Monitor Protection Register	0x16	16	read-write	0x0000	0xFFFF
				PSPMPUSA	Process Stack Pointer Monitor Start Address Register	0x18	32	read-write	0x0000 0000	0x00000 003
				PSPMPUEA	Process Stack Pointer Monitor End Address Register	0x1C	32	read-write	0x0000 0003	0x00000 003
MMF	-	-	-	MMSFR	MemMirror Special Function Register	0x00	32	read-write	0x0000 0000	0xFFFF FFFF
				MMEN	MemMirror Enable Register	0x04	32	read-write	0x0000 0000	0xFFFF FFFF
SRAM	-	-	-	PARIOAD	SRAM Parity Error Operation After Detection Register	0x00	8	read-write	0x00	0xFF
				SRAMPRCR	SRAM Protection Register	0x04	8	read-write	0x00	0xFF
BUS	2	0x4	M4I, M4D	BUSMCNT%s	Master Bus Control Register %s	0x1000	16	read-write	0x0000	0xFFFF
	-	-	-	BUSMCNTSYS	Master Bus Control Register SYS	0x1008	16	read-write	0x0000	0xFFFF
	-	-	-	BUSMCNTDMA	Master Bus Control Register DMA	0x100C	16	read-write	0x0000	0xFFFF
	2	0x4	FLI,RAMH	BUSSCNT%s	Slave Bus Control Register %s	0x1100	16	read-write	0x0000	0xFFFF
	-	-	-	BUSSCNTMBIU	Slave Bus Control Register MBIU	0x1108	16	read-write	0x0000	0xFFFF
	4	0x4	P0B, P2B, P3B, P4B	BUSSCNT%s	Slave Bus Control Register %s	0x1114	16	read-write	0x0000	0xFFFF
	-	-	-	BUSSCNTP6B	Slave Bus Control Register P6B	0x1128	16	read-write	0x0000	0xFFFF
	3	0x4	FBU	BUSSCNT%s	Slave Bus Control Register %s	0x1130	16	read-write	0x0000	0xFFFF
	4	0x10	1-4	BUS%sERRADD	Bus Error Address Register %s	0x1800	32	read-only	0x0000 0000	0x00000 000

Table 3.3 寄存器说明（25个中的2个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
SPMON	-	-	-	MSPMPUOAD	堆栈指针监视器之后的操作检测寄存器	0x00	16	读写	0x0000	0xFFFF
				MSPMPUCTL	堆栈指针监视器访问控制寄存器	0x04	16	读写	0x0000	0xFEFF
				MSPMPUPT	堆栈指针监视器保护登记册	0x06	16	读写	0x0000	0xFFFF
				MSPMPUSA	主堆栈指针监控起始地址 Register	0x08	32	读写	0x0000 0000	0x00000 003
				MSPMPUEA	主堆栈指针监控结束地址 Register	0x0C	32	读写	0x0000 0003	0x00000 003
				PSPMPUOAD	堆栈指针监视器之后的操作检测寄存器	0x10	16	读写	0x0000	0xFFFF
				PSPMPUCTL	堆栈指针监视器访问控制寄存器	0x14	16	读写	0x0000	0xFEFF
				PSPMPUPT	堆栈指针监视器保护登记册	0x16	16	读写	0x0000	0xFFFF
				PSPMPUSA	进程堆栈指针监视器起始地址 Register	0x18	32	读写	0x0000 0000	0x00000 003
				PSPMPUEA	进程堆栈指针监视器结束地址 Register	0x1C	32	读写	0x0000 0003	0x00000 003
MMF	-	-	-	MMSFR	MemMirror Special 功能寄存器	0x00	32	读写	0x0000 0000	0xFFFF FFFF
				MMEN	MemMirror Enable Register	0x04	32	读写	0x0000 0000	0xFFFF FFFF
SRAM	-	-	-	PARIOAD	SRAM奇偶校验错误操作后检测寄存器	0x00	8	读写	0x00	0xFF
				SRAMPRCR	SRAM Protection Register	0x04	8	读写	0x00	0xFF
BUS	2	0x4	M4I, M4D	BUSMCNT%s	主总线控制 Register %s	0x1000	16	读写	0x0000	0xFFFF
	-	-	-	BUSMCNTSYS	主总线控制注册系统	0x1008	16	读写	0x0000	0xFFFF
	-	-	-	BUSMCNTDMA	主总线控制 Register DMA	0x100C	16	读写	0x0000	0xFFFF
	2	0x4	FLI,RAMH	BUSSCNT%s	从总线控制 Register %s	0x1100	16	读写	0x0000	0xFFFF
	-	-	-	BUSSCNTMBIU	从总线控制 Register MBIU	0x1108	16	读写	0x0000	0xFFFF
	4	0x4	P0B, P2B, P3B, P4B	BUSSCNT%s	从总线控制 Register %s	0x1114	16	读写	0x0000	0xFFFF
	-	-	-	BUSSCNTP6B	从总线控制 Register P6B	0x1128	16	读写	0x0000	0xFFFF
	3	0x4	FBU	BUSSCNT%s	从总线控制 Register %s	0x1130	16	读写	0x0000	0xFFFF
	4	0x10	1-4	BUS%sERRADD	总线错误地址 Register %s	0x1800	32	只读	0x0000 0000	0x00000 000

RA生态工作室

Table 3.3 Register description (3 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
BUS	4	0x10	1-4	BUS%sERRSTAT	Bus Error Status Register %s	0x1804	8	read-only	0x00	0xFE
DMAC0-7	-	-	-	DMSAR	DMA Source Address Register	0x00	32	read-write	0x0000 0000	0xFFFF FFFF
				DMDAR	DMA Destination Address Register	0x04	32	read-write	0x0000 0000	0xFFFF FFFF
				DMCRA	DMA Transfer Count Register	0x08	32	read-write	0x0000 0000	0xFFFF FFFF
				DMCRB	DMA Block Transfer Count Register	0x0C	16	read-write	0x0000	0xFFFF
				DMTMD	DMA Transfer Mode Register	0x10	16	read-write	0x0000	0xFFFF
				DMINT	DMA Interrupt Setting Register	0x13	8	read-write	0x00	0xFF
				DMAMD	DMA Address Mode Register	0x14	16	read-write	0x0000	0xFFFF
				DMOFR	DMA Offset Register	0x18	32	read-write	0x0000 0000	0xFFFF FFFF
				DMCNT	DMA Transfer Enable Register	0x1C	8	read-write	0x00	0xFF
				DMREQ	DMA Software Start Register	0x1D	8	read-write	0x00	0xFF
				DMSTS	DMAC Module Activation Register	0x1E	8	read-write	0x00	0xFF
DMA	-	-	-	DMAST	DMA Module Activation Register	0x00	8	read-write	0x00	0xFF
DTC	-	-	-	DTCCR	DTC Control Register	0x00	8	read-write	0x08	0xFF
				DTCVBR	DTC Vector Base Register	0x04	32	read-write	0x0000 0000	0xFFFF FFFF
				DTCST	DTC Module Start Register	0x0C	8	read-write	0x00	0xFF
				DTCSTS	DTC Status Register	0x0E	16	read-only	0x0000	0xFFFF
ICU	14	0x1	0-13	IRQCR%s	IRQ Control Register %s	0x000	8	read-write	0x00	0xFF
	-	-	-	NMICR	NMI Pin Interrupt Control Register	0x100	8	read-write	0x00	0xFF
				NMIER	Non-Maskable Interrupt Enable Register	0x120	16	read-write	0x0000	0xFFFF
				NMICLR	Non-Maskable Interrupt Status Clear Register	0x130	16	write-only	0x0000	0xFFFF
				NMISR	Non-Maskable Interrupt Status Register	0x140	16	read-only	0x0000	0xFFFF
				WUPEN	Wakeup Interrupt Enable Register	0x1A0	32	read-write	0x0000 0000	0xFFFF FFFF
				SELSR0	SYS Event Link Setting Register	0x200	16	read-write	0x0000	0xFFFF
	8	0x4	0-7	DELSR%s	DMAC Event Link Setting Register %s	0x280	32	read-write	0x0000	0xFFFF
	96	0x4	0-95	IELSR%s	INT Event Link Setting Register %s	0x300	32	read-write	0x0000 0000	0xFFFF FFFF

Table 3.3 注册描述（3/25）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
BUS	4	0x10	1-4	BUS%sERRSTAT	总线错误状态 Register %s	0x1804	8	只读	0x00	0xFE
DMAC0-7	-	-	-	DMSAR	DMA源地址 Register	0x00	32	读写	0x0000 0000	0xFFFF FFFF
				DMDAR	DMA目标地址寄存器	0x04	32	读写	0x0000 0000	0xFFFF FFFF
				DMCRA	DMA传输计数 Register	0x08	32	读写	0x0000 0000	0xFFFF FFFF
				DMCRB	DMA块传输计数寄存器	0x0C	16	读写	0x0000	0xFFFF
				DMTMD	DMA传输模式 Register	0x10	16	读写	0x0000	0xFFFF
				DMINT	DMA中断设置 Register	0x13	8	读写	0x00	0xFF
				DMAMD	DMA地址模式 Register	0x14	16	读写	0x0000	0xFFFF
				DMOFR	DMA偏移寄存器	0x18	32	读写	0x0000 0000	0xFFFF FFFF
				DMCNT	DMA传输使能 Register	0x1C	8	读写	0x00	0xFF
				DMREQ	DMA软件启动 Register	0x1D	8	读写	0x00	0xFF
				DMSTS	DMAC Module 激活寄存器	0x1E	8	读写	0x00	0xFF
DMA	-	-	-	DMAST	DMA模块激活 Register	0x00	8	读写	0x00	0xFF
DTC	-	-	-	DTCCR	DTC控制寄存器	0x00	8	读写	0x08	0xFF
				DTCVBR	DTC向量基 Register	0x04	32	读写	0x0000 0000	0xFFFF FFFF
				DTCST	DTC模块启动 Register	0x0C	8	读写	0x00	0xFF
				DTCSTS	DTC状态寄存器	0x0E	16	只读	0x0000	0xFFFF
ICU	14	0x1	0-13	IRQCR%s	IRQ控制寄存器%s	0x000	8	读写	0x00	0xFF
	-	-	-	NMICR	NMI引脚中断控制寄存器	0x100	8	读写	0x00	0xFF
				NMIER	Non-Maskable Interrupt 启用注册	0x120	16	读写	0x0000	0xFFFF
				NMICLR	Non-Maskable Interrupt 状态清除寄存器	0x130	16	只写	0x0000	0xFFFF
				NMISR	Non-Maskable Interrupt 状态寄存器	0x140	16	只读	0x0000	0xFFFF
				WUPEN	唤醒中断 启用注册	0x1A0	32	读写	0x0000 0000	0xFFFF FFFF
				SELSR0	SYS事件链接设置 Register	0x200	16	读写	0x0000	0xFFFF
	8	0x4	0-7	DELSR%s	DMAC事件链接设置寄存器%s	0x280	32	读写	0x0000	0xFFFF
	96	0x4	0-95	IELSR%s	INT事件链接设置 Register %s	0x300	32	读写	0x0000 0000	0xFFFF FFFF

RA生态工作室

Table 3.3 Register description (4 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
DBG	-	-	-	DBGSTR	Debug Status Register	0x000	32	read-only	0x0000 0000	0xFFFF FFFF
				DBGSTOPCR	Debug Stop Control Register	0x010	32	read-write	0x0000 0003	0xFFFF FFFF
				TRACECTR	Trace Control Register	0x020	32	read-write	0x0000 0000	0xFFFF FFFF
FCACHE	-	-	-	FCACHEE	Flash Cache Enable Register	0x100	16	read-write	0x0000	0xFFFF
				FCACHEIV	Flash Cache Invalidate Register	0x104	16	read-write	0x0000	0xFFFF
				FLWT	Flash Wait Cycle Register	0x11C	8	read-write	0x00	0xFF
SYSTEM	-	-	-	SBYCR	Standby Control Register	0x00C	16	read-write	0x4000	0xFFFF
				MSTPCRA	Module Stop Control Register A	0x01C	32	read-write	0xFFBF FF1C	0xFFFF FFFF
				SCKDIVCR	System Clock Division Control Register	0x020	32	read-write	0x2202 2222	0xFFFF FFFF
				SCKSCR	System Clock Source Control Register	0x026	8	read-write	0x01	0xFF
				PLLCCR	PLL Clock Control Register	0x028	16	read-write	0x1300	0xFFFF
				PLLCR	PLL Control Register	0x02A	8	read-write	0x01	0xFF
				MOSCCR	Main Clock Oscillator Control Register	0x032	8	read-write	0x01	0xFF
				HOCOCR	High-Speed On-Chip Oscillator Control Register	0x036	8	read-write	0x00	0xFE
				MOCOCR	Middle-Speed On-Chip Oscillator Control Register	0x038	8	read-write	0x00	0xFF
				FLLCR1	FLL Control Register 1	0x039	8	read-write	0x00	0xFF
				FLLCR2	FLL Control Register 2	0x03A	16	read-write	0x0000	0xFFFF
				OSCSF	Oscillation Stabilization Flag Register	0x03C	8	read-only	0x00	0xFE
				CKOCR	Clock Out Control Register	0x03E	8	read-write	0x00	0xFF
				TRCKCR	Trace Clock Control Register	0x03F	8	read-write	0x01	0xFF
				OSTDCR	Oscillation Stop Detection Control Register	0x040	8	read-write	0x00	0xFF
				OSTDSR	Oscillation Stop Detection Status Register	0x041	8	read-write	0x00	0xFF
				MOCOUTCR	MOCO User Trimming Control Register	0x061	8	read-write	0x00	0xFF
				HOCOUTCR	HOCO User Trimming Control Register	0x062	8	read-write	0x00	0xFF
				SNZCR	Snooze Control Register	0x092	8	read-write	0x00	0xFF

Table 3.3 寄存器说明（25个中的4个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
DBG	-	-	-	DBGSTR	调试状态寄存器	0x000	32	只读	0x0000 0000	0xFFFF FFFF
				DBGSTOPCR	调试停止控制 Register	0x010	32	读写	0x0000 0003	0xFFFF FFFF
				TRACECTR	跟踪控制寄存器	0x020	32	读写	0x0000 0000	0xFFFF FFFF
FCACHE	-	-	-	FCACHEE	闪存缓存启用 Register	0x100	16	读写	0x0000	0xFFFF
				FCACHEIV	闪存缓存失效 Register	0x104	16	读写	0x0000	0xFFFF
				FLWT	闪存等待周期 Register	0x11C	8	读写	0x00	0xFF
SYSTEM	-	-	-	SBYCR	待机控制 Register	0x00C	16	读写	0x4000	0xFFFF
				MSTPCRA	模块停止控制 Register A	0x01C	32	读写	0xFFBF FF1C	0xFFFF FFFF
				SCKDIVCR	系统时钟划分 控制寄存器	0x020	32	读写	0x2202 2222	0xFFFF FFFF
				SCKSCR	系统时钟源 控制寄存器	0x026	8	读写	0x01	0xFF
				PLLCCR	PLL时钟控制 Register	0x028	16	读写	0x1300	0xFFFF
				PLLCR	锁相环控制寄存器	0x02A	8	读写	0x01	0xFF
				MOSCCR	主时钟振荡器 控制寄存器	0x032	8	读写	0x01	0xFF
				HOCOCR	High-Speed On-Chip 振荡器控制 Register	0x036	8	读写	0x00	0xFE
				MOCOCR	Middle-Speed On-Chip 振荡器控制 Register	0x038	8	读写	0x00	0xFF
				FLLCR1	FLL控制寄存器1	0x039	8	读写	0x00	0xFF
				FLLCR2	FLL控制寄存器2	0x03A	16	读写	0x0000	0xFFFF
				OSCSF	振荡稳定 标志寄存器	0x03C	8	只读	0x00	0xFE
				CKOCR	时钟输出控制 Register	0x03E	8	读写	0x00	0xFF
				TRCKCR	跟踪时钟控制 Register	0x03F	8	读写	0x01	0xFF
				OSTDCR	振荡停止 检测控制 Register	0x040	8	读写	0x00	0xFF
				OSTDSR	振荡停止检测状态 Register	0x041	8	读写	0x00	0xFF
				MOCOUTCR	MOCO用户修整 控制寄存器	0x061	8	读写	0x00	0xFF
				HOCOUTCR	HOCO用户修整 控制寄存器	0x062	8	读写	0x00	0xFF
				SNZCR	贪睡控制寄存器	0x092	8	读写	0x00	0xFF

Table 3.3 Register description (5 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
SYSTEM	-	-	-	SNZEDCR	Snooze End Control Register	0x094	8	read-write	0x00	0xFF
				SNZREQCR	Snooze Request Control Register	0x098	32	read-write	0x00000000	0xFFFFFFFF
				OPCCR	Operating Power Control Register	0x0A0	8	read-write	0x00	0xFF
				MOSCWTCR	Main Clock Oscillator Wait Control Register	0x0A2	8	read-write	0x05	0xFF
				HOCOWTCR	High-speed on-chip oscillator wait control register	0x0A5	8	read-write	0x02	0xFF
				SOPCCR	Sub Operating Power Control Register	0x0AA	8	read-write	0x00	0xFF
				RSTSR1	Reset Status Register 1	0x0C0	16	read-write	0x0000	0xE0F8
	2	0x2	1,2	LVD%sCR1	Voltage Monitor %s Circuit Control Register 1	0x0E0	8	read-write	0x01	0xFF
	2	0x2	1,2	LVD%sSR	Voltage Monitor %s Circuit Status Register	0x0E1	8	read-write	0x02	0xFF
	-	-	-	PRCR	Protect Register	0x3FE	16	read-write	0x0000	0xFFFF
				DPSBYCR	Deep Standby Control Register	0x400	8	read-write	0x01	0xFF
				DPSIER0	Deep Standby Interrupt Enable Register 0	0x402	8	read-write	0x00	0xFF
				DPSIER1	Deep Standby Interrupt Enable Register 1	0x403	8	read-write	0x00	0xFF
				DPSIER2	Deep Standby Interrupt Enable Register 2	0x404	8	read-write	0x00	0xFF
				DPSIER3	Deep Standby Interrupt Enable Register 3	0x405	8	read-write	0x00	0xFF
				DPSIFR0	Deep Standby Interrupt Flag Register 0	0x406	8	read-write	0x00	0xFF
				DPSIFR1	Deep Standby Interrupt Flag Register 1	0x407	8	read-write	0x00	0xFF
				DPSIFR2	Deep Standby Interrupt Flag Register 2	0x408	8	read-write	0x00	0xFF
				DPSIFR3	Deep Standby Interrupt Flag Register 3	0x409	8	read-write	0x00	0xFF
				DPSIEGR0	Deep Standby Interrupt Edge Register 0	0x40A	8	read-write	0x00	0xFF
				DPSIEGR1	Deep Standby Interrupt Edge Register 1	0x40B	8	read-write	0x00	0xFF
				DPSIEGR2	Deep Standby Interrupt Edge Register 2	0x40C	8	read-write	0x00	0xFF
				SYOCDCR	System Control OCD Control Register	0x40E	8	read-write	0x00	0xFE
				STCONR	Standby Condition Register	0x40F	8	read-write	0xC3	0xFF
				RSTSR0	Reset Status Register 0	0x410	8	read-write	0x00	0x70
				RSTSR2	Reset Status Register 2	0x411	8	read-write	0x00	0xFE

Table 3.3 注册描述（5/25）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
SYSTEM	-	-	-	SNZEDCR	贪睡结束控制 Register	0x094	8	读写	0x00	0xFF
				SNZREQCR	贪睡请求控制 Register	0x098	32	读写	0x00000000	0xFFFFFFFF
				OPCCR	工作电源控制寄存器	0x0A0	8	读写	0x00	0xFF
				MOSCWTCR	主时钟振荡器等待控制寄存器	0x0A2	8	读写	0x05	0xFF
				HOCOWTCR	高速内部振荡器等待控制寄存器	0x0A5	8	读写	0x02	0xFF
				SOPCCR	副作业功率控制寄存器	0x0AA	8	读写	0x00	0xFF
				RSTSR1	复位状态寄存器1	0x0C0	16	读写	0x0000	0xE0F8
	2	0x2	1,2	LVD%sCR1	电压监视器%s电路控制寄存器1	0x0E0	8	读写	0x01	0xFF
	2	0x2	1,2	LVD%sSR	电压监视器%s电路状态寄存器	0x0E1	8	读写	0x02	0xFF
	-	-	-	PRCR	保护寄存器	0x3FE	16	读写	0x0000	0xFFFF
				DPSBYCR	深度待机控制 Register	0x400	8	读写	0x01	0xFF
				DPSIER0	深度待机中断启用寄存器0	0x402	8	读写	0x00	0xFF
				DPSIER1	深度待机中断启用寄存器1	0x403	8	读写	0x00	0xFF
				DPSIER2	深度待机中断启用寄存器2	0x404	8	读写	0x00	0xFF
				DPSIER3	深度待机中断启用寄存器3	0x405	8	读写	0x00	0xFF
				DPSIFR0	深度待机中断标志寄存器0	0x406	8	读写	0x00	0xFF
				DPSIFR1	深度待机中断标志寄存器1	0x407	8	读写	0x00	0xFF
				DPSIFR2	深度待机中断标志寄存器2	0x408	8	读写	0x00	0xFF
				DPSIFR3	深度待机中断标志寄存器3	0x409	8	读写	0x00	0xFF
				DPSIEGR0	深度待机中断边缘寄存器0	0x40A	8	读写	0x00	0xFF
				DPSIEGR1	深度待机中断边缘寄存器1	0x40B	8	读写	0x00	0xFF
				DPSIEGR2	深度待机中断边缘寄存器2	0x40C	8	读写	0x00	0xFF
				SYOCDCR	系统控制强迫症控制寄存器	0x40E	8	读写	0x00	0xFE
				STCONR	待机状态 Register	0x40F	8	读写	0xC3	0xFF
				RSTSR0	复位状态寄存器0	0x410	8	读写	0x00	0x70
				RSTSR2	复位状态寄存器2	0x411	8	读写	0x00	0xFE

RA生态工作室

Table 3.3 Register description (6 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
SYSTEM	-	-	-	MOMCR	Main Clock Oscillator Mode Oscillation Control Register	0x413	8	read-write	0x00	0xFF
				FWEPROR	Flash P/E Protect Register	0x416	8	read-write	0x02	0xFF
				LVCMPCR	Voltage Monitor Circuit Control Register	0x417	8	read-write	0x00	0xFF
				LVDLVLR	Voltage Detection Level Select Register	0x418	8	read-write	0xF3	0xFF
	2	0x1	1, 2	LVD%sCR0	Voltage Monitor %s Circuit Control Register 0	0x41A	8	read-write	0x8A	0xF7
	-	-	-	SOSCCR	Sub-clock oscillator control register	0x480	8	read-write	0x00	0xFF
				SOMCR	Sub Clock Oscillator Mode Control Register	0x481	8	read-write	0x00	0xFD
				LOCOCR	Low-Speed On-Chip Oscillator Control Register	0x490	8	read-write	0x00	0xFF
				LOCOUTCR	LOCO User Trimming Control Register	0x492	8	read-write	0x00	0xFF
				VBTICTLR	AGT Input Control Register	0x4BB	8	read-write	0x00	0xF8
PORT0, 5-7	-	-	-	PCNTR1	Port Control Register 1	0x00	32	read-write	0x0000 0000	0xFFFF FFFF
				PODR	Output data register	0x00	16	read-write	0x0000	0xFFFF
				PDR	Data direction register	0x02	16	read-write	0x0000	0xFFFF
				PCNTR2	Port Control Register 2	0x04	32	read-only	0x0000 0000	0xFFFF 0000
				PIDR	Input data register	0x06	16	read-only	0x0000	0x0000
				PCNTR3	Port Control Register 3	0x08	32	write-only	0x0000 0000	0xFFFF FFFF
				PORR	Output reset register	0x08	16	write-only	0x0000	0xFFFF
				POSR	Output set register	0x0A	16	write-only	0x0000	0xFFFF
PORT1-4	-	-	-	PCNTR1	Port Control Register 1	0x00	32	read-write	0x0000 0000	0xFFFF FFFF
				PODR	Output data register	0x00	16	read-write	0x0000	0xFFFF
				PDR	Data direction register	0x02	16	read-write	0x0000	0xFFFF
				PCNTR2	Port Control Register 2	0x04	32	read-only	0x0000 0000	0xFFFF 0000
				EIDR	Event input data register	0x04	16	read-only	0x0000	0x0000
				PIDR	Input data register	0x06	16	read-only	0x0000	0x0000
				PCNTR3	Port Control Register 3	0x08	32	write-only	0x0000 0000	0xFFFF FFFF

Table 3.3 寄存器说明（25个中的6个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
SYSTEM	-	-	-	MOMCR	主时钟振荡器模式振荡控制 Register	0x413	8	读写	0x00	0xFF
				FWEPROR	FlashPE保护 Register	0x416	8	读写	0x02	0xFF
				LVCMPCR	电压监控电路控制寄存器	0x417	8	读写	0x00	0xFF
				LVDLVLR	电压检测电平选择注册	0x418	8	读写	0xF3	0xFF
	2	0x1	1, 2	LVD%sCR0	电压监视器%s电路控制寄存器 0	0x41A	8	读写	0x8A	0xF7
	-	-	-	SOSCCR	副时钟振荡器控制寄存器	0x480	8	读写	0x00	0xFF
				SOMCR	副时钟振荡器模式控制寄存器	0x481	8	读写	0x00	0xFD
				LOCOCR	Low-Speed On-Chip 振荡器控制 Register	0x490	8	读写	0x00	0xFF
				LOCOUTCR	LOCO用户修整控制寄存器	0x492	8	读写	0x00	0xFF
				VBTICTLR	AGT输入控制 Register	0x4BB	8	读写	0x00	0xF8
PORT0, 5-7	-	-	-	PCNTR1	端口控制寄存器1	0x00	32	读写	0x0000 0000	0xFFFF FFFF
				PODR	输出数据寄存器	0x00	16	读写	0x0000	0xFFFF
				PDR	数据方向寄存器	0x02	16	读写	0x0000	0xFFFF
				PCNTR2	端口控制寄存器2	0x04	32	只读	0x0000 0000	0xFFFF 0000
				PIDR	输入数据寄存器	0x06	16	只读	0x0000	0x0000
				PCNTR3	端口控制寄存器3	0x08	32	只写	0x0000 0000	0xFFFF FFFF
				PORR	输出复位寄存器	0x08	16	只写	0x0000	0xFFFF
				POSR	输出设置寄存器	0x0A	16	只写	0x0000	0xFFFF
PORT1-4	-	-	-	PCNTR1	端口控制寄存器1	0x00	32	读写	0x0000 0000	0xFFFF FFFF
				PODR	输出数据寄存器	0x00	16	读写	0x0000	0xFFFF
				PDR	数据方向寄存器	0x02	16	读写	0x0000	0xFFFF
				PCNTR2	端口控制寄存器2	0x04	32	只读	0x0000 0000	0xFFFF 0000
				EIDR	事件输入数据寄存器	0x04	16	只读	0x0000	0x0000
				PIDR	输入数据寄存器	0x06	16	只读	0x0000	0x0000
				PCNTR3	端口控制寄存器3	0x08	32	只写	0x0000 0000	0xFFFF FFFF

RA生态工作室

Table 3.3 Register description (7 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
PORT1-4	-	-	-	PORR	Output set register	0x08	16	write-only	0x0000	0xFFFF
				POSR	Output reset register	0x0A	16	write-only	0x0000	0xFFFF
				PCNTR4	Port Control Register 4	0x0C	32	read-write	0x0000 0000	0xFFFF FFFF
				EORR	Event output set register	0x0C	16	read-write	0x0000	0xFFFF
				EOSR	Event output reset register	0x0E	16	read-write	0x0000	0xFFFF
PFS	-	-	-	P000PFS	P000 Pin Function Control Register	0x000	32	read-write	0x0000 8000	0xFFFF FFFD
				P000PFS_HA	P000 Pin Function Control Register	0x002	16	read-write	0x8000	0xFFFD
				P000PFS_BY	P000 Pin Function Control Register	0x003	8	read-write	0x00	0xFD
	7	0x4	1-7	P00%sPFS	P00%s Pin Function Control Register	0x004	32	read-write	0x0000 8000	0xFFFF FFFD
	7	0x4	1-7	P00%sPFS_HA	P00%s Pin Function Control Register	0x006	16	read-write	0x8000	0xFFFD
	7	0x4	1-7	P00%sPFS_BY	P00%s Pin Function Control Register	0x007	8	read-write	0x00	0xFD
	-	-	-	P008PFS	P008 Pin Function Control Register	0x020	32	read-write	0x0000 0000	0xFFFF FFFD
				P008PFS_HA	P008 Pin Function Control Register	0x022	16	read-write	0x0000	0xFFFD
				P008PFS_BY	P008 Pin Function Control Register	0x023	8	read-write	0x00	0xFD
	2	0x4	14-15	P0%sPFS	P0%s Pin Function Control Register	0x038	32	read-write	0x0000 0000	0xFFFF FFFD
	2	0x4	14-15	P0%sPFS_HA	P0%s Pin Function Control Register	0x03A	16	read-write	0x0000	0xFFFD
	2	0x4	14-15	P0%sPFS_BY	P0%s Pin Function Control Register	0x03B	8	read-write	0x00	0xFD
	-	-	-	P100PFS	P100 Pin Function Control Register	0x040	32	read-write	0x0000 0000	0xFFFF FFFD
				P100PFS_HA	P100 Pin Function Control Register	0x042	16	read-write	0x0000	0xFFFD
				P100PFS_BY	P100 Pin Function Control Register	0x043	8	read-write	0x00	0xFD
	7	0x4	1-7	P10%sPFS	P10%s Pin Function Control Register	0x044	32	read-write	0x0000 0000	0xFFFF FFFD
	7	0x4	1-7	P10%sPFS_HA	P10%s Pin Function Control Register	0x046	16	read-write	0x0000	0xFFFD
	7	0x4	1-7	P10%sPFS_BY	P10%s Pin Function Control Register	0x047	8	read-write	0x00	0xFD
	-	-	-	P108PFS	P108 Pin Function Control Register	0x060	32	read-write	0x0001 0410	0xFFFF FFFD
				P108PFS_HA	P108 Pin Function Control Register	0x062	16	read-write	0x0410	0xFFFD
				P108PFS_BY	P108 Pin Function Control Register	0x063	8	read-write	0x10	0xFD

Table 3.3 寄存器说明（25个中的7个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
PORT1-4	-	-	-	PORR	输出设置寄存器	0x08	16	只写	0x0000	0xFFFF
				POSR	输出复位寄存器	0x0A	16	只写	0x0000	0xFFFF
				PCNTR4	端口控制寄存器4	0x0C	32	读写	0x0000 0000	0xFFFF FFFF
				EORR	事件输出设置寄存器	0x0C	16	读写	0x0000	0xFFFF
				EOSR	事件输出复位寄存器	0x0E	16	读写	0x0000	0xFFFF
PFS	-	-	-	P000PFS	P000引脚功能控制寄存器	0x000	32	读写	0x0000 8000	0xFFFF FFFD
				P000PFS_HA	P000引脚功能控制寄存器	0x002	16	读写	0x8000	0xFFFD
				P000PFS_BY	P000引脚功能控制寄存器	0x003	8	读写	0x00	0xFD
	7	0x4	1-7	P00%sPFS	P00%s引脚功能控制寄存器	0x004	32	读写	0x0000 8000	0xFFFF FFFD
	7	0x4	1-7	P00%sPFS_HA	P00%s引脚功能控制寄存器	0x006	16	读写	0x8000	0xFFFD
	7	0x4	1-7	P00%sPFS_BY	P00%s引脚功能控制寄存器	0x007	8	读写	0x00	0xFD
	-	-	-	P008PFS	P008引脚功能控制寄存器	0x020	32	读写	0x0000 0000	0xFFFF FFFD
				P008PFS_HA	P008引脚功能控制寄存器	0x022	16	读写	0x0000	0xFFFD
				P008PFS_BY	P008引脚功能控制寄存器	0x023	8	读写	0x00	0xFD
	2	0x4	14-15	P0%sPFS	P0%s引脚功能控制寄存器	0x038	32	读写	0x0000 0000	0xFFFF FFFD
	2	0x4	14-15	P0%sPFS_HA	P0%s引脚功能控制寄存器	0x03A	16	读写	0x0000	0xFFFD
	2	0x4	14-15	P0%sPFS_BY	P0%s引脚功能控制寄存器	0x03B	8	读写	0x00	0xFD
	-	-	-	P100PFS	P100引脚功能控制寄存器	0x040	32	读写	0x0000 0000	0xFFFF FFFD
				P100PFS_HA	P100引脚功能控制寄存器	0x042	16	读写	0x0000	0xFFFD
				P100PFS_BY	P100引脚功能控制寄存器	0x043	8	读写	0x00	0xFD
	7	0x4	1-7	P10%sPFS	P10%s引脚功能控制寄存器	0x044	32	读写	0x0000 0000	0xFFFF FFFD
	7	0x4	1-7	P10%sPFS_HA	P10%s引脚功能控制寄存器	0x046	16	读写	0x0000	0xFFFD
	7	0x4	1-7	P10%sPFS_BY	P10%s引脚功能控制寄存器	0x047	8	读写	0x00	0xFD
	-	-	-	P108PFS	P108引脚功能控制寄存器	0x060	32	读写	0x0001 0410	0xFFFF FFFD
				P108PFS_HA	P108引脚功能控制寄存器	0x062	16	读写	0x0410	0xFFFD
				P108PFS_BY	P108引脚功能控制寄存器	0x063	8	读写	0x10	0xFD

RA生态工作室

Table 3.3 Register description (8 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
PFS	-	-	-	P109PFS	P109 Pin Function Control Register	0x064	32	read-write	0x0001 0410	0xFFFF FFFD
				P109PFS_HA	P109 Pin Function Control Register	0x066	16	read-write	0x0410	0xFFFD
				P109PFS_BY	P109 Pin Function Control Register	0x067	8	read-write	0x10	0xFD
				P110PFS	P110 Pin Function Control Register	0x068	32	read-write	0x0001 0010	0xFFFF FFFD
				P110PFS_HA	P110 Pin Function Control Register	0x06A	16	read-write	0x0010	0xFFFD
				P110PFS_BY	P110 Pin Function Control Register	0x06B	8	read-write	0x10	0xFD
	5	0x4	11-15	P1%sPFS	P1%s Pin Function Control Register	0x06C	32	read-write	0x0000 0000	0xFFFF FFFD
	5	0x4	11-15	P1%sPFS_HA	P1%s Pin Function Control Register	0x06E	16	read-write	0x0000	0xFFFD
	5	0x4	11-15	P1%sPFS_BY	P1%s Pin Function Control Register	0x06F	8	read-write	0x00	0xFD
	-	-	-	P200PFS	P200 Pin Function Control Register	0x080	32	read-write	0x0000 0000	0xFFFF FFFD
				P200PFS_HA	P200 Pin Function Control Register	0x082	16	read-write	0x0000	0xFFFD
				P200PFS_BY	P200 Pin Function Control Register	0x083	8	read-write	0x00	0xFD
				P201PFS	P201 Pin Function Control Register	0x084	32	read-write	0x0000 0010	0xFFFF FFFD
				P201PFS_HA	P201 Pin Function Control Register	0x086	16	read-write	0x0010	0xFFFD
				P201PFS_BY	P201 Pin Function Control Register	0x087	8	read-write	0x10	0xFD
	5	0x4	5-9	P20%sPFS	P20%s Pin Function Control Register	0x094	32	read-write	0x0000 0000	0xFFFF FFFD
	5	0x4	5-9	P20%sPFS_HA	P20%s Pin Function Control Register	0x096	16	read-write	0x0000	0xFFFD
	5	0x4	5-9	P20%sPFS_BY	P20%s Pin Function Control Register	0x097	8	read-write	0x00	0xFD
	5	0x4	10-14	P2%sPFS	P2%s Pin Function Control Register	0x0A8	32	read-write	0x0000 0000	0xFFFF FFFD
	5	0x4	10-14	P2%sPFS_HA	P2%s Pin Function Control Register	0x0AA	16	read-write	0x0000	0xFFFD
	5	0x4	10-14	P2%sPFS_BY	P2%s Pin Function Control Register	0x0AB	8	read-write	0x00	0xFD
	-	-	-	P300PFS	P300 Pin Function Control Register	0x0C0	32	read-write	0x0001 0010	0xFFFF FFFD
				P300PFS_HA	P300 Pin Function Control Register	0x0C2	16	read-write	0x0010	0xFFFD
				P300PFS_BY	P300 Pin Function Control Register	0x0C3	8	read-write	0x10	0xFD
	7	0x4	1-7	P30%sPFS	P30%s Pin Function Control Register	0x0C4	32	read-write	0x0000 0000	0xFFFF FFFD
	7	0x4	1-7	P30%sPFS_HA	P30%s Pin Function Control Register	0x0C6	16	read-write	0x0000	0xFFFD

Table 3.3 寄存器说明（25个中的8个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
PFS	-	-	-	P109PFS	P109引脚功能控制寄存器	0x064	32	读写	0x0001 0410	0xFFFF FFFD
				P109PFS_HA	P109引脚功能控制寄存器	0x066	16	读写	0x0410	0xFFFD
				P109PFS_BY	P109引脚功能控制寄存器	0x067	8	读写	0x10	0xFD
				P110PFS	P110引脚功能控制寄存器	0x068	32	读写	0x0001 0010	0xFFFF FFFD
				P110PFS_HA	P110引脚功能控制寄存器	0x06A	16	读写	0x0010	0xFFFD
				P110PFS_BY	P110引脚功能控制寄存器	0x06B	8	读写	0x10	0xFD
	5	0x4	11-15	P1%sPFS	P1%s引脚功能控制寄存器	0x06C	32	读写	0x0000 0000	0xFFFF FFFD
	5	0x4	11-15	P1%sPFS_HA	P1%s引脚功能控制寄存器	0x06E	16	读写	0x0000	0xFFFD
	5	0x4	11-15	P1%sPFS_BY	P1%s引脚功能控制寄存器	0x06F	8	读写	0x00	0xFD
	-	-	-	P200PFS	P200引脚功能控制寄存器	0x080	32	读写	0x0000 0000	0xFFFF FFFD
				P200PFS_HA	P200引脚功能控制寄存器	0x082	16	读写	0x0000	0xFFFD
				P200PFS_BY	P200引脚功能控制寄存器	0x083	8	读写	0x00	0xFD
				P201PFS	P201引脚功能控制寄存器	0x084	32	读写	0x0000 0010	0xFFFF FFFD
				P201PFS_HA	P201引脚功能控制寄存器	0x086	16	读写	0x0010	0xFFFD
				P201PFS_BY	P201引脚功能控制寄存器	0x087	8	读写	0x10	0xFD
	5	0x4	5-9	P20%sPFS	P20%s引脚功能控制寄存器	0x094	32	读写	0x0000 0000	0xFFFF FFFD
	5	0x4	5-9	P20%sPFS_HA	P20%s引脚功能控制寄存器	0x096	16	读写	0x0000	0xFFFD
	5	0x4	5-9	P20%sPFS_BY	P20%s引脚功能控制寄存器	0x097	8	读写	0x00	0xFD
	5	0x4	10-14	P2%sPFS	P2%s引脚功能控制寄存器	0x0A8	32	读写	0x0000 0000	0xFFFF FFFD
	5	0x4	10-14	P2%sPFS_HA	P2%s引脚功能控制寄存器	0x0AA	16	读写	0x0000	0xFFFD
	5	0x4	10-14	P2%sPFS_BY	P2%s引脚功能控制寄存器	0x0AB	8	读写	0x00	0xFD
	-	-	-	P300PFS	P300引脚功能控制寄存器	0x0C0	32	读写	0x0001 0010	0xFFFF FFFD
				P300PFS_HA	P300引脚功能控制寄存器	0x0C2	16	读写	0x0010	0xFFFD
				P300PFS_BY	P300引脚功能控制寄存器	0x0C3	8	读写	0x10	0xFD
	7	0x4	1-7	P30%sPFS	P30%s引脚功能控制寄存器	0x0C4	32	读写	0x0000 0000	0xFFFF FFFD
	7	0x4	1-7	P30%sPFS_HA	P30%s引脚功能控制寄存器	0x0C6	16	读写	0x0000	0xFFFD

RA生态工作室

Table 3.3 Register description (9 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
PFS	7	0x4	1-7	P30%sPFS_BY	P30%s Pin Function Control Register	0x0C7	8	read-write	0x00	0xFD
	10	0x4	0-9	P40%sPFS	P40%s Pin Function Control Register	0x100	32	read-write	0x0000 0000	0xFFFF FFFD
	10	0x4	0-9	P40%sPFS_HA	P40%s Pin Function Control Register	0x102	16	read-write	0x0000	0xFFFD
	10	0x4	0-9	P40%sPFS_BY	P40%s Pin Function Control Register	0x103	8	read-write	0x00	0xFD
	6	0x4	10-15	P4%sPFS	P4%s Pin Function Control Register	0x128	32	read-write	0x0000 0000	0xFFFF FFFD
	6	0x4	10-15	P4%sPFS_HA	P4%s Pin Function Control Register	0x12A	16	read-write	0x0000	0xFFFD
	6	0x4	10-15	P4%sPFS_BY	P4%s Pin Function Control Register	0x12B	8	read-write	0x00	0xFD
	5	0x4	0-4	P50%sPFS	P50%s Pin Function Control Register	0x140	32	read-write	0x0000 0000	0xFFFF FFFD
	5	0x4	0-4	P50%sPFS_HA	P50%s Pin Function Control Register	0x142	16	read-write	0x0000	0xFFFD
	5	0x4	0-4	P50%sPFS_BY	P50%s Pin Function Control Register	0x143	8	read-write	0x00	0xFD
	-	-	-	P508PFS	P508 Pin Function Control Register	0x160	32	read-write	0x0000 0000	0xFFFF FFFD
				P508PFS_HA	P508 Pin Function Control Register	0x162	16	read-write	0x0000	0xFFFD
				P508PFS_BY	P508 Pin Function Control Register	0x163	8	read-write	0x00	0xFD
	3	0x4	0-2	P60%sPFS	P60%s Pin Function Control Register	0x180	32	read-write	0x0000 0000	0xFFFF FFFD
	3	0x4	0-2	P60%sPFS_HA	P60%s Pin Function Control Register	0x182	16	read-write	0x0000	0xFFFD
	3	0x4	0-2	P60%sPFS_BY	P60%s Pin Function Control Register	0x183	8	read-write	0x00	0xFD
	2	0x4	8-9	P60%sPFS	P60%s Pin Function Control Register	0x1A0	32	read-write	0x0000 0000	0xFFFF FFFD
	2	0x4	8-9	P60%sPFS_HA	P60%s Pin Function Control Register	0x1A2	16	read-write	0x0000	0xFFFD
	2	0x4	8-9	P60%sPFS_BY	P60%s Pin Function Control Register	0x1A3	8	read-write	0x00	0xFD
	-	-	-	P610PFS	P610 Pin Function Control Register	0x1A8	32	read-write	0x0000 0000	0xFFFF FFFD
				P610PFS_HA	P610 Pin Function Control Register	0x1AA	16	read-write	0x0000	0xFFFD
				P610PFS_BY	P610 Pin Function Control Register	0x1AB	8	read-write	0x00	0xFD
				P708PFS	P708 Pin Function Control Register	0x1E0	32	read-write	0x0000 0000	0xFFFF FFFD
				P708PFS_HA	P708 Pin Function Control Register	0x1E2	16	read-write	0x0000	0xFFFD
				P708PFS_BY	P708 Pin Function Control Register	0x1E3	8	read-write	0x00	0xFD
PMISC	-	-	-	PWPR	Write-Protect Register	0x03	8	read-write	0x80	0xFF

Table 3.3 寄存器说明（25个中的9个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
PFS	7	0x4	1-7	P30%sPFS_BY	P30%s引脚功能控制寄存器	0x0C7	8	读写	0x00	0xFD
	10	0x4	0-9	P40%sPFS	P40%s引脚功能控制寄存器	0x100	32	读写	0x0000 0000	0xFFFF FFFD
	10	0x4	0-9	P40%sPFS_HA	P40%s引脚功能控制寄存器	0x102	16	读写	0x0000	0xFFFD
	10	0x4	0-9	P40%sPFS_BY	P40%s引脚功能控制寄存器	0x103	8	读写	0x00	0xFD
	6	0x4	10-15	P4%sPFS	P4%s引脚功能控制寄存器	0x128	32	读写	0x0000 0000	0xFFFF FFFD
	6	0x4	10-15	P4%sPFS_HA	P4%s引脚功能控制寄存器	0x12A	16	读写	0x0000	0xFFFD
	6	0x4	10-15	P4%sPFS_BY	P4%s引脚功能控制寄存器	0x12B	8	读写	0x00	0xFD
	5	0x4	0-4	P50%sPFS	P50%s引脚功能控制寄存器	0x140	32	读写	0x0000 0000	0xFFFF FFFD
	5	0x4	0-4	P50%sPFS_HA	P50%s引脚功能控制寄存器	0x142	16	读写	0x0000	0xFFFD
	5	0x4	0-4	P50%sPFS_BY	P50%s引脚功能控制寄存器	0x143	8	读写	0x00	0xFD
	-	-	-	P508PFS	P508引脚功能控制寄存器	0x160	32	读写	0x0000 0000	0xFFFF FFFD
				P508PFS_HA	P508引脚功能控制寄存器	0x162	16	读写	0x0000	0xFFFD
				P508PFS_BY	P508引脚功能控制寄存器	0x163	8	读写	0x00	0xFD
	3	0x4	0-2	P60%sPFS	P60%s引脚功能控制寄存器	0x180	32	读写	0x0000 0000	0xFFFF FFFD
	3	0x4	0-2	P60%sPFS_HA	P60%s引脚功能控制寄存器	0x182	16	读写	0x0000	0xFFFD
	3	0x4	0-2	P60%sPFS_BY	P60%s引脚功能控制寄存器	0x183	8	读写	0x00	0xFD
	2	0x4	8-9	P60%sPFS	P60%s引脚功能控制寄存器	0x1A0	32	读写	0x0000 0000	0xFFFF FFFD
	2	0x4	8-9	P60%sPFS_HA	P60%s引脚功能控制寄存器	0x1A2	16	读写	0x0000	0xFFFD
	2	0x4	8-9	P60%sPFS_BY	P60%s引脚功能控制寄存器	0x1A3	8	读写	0x00	0xFD
	-	-	-	P610PFS	P610引脚功能控制寄存器	0x1A8	32	读写	0x0000 0000	0xFFFF FFFD
				P610PFS_HA	P610引脚功能控制寄存器	0x1AA	16	读写	0x0000	0xFFFD
				P610PFS_BY	P610引脚功能控制寄存器	0x1AB	8	读写	0x00	0xFD
				P708PFS	P708引脚功能控制寄存器	0x1E0	32	读写	0x0000 0000	0xFFFF FFFD
				P708PFS_HA	P708引脚功能控制寄存器	0x1E2	16	读写	0x0000	0xFFFD
				P708PFS_BY	P708引脚功能控制寄存器	0x1E3	8	读写	0x00	0xFD
PMISC	-	-	-	PWPR	Write-Protect Register	0x03	8	读写	0x80	0xFF

RA生态工作室

Table 3.3 Register description (10 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
ELC	-	-	-	ELCR	Event Link Controller Register	0x00	8	read-write	0x00	0xFF
	2	0x2	0,1	ELSEGR%s	Event Link Software Event Generation Register %s	0x02	8	read-write	0x80	0xFF
	19	0x4	0-18	ELSR%s	Event Link Setting Register %s	0x10	16	read-write	0x0000	0xFFFF
POEG	4	0x100	A,B,C,D	POEGG%s	POEG Group %s Setting Register	0x00	32	read-write	0x0000 0000	0xFFFF FFFF
INIT	-	-	-	RCR1	Reset Control Register 1	0x22	8	read-write	0x00	0x0A
				RCR2	Reset Control Register 2	0x24	8	read-write	0x00	0x0E
				RCR4	Reset Control Register 4	0x28	8	read-write	0x00	0xFE
WDT	-	-	-	WDTRR	WDT Refresh Register	0x00	8	read-write	0xFF	0xFF
				WDTCR	WDT Control Register	0x02	16	read-write	0x33F3	0xFFFF
				WDTSR	WDT Status Register	0x04	16	read-write	0x0000	0xFFFF
				WDTRCR	WDT Reset Control Register	0x06	8	read-write	0x80	0xFF
				WDTCSTPR	WDT Count Stop Control Register	0x08	8	read-write	0x80	0xFF
IWDT	-	-	-	IWDTRR	IWDT Refresh Register	0x00	8	read-write	0xFF	0xFF
				IWDTSR	IWDT Status Register	0x04	16	read-write	0x0000	0xFFFF
CAC	-	-	-	CACR0	CAC Control Register 0	0x00	8	read-write	0x00	0xFF
				CACR1	CAC Control Register 1	0x01	8	read-write	0x00	0xFF
				CACR2	CAC Control Register 2	0x02	8	read-write	0x00	0xFF
				CAICR	CAC Interrupt Control Register	0x03	8	read-write	0x00	0xFF
				CASTR	CAC Status Register	0x04	8	read-only	0x00	0xFF
				CAULVR	CAC Upper-Limit Value Setting Register	0x06	16	read-write	0x0000	0xFFFF
				CALLVR	CAC Lower-Limit Value Setting Register	0x08	16	read-write	0x0000	0xFFFF
				CACNTBR	CAC Counter Buffer Register	0x0A	16	read-only	0x0000	0xFFFF
MSTP	-	-	-	MSTPCRB	Module Stop Control Register B	0x00	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				MSTPCRC	Module Stop Control Register C	0x04	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				MSTPCRD	Module Stop Control Register D	0x08	32	read-write	0xFFFF FFFF	0xFFFF FFFF
CAN0	32	0x10	0-31	MB%s_ID	Mailbox Register	0x200	32	read-write	0x0000 0000	0x0000 000

Table 3.3 寄存器说明（25个中的10个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
ELC	-	-	-	ELCR	事件链接控制器 Register	0x00	8	读写	0x00	0xFF
	2	0x2	0,1	ELSEGR%s	活动链接软件事件生成 Register %s	0x02	8	读写	0x80	0xFF
	19	0x4	0-18	ELSR%s	活动链接设置 Register %s	0x10	16	读写	0x0000	0xFFFF
POEG	4	0x100	A,B,C,D	POEGG%s	POEG Group %s 设置寄存器	0x00	32	读写	0x0000 0000	0xFFFF FFFF
INIT	-	-	-	RCR1	复位控制寄存器1	0x22	8	读写	0x00	0x0A
				RCR2	复位控制寄存器2	0x24	8	读写	0x00	0x0E
				RCR4	复位控制寄存器4	0x28	8	读写	0x00	0xFE
WDT	-	-	-	WDTRR	WDT刷新寄存器	0x00	8	读写	0xFF	0xFF
				WDTCR	WDT控制寄存器	0x02	16	读写	0x33F3	0xFFFF
				WDTSR	WDT状态寄存器	0x04	16	读写	0x0000	0xFFFF
				WDTRCR	WDT复位控制 Register	0x06	8	读写	0x80	0xFF
				WDTCSTPR	WDT计数停止控制寄存器	0x08	8	读写	0x80	0xFF
IWDT	-	-	-	IWDTRR	IWDT刷新寄存器	0x00	8	读写	0xFF	0xFF
				IWDTSR	IWDT状态寄存器	0x04	16	读写	0x0000	0xFFFF
CAC	-	-	-	CACR0	CAC控制寄存器0	0x00	8	读写	0x00	0xFF
				CACR1	CAC控制寄存器1	0x01	8	读写	0x00	0xFF
				CACR2	CAC控制寄存器2	0x02	8	读写	0x00	0xFF
				CAICR	CAC中断控制 Register	0x03	8	读写	0x00	0xFF
				CASTR	CAC状态寄存器	0x04	8	只读	0x00	0xFF
				CAULVR	CAC上限值设置寄存器	0x06	16	读写	0x0000	0xFFFF
				CALLVR	CAC下限值设置寄存器	0x08	16	读写	0x0000	0xFFFF
				CACNTBR	CAC计数器缓冲器 Register	0x0A	16	只读	0x0000	0xFFFF
MSTP	-	-	-	MSTPCRB	模块停止控制 Register B	0x00	32	读写	0xFFFF FFFF	0xFFFF FFFF
				MSTPCRC	模块停止控制 Register C	0x04	32	读写	0xFFFF FFFF	0xFFFF FFFF
				MSTPCRD	模块停止控制 Register D	0x08	32	读写	0xFFFF FFFF	0xFFFF FFFF
CAN0	32	0x10	0-31	MB%s_ID	邮箱注册	0x200	32	读写	0x0000 0000	0x0000 000

RA生态工作室

Table 3.3 Register description (11 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
CAN0	32	0x10	0-31	MB%s_DL	Mailbox Register	0x204	16	read-write	0x0000	0x0000
	32	0x10	0-31	MB%s_D0	Mailbox Register	0x206	8	read-write	0x00	0x00
	32	0x10	0-31	MB%s_D1	Mailbox Register	0x207	8	read-write	0x00	0x00
	32	0x10	0-31	MB%s_D2	Mailbox Register	0x208	8	read-write	0x00	0x00
	32	0x10	0-31	MB%s_D3	Mailbox Register	0x209	8	read-write	0x00	0x00
	32	0x10	0-31	MB%s_D4	Mailbox Register	0x20A	8	read-write	0x00	0x00
	32	0x10	0-31	MB%s_D5	Mailbox Register	0x20B	8	read-write	0x00	0x00
	32	0x10	0-31	MB%s_D6	Mailbox Register	0x20C	8	read-write	0x00	0x00
	32	0x10	0-31	MB%s_D7	Mailbox Register	0x20D	8	read-write	0x00	0x00
	32	0x10	0-31	MB%s_TS	Mailbox Register	0x20E	16	read-write	0x0000	0x0000
	8	0x4	0-7	MKR[%s]	Mask Register	0x400	32	read-write	0x0000 0000	0x00000 000
	2	0x4	0,1	FIDCR%s	FIFO Received ID Compare Registers	0x420	32	read-write	0x0000 0000	0x00000 000
	-	-	-	MKIVLR	Mask Invalid Register	0x428	32	read-write	0x0000 0000	0x00000 000
				MIER	Mailbox Interrupt Enable Register	0x42C	32	read-write	0x0000 0000	0x00000 000
				MIER_FIFO	Mailbox Interrupt Enable Register for FIFO Mailbox Mode	0x42C	32	read-write	0x0000 0000	0x00000 000
	32	0x1	0-31	MCTL_TX[%s]	Message Control Register for Transmit	0x820	8	read-write	0x00	0xFF
	32	0x1	0-31	MCTL_RX[%s]	Message Control Register for Receive	0x820	8	read-write	0x00	0xFF
	-	-	-	CTLR	Control Register	0x840	16	read-write	0x0500	0xFFFF
				STR	Status Register	0x842	16	read-only	0x0500	0xFFFF
				BCR	Bit Configuration Register	0x844	32	read-write	0x0000 0000	0xFFFF FFFF
				RFCR	Receive FIFO Control Register	0x848	8	read-write	0x80	0xFF
				RFPCR	Receive FIFO Pointer Control Register	0x849	8	write-only	0x00	0x00
				TFCR	Transmit FIFO Control Register	0x84A	8	read-write	0x80	0xFF
				TFPCR	Transmit FIFO Pointer Control Register	0x84B	8	write-only	0x00	0x00
				EIER	Error Interrupt Enable Register	0x84C	8	read-write	0x00	0xFF
				EIFR	Error Interrupt Factor Judge Register	0x84D	8	read-write	0x00	0xFF

Table 3.3 寄存器说明（25个中的11个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
CAN0	32	0x10	0-31	MB%s_DL	邮箱注册	0x204	16	读写	0x0000	0x0000
	32	0x10	0-31	MB%s_D0	邮箱注册	0x206	8	读写	0x00	0x00
	32	0x10	0-31	MB%s_D1	邮箱注册	0x207	8	读写	0x00	0x00
	32	0x10	0-31	MB%s_D2	邮箱注册	0x208	8	读写	0x00	0x00
	32	0x10	0-31	MB%s_D3	邮箱注册	0x209	8	读写	0x00	0x00
	32	0x10	0-31	MB%s_D4	邮箱注册	0x20A	8	读写	0x00	0x00
	32	0x10	0-31	MB%s_D5	邮箱注册	0x20B	8	读写	0x00	0x00
	32	0x10	0-31	MB%s_D6	邮箱注册	0x20C	8	读写	0x00	0x00
	32	0x10	0-31	MB%s_D7	邮箱注册	0x20D	8	读写	0x00	0x00
	32	0x10	0-31	MB%s_TS	邮箱注册	0x20E	16	读写	0x0000	0x0000
	8	0x4	0-7	MKR[%s]	掩码寄存器	0x400	32	读写	0x0000 0000	0x00000 000
	2	0x4	0,1	FIDCR%s	FIFO接收ID比较寄存器	0x420	32	读写	0x0000 0000	0x00000 000
	-	-	-	MKIVLR	屏蔽无效寄存器	0x428	32	读写	0x0000 0000	0x00000 000
				MIER	邮箱中断启用 Register	0x42C	32	读写	0x0000 0000	0x00000 000
				MIER_FIFO	邮箱中断启用 注册先进先出 邮箱模式	0x42C	32	读写	0x0000 0000	0x00000 000
	32	0x1	0-31	MCTL_TX[%s]	消息控制 注册传输	0x820	8	读写	0x00	0xFF
	32	0x1	0-31	MCTL_RX[%s]	消息控制 注册接收	0x820	8	读写	0x00	0xFF
	-	-	-	CTLR	控制寄存器	0x840	16	读写	0x0500	0xFFFF
				STR	状态寄存器	0x842	16	只读	0x0500	0xFFFF
				BCR	位配置 Register	0x844	32	读写	0x0000 0000	0xFFFF FFFF
				RFCR	接收FIFO控制 Register	0x848	8	读写	0x80	0xFF
				RFPCR	接收FIFO指针 控制寄存器	0x849	8	只写	0x00	0x00
				TFCR	发送FIFO控制 Register	0x84A	8	读写	0x80	0xFF
				TFPCR	发送FIFO指针 控制寄存器	0x84B	8	只写	0x00	0x00
				EIER	错误中断使能 Register	0x84C	8	读写	0x00	0xFF
				EIFR	错误中断因素 法官名册	0x84D	8	读写	0x00	0xFF

RA生态工作室

Table 3.3 Register description (12 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
CAN0	-	-	-	RECR	Receive Error Count Register	0x84E	8	read-only	0x00	0xFF
				TECR	Transmit Error Count Register	0x84F	8	read-only	0x00	0xFF
				ECSR	Error Code Store Register	0x850	8	read-write	0x00	0xFF
				CSSR	Channel Search Support Register	0x851	8	read-write	0x00	0x00
				MSSR	Mailbox Search Status Register	0x852	8	read-only	0x80	0xFF
				MSMR	Mailbox Search Mode Register	0x853	8	read-write	0x00	0xFF
				TSR	Time Stamp Register	0x854	16	read-only	0x0000	0xFFFF
				AFSR	Acceptance Filter Support Register	0x856	16	read-write	0x0000	0x0000
				TCR	Test Control Register	0x858	8	read-write	0x00	0xFF
IIC0	-	-	-	ICCR1	I2C Bus Control Register 1	0x00	8	read-write	0x1F	0xFF
				ICCR2	I2C Bus Control Register 2	0x01	8	read-write	0x00	0xFF
				ICMR1	I2C Bus Mode Register 1	0x02	8	read-write	0x08	0xFF
				ICMR2	I2C Bus Mode Register 2	0x03	8	read-write	0x06	0xFF
				ICMR3	I2C Bus Mode Register 3	0x04	8	read-write	0x00	0xFF
				ICFER	I2C Bus Function Enable Register	0x05	8	read-write	0x72	0xFF
				ICSER	I2C Bus Status Enable Register	0x06	8	read-write	0x09	0xFF
				ICIER	I2C Bus Interrupt Enable Register	0x07	8	read-write	0x00	0xFF
				ICSR1	I2C Bus Status Register 1	0x08	8	read-write	0x00	0xFF
				ICSR2	I2C Bus Status Register 2	0x09	8	read-write	0x00	0xFF
	3	0x2	0-2	SARL%s	Slave Address Register L%s	0x0A	8	read-write	0x00	0xFF
	3	0x2	0-2	SARU%s	Slave Address Register U%s	0x0B	8	read-write	0x00	0xFF
	-	-	-	ICBRL	I2C Bus Bit Rate Low-Level Register	0x10	8	read-write	0xFF	0xFF
				ICBRH	I2C Bus Bit Rate High-Level Register	0x11	8	read-write	0xFF	0xFF
				ICDRT	I2C Bus Transmit Data Register	0x12	8	read-write	0xFF	0xFF
				ICDRR	I2C Bus Receive Data Register	0x13	8	read-only	0x00	0xFF
				ICWUR	I2C Bus Wake Up Unit Register	0x16	8	read-write	0x00	0xFF

Table 3.3 寄存器说明（25个中的12个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
CAN0	-	-	-	RECR	接收错误计数 Register	0x84E	8	只读	0x00	0xFF
				TECR	传输错误计数 Register	0x84F	8	只读	0x00	0xFF
				ECSR	错误代码存储 Register	0x850	8	读写	0x00	0xFF
				CSSR	频道搜索支持 Register	0x851	8	读写	0x00	0x00
				MSSR	邮箱搜索状态 Register	0x852	8	只读	0x80	0xFF
				MSMR	邮箱搜索模式 Register	0x853	8	读写	0x00	0xFF
				TSR	时间戳寄存器	0x854	16	只读	0x0000	0xFFFF
				AFSR	接受过滤器支持注册	0x856	16	读写	0x0000	0x0000
				TCR	测试控制寄存器	0x858	8	读写	0x00	0xFF
IIC0	-	-	-	ICCR1	I2C总线控制 Register 1	0x00	8	读写	0x1F	0xFF
				ICCR2	I2C总线控制 Register 2	0x01	8	读写	0x00	0xFF
				ICMR1	I2C总线模式寄存器 1	0x02	8	读写	0x08	0xFF
				ICMR2	I2C总线模式寄存器 2	0x03	8	读写	0x06	0xFF
				ICMR3	I2C总线模式寄存器 3	0x04	8	读写	0x00	0xFF
				ICFER	I2C总线功能使能寄存器	0x05	8	读写	0x72	0xFF
				ICSER	I2C总线状态启用 Register	0x06	8	读写	0x09	0xFF
				ICIER	I2C总线中断使能 Register	0x07	8	读写	0x00	0xFF
				ICSR1	I2C总线状态寄存器 1	0x08	8	读写	0x00	0xFF
				ICSR2	I2C总线状态寄存器 2	0x09	8	读写	0x00	0xFF
	3	0x2	0-2	SARL%s	从地址寄存器 L%s	0x0A	8	读写	0x00	0xFF
	3	0x2	0-2	SARU%s	从地址寄存器 U%s	0x0B	8	读写	0x00	0xFF
	-	-	-	ICBRL	I2C总线比特率低电平寄存器	0x10	8	读写	0xFF	0xFF
				ICBRH	I2C总线比特率高电平寄存器	0x11	8	读写	0xFF	0xFF
				ICDRT	I2C总线传输数据 Register	0x12	8	读写	0xFF	0xFF
				ICDRR	I2C总线接收数据 Register	0x13	8	只读	0x00	0xFF
				ICWUR	I2C总线唤醒单元 Register	0x16	8	读写	0x00	0xFF

RA生态工作室

Table 3.3 Register description (13 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
IIC0	-	-	-	ICWUR2	I2C Bus Wake Up Unit Register 2	0x17	8	read-only	0x03	0xFF
IIC1	-	-	-	ICCR1	I2C Bus Control Register 1	0x00	8	read-write	0x1F	0xFF
				ICCR2	I2C Bus Control Register 2	0x01	8	read-write	0x00	0xFF
				ICMR1	I2C Bus Mode Register 1	0x02	8	read-write	0x08	0xFF
				ICMR2	I2C Bus Mode Register 2	0x03	8	read-write	0x06	0xFF
				ICMR3	I2C Bus Mode Register 3	0x04	8	read-write	0x00	0xFF
				ICFER	I2C Bus Function Enable Register	0x05	8	read-write	0x72	0xFF
				ICSER	I2C Bus Status Enable Register	0x06	8	read-write	0x09	0xFF
				ICIER	I2C Bus Interrupt Enable Register	0x07	8	read-write	0x00	0xFF
				ICSR1	I2C Bus Status Register 1	0x08	8	read-write	0x00	0xFF
				ICSR2	I2C Bus Status Register 2	0x09	8	read-write	0x00	0xFF
	3	0x2	0-2	SARL%s	Slave Address Register L%s	0x0A	8	read-write	0x00	0xFF
	3	0x2	0-2	SARU%s	Slave Address Register U%s	0x0B	8	read-write	0x00	0xFF
	-	-	-	ICBRL	I2C Bus Bit Rate Low-Level Register	0x10	8	read-write	0xFF	0xFF
				ICBRH	I2C Bus Bit Rate High-Level Register	0x11	8	read-write	0xFF	0xFF
				ICDRT	I2C Bus Transmit Data Register	0x12	8	read-write	0xFF	0xFF
				ICDRR	I2C Bus Receive Data Register	0x13	8	read-only	0x00	0xFF
DOC	-	-	-	DOCR	DOC Control Register	0x00	8	read-write	0x00	0xFF
				DODIR	DOC Data Input Register	0x02	16	read-write	0x0000	0xFFFF
				DODSR	DOC Data Setting Register	0x04	16	read-write	0x0000	0xFFFF
ADC120	-	-	-	ADCSR	A/D Control Register	0x000	16	read-write	0x0000	0xFFFF
				ADANSA0	A/D Channel Select Register A0	0x004	16	read-write	0x0000	0xFFFF
				ADANSA1	A/D Channel Select Register A1	0x006	16	read-write	0x0000	0xFFFF
				ADADS0	A/D-Converted Value Addition/Average Channel Select Register 0	0x008	16	read-write	0x0000	0xFFFF
				ADADS1	A/D-Converted Value Addition/Average Channel Select Register 1	0x00A	16	read-write	0x0000	0xFFFF

Table 3.3 寄存器说明（25个中的13个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
IIC0	-	-	-	ICWUR2	I2C总线唤醒单元 Register 2	0x17	8	只读	0x03	0xFF
IIC1	-	-	-	ICCR1	I2C总线控制 Register 1	0x00	8	读写	0x1F	0xFF
				ICCR2	I2C总线控制 Register 2	0x01	8	读写	0x00	0xFF
				ICMR1	I2C总线模式寄存器 1	0x02	8	读写	0x08	0xFF
				ICMR2	I2C总线模式寄存器 2	0x03	8	读写	0x06	0xFF
				ICMR3	I2C总线模式寄存器 3	0x04	8	读写	0x00	0xFF
				ICFER	I2C总线功能使能寄存器	0x05	8	读写	0x72	0xFF
				ICSER	I2C总线状态启用 Register	0x06	8	读写	0x09	0xFF
				ICIER	I2C总线中断使能 Register	0x07	8	读写	0x00	0xFF
				ICSR1	I2C总线状态寄存器 1	0x08	8	读写	0x00	0xFF
				ICSR2	I2C总线状态寄存器 2	0x09	8	读写	0x00	0xFF
	3	0x2	0-2	SARL%s	从地址寄存器 L%s	0x0A	8	读写	0x00	0xFF
	3	0x2	0-2	SARU%s	从地址寄存器 U%s	0x0B	8	读写	0x00	0xFF
	-	-	-	ICBRL	I2C总线比特率低电平寄存器	0x10	8	读写	0xFF	0xFF
				ICBRH	I2C总线比特率高电平寄存器	0x11	8	读写	0xFF	0xFF
				ICDRT	I2C总线传输数据 Register	0x12	8	读写	0xFF	0xFF
				ICDRR	I2C总线接收数据 Register	0x13	8	只读	0x00	0xFF
DOC	-	-	-	DOCR	DOC控制寄存器	0x00	8	读写	0x00	0xFF
				DODIR	文档数据输入 Register	0x02	16	读写	0x0000	0xFFFF
				DODSR	文档数据设置 Register	0x04	16	读写	0x0000	0xFFFF
ADC120	-	-	-	ADCSR	AD控制寄存器	0x000	16	读写	0x0000	0xFFFF
				ADANSA0	AD频道选择 Register A0	0x004	16	读写	0x0000	0xFFFF
				ADANSA1	AD频道选择 Register A1	0x006	16	读写	0x0000	0xFFFF
				ADADS0	A/D-Converted Value Addition/Average 通道选择寄存器 0	0x008	16	读写	0x0000	0xFFFF
				ADADS1	A/D-Converted Value Addition/Average 通道选择寄存器 1	0x00A	16	读写	0x0000	0xFFFF

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Table 3.3 Register description (14 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
ADC120	-	-	-	ADADC	A/D-Converted Value Addition/Average Count Select Register	0x00C	8	read-write	0x00	0xFF
				ADCER	A/D Control Extended Register	0x00E	16	read-write	0x0000	0xFFFF
				ADSTRGR	A/D Conversion Start Trigger Select Register	0x010	16	read-write	0x0000	0xFFFF
				ADEXICR	A/D Conversion Extended Input Control Register	0x012	16	read-write	0x0000	0xFFFF
				ADANSB0	A/D Channel Select Register B0	0x014	16	read-write	0x0000	0xFFFF
				ADANSB1	A/D Channel Select Register B1	0x016	16	read-write	0x0000	0xFFFF
				ADDBLDR	A/D Data Duplication Register	0x018	16	read-only	0x0000	0xFFFF
				ADTSDR	A/D Temperature Sensor Data Register	0x01A	16	read-only	0x0000	0xFFFF
				ADOCDR	A/D Internal Reference Voltage Data Register	0x01C	16	read-only	0x0000	0xFFFF
				ADRD	A/D Self-Diagnosis Data Register	0x01E	16	read-only	0x0000	0xFFFF
	4	0x2	0-3	ADDR%s	A/D Data Register %s	0x020	16	read-only	0x0000	0xFFFF
	3	0x2	5-7	ADDR%s	A/D Data Register %s	0x02A	16	read-only	0x0000	0xFFFF
	3	0x2	16-18	ADDR%s	A/D Data Register %s	0x040	16	read-only	0x0000	0xFFFF
				ADDR20	A/D Data Register 20	0x048	16	read-only	0x0000	0xFFFF
	-	-	-	ADSHCR	A/D Sample and Hold Circuit Control Register	0x066	16	read-write	0x0018	0xFFFF
				ADDISCR	A/D Disconnection Detection Control Register	0x07A	8	read-write	0x00	0xFF
				ADSHMSR	A/D Sample and Hold Operation Mode Select Register	0x07C	8	read-write	0x00	0xFF
				ADGSPCR	A/D Group Scan Priority Control Register	0x080	16	read-write	0x0000	0xFFFF
				ADDBLDRA	A/D Data Duplication Register A	0x084	16	read-only	0x0000	0xFFFF
				ADDBLDRB	A/D Data Duplication Register B	0x086	16	read-only	0x0000	0xFFFF
				ADWINMON	A/D Compare Function Window A/B Status Monitor Register	0x08C	8	read-only	0x00	0xFF
				ADCMPCR	A/D Compare Function Control Register	0x090	16	read-write	0x0000	0xFFFF
				ADCMPANSER	A/D Compare Function Window A Extended Input Select Register	0x092	8	read-write	0x00	0xFF

Table 3.3 寄存器说明（25中的14）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
ADC120	-	-	-	ADADC	A/D-Converted Value Addition/Average Count 选择注册	0x00C	8	读写	0x00	0xFF
				ADCER	AD控制扩展 Register	0x00E	16	读写	0x0000	0xFFFF
				ADSTRGR	AD转换开始触发选择寄存器	0x010	16	读写	0x0000	0xFFFF
				ADEXICR	A/D Conversion 扩展输入控制 Register	0x012	16	读写	0x0000	0xFFFF
				ADANSB0	AD频道选择 Register B0	0x014	16	读写	0x0000	0xFFFF
				ADANSB1	AD频道选择 Register B1	0x016	16	读写	0x0000	0xFFFF
				ADDBLDR	AD数据复制 Register	0x018	16	只读	0x0000	0xFFFF
				ADTSDR	A/D Temperature 传感器数据寄存器	0x01A	16	只读	0x0000	0xFFFF
				ADOCDR	AD内部参考 电压数据寄存器	0x01C	16	只读	0x0000	0xFFFF
				ADRD	A/D Self-Diagnosis Data Register	0x01E	16	只读	0x0000	0xFFFF
	4	0x2	0-3	ADDR%s	AD数据寄存器%s	0x020	16	只读	0x0000	0xFFFF
	3	0x2	5-7	ADDR%s	AD数据寄存器%s	0x02A	16	只读	0x0000	0xFFFF
	3	0x2	16-18	ADDR%s	AD数据寄存器%s	0x040	16	只读	0x0000	0xFFFF
				ADDR20	AD数据寄存器20	0x048	16	只读	0x0000	0xFFFF
	-	-	-	ADSHCR	AD采样保持电路控制寄存器	0x066	16	读写	0x0018	0xFFFF
				ADDISCR	AD断线检测控制 Register	0x07A	8	读写	0x00	0xFF
				ADSHMSR	AD采样和保持操作模式选择 Register	0x07C	8	读写	0x00	0xFF
				ADGSPCR	AD组扫描优先级控制寄存器	0x080	16	读写	0x0000	0xFFFF
				ADDBLDRA	AD数据复制 Register A	0x084	16	只读	0x0000	0xFFFF
				ADDBLDRB	AD数据复制 Register B	0x086	16	只读	0x0000	0xFFFF
				ADWINMON	AD比较功能 窗口AB状态 监控寄存器	0x08C	8	只读	0x00	0xFF
				ADCMPCR	AD比较功能 控制寄存器	0x090	16	读写	0x0000	0xFFFF
				ADCMPANSER	AD比较功能 窗口A扩展输入选择寄存器	0x092	8	读写	0x00	0xFF

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Table 3.3 Register description (15 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
ADC120	-	-	-	ADCMPLER	A/D Compare Function Window A Extended Input Comparison Condition Setting Register	0x093	8	read-write	0x00	0xFF
				ADCMPANSR0	A/D Compare Function Window A Channel Select Register 0	0x094	16	read-write	0x0000	0xFFFF
				ADCMPANSR1	A/D Compare Function Window A Channel Select Register 1	0x096	16	read-write	0x0000	0xFFFF
				ADCMPLR0	A/D Compare Function Window A Comparison Condition Setting Register 0	0x098	16	read-write	0x0000	0xFFFF
				ADCMPLR1	A/D Compare Function Window A Comparison Condition Setting Register 1	0x09A	16	read-write	0x0000	0xFFFF
				ADCMPDR0	A/D Compare Function Window A Lower-Side Level Setting Register	0x09C	16	read-write	0x0000	0xFFFF
				ADCMPDR1	A/D Compare Function Window A Upper-Side Level Setting Register	0x09E	16	read-write	0x0000	0xFFFF
				ADCMPSR0	A/D Compare Function Window A Channel Status Register 0	0x0A0	16	read-write	0x0000	0xFFFF
				ADCMPSR1	A/D Compare Function Window A Channel Status Register 1	0x0A2	16	read-write	0x0000	0xFFFF
				ADCMPSER	A/D Compare Function Window A Extended Input Channel Status Register	0x0A4	8	read-write	0x00	0xFF
				ADCMPBNSR	A/D Compare Function Window B Channel Selection Register	0x0A6	8	read-write	0x00	0xFF
				ADWINLLB	A/D Compare Function Window B Lower-Side Level Setting Register	0x0A8	16	read-write	0x0000	0xFFFF
				ADWINULB	A/D Compare Function Window B Upper-Side Level Setting Register	0x0AA	16	read-write	0x0000	0xFFFF
				ADCMPBSR	A/D Compare Function Window B Status Register	0x0AC	8	read-write	0x00	0xFF
				ADSSTRL	A/D Sampling State Register L	0x0DD	8	read-write	0x0B	0xFF
				ADSSTRT	A/D Sampling State Register T	0x0DE	8	read-write	0x0B	0xFF
				ADSSTRO	A/D Sampling State Register O	0x0DF	8	read-write	0x0B	0xFF
	4	0x1	0-3	ADSSTR0%s	A/D Sampling State Register %s (Corresponding Channel is AN00%s)	0x0E0	8	read-write	0x0B	0xFF

Table 3.3 寄存器说明（25个中的15个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
ADC120	-	-	-	ADCMPLER	AD比较功能 窗口A扩展 输入比较条件设置 Register	0x093	8	读写	0x00	0xFF
				ADCMPANSR0	AD比较功能 窗口A通道 选择寄存器0	0x094	16	读写	0x0000	0xFFFF
				ADCMPANSR1	AD比较功能 窗口A通道 选择寄存器1	0x096	16	读写	0x0000	0xFFFF
				ADCMPLR0	AD比较功能窗口A比较 条件设定 Register 0	0x098	16	读写	0x0000	0xFFFF
				ADCMPLR1	AD比较功能窗口A比较 条件设定 Register 1	0x09A	16	读写	0x0000	0xFFFF
				ADCMPDR0	AD比较功能窗口A低端 电平设置寄存器	0x09C	16	读写	0x0000	0xFFFF
				ADCMPDR1	AD比较功能窗口A上位 电平设置寄存器	0x09E	16	读写	0x0000	0xFFFF
				ADCMPSR0	AD比较功能 窗口A通道 状态寄存器0	0x0A0	16	读写	0x0000	0xFFFF
				ADCMPSR1	AD比较功能 窗口A通道 状态寄存器1	0x0A2	16	读写	0x0000	0xFFFF
				ADCMPSER	AD比较功能 窗口A扩展输入通道 状态 Register	0x0A4	8	读写	0x00	0xFF
				ADCMPBNSR	AD比较功能 窗口B通道 选择寄存器	0x0A6	8	读写	0x00	0xFF
				ADWINLLB	AD比较功能窗口B低端 电平设置寄存器	0x0A8	16	读写	0x0000	0xFFFF
				ADWINULB	AD比较功能窗口B上层 电平设置寄存器	0x0AA	16	读写	0x0000	0xFFFF
				ADCMPBSR	AD比较功能 窗口B状态 Register	0x0AC	8	读写	0x00	0xFF
				ADSSTRL	AD采样状态 Register L	0x0DD	8	读写	0x0B	0xFF
				ADSSTRT	AD采样状态 Register T	0x0DE	8	读写	0x0B	0xFF
				ADSSTRO	AD采样状态 Register O	0x0DF	8	读写	0x0B	0xFF
	4	0x1	0-3	ADSSTR0%s	AD采样状态 寄存器%s（对应通道为AN00%s）	0x0E0	8	读写	0x0B	0xFF

Table 3.3 Register description (16 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
ADC120	3	0x1	5-7	ADSSTR0%s	A/D Sampling State Register %s (Corresponding Channel is AN00%s)	0x0E5	8	read-write	0x0B	0xFF
	-	-	-	ADPGACR	A/D Programmable Gain Amplifier Control Register	0x1A0	16	read-write	0x0000	0xFFFF
				ADPGAGS0	A/D Programmable Gain Amplifier Gain Setting Register 0	0x1A2	16	read-write	0x0000	0xFFFF
				ADPGADCR0	A/D Programmable Gain Amplifier Pseudo-Differential Input Control Register	0x1B0	16	read-write	0x8888	0xFFFF
ADC121	-	-	-	ADCSR	A/D Control Register	0x000	16	read-write	0x0000	0xFFFF
				ADANSA0	A/D Channel Select Register A0	0x004	16	read-write	0x0000	0xFFFF
				ADANSA1	A/D Channel Select Register A1	0x006	16	read-write	0x0000	0xFFFF
				ADADS0	A/D-Converted Value Addition/Average Channel Select Register 0	0x008	16	read-write	0x0000	0xFFFF
				ADADS1	A/D-Converted Value Addition/Average Channel Select Register 1	0x00A	16	read-write	0x0000	0xFFFF
				ADADC	A/D-Converted Value Addition/Average Count Select Register	0x00C	8	read-write	0x00	0xFF
				ADCER	A/D Control Extended Register	0x00E	16	read-write	0x0000	0xFFFF
				ADSTRGR	A/D Conversion Start Trigger Select Register	0x010	16	read-write	0x0000	0xFFFF
				ADEXICR	A/D Conversion Extended Input Control Register	0x012	16	read-write	0x0000	0xFFFF
				ADANSB0	A/D Channel Select Register B0	0x014	16	read-write	0x0000	0xFFFF
				ADANSB1	A/D Channel Select Register B1	0x016	16	read-write	0x0000	0xFFFF
				ADDBLDR	A/D Data Duplication Register	0x018	16	read-only	0x0000	0xFFFF
				ADTSDR	A/D Temperature Sensor Data Register	0x01A	16	read-only	0x0000	0xFFFF
				ADOCDR	A/D Internal Reference Voltage Data Register	0x01C	16	read-only	0x0000	0xFFFF
				ADRD	A/D Self-Diagnosis Data Register	0x01E	16	read-only	0x0000	0xFFFF
	3	0x2	0-2	ADDR%s	A/D Data Register %s	0x020	16	read-only	0x0000	0xFFFF
	3	0x2	5-7	ADDR%s	A/D Data Register %s	0x02A	16	read-only	0x0000	0xFFFF

Table 3.3 寄存器说明（25个中的16个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
ADC120	3	0x1	5-7	ADSSTR0%s	AD采样状态寄存器%s（对应通道为AN00%s）	0x0E5	8	读写	0x0B	0xFF
	-	-	-	ADPGACR	AD可编程增益放大器控制Register	0x1A0	16	读写	0x0000	0xFFFF
				ADPGAGS0	AD可编程增益放大器增益设置Register 0	0x1A2	16	读写	0x0000	0xFFFF
				ADPGADCR0	AD可编程增益放大器伪差分输入控制Register	0x1B0	16	读写	0x8888	0xFFFF
ADC121	-	-	-	ADCSR	AD控制寄存器	0x000	16	读写	0x0000	0xFFFF
				ADANSA0	AD频道选择Register A0	0x004	16	读写	0x0000	0xFFFF
				ADANSA1	AD频道选择Register A1	0x006	16	读写	0x0000	0xFFFF
				ADADS0	A/D-Converted Value Addition/Average通道选择寄存器0	0x008	16	读写	0x0000	0xFFFF
				ADADS1	A/D-Converted Value Addition/Average通道选择寄存器1	0x00A	16	读写	0x0000	0xFFFF
				ADADC	A/D-Converted Value Addition/Average Count选择注册	0x00C	8	读写	0x00	0xFF
				ADCER	AD控制扩展Register	0x00E	16	读写	0x0000	0xFFFF
				ADSTRGR	AD转换开始触发选择寄存器	0x010	16	读写	0x0000	0xFFFF
				ADEXICR	A/D Conversion扩展输入控制Register	0x012	16	读写	0x0000	0xFFFF
				ADANSB0	AD频道选择Register B0	0x014	16	读写	0x0000	0xFFFF
				ADANSB1	AD频道选择Register B1	0x016	16	读写	0x0000	0xFFFF
				ADDBLDR	AD数据复制Register	0x018	16	只读	0x0000	0xFFFF
				ADTSDR	A/D Temperature传感器数据寄存器	0x01A	16	只读	0x0000	0xFFFF
				ADOCDR	AD内部参考电压数据寄存器	0x01C	16	只读	0x0000	0xFFFF
				ADRD	A/D Self-Diagnosis Data Register	0x01E	16	只读	0x0000	0xFFFF
	3	0x2	0-2	ADDR%s	AD数据寄存器%s	0x020	16	只读	0x0000	0xFFFF
	3	0x2	5-7	ADDR%s	AD数据寄存器%s	0x02A	16	只读	0x0000	0xFFFF

RA生态工作室

Table 3.3 Register description (17 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
ADC121	2	0x2	16,17	ADDR%s	A/D Data Register %s	0x040	16	read-only	0x0000	0xFFFF
	-	-	-	ADSHCR	A/D Sample and Hold Circuit Control Register	0x066	16	read-write	0x0018	0xFFFF
				ADDISCR	A/D Disconnection Detection Control Register	0x07A	8	read-write	0x00	0xFF
				ADSHMSR	A/D Sample and Hold Operation Mode Select Register	0x07C	8	read-write	0x00	0xFF
				ADGSPCR	A/D Group Scan Priority Control Register	0x080	16	read-write	0x0000	0xFFFF
				ADDBLDRA	A/D Data Duplication Register A	0x084	16	read-only	0x0000	0xFFFF
				ADDBLDRB	A/D Data Duplication Register B	0x086	16	read-only	0x0000	0xFFFF
				ADWINMON	A/D Compare Function Window A/B Status Monitor Register	0x08C	8	read-only	0x00	0xFF
				ADCMPCR	A/D Compare Function Control Register	0x090	16	read-write	0x0000	0xFFFF
				ADCMPANSER	A/D Compare Function Window A Extended Input Select Register	0x092	8	read-write	0x00	0xFF
				ADCMPLER	A/D Compare Function Window A Extended Input Comparison Condition Setting Register	0x093	8	read-write	0x00	0xFF
				ADCMPANSR0	A/D Compare Function Window A Channel Select Register 0	0x094	16	read-write	0x0000	0xFFFF
				ADCMPANSR1	A/D Compare Function Window A Channel Select Register 1	0x096	16	read-write	0x0000	0xFFFF
				ADCMPLR0	A/D Compare Function Window A Comparison Condition Setting Register 0	0x098	16	read-write	0x0000	0xFFFF
				ADCMPLR1	A/D Compare Function Window A Comparison Condition Setting Register 1	0x09A	16	read-write	0x0000	0xFFFF
				ADCMPDR0	A/D Compare Function Window A Lower-Side Level Setting Register	0x09C	16	read-write	0x0000	0xFFFF
				ADCMPDR1	A/D Compare Function Window A Upper-Side Level Setting Register	0x09E	16	read-write	0x0000	0xFFFF
				ADCMPSR0	A/D Compare Function Window A Channel Status Register 0	0x0A0	16	read-write	0x0000	0xFFFF
				ADCMPSR1	A/D Compare Function Window A Channel Status Register 1	0x0A2	16	read-write	0x0000	0xFFFF

Table 3.3 寄存器说明（25个中的17个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
ADC121	2	0x2	16,17	ADDR%s	AD数据寄存器%s	0x040	16	只读	0x0000	0xFFFF
	-	-	-	ADSHCR	AD采样保持电路控制寄存器	0x066	16	读写	0x0018	0xFFFF
				ADDISCR	AD断线检测控制 Register	0x07A	8	读写	0x00	0xFF
				ADSHMSR	AD采样和保持操作模式选择 Register	0x07C	8	读写	0x00	0xFF
				ADGSPCR	AD组扫描优先级控制寄存器	0x080	16	读写	0x0000	0xFFFF
				ADDBLDRA	AD数据复制 Register A	0x084	16	只读	0x0000	0xFFFF
				ADDBLDRB	AD数据复制 Register B	0x086	16	只读	0x0000	0xFFFF
				ADWINMON	AD比较功能 窗口AB状态 监控寄存器	0x08C	8	只读	0x00	0xFF
				ADCMPCR	AD比较功能 控制寄存器	0x090	16	读写	0x0000	0xFFFF
				ADCMPANSER	AD比较功能 窗口A扩展输入选择寄存器	0x092	8	读写	0x00	0xFF
				ADCMPLER	AD比较功能 窗口A扩展 输入比较条件设置 Register	0x093	8	读写	0x00	0xFF
				ADCMPANSR0	AD比较功能 窗口A通道 选择寄存器0	0x094	16	读写	0x0000	0xFFFF
				ADCMPANSR1	AD比较功能 窗口A通道 选择寄存器1	0x096	16	读写	0x0000	0xFFFF
				ADCMPLR0	AD比较功能窗口A比较 条件设定 Register 0	0x098	16	读写	0x0000	0xFFFF
				ADCMPLR1	AD比较功能窗口A比较 条件设定 Register 1	0x09A	16	读写	0x0000	0xFFFF
				ADCMPDR0	AD比较功能窗口A低端电平设置寄存器	0x09C	16	读写	0x0000	0xFFFF
				ADCMPDR1	AD比较功能窗口A上位电平设置寄存器	0x09E	16	读写	0x0000	0xFFFF
				ADCMPSR0	AD比较功能 窗口A通道 状态寄存器0	0x0A0	16	读写	0x0000	0xFFFF
				ADCMPSR1	AD比较功能 窗口A通道 状态寄存器1	0x0A2	16	读写	0x0000	0xFFFF

RA生态工作室

Table 3.3 Register description (18 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
ADC121	-	-	-	ADCMPSER	A/D Compare Function Window A Extended Input Channel Status Register	0x0A4	8	read-write	0x00	0xFF
				ADCMPBNSR	A/D Compare Function Window B Channel Selection Register	0x0A6	8	read-write	0x00	0xFF
				ADWINLLB	A/D Compare Function Window B Lower-Side Level Setting Register	0x0A8	16	read-write	0x0000	0xFFFF
				ADWINULB	A/D Compare Function Window B Upper-Side Level Setting Register	0x0AA	16	read-write	0x0000	0xFFFF
				ADCMPBSR	A/D Compare Function Window B Status Register	0x0AC	8	read-write	0x00	0xFF
				ADSSTRL	A/D Sampling State Register L	0x0DD	8	read-write	0x0B	0xFF
				ADSSTRT	A/D Sampling State Register T	0x0DE	8	read-write	0x0B	0xFF
				ADSSTRO	A/D Sampling State Register O	0x0DF	8	read-write	0x0B	0xFF
	3	0x1	0-2	ADSSTR0%s	A/D Sampling State Register %s (Corresponding Channel is AN10%s)	0x0E0	8	read-write	0x0B	0xFF
	3	0x1	5-7	ADSSTR0%s	A/D Sampling State Register %s (Corresponding Channel is AN10%s)	0x0E5	8	read-write	0x0B	0xFF
	-	-	-	ADPGACR	A/D Programmable Gain Amplifier Control Register	0x1A0	16	read-write	0x0000	0xFFFF
				ADPGAGS0	A/D Programmable Gain Amplifier Gain Setting Register 0	0x1A2	16	read-write	0x0000	0xFFFF
				ADPGADCR0	A/D Programmable Gain Amplifier Pseudo-Differential Input Control Register	0x1B0	16	read-write	0x8888	0xFFFF
TSN	-	-	-	TSCR	Temperature Sensor Control Register	0x00	8	read-write	0x00	0xFF
DAC12	2	0x2	0,1	DADR%s	D/A Data Register %s	0x00	16	read-write	0x0000	0xFFFF
	-	-	-	DACR	D/A Control Register	0x0004	8	read-write	0x1F	0xFF
				DADPR	DADRm Format Select Register	0x0005	8	read-write	0x00	0xFF
				DAADSCR	D/A-A/D Synchronous Start Control Register	0x0006	8	read-write	0x00	0xFF
				DAAMPCR	D/A Output Amplifier Control Register	0x0008	8	read-write	0x00	0xFF
				DAASWCR	D/A Amplifier Stabilization Wait Control Register	0x101C	8	read-write	0x00	0xFF

Table 3.3 寄存器说明（25中的18）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
ADC121	-	-	-	ADCMPSER	AD比较功能 窗口A扩展输入通道状态 Register	0x0A4	8	读写	0x00	0xFF
				ADCMPBNSR	AD比较功能 窗口B通道 选择寄存器	0x0A6	8	读写	0x00	0xFF
				ADWINLLB	AD比较功能窗口B低端电平设置寄存器	0x0A8	16	读写	0x0000	0xFFFF
				ADWINULB	AD比较功能窗口B上层电平设置寄存器	0x0AA	16	读写	0x0000	0xFFFF
				ADCMPBSR	AD比较功能 窗口B状态 Register	0x0AC	8	读写	0x00	0xFF
				ADSSTRL	AD采样状态 Register L	0x0DD	8	读写	0x0B	0xFF
				ADSSTRT	AD采样状态 Register T	0x0DE	8	读写	0x0B	0xFF
				ADSSTRO	AD采样状态 Register O	0x0DF	8	读写	0x0B	0xFF
	3	0x1	0-2	ADSSTR0%s	AD采样状态 寄存器%s（对应通道为AN10%s）	0x0E0	8	读写	0x0B	0xFF
	3	0x1	5-7	ADSSTR0%s	AD采样状态 寄存器%s（对应通道为AN10%s）	0x0E5	8	读写	0x0B	0xFF
	-	-	-	ADPGACR	AD可编程增益 放大器控制 Register	0x1A0	16	读写	0x0000	0xFFFF
				ADPGAGS0	AD可编程增益 放大器增益设置 Register 0	0x1A2	16	读写	0x0000	0xFFFF
				ADPGADCR0	AD可编程增益放大器伪 差分输入控制 Register	0x1B0	16	读写	0x8888	0xFFFF
TSN	-	-	-	TSCR	温度感应器 控制寄存器	0x00	8	读写	0x00	0xFF
DAC12	2	0x2	0,1	DADR%s	DA数据寄存器%s	0x00	16	读写	0x0000	0xFFFF
	-	-	-	DACR	DA控制寄存器	0x0004	8	读写	0x1F	0xFF
				DADPR	DADRm格式选择 Register	0x0005	8	读写	0x00	0xFF
				DAADSCR	DA-AD同步启动控制寄存器	0x0006	8	读写	0x00	0xFF
				DAAMPCR	DA输出放大器 控制寄存器	0x0008	8	读写	0x00	0xFF
				DAASWCR	D/A Amplifier 稳定等待控制寄存器	0x101C	8	读写	0x00	0xFF

RA生态工作室

Table 3.3 Register description (19 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
DAC12	-	-	-	DAADUSR	D/A A/D Synchronous Unit Select Register	0x10C0	8	read-write	0x00	0xFF
SCI0-4,8,9	-	-	-	SMR	Serial Mode Register (SCMR.SMIF = 0)	0x00	8	read-write	0x00	0xFF
				SMR_SMCI	Serial mode register (SCMR.SMIF = 1)	0x00	8	read-write	0x00	0xFF
				BRR	Bit Rate Register	0x01	8	read-write	0xFF	0xFF
				SCR	Serial Control Register (SCMR.SMIF = 0)	0x02	8	read-write	0x00	0xFF
				SCR_SMCI	Serial Control Register (SCMR.SMIF =1)	0x02	8	read-write	0x00	0xFF
				TDR	Transmit Data Register	0x03	8	read-write	0xFF	0xFF
				SSR	Serial Status Register (SCMR.SMIF = 0 and FCR.FM=0)	0x04	8	read-write	0x84	0xFF
				SSR_FIFO	Serial Status Register (SCMR.SMIF = 0 and FCR.FM=1)	0x04	8	read-write	0x80	0xFD
				SSR_SMCI	Serial Status Register (SCMR.SMIF = 1)	0x04	8	read-write	0x84	0xFF
				RDR	Receive Data Register	0x05	8	read-only	0x00	0xFF
				SCMR	Smart Card Mode Register	0x06	8	read-write	0xF2	0xFF
				SEMR	Serial Extended Mode Register	0x07	8	read-write	0x00	0xFF
				SNFR	Noise Filter Setting Register	0x08	8	read-write	0x00	0xFF
				SIMR1	I2C Mode Register 1	0x09	8	read-write	0x00	0xFF
				SIMR2	I2C Mode Register 2	0x0A	8	read-write	0x00	0xFF
				SIMR3	I2C Mode Register 3	0x0B	8	read-write	0x00	0xFF
				SISR	I2C Status Register	0x0C	8	read-only	0x00	0xCB
				SPMR	SPI Mode Register	0x0D	8	read-write	0x00	0xFF
				TDRHL	Transmit 9-bit Data Register	0x0E	16	read-write	0xFFFF	0xFFFF
				FTDRHL	Transmit FIFO Data Register HL	0x0E	16	write-only	0xFFFF	0xFFFF
				FTDRH	Transmit FIFO Data Register H	0x0E	8	write-only	0xFF	0xFF
				FTDRL	Transmit FIFO Data Register L	0x0F	8	write-only	0xFF	0xFF
				RDRHL	Receive 9-bit Data Register	0x10	16	read-only	0x0000	0xFFFF
				FRDRHL	Receive FIFO Data Register HL	0x10	16	read-only	0x0000	0xFFFF
				FRDRH	Receive FIFO Data Register H	0x10	8	read-only	0x00	0xFF

Table 3.3 寄存器说明（25中的19）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
DAC12	-	-	-	DAADUSR	D/A A/D Synchronous 单位选择寄存器	0x10C0	8	读写	0x00	0xFF
SCI0-4,8,9	-	-	-	SMR	串行模式寄存器(SCMR.SMIF=0)	0x00	8	读写	0x00	0xFF
				SMR_SMCI	串行模式寄存器(SCMR.SMIF=1)	0x00	8	读写	0x00	0xFF
				BRR	比特率寄存器	0x01	8	读写	0xFF	0xFF
				SCR	串行控制寄存器(SCMR.SMIF=0)	0x02	8	读写	0x00	0xFF
				SCR_SMCI	串行控制寄存器(SCMR.SMIF=1)	0x02	8	读写	0x00	0xFF
				TDR	发送数据寄存器	0x03	8	读写	0xFF	0xFF
				SSR	串行状态寄存器（SCMR.SMIF=0和FCR.FM=0）	0x04	8	读写	0x84	0xFF
				SSR_FIFO	串行状态寄存器（SCMR.SMIF=0和FCR.FM=1）	0x04	8	读写	0x80	0xFD
				SSR_SMCI	串行状态寄存器(SCMR.SMIF=1)	0x04	8	读写	0x84	0xFF
				RDR	接收数据寄存器	0x05	8	只读	0x00	0xFF
				SCMR	智能卡模式 Register	0x06	8	读写	0xF2	0xFF
				SEMR	串行扩展模式 Register	0x07	8	读写	0x00	0xFF
				SNFR	噪音过滤器设置 Register	0x08	8	读写	0x00	0xFF
				SIMR1	I2C模式寄存器1	0x09	8	读写	0x00	0xFF
				SIMR2	I2C模式寄存器2	0x0A	8	读写	0x00	0xFF
				SIMR3	I2C模式寄存器3	0x0B	8	读写	0x00	0xFF
				SISR	I2C状态寄存器	0x0C	8	只读	0x00	0xCB
				SPMR	SPI模式寄存器	0x0D	8	读写	0x00	0xFF
				TDRHL	发送9位数据 Register	0x0E	16	读写	0xFFFF	0xFFFF
				FTDRHL	发送FIFO数据 Register HL	0x0E	16	只写	0xFFFF	0xFFFF
				FTDRH	发送FIFO数据 Register H	0x0E	8	只写	0xFF	0xFF
				FTDRL	发送FIFO数据 Register L	0x0F	8	只写	0xFF	0xFF
				RDRHL	接收9位数据 Register	0x10	16	只读	0x0000	0xFFFF
				FRDRHL	接收FIFO数据 Register HL	0x10	16	只读	0x0000	0xFFFF
				FRDRH	接收FIFO数据 Register H	0x10	8	只读	0x00	0xFF

RA生态工作室

Table 3.3 Register description (20 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
SCI0-4,8,9	-	-	-	FRDRL	Receive FIFO Data Register L	0x11	8	read-only	0x00	0xFF
				MDDR	Modulation Duty Register	0x12	8	read-write	0xFF	0xFF
				DCCR	Data Compare Match Control Register	0x13	8	read-write	0x40	0xFF
				FCR	FIFO Control Register	0x14	16	read-write	0xF800	0xFFFF
				FDR	FIFO Data Count Register	0x16	16	read-only	0x0000	0xFFFF
				LSR	Line Status Register	0x18	16	read-only	0x0000	0xFFFF
				CDR	Compare Match Data Register	0x1A	16	read-write	0x0000	0xFFFF
				SPTR	Serial Port Register	0x1C	8	read-write	0x03	0xFF
IRDA	-	-	-	IRCR	IrDA Control Register	0x00	8	read-write	0x00	0xFF
SPI0,1	-	-	-	SPCR	SPI Control Register	0x00	8	read-write	0x00	0xFF
				SSLP	SPI Slave Select Polarity Register	0x01	8	read-write	0x00	0xFF
				SPPCR	RSPI Pin Control Register	0x02	8	read-write	0x00	0xFF
				SPSR	SPI Status Register	0x03	8	read-write	0x20	0xFF
				SPDR	SPI Data Register	0x04	32	read-write	0x0000 0000	0xFFFF FFFF
				SPDR_HA	SPI Data Register (halfword access)	0x04	16	read-write	0x0000	0xFFFF
				SPSCR	SPI Sequence Control Register	0x08	8	read-write	0x00	0xFF
				SPSSR	SPI Sequence Status Register	0x09	8	read-only	0x00	0xFF
				SPBR	SPI Bit Rate Register	0x0A	8	read-write	0xFF	0xFF
				SPDCR	SPI Data Control Register	0x0B	8	read-write	0x00	0xFF
				SPCKD	SPI Clock Delay Register	0x0C	8	read-write	0x00	0xFF
				SSLND	SPI Slave Select Negation Delay Register	0x0D	8	read-write	0x00	0xFF
				SPND	SPI Next-Access Delay Register	0x0E	8	read-write	0x00	0xFF
				SPCR2	SPI Control Register 2	0x0F	8	read-write	0x00	0xFF
	8	0x2	0-7	SPCMD%s	SPI Command Register %s	0x10	16	read-write	0x070D	0xFFFF
	-	-	-	SPDCR2	SPI Data Control Register 2	0x20	8	read-write	0x00	0xFF
CRC	-	-	-	CRCCR0	CRC Control Register0	0x00	8	read-write	0x00	0xFF

Table 3.3 寄存器说明（25之20）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
SCI0-4,8,9	-	-	-	FRDRL	接收FIFO数据 Register L	0x11	8	只读	0x00	0xFF
				MDDR	调制任务 Register	0x12	8	读写	0xFF	0xFF
				DCCR	数据比较匹配 控制寄存器	0x13	8	读写	0x40	0xFF
				FCR	先进先出控制寄存器	0x14	16	读写	0xF800	0xFFFF
				FDR	FIFO数据计数 Register	0x16	16	只读	0x0000	0xFFFF
				LSR	线路状态寄存器	0x18	16	只读	0x0000	0xFFFF
				CDR	比较匹配数据 Register	0x1A	16	读写	0x0000	0xFFFF
				SPTR	串口寄存器	0x1C	8	读写	0x03	0xFF
IRDA	-	-	-	IRCR	红外线控制寄存器	0x00	8	读写	0x00	0xFF
SPI0,1	-	-	-	SPCR	SPI控制寄存器	0x00	8	读写	0x00	0xFF
				SSLP	SPI从机选择极性 寄存器	0x01	8	读写	0x00	0xFF
				SPPCR	RSPI引脚控制 Register	0x02	8	读写	0x00	0xFF
				SPSR	SPI状态寄存器	0x03	8	读写	0x20	0xFF
				SPDR	SPI数据寄存器	0x04	32	读写	0x0000 0000	0xFFFF FFFF
				SPDR_HA	SPI数据寄存器（ 半字访问）	0x04	16	读写	0x0000	0xFFFF
				SPSCR	SPI序列控制 Register	0x08	8	读写	0x00	0xFF
				SPSSR	SPI序列状态 Register	0x09	8	只读	0x00	0xFF
				SPBR	SPI比特率寄存器	0x0A	8	读写	0xFF	0xFF
				SPDCR	SPI数据控制 Register	0x0B	8	读写	0x00	0xFF
				SPCKD	SPI时钟延迟 Register	0x0C	8	读写	0x00	0xFF
				SSLND	SPI从机选择 否定延迟寄存器	0x0D	8	读写	0x00	0xFF
				SPND	SPI下一次访问延迟 Register	0x0E	8	读写	0x00	0xFF
				SPCR2	SPI控制寄存器2	0x0F	8	读写	0x00	0xFF
	8	0x2	0-7	SPCMD%s	SPI命令寄存器%s	0x10	16	读写	0x070D	0xFFFF
	-	-	-	SPDCR2	SPI数据控制 Register 2	0x20	8	读写	0x00	0xFF
CRC	-	-	-	CRCCR0	CRC Control Register0	0x00	8	读写	0x00	0xFF

Table 3.3 Register description (21 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
CRC	-	-	-	CRCCR1	CRC Control Register1	0x01	8	read-write	0x00	0xFF
				CRCDIR	CRC Data Input Register	0x04	32	read-write	0x0000 0000	0xFFFF FFFF
				CRCDIR_BY	CRC Data Input Register (byte access)	0x04	8	read-write	0x00	0xFF
				CRCDOR	CRC Data Output Register	0x08	32	read-write	0x0000 0000	0xFFFF FFFF
				CRCDOR_HA	CRC Data Output Register (halfword access)	0x08	16	read-write	0x0000	0xFFFF
				CRCDOR_BY	CRC Data Output Register (byte access)	0x08	8	read-write	0x00	0xFF
				CRCSAR	Snoop Address Register	0x0C	16	read-write	0x0000	0xFFFF
GPT32EH0-3,GPT32E4-7	-	-	-	GTWP	General PWM Timer Write-Protection Register	0x00	32	read-write	0x0000 0000	0xFFFF FFFF
				GTSTR	General PWM Timer Software Start Register	0x04	32	read-write	0x0000 0000	0xFFFF FFFF
				GTSTP	General PWM Timer Software Stop Register	0x08	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCLR	General PWM Timer Software Clear Register	0x0C	32	write-only	0x0000 0000	0xFFFF FFFF
				GTSSR	General PWM Timer Start Source Select Register	0x10	32	read-write	0x0000 0000	0xFFFF FFFF
				GTPSR	General PWM Timer Stop Source Select Register	0x14	32	read-write	0x0000 0000	0xFFFF FFFF
				GTCSR	General PWM Timer Clear Source Select Register	0x18	32	read-write	0x0000 0000	0xFFFF FFFF
				GTUPSR	General PWM Timer Up Count Source Select Register	0x1C	32	read-write	0x0000 0000	0xFFFF FFFF
				GTDNSR	General PWM Timer Down Count Source Select Register	0x20	32	read-write	0x0000 0000	0xFFFF FFFF
				GTICASR	General PWM Timer Input Capture Source Select Register A	0x24	32	read-write	0x0000 0000	0xFFFF FFFF
				GTICBSR	General PWM Timer Input Capture Source Select Register B	0x28	32	read-write	0x0000 0000	0xFFFF FFFF
				GTCR	General PWM Timer Control Register	0x2C	32	read-write	0x0000 0000	0xFFFF FFFF
				GTUDDTYC	General PWM Timer Count Direction and Duty Setting Register	0x30	32	read-write	0x0000 0001	0xFFFF FFFF
				GTIOR	General PWM Timer I/O Control Register	0x34	32	read-write	0x0000 0000	0xFFFF FFFF
				GTINTAD	General PWM Timer Interrupt Output Setting Register	0x38	32	read-write	0x0000 0000	0xFFFF FFFF

Table 3.3 寄存器描述（21的25）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
CRC	-	-	-	CRCCR1	CRC Control Register1	0x01	8	读写	0x00	0xFF
				CRCDIR	CRC数据输入 Register	0x04	32	读写	0x0000 0000	0xFFFF FFFF
				CRCDIR_BY	CRC数据输入 Register (byte access)	0x04	8	读写	0x00	0xFF
				CRCDOR	CRC数据输出 Register	0x08	32	读写	0x0000 0000	0xFFFF FFFF
				CRCDOR_HA	CRC数据输出寄存器（半字访问）	0x08	16	读写	0x0000	0xFFFF
				CRCDOR_BY	CRC数据输出 Register (byte access)	0x08	8	读写	0x00	0xFF
				CRCSAR	窥探地址寄存器	0x0C	16	读写	0x0000	0xFFFF
GPT32EH0-3,GPT32E4-7	-	-	-	GTWP	通用PWM定时器 Write-Protection Register	0x00	32	读写	0x0000 0000	0xFFFF FFFF
				GTSTR	通用PWM定时器 软件启动寄存器	0x04	32	读写	0x0000 0000	0xFFFF FFFF
				GTSTP	通用PWM定时器 软件停止寄存器	0x08	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCLR	通用PWM定时器 软件清除寄存器	0x0C	32	只写	0x0000 0000	0xFFFF FFFF
				GTSSR	通用PWM定时器启动源选择 Register	0x10	32	读写	0x0000 0000	0xFFFF FFFF
				GTPSR	通用PWM定时器停止源选择 Register	0x14	32	读写	0x0000 0000	0xFFFF FFFF
				GTCSR	通用PWM定时器清零源选择 Register	0x18	32	读写	0x0000 0000	0xFFFF FFFF
				GTUPSR	通用PWM定时器启动计数源选择 Register	0x1C	32	读写	0x0000 0000	0xFFFF FFFF
				GTDNSR	通用PWM定时器递减计数源 选择注册	0x20	32	读写	0x0000 0000	0xFFFF FFFF
				GTICASR	通用PWM定时器输入捕捉源 选择寄存器A	0x24	32	读写	0x0000 0000	0xFFFF FFFF
				GTICBSR	通用PWM定时器输入捕捉源 选择寄存器B	0x28	32	读写	0x0000 0000	0xFFFF FFFF
				GTCR	通用PWM定时器 控制寄存器	0x2C	32	读写	0x0000 0000	0xFFFF FFFF
				GTUDDTYC	通用PWM定时器计数方向和占空比设置寄存器	0x30	32	读写	0x0000 0001	0xFFFF FFFF
				GTIOR	通用PWM定时器IO 控制寄存器	0x34	32	读写	0x0000 0000	0xFFFF FFFF
				GTINTAD	通用PWM定时器 中断输出设置 Register	0x38	32	读写	0x0000 0000	0xFFFF FFFF

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Table 3.3 Register description (22 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
GPT32EH0-3,GPT32E4-7	-	-	-	GTST	General PWM Timer Status Register	0x3C	32	read-write	0x0000 8000	0xFFFF FFFF
				GTBER	General PWM Timer Buffer Enable Register	0x40	32	read-write	0x0000 0000	0xFFFF FFFF
				GTITC	General PWM Timer Interrupt and A/D Converter Start Request Skipping Setting Register	0x44	32	read-write	0x0000 0000	0xFFFF FFFF
				GTCNT	General PWM Timer Counter	0x48	32	read-write	0x0000 0000	0xFFFF FFFF
				GTCCRA	General PWM Timer Compare Capture Register A	0x4C	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRB	General PWM Timer Compare Capture Register B	0x50	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRC	General PWM Timer Compare Capture Register C	0x54	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRE	General PWM Timer Compare Capture Register E	0x58	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRD	General PWM Timer Compare Capture Register D	0x5C	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRF	General PWM Timer Compare Capture Register F	0x60	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTPR	General PWM Timer Cycle Setting Register	0x64	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTPBR	General PWM Timer Cycle Setting Buffer Register	0x68	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTPDBR	General PWM Timer Cycle Setting Double-Buffer Register	0x6C	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTADTRA	A/D Converter Start Request Timing Register A	0x70	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTADTBRA	A/D Converter Start Request Timing Buffer Register A	0x74	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTADTDBRA	A/D Converter Start Request Timing Double-Buffer Register A	0x78	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTADTRB	A/D Converter Start Request Timing Register B	0x7C	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTADTBRB	A/D Converter Start Request Timing Buffer Register B	0x80	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTADTDBRB	A/D Converter Start Request Timing Double-Buffer Register B	0x84	32	read-write	0xFFFF FFFF	0xFFFF FFFF

Table 3.3 寄存器说明（22之25）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
GPT32EH0-3,GPT32E4-7	-	-	-	GTST	通用PWM定时器 状态寄存器	0x3C	32	读写	0x0000 8000	0xFFFF FFFF
				GTBER	通用PWM定时器 缓冲区使能寄存器	0x40	32	读写	0x0000 0000	0xFFFF FFFF
				GTITC	通用PWM定时器 中断和AD转换器启动请求 跳过设置 Register	0x44	32	读写	0x0000 0000	0xFFFF FFFF
				GTCNT	通用PWM定时器 Counter	0x48	32	读写	0x0000 0000	0xFFFF FFFF
				GTCCRA	通用PWM定时器 比较捕获 Register A	0x4C	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRB	通用PWM定时器 比较捕获 Register B	0x50	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRC	通用PWM定时器 比较捕获 Register C	0x54	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRE	通用PWM定时器 比较捕获 Register E	0x58	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRD	通用PWM定时器 比较捕获 Register D	0x5C	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRF	通用PWM定时器 比较捕获 Register F	0x60	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTPR	通用PWM定时器周期 设置寄存器	0x64	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTPBR	通用PWM定时器周 期设置缓冲器 Register	0x68	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTPDBR	通用PWM定时器周期 设置双倍 缓冲寄存器	0x6C	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTADTRA	AD转换器启动 请求时间 Register A	0x70	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTADTBRA	AD转换器启动 请求定时缓冲区 Register A	0x74	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTADTDBRA	AD转换器启动 请求时间双倍 缓冲寄存器A	0x78	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTADTRB	AD转换器启动 请求时间 Register B	0x7C	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTADTBRB	AD转换器启动 请求定时缓冲区 Register B	0x80	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTADTDBRB	AD转换器启动 请求时间双倍 缓冲寄存器B	0x84	32	读写	0xFFFF FFFF	0xFFFF FFFF

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Table 3.3 Register description (23 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
GPT32EH0-3,GPT32E4-7	-	-	-	GTDTCR	General PWM Timer Dead Time Control Register	0x88	32	read-write	0x0000 0000	0xFFFF FFFF
				GTDVU	General PWM Timer Dead Time Value Register U	0x8C	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTDVD	General PWM Timer Dead Time Value Register D	0x90	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTDBU	General PWM Timer Dead Time Buffer Register U	0x94	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTDBD	General PWM Timer Dead Time Buffer Register D	0x98	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTSOS	General PWM Timer Output Protection Function Status Register	0x9C	32	read-only	0x0000 0000	0xFFFF FFFF
				GTSOTR	General PWM Timer Output Protection Function Temporary Release Register	0xA0	32	read-write	0x0000 0000	0xFFFF FFFF
GPT328-GPT3212	-	-	-	GTWP	General PWM Timer Write-Protection Register	0x00	32	read-write	0x0000 0000	0xFFFF FFFF
				GTSTR	General PWM Timer Software Start Register	0x04	32	read-write	0x0000 0000	0xFFFF FFFF
				GTSTP	General PWM Timer Software Stop Register	0x08	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCLR	General PWM Timer Software Clear Register	0x0C	32	write-only	0x0000 0000	0xFFFF FFFF
				GTSSR	General PWM Timer Start Source Select Register	0x10	32	read-write	0x0000 0000	0xFFFF FFFF
				GTPSR	General PWM Timer Stop Source Select Register	0x14	32	read-write	0x0000 0000	0xFFFF FFFF
				GTCSR	General PWM Timer Clear Source Select Register	0x18	32	read-write	0x0000 0000	0xFFFF FFFF
				GTUPSR	General PWM Timer Up Count Source Select Register	0x1C	32	read-write	0x0000 0000	0xFFFF FFFF
				GTDNSR	General PWM Timer Down Count Source Select Register	0x20	32	read-write	0x0000 0000	0xFFFF FFFF
				GTICASR	General PWM Timer Input Capture Source Select Register A	0x24	32	read-write	0x0000 0000	0xFFFF FFFF
				GTICBSR	General PWM Timer Input Capture Source Select Register B	0x28	32	read-write	0x0000 0000	0xFFFF FFFF
				GTCR	General PWM Timer Control Register	0x2C	32	read-write	0x0000 0000	0xFFFF FFFF

Table 3.3 寄存器描述（23的25）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
GPT32EH0-3,GPT32E4-7	-	-	-	GTDTCR	通用PWM定时器 死区时间控制 Register	0x88	32	读写	0x0000 0000	0xFFFF FFFF
				GTDVU	通用PWM定时器 死区时间值 Register U	0x8C	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTDVD	通用PWM定时器 死区时间值 Register D	0x90	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTDBU	通用PWM定时器 死区缓冲器 Register U	0x94	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTDBD	通用PWM定时器 死区缓冲器 Register D	0x98	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTSOS	通用PWM定时器 输出保护 功能状态寄存器	0x9C	32	只读	0x0000 0000	0xFFFF FFFF
				GTSOTR	通用PWM定时器输出保护功能临时 释放寄存器	0xA0	32	读写	0x0000 0000	0xFFFF FFFF
GPT328-GPT3212	-	-	-	GTWP	通用PWM定时器 Write-Protection Register	0x00	32	读写	0x0000 0000	0xFFFF FFFF
				GTSTR	通用PWM定时器 软件启动寄存器	0x04	32	读写	0x0000 0000	0xFFFF FFFF
				GTSTP	通用PWM定时器 软件停止寄存器	0x08	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCLR	通用PWM定时器 软件清除寄存器	0x0C	32	只写	0x0000 0000	0xFFFF FFFF
				GTSSR	通用PWM定时器启动源选择 Register	0x10	32	读写	0x0000 0000	0xFFFF FFFF
				GTPSR	通用PWM定时器停止源选择 Register	0x14	32	读写	0x0000 0000	0xFFFF FFFF
				GTCSR	通用PWM定时器清零源选择 Register	0x18	32	读写	0x0000 0000	0xFFFF FFFF
				GTUPSR	通用PWM定时器启动计数源选择 Register	0x1C	32	读写	0x0000 0000	0xFFFF FFFF
				GTDNSR	通用PWM定时器递减计数源 选择注册	0x20	32	读写	0x0000 0000	0xFFFF FFFF
				GTICASR	通用PWM定时器输入捕捉源 选择寄存器A	0x24	32	读写	0x0000 0000	0xFFFF FFFF
				GTICBSR	通用PWM定时器输入捕捉源 选择寄存器B	0x28	32	读写	0x0000 0000	0xFFFF FFFF
				GTCR	通用PWM定时器 控制寄存器	0x2C	32	读写	0x0000 0000	0xFFFF FFFF

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Table 3.3 Register description (24 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
GPT328-GPT3212	-	-	-	GTUDDTYC	General PWM Timer Count Direction and Duty Setting Register	0x30	32	read-write	0x0000 0001	0xFFFF FFFF
				GTIOR	General PWM Timer I/O Control Register	0x34	32	read-write	0x0000 0000	0xFFFF FFFF
				GTINTAD	General PWM Timer Interrupt Output Setting Register	0x38	32	read-write	0x0000 0000	0xFFFF FFFF
				GTST	General PWM Timer Status Register	0x3C	32	read-write	0x0000 8000	0xFFFF FFFF
				GTBER	General PWM Timer Buffer Enable Register	0x40	32	read-write	0x0000 0000	0xFFFF FFFF
				GTCNT	General PWM Timer Counter	0x48	32	read-write	0x0000 0000	0xFFFF FFFF
				GTCCRA	General PWM Timer Compare Capture Register A	0x4C	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRB	General PWM Timer Compare Capture Register B	0x50	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRC	General PWM Timer Compare Capture Register C	0x54	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRE	General PWM Timer Compare Capture Register E	0x58	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRD	General PWM Timer Compare Capture Register D	0x5C	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTCCRF	General PWM Timer Compare Capture Register F	0x60	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTPR	General PWM Timer Cycle Setting Register	0x64	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTPBR	General PWM Timer Cycle Setting Buffer Register	0x68	32	read-write	0xFFFF FFFF	0xFFFF FFFF
				GTDTCR	General PWM Timer Dead Time Control Register	0x88	32	read-write	0x0000 0000	0xFFFF FFFF
				GTDVU	General PWM Timer Dead Time Value Register U	0x8C	32	read-write	0xFFFF FFFF	0xFFFF FFFF
GPT32EH0-3,GPT32E4-7	-	-	-	OPSCR	Output Phase Switching Control Register	0x00	32	read-write	0x0000 0000	0xFFFF FFFF
GPT_ODC	-	-	-	GTDLYCR	PWM Output Delay Control Register	0x00	16	read-write	0x0000	0xFFFF
				GTDLYCR2	PWM Output Delay Control Register2	0x02	16	read-write	0x0000	0xFFFF
	4	0x4	0-3	GTDLYR%sA	GTIOC%sA Rising Output Delay Register	0x18	16	read-write	0x0000	0xFFFF
	4	0x4	0-3	GTDLYR%sB	GTIOC%sB Rising Output Delay Register	0x1A	16	read-write	0x0000	0xFFFF

Table 3.3 注册说明（24篇，共25篇）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
GPT328-GPT3212	-	-	-	GTUDDTYC	通用PWM定时器计数方向和占空比设置寄存器	0x30	32	读写	0x0000 0001	0xFFFF FFFF
				GTIOR	通用PWM定时器IO控制寄存器	0x34	32	读写	0x0000 0000	0xFFFF FFFF
				GTINTAD	通用PWM定时器中断输出设置Register	0x38	32	读写	0x0000 0000	0xFFFF FFFF
				GTST	通用PWM定时器状态寄存器	0x3C	32	读写	0x0000 8000	0xFFFF FFFF
				GTBER	通用PWM定时器缓冲区使能寄存器	0x40	32	读写	0x0000 0000	0xFFFF FFFF
				GTCNT	通用PWM定时器Counter	0x48	32	读写	0x0000 0000	0xFFFF FFFF
				GTCCRA	通用PWM定时器比较捕获Register A	0x4C	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRB	通用PWM定时器比较捕获Register B	0x50	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRC	通用PWM定时器比较捕获Register C	0x54	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRE	通用PWM定时器比较捕获Register E	0x58	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRD	通用PWM定时器比较捕获Register D	0x5C	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTCCRF	通用PWM定时器比较捕获Register F	0x60	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTPR	通用PWM定时器周期设置寄存器	0x64	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTPBR	通用PWM定时器周期设置缓冲器Register	0x68	32	读写	0xFFFF FFFF	0xFFFF FFFF
				GTDTCR	通用PWM定时器死区时间控制Register	0x88	32	读写	0x0000 0000	0xFFFF FFFF
				GTDVU	通用PWM定时器死区时间值Register U	0x8C	32	读写	0xFFFF FFFF	0xFFFF FFFF
GPT32EH0-3,GPT32E4-7	-	-	-	OPSCR	输出相位切换控制寄存器	0x00	32	读写	0x0000 0000	0xFFFF FFFF
GPT_ODC	-	-	-	GTDLYCR	PWM输出延迟控制寄存器	0x00	16	读写	0x0000	0xFFFF
				GTDLYCR2	PWM输出延迟Control Register2	0x02	16	读写	0x0000	0xFFFF
	4	0x4	0-3	GTDLYR%sA	GTIOC%sA Rising输出延迟寄存器	0x18	16	读写	0x0000	0xFFFF
	4	0x4	0-3	GTDLYR%sB	GTIOC%sB Rising输出延迟寄存器	0x1A	16	读写	0x0000	0xFFFF

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Table 3.3 Register description (25 of 25)

Peripheral	Dim	Dim incr.	Dim index	Register name	Description	Address offset	Size	Access	Reset value	Reset mask
GPT_ODC	4	0x4	0-3	GTDLYF%sA	GTIOC%sA Falling Output Delay Register	0x28	16	read-write	0x0000	0xFFFF
	4	0x4	0-3	GTDLYF%sB	GTIOC%sB Falling Output Delay Register	0x2A	16	read-write	0x0000	0xFFFF
KINT	-	-	-	KRCTL	KEY Return Control Register	0x00	8	read-write	0x00	0xFF
				KRF	KEY Return Flag Register	0x04	8	read-write	0x00	0xFF
				KRM	KEY Return Mode Register	0x08	8	read-write	0x00	0xFF
AGT0,1	-	-	-	AGT	AGT Counter Register	0x00	16	read-write	0xFFFF	0xFFFF
				AGTCMA	AGT Compare Match A Register	0x02	16	read-write	0xFFFF	0xFFFF
				AGTCMB	AGT Compare Match B Register	0x04	16	read-write	0xFFFF	0xFFFF
				AGTCR	AGT Control Register	0x08	8	read-write	0x00	0xFF
				AGTMR1	AGT Mode Register 1	0x09	8	read-write	0x00	0xFF
				AGTMR2	AGT Mode Register 2	0x0A	8	read-write	0x00	0xFF
				AGTIOC	AGT I/O Control Register	0x0C	8	read-write	0x00	0xFF
				AGTISR	AGT Event Pin Select Register	0x0D	8	read-write	0x00	0xFF
				AGTCMSR	AGT Compare Match Function Select Register	0x0E	8	read-write	0x00	0xFF
				AGTIOSEL	AGT Pin Select Register	0x0F	8	read-write	0x00	0xFF
ACMPHS0	-	-	-	CMPCTL	Comparator Control Register	0x000	8	read-write	0x00	0xFF
				CMPSEL0	Comparator Input Select Register	0x004	8	read-write	0x00	0xFF
				CMPSEL1	Comparator Reference Voltage Select Register	0x008	8	read-write	0x00	0xFF
				CMPMON	Comparator Output Monitor Register	0x00C	8	read-only	0x00	0xFF
				CPIOC	Comparator Output Control Register	0x010	8	read-write	0x00	0xFF
ACMPHS1-5	-	-	-	CMPCTL	Comparator Control Register	0x000	8	read-write	0x00	0xFF
				CMPSEL0	Comparator Input Select Register	0x004	8	read-write	0x00	0xFF
				CMPSEL1	Comparator Reference Voltage Select Register	0x008	8	read-write	0x00	0xFF
				CMPMON	Comparator Output Monitor Register	0x00C	8	read-only	0x00	0xFF
				CPIOC	Comparator Output Control Register	0x010	8	read-write	0x00	0xFF
TSD	-	-	-	TSCDR	Temperature Sensor Calibration Data Register	0x00	32	read-only	0x0000 0000	0xFFFF F000

Table 3.3 寄存器说明（25个中的25个）

Peripheral	Dim	昏暗的增量。	暗淡指数	注册名称	Description	地址偏移	Size	Access	重置值	重置蒙版
GPT_ODC	4	0x4	0-3	GTDLYF%sA	GTIOC%sA Falling 输出延迟寄存器	0x28	16	读写	0x0000	0xFFFF
	4	0x4	0-3	GTDLYF%sB	GTIOC%sB Falling 输出延迟寄存器	0x2A	16	读写	0x0000	0xFFFF
KINT	-	-	-	KRCTL	KEY返回控制 Register	0x00	8	读写	0x00	0xFF
				KRF	KEY返回标志 Register	0x04	8	读写	0x00	0xFF
				KRM	KEY返回模式 Register	0x08	8	读写	0x00	0xFF
AGT0,1	-	-	-	AGT	AGT计数器寄存器	0x00	16	读写	0xFFFF	0xFFFF
				AGTCMA	AGT比较匹配A Register	0x02	16	读写	0xFFFF	0xFFFF
				AGTCMB	AGT比较匹配B Register	0x04	16	读写	0xFFFF	0xFFFF
				AGTCR	AGT控制寄存器	0x08	8	读写	0x00	0xFF
				AGTMR1	AGT模式寄存器1	0x09	8	读写	0x00	0xFF
				AGTMR2	AGT模式寄存器2	0x0A	8	读写	0x00	0xFF
				AGTIOC	AGT I/O Control Register	0x0C	8	读写	0x00	0xFF
				AGTISR	AGT事件引脚选择 Register	0x0D	8	读写	0x00	0xFF
				AGTCMSR	AGT比较匹配 功能选择寄存器	0x0E	8	读写	0x00	0xFF
				AGTIOSEL	AGT引脚选择寄存器	0x0F	8	读写	0x00	0xFF
ACMPHS0	-	-	-	CMPCTL	比较器控制 Register	0x000	8	读写	0x00	0xFF
				CMPSEL0	比较器输入选择 Register	0x004	8	读写	0x00	0xFF
				CMPSEL1	比较器参考电压选择寄存器	0x008	8	读写	0x00	0xFF
				CMPMON	比较器输出 监控寄存器	0x00C	8	只读	0x00	0xFF
				CPIOC	比较器输出 控制寄存器	0x010	8	读写	0x00	0xFF
ACMPHS1-5	-	-	-	CMPCTL	比较器控制 Register	0x000	8	读写	0x00	0xFF
				CMPSEL0	比较器输入选择 Register	0x004	8	读写	0x00	0xFF
				CMPSEL1	比较器参考电压选择寄存器	0x008	8	读写	0x00	0xFF
				CMPMON	比较器输出 监控寄存器	0x00C	8	只读	0x00	0xFF
				CPIOC	比较器输出 控制寄存器	0x010	8	读写	0x00	0xFF
TSD	-	-	-	TSCDR	温度感应器 校准数据 Register	0x00	32	只读	0x0000 0000	0xFFFF F000

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Peripheral name = Name of peripheral
Dim = Number of elements in an array of registers
Dim inc = Address increment between two simultaneous registers of a register array in the address map
Dim index = Sub string that replaces the %s placeholder within the register name
Register name = Name of register
Description = Register description
Address offset = Address of the register relative to the base address defined by the peripheral of the register
Size = Bit width of the register
Access = Register access rights:
Read-only: Read access is permitted. Write operations have undefined results.
Write-only: Write access is permitted. Read operations have undefined results.
Read-write: Both read and write accesses are permitted. Writes affect the state of the register and reads return a value related to the register.
Reset value = Default reset value of a register
Reset mask = Identifies which register bits have a defined reset value

外设名称=外设名称
Dim=寄存器数组中的元素数
Diminc=地址映射中寄存器阵列的两个同时寄存器之间的地址增量
暗淡索引=替换寄存器名称中的%s占位符的子字符串
寄存器名称=寄存器名称描述=寄存器描述
地址偏移量=相对于寄存器外设定义的基地址的寄存器地址
大小=寄存器的位宽
访问=注册访问权限：
只读：允许读访问。写操作有未定义的结果。只写：允许写访问。读取操作具有未定义的结果。
读写：允许读写访问。写入会影响寄存器的状态，读取会返回与寄存器相关的值。复位值=寄存器的默认复位值

复位掩码=标识哪些寄存器位具有定义的复位值

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Rev.	Date	Chapter	Summary
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