

**ASR6601**

**Reference manual**

**Version 1.5.0**



**Issue date 2022-08-11**

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**About this document**

This document provides detailed and complete information on the IoT LPWAN SoC-ASR6601 for application developers.

**Intended Readers**

This document is mainly for engineers who use this chip to develop their own platform and products, for instance:

Hardware Development Engineer

Software Engineer

Technical Support Engineer

**Included Chip Models**

The product models corresponding to this document are as follows.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Model** | **Flash** | **SRAM** | **Processor** | **Package** | **Frequency** |
| ASR6601SE | 256 KB | 64 KB | 32-bit 48 MHz Arm China STAR-MC1 | QFN68,  8\*8 mm | 150 ~ 960 MHz |
| ASR6601CB | 128 KB | 16 KB | 32-bit 48 MHz Arm China STAR-MC1 | QFN48,  6\*6 mm | 150 ~ 960 MHz |

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**Revision History**

|  |  |  |
| --- | --- | --- |
| **Date** | **Version** | **Release notes** |
| 2021.03 | V1.0.0 | Initial Release. |
| 2021.05 | V1.1.0 | Updated the overview and Table 6-1 of Chapter 6.  Updated some descriptions in Section 16.3, Section 16.9, and Section 16.14.1.  Corrected the description of LORAC\_SR register in Section 12.4.13. |
| 2021.07 | V1.2.0 | Updated CPU description.. |
| 2022.03 | V1.3.0 | Added Chapter 21: DMA and Chapter 22: GPTIMER.  Fixed several typos. |
| 2022.05 | V1.4.0 | Modified RCO4M to RCO3.6M due to crystal frequency adjustment. |
| 2022.08 | V1.5.0 | Updated register bits descriptions in Sections 7.5.3, 8.3.3, 8.3.4, 8.3.7, 8.3.12, and 8.3.13  Updated Figure 8-1: Clock network diagram. |

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# Overview

ASR6601 is a general LPWAN Wireless Communication SoC chip developed by ASR which supports LoRa modulation. The chip integrates Sub-1G RF transceiver, Arm China STAR-MC1 processor, embedded Flash memory and SRAM, as well as diverse analog modules. ASR6601 is designed for a wide variety of applications, such as smart meters, building automation, smart cities, agricultural sensors, safety and security sensors, supply chain and logistics, etc.

This manual provides detailed and complete information on the IoT LPWAN SoC-ASR6601 for application developers. Together with the API file in SDK, it helps developers solve various problems they may encounter during development. If any further support is needed, please contact us. We will keep this manual updated.

# ASR6601 Introduction

2.1 General

ASR6601 SoC is a low-power wide area network wireless communication SoC chip that supports LoRa modulation. The ultra-low power transceiver integrated in the ASR6601 chip supports the full frequency band of 150 MHz ~ 960 MHz with the off-chip matching network. In addition to supporting LoRa modulation, it can also support FSK transceiver, MSK transceiver and BPSK transmitter. When powered by 3.3 V power supply, the maximum output power of 22 dBm can be transmitted using the high-power PA. ASR6601 SoC mainly has Run, LpRun, Sleep, LpSleep, Stop0, Stop1, Stop2, Stop3, Standby working modes. Each mode supports different functions, working modules and power consumption. End users can choose the corresponding working mode according to their application scenarios. The two most commonly used low-power modes are Standby mode and Stop3 mode. When powered by 3.3 V, the Standby mode consumes as little as 0.9 uA; the Stop3 mode consumes as little as 1.3 uA (ASR6601CB) and 1.6 uA (ASR6601SE).

The ASR6601 SoC uses a 32-bit ARM STAR core with a maximum main frequency of 48 MHz, supports SWD debug interface, supports SysTick, MPU, FPU functions, and supports 37 IRQs with 8 interrupt priorities.

ASR6601 supports UART, I2C, I2S, LPUART, SSP, QSPI and other interfaces. With the peripherals of different types of corresponding interfaces, it can realize rich functions to meet customer needs. In addition to supporting rich number functions, ASR6601 also integrates rich analog functions, including ADC, DAC, OPA and LCD driver.  
  
 ASR6601 implements AES encryption through hardware, greatly simplifying the efficiency of encryption and decryption. It also supports national encryption SM2/3/4.

2.2 Key Features

* Small footprint: QFN48, 6 mm x 6 mm or QFN68, 8 mm x 8 mm
* Frequency Range: 150 MHz ~ 960 MHz
* Maximum Power +22 dBm constant RF output
* High sensitivity: -148 dBm
* Programmable bit rate up to 62.5 Kbps in LoRa modulation mode
* Programmable bit rate up to 300 Kbps in (G)FSK modulation mode
* Preamble detection
* Embedded memories (up to 256 KB of Flash memory and 64 KB of SRAM).
* Up to 42 configurable GPIOs: 3 x I2C, 1 x I2S, 4 x UART, 1 x LPUART, 1 x SWD, 3 x SPI,1 x QSPI and 2 x WDG
* 4 x GPtimer, 2 x Basic Timer, 2 x LP timer and 1 x Sys Ticker2. ASR6601 Introduction
* 48 MHz Arm China STAR-MC1 Processor
* 4-channel DMA engine x 2
* Support 37 IRQ interrupts with configurable 0~7 priority levels for each IRQ interrupt
* Embedded 12-bit 1 Msps SAR ADC
* Embedded 12-bit DAC
* 32.768 KHz External Watch Crystal Oscillator
* 32 MHz External Crystal Oscillator for RF Transceiver
* 24 MHz External Crystal Oscillator for SoC (optional)
* Embedded internal 4 MHz RC oscillator
* Embedded internal High frequency (48 MHz) RC oscillator
* Embedded internal Low frequency (32.768 KHz) RC oscillator Embedded internal PLL to generate 48 MHz clock
* Embedded 3 x OPA
* Embedded 2 x Low Power Comparator
* Embedded LCD driver
* Embedded LD, TD, VD and FD
* Supports AES, DES, RSA, ECC, SHA and SM2/3/4

# ASR6601 functions

## 3.1 ASR6601 SoC Diagram



**Figure 3-1 ASR6601 SoC Diagram**

#### **3.2 ASR6601 functional modules**

**Table 3-1 ASR6601 functional modules**

|  |  |  |
| --- | --- | --- |
| Module Name | Functions supported by the module | |
| RCC | Clock and reset control | |
| SYSCFG | System function registers | |
| PWR | 1. | Chip low power mode control |
|  | 2. | Interrupt signal generation |
| SEC | 1. | Security IP Enable |
| 2. | Filtering Security IP alarm signal filtering |
|  | 3. | Alarm signal processing, support status generation, interrupt request, and reset bit request |
| CPU | 1. | SWD debug interface |
| 2. | Systick function |
| 3. | MPU function |
|  | 4. | FPU function |
|  | 5. | 37 IRQs, 8 interrupt priorities |
| MPU | Access Security control, including slave access operations of cpu, dma, and swd debug interfaces | |
| EFC | 1. | Power-on chip mode determination |
| 2. | Flash info area data is loaded at power-on |
| 3. | Basic flash operations, including read, program, page erase, mass erase |
| 4. | Flash operation key timing control, including reading beat number, program high-voltage time, erase high-voltage time |
| 5. | Flash instruction prefetch function, 1 depth prefetch buffer |
|  | 6. | Flash program operation supports single and continuous modes |
|  | 7. | Flash info area option bytes operation |
|  | 8. | Interrupt signals generating |
| I2S | 1. | Philips I2S serial protocol |
| 2. | Support Master and Slave modes |
| 3. | 1 RX channel, 1 TX channel, full duplex |
| 4. | Receive FIFO depth is 4 |
| 5. | Transmit FIFO depth is 4 |
| 6. | Receiver supports 12, 16, 20, 24, 32-bit resolution |
|  | 7. | Transmitter supports 12, 16, 20, 24, 32-bit resolution |
|  | 8. | Supports programmable DMA registers |
|  |  | 1. Supports programmable FIFO Threshold |
| 10. | Support 1 interrupt signal generation |
| UART |  | 1. Support IrDA, support 3/16 and low-power (1.41-2.23us) Bit width |
|  | 1. Support FIFO transmission and reception, 16x8bits transmission FIFO, 16x10bits reception FIFO |
|  | 1. Supports Buffer sending and receiving, 1 deep sending and receiving buffer |
|  | 1. Baud rate generation, using 16 times oversampling, supports 16-bit integer division and 6-bit fractional division, and supports up to interface clok frequency/16 |
|  |  | UART data format configuration, including 1-2 bits Stop, 0-1 bits parity (odd, even, mark, space, none), 5-8 data bits |
|  | Support DMA transfer |
|  | Support false start detection |
|  | Support line break sending and detection |
|  | Support hardware flow control CTS and RTS |
|  | Support interrupt signal generation |
|  | 1. | Support low power wake-up |
| LPUART | 2. | Baud rate generation, does not support oversampling, supports 4-bit fractional frequency division and 12-bit integer frequency division, the minimum integer frequency division is 3 |
|  | 3. | UART data format configuration, including 1-2 bits Stop, 0-1 bits parity (odd, even, mark, space, none), 5-8 data bits |
|  | 4. | Support hardware flow control CTS and RTS |
|  | 5. | Support DMA transfer |
|  | 6. | Interrupt signal generation |
| SSP | 1. | Support Master and Slave |
| 2. | Programmable baud rate and prescaler, Master supports up to 1/2 interface clock frequency, Slave supports up to 1/12 interface clock frequency |
| 3. | Supports 8\*16 Bit receiving and transmitting FIFO |
| 4. | Data length is configurable, 4-16 Bit |
|  | 5. | Supports DMA requests |
|  | 6. | Supports Motorola, Microwire (NS), TI formats |
|  | 7. | Motorola supports 4 polarity phase bit combinations |
|  | 8. | Interrupt signal generation |
| I2C | 1. | Support master mode and slave module support multi-master arbitration |
| 2. | Support multi-host arbitration |
| 3. | Support Standard Mode and Fast Mode |
| 4. | Support 7 Bit address mode |
|  | 5. | Support Clock Stretching |
|  | 6. | Supports generating interrupt signals |
|  | 7. | Support DMA requests |
| AFEC | 1. | Simulate IP status register |
| 2. | Simulate IP control register |
| 3. | Some registers support Safety lockControl |
|  | 4. | Interrupt signal generation |
| LORAC | 1. | LORA IP control register |
| 2. | LORA status register |
| 3. | LORA IP SPI interface source, supports ssp master control and reg control |
|  | 4. | Support DMA request and response |
|  | 5. | Interrupt signal generation |

|  |  |  |
| --- | --- | --- |
| RTC |  | Calendar counting function in BCD format, supports seconds, minutes, hours, days, months, years, and days of the week |
|  | Ppm adjustment, adjustment step size 0.5ppm, +/-1024 ppm adjustment |
|  | Low power wake-up |
|  | Tamper/wakeup IO detection function, active level selection, and the number of filter beats is configurable |
|  | Cycle counting function, 32-bit counter |
|  | Alarm clock function, supports two alarm clocks, supports mask selection and calendar matching |
|  | Clear retention sram on Tamper alarm |
|  | Some registers support Safety lockControl |
|  | Internal signal IO output, including alarm0 matching pulse, alarm1 matching pulse, cycle count configuration pulse, seconds signal output |
|  | Calendar count value reading |
|  | Sub-second count value reading |
|  | Cycle count value reading |
|  | Interrupt signal generation |
| IWDG | 1. | Watchdog counting function, down-counting, clock prescaler (4-256) |
| 2. | Watchdog exception status occurs when the count reaches 0 (feeding the dog too late) or when the count value when feeding the dog is greater than the counting window value (feeding the dog too early) |
| 3. | Interrupt signal generation |
|  | 4. | Dog feeding window configuration |
|  | 5. | Count value reading |
|  | 6. | Low power wake-up |
| QSPI | 1. | Master interface only |
| 2. | 1-wire, 2-wire, 4-wire modes |
| 3. | 3 working modes, including indirect access, status query and Memory-mapping |
|  | 4. | Baud rate division, up to interface clock frequency/2 |
|  | 5. | Interrupt signals generation |
| CRC | 1. | Configurable polynomial bit width: 7, 8, 16, 32 bits |
| 2. | Different hsize accesses, the lower byte is calculated first and can be edited |
| 3. | Programmable crc initial value |
|  | 4. | Input data reverse, support byte, halfword and word |
|  | 5. | Output data reverse, support word |
| DMA | 1. | 1 master interface AHB bus |
| 2. | AHB interface only supports little-endian structure |
| 3. | Interrupt signal generation |
| 4. | Transfer mode supports M2M, P2M, M2P, P2P |
| 5. | Software triggering handshake signal |
|  | 6. | 4 sets of hardware handshake signals, including burst and single requests |
|  | 7. | Hardware handshake signal sources, each group supports 64 source selections |
|  | 8. | 4 logical channels |
|  | 9. | Channel 0 configutation:  (1) 8 bytes deep FIFO  Maximum burst length is 8  Maximum transfer length is 2047  Supports dmac flow control only  Source address data bit width configurable  Destination address data bit width configurable  Address increment, decrement, and unchanged  Block transfer, including continuous address, automatic loading and linked list  Scatter and gather |

|  |  |  |
| --- | --- | --- |
|  | 10. | Channel 1-3 configuration:  8 bytes deep FIFO  Maximum burst length is 8  Maximum transfer length is 2047  Supports dmac flow control only  Source address data bit width configurable  Destination address data bit width configurable  Address increment, decrement, and unchanged  Block transfer, including continuous addresses and automatic loading, but does not support linked lists  Scatter and gather not supported |
| GPIO | 1. | IO output configuration, push-pull, open drain, output high impedance |
| 2. | IO input configuration, floating, input pull-up, input pull-down, analog input |
| 3. | IO pull-up configuration, pull-down configuration, drive capability control |
|  | 4. | Interrupt signals generation, including rising edge interrupt, falling edge interrupt, and both edges interrupt |
|  | 5. | Wake-up signals generation, including high level and low level |
| SAE | 1. | AES128/192/256 |
| 2. | DES and 3DES |
| 3. | SM2, SM3, SM4 (ASR6601SE) |
| 4. | RSA1024/2048 |
|  | 5. | ECC224/256/384/512 |
|  | 6. | SHA1, SHA-224, SHA256, SHA384, SHA512 |
|  | 7. | Random number generation |
| BSTIMER | 1. | 32bits counter, supports auto-reload, up-counting, down-counting, center-aligned counting |
| 2. | 16-bit counter clock prescaler |
| 3. | Supports DMA requests |
|  | 4. | Interrupt signals generation |
| GPTIMER | 1. | 32bits counter, supports auto-reload, up-counting, down-counting, center-aligned counting |
| 2. | 16-bit counter clock prescaler |
| 3. | gptimer0 and gptimer1 supports 4 Channels, gptimer2 and gptimer3 supports 2 Channels, each channel can support input capture, output comparison, PWM generation, single pulse output |
|  | 4. | Quadrature decoding |
|  | 5. | Interrupt signals generation |
|  | 6. | Supports DMA requests |
| LPTIMER | 1. | Supports selecting internal clock and IO clock as counting clock |
| 2. | 16 bits counter, up-counting, auto-reload |
| 3. | Counter clock prescaler |
| 4. | Quadrature decoding support |
|  | 5. | Input capture, output comparison, PWM generation, single pulse output |
|  | 6. | Interrupt signals generation |
|  | 7. | Supports DMA requests |
| ADC | 1. | 12 bits sampling resolution |
| 2. | Configurable sampling rate up to 1 MHz |
| 3. | Single-ended and differential sampling |
| 4. | Only right data alignment |
| 5. | 8 external channels |
| 6. | 7 internal channels, including DAC output, internal Vref, VDD/3 (battery power), Vts (internal temperature sensor), OPA output (3) |
|  | 7. | Trigger mode, supports software trigger and hardware trigger |
|  | 8. | Sequential, continuous, single, and non-continuous sampling modes |
|  |  | Analog watchdog function, 3 channels in total, configurable Channel selection and thresholds |
|  | Supports DMA requests |
|  | Interrupt signals generation |
| DAC | 1. | 10 bits output resolution |
| 2. | Configurable output speed up to 1 MHz |
| 3. | Right data alignment only |
| 4. | Special waveform output, supports triangle wave |
|  | 5. | Software trigger and hardware trigger |
|  | 6. | Supports DMA requests |
|  | 7. | Interrupt signals generation |
| LCDCTRL | 1. | Frame rate control |
| 2. | Bias control, supports static, 1/2, 1/3, 1/4 |
| 3. | Duty Control, supports static (1comx27seg), 1/2 (2comx26seg), 1/3 (3comx25seg), 1/4 (4comx24seg), 1/8 (8comx20seg) |
| 4. | Dead frame control, supports dead frame of 0-7 shots, used to adjust contrast |
|  | 5. | Blink control, supports the blinking function of 1, 2, 3, 4, 8 or all pixels, configurable blinking frequency |
|  | 6. | High and low current selection control, including state machine dynamic control and register static control. During state machine dynamic control, high current can be configured to maintain the number of beats. |
|  | 7. | Interrupt signal generation |

# 4. Power Management Unit

#### **4.1 Power supply pins**

ASR6601 has several separated power supply pins. With these separated power supply pins, the interference from digital parts of SoC to RF blocks is reduced.

ASRR6601 Power Grid is shown in Figure 4-1:

* VDD\_IN: The power supply for the PA in the RF transmitter.
* VBAT\_RF: The power supply for the RF TRX, excluding the PA.
* VDCC\_RF: The low-power supply for RF TRX, must be connected to VREG pin
* of SoC through the PCB.
* VBAT\_ESD0: The power supply for digital IO.
* VBAT\_ESD1: The power supply for digital IO.
* VBAT\_ESD2: The power supply for digital IO.
* VBAT\_ESD3: The power supply for digital IO.
* VBAT\_DCC: The dedicated power supply for DCDC in analog circuit.
* VBAT\_ESD\_RTC: The power supply for IOs in RTC domain.
* VBAT\_RTC: The power supply for analog blocks in RTC domain.
* VBAT\_ANA: The power supply for analog blocks.



**Figure 4-1 ASR6601 Power Grid**

## 4.2 Power Supply Architecture

#### 

Internal power domains of the chip are mainly divided into main domain, aon domain and aonr domain. Please note that the power domains are divided according to functions, as shown in Figure 4-2.

**Main** domain contains most of the digital logic circuits of the SoC chip. In the frequently used low-power modes (Standby and Stop3), the power supply of main domain will be turned off.

**Aon** (**A**lways **On** domain) means that the power supply for this domain is always available, even in low-power mode. Most blocks in aon domain keep running in all power modes.

**Aonr** (**A**lways **On** and **R**etention) domain contains the modules that need to keep running in Stop3 mode. These modules will be powered off in Standby mode. When aonr domain modules remain in the current state without power off, the system can quickly recover and continue to execute.



**Figure 4-2 ASR6601 Power Supply Architecture**

# 5. Access Control

#### **5.1 Simple configuration**

This section provides customers with commonly used simple configurations to meet their basic security needs.

### 5.1.1 Recoverable Security Configuration

* **Enable Security**

Configure FlashSecStart to 0 and FlashSecEnd to 0x3F in OPTION1 tab, and set the entire Flash\_main area as a secure area.

Consequently, the code in SWD (Serial Wire Debug) and non-secure area cannot read and write data into Flash\_main to guarantee security. Please note that code in non-secure SRAM area or non secure DMA will not be able to access Flash\_main.

* **Disable Security**

Configure FlashSecStart to 0x3F and FlashSecEnd to 0 in OPTION1 tab, and set the entire Flash\_main area as a non-secure area.

The above configurations will erase the entire Flash\_main area, and then the program can be re- downloaded.

### 5.1.2 Unrecoverable Security Configuration

Configure the DebugLevel to 2 in Option0 tab. This operation is irreversible, and the code must be correct and mature.

## 5.2 Access control

Based on debug level rules, boot startup mode, exe-only access rules, write-protected access rules, info area access rules, and secure area access rules, access rights from the four main interfaces (cpucode, cpusw, dmac0, and dmac1) are controlled.

### 5.2.1 Debug Level Rules

Debug level mainly affects the access rights of cpu\_code (boot from SRAM and boot from bootloader), cpu\_sw, dmac0 and dmac1 to sensitive areas. Sensitive areas include flash\_main, otp area of flash\_info and retention SRAM. For details see "ASR6601 Access Rights Control Instructions".

### 5.2.2 Secure and Non-Secure Operation

* **Secure Operation**
* The operations initiated by the code in the secure area include:
* Operations initiated by DMAC0 configured as a secure area
* Operations initiated by flash\_main configured as a secure area (CPU\_Code)
* Operations initiated by system\_sram configured as a secure area (CPU\_Code)
* **Non-secure Operation**
* The operations initiated by the code in the non-secure area include:
* Operations initiated by DMAC0 configured as a non-secure area
* Operations initiated by DMAC1
* Operations initiated by Debug Port (CPU\_SW)
* Operations initiated by Bootloader (CPU\_Code)
* Operations initiated by flash\_main configured as a non-secure area (CPU\_Code)
* Operations initiated by system\_sram configured as a non-secure area (CPU\_Code)

# 6. Operation Modes

ASR6601 LPWAN SoC supports Run, LpRun, Sleep, LpSleep, Stop0, Stop1, Stop2, Stop3 and Standby modes. Each mode supports different functions with different working modules and power consumption. The user can choose the appropriate operation mode according to specific application scenarios. All modes are described detailedly in the contents below.

In addition, please note the following points:

When entering a low-power mode, peripherals marked as “O” (excluding GPIO) are turned off by default. The functions used in low-power mode must be turned on before entering low-power mode.

When entering a low-power mode, developers need to configure below items to achieve specified power consumption:

Configure unused GPIOs to ANALOG mode (high impedance)

If the GPIOs are in input mode, users should configure them pull-up or pull-down

In output mode, configure the connected peripherals pull-up or pull-down according to the output level.

Use RCO48M/2 to enter or exit a low-power mode. If you use a clock other than RCO48M/2 before entering a low-power mode, you need to switch to RCO48M/2. After exiting the low power mode, you can switch to the previously used clock.

RCO32K/XO32K and some other analog functions can retain active in low-power modes. If needed, turn on these functions before entering a low-power mode by software.

Clocks other than RCO48M/RCO32K/XO32K and the remaining analog function modules must be turned off by the software before entering a low-power mode.

#### Table 6-1 Modules Working Status in Various Operation Modes

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Run | | LpRun | | Sleep | | LpSleep | Stop0 | | Stop1 | | Stop2 | |  | | Stop3 | Standby |  | Stop0-2  Wakeup | Stop3  Wakeup | Standby  Wakeup |
| cpu | Y | | Y | | NA | | NA | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| efc | Y | | Y | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| sysramc | Y | | Y | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| retramc | Y | | Y | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| i2s | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| uart0 | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| uart1 | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| uart2 | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| uart3 | O | | O | | O | | O | NA | | NA | | NA | | NA | |  | NA | |  |  |  |
| ssp0 | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| ssp1 | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| ssp2 | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| qspi | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| i2c0 | O | | O | | O | | O | NA | | NA | | NA | | NA | | | NA | |  |  |  |
| i2c1 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| i2c2 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| adcctrl | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| dacctrl | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| gptim0 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| gptim1 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| gptim2 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| gptim3 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| basictim0 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| basictim1 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| wwdg | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| crc | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| sec | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| sac | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| mpu | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| dmac0 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| dmac1 | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| syscfg | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| afec | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| lorac | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| gpio | | O | | O | | O | O | | NA | | NA | | NA | | GPIO0~55: Y3  GPIO56~63:Y4 | | GPIO0~55: NA3  GPIO56~63: Y4 | | Y | Y |  |
| rcc | | Y | | Y | | Y | Y | | Y | | Y | | Y | | Y | | Y | |  |  |  |
| pwr | | Y | | Y | | Y | Y | | Y | | Y | | Y | | Y | | Y | |  |  |  |
| lpuart | | O | | O | | O | O | | O | | O | | O | | O (RX only) | | O (RX only) | | Y | Y | Y |
| lcdctrl | | O | | O | | O | O | | O | | O | | O | | O | | O | |  |  |  |
| lptim0 | | O | | O | | O | O | | O | | O | | O | | O | | O | | Y | Y | Y |
| lptim1 | | O | | O | | O | O | | O | | O | | O | | O | | O | | Y | Y | Y |
| iwdg | | O | | O | | O | O | | O | | O | | O | | O | | O | | Y1 | Y | Y |
| rtc | | O | | O | | O | O | | O | | O | | O | | O | | O | | Y | Y | Y |
| ADC | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| RCO48M | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| XO24M | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| PLL48M | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| RNG | | O | | O | | O | O | | NA | | NA | | NA | | NA | | NA | |  |  |  |
| DAC | | O | | O | | O | O | | O3 | | O3 | | O3 | | NA | | NA | |  |  |  |
| OPA | | O | | O | | O | O | | O | | O | | O | | NA | | NA | |  |  |  |
| COMP | | O | | O | | O | O | | O | | O | | O | | O | | O | | Y | Y | Y |
| VD | | O | | O | | O | O | | O | | O | | O | | O | | O | | Y | Y | Y |
| RCO3.6M | | O | | O | | O | O | | O | | O | | O | | O | | O | |  |  |  |
| RCO32K | | O | | O | | O | O | | O | | O | | O | | O | | O | |  |  |  |
| XO32K | | O | | O | | O | O | | O | | O | | O | | O | | O | |  |  |  |
| LCD | | O | | O | | O | O | | O | | O | | O | | O | | O | |  |  |  |
| BOR | | Y | | Y | | Y | Y | | Y | | Y | | Y | | Y | | Y | | Y2 | Y2 | Y2 |
| FLASH | | Y | | Y | | Y | Y | | SLM | | SLM | | SLM | | PDM | | PDM | |  |  |  |
| SRAM | | Y | | Y | | Y | Y | | NA | | NA | | NA | | NA1 | | NA2 | |  |  |  |
| IO | | Y | | Y | | Y | Y | | Y | | Y | | Y | | Y | | Y | |  |  |  |
| RF | | O | | O | | O | O | | O | | O | | O | | O | | O | | Y | Y | Y |

Notes and symbol annotations for the table above：

* **Stop0-2:** all GPIOs can be configured to wake up the CPU; all GPIOs retain the previous state in Stop0-2 mode.
* **Stop3:** 56 GPIOs in the main domain can be configured to wake up the CPU; all GPIOs retain the previous state in Stop3 mode.
* **Standby:** 8 GPIOs in the AON domain retain the previous state in Standby mode; 56 GPIOs in the main domain are used as analog functions (such as LCD, COMP) and cannot be used to wake up the CPU. The LPUART only supports RX in Standby/Stop3 mode.
* **Y:** Work normally
* **O:** Optional, configured by software
* **O3:** Data update is not supported, but the output retains current voltage level
* **Y1:** Generate system reset to wake up the system indirectly
* **Y2:** Generate BOR reset to wake up the system indirectly
* **Y3:** Retain the state before entering low-power mode, and can be used to wake up the CPU.
* **Y4:** MUX Function1 of GPIO56~63 is not available and the other alternate functions is available
* **NA1:** Retention and algorithm contents are kept. System content can be configured to be kept or not.
* **NA2:** Retention content is kept
* **NA3:** Analog Output Only

#### 6.1 Run

##### 6.1.1 Enter and Exit

***Run*** mode is the default operation mode after power-on or system reset.

ASR6601 can enter Sleep, LpRun, Stop0, Stop1, Stop2, Stop3 or Standby mode from Run mode.

ASR6601 can return to Run mode from Sleep, LpRun, Stop0, Stop1, Stop2, Stop3 or Standby mode.

For detailed mode switching conditions, please refer to the descriptions of other operation modes.

**6.1.2 Wakeup Source**

N/A

**6.2 LpRun**

##### 6.2.1 Enter and Exit

Enter ***LpRun*** mode from Run mode in the following way:

Turn off all high-speed clocks to make CPU run at 32K clock frequency. Then switch the working state of LDO by software.

***LpRun*** config register is used to switch LDO working state:

1. Set bits[3:3] of the register (address 0x05) to 1, and the other bits remain unchanged.
2. Set bits[21:20] of the register (address 0x06) to 1, and the other bits remain unchanged.

Return to ***Run*** mode from ***LpRun*** mode in the following way:

Switch the working state of LDO by software. Then turn on the high-speed clock LpRun config register is used to switch LDO working state:

1. Clear bits[21:20] of the register (address 0x06) to 0, and the other bits remain unchanged.
2. Clear bits[3:3] of the register (address 0x05) to 0, and the other bits remain unchanged.

**6.2.2 Wakeup Source**

N/A

#### 6.3 Sleep

##### 6.3.1 Enter and Exit

Enter ***Sleep*** mode from ***Run*** mode in the following way:

CPU executes WFI/WFE instruction SLEEPDEEP=0, or isr returns SLEEPONEXIT=1 and SLEEPDEEP=0.

Return to ***Run*** mode from ***Sleep*** mode in the following ways:

* If WFI instruction is used to enter Sleep mode, then the system is waked-up by interrupts.
* If WFE instruction is used to enter Sleep mode, then the system is waked-up by events.

***Note:*** *Since there is no dedicated wake-up event signal, the interrupt signal is used to generate wake-up events by instruction SVONPEND=1 and turning off the corresponding NVIC.*

**6.3.2 Wakeup Source**

Interrupt signal generated by each module.

#### 6.4 LpSleep

##### 6.4.1 Enter and Exit

Enter ***LpSleep*** mode from ***LpRun*** mode in the following way:

CPU executes WFI/WFE instruction SLEEPDEEP=0, or isr returns SLEEPONEXIT=1 and SLEEPDEEP=0.

Return to ***LpRun*** mode from ***LpSleep*** mode in the following ways:

* If WFI instruction is used to enter ***LpSleep*** mode, then the system returns ***LpRun*** mode by interrupts.
* If WFE instruction is used to enter ***LpSleep*** mode, then the system returns ***LpRun*** mode by wake-up events.

***Note:*** *Since there is no dedicated event wake-up signal, the interrupt signal is used to generate wake-up events by instruction SVONPEND=1 and turning off the corresponding NVIC.*

**6.4.2 Wakeup Source**

Interrupt signal of each module

#### 6.5 Stop0

##### 6.5.1 Enter and Exit

Enter ***Stop0*** mode from ***Run*** mode in the following way:

Configure lp\_mode to 2’b00, then CPU executes WFI/WFE instruction SLEEPDEEP=1, or isr returns SLEEPONEXIT=1 and SLEEPDEEP=1.

Return to ***Run*** mode from ***Stop0*** mode in the following ways:

* If WFI instruction is used to enter ***Stop0*** mode, then the system is waked-up by interrupts.
* If WFE instruction is used to enter ***Stop0*** mode, then the system is waked-up by events.

The pwr module manages the status of the wake-up sources and outputs the pwr\_wakeup\_int signal and the pwr\_wakeup\_event signal to wake up the CPU.

##### 6.5.2 Wakeup Source

* GPIO00-GPIO63 can all be used to wake up the CPU, 4 IOs make up a group, and each group can select any of the 4 IOs for wake-up. A group generates a wake-up signal, and any of the IOs can wake up the CPU at high or low level. The wake-up sources other than GPIOs are listed below.
* PVM Alarm
* Wakeup/Tamper IO
* VD Alarm
* RTC Alarm
* TD Alarm
* RTC CYC Timer
* LD Alarm
* LPUART RX Status
* Comparator
* LORA BUSY
* LPTIM0/1
* LORA IRQ
* FD\_32K Alarm

#### 6.6 Stop1

##### 6.6.1 Enter and Exit

Enter ***Stop1*** mode from ***Run*** mode in the following way:

Configure lp\_mode to 2’b01, then CPU executes WFI/WFE instruction SLEEPDEEP=1, or isr returns SLEEPONEXIT=1 and SLEEPDEEP=1.

Return to ***Run*** mode from ***Stop1*** mode in the following ways:

* If WFI instruction is used to enter ***Stop1*** mode, then the system is waked-up by interrupts.
* If WFE instruction is used to enter ***Stop1*** mode, then the system is waked-up by events.

The pwr module manages the status of the wake-up sources and outputs the pwr\_wakeup\_int signal and the pwr\_wakeup\_event signal to wake up the CPU.

###### 6.6.2 Wakeup Source

* GPIO00-GPIO63 can all be used to wake up the CPU, 4 IOs make up a group, and each group can select any of the 4 IOs for wake-up. A group generates a wake-up signal, and any of the IOs can wake up the CPU at high or low level. The wake-up sources other than GPIOs are listed below.
* PVM Alarm
* Wakeup/Tamper IO
* VD Alarm
* RTC Alarm
* TD Alarm
* RTC CYC Timer
* LD Alarm
* LPUART RX Status
* Comparator
* LORA BUSY
* LPTIM0/1
* LORA IRQ
* FD\_32K Alarm

#### 6.7 Stop2

##### 6.7.1 Enter and Exit

Enter ***Stop2*** mode from ***Run*** mode in the following way:

Configure lp\_mode to 2’b10, then CPU executes WFI/WFE instruction SLEEPDEEP=1, or isr returns SLEEPONEXIT=1 and SLEEPDEEP=1.

Return to ***Run*** mode from ***Stop2*** mode in the following ways:

* If WFI instruction is used to enter Stop2 mode, then the system is waked-up by interrupts.
* If WFE instruction is used to enter Stop2 mode, then the system is waked-up by events.

The pwr module manages the status of the wake-up sources, and outputs pwr\_wakeup\_int signal and pwr\_wakeup\_event signal to wake up the CPU.

###### 6.7.2 Wakeup Source

* GPIO00-GPIO63 can all be used to wake up the CPU, 4 IOs make up a group, and each group can select any of the 4 IOs for wake-up. A group generates a wake-up signal, and any of the IOs can wake up the CPU at high or low level. The wake-up sources other than GPIOs are listed below.
* PVM Alarm
* Wakeup/Tamper IO
* VD Alarm
* RTC Alarm
* TD Alarm
* RTC CYC Timer
* LD Alarm
* LPUART RX Status
* Comparator
* LORA BUSY
* LPTIM0/1
* LORA IRQ
* FD\_32K Alarm

#### 6.8 Stop3

##### 6.8.1 Enter and Exit

Enter ***Stop3*** mode from ***Run*** mode in the following way:

Configure lp\_mode to 2’b11 and lp\_mode\_ext to 1’b1, then CPU executes WFI/WFE instruction SLEEPDEEP=1, or isr returns SLEEPONEXIT=1 and SLEEPDEEP=1.

The system returns to ***Run*** mode if a wake-up event occurred in ***Stop3*** mode.

###### 6.8.2 Wakeup Source

* GPIO00-GPIO55 can all be used to wake up the CPU, 4 IOs make up a group, and each group can select any of the 4 IOs for wake-up. A group generates a wake-up signal, and any of the IOs can wake up the CPU at high or low level. The wake-up sources other than GPIOs are listed below.
* PVM Alarm
* RTC Alarm
* VD Alarm
* RTC CYC Timer
* Comparator
* LPUART RX Status
* LPTIM0/1
* LORA BUSY
* FD\_32K Alarm
* LORA IRQ
* Wakeup/Tamper IO
* IWDG Timeout

#### 6.9 Standby

##### 6.9.1 Enter and Exit

Enter ***Standby*** mode from ***Run*** mode in the following way:

Configure lp\_mode to 2’b11 and lp\_mode\_ext to 1’b0, then CPU executes WFI/WFE instruction SLEEPDEEP=1, or isr returns SLEEPONEXIT=1 and SLEEPDEEP=1.

The system returns to ***Run*** mode if a wake-up event occurred in ***Standby*** mode.

***Note:***

1. *When the power supply is switched between DCDC and VBAT, the CPU will return to Run mode immediately after entering Standby mode without any wake-up event.*
2. *When dbg\_standby=1, the switch between DCDC and VBAT is disabled.*

###### 6.9.2 Wakeup Source

* PVM Alarm
* RTC Alarm
* VD Alarm
* RTC CYC Timer
* Comparator
* LPUART RX Status
* LPTIM0/1
* LORA BUSY
* FD\_32K Alarm
* LORA IRQ
* Wakeup/Tamper IO
* IWDG Timeout

### 7. System Configuration

#### 7.1 System Architecture

#### 



**Figure 7-1 System Architecture Diagram**

##### 7.1.1 Arm China STAR-MC1 Processor

Arm China STAR-MC1 Processor consists of three master buses, including icode AHB bus, dcode AHB bus and system AHB bus, which are used for program access, data access and register access.

**7.1.2 DMAC0**

DMAC0 has a master bus, which can assist the CPU to transfer data.

##### 7.1.3 DMAC1

DMAC1 has a master bus, which can assist the CPU to transfer data.

**7.1.4 Master**

The addresses accessible by each master bus is shown in the table below.

***(1)*** *Only accessible when boot from Bootloader.*

**Table 7-1 Master Bus Access Scope**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Start  Address | End Address | Description | Execut- able | icode  Access | dcode  Access | system  Access | dmac0 Access | dmac1 Access |
| 0xE0100000 | 0xFFFFFFFFF | Reserved |  |  |  |  |  |  |
| 0xE0000000 | 0xE00FFFFF | ARM STAR peripherals |  |  |  |  |  |  |
| 0xA0000000 | 0xDFFFFFFF | Reserved |  |  |  |  |  |  |
| 0x70000000 | 0x9FFFFFFF | Reserved |  |  |  |  |  |  |
| 0x60000000 | 0x6FFFFFFF | Qspi Flash Bank | Y |  |  | Y | Y | Y |
| 0x50000000 | 0x5FFFFFFF | Reserved |  |  |  |  |  |  |
| 0x40030000 | 0x4FFFFFFF | AHB1 SFR |  |  |  | Y | Y | Y |
| 0x40020000 | 0x4002FFFF | AHB0 SFR |  |  |  | Y | Y | Y |
| 0x40010000 | 0x4001FFFF | APB1 SFR |  |  |  | Y | Y | Y |
| 0x40000000 | 0x4000FFFF | APB0 SFR |  |  |  | Y | Y | Y |
| 0x30000400 | 0x3FFFFFFF | Reserved |  |  |  |  |  |  |
| 0x30000000 | 0x300003FF | Retention SRAM |  |  |  | Y | Y | Y |
| 0x20010000 | 0x2FFFFFFF | Reserved |  |  |  |  |  |  |
| 0x20000000 | 0x2000FFFF | System SRAM | Y |  |  | Y | Y | Y |
| 0x18010000 | 0x1FFFFFFF | Reserved |  |  |  |  |  |  |
| 0x18000000 | 0x1800FFFF | System SRAM | Y | Y | Y |  |  |  |
| 0x10004000 | 0x17FFFFFF | Reserved |  |  |  |  |  |  |
| 0x10003000 | 0x10003FFF | Option Bytes |  |  | Y |  |  |  |
| 0x10002000 | 0x10002FFF | Factory Bytes |  |  | Y |  |  |  |
| 0x10001C00 | 0x10001FFF | OTP |  |  | Y |  |  |  |
| 0x10000000 | 0x10001BFF | BootLoader |  | Y(1) | Y(1) |  |  |  |
| 0x08040000 | 0x0FFFFFFF | Reserved |  |  |  |  |  |  |
| 0x08000000 | 0x0803FFFF | Main Flash | Y | Y | Y |  | Y | Y |
| 0x00040000 | 0x07FFFFFF | Reserved |  |  |  |  |  |  |
| 0x00000000 | 0x0003FFFF | Flash Main/BootLoader/  System SRAM(1) | Y | Y | Y |  |  |  |

#### 7.2 Memory Mapping

The Memory Mapping table is shown below. The bytes are coded in memory in Little Endian format, i.e. the least significant byte is in the lowest address.

##### Table 7-2 Memory Mapping

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Category | Start Address | End Address | Description | Size |
| SYSTEM | 0xE0100000 | 0xFFFFFFFFF | Reserved |  |
| PPB | 0xE0000000 | 0xE00FFFFF | ARM STAR peripherals |  |
| EXT PERIPHERAL | 0xA0000000 | 0xDFFFFFFF | Reserved |  |
| EXT SRAM | 0x70000000 | 0x9FFFFFFF | Reserved |  |
| 0x60000000 | 0x6FFFFFFF | Qspi Flash Bank | 256MB |
| PERIPHERAL | 0x50000000 | 0x5FFFFFFF | Reserved |  |
| 0x40030000 | 0x4FFFFFFF | AHB1 SFR |  |
| 0x40020000 | 0x4002FFFF | AHB0 SFR |  |
| 0x40010000 | 0x4001FFFF | APB1 SFR |  |
| 0x40000000 | 0x4000FFFF | APB0 SFR |  |
| SRAM | 0x30000400 | 0x3FFFFFFF | Reserved |  |
| 0x30000000 | 0x300003FF | Retention SRAM | 1KB |
| 0x20010000 | 0x2FFFFFFF | Reserved |  |
| 0x20000000 | 0x2000FFFF | System SRAM | 64KB |
| CODE | 0x18010000 | 0x1FFFFFFF | Reserved |  |
| 0x18000000 | 0x1800FFFF | System SRAM | 64KB |
| 0x10004000 | 0x17FFFFFF | Reserved |  |
| 0x10003000 | 0x10003FFF | Option Bytes | 4KB |
| 0x10002000 | 0x10002FFF | Factory Bytes | 4KB |
| 0x10001C00 | 0x10001FFF | OTP | 1KB |
| 0x10000000 | 0x10001BFF | BootLoader | 7KB |
| 0x08040000 | 0x0FFFFFFF | Reserved |  |
| 0x08000000 | 0x0803FFFF | Flash Main | 256KB |
| 0x00040000 | 0x07FFFFFF | Reserved |  |
| 0x00000000 | 0x0003FFFF | Flash Main/BootLoader/  System SRAM**(1)** | 256KB |

***(1)*** *The memory corresponding to address 0x00000000 is determined by the boot mode.*

##### 7.2.1 AHB0 SFR

See the table below for AHB0 SFR Internal Address Mapping.

**Table 7-3 AHB0 SFR Internal Address mapping**

|  |  |  |  |
| --- | --- | --- | --- |
| Start Address | End Address | Description | Size |
| 0x40025000 | 0x4002FFFF | Reserved |  |
| 0x40024000 | 0x40024FFF | DMAC1 | 4KB |
| 0x40023000 | 0x40023FFF | DMAC0 | 4KB |
| 0x40022000 | 0x40022FFF | CRC | 4KB |
| 0x40021000 | 0x40021FFF | QSPI | 4KB |
| 0x40020000 | 0x40020FFF | EFC | 4KB |

##### 7.2.2 AHB1 SFR

See the table below for AHB1 SFR Internal Address Mapping.

**Table 7-4 AHB1 SFR Internal Address mapping**

|  |  |  |  |
| --- | --- | --- | --- |
| Start Address | End Address | Description | Size |
| 0x40034000 | 0x4003FFFF | Reserved |  |
| 0x40033000 | 0x40033FFF | RNGC | 4KB |
| 0x40030000 | 0x40032FFF | SAC | 12KB**(1)(2)** |

***(1)*** *Low 8KB is ARAM space, and high 4KB is for registers.*

***(2)*** *ARAM space can only be accessed in word.*

##### 7.2.3 APB0 SFR

See the table below for APB0 SFR Internal Address Mapping.

**Table 7-5 APB0 SFR Internal Address mapping**

|  |  |  |  |
| --- | --- | --- | --- |
| Start Address | End Address | Description | Size |
| 0x4000F000 | 0x4000FFFF | SEC | 4KB |
| 0x4000E000 | 0x4000EFFF | RTC | 4KB |
| 0x4000D800 | 0x4000DFFF | LPTIM1 | 2KB |
| 0x4000D000 | 0x4000D7FF | LPTIM0 | 2KB |
| 0x4000C000 | 0x4000CFFF | BASICTIM0 | 4KB |
| 0x4000B000 | 0x4000BFFF | GPTIM2 | 4KB |
| 0x4000A000 | 0x4000AFFF | GPTIM0 | 4KB |
| 0x40009000 | 0x40009FFF | LORAC | 4KB |
| 0x40008000 | 0x40008FFF | AFEC | 4KB |
| Start Address | End Address | Description | Size |
| 0x40007000 | 0x40007FFF | I2C0 | 4KB |
| 0x40006000 | 0x40006FFF | SSP0 | 4KB |
| 0x40005000 | 0x40005FFF | LPUART | 4KB |
| 0x40004000 | 0x40004FFF | UART1 | 4KB |
| 0x40003000 | 0x40003FFF | UART0 | 4KB |
| 0x40002000 | 0x40002FFF | I2S | 4KB |
| 0x40001800 | 0x40001FFF | PWR | 2KB |
| 0x40001000 | 0x400017FF | SYSCFG | 2KB |
| 0x40000000 | 0x40000FFF | RCC | 4KB |

##### 7.2.4 APB1 SFR

See the table below for APB1 SFR Internal Address Mapping.

**Table 7-6 APB1 SFR Internal Address mapping**

|  |  |  |  |
| --- | --- | --- | --- |
| Start Address | End Address | Description | Size |
| 0x4001FC00 | 0x4001FFFF | PortD | 1KB |
| 0x4001F800 | 0x4001FBFF | PortC | 1KB |
| 0x4001F400 | 0x4001F7FF | PortB | 1KB |
| 0x4001F000 | 0x4001F3FF | PortA | 1KB |
| 0x4001E000 | 0x4001EFFF | WWDG | 4KB |
| 0x4001D000 | 0x4001DFFF | IWDG | 4KB |
| 0x4001C000 | 0x4001CFFF | BASICTIM1 | 4KB |
| 0x4001B000 | 0x4001BFFF | GPTIM3 | 4KB |
| 0x4001A000 | 0x4001AFFF | GPTIM1 | 4KB |
| 0x40019000 | 0x40019FFF | DACCTRL | 4KB |
| 0x40018000 | 0x40018FFF | LCDCTRL | 4KB |
| 0x40017000 | 0x40017FFF | ADCCTRL | 4KB |
| 0x40016000 | 0x40016FFF | Reserved | 4KB |
| 0x40015000 | 0x40015FFF | I2C2 | 4KB |
| 0x40014000 | 0x40014FFF | I2C1 | 4KB |
| 0x40013000 | 0x40013FFF | SSP2 | 4KB |
| 0x40012000 | 0x40012FFF | SSP1 | 4KB |
| 0x40011000 | 0x40011FFF | UART3 | 4KB |
| 0x40010000 | 0x40010FFF | UART2 | 4KB |

##### 7.3 SRAM

The SRAM in ASR6601 includes system SRAM, retention SRAM and SAC SRAM. SAC SRAM only supports word access, and system SRAM and retention SRAM support word, halfword, and byte access.

#### 7.4 Boot Mode

The boot mode can be configured by the levels of BOOT0 pin (GPIO02) and the data in the Flash.

##### Table 7-7 ASR6601 Boot Mode Configuration

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| DEBUG\_  LEVEL | USE\_FLASH\_  BOOT0 | FLASH\_  BOOT0 | BOOT0  PIN | FLASH\_  BOOT1 | MAIN\_FLASH\_  EMPTY | Boot Config |
| 2 | X | X | X | X | X | Boot from Flash Main |
| <2 | 0 | X | 0 | X | 0 | Boot from Flash Main |
| <2 | 0 | X | 0 | X | 1 | Boot from Flash Bootloader |
| <2 | 0 | X | 1 | 1 | X | Boot from Flash Bootloader |
| <2 | 0 | X | 1 | 0 | X | Boot from System SRAM |
| <2 | 1 | 1 | X | X | 0 | Boot from Flash Main |
| <2 | 1 | 1 | X | X | 1 | Boot from Flash Bootloader |
| <2 | 1 | 0 | X | 1 | X | Boot from Flash Bootloader |
| <2 | 1 | 0 | X | 0 | X | Boot from System SRAM |

* DebugLevel, UseFlashBoot0, FlashBoot0 and FlashBoot1 is the information area of the Flash, they can be modified according to the application. MainFlashEmpty is determined by the data of address 0 in the Flash Main area. If the data in the address 0 of Flash Main area is 0xFFFFFFFF, the value of MainFlashEmpty is 1, otherwise the value of MainFlashEmpty is 0. BOOT0 pin is GPIO02 in the package.
* The boot mode is selected according to the configurations when the system is in these status: first powered up, exit the Standby mode or reset.

#### 7.5 System Configuration Registers

Base Address: 0x40001000

**Table 7-8 SYSCFG Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| SYSCFG\_CR0 | 0x000 | Control Register 0, DMA handshake |
| SYSCFG\_CR1 | 0x004 | Control Register 1, DMA handshake |
| SYSCFG\_CR2 | 0x008 | Control Register 2 |
| SYSCFG\_CR3 | 0x00C | Control Register 3, Low power debug connection control |
| SYSCFG\_CR4 | 0x010 | Control Register 4 |
| SYSCFG\_CR5 | 0x014 | Control Register 5 |
| SYSCFG\_CR6 | 0x018 | Control Register 6,secure lock control |
| SYSCFG\_CR7 | 0x01C | Control Register 7,secure lock control |
| SYSCFG\_CR8 | 0x020 | Control Register 8,QSPI memory encryption key |
| SYSCFG\_CR9 | 0x024 | Control Register 9,QSPI REMAP |
| SYSCFG\_CR10 | 0x028 | Control Register 10 |

##### 7.5.1 SYSCFG\_CR0

Offset: 0x000

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-30** | **29-24** | **23-22** | **21-16** |
| RESERVED | DMAC0\_HANDSHAKE0\_SEL | RESERVED | DMAC0\_HANDSHAKE1\_SEL |
| r | r/w | r | r/w |
| **15-14** | **13-8** | **7-6** | **5-0** |
| RESERVED | DMAC0\_HANDSHAKE2\_SEL | RESERVED | DMAC0\_HANDSHAKE3\_SEL |
| r | r | r | r/w |

**Bits 31-30 RESERVED:** Must be kept, and can't be modified.

**Bits 29-24 DMAC0\_HANDSHAKE0\_SEL:** DMAC0 HANDSHAKE0 selection. For details, please refer to *Table7-9 DMA Request MUX.*

**Bits 23-22 RESERVED:** Must be kept, and can't be modified.

**Bits 21-16 DMAC0\_HANDSHAKE1\_SEL: DMAC0 HANDSHAKE1** selection. For details, please refer to *Table7-9 DMA Request MUX.*

**Bits 15-14 RESERVED:** Must be kept, and cannot be modified.

**Bits 13-8 DMAC0\_HANDSHAKE2\_SEL:** DMAC0 HANDSHAKE2 selection. For details, please refer to *Table7-9 DMA Request MUX.*

**Bits 7-6 RESERVED:** Must be kept, and cannot be modified.

**Bits 5-0 DMAC0\_HANDSHAKE3\_SEL:** DMAC0 HANDSHAKE3 selection. For details, please refer to *Table7-9 DMA Request MUX.*

##### 7.5.2 SYSCFG\_CR1

Offset: 0x004

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-30** | **29-24** | **23-22** | **21-16** |
| RESERVED | DMAC1\_HANDSHAKE0\_SEL | RESERVED | DMAC1\_HANDSHAKE1\_SEL |
| r | r/w | r | r/w |
| **15-14** | **13-8** | **7-6** | **5-0** |
| RESERVED | DMAC1\_HANDSHAKE2\_SEL | RESERVED | DMAC1\_HANDSHAKE3\_SEL |
| r | r | r | r/w |

**Bits 31-30 RESERVED:** Must be kept, and cannot be modified.

**Bits 29-24 DMAC1\_HANDSHAKE0\_SEL:** DMAC1 HANDSHAKE0 selection. For details, please refer to *Table7-9 DMA Request MUX.*

**Bits 23-22 RESERVED:** Must be kept, and cannot be modified.

**Bits 21-16 DMAC1\_HANDSHAKE1\_SEL:** DMAC1 HANDSHAKE1 selection. For details, please refer to *Table7-9 DMA Request MUX.*

**Bits 15-14 RESERVED:** Must be kept, and cannot be modified.

**Bits 13-8 DMAC1\_HANDSHAKE2\_SEL:** DMAC1 HANDSHAKE2 selection. For details, please refer to *Table7-9 DMA Request MUX.*

**Bits 7-6 RESERVED:** Must be kept, and cannot be modified.

**Bits 5-0 DMAC1\_HANDSHAKE3\_SEL:** DMAC1 HANDSHAKE3 selection. For details, please refer to *Table7-9 DMA Request MUX.*

##### 7.5.3 SYSCFG\_CR2

Offset: 0x008

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31** | **30** | **29-28** | **27** |
| RESERVED | SYSCFG\_HALTED\_IPTI  M1\_EN | RESERVED | SYSCFG\_HALTED\_LPT  IM0\_EN |
| r | r/w | r | r/w |
| **26** | **25** | **24** | **23** |
| SYSCFG\_HALTED\_IW  DG\_EN | SYSCFG\_HALTED\_WW  DG\_EN | SYSCFG\_HALTED\_GP  TIM0\_EN | SYSCFG\_HALTED\_GP  TIM1\_EN |
| r/w | r/w | r/w | r/w |
| **22** | **21** | **20** | **19** |
| SYSCFG\_HALTED\_GP  TIM2\_EN | SYSCFG\_HALTED\_GP  TIM3\_EN | SYSCFG\_HALTED\_BA  SICTIM0\_EN | SYSCFG\_HALTED\_BA  SICTIM1\_EN |
| r/w | r/w | r/w | r/w |
| **18** | **17** | **16-12** | |
| QSPI\_MEM\_ENCRYPT  \_EN | QSPI\_REMAP\_ENABLE | RESERVED | |
| r/w | r/w | r | |
| **11** | **10** | **9-8** | |
| CPU\_STCALIB\_SKEW | SYSCFG\_DBG\_SLEEP | RESERVED | |
| r/w | r/w | r | |
| **7** | **6** | **5** | **4** |
| UART0\_DMA\_CLR\_SEL | UART1\_DMA\_CLR\_SEL | UART2\_DMA\_CLR\_SEL | UART3\_DMA\_CLR\_SEL |
| r/w | r/w | r/w | r/w |
| **3** | **2** | **1** | **0** |
| SSP0\_DMA\_CLR\_SEL | SSP1\_DMA\_CLR\_SEL | SSP2\_DMA\_CLR\_SEL | SSP\_AFEC\_DMA\_CLR  \_SEL |
| r/w | r/w | r/w | r/w |

**Bit 31 RESERVED:** Must be kept, and cannot be modified.

**Bit 30 SYSCFG\_HALTED\_LPTIM1\_EN:** Stop LPTIM1 counter if the core is halted

* 0: LPTIM1 counter continues to work normally when the core is halted
* 1: LPTIM1 counter is stopped when the core is halted

**Bits 29-28 RESERVED:** Must be kept, and cannot be modified.

**Bit 27 SYSCFG\_HALTED\_LPTIM0\_EN:** Stop LPTIM0 counter if the core is halted

* 0: LPTIM0 counter continues to work normally when the core is halted
* 1: LPTIM0 counter is stopped when the core is halted

Bit 26 SYSCFG\_HALTED\_IWDG\_EN: Stop independent watchdog counter if the core is halted

0: the independent watchdog counter continues to work normally when the core is halted

1: the independent watchdog counter is stopped when the core is halted

**Bit 25 SYSCFG\_HALTED\_WWDG\_EN:** Stop window watchdog counter if the core is halted

0: The window watchdog counter continues to work normally when the core is halted

1: The window watchdog counter is stopped when the core is halted

**Bit 24 SYSCFG\_HALTED\_GPTIM0\_EN:** Stop GPTIM0 counter if the core is halted

0: GPTIM0 counter continues to work normally when the core is halted

1: GPTIM0 counter is stopped when the core is halted

**Bit 23 SYSCFG\_HALTED\_GPTIM1\_EN:** Stop GPTIM1 counter if the core is halted

0: GPTIM1 counter continues to work normally when the core is halted

1: GPTIM1 counter is stopped when the core is halted

**Bit 22 SYSCFG\_HALTED\_GPTIM2\_EN:** Stop GPTIM2 counter if the core is halted

0: GPTIM2 counter continues to work normally when the core is halted

1: GPTIM2 counter is stopped when the core is halted

**Bit 21 SYSCFG\_HALTED\_GPTIM3\_EN:** Stop GPTIM3 counter if the core is halted

0: GPTIM3 counter continues to work normally when the core is halted

1: GPTIM3 counter is stopped when the core is halted

**Bit 20 SYSCFG\_HALTED\_BASICTIM0\_EN:** Stop BASICTIM0 counter if the core is halted

0: BASICTIM0 counter continues to work normally when the core is halted

1: BASICTIM0 counter is stopped when the core is halted

**Bit 19 SYSCFG\_HALTED\_BASICTIM1\_EN:** Stop BASICTIM1 counter if the core is halted

0: BASICTIM1 counter continues to work normally when the core is halted

1: BASICTIM1 counter is stopped when the core is halted

**Bit 18 QSPI\_MEM\_ENCRYPT\_EN:** QSPI memory encryption enable

0: disabled

1: enabled

**Bit 17 QSPI\_REMAP\_ENABLE:** QSPI remap function enable

0: disabled

1: enabled

**Bit 16-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 CPU\_STCALIB\_SKEW:** CPU SysTick skew configuration

0: no skew

1: skew exist

**Bit 10 SYSCFG\_DBG\_SLEEP:** Allow debug connection in Deepsleep mode

It is only used in debug mode and it will affect the Deepsleep mode.

0: not allowed

1: allowed

**Bits 9-8 RESERVED:** Must be kept, and cannot be modified.

**Bit 7 UART0\_DMA\_CLR\_SEL:** UART0 DMA\_CLR signal selection

It is recommended to set this bit to improve DMAC transfer efficiency. UART module uses the synchronized DMA\_CLR signal by default.

0: use the DMA\_CLR signal after 2 cycles

1: directly use the DMA\_CLR signal output by DMAC

**Bit 6 UART1\_DMA\_CLR\_SEL:** UART1 DMA\_CLR signal selection

It is recommended to set this bit to improve DMAC transfer efficiency. UART module uses the synchronized DMA\_CLR signal by default.

0: use the DMA\_CLR signal after 2 cycles

1: directly use the DMA\_CLR signal output by DMAC

**Bit 5 UART2\_DMA\_CLR\_SEL:** UART2 DMA\_CLR signal selection

It is recommended to set this bit to improve DMAC transfer efficiency. UART module uses the synchronized DMA\_CLR signal by default.

0: use the DMA\_CLR signal after 2 cycles

1: directly use the DMA\_CLR signal output by DMAC

**Bit 4 UART3\_DMA\_CLR\_SEL:** UART3 DMA\_CLR signal selection

It is recommended to set this bit to improve DMAC transfer efficiency. UART module uses the synchronized DMA\_CLR signal by default.

0: use the DMA\_CLR signal after 2 cycles

1: directly use the DMA\_CLR signal output by DMAC

**Bit 3 SSP0\_DMA\_CLR\_SEL:** SSP0 DMA\_CLR signal selection

It is recommended to set this bit to improve DMAC transfer efficiency. SSP module uses the synchronized DMA\_CLR signal by default.

0: use the DMA\_CLR signal after 2 cycles

1: directly use the DMA\_CLR signal output by DMAC

**Bit 2 SSP1\_DMA\_CLR\_SEL:** SSP1 DMA\_CLR signal selection

It is recommended to set this bit to improve DMAC transfer efficiency. SSP module uses the synchronized DMA\_CLR signal by default.

0: use the DMA\_CLR signal after 2 cycles

1: directly use the DMA\_CLR signal output by DMAC

**Bit 1 SSP2\_DMA\_CLR\_SEL:** SSP2 DMA\_CLR signal selection

It is recommended to set this bit to improve DMAC transfer efficiency. SSP module uses the synchronized DMA\_CLR signal by default.

0: use the DMA\_CLR signal after 2 cycles

1: directly use the DMA\_CLR signal output by DMAC

**Bit 0 SSP\_AFEC\_DMA\_CLR\_SEL:** SSP (for afec) DMA\_CLR signal selection

It is recommended to set this bit to improve DMAC transfer efficiency. SSP module uses the synchronized DMA\_CLR signal by default.

0: use the DMA\_CLR signal after 2 cycles

1: directly use the DMA\_CLR signal output by DMAC

##### 7.5.4 SYSCFG-CR3

Offset: 0x00C

Reset Value: 0x00000000

This register is in the AON domain.

|  |  |  |
| --- | --- | --- |
| **31-2** | **1** | **0** |
| RESERVED | SYSCFG\_DBG\_STOP | SYSCFG\_DBG\_STANDBY |
| r | r/w | r/w |

**Bits 31-2 RESERVED:** Must be kept, and cannot be modified.

**Bit 1 SYSCFG\_DBG\_STOP:** Allow a debug connection in Stop mode. It is only used in debug and it will affect Stop mode implementation.

* 0: not allowed
* 1: allowed

**Bit 0 SYSCFG\_DBG\_STANDBY:** Allow a debug connection in Standby mode. It is only used in debug and it will affect Standby mode implementation.

* 0: not allowed
* 1: allowed

##### 7.5.5 SYSCFG\_CR4

Offset: 0x010

Reset Value: 0x00000000

This register is in the AON domain.

|  |  |
| --- | --- |
| **31** | **30-0** |
| SYSCFG\_CR4\_REG | USER-DEFINED |
| r/w | r/w |

**Bit 31 SYSCFG\_CR4\_REG:** LPTIM1 IN2 remapping enable

* 0: disabled, LPTIM1\_IN2 is determined by GPIO AFR
* 1: enabled, LPTIM1\_IN2 is derived from LPTIM0\_IN1

**Bits 30-0 USER-DEFINED:** These bits are user-defined and can be used to store a small amount of data by software.

##### 7.5.6 SYSCFG\_CR5

Offset: 0x014

Reset Value: 0x00000000

This register is in the AON domain.

|  |
| --- |
| **31-0** |
| SYSCFG\_CR5\_REG |
| r/w |

**Bits 31-0 SYSCFG\_CR5\_REG:** These bits are user-defined and can be used to store a small amount of data by software.

##### 7.5.7 SYSCFG\_CR6

Offset: 0x018

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-16** | **15** | **14-5** | **4** |
| RESERVED | RNGC\_SECURE\_LOCK | ANALOG\_MAIN\_SECU  RE\_LOCK | RESERVED |
| r | r/w | r/w | r |
| **3** | **2** | **1** | **0** |
| SEC\_SECURE\_LOCK | SAC\_SECURE\_LOCK | DMAC0\_SLAVE\_SECU  RE\_LOCK | DMAC0\_MASTER\_SEC  URE\_LOCK |
| r/w | r/w | r/w | r/w |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bit 15 RNGC\_SECURE\_LOCK:** RNGC security lock

* 0: security lock disabled
* 1: security lock enabled

**Bits 14-5 ANALOG\_MAIN\_SECURE\_LOCK:** Security lock for main domain configuration of AFEC

[5] Correspond to VD

* 0: security lock disabled
* 1: security lock enabled

[6] Correspond to TD

* 0: security lock disabled
* 1: security lock enabled

[7] Correspond to LD

* 0: security lock disabled
* 1: security lock enabled

[8] Correspond to FD24M

* 0: security lock disabled
* 1: security lock enabled

[9] Correspond to FD32M

* 0: security lock disabled
* 1: security lock enabled

[10] Correspond to RNG

* 0: security lock disabled
* 1: security lock enabled

[11] Correspond to TEST

* 0: security lock disabled
* 1: security lock enabled

[14:12]: Unused

* 0: security lock disabled
* 1: security lock enabled

**Bit 4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 SEC\_SECURE\_LOCK:** SEC security lock

* 0: security lock disabled
* 1: security lock enabled

**Bit 2 SAC\_SECURE\_LOCK:** SAC security lock

* 0: security lock disabled
* 1: security lock enabled

**Bit 1 DMAC0\_SLAVE\_SECURE\_LOCK:** DMAC0 slave interface security lock

* 0: security lock disabled
* 1: security lock enabled

**Bit 0 DMAC0\_MASTER\_SECURE\_LOCK:** DMAC0 master interface security lock

* 0: security lock disabled
* 1: security lock enabled

##### 7.5.8 SYSCFG\_CR7

Offset: 0x01C

Reset Value: 0x00000000

This register is in the AON domain.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-15** | **14-5** | | **4** | |
| RESERVED | ANALOG\_AON\_SECURE\_LOCK | | RTC\_CALENDAR\_SECURE\_LOCK | |
| r | r/w | | r/w | |
| **3** | **2** | **1** | | **0** |
| RTC\_WAKEUP2\_SEC  URE\_LOCK | RTC\_WAKEUP1\_SECU  RE\_LOCK | RTC\_WAKEUP0\_SECU  RE\_LOCK | | RTC\_TAMPER\_SECUR  E\_LOCK |
| r/w | r/w | r/w | | r/w |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 14-5 ANALOG\_AON\_SECURE\_LOCK:** Security lock for AON domain configuration of AFEC

[5] Correspond to LPLDO

* 0: security lock disabled
* 1: security lock enabled

[6] Correspond to RCO3.6M

* 0: security lock disabled
* 1: security lock enabled

[7] Correspond to PWRSW

* 0: security lock disabled
* 1: security lock enabled

[8] Correspond to RCO32K

* 0: security lock disabled
* 1: security lock enabled

[9] Correspond to XO32K

* 0: security lock disabled
* 1: security lock enabled

[10] Correspond to LDO12

* 0: security lock disabled
* 1: security lock enabled

[11] Correspond to FD32K

* 0: security lock disabled
* 1: security lock enabled

[14:12] Unused

* 0: security lock disabled
* 1: security lock enabled

**Bit 4 RTC\_CALENDAR\_SECURE\_LOCK:** Calendar configuration security lock in RTC

* 0: security lock disabled
* 1: security lock enabled

**Bit 3 RTC\_WAKEUP2\_SECURE\_LOCK:** Wakeup2 configuration security lock in RTC

* 0: security lock disabled
* 1: security lock enabled

**Bit 2 RTC\_WAKEUP1\_SECURE\_LOCK:** Wakeup1 configuration security lock in RTC

* 0: security lock disabled
* 1: security lock enabled

**Bit 1 RTC\_WAKEUP0\_SECURE\_LOCK:** Wakeup0 configuration security lock in RTC

* 0: security lock disabled
* 1: security lock enabled

**Bit 0 RTC\_TAMPER\_SECURE\_LOCK:** Tamper configuration security lock in RTC

* 0: security lock disabled
* 1: security lock enabled

##### 7.5.9 SYSCFG\_CR8

Offset: 0x020

Reset Value: 0x00000000

|  |
| --- |
| **31-0** |
| QSPI\_MEM\_ENCRYPT\_KEY |
| r/w |

**Bits 31-0 QSPI\_MEM\_ENCRYPT\_KEY:** Encryption key for QSPI memory

##### 7.5.10 SYSCFG\_CR9

Offset:0x024

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-28** | **27-14** | **13-0** |
| RESERVED | QSPI\_REMAP\_SRC\_ADDR | QSPI\_REMAP\_DST\_ADDR |
| r | r/w | r/w |

**Bits 31-28 RESERVED:** Must be kept, and cannot be modified.

**Bits 27-14 QSPI\_REMAP\_SRC\_ADDR:** QSPI remap source address, aligned in 1KB

**Bits 13-0 QSPI\_REMAP\_DST\_ADDR:** QSPI remap destination address, aligned in 1KB

##### 7.5.11 SYSCFG\_CR10

Offset: 0x028

Reset Value: 0x00000000

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-24** | **23** | **22** | **21-15** | **14** | **13-0** |
| RESERVED | I2S\_WS\_SEL | I2S\_WS\_EN | I2S\_WS\_LEN | I2S\_MODE\_SEL | QSPI\_REMAP\_  SIZE |
| r | r/w | r/w | r/w | r/w | r/w |

**Bits 31-24 RESERVED:** Must be kept, and cannot be modified.

**Bit 23 I2S\_WS\_SEL:** I2S WS output delay enable

* 0: output delay disabled
* 1: output delay enabled

***Note:*** *This bit can only be configured when the I2S acts as master interface. When enabled, the WS signal is output one cycle later than the data transmission.*

**Bit 22 I2S\_WS\_EN:** I2S WS enable

* 0: disabled
* 1: enabled

***Note:*** *This bit can only be configured when the I2S acts as master interface. When enabled, the WS signal is generated based on the I2S\_WS\_LEN configuration.*

**Bits 21-15 I2S\_WS\_LEN:** I2S main interface resolution configuration

N: WS frequency=I2S interface clock frequency/[(N+1)\*2]

The I2S interface clock frequency is jointly determined by the I2S\_CLK\_DIV and I2S\_CLK\_SEL bits in the RCC\_CR3 and RCC\_CR2 registers.

**Bit 14 I2S\_MODE\_SEL:** I2S works in master or slave mode

* 0: slave mode
* 1: master mode

***Note:*** *In addition to this register, it is also necessary to configure the I2S\_CLK\_DIV and I2S\_CLK\_SEL bits in the RCC\_CR3 and RCC\_CR2 registers, as well as the alternate functions of GPIOs.*

**Bits 13-0 QSPI\_REMAP\_SIZE:** Address space for QSPI remapping, aligned in 1KB

##### 7.6 DMA Request MUX

**Table 7-9 DMA Request MUX**

|  |  |
| --- | --- |
| No. | Source |
| 63 |  |
| 62 |  |
| 61 |  |
| 60 |  |
| 59 |  |
| 58 |  |
| 57 |  |
| 56 |  |
| 55 |  |
| 54 |  |
| 53 | basictim0\_up |
| 52 | basictim1\_up |
| 51 | gptim3\_up |
| 50 | gptim3\_trg |
| 49 | gptim3\_ch0 |
| 48 | gptim3\_ch1 |
| 47 | gptim2\_up |
| 46 | gptim2\_trg |
| 45 | gptim2\_ch0 |
| 44 | gptim2\_ch1 |
| 43 | gptim1\_up |
| 42 | gptim1\_trg |
| 41 | gptim1\_ch0 |
| 40 | gptim1\_ch1 |
| 39 | gptim1\_ch2 |
| 38 | gptim1\_ch3 |
| 37 | gptim0\_up |
| 36 | gptim0\_trg |
| 35 | gptim0\_ch0 |
| 34 | gptim0\_ch1 |
| 33 | gptim0\_ch2 |
| 32 | gptim0\_ch3 |
| 31 | uart0\_rx |
| 30 | uart0\_tx |
| 29 | uart1\_rx |
| 28 | uart1\_tx |
| 27 | uart2\_rx |
| 26 | uart2\_tx |
| 25 | uart3\_rx |
| 24 | uart3\_tx |
| 23 | lpuart\_rx |
| 22 | lpuart\_tx |
| 21 | ssp0\_rx |
| 20 | ssp0\_tx |
| 19 | ssp1\_rx |
| 18 | ssp1\_tx |
| 17 | ssp2\_rx |
| 16 | ssp2\_tx |
| 15 | i2c0\_rx |
| 14 | i2c0\_tx |
| 13 | i2c1\_rx |
| 12 | i2c1\_tx |
| 11 | i2c2\_rx |
| 10 | i2c2\_tx |
| 9 |  |
| 8 |  |
| 7 | adcctrl |
| 6 | dacctrl |
| 5 | lorac\_rx |
| 4 | lorac\_tx |
| 3 |  |
| 2 |  |
| 1 |  |
| 0 |  |

### 8. Reset and clock control (RCC)

#### 8.1 Reset

There are four types of reset: external reset, power reset, system reset and low-power reset.

##### 8.1.1 External Reset

The external reset is triggered by RSTN IO input (active at low level).

The external reset is used to reset all digital logic.

##### 8.1.2 Power-on Reset

The power-on reset is generated by the BOR (Brownout reset) circuitry. The BOR circuitry monitors VBAT to ensure that the internal reset is released when the voltage is greater than 1.8V.

Power-on reset is used to reset all digital logic.

##### 8.1.3 System Reset

System reset sources include IWDG Reset, WWDG Reset, Option Byte Load Reset, Software Reset, Sec Reset, Power-on Reset, and External Reset.

* IWDG Reset: generated by the IWDG module for exception recovery
* WWDG Reset: generated by the WWDG module for exception recovery
* Option Byte Load Reset: generated by the EFC module and used to start option byte reloading
* Software Reset: generated by the CPU
* Sec Reset: generated by the Sec module and used for system reset after security alarm.

The system reset is used to reset most of the data logic in the Main domain excluding the Reset Source Status Register (*RCC\_RST\_SR*) which is used to record the latest system reset source.

##### 8.1.4 Low-power Reset

The low-power reset is generated by the low-power state machine and is used to reset the logic of the main domain when the CPU exits Standby or Stop3 mode.

The low-power reset is used to reset all digital logic in the main domain.

#### 8.2 Clock

Figure 8-1 shows the system clock structure.

iwdg, gpio

**Figure 8-1 Clock Tree**

##### 8.2.1 SYS\_CLK

RCO48M divided by 2, RCO32K, XO32K, PLL, XO24M, XO32M, RCO3.6M or RCO48M can be selected as the SYS\_CLK clock source. The default is RCO48M divided by 2.

* RCO48M (48MHz) is generated from the internal clock circuit.
* RCO32K (32kHz) is generated from the internal clock circuit.
* RCO3.6M (3.6MHz) is generated from the internal clock circuit.
* XO32K (32.768kHz) is generated from an external crystal oscillator.
* XO32M (32MHz) is generated from an external crystal oscillator.
* XO24M (24MHz) is generated from an external crystal oscillator.
* PLL is an internal clock circuit, RCO48M, XO32M, XO24M or RCO3.6M can be selected as PLL clock source, and the PLL clock output supports up to 48MHz.

AHB bus clock HCLK is generated from SYS\_CLK divided by 2^N (N ranges from 0 to 9).

The system includes two APB buses, the APB bus clock PCLK1 and PCLK2 are generated from HCLK divided by 2^M (M ranges from 0 to 4). The clock division factor for the two APB buses can be configured independently.

##### 8.2.2 **Clocks for the Modules**

The clocks for the modules consist of bus clocks and interface clocks.

The bus clock is generated by HCLK or PCLK gating and is used for modules to access bus.

In addition to a bus clock, some modules also have an independent interface clock, which is different from the bus clock, and is used to realize the function of the module.

The interface clock source for each module is selectable by software:

* LPTIM: PCLK0, RCO3.6M, XO32K, RCO32K, IO input clock
* LCDCTRL: XO32K, RCO32K, RCO3.6M
* LPUART: XO32K, RCO32K, RCO3.6M
* RTC: XO32K, RCO32K
* IWDG: XO32K, RCO32K
* UART: PCLK0/PCLK1, RCO3.6M, XO32K, XO24M
* ADCCTRL: PCLK1, SYS\_CLK, PLL, RCO48M
* I2S: PCLK0, XO24M, PLL, XO32M, IO input clock
* QSPI: HCLK, SYS\_CLK, PLL

ADCCTRL and I2S also support interface clock division, which is used to generate low

frequency interface clocks.

LPTIM, LCDCTRL, LPUART, RTC and IWDG in AON domain and those in Main domain can

be enabled or disabled independently.

##### 8.2.3 **Clock-out Capability** (MCO)

The microcontroller clock output (MCO) capability allows the internal clock to be output by IO.

MCO clock source can be RCO32K, XO32K, RCO3.6M, XO24M, XO32M, RCO48M, PLL or SYS\_CLK.

The clock can be output with a frequency divided by software configuration.

#### 8.3 RCC **Registers**

#### Base Address: 0x40000000

##### Table 8-1 RCC Register Summary

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| RCC\_CR0 | 0x000 | Control register 0 |
| RCC\_CR1 | 0x004 | Control register 1, interface clock source selection |
| RCC\_CR2 | 0x008 | Control register 2, interface clock source selection |
| RCC\_CGR0 | 0x00C | Module clock configure register 0 |
| RCC\_CGR1 | 0x010 | Module clock configure register 1 |
| RCC\_CGR2 | 0x014 | Module clock configure register 2 |
| RCC\_RST0 | 0x018 | Module reset control register 0 |
| RCC\_RST1 | 0x01C | Module reset control register 1 |
| RCC\_RST\_SR | 0x020 | System reset source Status register |
| RCC\_RST\_CR | 0x024 | System reset source control register |
| RCC\_SR | 0x028 | Status register, RCC\_CGR2 configuration status |
| RCC\_SR1 | 0x02C | Status register 1, module clock configuration status |
| RCC\_CR3 | 0x030 | Control register 3, interface clock division |

##### 8.3.1 RCC\_CR0

Offset: 0x000

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-26** | **25** | **24-22** | **21-19** | **18** |
| RESERVED | STCLKEN\_SEL | MCO\_CLK\_DIV\_NUM | MCO\_CLK\_SEL | MCO\_CLK\_OUT\_EN |
| r | r/w | r/w | r/w | r/w |
| **17-15** | **14-12** | **11-8** | **7-5** | **4-0** |
| PCLK1\_DIV | SYS\_CLK\_SEL | HCLK\_DIV | PCLK0\_DIV | RESERVED |
| r/w | r/w | r/w | r/w | r |

**Bits 31-26 RESERVED:** Must be kept, and cannot be modified.

**Bit 25 STCLKEN\_SEL:** CPU SysTick clock source selection

* 0: XO32K
* 1: RCO32K

**Bits 24-22 MCO\_CLK\_DIV\_NUM:** MCO division factor

* <4: division factor 1
* 4: division factor 2
* 5: division factor 4
* 6: division factor 8
* 7: division factor 16

***Note:*** *Make sure to configure this bit when MCO\_CLK\_OUT\_EN=0. If the MCO\_CLK\_OUT\_EN bit is enabled, users must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the MCO division factor.*

**Bits 21-19 MCO\_CLK\_SEL:** MCO clock source selection

* 0: RCO32K
* 1: XO32K
* 2: RCO3.6M
* 3: XO24M
* 4: XO32M
* 5: RCO48M
* 6: PLL
* 7: SYS\_CLK

***Note:*** *Make sure to configure this bit when MCO\_CLK\_OUT\_EN=0. If the MCO\_CLK\_OUT\_EN bit is enabled, users must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the MCO clock source.*

**Bit 18 MCO\_CLK\_OUT\_EN:** MCO output enable

* 0: disabled
* 1: enabled

**Bits 17-15 PCLK1\_DIV:** PCLK1 division factor

* 0: PCLK1 clock frequency = HCLK clock frequency
* 1: PCLK1 clock frequency = 1/2 HCLK clock frequency
* 2: PCLK1 clock frequency = 1/4 HCLK clock frequency
* 3: PCLK1 clock frequency = 1/8 HCLK clock frequency
* >3: PCLK1 clock frequency = 1/16 HCLK clock frequency

**Bits 14-12 SYS\_CLK\_SEL:** SYS\_CLK clock source selection

* 0: RCO48M divided by 2
* 1: RCO32K
* 2: XO32K
* 3: PLL
* 4: XO24M
* 5: XO32M
* 6: RCO3.6M
* 7: RCO48M

**Bits 11-8 HCLK\_DIV:** HCLK division factor

* 0: HCLK clock frequency = SYS\_CLK clock frequency
* 1: HCLK clock frequency = 1/2 SYS\_CLK clock frequency
* 2: HCLK clock frequency = 1/4 SYS\_CLK clock frequency
* 3: HCLK clock frequency = 1/8 SYS\_CLK clock frequency
* 4: HCLK clock frequency = 1/16 SYS\_CLK clock frequency
* 5: HCLK clock frequency = 1/32 SYS\_CLK clock frequency
* 6: HCLK clock frequency = 1/64 SYS\_CLK clock frequency
* 7: HCLK clock frequency = 1/128 SYS\_CLK clock frequency
* 8: HCLK clock frequency = 1/256 SYS\_CLK clock frequency
* >8: HCLK clock frequency = 1/512 SYS\_CLK clock frequency

**Bits 7-5 PCLK0\_DIV:** PCLK0 division factor

* 0: PCLK0 clock frequency = HCLK clock frequency
* 1: PCLK0 clock frequency = 1/2 HCLK clock frequency
* 2: PCLK0 clock frequency = 1/4 HCLK clock frequency
* 3: PCLK0 clock frequency = 1/8 HCLK clock frequency
* >3: PCLK0 clock frequency = 1/16 HCLK clock frequency

**Bits 4-0 RESERVED:** Must be kept, and cannot be modified.

##### 8.3.2 RCC\_CR1

Offset: 0x004

Reset Value: 0x00000000

This register is in the AON domain.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-12** | **11** | **10** | **9-8** | |
| RESERVED | LPTIM1\_EXT\_CLK\_SEL | LPTIM0\_EXT\_CLK\_SEL | LPTIM1\_CLK\_SEL | |
| r | r/w | r/w | r/w | |
| **7-6** | **5-4** | **3-2** | **1** | **0** |
| LPTIM0\_CLK\_SEL | LCDCTRL\_CLK\_SEL | LPUART\_CLK\_SEL | RTC\_CLK\_  SEL | IWDG\_CLK\_  SEL |
| r/w | r/w | r/w | r/w | r/w |

**Bits 31-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 LPTIM1\_EXT\_CLK\_SEL:** LPTIM1 interface clock source selection

* 0: decided by the LPTIM1\_CLK\_SEL bit
* 1: use external clock from IN1

***Note:***

*1. Make sure to configure this bit when LPTIM1\_CLK\_EN=0. If the LPTIM1\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the LPTIM1 interface clock source.*

*2. This bit and the LPTIM1\_CLK\_SEL bit jointly determine the LPTIM1 interface clock source.*

**Bit 10 LPTIM0\_EXT\_CLK\_SEL:** LPTIM0 interface clock source selection

* 0: decided by the LPTIM0\_CLK\_SEL bit
* 1: use external clock from IN1

***Note:***

*1. Make sure to configure this bit when LPTIM0\_CLK\_EN=0. If the LPTIM0\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the LPTIM0 interface clock source.*

*2. This bit and the LPTIM0\_CLK\_SEL bit jointly determine the LPTIM0 interface clock source.*

**Bits 9-8 LPTIM1\_CLK\_SEL:** LPTIM1 interface clock source selection

* 0: PCLK0
* 1: RCO3.6M
* 2: XO32K
* 3: RCO32K

***Note:***

*1. Make sure to configure this bit when LPTIM1\_CLK\_EN=0. If the LPTIM1\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the LPTIM1 interface clock source.*

*2. This bit and the LPTIM1\_EXT\_CLK\_SEL bit jointly determine the LPTIM1 interface clock source.*

*3. To select PCLK0 as clock source, the LPTIM1\_INF\_CLK\_EN bit in the RCC\_CGR1 register must have been enabled.*

**Bits 7-6 LPTIM0\_CLK\_SEL:** LPTIM0 interface clock source selection

* 0: PCLK0
* 1: RCO3.6M
* 2: XO32K
* 3: RCO32K

***Note:***

*1. Make sure to configure this bit when LPTIM0\_CLK\_EN=0. If the LPTIM0\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the LPTIM0 interface clock source.*

*2. This bit and the LPTIM0\_EXT\_CLK\_SEL bit jointly determine the LPTIM0 interface clock source.*

*3. To select PCLK0 as clock source, the LPTIM0\_INF\_CLK\_EN bit in the RCC\_CGR1 register must have been enabled.*

**Bits 5-4 LCDCTRL\_CLK\_SEL:** LCDCTRL interface clock source selection

* 0: XO32K
* 1: RCO32K
* >1: RCO3.6M

**Bits 3-2 LPUART\_CLK\_SEL:** LPUART interface clock source selection

* 0: XO32K
* 1: RCO32K
* >1: RCO3.6M

**Bit 1 RTC\_CLK\_SEL:** RTC interface clock source selection

* 0: XO32K
* 1: RCO32K

**Bit 0 IWDG\_CLK\_SEL:** IWDG interface clock source selection

* 0: XO32K
* 1: RCO32K

##### 8.3.3 RCC\_CR2

Offset: 0x008

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-17** | **16-15** | **14-13** | **12-11** | |
| RESERVED | UART0\_CLK\_SEL | UART1\_CLK\_SEL | UART2\_CLK\_SEL | |
| r | r/w | r/w | r/w | |
| **10-9** | **8-7** | **6-5** | **4-2** | **1-0** |
| UART3\_CLK\_SEL | RESERVED | ADCCTRL\_CLK\_SEL | I2S\_CLK\_SEL | QSPI\_CLK\_SEL |
| r/w | r | r/w | r/w | r/w |

**Bits 31-17 RESERVED:** Must be kept, and cannot be modified.

**Bits 16-15 UART0\_CLK\_SEL:** UART0 interface clock source selection

* 0: PCLK0
* 1: RCO3.6M
* 2: XO32K
* 3: XO24M

***Note:*** *Make sure to configure this bit when UART0\_CLK\_EN=0. If the UART0\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the UART0 interface clock source.*

**Bits 14-13 UART1\_CLK\_SEL:** UART1 interface clock source selection

* 0: PCLK0
* 1: RCO3.6M
* 2: XO32K
* 3: XO24M

***Note:*** *Make sure to configure this bit when UART1\_CLK\_EN=0. If the UART1\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the UART1 interface clock source.*

**Bits 12-11 UART2\_CLK\_SEL:** UART2 interface clock source selection

* 0: PCLK1
* 1: RCO3.6M
* 2: XO32K
* 3: XO24M

***Note:*** *Make sure to configure this bit when UART2\_CLK\_EN=0. If the UART2\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the UART2 interface clock source.*

**Bits 10-9 UART3\_CLK\_SEL:** UART3 interface clock source selection

* 0: PCLK1
* 1: RCO3.6M
* 2: XO32K
* 3: XO24M

***Note:*** *Make sure to configure this bit when UART3\_CLK\_EN=0. If the UART3\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the UART3 interface clock source.*

**Bits 8-7 RESERVED:** Must be kept, and cannot be modified.

**Bits 6-5 ADCCTRL\_CLK\_SEL:** ADCCTRL interface clock source selection

* 0: PCLK1
* 1: SYS\_CLK
* 2: PLL
* 3: RCO48M

***Note:*** *Make sure to configure this bit when ADCCTRL\_CLK\_EN=0. If the ADCCTRL\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the ADCCTRL interface clock source.*

**Bits 4-2 I2S\_CLK\_SEL:** I2S interface clock source selection

* 0: PCLK0
* 1: XO24M
* 2: PLL
* 3: XO32M
* >3: external IOM\_I2S\_CLK

***Note:***

*1. Make sure to configure this bit when I2S\_CLK\_EN=0. If the I2S\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the I2S interface clock source.*

*2. When I2S acts as a slave, the clock source must be configured to external IOM\_I2S\_CLK; when I2S acts as a master, the clock source is selected according to functional requirements.*

**Bits 1-0 QSPI\_CLK\_SEL:** QSPI interface clock source selection

* 0: HCLK
* 1: SYS\_CLK
* >1: PLL

***Note:*** *Make sure to configure this bit when QSPI\_CLK\_EN=0. If the QSPI\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure the QSPI interface clock source.*

**8.3.4 RCC\_CGR0**

Offset: 0x00C

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31** | **30** | **29** | **28** | **27** | **26** | **25** | **24** |
| PWR\_CLK  \_EN | DMAC0\_C  LK\_EN | DMAC1\_C  LK\_EN | CRC\_CLK  \_EN | BASICTIM0  \_CLK\_EN | BASICTIM1  \_CLK\_EN | IOM0\_CL  K\_EN | IOM1\_CL  K\_EN |
| r/w | r/w | r/w | r/w | r/w | r/w | r/w | r/w |
| **23** | **22** | **21** | **20** | **19** | **18** | **17** | **16** |
| IOM2\_CLK  \_EN | IOM3\_CL  K\_EN | SYSCFG\_  CLK\_EN | UART0\_C  LK\_EN | UART1\_CL  K\_EN | UART2\_CL  K\_EN | UART3\_C  LK\_EN | LPUART\_  CLK\_EN |
| r/w | r/w | r/w | r/w | r/w | r/w | r/w | r/w |
| **15** | **14** | **13** | **12** | **11** | **10** | **9** | **8** |
| SSP0\_CLK  \_EN | SSP1\_CL  K\_EN | SSP2\_CL  K\_EN | I2C0\_CLK  \_EN | I2C1\_CLK\_  EN | I2C2\_CLK\_  EN | RESERVE  D | ADCCTRL \_CLK\_EN |
| r/w | r/w | r/w | r/w | r/w | r/w | r | r/w |
| **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| AFEC\_CL  K\_EN | LCDCTRL \_CLK\_EN | DACCTRL \_CLK\_EN | LORAC\_C  LK\_EN | GPTIM0\_C  LK\_EN | GPTIM1\_C  LK\_EN | GPTIM2\_ CLK\_EN | GPTIM3\_ CLK\_EN |
| r/w | r/w | r/w | r/w | r/w | r/w | r/w | r/w |

**Bit 31 PWR\_CLK\_EN:** PWR clock enable

* 0: disabled
* 1: enabled

**Bit 30 DMAC0\_CLK\_EN:** DMAC0 clock enable

* 0: disabled
* 1: enabled

**Bit 29 DMAC1\_CLK\_EN:** DMAC1 clock enable

* 0: disabled
* 1: enabled

**Bit 28 CRC\_CLK\_EN:** CRC clock enable

* 0: disabled
* 1: enabled

**Bit 27 BASICTIM0\_CLK\_EN:** BASICTIM0 clock enable

* 0: disabled
* 1: enabled

**Bit 26 BASICTIM1\_CLK\_EN:** BASICTIM1 clock enable

* 0: disabled
* 1: enabled

**Bit 25 IOM0\_CLK\_EN:** IOM0 clock enable

* 0: disabled
* 1: enabled

**Bit 24 IOM1\_CLK\_EN:** IOM1 clock enable

* 0: disabled
* 1: enabled

**Bit 23 IOM2\_CLK\_EN:** IOM2 clock enable

* 0: disabled
* 1: enabled

**Bit 22 IOM3\_CLK\_EN:** IOM3 clock enable

* 0: disabled
* 1: enabled

**Bit 21 SYSCFG\_CLK\_EN:** SYSCFG clock enable

* 0: disabled
* 1: enabled

**Bit 20 UART0\_CLK\_EN:** UART0 clock enable

* 0: disabled
* 1: enabled

**Bit 19 UART1\_CLK\_EN:** UART1 clock enable

* 0: disabled
* 1: enabled

**Bit 18 UART2\_CLK\_EN:** UART2 clock enable

* 0: disabled
* 1: enabled

**Bit 17 UART3\_CLK\_EN:** UART3 clock enable

* 0: disabled
* 1: enabled

**Bit 16 LPUART\_CLK\_EN:** LPUART clock enable

* 0: disabled
* 1: enabled

**Bit 15 SSP0\_CLK\_EN:** SSP0 clock enable

* 0: disabled
* 1: enabled

**Bit 14 SSP1\_CLK\_EN:** SSP1 clock enable

* 0: disabled
* 1: enabled

**Bit 13 SSP2\_CLK\_EN:** SSP2 clock enable

* 0: disabled
* 1: enabled

**Bit 12 I2C0\_CLK\_EN:** I2C0 clock enable

* 0: disabled
* 1: enabled

**Bit 11 I2C1\_CLK\_EN:** I2C1 clock enable

* 0: disabled
* 1: enabled

**Bit 10 I2C2\_CLK\_EN:** I2C2 clock enable

* 0: disabled
* 1: enabled

**Bit 9 RESERVED:** Must be kept, and cannot be modified.

**Bit 8 ADCCTRL\_CLK\_EN:** ADCCTRL clock enable

* 0: disabled
* 1: enabled

**Bit 7 AFEC\_CLK\_EN:** AFEC clock enable

* 0: disabled
* 1: enabled

**Bit 6 LCDCTRL\_CLK\_EN:** LCDCTRL clock enable

* 0: disabled
* 1: enabled

**Bit 5 DACCTRL\_CLK\_EN:** DACCTRL clock enable

* 0: disabled
* 1: enabled

**Bit 4 LORAC\_CLK\_EN:** LORAC clock enable.

* 0: disabled
* 1: enabled

**Bit 3 GPTIM0\_CLK\_EN:** GPTIM0 clock enable.

* 0: disabled
* 1: enabled

**Bit 2 GPTIM1\_CLK\_EN:** GPTIM1 clock enable.

* 0: disabled
* 1: enabled

**Bit 1 GPTIM2\_CLK\_EN:** GPTIM2 clock enable.

* 0: disabled
* 1: enabled

**Bit 0 GPTIM3\_CLK\_EN:** GPTIM3 clock enable.

* 0: disabled
* 1: enabled

##### 8.3.5 RCC\_CGR1

Offset: 0x010

Reset Value: 0x00000000

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **31-13** | **12** | **11** | **10** | **9** | **8** | **7** |
| RESERVED | LPTIM1\_INF  \_CLK\_EN | LPTIM1\_CLK  \_EN | RNGC\_CLK  \_EN | LPTIM0\_INF  \_CLK\_EN | I2S\_CLK\_  EN | SAC\_CLK\_  EN |
| r | r/w | r/w | r/w | r/w | r/w | r/w |
| **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| WWDG\_CN  T\_CLK\_EN | QSPI\_CLK\_  EN | LPTIM0\_CLK  \_EN | IWDG\_CLK  \_EN | WWDG\_CL  K\_EN | RTC\_CLK\_  EN | SEC\_CLK\_  EN |
| r/w | r/w | r/w | r/w | r/w | r/w | r/w |

**Bits 31-13 RESERVED:** Must be kept, and cannot be modified.

**Bit 12 LPTIM1\_INF\_CLK\_EN:** LPTIM1 interface PCLK0 clock enable.

* 0: disabled
* 1: enabled

**Bit 11 LPTIM1\_CLK\_EN:** LPTIM1 clock enable.

* 0: disabled
* 1: enabled

***Note:*** *If PCLK0 is selected as the clock source, the LPTIM1\_INF\_CLK\_EN bit must be enabled before enabling the LPTIM1 clock, while it must be disabled after the LPTIM1 clock is disabled.*

**Bit 10 RNGC\_CLK\_EN:** RNGC clock enable.

* 0: disabled
* 1: enabled

**Bit 9 LPTIM0\_INF\_CLK\_EN:** LPTIM0 interface PCLK0 clock enable.

* 0: disabled
* 1: enabled

**Bit 8 I2S\_CLK\_EN:** I2S clock enable.

* 0: disabled
* 1: enabled

**Bit 7 SAC\_CLK\_EN:** SAC clock enable.

* 0: disabled
* 1: enabled

**Bit 6 WWDG\_CNT\_CLK\_EN:** WWDG counter clock enable.

* 0: disabled
* 1: enabled

**Bit 5 QSPI\_CLK\_EN:** QSPI clock enable.

* 0: disabled
* 1: enabled

**Bit 4 LPTIM0\_CLK\_EN:** LPTIM0 clock enable.

* 0: disabled
* 1: enabled

***Note:*** *If PCLK0 is selected as the clock source, the LPTIM0\_INF\_CLK\_EN bit must be enabled before enabling the LPTIM0 clock, while it must be disabled after the LPTIM0 clock is disabled.*

**Bit 3 IWDG\_CLK\_EN:** IWDG clock enable.

* 0: disabled
* 1: enabled

**Bit 2 WWDG\_CLK\_EN:** WWDG clock enable.

* 0: disabled
* 1: enabled

**Bit 1 RTC\_CLK\_EN:** RTC clock enable.

* 0: disabled
* 1: enabled

**Bit 0 SEC\_CLK\_EN:** SEC clock enable.

* 0: disabled
* 1: enabled

##### 8.3.6 RCC\_CGR2

Offset:0x014

Reset Value: 0x00000000

This register is in the AON power domain. Read the *RCC\_SR* register before configuring this register.

When the corresponding bit is set in the *RCC\_SR* register, this register can be read; when all the

bits are set in the *RCC\_SR* register, this register can be written.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **31-6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | LPTIM1\_AO N\_CLK\_EN | LPTIM\_AON  \_CLK\_EN | LCDCTRL\_A ON\_CLK\_EN | LPUART\_AO  N\_CLK\_EN | RTC\_AON \_CLK\_EN | IWDG\_AON  \_CLK\_EN |
| r | r/w | r/w | r/w | r/w | r/w | r/w |

**Bits 31-6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 LPTIM1\_AON\_CLK\_EN:** Enable the LPTIM1 interface clock in AON domain.

* 0: disabled
* 1: enabled

**Bit 4 LPTIM\_AON\_CLK\_EN:** Enable the LPTIM interface clock in AON domain.

* 0: disabled
* 1: enabled

**Bit 3 LCDCTRL\_AON\_CLK\_EN:** Enable the LCDCTRL interface clock in AON domain.

* 0: disabled
* 1: enabled

**Bit 2 LPUART\_AON\_CLK\_EN:** Enable the LPUART interface clock in AON domain.

* 0: disabled
* 1: enabled

**Bit 1 RTC\_AON\_CLK\_EN:** Enable the RTC interface clock in AON domain.

* 0: disabled
* 1: enabled

**Bit 0 IWDG\_AON\_CLK\_EN:** Enable the IWDG interface clock in AON domain.

* 0: disabled
* 1: enabled

##### 8.3.7 RCC\_RST0

Offset: 0x018

Reset Value: 0xffffffff

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31** | **30** | **29** | **28** | **27** | **26** | **25** | **24** |
| UART0\_R  ST\_N | UART1\_R  ST\_N | UART2\_R  ST\_N | UART3\_R  ST\_N | LPUART\_  RST\_N | SSP0\_RS  T\_N | SSP1\_RS  T\_N | SSP2\_RS  T\_N |
| r/w | r/w | r/w | r/w | r/w | r/w | r/w | r/w |
| **23** | **22** | **21** | **20** | **19** | **18** | **17** | **16** |
| QSPI\_RST  \_N | I2C0\_RST  \_N | I2C1\_RST  \_N | I2C2\_RST  \_N | RESERVE  D | ADCCTRL  \_RST\_N | AFEC\_RS  T\_N | LCDCTRL  \_RST\_N |
| r/w | r/w | r/w | r/w | r | r/w | r/w | r/w |
| **15** | **14** | **13** | **12** | **11** | **10** | **9** | **8** |
| DACCTRL  \_RST\_N | LORAC\_R  ST\_N | IOM\_RST  \_N | GPTIM0\_  RST\_N | GPTIM1\_  RST\_N | GPTIM2\_  RST\_N | GPTIM3\_  RST\_N | BASICTIM 0\_RST\_N |
| r/w | r/w | r/w | r/w | r/w | r/w | r/w | r/w |
| **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| BASICTIM 1\_RST\_N | LPTIM\_R  ST\_N | IWDG\_RS  T\_N | WWDG\_R  ST\_N | RTC\_RST  \_N | CRC\_RST  \_N | SEC\_RST  \_N | SAC\_RST  \_N |
| r/w | r/w | r/w | r/w | r/w | r/w | r/w | r/w |

**Bit 31 UART0\_RST\_N:** UART0 reset control.

* 0: reset
* 1: no action

**Bit 30 UART1\_RST\_N:** UART1 reset control.

* 0: reset
* 1: not reset

**Bit 29 UART2\_RST\_N:** UART2 reset control.

* 0: reset
* 1: not reset

**Bit 28 UART3\_RST\_N:** UART3 reset control.

* 0: reset
* 1: not reset

**Bit 27 LPUART\_RST\_N:** LPUART reset control.

* 0: reset
* 1: not reset

**Bit 26 SSP0\_RST\_N:** SSP0 reset control.

* 0: reset
* 1: not reset

**Bit 25 SSP1\_RST\_N:** SSP1 reset control.

* 0: reset
* 1: not reset

**Bit 24 SSP2\_RST\_N:** SSP2 reset control.

* 0: reset
* 1: not reset

**Bit 23 QSPI\_RST\_N:** QSPI reset control.

* 0: reset
* 1: not reset

**Bit 22 I2C0\_RST\_N:** I2C0 reset control.

* 0: reset
* 1: not reset

**Bit 21 I2C1\_RST\_N:** I2C1 reset control.

* 0: reset
* 1: not reset

**Bit 20 I2C2\_RST\_N:** I2C2 reset control.

* 0: reset
* 1: not reset

**Bit 19 RESERVED:** Must be kept, and cannot be modified.

**Bit 18 ADCCTRL\_RST\_N:** ADCCTRL reset control.

* 0: reset
* 1: not reset

**Bit 17 AFEC\_RST\_N:** AFEC reset control.

* 0: reset
* 1: not reset

**Bit 16 LCDCTRL\_RST\_N:** LCDCTRL reset control.

* 0: reset
* 1: not reset

**Bit 15 DACCTRL\_RST\_N:** DACCTRL reset control.

* 0: reset
* 1: not reset

**Bit 14 LORAC\_RST\_N:** LORAC reset control.

* 0: reset
* 1: not reset

**Bit 13 IOM\_RST\_N:** IOM reset control.

* 0: reset
* 1: not reset

**Bit 12 GPTIM0\_RST\_N:** GPTIM0 reset control.

* 0: reset
* 1: not reset

**Bit 11 GPTIM1\_RST\_N:** GPTIM1 reset control.

* 0: reset
* 1: not reset

**Bit 10 GPTIM2\_RST\_N:** GPTIM2 reset control.

* 0: reset
* 1: not reset

**Bit 9 GPTIM3\_RST\_N:** GPTIM3 reset control.

* 0: reset
* 1: not reset

**Bit 8 BASICTIM0\_RST\_N:** BASICTIM0 reset control.

* 0: reset
* 1: not reset

**Bit 7 BASICTIM1\_RST\_N:** BASICTIM1 reset control.

* 0: reset
* 1: not reset

**Bit 6 LPTIM0\_RST\_N:** LPTIM0 reset control.

* 0: reset
* 1: not reset

**Bit 5 IWDG\_RST\_N:** IWDG reset control.

* 0: reset
* 1: not reset

**Bit 4 WWDG\_RST\_N:** WWDG reset control.

* 0: reset
* 1: not reset

**Bit 3 RTC\_RST\_N:** RTC reset control.

* 0: reset
* 1: not reset

**Bit 2 CRC\_RST\_N:** CRC reset control.

* 0: reset
* 1: not reset

**Bit 1 SEC\_RST\_N:** SEC reset control.

* 0: reset
* 1: not reset

**Bit 0 SAC\_RST\_N:** SAC reset control.

* 0: reset
* 1: not reset

##### 8.3.8 RCC\_RST1

Offset: 0x01C

Reset Value: 0x0000001f

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | LPTIM1\_RST\_N | RNGC\_RST\_N | I2S\_RST\_N | DMAC0\_RST\_N | DMAC1\_RST\_N |
| r | r/w | r/w | r/w | r/w | r/w |

**Bits 31-5 RESERVED:** Must be kept, and cannot be modified.

**Bit 4 LPTIM1\_RST\_N:** LPTIM1 reset control.

* 0: reset
* 1: not reset

**Bit 3 RNGC\_RST\_N:** RNGC reset control.

* 0: reset
* 1: not reset

**Bit 2 I2S\_RST\_N:** I2S reset control.

* 0: reset
* 1: not reset

**Bit 1 DMAC0\_RST\_N:** DMAC0 reset control.

* 0: reset
* 1: not reset

**Bit 0 DMAC1\_RST\_N:** DMAC1 reset control.

* 0: reset
* 1: not reset

##### 8.3.9 RCC\_RST\_SR

Offset: 0x020

Reset Value: 0x00000040

***Note:*** *The BOR\_RESET\_SR and STANDBY\_RESET\_SR are in the AON domain.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | BOR\_RE SET\_SR | IWDG\_RE  SET\_SR | WWDG\_RE  SET\_SR | EFC\_RE SET\_SR | CPU\_RE SET\_SR | SEC\_RE SET\_SR | STANDBY\_ RESET\_SR |
| r | r/w | r/w | r/w | r/w | r/w | r/w | r/w |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 BOR\_RESET\_SR:** BOR reset status. Set by hardware and cleared by software by writing 1.

* 0: no BOR reset
* 1: BOR reset occurred

**Bit 5 IWDG\_RESET\_SR:** IWDG reset status. Set by hardware and cleared by software by writing 1.

* 0: no IWDG reset
* 1: IWDG reset occurred

**Bit 4 WWDG\_RESET\_SR:** WWDG reset status. Set by hardware and cleared by software by writing 1.

* 0: no WWDG reset
* 1: WWDG reset occurred

**Bit 3 EFC\_RESET\_SR:** EFC reset status. Set by hardware and cleared by software by writing 1.

* 0: no EFC reset
* 1: EFC reset occurred

**Bit 2 CPU\_RESET\_SR:** CPU reset status. Set by hardware and cleared by software by writing 1.

* 0: no CPU reset
* 1: CPU reset occurred

**Bit 1 SEC\_RESET\_SR:** SEC reset status. Set by hardware and cleared by software by writing 1.

* 0: no SEC reset
* 1: SEC reset occurred

**Bit 0 STANDBY\_RESET\_SR:** Standby reset status. Set by hardware and cleared by software by writing 1.

* 0: no MPU reset
* 1: MPU reset occurred

##### 8.3.10 RCC\_RST\_CR

Offset: 0x024

Reset Value: 0x00000004

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **31-6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | IWDG\_RESE  T\_REQ\_EN | WWDG\_RES ET\_REQ\_EN | EFC\_RESE  T\_REQ\_EN | CPU\_RESE T\_REQ\_EN | SEC\_RESE T\_REQ\_EN | RESERVED |
| r | r/w | r/w | r/w | r/w | r/w | r |

**Bits 31-6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 IWDG\_RESET\_REQ\_EN:** IWDG reset enable.

* 0: disabled
* 1: enabled

**Bit 4 WWDG\_RESET\_REQ\_EN:** WWDG reset enable.

* 0: disabled
* 1: enabled

**Bit 3 EFC\_RESET\_REQ\_EN:** EFC reset enable.

* 0: disabled
* 1: enabled

**Bit 2 CPU\_RESET\_REQ\_EN:** CPU reset enable.

* 0: disabled
* 1: enabled

**Bit 1 SEC\_RESET\_REQ\_EN:** SEC reset enable.

* 0: disabled
* 1: enabled

**Bit 0 RESERVED:** Must be kept, and cannot be modified.

##### 8.3.11 RCC\_SR

Offset: 0x028

Reset Value: 0x0000003f

|  |  |  |  |
| --- | --- | --- | --- |
| **31-6** | | **5** | **4** |
| RESERVED | | SET\_LPTIM1\_AON\_CL  K\_EN\_DONE | SET\_LPTIM\_AON\_CLK  \_EN\_DONE |
| r | | r | r |
| **3** | **2** | **1** | **0** |
| SET\_LCDCTRL\_AON\_  CLK\_EN\_DONE | SET\_LPUART\_AON\_C  LK\_EN\_DONE | SET\_RTC\_AON\_CLK\_  EN\_DONE | SET\_IWDG\_AON\_CLK  \_EN\_DONE |
| r | r | r | r |

**Bits 31-6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 SET\_LPTIM1\_AON\_CLK\_EN\_DONE:** LPTIM1\_AON\_CLK\_EN configuration status. This bit is set and cleared by hardware.

* 0: configuration in progress
* 1: configuration completed

**Bit 4 SET\_LPTIM0\_AON\_CLK\_EN\_DONE:** LPTIM0\_AON\_CLK\_EN configuration status. This bit is set and cleared by hardware.

* 0: configuration in progress
* 1: configuration complete

**Bit 3 SET\_LCDCTRL\_AON\_CLK\_EN\_DONE:** LCDCTRL\_AON\_CLK\_EN configuration status. This bit is set and cleared by hardware.

* 0: configuration in progress
* 1: configuration complete

**Bit 2 SET\_LPUART\_AON\_CLK\_EN\_DONE:** LPUART\_AON\_CLK\_EN configuration status. This bit is set and cleared by hardware.

* 0: configuration in progress
* 1: configuration complete

**Bit 1 SET\_RTC\_AON\_CLK\_EN\_DONE:** RTC\_AON\_CLK\_EN configuration status. This bit is set and cleared by hardware.

* 0: configuration in progress
* 1: configuration complete

**Bit 0 SET\_IWDG\_AON\_CLK\_EN\_DONE:** IWDG\_AON\_CLK\_EN configuration status. This bit is set and cleared by hardware.

* 0: configuration in progress
* 1: configuration complete

##### 8.3.12 RCC\_SR1

Offset: 0x02C

Reset Value: 0x00000000

The clock should be disabled before the clock source is switched or the frequency division changes to avoid glitches. This register is used to determine whether the clock is disabled.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **31-21** | **20** | | **19** |  | **18** | **17** | | **16** |
| RESERVED | LPTIM1\_CLK  \_EN\_SYNC | | LPTIM1\_AON\_C  LK\_EN\_SYNC |  | UART0\_CLK\_  EN\_SYNC | UART1\_CLK \_EN\_SYNC | | UART2\_CLK\_E  N\_SYNC |
| r | r | | r |  | r | r | | r |
| **15** | **14** | | **13** |  | **12** | **11** | | **10** |
| UART3\_CLK\_  EN\_SYNC | RESERVED | | ADCCTRL\_CLK  \_EN\_SYNC |  | LPTIM\_CLK\_  EN\_SYNC | QSPI\_CLK\_E  N\_SYNC | | LPUART\_CLK\_  EN\_SYNC |
| r | r | | r |  | r | r | | r |
| **9** | **8** | | **7** |  | **6** | **5** | | **4** |
| LCDCTRL\_CL K\_EN\_SYNC | IWDG\_CLK\_  EN\_SYNC | | RTC\_CLK\_EN\_S  YNC |  | MCO\_CLK\_E  N\_SYNC | I2S\_CLK\_EN  \_SYNC | | LPTIM\_AON\_C LK\_EN\_SYNC |
| r | r | | r |  | r | r | | r |
| **3** | | **2** | | **1** | | | **0** | |
| LCDCTRL\_AON\_CLK\_  EN\_SYNC | | LPUART\_AON\_CLK\_E  N\_SYNC | | RTC\_AON\_CLK\_EN\_S  YNC | | | IWDG\_AON\_CLK\_EN\_  SYNC | |
| r | | r | | r | | | r | |

**Bits 31-21 RESERVED:** Must be kept, and cannot be modified.

**Bit 20 LPTIM1\_CLK\_EN\_SYNC:** LPTIM1\_CLK\_EN actual status.

* 0: disabled
* 1: enabled

**Bit 19 LPTIM1\_AON\_CLK\_EN\_SYNC:** LPTIM1\_AON\_CLK\_EN actual status.

* 0: LPTIM1 clock is disabled in AON domain
* 1: LPTIM1 clock is enabled in AON domain

**Bit 18 UART0\_CLK\_EN\_SYNC:** UART0\_CLK\_EN actual status.

* 0: UART0 clock is disabled
* 1: UART0 clock is enabled

**Bit 17 UART1\_CLK\_EN\_SYNC:** UART1\_CLK\_EN actual status.

* 0: UART1 clock is disabled
* 1: UART1 clock is enabled

**Bit 16 UART2\_CLK\_EN\_SYNC:** UART2\_CLK\_EN actual status.

* 0: UART2 clock is disabled
* 1: UART2 clock is enabled

**Bit 15 UART3\_CLK\_EN\_SYNC:** UART3\_CLK\_EN actual status.

* 0: UART3 clock is disabled
* 1: UART3 clock is enabled

**Bit 14 RESERVED:** Must be kept, and cannot be modified.

**Bit 13 ADCCTRL\_CLK\_EN\_SYNC:** ADCCTRL\_CLK\_EN actual status.

* 0: ADCCTRL clock is disabled
* 1: ADCCTRL clock is enabled

**Bit 12 LPTIM0\_CLK\_EN\_SYNC:** LPTIM0\_CLK\_EN actual status.

* 0: LPTIM0 clock is disabled
* 1: LPTIM0 clock is enabled

**Bit 11 QSPI\_CLK\_EN\_SYNC:** QSPI\_CLK\_EN actual status.

* 0: QSPI clock is disabled
* 1: QSPI clock is enabled

**Bit 10 LPUART\_CLK\_EN\_SYNC:** Indicate LPUART\_CLK\_EN actual status.

* 0: LPUART clock is disabled
* 1: LPUART clock is enabled

**Bit 9 LCDCTRL\_CLK\_EN\_SYNC:** LCDCTRL\_CLK\_EN actual status.

* 0: LCDCTRL clock is disabled
* 1: LCDCTRL clock is enabled

**Bit 8 IWDG\_CLK\_EN\_SYNC:** IWDG\_CLK\_EN actual status.

* 0: IWDG clock is disabled
* 1: IWDG clock is enabled

**Bit 7 RTC\_CLK\_EN\_SYNC:** RTC\_CLK\_EN actual status.

* 0: RTC clock is disabled
* 1: RTC clock is enabled

**Bit 6 MCO\_CLK\_EN\_SYNC:** MCO\_CLK\_EN actual status.

* 0: MCO clock is disabled
* 1: MCO clock is enabled

**Bit 5 I2S\_CLK\_EN\_SYNC:** I2S\_CLK\_EN actual status.

* 0: I2S clock is disabled
* 1: I2S clock is enabled

**Bit 4 LPTIM0\_AON\_CLK\_EN\_SYNC:** LPTIM0\_AON\_CLK\_EN actual status.

* 0: LPTIM0 clock in AON domain is disabled
* 1: LPTIM0 clock in AON domain is enabled

**Bit 3 LCDCTRL\_AON\_CLK\_EN\_SYNC:** LCDCTRL\_AON\_CLK\_EN actual status.

* 0: LCDCTRL clock is disabled in AON domain
* 1: LCDCTRL clock is enabled in AON domain

**Bit 2 LPUART\_AON\_CLK\_EN\_SYNC:** LPUART\_AON\_CLK\_EN actual status.

* 0: LPUART clock is disabled in AON domain
* 1: LPUART clock is enabled in AON domain

**Bit 1 RTC\_AON\_CLK\_EN\_SYNC:** Indicate RTC\_AON\_CLK\_EN actual status.

* 0: RTC clock is disabled in AON domain
* 1: RTC clock is enabled in AON domain

**Bit 0 IWDG\_AON\_CLK\_EN\_SYNC:** IWDG\_AON\_CLK\_EN actual status.

* 0: IWDG clock is disabled in AON domain
* 1: IWDG clock is enabled in AON domain

##### 8.3.13 RCC\_CR3

Offset: 0x030

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-16** | **15-8** | **7-0** |
| RESERVED | I2S\_MCLK\_DIV | I2S\_SCLK\_DIV |
| r | r/w | r/w |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-8 I2S\_MCLK\_DIV:** I2S interface clock MCLK frequency division.

* 0: not divided
* 1: not divided
* 2: divided by 2
* 3: divided by 3
* N: divided by N

***Note:***

*1. Make sure to configure I2S\_MCLK\_DIV when I2S\_CLK\_EN=0. If the I2S\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure I2S\_MCLK\_DIV.*

*2. When I2S acts as a slave, this bit must be configured to 0 or 1; when I2S acts as a master, this bit is configured according to functional requirements.*

*3. The duty cycle of the output clock is 50%.*

**Bits 7-0 I2S\_SCLK\_DIV:** I2S interface clock SCLK frequency division.

* 0: not divided
* 1: not divided
* 2: divided by 2
* 3: divided by 3
* N: divided by N

***Note:***

*1. Make sure to configure I2S\_SCLK\_DIV when I2S\_CLK\_EN=0. If the I2S\_CLK\_EN bit is enabled, the user must disable it by software first, wait for at least 2 current clock cycles or query the RCC\_SR1 register, and then configure I2S\_SCLK\_DIV.*

*2. When I2S acts as a slave, this bit must be configured to 0 or 1; when I2S acts as a master, this bit is configured according to functional requirements.*

*3. The duty cycle of the output clock is 50%.*

## 9. Interrupts

### 9.1 Main Features

* Support 37 IRQ interrupts
* Configurable 0~7 priority levels for each IRQ interrupt

#### 9.2 SysTick

SysTick calibration value is 0x147. Using a 32.768 kHz clock source for SysTick counting gives

a reference time base of 10 ms.

### 9.3 Interrupt Vector Table

The interrupt vector Table is as follows:

#### Table 9-1 Interrupt Vector Table

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Position | Priority | Type of priority | Acronym | Description | Address |
|  | - | - | - | Reserved | 0x0000\_0000 |
|  | -3 | fixed | Reset | Reset | 0x0000\_0004 |
|  | -2 | fixed | NMI\_Handler | Secure area check error | 0x0000\_0008 |
|  | -1 | fixed | HardFault\_Handler | fault | 0x0000\_000C |
|  | 0 | settable | MemManage Handler | fault | 0x0000\_0010 |
|  | 1 | settable | BusFault Handler | fault | 0x0000\_0014 |
|  | 2 | settable | UsageFault Handler | fault | 0x0000\_0018 |
|  | - | - | - | Reserved | 0x0000\_001C -  0x0000\_002B |
|  | 3 | settable | SVC\_Handler | System service call via SWI instruction | 0x0000\_002C |
|  | - | - | - | Reserved | 0x0000\_0030 -  0x0000\_0037 |
|  | 5 | settable | PendSV\_Handler | Pendable request for system service | 0x0000\_0038 |
|  | 6 | settable | SysTick\_Handler | System tick timer | 0x0000\_003C |
| 0 | 7 | settable | sec | Include mpu | 0x0000\_0040 |
| 1 | 8 | settable | rtc | Include tamper io, cyc, wakeup io | 0x0000\_0044 |

9 interrupt (Interrupt)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Position | Priority | Type of priority | Acronym | Description | Address |
| 2 | 9 | settable | wwdg |  | 0x0000\_0048 |
| 3 | 10 | settable | efc |  | 0x0000\_004C |
| 4 | 11 | settable | uart3 |  | 0x0000\_0050 |
| 5 | 12 | settable | i2c2 |  | 0x0000\_0054 |
| 6 | 13 | settable | uart0 |  | 0x0000\_0058 |
| 7 | 14 | settable | uart1 |  | 0x0000\_005C |
| 8 | 15 | settable | uart2 |  | 0x0000\_0060 |
| 9 | 16 | settable | lpuart |  | 0x0000\_0064 |
| 10 | 17 | settable | ssp0 |  | 0x0000\_0068 |
| 11 | 18 | settable | ssp1 |  | 0x0000\_006C |
| 12 | 19 | settable | qspi |  | 0x0000\_0070 |
| 13 | 20 | settable | i2c0 |  | 0x0000\_0074 |
| 14 | 21 | settable | i2c1 |  | 0x0000\_0078 |
| 15 | 22 | settable | - |  | 0x0000\_007C |
| 16 | 23 | settable | adcctrl |  | 0x0000\_0080 |
| 17 | 24 | settable | afec |  | 0x0000\_0084 |
| 18 | 25 | settable | ssp2 |  | 0x0000\_0088 |
| 19 | 26 | settable | dmac1 |  | 0x0000\_008C |
| 20 | 27 | settable | dacctrl |  | 0x0000\_0090 |
| 21 | 28 | settable | lorac |  | 0x0000\_0094 |
| 22 | 29 | settable | iom |  | 0x0000\_0098 |
| 23 | 30 | settable | gptim0 |  | 0x0000\_009C |
| 24 | 31 | settable | gptim1 |  | 0x0000\_00A0 |
| 25 | 32 | settable | gptim2 |  | 0x0000\_00A4 |
| 26 | 33 | settable | gptim3 |  | 0x0000\_00A8 |
| 27 | 34 | settable | basictim0 |  | 0x0000\_00AC |
| 28 | 35 | settable | basictim1 |  | 0x0000\_00B0 |
| 29 | 36 | settable | lptim0 |  | 0x0000\_00B4 |
| 30 | 37 | settable | sac |  | 0x0000\_00B8 |
| 31 | 38 | settable | dmac0 |  | 0x0000\_00BC |
| 32 | 39 | settable | i2s |  | 0x0000\_00C0 |
| 33 | 40 | settable | lcdctrl |  | 0x0000\_00C4 |
| 34 | 41 | settable | pwr |  | 0x0000\_00C8 |
| 35 | 42 | settable | lptim1 |  | 0x0000\_00CC |
| 36 | 43 | settable | iwdg |  | 0x0000\_00D0 |

## 10. Embedded Flash

### 10.1 Introduction

* The whole Flash is divided into Flash info area and Flash main area.
* Flash size:
* Flash info area: 16 KB in total
* Flash main area: 256 KB for ASR6601SE, 128 KB for ASR6601CB
* Page erase (4 KB) and Mass erase (all main flash area)

### 10.2 Main features

* Flash operations include read, program, page erase and mass erase
* Read access latency
* Acceleration for accessing the Flash memory
* Support instruction prefetch with 1 deep buffer
* Flash program operation supports single and continuous mode
* Option bytes in Flash info area
* Can be used to generate interrupt signals

### 10.3 Functional Description

#### 10.3.1 Flash info Area Division

The Flash info area is divided into four parts: Option Bytes, Factory Bytes, OTP and BootLoader.

See the table below for details.

**Table 10-1 Flash info Area Division**

|  |  |  |
| --- | --- | --- |
| Start Address | Description | Size |
| 0x10003000 | Option Bytes | 4KB |
| 0x10002000 | Factory Bytes | 4KB |
| 0x10001C00 | OTP | 1KB |
| 0x10000000 | BootLoader | 7KB |

#### 10.3.2 EFC\_CR **Protection**

By default, the EFC\_CR register cannot be modified, to modify it, the user must configure the

protection sequence correctly through the *EFC\_PROTECT\_SEQ* register in the following order.

If there is an error in the configuration, then the configuration is invalid, and the protection

sequence should be reconfigured.

1. First write “0x8C9DAEBF” to EFC\_PROTECT\_SEQ register
2. Then write “0x13141516” to EFC\_PROTECT\_SEQ reg

#### 10.3.3 **Read Access Latency**

In order to improve Flash read performance, the number of wait states (READ\_NUM[19:16]) should be correctly programmed in *EFC\_TIMING\_CFG* register according to the frequency of SYS\_CLK. The number of wait states (READ\_NUM) equals to (READ\_NUM+1) multiplied by SYS\_CLK clock period. Details are as follows:

* For 48MHz SYS\_CLK frequency READ\_NUM must ≥ 2.
* For 32MHz SYS\_CLK frequency READ\_NUM must ≥ 1.
* For 24MHz SYS\_CLK frequency READ\_NUM must ≥ 1.
* For 3.6MHz SYS\_CLK frequency READ\_NUM must ≥ 0.
* For 32kHz SYS\_CLK frequency READ\_NUM must ≥ 0.

**The operations to switch to a high-frequency clock source for SYS\_CLK:**

1. Modify the READ\_NUM value in *EFC\_TIMING\_CFG* register to match the SYS\_CLK after its clock source is switched.
2. Wait for the READ\_NUM\_DONE status bit in *EFC\_SR* register to be set.
3. Modify the SYS\_CLK\_SEL field in *RCC\_CR0* register to switch to the target clock source.

**The operations to switch to a low-frequency clock source for SYS\_CLK:**

1. Modify the SYS\_CLK\_SEL field in *RCC\_CR0* register to switch to the target clock source.
2. Modify the READ\_NUM value in *EFC\_TIMING\_CFG* register to match the SYS\_CLK after its clock source is switched.
3. Wait for the READ\_NUM\_DONE status bit in *EFC\_SR* register to be set.

***Note:*** *When the user wants to switch to a high-frequency clock source, first increase the READ\_NUM, and then configure the clock source selection bit; otherwise, first configure the clock source selection bit, and then decrease the READ\_NUM.*

#### 10.3.4 **Acceleration for Accessing the Flash Memory**

Read acceleration is disabled by default. If READ\_NUM < (2^HCLK\_DIV), read acceleration

can be enabled to achieve the maximum bus access efficiency. Note that read acceleration

must be enabled after READ\_NUM and HCLK\_DIV are configured.

***Note:*** *Read acceleration and instruction prefetch can’t be enabled at the same time.*

#### 10.3.5 **Instruction Prefetch**

It is disabled by default. If READ\_NUM ≥ (2^HCLK\_DIV), read acceleration cannot be enabled.

You can choose to enable instruction prefetch to improve access efficiency.

***Note:*** *Read acceleration and instruction prefetch can’t be enabled at the same time.*

#### 10.3.6 Flash Program Operation

There are two modes for Flash programming:

* **Single Programming Mode**

In single mode, it programs 2 words (8 Bytes) each time.

* **Continuous Programming Mode**

In continuous mode, it programs a complete word line (512 Bytes) each time.

During continuous programming, Flash cannot be read or executed, so the continuous

programming code must be executed in RAM.

**Steps for single programming:**

1. Set the PROG\_EN bit in register *EFC\_CR*.
2. Write the low 4 Bytes data into register *EFC\_PROG\_DATA0*.
3. Write the high 4 Bytes data into register *EFC\_PROG\_DATA1*.
4. Write any value to the Flash address to be written into.
5. Wait for the OPERATION\_DONE bit in register *EFC\_SR* to be set.
6. Write 1 to the OPERATION\_DONE bit in register *EFC\_SR* to clear the flag.

**Steps for continuous programming:**

1. Set the PROG\_EN, WRITE\_RELEASE\_EN and PROG\_MODE bits in register *EFC\_CR*.
2. Wait for the PROG\_DATA\_WAIT bit in register *EFC\_SR* to be set.
3. Write the low 4 Bytes data into register *EFC\_PROG\_DATA0*.
4. Write the high 4 Bytes data into register *EFC\_PROG\_DATA1*.
5. Write any value to the Flash address to be written into.
6. Wait for the PROG\_DATA\_WAIT bit in register *EFC\_SR* to be set.
7. Continue to write data to the *EFC\_PROG\_DATA0* and *EFC\_PROG\_DATA1 registers*.
8. Repeat **Step 6** and **Step 7** until 512 Bytes are written.
9. Wait for the OPERATION\_DONE bit in register *EFC\_SR* to be set.
10. Write 1 to the OPERATION\_DONE bit in register *EFC\_SR* to clear the flag.

#### 10.3.7 Flash Erase Operation

The Flash memory erase operation can be performed at page level (page erase) or on the

whole memory (mass erase).

* **Page Erase**

The page erase is measured in 4 Bytes.

* **Mass Erase**

After a mass erase, the entire Flash main area will be 0xFF.

**Steps for page erase:**

1. Set the PAGE\_ERASE\_EN bit in register *EFC\_CR*.
2. Write any value to the Flash address to be erased.
3. Wait for the OPERATION\_DONE bit in register *EFC\_SR* to be set.
4. Write 1 to the OPERATION\_DONE bit in register *EFC\_SR* to clear the flag.

**Steps for mass erase:**

1. Set the MASS\_ERASE\_EN bit in register *EFC\_CR*.
2. Write any value to the Flash address 0x08000000.
3. Wait for the OPERATION\_DONE bit in register *EFC\_SR* to be set.
4. Write 1 to the OPERATION\_DONE bit in register *EFC\_SR* to clear the flag.

#### 10.4 Flash Option Bytes

Flash option bytes is divided into option0 and option1.

##### 10.4.1 Flash Option0

Option0 has 64 bits in total, and its format is as follows:

**Table 10-2 Flash Option0**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **63-50** | **49-44** | **43-38** | **37-32** | **31-26** | **25** | **24-19** |
| RESERVED | WR\_PROT ECT\_END | WR\_PROTE  CT\_START | EXE\_ONLY2  \_END | EXE\_ONLY2  \_START | EXE\_ONLY  \_KEEEP | EXE\_ONLY1  \_END |
| **18-13** | **12-5** | **4** | **3** | **2** | **1** | **0** |
| EXE\_ONLY  1\_START | DEBUG\_L  EVEL | RESERVED | SYS\_SRAM  \_RESET | FLASH\_BOO  T1 | USE\_FLAS H\_BOOT0 | FLASH\_BOO  T0 |

**Bits 63-50 RESERVED:** Must be kept, and cannot be modified.

**Bits 49-44 WR\_PROTECT\_END:** Write-protected area end

When *WR\_PROTECT\_START > WR\_PROTECT\_END*, the write-protected area is disabled. It is disabled by default.

**Bits 43-38 WR\_PROTECT\_START:** Write-protected area start

When *WR\_PROTECT\_START > WR\_PROTECT\_END*, the write-protected area is disabled. It is disabled by default.

**Bits 37-32 EXE\_ONLY2\_END:** Exe\_Only2 area end

When *EXE\_ONLY2\_START > EXE\_ONLY2\_END*, the Exe\_Only2 area is disabled. It is disabled by default. Once enabled, this area can only be expanded but can’t be disabled or narrowed.

**Bits 31-26 EXE\_ONLY2\_START:** Exe\_Only2 area start

When *EXE\_ONLY2\_START > EXE\_ONLY2\_END*, the Exe\_Only2 area is disabled. It is disabled by default. Once enabled, this area can only be expanded but can’t be disabled or narrowed.

**Bit 25 EXE\_ONLY\_KEEP:** Whether Exe\_Only area is kept when the Debug\_Level changes from 1 to 0

* 0: not keep Exe\_Only area
* 1: keep the Exe\_Only area

This bit can only be set to 0 by software. When Debug\_Level changes from 1 to 0, EXE\_ONLY\_KEEP is set to 1 automatically by hardware.

**Bits 24-19 EXE\_ONLY1\_END:** Exe\_Only1 area end

When *EXE\_ONLY1\_START > EXE\_ONLY1\_END*, the Exe\_Only1 area is disabled. It is disabled by default. Once enabled, this area can only be expanded but can’t be disabled or narrowed.

**Bits 18-13 EXE\_ONLY1\_START:** Exe\_Only1 area start

When *EXE\_ONLY1\_START > EXE\_ONLY1\_END*, the Exe\_Only1 area is disabled. It is disabled by default. Once enabled, this area can only be expanded but can’t be disabled or narrowed.

**Bits 12-5 DEBUG\_LEVEL:** Debug\_level configuration

* AA: Level 0
* CC: Level 2
* Others: Level 1

**Bit 4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 SYS\_SRAM\_RESET:** Whether to clear system SRAM during system startup after its reset

* 1: clear system SRAM
* 0: not clear system SRAM

**Bit 2 FLASH\_BOOT1:** This bit can be used to identify the boot mode.

**Bit 1 USE\_FLASH\_BOOT0:** This bit can be used to identify the boot mode.

**Bit 0 FLASH\_BOOT0:** This bit can be used to identify the boot mode.

See table below for the boot mode configuration summary:

**Table 10-3 ASR6601 Boot Mode Configuration**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| DEBUG\_  LEVEL | USE\_FLASH\_  BOOT0 | FLASH\_  BOOT0 | BOOT0  PIN | FLASH\_  BOOT1 | MAIN\_FLASH\_  EMPTY | Boot Config |
| 2 | X | X | X | X | X | Boot from Flash Main |
| <2 | 0 | X | 0 | X | 0 | Boot from Flash Main |
| <2 | 0 | X | 0 | X | 1 | Boot from Flash Bootloader |
| <2 | 0 | X | 1 | 1 | X | Boot from Flash Bootloader |
| <2 | 0 | X | 1 | 0 | X | Boot from System SRAM |
| <2 | 1 | 1 | X | X | 0 | Boot from Flash Main |
| <2 | 1 | 1 | X | X | 1 | Boot from Flash Bootloader |
| <2 | 1 | 0 | X | 1 | X | Boot from Flash Bootloader |
| <2 | 1 | 0 | X | 0 | X | Boot from System SRAM |

##### 10.4.2 Flash Option1

Option1 has 64 bits in total, and its format is as follows:

**Table 10-4 Flash Option1**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **63-56** | **55** | **54-49** | **48** | **47-42** | **41-37** |
| RESERVED | SYSRAM\_HID  E\_EN | SYSRAM\_HID  E\_START | FLASH\_HIDE\_  EN | FLASH\_HIDE  \_START | RETRAM\_SEC  URE\_END |
| **36-32** | **31-24** | **23-18** | **17-12** | **11-6** | **5-0** |
| RETRAM\_SEC  URE\_START | RESERVED | SYSRAM\_SEC  URE\_END | SYSRAM\_SEC  URE\_START | FLASH\_SEC  URE\_END | FLASH\_SECU  RE\_START |

**Bits 63-56 RESERVED:** Must be kept, and cannot be modified.

**Bit 55 SYSRAM\_HIDE\_EN:** SysRamHide area enable control.

* 0: SysRamHide area enabled
* 1: SysRamHide area disabled

The configuration is only valid when the FlashSecure area is enabled by bits[11:0].

**Bits 54-49 SYSRAM\_HIDE\_START:** SysRamHide area start.

The configuration is only valid when the SysRamHide area is within the SysRamSecure area and the FlashSecure area is enabled by bits[11:0].

The SysRamHide area is from SysRamHideStart to SysRamSecureEnd.

**Bit 48 FLASH\_HIDE\_EN:** FlashHide area enable control.

* 0: FlashHide area enabled
* 1: FlashHide area disabled

The configuration is only valid when the FlashSecure area is enabled by bits[11:0].

**Bits 47-42 FLASH\_HIDE\_START:** FlashHide area start.

The configuration is only valid when the FlashHide area is within the FlashSecure area and the FlashSecure area is enabled by bits[11:0].

The FlashHide area is from FlashHideStart to FlashSecureEnd.

**Bits 41-37 RETRAM\_SECURE\_END:** RetRam Secure area end.

When *RETRAM\_SECURE\_START > RETRAM\_SECURE\_END*, the RetRam Secure area is disabled.

The configuration is only valid when the FlashSecure area is enabled by bits[11:0].

**Bits 36-32 RETRAM\_SECURE\_START:** RetRam Secure area start.

When *RETRAM\_SECURE\_START > RETRAM\_SECURE\_END*, the RetRam Secure area is disabled.

The configuration is only valid when the FlashSecure area is enabled by bits[11:0].

**Bits 31-24 RESERVED:** Must be kept, and cannot be modified.

**Bits 23-18 SYSRAM\_SECURE\_END:** SysRam Secure area end.

When *SYSRAM\_SECURE\_START > SYSRAM\_SECURE\_END*, the SysRam Secure area is disabled.

The configuration is only valid when the FlashSecure area is enabled by bits[11:0].

**Bits 17-12 SYSRAM\_SECURE\_START:** SysRam Secure area start.

When *SYSRAM\_SECURE\_START > SYSRAM\_SECURE\_END*, the SysRam Secure area is disabled.

The configuration is only valid when the FlashSecure area is enabled by bits[11:0].

**Bits 11-6 FLASH\_SECURE\_END:** Flash Secure area end.

When *FLASH \_SECURE\_START > FLASH \_SECURE\_END*, the Flash Secure area is disabled.

The Flash Secure area enable is the master switch for enabling other secure areas. When the Flash Secure area is disabled, the erase operation is triggered.

**Bits 5-0 FLASH\_SECURE\_START:** Flash Secure area start.

When *FLASH\_SECURE\_START > FLASH \_SECURE\_END*, the Flash Secure area is disabled.

The Flash Secure area enable is the master switch for enabling other secure areas. When the Flash Secure area is disabled, the erase operation is triggered.

**10.5 Embedded Flash Registers**

Base Address: 0x40020000

**Table 10-5 Embedded Flash Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| EFC\_CR | 0x000 | Control Register |
| EFC\_INT\_EN | 0x004 | Interrupt enable register |
| EFC\_SR | 0x008 | Status Register |
| EFC\_PROG\_DATA0 | 0x00C | Program Data 0 |
| EFC\_PROG\_DATA1 | 0x010 | Program Data 1 |
| EFC\_TIMING\_CFG | 0x014 | Timing configuration register |
| EFC\_PROTECT\_SEQ | 0x018 | Protection Sequence |
| RESERVED | 0x01C-0x028 | Reserved |
| SERIAL\_NUM\_LOW | 0x02C | Less Significant 32 bits of the  Chip Serial Number |
| SERIAL\_NUM\_HIGH | 0x030 | More Significant 32 bits of the  Chip Serial Number |
| RESERVED | 0x034-0x038 | Reserved |
| OPTION\_CSR\_BYTES | 0x03C | OPTION control and status data |
| OPTION\_EXE\_ONLY\_BYTES | 0x040 | OPTION Execution-only data |
| OPTION\_WR\_PROTECT\_BYTES | 0x044 | OPTION Write-protection data |
| OPTION\_SECURE\_BYTES0 | 0x048 | OPTION Secure Data 0 |
| OPTION\_SECURE\_BYTES1 | 0x04C | OPTION Secure Data 1 |

#### 10.5.1 EFC\_CR

Offset: 0x00

Reset Value: 0x00000000

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31** | **30-10** | **9** | **8** | **7** | **6** |
| INFO\_BYTE\_LO  AD | RESERVED | ECC\_DIS | OPTION\_OPR  \_EN | RESERVED | WRITE\_RELEA  SE\_EN |
| w | r | r/w | r/w | r | r/w |
| **5** | **4** | **3** | **2** | **1** | **0** |
| PREFETCH\_EN | READ\_ACC\_EN | PROG\_MODE | PROG\_EN | PAGE\_ERA  SE\_EN | MASS\_ERASE  \_EN |
| r/w | r/w | r/w | r/w | r/w | r/w |

**Bit 31 INFO\_BYTE\_LOAD:** Info byte load reset request.

* Write 0: no action
* Write 1: system will reset, and reload the information in the Flash info area, such as options. This bit is automatically cleared by hardware.

**Bits 30-10 RESERVED:** Must be kept, and cannot be modified.

**Bit 9 ECC\_DIS:** ECC encoding disable.

**Bit 8 OPTION\_OPR\_EN:** Option operation enable.

* 0: Option operation disabled
* 1: Option operation enabled

***Note:***

*1. Any two of OPTION\_OPR\_EN, PROG\_EN and PAGE\_ERASE\_EN cannot be enabled at the same time.*

*2. After each option operation is performed, the system should be reset for the configuration to take effect.*

**Bit 7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 WRITE\_RELEASE\_EN:** When the system executes Flash program, erase (including Mass) and option operations, the AHB bus mode should be selected.

* 0: hold mode
* 1: release mode

***Note:*** *Once configured in the release mode, the Flash cannot be read or executed during programming/erasing operation, otherwise, the FLASHBUSY\_ERR error flag will be set. But you can access the EFC\_SR register and wait the operation to be completed.*

**Bit 5 PREFETCH\_EN:** Flash instruction prefetch enable.

* 0: prefetch disabled
* 1: prefetch enabled

***Note:*** *Read acceleration and instruction prefetch can’t be enabled at the same time.*

**Bit 4 READ\_ACC\_EN:** Flash read acceleration enable.

* 0: read acceleration disabled (hold mode)
* 1: read acceleration enabled (release mode)

***Note:***

*1. When READ\_NUM < (2^HCLK\_DIV), the read acceleration can be enabled. And it must be enabled after READ\_NUM and HCLK\_DIV configurations are completed.*

*2. Read acceleration and instruction prefetch can’t be enabled at the same time.*

**Bit 3 PROG\_MODE:** flash program mode selection.

* 0: single programming mode. In this mode, the data in the *EFC\_PROG\_DATA1* and *EFC\_PROG\_DATA0* registers are written to the specified address in each program.
* 1: WL continuous programming mode. In this mode, a word line (512 Bytes) is programmed to the continuous address of the Flash memory automatically. During the procedure, the software checks the PROG\_DATA\_WAIT flag to determine whether to write new data into the *EFC\_PROG\_DATA1* and *EFC\_PROG\_DATA0* registers.

***Note:***

*1. The ECC encoding format in Flash is 64+8, so an even number of words are programmed each time.*

*2. In WL continuous programming mode, the WRITE\_RELEASE\_EN bit should be set to 1. During the programming process, only the EFC\_SR, EFC\_PROG\_DATA1 and EFC\_PROG\_DATA0 registers can be read or written, the Flash cannot be read or executed.*

**Bit 2 PROG\_EN:** Flash programming enable.

* 0: write to the Flash memory does not trigger Flash programming operation
* 1: write to the Flash memory triggers Flash programming operation

***Note:***

*1. In single programming mode, the programming is started by writing data to the 8-Byte aligned Flash address. The data of register EFC\_PROG\_DATA0 will be written into the low 4-Byte address space, and the data of register EFC\_PROG\_DATA1 will be written into the high 4-Byte address space.*

*2. In WL continuous programming mode, programming is started by writing data to the Flash address, and the programming address is accumulated by 8 Bytes until the end of a WL programming.*

**Bit 1 PAGE\_ERASE\_EN:** Flash page erasing enable.

* 0: write to the Flash memory does not trigger Flash page erasing operation
* 1: write to the Flash memory triggers Flash page erasing operation

**Bit 0 MASS\_ERASE\_EN:** Flash mass erasing enable

* 0: write to the Flash memory does not trigger Flash mass erasing operation
* 1: write to the Flash memory triggers Flash mass erasing operation

***Note:***

*1. When the bit is set, if there is a write to the address belonging to the Flash main area, mass erase is only performed on the main area; if there is a write to the address belonging to the Flash info area, mass erase is performed on both the main and info areas.*

*2. Do not perform mass erase on the Flash info area, otherwise the chip will be destroyed.*

#### 10.5.2 EFC\_INT\_EN

Offset: 0x04

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-9** | **8** | **7** | **6** | **5** |
| RESERVED | TWO\_BIT\_ERROR  \_INT\_EN | ONE\_BIT\_CORRE  CT\_INT\_EN | PROG\_ERR\_INT\_  EN | PAGE\_ERASE\_  ERR\_INT\_EN |
| r | r/w | r/w | r/w | r/w |
| **4** | **3** | **2** | **1** | **0** |
| OPTION\_WR\_ERR  \_INT\_EN | FLASHBUSY\_ERR  \_INT\_EN | PROG\_DATA\_WAI  T\_INT\_EN | RESERVED | OPERATION\_D  ONE\_INT\_EN |
| r/w | r/w | r/w | r | r/w |

**Bits 31-9 RESERVED:** Must be kept, and cannot be modified.

**Bit 8 TWO\_BIT\_ERROR\_INT\_EN:** ECC TWO\_BIT\_ERROR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 7 ONE\_BIT\_CORRECT\_INT\_EN:** ECC ONE\_BIT\_CORRECT interrupt enable.

* 0: disabled
* 1: enabled

**Bit 6 PROG\_ERR\_INT\_EN:** PROG\_ERR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 5 PAGE\_ERASE\_ERR\_INT\_EN:** PAGE\_ERASE\_ERR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 4 OPTION\_WR\_ERR\_INT\_EN:** OPTION\_WR\_ERR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 3 FLASHBUSY\_ERR\_INT\_EN:** FLASHBUSY\_ERR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 2 PROG\_DATA\_WAIT\_INT\_EN:** PROG\_DATA\_WAIT interrupt enable.

* 0: disabled
* 1: enabled

**Bit 1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 OPERATION\_DONE\_INT\_EN:** OPERATION\_DONE interrupt enable.

* 0: disabled
* 1: enabled

#### 10.5.3 EFC\_SR

Offset: 0x08

Reset Value: 0x00000006

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-9** | **8** | **7** | **6** | **5** |
| RESERVED | TWO\_BIT\_ERROR | ONE\_BIT\_CORRECT | PROG\_ERR | PAGE\_ERASE\_ERR |
| r | r/w | r/w | r/w | r/w |
| **4** | **3** | **2** | **1** | **0** |
| OPTION\_WR\_  ERR | FLASHBUSY\_ERR | PROG\_DATA\_WAIT | READ\_NUM\_  DONE | OPERATION\_DONE |
| r/w | r/w | r/w | r | r/w |

**Bits 31-9 RESERVED:** Must be kept, and cannot be modified.

**Bit 8 TWO\_BIT\_ERROR:** TWO\_BIT\_ERROR flag is set when the Flash memory is read.

* 0: no two-bit error occurred
* 1: two-bit error occurred when reading the Flash memory and ECC did not correct

**Bit 7 ONE\_BIT\_CORRECT:** ONE\_BIT\_CORRECT flag is set when the Flash memory is read.

* 0: no one-bit error occurred
* 1: one-bit error occurred when reading the Flash memory and ECC corrected it

**Bit 6 PROG\_ERR:** Some partitions within the Flash info area don’t support programming operation(PROG\_EN). Programming operation to these partitions will be blocked, and this bit will be set by hardware and cleared by software writing 1 to it.

* 0: no programming error occurred
* 1: programming error occurred

***Note:*** *The option area cannot be written by direct program operations. The bootloader area cannot be programmed.*

**Bit 5 PAGE\_ERASE\_ERR:** The Flash info area don’t support erasing operation. Erasing operation to the info area will be blocked, and this bit will be set by hardware and cleared by software writing 1 to it.

* 0: no page erase error occurred
* 1: a page erase error occurred

**Bit 4 OPTION\_WR\_ERR:** The Option area should be configured with the limitations respected, or the configuration is invalid and this bit is set by hardware. It is cleared by software writing 1 to it.

* 0: no write permission error on Option byte
* 1: a write permission error on Option byte occurred

The configuration for the Option area must respect the following limitations:

1. Flash EXE\_Only1/EXE\_Only2 area can’t be disabled or narrowed once it is enabled.

2. Bit EXE\_ONLY\_KEEP can’t be modified from 0 to 1.

3. When SECURE\_AREA\_EN=1, operations initiated by non-secure areas only act on the FLASH\_SECURE\_END/FLASH\_SECURE\_START bits in Option bytes to clear the secure\_area\_en status bit.

**Bit 3 FLASHBUSY\_ERR:** When Flash is performing programming, erasing (including mass), and option operations, the read operation by the software will be blocked, the data returned by the bus is uncertain, it is an abnormal state, this bit will be set by hardware and cleared by software writing 1 to it.

* 0: no error occurred
* 1: read error occurred during a Flash operation

**Bit 2 PROG\_DATA\_WAIT:** Waiting for data to be written to the Flash memory in WL continuous programming mode. This bit is set by hardware and is cleared automatically by hardware when the software writes new data to the *FC\_PROG\_DATA0* and *EFC\_PROG\_DATA1* registers. It can also be cleared by software writing 1 to it.

* 0: the value of registers EFC\_PROG\_DATA0 and EFC\_PROG\_DATA1 has been written to the Flash memory
* 1: wait for the value of registers EFC\_PROG\_DATA0 and EFC\_PROG\_DATA1 to be written to the Flash memory

**Bit 1 READ\_NUM\_DONE:** READ\_NUM configuration status flag, it indicates whether the READ\_NUM configuration is complete. This bit is set and cleared by hardware.

* 0: in progress
* 1: complete

**Bit 0 OPERATION\_DONE:** Flash operation status flag, it indicates whether Flash mass erase/page erase/program/option operation is complete. This bit is set by hardware and cleared by software writing 1 to it.

* 0: not complete
* 1: complete

#### 10.5.4 EFC\_PROG\_DATA0

Offset: 0x0C

Reset Value: 0x00000000

|  |
| --- |
| **31-0** |
| PROG\_DATA0 |
| r/w |

**Bits 31-0 PROG\_DATA0:** programming data 0.

***Note:*** *When programming, write data to register EFC\_PROG\_DATA0 first.*

#### 10.5.5 EFC\_PROG\_DATA1

Offset: 0x10

Reset Value: 0x00000000

|  |
| --- |
| **31-0** |
| PROG\_DATA1 |
| r/w |

**Bits 31-0 PROG\_DATA1:** programming data 1

***Note:*** *When programming, write data to register EFC\_PROG\_DATA0 first.*

#### 10.5.6 EFC\_TIMING\_CFG

Offset: 0x14

Reset Value: 0x00031D1D

|  |  |  |
| --- | --- | --- |
| **31-20** | **19-16** | **15-0** |
| RESERVED | READ\_NUM | RESERVED |
| r | r/w | r |

**Bits 31-20 RESERVED:** Must be kept, and cannot be modified.

**Bits 19-16 READ\_NUM:** Program the number of wait states.

The READ\_NUM equals to (READ\_NUM+1) multiplied by SYS\_CLK clock period.

* For 48 MHz SYS\_CLK frequency, READ\_NUM must ≥ 2.
* For 32 MHz SYS\_CLK frequency, READ\_NUM must ≥ 1.
* For 24 MHz SYS\_CLK frequency, READ\_NUM must ≥ 1.
* For 4 MHz SYS\_CLK frequency, READ\_NUM must ≥ 0.
* For 32 kHz SYS\_CLK frequency, READ\_NUM must ≥ 0.

***Note:*** *When changing the SYS\_CLK clock source in register RCC\_CR0, pay attention to the sequence of operations. If you intend to switch to a faster clock source, first increase the READ\_NUM, and then configure the clock source selection bit; otherwise, first configure the clock source selection bit, and then decrease the READ\_NUM.*

**Bits 15-0 RESERVED:** Must be kept, and cannot be modified.

#### 10.5.7 EFC\_PROTECT\_SEQ

Offset: 0x18

Reset Value: 0x00000000

|  |
| --- |
| **31-0** |
| PROTECT\_SEQ |
| w |

**Bits 31-0 PROTECT\_SEQ:** Protection sequence for the configuration of register *EFC\_CR* By default, the EFC\_CR register cannot be modified, to modify it, the user must configure the protection sequence correctly through the FC\_PROTECT\_SEQ register in the following order. If there is an error in the configuration, then the configuration is invalid, and the protection sequence should be reconfigured.

1. Write 0x8C9DAEBF
2. Write 0x13141516
3. You can operate with EFC\_CR

##### 10.5.8 SERIAL\_NUM\_LOW

Offset:0x2C

|  |
| --- |
| **31-0** |
| SERIAL\_NUM\_LOW |
| r |

**Bits 31-0 SERIAL\_NUM\_LOW:** Less significant 32 bits of the chip serial number.

##### 10.5.9 SERIAL\_NUM\_HIGH

Offset:0x30

|  |
| --- |
| **31-0** |
| SERIAL\_NUM\_HIGH |
| r |

**Bits 31-0 SERIAL\_NUM\_HIGH:** Most significant 32 bits of the chip serial number.

#### 10.5.10 OPTION\_CSR\_BYTES

Offset: 0x3C

Reset Value: 0x000000BD

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **31-7** | **6-5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | DEBUG\_LEVEL | SECURE\_AREA  \_EN | SYS\_SRAM  \_RST | FLASH\_ BOOT1 | USE\_FLASH  \_BOOT0 | FLASH\_ BOOT0 |
| r | r | r | r | r | r | r |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bits 6-5 DEBUG\_LEVEL:** Debug level setting.

* 0: Level 0
* 1: Level 1
* 2: Level 2

**Bit 4 SECURE\_AREA\_EN:** Flash secure area status flag.

* 0: secure area disabled
* 1: secure area enabled

**Bit 3 SYS\_SRAM\_RST:** Clear system SRAM during system startup after its reset.

* 0: do not clear system SRAM
* 1: clear system SRAM

**Bit 2 FLASH\_BOOT1:** This bit can be used for boot mode identification. See *Table 7-7* for more details.

* 0: System SRAM boot
* 1: BootLoader

**Bit 1 USE\_FLASH\_BOOT0:** This bit can be used for boot mode identification. See *Table 7-7* for more details.

* 0: Use BOOT0 pin
* 1: Use FLASH\_BOOT0 option bit

**Bit 0 FLASH\_BOOT0:** This bit can be used for boot mode identification, and the configuration is only valid when USE\_FLASH\_BOOT0=1. See *Table 7-7* for more details.

* 0: FLASH\_BOOT1 controls the startup mode
* 1: Boot from Main Flash

#### 10.5.11 OPTION\_EXE\_ONLY\_BYTES

Offset: 0x40

Reset Value: 0x00FC0FC0

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-25** | **24** | **23-18** | **17-12** | **11-6** | **5-0** |
| RESERVED | EXE\_ONLY\_K  EEP | EXE\_ONLY2\_  END | EXE\_ONLY2\_  START | EXE\_ONLY1\_  END | EXE\_ONLY1\_  START |
| r | r | r | r | r | r |

**Bits 31-25 RESERVED:** Must be kept, and cannot be modified.

**Bit 24 EXE\_ONLY\_KEEP:** Keep Exe\_Only area when the Debug\_Level changes from 1 to 0.

* 0: erase ExeOnly area
* 1: keep the ExeOnly area

This bit can only be cleared by software.

**Bits 23-18 EXE\_ONLY2\_END:** Exe\_Only2 area end offset.

If *EXEONLY2\_START > EXEONLY2\_END*, the ExeOnly2 area is disabled.

**Bits 17-12 EXE\_ONLY2\_START:** Exe\_Only2 area start offset.

If *EXEONLY2\_START > EXEONLY2\_END*, the ExeOnly2 area is disabled. Once enabled, this area can only be expanded but can’t be disabled or narrowed.

**Bits 11-6 EXE\_ONLY1\_END:** Exe\_Only1 area end offset.

If *EXEONLY1\_START > EXEONLY1\_END*, the ExeOnly1 area is disabled.

**Bits 5-0 EXE\_ONLY1\_START:** Exe\_Only1 area start offset.

If *EXEONLY1\_START > EXEONLY1\_END*, the ExeOnly1 area is disabled. Once enabled, this area can only be expanded but can’t be disabled or narrowed.

#### 10.5.12 OPTION\_WR\_PROTECT\_BYTES

Offset: 0x44

Reset Value: 0x0003F03F

|  |  |  |
| --- | --- | --- |
| **31-12** | **11-6** | **5-0** |
| RESERVED | WRPROTECT\_END | WRPROTECT\_START |
| r | r | r |

**Bits 31-12 RESERVED:** Must be kept, and cannot be modified.

**Bits 11-6 WRPROTECT\_END:** Write-protected area end offset.

If *WRPROTECT\_START > WRPROTECT\_END*, the write-protected area is disabled.

**Bits 5-0 WRPROTECT\_START:** Write-protected area start offset.

If *WRPROTECT\_START > WRPROTECT\_END*, the write-protected area is disabled.

#### 10.5.13 OPTION\_SECURE\_BYTES0

Offset: 0x48

Reset Value: 0x00FC0FC0

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-24** | **23-18** | **17-12** | **11-6** | **5-0** |
| RESERVED | SYSRAM\_SECURE\_  END | SYSRAM\_SECURE\_  START | FLASH\_SECURE\_  END | FLASH\_SECURE\_  START |
| r | r | r | r | r |

**Bits 31-24 RESERVED:** Must be kept, and can't be modified.

**Bits 23-18 SYSRAM\_SECURE\_END:** SysRam Secure area end.

If *SYSRAM\_SECURE\_START > SYSRAM\_SECURE\_END*, the SysRam Secure area is disabled.

The configuration is only valid when SECURE\_AREA\_EN=1.

**Bits 17-12 SYSRAM\_SECURE\_START:** SysRam Secure area start.

If *SYSRAM\_SECURE\_START > SYSRAM\_SECURE\_END*, the SysRam Secure area is disabled.

The configuration is only valid when SECURE\_AREA\_EN=1.

**Bits 11-6** Flash Secure area end.

If *FLASH\_SECURE\_START > FLASH\_SECURE\_END*, the Flash Secure area is disabled.

**Bits 5-0 FLASH\_SECURE\_START:** Flash Secure area start.

If *FLASH\_SECURE\_START > FLASH\_SECURE\_END*, the Flash Secure area is disabled.

The Flash Secure area enable is the master switch for enabling other secure areas.

If the Flash Secure area is enabled, the SECURE\_AREA\_EN bit is set, which means all the other

secure areas can be enabled.

If the Flash Secure area is disabled, the SECURE\_AREA\_EN bit is cleared, which triggers the erase

operation.

#### 10.5.14 OPTION\_SECURE\_BYTES1

Offset: 0x4C

Reset Value: 0x008103E0

|  |  |  |  |
| --- | --- | --- | --- |
| **31-24** | **23** | | **22-17** |
| RESERVED | SYSRAM\_HIDE\_ENABLE | | SYSRAM\_HIDE\_START |
| r | r | | r |
| **16** | **15-10** | **9-5** | **4-0** |
| FLASH\_HIDE\_ENABLE | FLASH\_HIDE\_START | RETRAM\_SECURE\_  END | RETRAM\_SECURE\_START |
| r | r | r | r |

**Bits 31-24 RESERVED:** Must be kept, and can't be modified.

**Bit 23 SYSRAM\_HIDE\_ENABLE:** SysRamHide area enable control.

* 0: SysRamHide area enabled
* 1: SysRamHide area disabled

The configuration is only valid when SECURE\_AREA\_EN=1.

**Bits 22-17 SYSRAM\_HIDE\_START:** SysRamHide area start.

The configuration is only valid when the SysRamHide area is within the SysRamSecure area and when

SECURE\_AREA\_EN=1.

The SysRamHide area is from SYSRAM\_HIDE\_START to SYSRAM\_SECURE\_END.

**Bit 16 FLASH\_HIDE\_ENABLE:** FlashHide area enable control.

* 0: FlashHide area enabled
* 1: FlashHide area disabled

The configuration is only valid when SECURE\_AREA\_EN=1.

**Bits 15-10 FLASH\_HIDE\_START:** FlashHide area start.

The configuration is only valid when the FlashHide area is within the FlashSecure area and when

SECURE\_AREA\_EN=1.

The FlashHide area is from FLASH\_HIDE\_START to FLASH\_SECURE\_END.

**Bits 9-5 RETRAM\_SECURE\_END:** RetRam Secure area end.

If *RETRAM\_SECURE\_START > RETRAM\_SECURE\_END*, the RetRam Secure area is disabled.

The configuration is only valid when SECURE\_AREA\_EN=1.

**Bits 4-0 RETRAM\_SECURE\_START:** RetRam Secure area start.

If *RETRAM\_SECURE\_START > RETRAM\_SECURE\_END*, the RetRam Secure area is disabled.

The configuration is only valid when SECURE\_AREA\_EN=1.

### 11. GPIO

#### 11.1 Introduction

ASR6601 GPIOs are divided into four groups: Ports A, B, C, and D. The SFR registers of each group are allocated the same, and they are distinguished by different base addresses. PortD Pin8 ~ Pin15 are located in the AON domain, and the other IOs are located in the Main domain.

All GPIOs support input and output, pull-up and pull-down, push-pull output and open-drain output. The output drive current can be configured as 4mA or 8mA. All GPIOs can generate interrupts, which can be triggered by rising edge, falling edge or both edges. In Sleep/Stop0~2 mode, all GPIOs can be used for wake-up; while in Stop3 mode, only some GPIOs can be used to wake-up MCU. All GPIOs support alternate functions.

**11.2 Output Configuration**

GPIO data output is configured by the *GPIOx\_OER* and *GPIOx\_ODR* registers.

GPIO output can be set or cleared. Writing 1 to bits[15:0] in register *GPIOx\_BRR* or writing 1 to bits[31-16] in register *GPIOx\_BSRR* can **clear** the corresponding bit in register *GPIOx\_ODR*. And writing 1 to bits[15:0] in register *GPIOx\_BSRR* can **set** the corresponding bit in register *GPIOx\_ODR*.

GPIO port is configured as **push-pull** output through register *GPIOx\_OTYPER*. As to output in **open-drain** mode, for PortD Pin8 ~ PortD Pin15, it is enabled by configuring the *GPIOx\_IER, GPIOx\_OER, GPIOx\_ODR and GPIOx\_PSR* registers, and for other IO ports, it is enabled by configuring the *GPIOx\_OER, GPIOx\_IER, GPIOx\_ODR and GPIOx\_OTYPER* registers. Not implementing a real open drain struct, the open drain function is achieved by control of the *GPIOx\_OER* and *GPIOx\_ODR* registers.

GPIO can be configured as analog output.

**11.3 Input Configuration**

GPIO data input is enabled by configuring register *GPIOx\_IER*, and you can read register *GPIOx\_IDR* to get the input status.

Input floating mode is realized by configuring register *GPIOx\_PER* to disable pull-up and pull-down.

Pull-up or pull-down is enabled by configuring register *GPIOx\_PER*, and register *GPIOx\_PSR* is used for pull-up or pull-down selection.

GPIO can be configured as analog input.

**11.4 Output Drive Strength**

High (8 mA) or low (4 mA) output drive strength is configured by *GPIOx\_DSR* register.

**11.5 GPIO Interrupts**

All GPIOs support interrupts, which can be triggered by rising edge, falling edge or both edges.

Interrupts are enabled by configuring *GPIOx\_INT\_CR* register.

**11.6 Wakeup from Sleep/Stop0~2 Mode**

In Sleep or Stop 0/1/2 mode, MCU can be woken up at high level or low level, and the output wake-up signal is high level. GPIO00-GPIO63 can all be used for wakeup, four IOs make up a group. A group can generate a wakeup signal, and each IO in a group can wake up MCU at high level or low level. In Sleep/Stop0~2 mode, the wakeup function is enabled by configuring the *GPIOx\_WU\_EN* register, and the high-level or low-level wakeup is selected by configuring the *GPIOx\_WU\_LVL* register.

**11.7 Wakeup from Stop3 Mode**

For GPIO00~GPIO55 in the Main domain, every 4 IO MUX outputs a wake- up signal, thus a total of 14 wake-up signals.

In Stop3 mode, wakeup enabling and wakeup at high or low level are configured by the corresponding bits in registers *GPIOA\_STOP3\_WU\_CR*, *GPIOx\_STOP3\_WU\_CR (x=B, C)* and *GPIOD\_STOP3\_WU\_CR*.

**11.8 Alternate Function Configuration**

GPIO can be used as general I/O or configured as alternate function. GPIO input/output is enabled or disabled by the *GPIOx\_OER* and *GPIOx\_IER* registers, while the alternate function input/output is enabled or disabled by alternate peripherals. The I/O pull-up or pull-down is configured by the *GPIOx\_PER* and *GPIOx\_PSR* registers.

As to alternate function control, 3-bit for each pin among PortD Pin8~Pin15, and 4-bit for each of the other pins. By default, PortA Pin6 and Pin7 are configured as SWD pins, and the other IOs are configured as GPIO.

Configure the function of Portx Pin[7:0] by register *GPIOx\_AFRL*, and configure the function of Portx Pin[15:8] by registers *GPIOx\_AFRH (x=A, B, C)* and *GPIOD\_AFRH*.

**11.9 Clock and Reset**

There are four groups of APB bus clock and APB bus reset, each group has an independent bus clock and bus reset.

**11.10 Power Domain**

**Main Domain:**

For all pins except PortD Pin8~Pin15, the corresponding pads are in the Main domain.

**AON (always-on) Domain:**

The PADs corresponds to PortD Pin8~Pin15 are in the AlwaysOn domain. If they are configured as alternate function, they are directly controlled by the peripherals. Otherwise, they will be controlled by the GPIO registers in the AlwaysOn domain.

11.11 **Low-power Mode Operation and Wakeup**

1. In Sleep mode, all GPIOs can work and output wake-up signal.
2. In Stop0/Stop1/Stop2 mode, all GPIOs can work and output wake-up signal.
3. In Stop3 mode, GPIO00~GPIO55 can retain the state, and can be configured as wake-up signal.
4. In Stop3 mode, PortD Pin8~Pin15 in AlwaysOn domain can retain the state, CPU can also be woken up through RTC.
5. In Standby mode, PortD Pin8~PortD Pin15 can work, while the other IOs can’t work.

##### 11.12 SWD IO

**Default Control:** The GPIO alternate function low register selects SWD by default, and SWC pull-down (PortA Pin7) and SWD pull-up (PortA Pin6) are default.

**Seal Control:** IO status is determined by the default value of the *GPIOx\_AFRL* register at power-on until the DebugLevel decision is carried out. If sealing is needed, then the SWD interface will be sealed (disabled) eternally, otherwise, it is still controlled by the register.

**Software Configuration:** The SWD port can be disabled by the *GPIOx\_AFRL* register. Note that it is one-way sealing, which means it cannot be enabled after being disabled.

**11.13 BOOT0 Control**

**Default Control:** Since all IOs except the SWC and SWD IOs are analog IOs by default, the BOOT0, SWC and SWD pins require special control at power-on.

**BOOT0 (GPIO02):** BOOT0 is in input pull-down status before io\_lock. After EFC is locked, it switches to GPIO mode.

**11.14 GPIO Registers**

GPIO Port A Base Address: 0x4001F000

GPIO Port B Base Address: 0x4001F400

GPIO Port C Base Address: 0x4001F800

GPIO Port D Base Address: 0x4001FC00

**Table 11-1 GPIO Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| GPIOx\_OER | 0x000 | General output enable register |
| GPIOx\_OTYPER | 0x004 | General output type control register |
| GPIOx\_IER | 0x008 | General input enable register |
| GPIOx\_PER | 0x00C | Pull-up/pull-down enable register |
| GPIOx\_PSR | 0x010 | Pull-up/pull-down selection register |
| GPIOx\_IDR | 0x014 | Input data register |
| GPIOx\_ODR | 0x018 | Output data register |
| GPIOx\_BRR | 0x01C | Bit reset register |
| GPIOx\_BSRR | 0x020 | Bit set or reset register |
| GPIOx\_DSR | 0x024 | Output drive strength register |
| GPIOx\_INT\_CR | 0x028 | Interrupt enable register |
| GPIOx\_FR | 0x02C | Interrupt edge flag register |
| GPIOx\_WU\_EN | 0x030 | Wake-up from Sleep/Stop0~2 mode enable register |
| GPIOx\_WU\_LVL | 0x034 | Wake-up level control register for Sleep/Stop0~2 mode |
| GPIOx\_AFRL | 0x038 | GPIO alternate function low register |
| GPIOx\_AFRH | 0x03C | GPIO alternate function high register |
| GPIOx\_STOP3\_WU\_CR | 0x040 | Wake-up enable control register in Stop3 mode |

###### 11.14.1 GPIOx\_OER (x=A, B, C, D)

Offset: 0x00

Reset Value: 0x0000FFFF

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | OEN |
| r-0h | rw-ffffh |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 OEN:** Portx Pin[15:0] output enable.

* 0: output enabled
* 1: output disabled

###### 11.14.2 GPIOx\_OTYPER (x=A, B, C, D)

Offset: 0x04

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | OTYPE |
| r-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 OTYPE:** Portx Pin[15:0] output type control.

* 0: push-pull
* 1: open-drain

***Note:*** *The output type of the pads in the AON domain (PortD\_Pin[15:8]) is controlled by the GPIOx\_IER, GPIOx\_OER, GPIOx\_ODR and GPIOx\_PSR registers instead of this register. For the other pins, the open drain mode is enabled through the GPIOx\_IER, GPIOx\_OER, GPIOx\_ODR and GPIOx\_OTYPER registers.*

###### 11.14.3 GPIOx\_IER (x=A, B, C, D)

Offset: 0x08

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | IE |
| r-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 IE:** Portx Pin[15:0] input enable.

* 0: input disabled
* 1: input enabled

###### 11.14.4 GPIOx\_PER (x=A, B, C, D)

Offset: 0x0C

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | PE |
| r-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 PE:** Portx Pin[15:0] pull-up/pull-down enable.

* 0: pull-up/pull-down disabled
* 1: pull-up/pull-down enabled

GPIO pull-up and pull-down is selected by the *GPIOx\_PSR* register. By default, pull-up/pull-down is disabled, and all the IOs except PortA\_Pin[7:6] are in analog mode. PortA\_Pin[7:6] are used as SWD function.

###### 11.14.5 GPIOx\_PSR (x=A, B, C, D)

Offset: 0x10

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | PS |
| r-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 PS:** Portx Pin[15:0] pull-up/pull-down selection.

* 0: pull-down
* 1: pull-up

###### 11.14.6 GPIOx\_IDR (x=A, B, C, D)

Offset:0x14

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | ID |
| r-0h | r-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 ID:** Portx Pin[15:0] input.

* 0: low level
* 1: high level

###### 11.14.7 GPIOx\_ODR (x=A, B, C, D)

Offset: 0x18

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | OD |
| r-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 OD:** Portx Pin[15:0] output

* 0: low level
* 1: high level

###### 11.14.8 GPIOx\_BRR (x=A, B, C, D)

Offset: 0x1C

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | BR |
| r-0h | w-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 BR:** Portx Pin[15:0] output data clear.

* 0: no action
* 1: clear the corresponding bit of the GPIOx\_ODR register

###### 11.14.9 GPIOx\_BSRR (x=A, B, C, D)

Offset: 0x20

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| BR | BSR |
| w-0h | w-0h |

**Bits 31-16 BR:** Portx Pin[15:0] output data clear.

* 0: no action
* 1: clear the corresponding bit of the GPIOx\_ODR register

**Bits 15-0 BSR:** Portx Pin[15:0] output data set.

* 0: no action
* 1: set the corresponding bit of the GPIOx\_ODR register

***Note:*** *If both the BSR and BR bits are enabled, the BSR bit has a higher priority.*

**11.14.10 GPIOx\_DSR (x=A, B, C, D)**

Offset: 0x24

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | DS |
| r-0h | w-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 DS:** Portx Pin[15:0] output drive strength configuration.

* 0: low drive strength (4 mA)
* 1: high drive strength (8 mA)

###### 11.14.11 GPIOx\_INT\_CR (x=A, B, C, D)

Offset: 0x28

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **2\*n + 1** | **2\*n** |
| NEG\_INT\_EN | POS\_INT\_EN |
| rw-0h | rw-0h |

**Bits 2\*n + 1 NEG\_INT\_EN:** Portx Pin[15:0] enable interrupt triggered by falling edge.

* 0: interrupt triggered by falling edge disabled
* 1: interrupt triggered by falling edge enabled

**Bits 2\*n POS\_INT\_EN:** Portx Pin[15:0] enable interrupt triggered by rising edge.

* 0: interrupt triggered by rising edge disabled
* 1: interrupt triggered by rising edge enabled

###### 11.14.12 GPIOx\_FR (x=A, B, C, D)

Offset: 0x2C

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **2\*n + 1** | **2\*n** |
| NEG\_F | POS\_F |
| rw1c-0h | rw1c-0h |

**Bits 2\*n + 1 NEG\_INT\_F:** Portx Pin[15:0] interrupt flag (falling edge)

* 0: no interrupt triggered by falling edge occurred
* 1: interrupt triggered by falling edge occurred

**Bits 2\*n POS\_INT\_F:** Portx Pin[15:0] interrupt flag (rising edge)

* 0: no interrupt triggered by rising edge occurred
* 1: interrupt triggered by rising edge occurred

###### 11.14.13 GPIOx\_WU\_EN (x=A, B, C, D)

Offset: 0x30

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | WU\_EN |
| r-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 WU\_EN:** Enable/disable Portx Pin[15:0] to wake-up CPU from Sleep/Stop0~2 modes.

* 0: disable Sleep/Stop0~2 wakeup
* 1: enable Sleep/Stop0~2 wakeup

###### 11.14.14 GPIOx\_WU\_LVL (x=A, B, C, D)

Offset: 0x34

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | WU\_LVL |
| r-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 WU\_LVL:** Configure Portx Pin[15:0] CPU Sleep/Stop0~2 mode wakeup to high or low level.

* 0: wake-up at low level
* 1: wake-up at high level

###### 11.14.15 GPIOx\_AFRL (x=A, B, C, D)

Offset: 0x38

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-28** | **27-24** | **23-20** | **19-16** | **15-12** | **11-8** | **7-4** | **3-0** |
| AF7 | AF6 | AF5 | AF4 | AF3 | AF2 | AF1 | AF0 |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-28 AF7:** Portx Pin7 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 27-24 AF6:** Portx Pin6 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 23-20 AF5:** Portx Pin5 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 19-16 AF4:** Portx Pin4 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2 (to be continued on the next page)
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 15-12 AF3:** Portx Pin3 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 11-8 AF2:** Portx Pin2 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 7-4 AF1:** Portx Pin1 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 3-0 AF0:** Portx Pin0 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

###### 11.14.16 GPIOx\_AFRH (x=A, B, C)

Offset: 0x3C

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-28** | **27-24** | **23-20** | **19-16** | **15-12** | **11-8** | **7-4** | **3-0** |
| AF15 | AF14 | AF13 | AF12 | AF11 | AF10 | AF9 | AF8 |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-28 AF15:** Portx Pin15 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 27-24 AF14:** Portx Pin14 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 23-20 AF13:** Portx Pin13 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 19-16 AF12:** Portx Pin12 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 15-12 AF11:** Portx Pin11 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 11-8 AF10:** Portx Pin10 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 7-4 AF9:** Portx Pin9 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

**Bits 3-0 AF8:** Portx Pin8 function selection.

* 0000: Function0
* 0001: Function1
* 0010: Function2
* 0011: Function3
* 0100: Function4
* 0101: Function5
* 0110: Function6
* 0111: Function7
* others: Reserved

###### 11.14.17 GPIOD\_AFRH

Offset: 0x3C

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **31-24** | **23-21** | **20-18** | **17-15** | **14-12** | **11-9** | **8-6** | **5-3** | **2-0** |
| RESERVED | AF15 | AF14 | AF13 | AF12 | AF11 | AF10 | AF9 | AF8 |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-24 RESERVED:** Must be kept, and cannot be modified.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

**Bits 23-21 AF15:** PortD Pin15 function selection.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

**Bits 20-18 AF14:** PortD Pin14 function selection.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

**Bits 17-15 AF13:** PortD Pin13 function selection.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

**Bits 14-12 AF12:** PortD Pin12 function selection.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

**Bits 11-9 AF11:** Pin11 function selection.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

**Bits 8-6 AF10:** PortD Pin10 function selection.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

**Bits 5-3 AF9:** PortD Pin9 function selection.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

**Bits 2-0 AF8:** PortD Pin8 function selection.

* 001: Function1
* 010: Function2
* 011: Function3
* 100: Function4
* 101: Function5
* 110: Function6
* 111: Function7

###### 11.14.18 GPIOA\_STOP3\_WU\_CR

Offset: 0x40

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-16** | **15** | **14** | **13-12** | **11** |
| RESERVED | STOP3\_WU\_EN  \_G1 | STOP3\_WU\_LVL\_G3 | STOP3\_WU\_SEL\_G  3 | STOP3\_WU\_EN\_G2 |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h |
| **10** | | **9-8** | **7** | **6** |
| STOP3\_WU\_LVL\_G2 | | STOP3\_WU\_SEL\_G  2 | STOP3\_WU\_EN\_G1 | STOP3\_WU\_LVL\_G  1 |
| rw-0h | | rw-0h | rw-0h | rw-0h |
| **5-4** | | **3** | **2** | **1-0** |
| STOP3\_WU\_SEL\_G1 | | STOP3\_WU\_EN\_G0 | STOP3\_WU\_LVL\_G  0 | STOP3\_WU\_SEL\_G  0 |
| rw-0h | | rw-0h | rw-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bit 15 STOP3\_WU\_EN\_G3:** PortA Group3 wake-up pin enable control in Stop3 mode.

* 0: PortA Pin[15/14/7/6] wake-up disabled
* 1: PortA Pin[15/14/7/6] wake-up enabled

**Bit 14 STOP3\_WU\_LVL\_G3:** PortA Group3 wake-up pin level selection in Stop3 mode.

* 0: low level
* 1: high level

**Bits 13-12 STOP3\_WU\_SEL\_G3:** PortA Pin Group3 wake-up source selection in Stop3 mode.

* 00: PortA Pin6
* 01: PortA Pin7
* 10: PortA Pin14
* 11: PortA Pin15

**Bit 11 STOP3\_WU\_EN\_G2:** PortA Group2 wake-up pin enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 10 STOP3\_WU\_LVL\_G2:** PortA Group2 wake-up pin level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 9-8 STOP3\_WU\_SEL\_G2:** PortA Pin Group2 wake-up source selection in Stop3 mode.

* 00: PortA Pin8
* 01: PortA Pin9
* 10: PortA Pin10
* 11: PortA Pin11

**Bit 7 STOP3\_WU\_EN\_G1:** PortA Group1 wake-up pin enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 6 STOP3\_WU\_LVL\_G1:** PortA Group1 wake-up pin level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 5-4 STOP3\_WU\_SEL\_G1:** PortA Pin Group1 wake-up source selection in Stop3 mode.

* 00: PortA Pin4
* 01: PortA Pin5
* 10: PortA Pin12
* 11: PortA Pin13

**Bit 3 STOP3\_WU\_EN\_G0:** PortA Group0 wake-up pin enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 2 STOP3\_WU\_LVL\_G0:** PortA Group0 wake-up pin level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 1-0 STOP3\_WU\_SEL\_G0:** PortA Pin Group0 wake-up source selection in Stop3 mode.

* 00: PortA Pin0
* 01: PortA Pin1
* 10: PortA Pin2
* 11: PortA Pin3

###### 11.14.19 GPIOx\_STOP3\_WU\_CR (x=B, C)

Offset: 0x40

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-16** | **15** | **14** | **13-12** | **11** |
| RESERVED | STOP3\_WU\_EN  \_G3 | STOP3\_WU\_LVL\_G3 | STOP3\_WU\_SEL\_G  3 | STOP3\_WU\_EN\_G2 |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h |
| **10** | | **9-8** | **7** | **6** |
| STOP3\_WU\_LVL\_G2 | | STOP3\_WU\_SEL\_G  2 | STOP3\_WU\_EN\_G1 | STOP3\_WU\_LVL\_G  1 |
| rw-0h | | rw-0h | rw-0h | rw-0h |
| **5-4** | | **3** | **2** | **1-0** |
| STOP3\_WU\_SEL\_G1 | | STOP3\_WU\_EN\_G0 | STOP3\_WU\_LVL\_G  0 | STOP3\_WU\_SEL\_G  0 |
| rw-0h | | rw-0h | rw-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bit 15 STOP3\_WU\_EN\_G3:** Portx Pin Group3 wake-up enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 14 STOP3\_WU\_LVL\_G3:** Portx Pin Group3 wake-up level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 13-12 STOP3\_WU\_SEL\_G3:** Portx Pin Group3 wake-up source selection in Stop3 mode.

* 00: Portx Pin12
* 01: Portx Pin13
* 10: Portx Pin14
* 11: Portx Pin15

**Bit 11 STOP3\_WU\_EN\_G2:** Portx Pin Group2 wake-up enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 10 STOP3\_WU\_LVL\_G2:** Portx Pin Group2 wake-up level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 9-8 STOP3\_WU\_SEL\_G2:** Portx Pin Group2 wake-up source selection in Stop3 mode.

* 00: Portx Pin8
* 01: Portx Pin9
* 10: Portx Pin10
* 11: Portx Pin11

**Bit 7 STOP3\_WU\_EN\_G1:** Portx Pin Group1 wake-up enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 6 STOP3\_WU\_LVL\_G1:** Portx Pin Group1 wake-up level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 5-4 STOP3\_WU\_SEL\_G1:** Portx Pin Group1 wake-up source selection in Stop3 mode.

* 00: Portx Pin4
* 01: Portx Pin5
* 10: Portx Pin6
* 11: Portx Pin7

**Bit 3 STOP3\_WU\_EN\_G0:** Portx Pin Group0 wake-up enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 2 STOP3\_WU\_LVL\_G0:** Portx Pin Group0 wake-up level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 1-0 STOP3\_WU\_SEL\_G0:** Portx Pin Group0 wake-up source selection in Stop3 mode.

* 00: Portx Pin0
* 01: Portx Pin1
* 10: Portx Pin2
* 11: Portx Pin3

###### 11.14.20 GPIOD\_STOP3\_WU\_CR

Offset: 0x40

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-8** | | **7** | **6** |
| RESERVED | | STOP3\_WU\_EN\_G1 | STOP3\_WU\_LVL\_G1 |
| r-0h | | rw-0h | rw-0h |
| **5-4** | **3** | **2** | **1-0** |
| STOP3\_WU\_SEL\_G1 | STOP3\_WU\_EN\_G0 | STOP3\_WU\_LVL\_G0 | STOP3\_WU\_SEL\_G0 |
| rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bit 7 STOP3\_WU\_EN\_G1:** PortD Pin Group1 wake-up enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 6 STOP3\_WU\_LVL\_G1:** PortD Pin Group1 wake-up level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 5-4 STOP3\_WU\_SEL\_G1:** PortD Pin Group1 wake-up source selection in Stop3 mode.

* 00: PortD Pin4
* 01: PortD Pin5
* 10: PortD Pin6
* 11: PortD Pin7

**Bit 3 STOP3\_WU\_EN\_G0:** PortD Pin Group0 Stop3 wake-up enable control in Stop3 mode.

* 0: disabled
* 1: enabled

**Bit 2 STOP3\_WU\_LVL\_G0:** PortD Pin Group0 Stop3 wake-up level selection in Stop3 mode.

* 0: wake-up at low level
* 1: wake-up at high level

**Bits 1-0 STOP3\_WU\_SEL\_G0:** PortD Pin Group0 Stop3 wake-up source selection in Stop3 mode.

* 00: PortD Pin0
* 01: PortD Pin1
* 10: PortD Pin2
* 11: PortD Pin3

**12.**  **LoRa Controller(LoRaC)**

**12.1 Introduction**

LoRa Controller is used to control the internal RF TRX to transmit and reception LoRa

signals.

### 12.2 Main features

* SPI interface for RF TRX control
* Interrupt signal generation

### 12.3 Functional Description

**12.3.1 Internal SPI Interface**

There is an internal SPI interface in the LoRa Controller, which allows the LoRa Controller to

directly control RF TRX through registers. The communication between the MCU and RF TRX

is as follows:

1. Initialize the internal SSP in LoRa Controller.
2. Check the BUSY\_DIG\_SR bit in register *LORAC\_SR* is 0, if it is 0, it means that

RF TRX is currently free for communication.

1. Clear REG\_NSS bit in register *LORAC\_NSS\_CR*.
2. Write data into register *SSP\_DR* which belonging to the internal SSP of LoRa Controller.
3. Wait for the transmission to be completed.
4. Read back the data through register *SSP\_DR*.
5. Repeat Steps 4 ~ Step 6 as required.
6. Set the REG\_NSS bit in register *LORAC\_NSS\_CR*.

**12.3.2** **Timing Sequence of Power-on**



**Figure 12-1 Timing Sequence of Power-on**

As shown in the figure above, the process of power-on is:

1. Set NRESET\_BAT bit in register *LORAC\_CR1*.
2. Clear POR\_BAT bit in register *LORAC\_CR1*.
3. Wait for the BUSY\_DIG\_SR bit in register *LORAC\_SR* to be cleared.

Tpor\_min is 100 µs and Tnrst\_min is 50 µs.

12.3.3 **Interrupts**

The LoRa Controller transparently transmits the RF TRX interrupt request, and generates

the interrupt signal. Note that once the interrupt request of the LoRa Controller is triggered,

software must send the *ClearIrqStatus* command to the RF TRX to clear the interrupt, otherwise

the interrupt request will be triggered again.

#### 12.4 LoRaC Registers

LORAC Base Address: 0x40009000

**Table 12-1 LORAC Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| SSP\_CR0 | 0x000 | LORAC Internal SSP Control Register 0 |
| SSP\_CR1 | 0x004 | LORAC Internal SSP Control Register 1 |
| SSP\_DR | 0x008 | LORAC Internal SSP Data Register |
| SSP\_SR | 0x00C | LORAC Internal SSP Status Register |
| SSP\_CPSR | 0x010 | LORAC Internal SSP Clock Prescaler Register |
| SSP\_IMSC | 0x014 | LORAC Internal SSP Interrupt Mask Set/Clear Register |
| SSP\_RIS | 0x018 | LORAC Internal SSP Raw Interrupt Status register |
| SSP\_MIS | 0x01C | LORAC Internal SSP Masked Interrupt Status register |
| SSP\_ICR | 0x020 | LORAC Internal SSP Interrupt Clear Register |
| SSP\_DMACR | 0x024 | LORAC Internal SSP DMA Control Register |
| RESERVED | 0x028-0x0FC | Must be kept, and cannot be modified |
| LORAC\_CR0 | 0x100 | LORAC Control Register 0 |
| LORAC\_CR1 | 0x104 | LORAC Control Register 1 |
| LORAC\_SR | 0x108 | LORAC Status Register |
| LORAC\_NSS\_CR | 0x10C | LORAC NSS Control Register |
| LORAC\_SCK\_CR | 0x110 | LORAC SCK Control Register |
| LORAC\_MOSI\_CR | 0x114 | LORAC MOSI Control Register |
| LORAC\_MISO\_SR | 0x118 | LORAC MISO Status Register |

##### 12.4.1 SSP\_CR0

Offset: 0x00

Reset Value: 0x00000000

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-16** | **15-8** | **7** | **6** | **5-4** | **3-0** |
| RESERVED | SCR | SPH | SPO | FRF | DSS |
| r | r/w | r/w | r/w | r/w | r/w |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-8 SCR:** Serial clock rate, used to set the SSP transfer rate.



The formula to calculate the SSP transfer rate is as above, where CPSDVR is an even number ranging from 2 to 254.

**Bit 7 SPH:** SSP phase setting, only applied in Motorola SPI format.

**Bit 6 SPO:** SSP polarity setting, only applied in Motorola SPI format.

**Bits 5-4 FRF:** SSP frame formats setting.

* 0: Motorola SPI
* 1: Texas Instruments SPI
* 2: National Semiconductor Microwire
* 3: reserved

**Bits 3-0 DSS:** Data width setting.

* 0: reserved
* 1: reserved
* 2: reserved
* 3: 4 bits
* 4: 5 bits
* 5: 6 bits
* 6: 7 bits
* 7: 8 bits
* 8: 9 bits
* 9: 10 bits
* 10: 11 bits
* 11: 12 bits
* 12: 13 bits
* 13: 14 bits
* 14: 15 bits
* 15: 16 bits

##### 12.4.2 SSP\_CR1

Offset: 0x04

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | SOD | MS | SSE | LBM |
| r | r/w | r/w | r/w | r/w |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 SOD:** SSP output disable in slave mode.

* 0: SSP output enabled in slave mode
* 1: SSP output disabled in slave mode

**Bit 2 MS:** Master/slave mode selection.

* 0: master mode
* 1: slave mode

**Bit 1 SSE:** SSP enable.

* 0: disabled
* 1: enabled

**Bit 0 LBM:** loopback mode.

* 0: normal mode
* 1: loopback mode

##### 12.4.3 SSP\_DR

Offset: 0x08

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | DATA |
| r | r/w |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 DATA:** SSP TX/RX data.

##### 12.4.4 SSP\_SR

Offset: 0x0C

Reset Value: 0x00000003

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | BSY | RFF | RNE | TNF | TFE |
| r | r | r | r | r | r |

**Bits 31-5 RESERVED:** Must be kept, and cannot be modified.

**Bit 4 BSY:** SSP busy flag.

* 0: SSP is idle
* 1: SSP transfer in progress

**Bit 3 RFF:** RX FIFO full flag.

* 0: RX FIFO is not full
* 1: RX FIFO is full

**Bit 2 RNE:** RX FIFO not empty flag.

* 0: RX FIFO is empty
* 1: RX FIFO is not empty

**Bit 1 TNF:** TX FIFO not full flag.

* 0: TX FIFO is full
* 1: TX FIFO is not full

**Bit 0 TFE:** TX FIFO empty flag.

* 0: TX FIFO is not empty
* 1: TX FIFO is empty

##### 12.4.5 SSP\_CPSR

Offset: 0x00C

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | CPSDVSR |
| r | r/w |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 CPSDVSR:** Clock prescaler divider, must be an even number between 2~254.

###### 12.4.6 SSP\_IMSC

Offset: 0x010

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | TXIM | RXIM | RTIM | RORIM |
| r | r/w | r/w | r/w | r/w |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 TXIM:** TX interrupt mask bit.

* 0: TX interrupt is masked
* 1: TX interrupt is not masked

**Bit 2 RXIM:** RX interrupt mask bit.

* 0: RX interrupt is masked
* 1: RX interrupt is not masked

**Bit 1 RTIM:** RX timeout interrupt mask bit.

* 0: RX timeout interrupt is masked
* 1: RX timeout interrupt is not masked

**Bit 0 RORIM:** RX overrun interrupt mask bit.

* 0: RX overrun interrupt is masked
* 1: RX overrun interrupt is not masked

##### 12.4.7 SSP\_RIS

Offset: 0x014

Reset Value: 0x00000008

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | TXRIS | RXRIS | RTRIS | RORRIS |
| r | r | r | r | r |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 TXRIS:** TX raw interrupt status.

**Bit 2 RXRIS:** RX raw interrupt status.

**Bit 1 RTRIS:** RX timeout raw interrupt status.

**Bit 0 RORRIS:** RX overrun raw interrupt status.

##### 12.4.8 SSP\_MIS

Offset: 0x018

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | TXMIS | RXMIS | RTMIS | RORMIS |
| r | r | r | r | r |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 TXMIS:** TX masked interrupt status.

**Bit 2 RXMIS:** RX masked interrupt status.

**Bit 1 RTMIS:** RX timeout masked interrupt status.

**Bit 0 RORMIS:** RX overrun masked interrupt status.

##### 12.4.9 SSP\_ICR

Offset: 0x01C

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-2** | **1** | **0** |
| RESERVED | RTIC | RORIC |
| r | w | w |

**Bits 31-2 RESERVED:** Must be kept, and cannot be modified.

**Bit 1 RTIC:** RX timeout interrupt clear. This bit is cleared by software writing 1 to it, writing 0 has no effect.

**Bit 0 RORIC:** RX overrun interrupt clear. This bit is cleared by software writing 1 to it, writing 0 has no effect.

##### 12.4.10 SSP\_DMACR

Offset: 0x020

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-2** | **1** | **0** |
| RESERVED | TXDMAE | RXDMAE |
| r | r/w | r/w |

**Bits 31-2 RESERVED:** Must be kept, and cannot be modified.

**Bit 1 TXDMAE:** DMA TX enable.

* 0: DMA TX disabled
* 1: DMA TX enabled

**Bit 0 RXDMAE:** DMA RX enable.

* 0: DMA RX disabled
* 1: DMA RX enabled

##### 12.4.11 LORAC\_CR0

Offset: 0x100

Reset Value: 0x00000000

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-11** | **10** | **9** | **8** | **7-5** | **4-0** |
| RESERVED | NSS\_SEL | SCK\_MOSI\_SEL | RESERVED | IRQ\_DIG\_INT\_EN | RESERVED |
| r | r/w | r/w | r | r/w | r |

**Bits 31-11 RESERVED:** Must be kept, and cannot be modified.

**Bit 10 NSS\_SEL:** NSS source selection for RF TRX.

* 0: from register LORAC\_NSS\_CR
* 1: from internal SSP of LORAC

**Bit 9 SCK\_MOSI\_SEL:** SCK/MOSI/MISO source selection for RF TRX.

* 0: from LORAC\_SCK\_CR, LORAC\_MOSI\_CR and LORA\_MISO\_SR
* 1: from internal SSP of LORAC

**Bit 8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-5 IRQ\_DIG\_INT\_EN:** IRQ\_DIG\_INT high level interrupt enable.

Bit[5] corresponds to IRQ\_DIG[0], bit[6] corresponds to IRQ\_DIG[1] and bit[7] corresponds to

IRQ\_DIG[2].

* 0: disabled
* 1: enabled

**Bits 4-0 RESERVED:** Must be kept, and cannot be modified.

##### 12.4.12 LORAC\_CR1

Offset: 0x104

Reset Value: 0x00000080

|  |  |  |  |
| --- | --- | --- | --- |
| **31-8** | **7** | **6** | **5** |
| RESERVED | POR\_BAT | RESERVED | NRESET\_BAT |
| r | r/w | r | r/w |
| **4-3** | **2** | **1** | **0** |
| RESERVED | CLK\_32M\_EN\_BAT | TCXO\_EN\_BAT | PWRTCXO\_EN\_BAT |
| r | r/w | r/w | r/w |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bit 7 POR\_BAT:** POR\_BAT control.

* 0: no reset
* 1: reset

**Bit 6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 NRESET\_BAT:** NRESET\_BAT control.

* 0: reset
* 1: no reset

**Bits 4-3 RESERVED:** Must be kept, and cannot be modified.

**Bit 2 CLK\_32M\_EN\_BAT:** CLK\_32M\_EN\_BAT control.

* 0: disabled
* 1: enabled

**Bit 1 TCXO\_EN\_BAT:** TCXO\_EN\_BAT control.

* 0: disabled
* 1: enabled

**Bit 0 PWRTCXO\_EN\_BAT:** PWRTCXO\_EN\_BAT control.

* 0: disabled
* 1: enabled

##### 12.4.13 LORAC\_SR

Offset: 0x108

Reset Value: 0x00000100

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-9** | **8** | **7-5** | **4-2** | **1** | **0** |
| RESERVED | BUSY\_DIG\_SR | IRQ\_DIG\_SR | RESERVED | CLK\_32M\_RDY\_BAT  \_SR | RESERVED |
| r | r | r | r | r | r |

**Bits 31-9 RESERVED:** Must be kept, and cannot be modified.

**Bit 8 BUSY\_DIG\_SR:** BUSY\_DIG status flag, it indicates whether the RF TRX is busy with

processing commands. This bit is set and cleared by hardware.

* 0: RF TRX is not busy
* 1: RF TRX is busy with processing commands

**Bits 7-5 IRQ\_DIG\_SR:** IRQ\_DIG flag, it indicates the RF TRX interrupt request. This bit is set and cleared by hardware. Noted that once the interrupt request is triggered, software must send the *ClearIrqStatus* command to the RF TRX to clear the interrupt, otherwise the interrupt request will be triggered again.

* 0: no interrupt
* 1: interrupt occurred

**Bits 4-2 RESERVED:** Must be kept, and cannot be modified.

**Bit 1 CLK\_32M\_RDY\_BAT\_SR:** CLK\_32M\_RDY\_BAT status flag, it indicates whether the XO32M clock for RF TRX is ready. This bit is set and cleared by hardware.

* 0: not ready
* 1: ready

**Bit 0 RESERVED:** Must be kept, and cannot be modified.

##### 12.4.14 LORAC\_NSS\_CR

Offset: 0x10C

Reset Value: 0x00000001

|  |  |
| --- | --- |
| **31-1** | **0** |
| RESERVED | REG\_NSS |
| r | r/w |

**Bits 31-1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 REG\_NSS:** NSS control bit.

* 0: pull down NSS pin
* 1: pull up NSS pin

##### 12.4.15 LORAC\_SCK\_CR

Offset: 0x110

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-1** | **0** |
| RESERVED | REG\_SCK |
| r | r/w |

**Bits 31-1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 REG\_SCK:** SCK control bit

* 0: pull down SCK pin
* 1: pull up SCK pin

##### 12.4.16 LORAC\_MOSI\_CR

Offset: 0x114

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-1** | **0** |
| RESERVED | REG\_MOSI |
| r | r/w |

**Bits 31-1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 REG\_MOSI:** MOSI control bit.

* 0: pull down MOSI pin
* 1: pull up MOSI pin

##### 12.4.17 LORAC\_MISO\_SR

Offset: 0x118

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-1** | **0** |
| RESERVED | REG\_MISO |
| r | r |

**Bits 31-1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 REG\_MISO:** MISO status flag, it indicates the status of MISO (RF TRX output pin). This bit is set and cleared by hardware.

* 0: low
* 1: high

### 13. UART

#### 13.1 Introduction

ASR6601 UART unit supports UART and IrDA modes. 

* **UART mode:**
*  Independent Receive FIFO and transmit FIFO
*  FIFO enable (16 deep) or disable (1 deep)
*  Programmable FIFO trigger levels: 1 /8, 1 /4, 1 /2, 3 /4, 7 /8
*  Baud rate divisor: 16-bit integer part and 6-bit fractional part
*  Standard asynchronous communication bits: support 5, 6, 7 or 8 data bits, the parity bit and 1 or 2 stop bits
*  Support DMA
*  Support false start bit detection
*  Support line break generation and detection
*  Support hardware flow control
* **IrDA mode:**
* Support the maximum baud rates (460800 bps) in IrDA mode, and the maximum baud rates (115200 bps) in Low-power IrDA mode (half-duplex)
* Support normal **3 /16** and low-power (1.41~2.23 µs) bit durations.
* Appropriate bit duration generated by the UARTCLK reference clock division in low power IrDA mode

Each UART port can be uniquely identified by the ID register.

**13.2 Clock and Reset**

Each UART has independent APB bus clock and independent APB bus reset.

13.3 **Reference Clock**

#### 

Each UART has independent APB bus clock and independent APB bus reset.

***FUARTCLK(min) >= 16 x baudrate(max) F UARTCLK(max) <= 16 x 65535 x baudrate(min)***

For example, to generate baud rates from 110 bps to 460800 bps, the UARTCLK frequency

must be between 7.3728 MHz to 115.34 MHz.

In the meantime, the UARTCLK frequency cannot be greater than **5 /3** times the frequency of

PCLK：

***FUARTCLK <= 5/3 \* FPCLK***

For example, in UART mode, when UARTCLK is 14.7456 MHz, to generate 921600 baud,

PCLK must be greater than or equal to 8.85276 MHz. This ensures that the UART has enough

time to write the received data into the receive FIFO.

13.4 **Baud Rate Generator**

#### 

The baud rate generator contains free-running counters that generate the internal ×16 clocks,

*Baud16* and *IrLPBaud16*. *Baud16* provides timing information for UART transmission and

reception control. *Baud16* is a pulse stream with a width of one UARTCLK clock cycle and a

frequency of 16 times the baud rate. *IrLPBaud16* provides timing information to generate the

pulse width of the IrDA encoded transmit bit stream in low-power IrDA mode.

##### 13.5 FIFO

The transmit FIFO and receive FIFO are independent, and they are enabled or disabled by the

FEN bit in the UART Line Control Register (*UARTx\_LCR\_H*). The transmit FIFO is an 8-bit

wide and 16 deep FIFO memory buffer. The receive FIFO is a 12-bit wide and 16 deep FIFO

memory buffer, and it has four extra bits per character for status information. You can program

the watermark level to 1 /8, 1 /4, 1 /2, 3 /4 or 7 /8 for each FIFO through the Interrupt FIFO Level

Selection Register (*UARTx\_IFLS*). When FIFO is disabled, the depth is 1 byte. The FIFO status

can be read from the Flag Register (*UARTx\_FR*).

Bits[10:8] of the receive FIFO are error bits indicating associated errors. Bit[11] of the receive

FIFO serves as an overrun indicator.

**Table 13-1 Receive FIFO Bit Functions**

###### 

|  |  |
| --- | --- |
| FIFO Bit | Function |
| 11 | Overrun indicator |
| 10 | Break error |
| 9 | Parity error |
| 8 | Framing error |
| 7:0 | Received data |

13.6 UART **Operation**

13.6.1 **Baud Rate Divisor**

The baud rate divisor consists of a 16-bit integer and a 6-bit fractional part. The 16-bit integer

is written to register *UARTx\_IBRD*. The 6-bit fractional part is written to register *UARTx\_FBRD*.

The fractional baud rate divider enables the use of any clock with a frequency >3.6864 MHz to

act as UARTCLK, while it is still possible to generate all the standard baud rates. The Baud

Rate Divisor has the following relationship to UARTCLK:

*Baud Rate Divisor = UARTCLK / (16 x BautRate) = BRDI + BRDF*

BRDI is the integer part and BRDF is the fractional part separated by a decimal point:

|  |  |  |
| --- | --- | --- |
| 16-bit Integer Part | **.** | 6-bit Fractional Part |

The 6-bit number can be calculated by taking the fractional part of the required baud rate divisor

and multiplying it by 64 (that is, 2n , where n is the effective width of the *UARTx\_FBRD* register)

and adding 0.5 to account for rounding errors:

***Fractional Part = BRDF x 2n + 0.5***

13.6.2 **Data Transmission**

###### 

Data received or transmitted is stored in two 16-Byte FIFOs, and the receive FIFO has four

extra bits per character for status information.

For transmission, data is written into the TX FIFO through the Data Register (*UARTx\_DR*).

Enable the UART through the UARTEN bit in the Data Register (*UARTx\_CR*), then data starts

transmitting with the data bit, stop bits, parity bit and other parameters indicated in the Line

Control Register (*UARTx\_LCR\_H*) until the TX FIFO is empty. Once data is written into the TX

FIFO, the BUSY signal goes high and remains high while data is being transmitted. Only when

the TX FIFO is empty and the stop bits included in the last character have been transmitted

from the shift register, the BUSY signal will go low. Even though the UART is no longer enabled,

the BUSY signal is still high.

13.6.3 **Data Reception**

###### 

Enable the UART through the UARTEN bit in the Control Register (*UARTx\_CR*) and configure

the data width, stop bits, parity bit and other parameters by the Line Control Register

(*UARTx\_LCR\_H*).

When the receiver is idle, UARTRXD is pulled low, Baud16 enables the receive counter to start

running, and data is sampled on the 8th cycle of that counter in UART mode or the 4th cycle of

the counter in IrDA mode to allow for the shorter logic 0 pulses.

If UARTRXD remains low on the 8th cycle of Baud16, then a valid start bit is detected, otherwise

a false start bit is detected and is ignored.

If the start bit is valid, then data sampling is performed every 16th cycle of Baud16 according

to the length configured by the WLEN bit in register *UARTx\_LCR\_H*. If parity mode is enabled,

the parity bit will be checked.

Finally, if UARTRXD is high, a valid stop bit is confirmed, otherwise a framing error is occurred.

The full character received is stored in the RX FIFO along with the associated error bits.

13.7 IrDA SIR **Operation**

##### 

The IrDA SIR ENDEC provides the function of converting between an UART data stream and

half-duplex serial SIR interface. The role of the SIR ENDEC is to provide a digital encoded

output, and decoded input to the UART. There are two modes of operation:

* **In IrDA mode**, a zero logic level is transmitted as high pulse, and the pulse width is

specified as **3 /16** of the selected baud rate bit period on the nSIROUT signal, while logic

one levels are transmitted as a LOW signal.

* **In low-power IrDA mode**, the width of the transmitted infrared pulse is set to three times

the period of the internally generated IrLPBaud16 signal (1.63 µs, assuming a nominal

frequency of 1.842 MHz).

The IrDA SIR physical layer specifies a half-duplex communication link, with a minimum 10ms

delay between transmission and reception. This delay must be generated by software because

it is not supported by the UART. The delay is required because the infrared receiver circuits

might become biased.

13.7.1 **Low-Power Divisor**

###### 

The IrLPBAUD16 signal is generated by dividing the UARTCLK signal according to the low

power divider value configured by the ILPDVSR bit in register *UARTx\_ILPR*.

***Low-Power Divider = (FUARTCLK / FIrLPBAUD16)***

FIrLPBAUD16 is nominally 1.8432 MHz, which meets the requirement of **1.42MHz < FIrLPBAUD16 <**

**2.12MHz**.

13.7.2 IrDA SIR **Transmit Encoder**

###### 

The SIR transmit encoder modulates the NRZ (Non Return-to-Zero) transmit bit stream output

from the UART. The IrDA SIR physical layer specifies use of a RZI (Return to Zero, Inverted)

modulation scheme, which represents logic 0 as an infrared light pulse. The modulated output

pulse stream is transmitted to an external output driver and infrared LED.

In IrDA mode the transmitted pulse width is specified as three times the period of the internal

×16 clock (Baud16), that is, **3 /16** of a bit period.

In low-power IrDA mode the transmit pulse width is specified as **3 /16** of a 115200 bps bit period.

This is implemented as three times the period of a nominal 1.8432 MHz clock (IrLPBaud16).

In normal and low-power IrDA modes, when the fractional baud rate divider is used, the

transmitted SIR pulse stream includes more jitter. The is because the Baud16 pulses cannot

be generated at regular intervals when fractional division is used. That is, the Baud16 cycles

have a different number of UARTCLK cycles. The worst case jitter in the SIR pulse stream can

be up to three UARTCLK cycles. Provided that the UARTCLK is > 3.6864 MHz and the baud

rate used for IrDA mode is ≤ 115200 bps, the jitter is less than 9%. This is within the limits of

the SIR IrDA Specification where the maximum amount of jitter permitted is 13%.

13.7.3 IrDA SIR **Receive Decoder**

###### 

The SIR receive decoder demodulates the Return-to-Zero bit stream from the infrared detector

and outputs the received NRZ serial bit stream to the UART received data input. The decoder

input is normally HIGH in the idle state. The transmit encoder output has the opposite polarity

to the decoder input.

A START bit is detected when the decoder input is LOW.

To prevent the UART from responding to glitches on the received data input, SIRIN pulses less

than **3 /16** of Baud16 will be ignored in IrDA mode; and SIRIN pulses less than **3 /16** of IrLPBaud16

will be ignored in low-power IrDA mode.

13.8 UART **Character Frame**

##### 

The UART character frame is shown below.



**Figure 13-1 UART Character Frame**

13.9 IrDA **Data Modulation**

The IrDA **3 /16** data modulation is shown below.



**Figure 13-2 IrDA Data Modulation (3 /16)**

13.10 **Hardware Flow Control**

##### 

The hardware flow control is selectable using the CTSEn and RTSEn bits in the *UARTx\_CR*

Register.

When RTS flow control is enabled, the nUARTRTS signal is asserted until the receive FIFO is

filled up to the watermark level.

When the CTS flow control is enabled, the transmitter can only transfer data when nUARTCTS

signal is asserted and the transmit FIFO is not empty.

##### 13.11 Interrupts

The UART supports the generation of Tx Done, Rx Done, Rx Timeout, Frame Error, Break Error,

Parity Error and Overrun Error interrupts. The individual interrupts can be enabled or disabled

by configuring the mask bits in the Interrupt Mask Set/Clear Register (*UARTx\_IMSC*). The

status of all interrupt signals, including the interrupt bits that are disabled, can be read from the

Raw Interrupt Status Register (*UARTx\_RIS*). The status of the enabled interrupt signals can

be read from the Masked Interrupt Status Register (*UARTx\_MIS*). The interrupt is cleared by

writing “1” to the corresponding bit in the Interrupt Clear Register (*UARTx\_ICR*).

**13.12 DMA**

The UART module supports DMA transmission and reception, which is configured by register

*UARTx\_DMACR*.

##### 13.13 UART Registers

UART0 Base Address: 0x40003000

UART1 Base Address: 0x40004000

UART2 Base Address: 0x40010000

UART3 Base Address: 0x40011000

**Table 13-2 UART Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| UARTx\_DR | 0x000 | Data Register |
| UARTx\_RSR\_ECR | 0x004 | Receive Status Register/Error Clear Register |
| UARTx\_RSV0[4] | 0x008 | 4 x 4 Bytes reserved |
| UARTx\_FR | 0x018 | Flag Register |
| UARTx\_RSV1 | 0x01C | 4 Bytes reserved |
| UARTx\_ILPR | 0x020 | IrDA Low-Power Counter Register |
| UARTx\_IBRD | 0x024 | Integer Baud Rate Register |
| UARTx\_FBRD | 0x028 | Fractional Baud Rate Register |
| UARTx\_LCR\_H | 0x02C | Line Control Register |
| UARTx\_CR | 0x030 | Control Register |
| UARTx\_IFLS | 0x034 | Interrupt FIFO Level Selection Register |
| UARTx\_IMSC | 0x038 | Interrupt Mask Set/Clear Register |
| UARTx\_RIS | 0x03C | Raw Interrupt Status Register |
| UARTx\_MIS | 0x040 | Masked Interrupt Status Register |
| UARTx\_ICR | 0x044 | Interrupt Clear Register |
| UARTx\_DMACR | 0x048 | DMA Control Register |
| UARTx\_RSV2[997] | 0x04C | 4 x 997 Bytes reserved |

###### 13.13.1 UARTx\_DR (x=0, 1, 2, 3)

Offset: 0x000

Reset Value: 0x00000000

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-12** | **11** | **10** | **9** | **8** | **7-0** |
| RESERVED | OE | BE | PE | FE | DATA |
| r-0h | r-0h | r-0h | r-0h | r-0h | rw-0h |

**Bits 31-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 OE:** Overrun error flag.

* 0: no overrun error
* 1: overrun occurred

**Bit 10 BE:** Break error flag.

* 0: no break error
* 1: break error occurred

When this bit is set, it indicates that the received data input was held LOW for longer than a full-word (defined as start, data, parity and stop bits) transmission time.

In FIFO mode, this error is associated with the character at the top of the FIFO. When a break occurs, only

one 0 character is loaded into the FIFO.

**Bit 9 PE:** Parity error flag.

* 0: no parity error
* 1: parity error occurred

When this bit is set, it indicates that the parity of the received data character does not match the configuration of the EPS bit in the *UARTx\_LCR\_H* Register.

In FIFO mode, this error is associated with the character at the top of the FIFO.

**Bit 8 FE:** Framing error flag.

* 0: no framing error
* 1: framing error occurred

When this bit is set, it indicates that the received character did not have a valid stop bit.

In FIFO mode, this error is associated with the character at the top of the FIFO.

**Bits 7-0 DATA:** Transmit data character/Receive data character.

###### 13.13.2 UARTx\_RSR\_ECR (x=0, 1, 2, 3)

Offset: 0x004

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | OE | BE | PE | FE |
| r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 OE:** Overrun error flag.

* 0: no overrun error
* 1: overrun occurred

**Bit 2 BE:** Break error flag.

* 0: no break error
* 1: break error occurred

When this bit is set, it indicates that the received data input was held LOW for longer than a full-word (defined as start, data, parity and stop bits) transmission time.

In FIFO mode, this error is associated with the character at the top of the FIFO. When a break occurs, only one 0 character is loaded into the FIFO.

**Bit 1 PE:** Parity error flag.

* 0: no parity error
* 1: parity error occurred

When this bit is set, it indicates that the parity of the received data character does not match the configuration of the EPS bit in the *UARTx\_LCR\_H* Register.

In FIFO mode, this error is associated with the character at the top of the FIFO.

**Bit 0 FE:** Framing error flag.

* 0: no framing error
* 1: framing error occurred

When this bit is set, it indicates that the received character did not have a valid stop bit.

In FIFO mode, this error is associated with the character at the top of the FIFO.

13.13.3 UARTx\_FR (x=0, 1, 2, 3)

Offset: 0x018

Reset Value: 0x00000000

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **31-8** | **7** | **6** | **5** | **4** | **3** | **2-0** |
| RESERVED | TXFE | RXFF | TXFF | RXFE | BUSY | RESERVED |
| r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bit 7 TXFE:** Transmit FIFO empty.

* 0: transmit FIFO/UART\_DR register not empty
* 1: transmit FIFO/UART\_DR empty

This bit is associated with the FEN bit in the *UARTx\_LCR\_H* register.

This bit does not indicate if there is data in the transmit shift register.

**Bit 6 RXFF:** Receive FIFO full.

* 0: receive FIFO/UART\_DR not full
* 1: receive FIFO/UART\_DR full

This bit is associated with the FEN bit in the *UARTx\_LCR\_H* register.

**Bit 5 TXFF:** Transmit FIFO full.

* 0: transmit FIFO/UART\_DR not full
* 1: transmit FIFO/UART\_DR full

This bit is associated with the FEN bit in the *UARTx\_LCR\_H* register.

**Bit 4 RXFE:** Receive FIFO empty.

* 0: receive FIFO/UART\_DR not empty
* 1: receive FIFO/UART\_DR empty

This bit is associated with the FEN bit in the *UARTx\_LCR\_H* register.

**Bit 3 BUSY:** UART busy.

* 0: no transfer
* 1: transfer in progress

This bit is set to 1 as soon as the transmit FIFO becomes non-empty, irrespective of whether the UART is enabled or not.

**Bits 2-0 RESERVED:** Must be kept, and cannot be modified.

13.13.4 UARTx\_ILPR (x=0, 1, 2, 3)

Offset: 0x020

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | ILPDVSR |
| r-0h | rw-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 ILPDVSR:** low-power divisor value. Zero is an illegal value. Writing “0” results in no

generation of IrLPBaud16 pulses.

13.13.5 UARTx\_IBRD (x=0, 1, 2, 3)

Offset: 0x024

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | BAUD\_DIVINT |
| r-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 BAUD\_DIVINT:** The integer baud rate divisor.

13.13.6 UARTx\_FBRD (x=0, 1, 2, 3)

Offset: 0x028

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-6** | **5-0** |
| RESERVED | BAUD\_DIVFRAC |
| r-0h | rw-0h |

**Bits 31-6 RESERVED:** Must be kept, and cannot be modified.

**Bits 5-0 BAUD\_DIVFRAC:** The fractional baud rate divisor.

13.13.7 UARTx\_LCR\_H (x=0, 1, 2, 3)

Offset: 0x02C

Reset Value: 0x00000000

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **31-7** | **6-5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | WLEN | FEN | STP2 | EPS | PEN | BRK |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bits 6-5 WLEN:** Word length.

* 00: 5 bits
* 01: 6 bits
* 10: 7 bits
* 11: 8 bits

**Bit 4 FEN:** FIFO enable.

* 0: FIFO disabled
* 1: FIFO enabled

**Bit 3 STP2:** Stop bits selection.

* 0: 1 stop bit
* 1: 2 stop bits

**Bit 2 EPS:** Parity selection.

* 0: odd parity
* 1: even parity

This bit has no effect if the PEN bit is 0.

**Bit 1 PEN:** Parity enable.

* 0: parity checking disabled
* 1: parity checking enabled.

**Bit 0 BRK:** Send break.

* write 0: end the Break command
* write 1: a low-level is continually output on the UART\_TXD pin, after completing transmission of the current character.

For the proper execution of the Break command, the software must set this bit for at least two complete frames.

13.13.8 UARTx\_CR (x=0, 1, 2, 3)

Offset: 0x030

Reset Value: 0x00000000

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-24** | | **23-16** | **15** | **14** | **13-10** |
| RESERVED | | RESERVED | CTSEn | RTSEn | RESERVED |
| r-0h | | r-0h | rw-0h | rw-0h | r-0h |
| **9** | **8** | **7-3** | **2** | **1** | **0** |
| RXE | TXE | RESERVED | SIRLP | SIREN | UARTEN |
| rw-0h | rw-0h | r-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bit 15 CTSEn:** CTS hardware flow control enable.

* 0: CTS hardware flow control disabled
* 1: CTS hardware flow control enabled

**Bit 14 RTSEn:** RTS hardware flow control enable.

* 0: RTS hardware flow control disabled
* 1: RTS hardware flow control enabled

**Bits 13-10 RESERVED:** Must be kept, and cannot be modified.

**Bit 9 RXE:** Receiver enable.

* 0: receiver disabled. If the UART is disabled during of reception, then it completes the current character before stopping.
* 1: receiver enabled

**Bit 8 TXE:** Transmitter enable.

* 0: transmitter disabled. If the UART is disabled during transmission, then it completes the current character before stopping.
* 1: transmitter enabled

**Bits 7-3 RESERVED:** Must be kept, and cannot be modified.

**Bit 2 SIRLP:** Low-power IrDA SIR encoding mode selection.

* 0: low-level bits are transmitted with a pulse width of **3 /16** of the bit period.
* 1: low-level bits are transmitted with a pulse width of 3 times the period of the IrLPBaud16 input signal. Setting this bit helps reduce power consumption, but might reduce transmission distances.

**Bit 1 SIRE:** IrDA SIR enable.

* 0: IrDA SIR ENDEC is disabled. SIR\_OUT remains LOW, and signal transitions on SIR\_IN are ignored. Data is transmitted and received on UART\_TXD and UART\_RXD.
* 1: IrDA SIR ENDEC is enabled. UARTTXD remains HIGH, and signal transitions on UART\_RXD are ignored. Data is transmitted and received on SIR\_OUT and SIR\_IN. This bit has no effect if the UARTEN bit is 0.

**Bit 0 UARTEN:** UART enable.

* 0: UART disabled. If the UART is disabled during transmission or reception, then it completes the current character before stopping.
* 1: UART enabled

13.13.9 UARTx\_IFLS (x=0, 1, 2, 3)

Offset: 0x034

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-6** | **5-3** | **2-0** |
| RESERVED | RXIFLSEL | TXIFLSEL |
| r-0h | rw-0h | rw-0h |

**Bits 31-6 RESERVED:** Must be kept, and cannot be modified.

**Bits 5-3 RXIFLSEL:** Receive interrupt FIFO level selection.

* 000: receive FIFO becomes ≥ **1 /8** full
* 001: receive FIFO becomes ≥ **1 /4** full
* 010: receive FIFO becomes ≥ **1 /2** full
* 011: receive FIFO becomes ≥ **3 /4** full
* 100: receive FIFO becomes ≥ **7 /8** full
* 101~111: reserved

**Bits 2-0 TXIFLSEL:** Transmit interrupt FIFO level selection.

* 000: transmit FIFO becomes ≥ **1/8** full
* 001: transmit FIFO becomes ≥ **1/4** full
* 010: transmit FIFO becomes ≥ **1/2** full
* 011: transmit FIFO becomes ≥ **3/4** full
* 100: transmit FIFO becomes ≥ **7/8** full
* 101~111: reserved

13.13.10 UARTx\_IMSC (x=0, 1, 2, 3)

Offset: 0x038

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **31-16** | **15-11** | **10** | **9** | **8** | **7** | **6** | **5** | **4** | **3-0** |
| RESERVED | RESERVED | OEIM | BEIM | PEIM | FEIM | RTIM | TXIM | RXIM | RESERVED |
| r-0h | r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | r-0h |

**Bits 31-11 RESERVED:** Must be kept, and cannot be modified.

**Bit 10 OEIM:** Overrun error interrupt mask bit.

* 0: overrun error interrupt disabled
* 1: overrun error interrupt enabled

**Bit 9 BEIM:** Break error interrupt mask bit.

* 0: break error interrupt disabled
* 1: break error interrupt enabled

**Bit 8 PEIM:** Parity error interrupt mask bit.

* 0: parity error interrupt disabled
* 1: parity error interrupt enabled

**Bit 7 FEIM:** Framing error interrupt mask bit.

* 0: framing error interrupt disabled
* 1: framing error interrupt enabled

**Bit 6 RTIM:** Receive timeout interrupt mask bit.

* 0: receive timeout interrupt disabled
* 1: receive timeout interrupt enabled

**Bit 5 TXIM:** Transmission completion interrupt mask bit.

* 0: transmission completion interrupt disabled
* 1: transmission completion interrupt enabled

**Bit 4 RXIM:** Reception completion interrupt mask bit.

* 0: reception completion interrupt disabled
* 1: reception completion interrupt enabled

**Bits 3-0 RESERVED:** Must be kept, and cannot be modified.

13.13.11 UARTx\_RIS (x=0, 1, 2, 3)

Offset: 0x03C

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **31-16** | **15-11** | **10** | **9** | **8** | **7** | **6** | **5** | **4** | **3-0** |
| RESERVED | RESERVED | OERIS | BERIS | PERIS | FERIS | RTRIS | TXRIS | RXRIS | RESERVED |
| r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 31-11 RESERVED:** Must be kept, and cannot be modified.

**Bit 10 OERIS:** Overrun error raw interrupt status.

**Bit 9 BERIS:** Break error raw interrupt status.

**Bit 8 PERIS:** Parity error raw interrupt status.

**Bit 7 FERIS:** Framing error raw interrupt status.

**Bit 6 RTRIS:** Receive timeout raw interrupt status.

**Bit 5 TXRIS:** Transmission completion raw interrupt status.

**Bit 4 RXRIS:** Reception completion raw interrupt status.

**Bits 3-0 RESERVED:** Must be kept, and cannot be modified.

13.13.12 UARTx\_MIS (x=0, 1, 2, 3)

Offset: 0x040

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **31-16** | **15-11** | **10** | **9** | **8** | **7** | **6** | **5** | **4** | **3-0** |
| RESERVED | RESERVED | OEMIS | BEMIS | PEMIS | FEMIS | RTMIS | TXMIS | RXMIS | RESERVED |
| r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 31-11 RESERVED:** Must be kept, and cannot be modified.

**Bit 10 OEMIS:** Overrun error masked interrupt status.

**Bit 9 BEMIS:** Break error masked interrupt status.

**Bit 8 PEMIS:** Parity error masked interrupt status.

**Bit 7 FEMIS:** Framing error masked interrupt status.

**Bit 6 RTMIS:** Receive timeout masked interrupt status.

**Bit 5 TXMIS:** Transmission completion masked interrupt status.

**Bit 4 RXMIS:** Reception completion masked interrupt status.

**Bits 3-0 RESERVED:** Must be kept, and cannot be modified.

13.13.13 UARTx\_ICR (x=0, 1, 2, 3)

Offset: 0x044

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **31-16** | **15-11** | **10** | **9** | **8** | **7** | **6** | **5** | **4** | **3-0** |
| RESERVED | RESERVED | OEIC | BEIC | PEIC | FEIC | RTIC | TXIC | RXIC | RESERVED |
| r-0h | r-0h | w-0h | w-0h | w-0h | w-0h | w-0h | w-0h | w-0h | r-0h |

**Bits 31-11 RESERVED:** Must be kept, and cannot be modified.

**Bit 10 OEIC:** Clear Overrun Error interrupt.

* 0: no action
* 1: clear overrun error interrupt

**Bit 9 BEIC:** Clear Break Error interrupt.

* 0: no action
* 1: clear break error interrupt

**Bit 8 PEIC:** Clear Parity Error interrupt.

* 0: no action
* 1: clear parity error interrupt

**Bit 7 FEIC:** Clear Framing Error interrupt.

* 0: no action
* 1: clear framing error interrupt

**Bit 6 RTIC:** Clear Receive Timeout interrupt.

* 0: no action
* 1: clear receive timeout interrupt

**Bit 5 TXIC:** Clear Transmission Completion interrupt.

* 0: no action
* 1: clear transmission completion interrupt

**Bit 4 RXIC:** Clear Reception Completion interrupt.

* 0: no action
* 1: clear reception completion interrupt

**Bits 3-0 RESERVED:** Must be kept, and cannot be modified.

###### 13.13.14 UARTx\_DMACR (x=0, 1, 2, 3)

Offset: 0x048

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-3** | **2** | **1** | **0** |
| RESERVED | DMAONERR | TXDMAE | RXDMAE |
| r-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-3 RESERVED:** Must be kept, and cannot be modified.

**Bit 2 DMAONERR:** DMA on error.

**Bit 1 TXDMAE:** Transmit DMA enable.

* 0: disabled
* 1: enabled

**Bit 0 RXDMAE:** Receive DMA enable.

* 0: disabled
* 1: enabled

13.13.15 UARTx\_ID[8] (x=0, 1, 2, 3)

13.13.15.1 PeriphID0

Offset: 0x0FE0

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | PARTNUMBER0 |
| r-0h | r-11h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 PARTNUMBER0:** 0x11.

13.13.15.2 PeriphID1

Offset: 0x0FE4

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-8** | **7-4** | **3-0** |
| RESERVED | DESIGNER0 | PARTNUMBER1 |
| r-0h | r-1h | r-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-4 DESIGNER0:** 0x1.

**Bits 3-0 PARTNUMBER1:** 0x0.

13.13.15.3 PeriphID2

Offset: 0x0FE8

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-8** | **7-4** | **3-0** |
| RESERVED | REVISION0 | DESIGNER1 |
| r-0h | r-xh | r-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-4 REVISION0:**

* 0x0: r1p0
* 0x1: r1p1
* 0x2: r1p3/r1p4
* 0x3: r1p5

**Bits 3-0 DESIGNER1:** 0x0.

13.13.15.4 PeriphID3

Offset: 0x0FEC

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | CONFIGURATION |
| r-0h | r-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 CONFIGURATION:** 0x00.

13.13.15.5 PCellID0

Offset: 0x0FD0

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | CellID0 |
| r-0h | r-dh |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 CellID0:** 0x0d.

13.13.15.6 PCellID1

Offset: 0x0FD4

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | CellID1 |
| r-0h | r-f0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 CellID1:** 0xf0.

13.13.15.7 PCellID2

Offset: 0x0FD8

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | CellID2 |
| r-0h | r-5h |

**Bits 31-8** RESERVED: Must be kept, and cannot be modified.

**Bits 7-0** CellID2**:** 0x05.

13.13.15.8 PCellID3

Offset: 0x0FDC

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | CellID3 |
| r-0h | r-b1h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 CellID3:** 0xb1.

### 14. (SSP)

#### 14.1 Introduction

All three SSP (synchronous serial port) can be configured as a master or slave device.

SSP support multiple frame formats, with configurable data width and transfer rate.

#### 14.2 Main features

* Master or slave operation
* Up to 16 MHz output
* 16-bit wide TX/RX FIFO with a depth of 8
* Multiple frame formats
* 4-bit to 16-bit data width
* DMA
* Interrupt signal generation

14.3 **Functional** Description

**14.3.1 Basic Information**

Four I/O pins (SSP\_NSS, SSP\_CLK, SSP\_TX, SSP\_RX) are dedicated to SSP communication

with external devices.

1. **SSP\_NSS**

The chip select pin is active at low level.

1. **SSP\_CLK**

SSP clock pin acts as clock output in master mode and as the clock input in slave

mode.

1. **SSP\_TX**

The SSP TX pin is used to transmit data in both master and slave modes.

1. **SSP\_RX**

The SSP RX pin is used to receive data in both master and slave modes.

The connection between SSP and SPI device is shown in the figure below. Note the difference

between SSP\_TX/SSP\_RX and SPI\_MOSI/SPI\_MISO.



**Figure 14-1 Connection between a SSP Master and a SPI Slave**



**Figure 14-2 Connection between a SPI Master and a SSP Slave**

**14.3.2 Clock Division**

##### 

SSP clock should meet below requirements:

1. Up to 16 MHz output clock
2. The clock frequency in master mode is at most 1/2 of PCLK clock frequency
3. The clock frequency in slave mode is at most 1/12 of PCLK clock frequency

The formula to calculate clock output in master mode is below:



**Figure 14-3 The Formula to Calculate Clock Output in Master Mode**

###### 

SSPCLK is the interface clock for SSP, and SSPCLKOUT is the output clock. For example,

SSPCLK is 24MHz by default and 1MHz SSPCLKOUT is required, then the user should set bit

CPSDVR in register *SSP\_CPSR* to 2, and set bit SCR in register *SSP\_CR0* to 11.

**14.3.3 Data Format**

SSP supports three frame formats:

* Motorola SPI
* Texas Instruments SPI
* National Semiconductor Microwire

**14.3.4 DMA Transaction**

**SSP DMA Transfer Process**

1. Enable the TXDMAE bit in register *SSP\_DMACR*.
2. Configure *SSP\_DR* register as the destination address of DMA.
3. Configure the memory address of the data to be sent as the source address of DMA.
4. Configure the data width of DMA transfer to 8 bits by configuring the SRC\_TR\_WIDTH

and DES\_TR\_WIDTH bits to 0 in the *DMA\_CTLx* register.

1. Configure the DMA burst length to 4 by configuring the SRC\_MSIZE and DEST\_MSIZE

bits to 1 in the *DMA\_CTLx* register.

1. Configure the total length of DMA data transfer.
2. Configure DMA handshake type to the corresponding SSP TX type (for example, for

SSP0, configure it to DMA\_HANDSHAKE\_SSP\_0\_TX).

1. Activate the DMA.

When the DMA transfer is completed, the CH\_EN\_x bit in the DMA\_CHENREG register is

cleared.

**SSP DMA Reception Process:**

1. Enable the RXDMAE bit in register *SSP\_DMACR*.
2. Configure register *SSP\_DR* as the source address of DMA.
3. Configure the memory address of the data to be received as the destination address of DMA.
4. Configure the data width of DMA transfer to 8 bits by configuring the SRC\_TR\_WIDTH and DES\_TR\_WIDTH bits to 0 in the *DMA\_CTLx* register.
5. Configure the DMA burst length to 4 by configuring the SRC\_MSIZE and DEST\_MSIZE bits to 1 in the *DMA\_CTLx* register.
6. Configure the total length of DMA data transfer.
7. Configure DMA handshake type to the corresponding SSP RX type (for example, for SSP0, configure it to DMA\_HANDSHAKE\_SSP\_0\_RX).
8. Activate the DMA.

When the DMA transfer is completed, the CH\_EN\_x bit in the DMA\_CHENREG register is

cleared.

**14.3.5 SSP Interrupts**

##### 

There are four SSP interrupt signals.

1. **SSP RX Interrupt**

SSP RX interrupt is triggered when there are 4 or more locations in SSP RX FIFO.

1. **SSP TX Interrupt**

SSP TX interrupt is triggered when there are 4 or less locations in SSP TX FIFO.

1. **SSP RX Overrun Interrupt**

SSP RX overrun interrupt is triggered when the SSP RX FIFO is full and continues to

receive data.

1. **SSP RX Timeout Interrupt**

SSP RX timeout interrupt is triggered when the SSP RX FIFO is not empty but SSP has

not received any new data for the duration time of 32-bit data transfer.

#### 14.4 SSP Registers

SSP0 Base Address: 0x40006000

SSP1 Base Address: 0x40012000

SSP2 Base Address: 0x40013000

**Table 14-1 SSP Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| SSP\_CR0 | 0x00 | SSP Control register 0 |
| SSP\_CR1 | 0x04 | SSP Control register 1 |
| SSP\_DR | 0x08 | SSP Data register |
| SSP\_SR | 0x0C | SSP Status register |
| SSP\_CPSR | 0x10 | SSP Clock Prescaler Register |
| SSP\_IMSC | 0x14 | SSP Interrupt Mask Set/Clear Register |
| SSP\_RIS | 0x18 | SSP Raw Interrupt Status register |
| SSP\_MIS | 0x1C | SSP Masked Interrupt Status register |
| SSP\_ICR | 0x20 | SSP Interrupt Clear Register |
| SSP\_DMACR | 0x24 | SSP DMA Control Register |

##### 14.4.1 SSP\_CR0

Offset: 0x000

Reset Value: 0x00000000

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-16** | **15-8** | **7** | **6** | **5-4** | **3-0** |
| RESERVED | SCR | SPH | SPO | FRF | DSS |
| r | r/w | r/w | r/w | r/w | r/w |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-8 SCR:** Serial clock rate, used to set the SSP transfer rate.



The formula to calculate the SSP transfer rate is as above, where CPSDVR is an even number ranging from 2 to 254.

**Bit 7 SPH:** SSP phase setting, only applied in Motorola SPI format.

**Bit 6 SPO:** SSP polarity setting, only applied in Motorola SPI format.

**Bits 5-4 FRF:** SSP frame formats setting.

* 0: Motorola SPI
* 1: Texas Instruments SPI
* 2: National Semiconductor Microwire
* 3: reserved

**Bits 3-0 DSS:** Data width setting.

* 0: reserved
* 1: reserved
* 2: reserved
* 3: 4 bits
* 4: 5 bits
* 5: 6 bits
* 6: 7 bits
* 7: 8 bits
* 8: 9 bits
* 9: 10 bits
* 10: 11 bits
* 11: 12 bits
* 12: 13 bits
* 13: 14 bits
* 14: 15 bits
* 15: 16 bits

##### 14.4.2 SSP\_CR1

Offset: 0x004

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | SOD | MS | SSE | LBM |
| r | r/w | r/w | r/w | r/w |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 SOD:** SSP output disable in slave mode.

* 0: SSP output enabled in slave mode
* 1: SSP output disabled in slave mode

**Bit 2 MS:** Master/slave mode selection.

* 0: master mode
* 1: slave mode

**Bit 1 SSE:** SSP enable.

* 0: disabled
* 1: enabled

**Bit 0 LBM:** loopback mode.

* 0: normal mode
* 1: loopback mode

##### 14.4.3 SSP\_DR

Offset: 0x008

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | DATA |
| r | r/w |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 DATA:** SSP TX/RX data.

##### 14.4.4 SSP\_SR

Offset: 0x00C

Reset Value: 0x00000003

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | BSY | RFF | RNE | TNF | TFE |
| r | r | r | r | r | r |

**Bits 31-5 RESERVED:** Must be kept, and cannot be modified.

**Bit 4 BSY:** SSP busy flag.

* 0: SSP is idle
* 1: SSP transfer in progress

**Bit 3 RFF:** RX FIFO full flag.

* 0: RX FIFO is not full
* 1: RX FIFO is full

**Bit 2 RNE:** RX FIFO not empty flag.

* 0: RX FIFO is empty
* 1: RX FIFO is not empty

**Bit 1 TNF:** TX FIFO not full flag.

* 0: TX FIFO is full
* 1: TX FIFO is not full

**Bit 0 TFE:** TX FIFO empty flag.

* 0: TX FIFO is not empty
* 1: TX FIFO is empty

##### 14.4.5 SSP\_CPSR

Offset: 0x010

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | CPSDVSR |
| r | r/w |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 CPSDVSR:** Clock prescaler divider, must be an even number between 2~254.

###### 14.4.6 SSP\_IMSC

Offset: 0x014

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | TXIM | RXIM | RTIM | RORIM |
| r | r/w | r/w | r/w | r/w |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 TXIM:** TX interrupt mask bit.

* 0: TX interrupt is masked
* 1: TX interrupt is not masked

**Bit 2 RXIM:** RX interrupt mask bit.

* 0: RX interrupt is masked
* 1: RX interrupt is not masked

**Bit 1 RTIM:** RX timeout interrupt mask bit.

* 0: RX timeout interrupt is masked
* 1: RX timeout interrupt is not masked

**Bit 0 RORIM:** RX overrun interrupt mask bit.

* 0: RX overrun interrupt is masked
* 1: RX overrun interrupt is not masked

##### 14.4.7 SSP\_RIS

Offset: 0x018

Reset Value: 0x00000008

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | TXRIS | RXRIS | RTRIS | RORRIS |
| r | r | r | r | r |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 TXRIS:** TX raw interrupt status.

**Bit 2 RXRIS:** RX raw interrupt status.

**Bit 1 RTRIS:** RX timeout raw interrupt status.

**Bit 0 RORRIS:** RX overrun raw interrupt status.

##### 14.4.8 SSP\_MIS

Offset: 0x01C

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | TXMIS | RXMIS | RTMIS | RORMIS |
| r | r | r | r | r |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 TXMIS:** TX masked interrupt status.

**Bit 2 RXMIS:** RX masked interrupt status.

**Bit 1 RTMIS:** RX timeout masked interrupt status.

**Bit 0 RORMIS:** RX overrun masked interrupt status.

##### 14.4.9 SSP\_ICR

Offset: 0x020

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-2** | **1** | **0** |
| RESERVED | RTIC | RORIC |
| r | w | w |

**Bits 31-2 RESERVED:** Must be kept, and cannot be modified.

**Bit 1 RTIC:** RX timeout interrupt clear. This bit is cleared by software writing 1 to it, while writing 0

has no effect.

**Bit 0 RORIC:** RX overrun interrupt clear. This bit is cleared by software writing 1 to it, while writing

0 has no effect.

##### 14.4.10 SSP\_DMACR

Offset: 0x024

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-2** | **1** | **0** |
| RESERVED | TXDMAE | RXDMAE |
| r | r/w | r/w |

**Bits 31-2 RESERVED:** Must be kept, and cannot be modified.

**Bit 1 TXDMAE:** DMA TX enable.

* 0: DMA TX disabled
* 1: DMA TX enabled

**Bit 0 RXDMAE:** DMA RX enable.

* 0: DMA RX disabled
* 1: DMA RX enabled

### 15. I2C

#### 15.1 Introduction

The main features of I2C (inter-integrated circuit) bus interface are as follows:

* Supports master mode and slave mode.
* SDA is the data transmission line, and SCL is the reference clock line
* Supports multi-master and bus arbitration
* Support standard mode (up to 100 Kbps) and fast mode (up to 400 Kbps)
* Support FIFO mode with configurable read and write pointers, TxFIFO depth is 8, and

RxFIFO depth is 16



**Figure 15-1 I2C Block Diagram**

**15.2 Start and Stop Conditions**

#### 

**Start condition**: When SCL level is high, SDA level changes from high to low, thus generating

a Start condition.

**Stop condition**: When SCL level is high, SDA level changes from low to high, thus generating

a Stop condition.



**Figure 15-2 SDA and SCL Signals During Start and Stop Conditions**

Start a byte transmission or generate Start, Repeated Start or Stop conditions by configuring

the START and STOP bits in register *I2Cx\_CR*.

**Table 15-1 Start and Stop Conditions**

|  |  |  |  |
| --- | --- | --- | --- |
| Start bit | Stop bit | Condition Type | Description |
| 0 | 0 | No Start or Stop | When multiple data bytes are to be transmitted, I2C will  not send a Start or Stop condition. |
| 0 | 1 | Start or  Repeated Start | I2C sends a Start condition and then transmits the 8-bit  data in the *I2Cx\_DBR* register. Before a Start condition  is sent, register *I2Cx\_DBR* must contain the 7-bit slave  address and the R/nW bit.  For a Repeated Start, the *I2Cx\_DBR* register must  contain the target slave address and the R/nW bit,  which allows a master to perform multiple transfers  without freeing the bus.  The interface stays in master transmit mode for writes,  and switches to master receive mode for reads. |
| 1 | x | Stop | In master transmit mode, a Stop condition is sent on the  I2C bus after the 8-bit data in the *I2Cx\_DBR* register  has been transferred.  In master receive mode, bit ACKNAK in the *I2Cx\_CR*  register must be set to send a NAK. The received data  is stored in the *I2Cx\_DBR* register, and then a Stop  condition is sent on the I2C bus. |

1. **Start Condition**

The Start condition and the data in register *I2Cx\_DBR* will be sent after bit TB in register

*I2Cx\_CR* is set. I2C bus stays in master transmit mode for write requests and stays in

master receive mode for read requests. For a Repeated Start, a change in Read, Write or

the target slave address, the register *I2Cx\_DBR* contains the updated target slave address

and the R/nW bit.

The START condition will not be cleared by the I2C. If I2C loses bus arbitration when it

starts to send a Start condition, it will try to resend the Start condition when the bus is freed.

1. **No Start or Stop Condition**

When I2C is transmitting multiple data bytes, the START and STOP bits in the *I2Cx\_CR*

register are set to 0, there is no Start or Stop condition. Software writes the data byte, and

I2C sets bit ITE in register *I2Cx\_SR* and clears bit TB in register *I2Cx\_CR*. Then software

writes a new byte to register *I2Cx\_DBR* and sets bit TB in register *I2Cx\_CR*, which starts

the new byte transmission. This process continues until the START or STOP bit in register

*I2Cx\_CR* is set by software. After a Start, Stop or Repeated Start condition is transmitted,

the START and STOP bits in register *I2Cx\_CR* are not cleared automatically by I2C.

After each byte and ACK/NAK are transferred, I2C holds the SCL line low and waits until

the TB bit in register *I2Cx\_CR* is set.

1. **Stop Condition**

A Stop condition terminates a data transfer. In master transmit mode, the STOP and TB

bits in register *I2Cx\_CR* must be set to start the transmission of the last byte. In master

receive mode, the ACKNAK, STOP and TB bits in register *I2Cx\_CR* must be set to start

the reception of the last byte. After a Stop condition is transmitted, software must clear the

STOP bit in register *I2Cx\_CR*.

**15.3 Data Transmission Sequence**

#### 

I2C transmits data in 1-byte increments and by following sequence:

1. Start
3. R/nW bit
4. Acknowledge pulse
5. 8 bits of data
6. Acknowledge pulse
7. Repeat of Step 5 and Step 6
8. Repeated Start (repeat Step 1) or Stop

**15.4 Data and Addressing**

#### 

The I2C Data Buffer Register (*I2Cx\_DBR*) and the I2C Slave Address Register (*I2Cx\_SAR*)

manage data and slave addressing. *I2Cx\_DBR* contains 1 byte of data or a 7-bit target slave

address and the R/nW bit. *I2Cx\_SAR* contains the ASR6601 I2C slave address when the I2C

is in slave mode. After I2C receives a full byte of data and an ACK, it stores the data in register

*I2Cx\_DBR*. To transmit data, the CPU writes to the *I2Cx\_DBR* register, and the I2C transmits

the data to the serial bus when the TB bit in register *I2Cx\_CR* is set.

1. **I2C is in Master/Slave Transmit mode:**
2. Software writes data to the *I2Cx\_DBR* register, which makes the I2C to start a master

transaction or to send the next data byte after the ITE bit in register *I2Cx\_SR* is set.

1. When bit TB in register *I2Cx\_CR* is set, the data in register *I2Cx\_DBR* is transmitted.
2. If the ITEIE bit in register *I2Cx\_CR* is set, an I2Cx\_DBR transmit-empty interrupt is

triggered after a byte and an ACK is transferred.

1. When the I2C is ready to send the next byte before the CPU writes to the *I2Cx\_DBR*

register and there is no Stop condition, the I2C is in a wait state until the CPU writes

to the *I2Cx\_DBR* register and sets the TB bit in the *I2Cx\_CR* register.

***Note:*** *In FIFO mode, software writes to the TX FIFO instead of the I2Cx\_DBR register.*

1. **I2C is in Master/Slave Receive mode:**
2. When a full byte of data is received (if the DRFIE bit in register *I2Cx\_CR* is set), the

I2Cx\_DBR receive-full interrupt is generated and the IRF bit in register *I2Cx\_SR* is

set, the CPU then reads the I2Cx\_DBR register to retrieve the data.

1. After the ACK cycle is completed, I2C transfers data from the shift register to the

*I2Cx\_DBR* register.

1. I2C is in wait state until the *I2Cx\_DBR* register is read by the CPU.
2. After the CPU reads the *I2Cx\_DBR* register, the I2C updates the ACKNAK and TB

bits in register *I2Cx\_CR* to allow the transmission of the next byte.

***Note:*** *In FIFO mode, software reads from the RX FIFO instead of the I2Cx\_DBR register.*

1. **Addressing a Slave Device:**

As a master device, the I2C must form and send the first byte of a transaction. This byte

consists of a 7-bit slave address and a R/nW bit. After the first byte is transmitted, the I2C

must receive an ACK from the slave device. When it is a Write transaction, the I2C remains

in master transmit mode, and the slave device remains in slave receive mode. When it is

a Read transaction, the I2C switches to master receive mode immediately after receiving

an ACK, and the slave device switches to slave transmit mode. When a NAK is returned,

the I2C automatically sends a Stop condition and sets the BED bit in register *I2Cx\_SR* to

abort the current transaction.

**15.5 Acknowledge**

##### 

Each byte transmission must be accompanied by an ACK generated by the master or slave

receiver. The transmitter must release the SDA line for the receiver to transmit the ACK.

In master transmit mode, if the target slave receiver does not generate an ACK, the SDA line

remains high, which indicates a NAK. The lack of an ACK causes I2C to set the BED bit in

register *I2Cx\_SR* and generate an interrupt. I2C automatically generates a Stop condition and

aborts the transmission.

In master receive mode, I2C sends a NAK to notify the slave transmitter to stop sending data.

The ACKNAK bit in the *I2Cx\_CR* register controls the generation of ACK/NAK on the bus.

According to the I2C protocol, the BED bit in the *I2Cx\_SR* register is not set for a master receive

mode NAK. I2C automatically sends the ACK every time it receives a byte from the bus. Before

the master receiver receives the last byte, software must set the ACKNAK bit in the *I2Cx\_CR*

register to generate a NAK. The NAK is sent after the last byte to indicate that the last byte has

been sent.

In slave receive mode, I2C automatically acknowledges its own slave address, irrespective of

whether the ACKNAK bit in the *I2Cx\_CR* register is set. In slave mode, I2C automatically sends

the ACK after receiving a byte, irrespective of whether the ACKNAK bit in the *I2Cx\_CR* register

is set.

In slave transmit mode, receiving a NAK indicates that the last byte has been transferred. The

master then sends a Stop condition or Repeated Start condition. The UB bit in register *I2Cx\_SR*

remains set until a Stop condition or Repeated Start condition is received.

**15.6 Arbitration**

##### 

I2C bus arbitration is required by a multi-master capability. Bus arbitration is used when two or

more masters simultaneously generate a Start condition within the minimum time of a Start

condition.

Arbitration can last for a long time. If the slave address and the R/nW bit are the same, the

arbitration moves to the data. Due to the Wired-And nature of the I2C bus, no data is lost if two

or all masters are outputting the same bus state. If the address, the R/nW bit, or the data are

different, the master that transitioned to the high state (the master data is different from the

SDA line) loses arbitration and aborts the data transfer. The I2C bus sets bit ALD in register

*I2Cx\_SR*, then returns to the idle state.

In FIFO mode, software must empty the FIFOs once arbitration is lost. This can be done by

clearing the read and write pointer registers for TxFIFO and RxFIFO.

15.7 **I2C Master Mode**

#### 

When software starts a read or write operation on the I2C bus, the I2C switches from the default

slave receive mode to master transmit mode. The Start condition is followed by the 7-bit slave

address and the R/nW bit.

After receiving an ACK, the I2C enters one of the two master modes:

* Master transmit: I2C writes data
* Master receive: I2C reads data

The CPU writes to register *I2Cx\_CR* to start a master transaction.

**Table 15-2 Master Transactions**

##### 

|  |  |  |
| --- | --- | --- |
| I2C Master Action | Mode of  Operation | Definition |
| Generate clock output | Master transmit  Master receive | * The master drives the SCL line. * The SCLE and UE bits in the *I2Cx\_CR* register must be set. |
| Write slave  address to I2Cx\_DBR | Master transmit  Master receive | * CPU writes to bits[7:1] in the *I2Cx\_DBR* register before a   Start condition is enabled.   * The first 7 bits are sent after Start. |
| Write R/nW bit to  I2Cx\_DBR | Master transmit  Master receive | * CPU writes the R/nW control bit to the least significant bit in register *I2Cx\_DBR*. * If the R/nW bit is low, master remains a master transmitter, if the R/nW bit is high, master switches to a master receiver |
| Send Start condition | Master transmit  Master receive | After the 7-bit target slave address and the R/nW bit are written into the *I2Cx\_DBR* register,   * Software sets the START bit in register *I2Cx\_CR*. * Software sets the TB bit in register *I2Cx\_CR* to initiate the   Start condition. |
| Initiate first data byte  transmission | Master transmit  Master receive | * CPU writes one data byte to the *I2Cx\_DBR* register. * Software sets the TB bit in register *I2Cx\_CR* and I2C starts the transmission of the Byte. * The TB bit in register *I2Cx\_CR* is cleared and the ITE bit in register *I2Cx\_SR* is set when the transfer is complete. |
| Arbitrate for I2C bus | Master transmit  Master receive | If 2 or more masters send a Start condition within the same clock period, then bus arbitration must occur.   * I2C arbitrates as long as there is a need. Bus arbitration takes place during the transmission of target slave address, R/nW bit or data, and it continues until all masters except one master lose the bus. No data is lost. * If I2C loses arbitration, the ALD bit in register *I2Cx\_SR* is set, and I2C switches to slave receive mode. * If I2C loses arbitration when it starts to send the target slave address, it will try to resend the address when the bus is freed. |
| Write one data byte to  I2Cx\_DBR | Master transmit  only | * When the ITE bit in the *I2Cx\_SR* register is set and the TB bit in the *I2Cx\_CR* register is cleared, if enabled, the I2Cx\_DBR transmit-empty interrupt is generated. * The CPU writes a data byte to the *I2Cx\_DBR* register, sets the appropriate Start/Stop condition combination as required, and sets the TB bit in register *I2Cx\_CR* to send data. The 8 bits of data are transferred from the shift register to the serial bus. If the STOP bit in register *I2Cx\_CR* is set before the transfer, then the 8 bits of data is followed by a Stop condition. |
| Wait for ACK from  slave receiver | Master transmit  only | As a master transmitter, the I2C generates the ACK clock, and  releases the SDA line for the slave receiver to transmit the ACK. |
| Read one byte from  I2Cx\_DBR | Master receive  only | After the ACKNAK bit in register *I2Cx\_CR* is read, the 8 bits of data in the shift register is transferred to the I2Cx\_DBR register:   * The CPU reads the I2Cx\_DBR register when the IRF bit in register *I2Cx\_SR* is set and the TB bit in register *I2Cx\_CR* is cleared. If the I2Cx\_DBR receive-full interrupt is enabled, it is signalled to the CPU. * When the *I2Cx\_DBR* register is read, if the ACKNAK bit in register *I2Cx\_SR* is cleared (indicating ACK), the software must clear the ACKNAK bit and set the TB bit in register *I2Cx\_CR* to start the next byte Read. * If the ACKNAK bit in *I2Cx\_SR* is set (indicating NAK), the TB bit in *I2Cx\_CR* is cleared, the STOP bit in *I2Cx\_CR* is set, and the UB bit in *I2Cx\_SR* is set, then the last byte has been read from the *I2Cx\_DBR* register, and the I2C is sending the Stop. * If the ACKNAK bit in *I2Cx\_SR* is set (indicating NAK) and the TB bit in *I2Cx\_CR* is cleared, but the STOP bit in *I2Cx\_CR* is cleared, then the software has two options:  1. Set the START bit in *I2Cx\_CR*, write a new target slave address to the *I2Cx\_DBR* register, set the TB bit in *I2Cx\_CR*, and send a Repeated Start. 2. Set the MA bit in *I2Cx\_CR* and keep the TB bit as 0 in *I2Cx\_CR*, and only send a Stop. |
| Transmit ACK to  slave transmitter | Master receive  only | * As a master receiver, the I2C generates the ACK clock and drives the SDA line during the ACK cycle. * If the next data byte is the last transaction, the user software sets the ACKNAK bit in register *I2Cx\_CR* to generate NAK. |
| Generate a Repeated  Start | Master transmit  Master receive | Use a Repeated Start condition instead of a Stop condition to  initiate a new transaction without releasing the bus.   * The Repeated Start is generated after the last data byte has been transmitted. * Software must write the next 7-bit target slave address and the R/nW bit to the *I2Cx\_DBR* register, set the START bit in register *I2Cx\_CR*, and set the TB bit in register *I2Cx\_CR*. |
| Generate Stop | Master transmit  Master receive | * A Stop is generated after the last data byte has been transmitted. * The STOP bit in register *I2Cx\_CR* must be set before the transmission of the last byte. |

**15.8 FIFO Mode**

The FIFO mode can only be used when the I2C is in *Master Mode*.



**Figure 15-3 FIFO Mode Block Diagram**

FIFOs can be used for both transmission and reception to help reducing the empty and full

interrupts of register I2Cx\_DBR. The FIFOs allow reading and writing multiple bytes without

interrupting the CPU after each byte.

DMA is used to improve I2C transactions (typically more than 8 Bytes). The entire transaction

can be completed by DMA without generating multiple FIFO interrupts.

The FIFO mode is backward compatible, and it is disabled by clearing the FIFO\_EN bit in the

*I2Cx\_CR* register.

Transmit FIFO has a width of 12 (4 control bits and 8 data bits) and a depth of 8. The 4 control

bits are bits[3:0] in register *I2Cx\_CR*, which are required for each data byte transmission. After

a byte is transmitted, the next byte is copied from the TX FIFO into the shift register, and the

control bits are copied into the *I2Cx\_CR* register. This byte is now transferred, and it continues

like that until the Stop bit is set.

Receive FIFO has a width of 8 (8 data bits) and a depth of 16, which is used to store the

received data. The control bits for each byte and dummy data are put in the corresponding

position in the TX FIFO. When the RX FIFO is half full, an interrupt or DMA request is sent out

for the data in the RX FIFO to be read out.

In order to support the FIFO mode and fully utilize its capabilities, the following status and

control bits need to be configured:

1. Set the FIFO\_EN bit in register *I2Cx\_CR* to enable the FIFO mode.
2. Set the TXBEGIN bit in register *I2Cx\_CR* to start a transaction.
3. Bits[31:28] in register *I2Cx\_CR* enables or disables all the FIFO related interrupts, and bits[31:28] in register *I2Cx\_SR* is used to inquire the interrupt status.
4. TXDONE interrupt is generated when each transaction is completed (that is, a Stop condition is sent).
5. The DMA\_EN bit in register *I2Cx\_CR* is used to enable/disable DMA mode.

In DMA mode, all the FIFO related interrupts must be disabled in register *I2Cx\_CR* (bits[31:28]),

and the DMA\_EN bit in this register must be set. In this way, all DMA requests are sent to the

DMA without interrupting the CPU. The TXDONE\_IE bit in the *I2Cx\_CR* register needs to be

set in both FIFO and DMA modes to generate an interrupt to the CPU after each transaction is

completed.

**15.9 I2C Slave Mode**

#### 

**Table 15-3 Slave Transaction**

##### 

|  |  |  |
| --- | --- | --- |
| Slave Operation | Type | Description |
| Slave receive mode  (default) | Slave receive  only | * The I2C monitors all slave address transactions. * The UE bit in register *I2Cx\_CR* must be set. * I2C monitors the Start conditions on the bus. When a Start condition is detected, the interface reads the first 8 bits of data and compares the most significant 7 bits with those in the *I2Cx\_SAR* register. If they match, the I2C sends an ACK. * If the 8th bit (R/nW bit) of the first byte is low, then I2C stays in slave receive mode, and the SAD bit in register *I2Cx\_SR* is cleared. If the R/nW bit is high, I2C switches to slave transmit mode and sets the SAD bit in register *I2Cx\_SR*. |
| Set the slave address  detection bit | Slave receive  Slave transmit | * Indicates that the interface has defected the matching slave address. * If enabled, an slave address detection interrupt is generated after the matching slave address is received and acknowledged, and the SAD bit in register *I2Cx\_SR* is set. |
| Read one byte from  *I2Cx\_DBR* | Slave receive  only | * 8 bits are read from the serial bus into the shift register. When a full byte has been received and the ACK/NAK bit is completed, the byte in the shift register is transferred to the I2Cx\_DBR register. * When the IRF bit in register *I2Cx\_SR* is set, and the TB bit in register *I2Cx\_CR* is cleared, if enabled, the I2Cx\_DBR receive-full interrupt is generated. * Software reads one data byte from the I2Cx\_DBR register, then configures the ACKNAK bit in register *I2Cx\_CR* as required and sets the TB bit in register *I2Cx\_CR*. This makes the I2C exit from the wait state and continue to receive data from the master transmitter. |
| Transmit ACK to master  transmitter | Slave receive  only | * As a slave receiver, the I2C pulls the SDA line low to generate the ACK when SCL is high. * ACK/NAK is controlled by bit ACKNAK in register *I2Cx\_CR*. |
| Write one byte to  *I2Cx\_DBR* | Slave transmit  only | * When the ITE bit in register *I2Cx\_SR* is set and the TB bit in register *I2Cx\_CR* is cleared, if enabled, the I2Cx\_DBR transmit-empty interrupt is generated. * Software writes a byte into register *I2Cx\_DBR* and then sets the TB bit in register *I2Cx\_CR* to start the transmission. |
| Waiting for ACK from  master receiver | Slave transmit  only | As a slave transmitter, the I2C releases the SDA line for  the master receiver to pull the line low to transmit the  ACK. |

**15.10 I2C Clock and Reset**

##### 

Each I2C interface has independent APB bus clock and independent APB bus reset.

Software must ensure that the I2C unit is disabled (*I2Cx\_CR*[UE]=0) before reset, and ensure

that the I2C bus is idle (*I2Cx\_SR*[IBB]=0) when the unit is enabled after reset. When reset, all

registers except the *I2Cx\_SAR*, return to the default reset condition. *I2Cx\_SAR* is not affected

by a reset.

Steps for I2C clock reset:

1. Set the UR bit in the *I2Cx\_CR* register, and clear the remaining bits of this register.
2. Clear the *I2Cx\_SR* register.
3. Clear the UR bit in the *I2Cx\_CR* register.

**15.11 I2C Interrupts**

I2C interrupts are configured by register *I2Cx\_CR*, and the interrupt status can be obtained by

querying the corresponding bit in register *I2Cx\_SR*.

**15.12 DMA Requests**

DMA (Direct Memory Access) is enabled by setting the DMA\_EN bit in register *I2Cx\_CR* to

support transmission and reception.

**15.13 I2C Registers**

##### 

I2C0 Base Address: 0x40007000

I2C1 Base Address: 0x40014000

I2C2 Base Address: 0x40015000

**Table 15-4 I2C Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| I2Cx\_CR | 0x00 | Control Register |
| I2Cx\_SR | 0x04 | Status Register |
| I2Cx\_SAR | 0x08 | Slave Address Register |
| I2Cx\_DBR | 0x0C | Data Buffer Register |
| I2Cx\_LCR | 0x10 | Load Count Register |
| I2Cx\_WCR | 0x14 | Wait Count Register |
| I2Cx\_RST\_CYCL | 0x18 | Reset SCL Cycle |
| I2Cx\_BMR | 0x1C | Bus Monitor Register |
| I2Cx\_WFIF0 | 0x20 | Write FIFO Register |
| I2Cx\_WFIFO\_WPTR | 0x24 | Write FIFO Write Pointer Register |
| I2Cx\_WFIFO\_RPTR | 0x28 | Write FIFO Read Pointer Register |
| I2Cx\_RFIFO | 0x2C | Read FIFO Register |
| I2Cx\_RFIFO\_WPTR | 0x30 | Read FIFO Write Pointer Register |
| I2Cx\_RFIFO\_RPTR | 0x34 | Read FIFO Read Pointer Register |
| I2Cx\_RESV[2] | 0x38 | Reserved |
| I2Cx\_WFIFO\_STATUS | 0x40 | Write FIFO Status Register |
| I2Cx\_RFIFO\_STATUS | 0x44 | Read FIFO Status Register |

###### 15.13.1 I2Cx\_CR (x=0, 1, 2)

Offset: 0x000

Reset Value: 0x00000200

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31** | **30** | **29** | **28** | **27** | **26** | **25** | **24** |
| RXOV\_IE | RXF\_IE | RXHF\_IE | TXE\_IE | TXDONE\_IE | MSDE | MSDIE | SSDIE |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |
| **23** | **22** | **21** | **20** | **19** | **18** | **17-16** | |
| SADIE | BEIE | RESERVED | DRFIE | ITEIE | ALDIE | RESERVED | |
| rw-0h | rw-0h | r-0h | rw-0h | rw-0h | rw-0h | r-0h | |
| **15** | **14** | **13** | **12** | **11** | **10** | **9-8** | |
| RESERVED | UE | SCLE | MA | IBRR | UR | MODE | |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-2h | |
| **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| DMA\_EN | RESERVED | FIFOEN | TXBEGIN | TB | ACKNAK | STOP | START |
| rw-0h | r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bit 31 RXOV\_IE:** Receive FIFO overrun interrupt enable.

* 0: receive FIFO overrun interrupt disabled
* 1: receive FIFO overrun interrupt enabled

**Bit 30 RXF\_IE:** Receive FIFO full interrupt enable.

* 0: receive FIFO full interrupt disabled
* 1: receive FIFO full interrupt enabled

**Bit 29 RXHF\_IE:** Receive FIFO half full interrupt enable.

* 0: Receive FIFO half full interrupt disabled
* 1: Receive FIFO half full interrupt enabled

**Bit 28 TXE\_IE:** Transmit FIFO empty interrupt enable.

* 0: Transmit FIFO empty interrupt disabled
* 1: Transmit FIFO empty interrupt enabled

**Bit 27 TXDONE\_IE:** Transaction done interrupt enable.

* 0: transaction done interrupt disabled
* 1: transaction done interrupt enabled

**Bit 26 MSDE:** Master Stop detection enable.

* 0: Master Stop detection disabled
* 1: Master Stop detection enabled

**Bit 25 MSDIE:** Master Stop detection interrupt enable.

* 0: Master Stop detection interrupt disabled
* 1: Master Stop detection interrupt enabled

**Bit 24 SSDIE:** Slave Stop detection interrupt enable.

* 0: Slave Stop detection interrupt disabled
* 1: Slave Stop detection interrupt enabled

**Bit 23 SADIE:** Slave address detection interrupt enable.

* 0: Slave address detection interrupt disabled
* 1: Slave address detection interrupt enabled

**Bit 22 BEIE:** Bus error interrupt enable.

* 0: Bus error interrupt disabled
* 1: Bus error interrupt enabled

**Bit 21 RESERVED:** Must be kept, and cannot be modified.

**Bit 20 DRFIE:** I2Cx\_DBR receive-full interrupt enable.

* 0: I2Cx\_DBR receive-full interrupt disabled
* 1: I2Cx\_DBR receive-full interrupt enabled

**Bit 19 ITEIE:** I2Cx\_DBR transmit-empty interrupt enable.

* 0: I2Cx\_DBR transmit-empty interrupt disabled
* 1: I2Cx\_DBR transmit-empty interrupt enabled

**Bit 18 ALDIE:** Arbitration loss detection interrupt enable.

* 0: Arbitration loss detection interrupt disabled
* 1: Arbitration loss detection interrupt enabled

**Bits 17-15 RESERVED:** Must be kept, and cannot be modified.

**Bit 14 UE:** I2C unit enable.

* 0: I2C unit disabled
* 1: I2C unit enabled (the default is slave receive mode)

Software must ensure that the I2C bus is idle before enabling the I2C unit, and ensure that the internal I2C clock is enabled before setting or clearing this bit.

**Bit 13 SCLE:** SCL enable.

* 0: disable the I2C from driving the SCL line
* 1: enable the I2C clock output for master-mode operation

**Bit 12 MA:** Master abort.

This bit is used for the I2C to generate a Stop condition in master mode.

* 0: Stop condition is generated when the STOP bit in this register is set
* 1: Stop condition is generated without data transmission

In master transmit mode, after a data byte is transmitted, the TB bit in this register is cleared and the ITE bit in register *I2Cx\_SR* is set. When no more data bytes need to be sent, setting the MA bit to generate a Stop condition to free the bus. In master receive mode, when a NAK is sent with the STOP bit=0 and without a Repeated Start condition followed, setting the MA bit to generate a Stop condition to free the bus. The TB bit in this register must remain clear.

**Bit 11 IBRR:** I2C bus reset request.

* 0: no action
* 1: I2C bus reset, and this bit is cleared automatically

**Bit 10 UR:** Unit reset.

* 0: no action
* 1: reset the I2C unit

**Bits 9-8 MODE:** Bus clock mode for the master.

* 00: standard mode – 100 Kbps
* 01: fast mode – 400 Kbps

**Bit 7 DMA\_EN:** DMA enable.

* 0: DMA requests disabled
* 1: DMA requests enabled

**Bit 6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 FIFOEN:** FIFO mode enable.

* 0: FIFO mode disabled
* 1: FIFO mode enabled

**Bit 4 TXBEGIN:** Transaction begin.

* 0: no action
* 1: new transaction begins

This bit is cleared by hardware after a Stop condition is generated, and the software needs to set it again to start a new transaction.

**Bit 3 TB:** Transfer byte, used to send or receive a byte on the I2C bus.

* 0: cleared by I2C when one byte is sent or received
* 1: send or receive a byte

The I2C unit monitors this bit to determine whether the byte transfer has completed. In master or slave mode, after each byte including the ACK is transferred, I2C holds the SCL line low until the TB bit is set.

**Bit 2 ACKNAK:** The positive/negative acknowledge (ACK/NAK) control bit in master receive mode.

* 0: send ACK after receiving a data byte
* 1: send NAK after receiving a data byte

In slave mode, when the I2C responds to its slave address or the reception is complete, it automatically

sends an ACK, regardless of whether the ACKNAK bit is set.

**Bit 1 STOP:** Generate a Stop condition.

* 0: no action
* 1: generate Stop condition

This bit is used to generate a Stop condition on the I2C bus after the transmission of the next data byte in master mode. In master receive mode, the ACKNAK bit and the STOP bit must be set to 1 at the same time.

**Bit 0 START:** Generate a Start condition.

* 0: no action
* 1: generate a Start condition

This bit is used to generate a Start condition on the I2C bus in master mode.

###### 15.13.2 I2Cx\_SR (x=0, 1, 2)

Offset: 0x004

Reset Value: 0x00000000

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **31** | **30** | **29** | **28** | **27** | **26** | **25** |
| RXOV | RXF | RXHF | TXE | TXDONE | MSD | RESERVED |
| rw1c-0h | rw1c-0h | rw1c-0h | rw1c-0h | rw1c-h | r1ch | r-0h |
| **24** | **23** | **22** | **21** | **20** | **19** | **18** |
| SSD | SAD | BED | RESERVED | IRF | ITE | ALD |
| rw1c-0h | rw1c-0h | rw1c-0h | r-0h | rw1c-0h | rw1c-0h | rw1c-0h |
| **17** | **16** | **15** | **14** | **13-8** | **7-0** | |
| RESERVED | IBB | UB | ACKNAK | RESERVED | RESERVED | |
| r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | |

**Bit 31 RXOV:** Receive FIFO overrun flag.

* 0: no receive FIFO overrun occurred
* 1: receive FIFO overrun occurred, and it is cleared by software writing 1 to it.

**Bit 30 RXF:** Receive FIFO full flag.

* 0: receive FIFO is not full
* 1: receive FIFO is full, and it is cleared by software writing 1 to it.

**Bit 29 RXHF:** Receive FIFO half-full flag.

* 0: receive FIFO is not half full
* 1: receive FIFO is half full, and it is cleared by software writing 1 to it.

**Bit 28 TXE:** Transmit FIFO empty flag.

* 0: transmit FIFO is not empty
* 1: transmit FIFO is empty, and it is cleared by software writing 1 to it.

**Bit 27 TXDONE:** Transaction done flag (used in FIFO mode).

* 0: transaction in progress
* 1: transaction is done, and it is cleared by software writing 1 to it.

**Bit 26 MSD:** Master Stop detection flag (only effective in master mode).

* 0: no master Stop detected
* 1: master Stop detected, and it is cleared by software writing 1 to it.

**Bit 25 RESERVED:** Must be kept, and cannot be modified.

**Bit 24 SSDIE:** Slave Stop detection flag.

* 0: no slave Stop detected
* 1: slave Stop was detected, and it is cleared by software writing 1 to it.

**Bit 23 SAD:** Slave address detection flag.

* 0: no matching slave address detected
* 1: matching slave address detected, and it is cleared by software writing 1 to it.

**Bit 22 BED:** Bus error detection flag.

* 0: no bus error detected
* 1: bus error detected, and it is cleared by software writing 1 to it.

This bit is set in two cases:

- As a master transmitter, the I2C did not receive an ACK after sending a byte.

- As a slave receiver, the I2C generates a NAK.

**Bit 21 RESERVED:** Must be kept, and cannot be modified.

**Bit 20 IRF:** I2Cx\_DBR receive full flag.

* 0: the I2Cx\_DBR register has not received a new data byte or the I2C bus is idle.
* 1: the I2Cx\_DBR register received a new data byte, and it is cleared by software writing 1 to it.

**Bit 19 ITE:** I2Cx\_DBR transmit empty flag.

* 0: the data byte transmit in progress
* 1: the I2C has finished transmitting a byte on the I2C bus, and it is cleared by software writing 1 to it.

**Bit 18 ALD:** Arbitration loss detection flag, used in multi-master scenarios.

* 0: I2C wins the arbitration or no arbitration took place
* 1: I2C loses the arbitration, and it is cleared by software writing 1 to it.

**Bit 17 RESERVED:** Must be kept, and cannot be modified.

**Bit 16 IBB:** I2C bus busy flag.

* 0: the I2C bus is idle, or the ASR6601 I2C is using the bus
* 1: the I2C bus is busy but not used by the ASR6601 I2C

**Bit 15 UB:** I2C unit busy flag.

* 0: the I2C unit is idle
* 1: the I2C unit is busy

**Bit 14 ACKNAK:** ACK/NAK status flag.

* 0: I2C received or sent an ACK
* 1: I2C received or sent a NAK

In slave transmit mode, this bit is used to determine whether the byte transmitted is the last one. This bit is updated after each byte and ACK/NAK information is received.

**Bits 13-0 RESERVED:** Must be kept, and cannot be modified.

###### 15.13.3 I2Cx\_SAR (x=0, 1, 2)

Offset: 0x008

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-7** | **6-0** |
| RESERVED | SLAVE\_ADDRESS |
| r-0h | rw-0h |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bits 6-0 SLAVE\_ADDRESS:** The ASR6601 I2C slave address used in slave mode.

###### 15.13.4 I2Cx\_DBR (x=0, 1, 2)

Offset: 0x00C

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | DATA\_BUFFER |
| r-0h | rw-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 DATA\_BUFFER:** Buffer for I2C bus transmit/receive data.

###### 15.13.5 I2Cx\_LCR (x=0, 1, 2)

Offset: 0x010

Reset Value: 0x18183a7e

|  |  |  |
| --- | --- | --- |
| **31-18** | **17-9** | **8-0** |
| RESERVED | FLV | SLV |
| r-1818h | rw-1dh | rw-7eh |

**Bits 31-18 RESERVED:** Must be kept, and cannot be modified.

**Bits 17-9 FLV:** Phase decrementer load value for fast mode SCL in master mode.

**Bits 8-0 SLV:** Phase decrementer load value for standard mode SCL in master mode.

###### 15.13.6 I2Cx\_WCR (x=0, 1, 2)

Offset: 0x14

Reset Value: 0x0000143a

|  |  |
| --- | --- |
| **31-5** | **4-0** |
| RESERVED | COUNT |
| r-a1h | rw-1ah |

**Bits 31-5 RESERVED:** Must be kept, and cannot be modified.

**Bits 4-0 COUNT:** Counter values for defining the setup and hold times in standard and fast modes.

###### 15.13.7 I2Cx\_RST\_CYCL (x=0, 1, 2)

Offset: 0x018

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-4** | **3-0** |
| RESERVED | RST\_CYC |
| r-0h | rw-0h |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bits 3-0 RST\_CYC:** Serial bus reset SCL cycle count.

15.13.8 I2Cx\_BMR (x=0, 1, 2)

Offset: 0x01C

Reset Value: 0x00000003

|  |  |  |
| --- | --- | --- |
| **31-2** | **1** | **0** |
| RESERVED | SCL | SDA |
| r-0h | r-1h | r-1h |

**Bits 31-2 RESERVED:** Must be kept, and cannot be modified.

**Bit 1 SCL:** SCL pin state.

**Bit 0 SDA:** SDA pin state.

15.13.9 I2Cx\_WFIF0 (x=0, 1, 2)

Offset: 0x020

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-12** | **11-8** | **7-0** |
| RESERVED | CONTROL | DATA |
| r-0h | w-0h | w-0h |

**Bits 31-12 RESERVED:** Must be kept, and cannot be modified.

**Bits 11-8 CONTROL:** I2C bus transmit/receive data control bits.

**Bits 7-0 DATA:** I2C bus send data for write transactions and dummy data for read transactions.

###### 15.13.10 I2Cx\_WFIFO\_WPTR (x=0, 1, 2)

Offset: 0x024

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-4** | **3-0** |
| RESERVED | DATA |
| r-0h | rw-0h |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bits 3-0 DATA:** The position in the Transmit FIFO where the software will write the next entry.

###### 15.13.11 I2Cx\_WFIFO\_RPTR (x=0, 1, 2)

Offset: 0x028

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-4** | **3-0** |
| RESERVED | DATA |
| r-0h | rw-0h |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bits 3-0 DATA:** The position in the Transmit FIFO where the hardware will read the next entry.

15.13.12 I2Cx\_RFIFO (x=0, 1, 2)

Offset: 0x02C

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | DATA |
| r-0h | r-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 DATA:** I2C bus receive data for read transactions.

###### 15.13.13 I2Cx\_RFIFO\_WPTR (x=0, 1, 2)

Offset: 0x030

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-4** | **3-0** |
| RESERVED | DATA |
| r-0h | r-0h |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bits 3-0 DATA:** The position in the Receive FIFO where the hardware will write the next entry.

###### 15.13.14 I2Cx\_RFIFO\_RPTR (x=0, 1, 2)

Offset: 0x034

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-4** | **3-0** |
| RESERVED | DATA |
| r-0h | r-0h |

**Bits 31-4 RESERVED:** Must be kept, and cannot be modified.

**Bits 3-0 DATA:** The position in the Receive FIFO where the software will read the next entry.

###### 15.13.15 I2Cx\_WFIFO\_STATUS (x=0, 1, 2)

Offset: 0x040

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-16** | **15-9** | **8-1** | **0** |
| RESERVED | WFIFO\_SIZE | WFIFO\_EMPTY | WFIFO\_FULL |
| r-0h | r-0h | r-0h | r-0h |

**Bits 31-6 RESERVED:** Must be kept, and cannot be modified.

**Bits 5-2 WFIFO\_SIZE:** The Transmit FIFO size.

**Bit 1 WFIFO\_EMPTY:** Transmit FIFO empty.

**Bit 0 WFIFO\_FULL:** Transmit FIFO full.

###### 15.13.16 I2Cx\_RFIFO\_STATUS (x=0, 1, 2)

Offset: 0x044

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-24** | **23-16** | **15-8** | **7-4** |
| RESERVED | RESERVED | RESERVED | RFIFO\_SIZE |
| r-0h | r-0h | r-0h | r-0h |
| **3** | **2** | **1** | **0** |
| RFIFO\_EMPTY | RFIFO\_FULL | RFIFO\_HALFFULL | RFIFO\_OVERRUN |
| r-0h | r-0h | r-0h | r-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-4 RFIFO\_SIZE:** The Receive FIFO size.

**Bit 3 RFIFO\_EMPTY:** Receive FIFO empty.

**Bit 2 RFIFO\_FULL:** Receive FIFO full.

**Bit 1 RFIFO\_HALFFULL:** Receive FIFO half full.

**Bit 0 RFIFO\_OVERRUN:** Receive FIFO overrun.

### 16. ADC

#### 16.1 Introduction

The 12-bit ADC (Analog to Digital Converter) has 8 external channels and 7 internal channels

for measuring signals with up to 1M sampling rate. The internal VBAT/3 channel allows the

ADC to measure the VBAT/3 signal. ADC analog input channels can be configured in single

ended (range: 0.1V~1.1V) or differential mode (range: -1.0~1.0V). The ADC conversion

supports a programmable channel sequence with a length between 1 to 16 in continuous,

single, or discontinuous sampling modes. The conversion can be initiated by software or

hardware configurable trigger sources. In addition, the ADC supports DMA request and

interrupt generation.



**Figure 16-1 ADC Diagram**

**16.2 ADC Input Mode**

#### 

Channels can be configured to be either single-ended input or differential input through the

differential mode selection register (*ADC\_DIFFSEL*). External channels support both single

ended and differential modes, and internal channels only support single-ended mode. A fixed

combination is required in differential mode, channel 0 and 1 is a differential group, channel 2

and 3 is a differential group, channel 4 and 5 is a differential group, and channel 6 and 7 is a differential group. The width of the last data result of a conversion stored in the data buffer is

12-bit, where the MSB is a sign bit and the other 11 bits are data bits in differential input mode,

but no sign bit is presented in single-ended mode, all 12 bits are data bits.

**16.3 Sampling Channels**

* **8 External Channels:** In single-ended mode, each channel is independent. In differential mode, every two channels form a group and cannot be split.
* **7 Internal Channels:** include DAC output, internal VRef, VBAT/3 (battery voltage), Vts (internal temperature sensor) and a channel dedicated for internal tests. The internal channels do not support differential mode.

**Table 16-1 ADC Sampling Channels**

|  |  |  |
| --- | --- | --- |
| Sampling Channel No. | Signal | Remark |
| 1 | ADC\_PAD\_IN<0> | GPIO11 |
| 2 | ADC\_PAD\_IN<1> | GPIO08 |
| 3 | ADC\_PAD\_IN<2> | GPIO05 |
| 4 | ADC\_PAD\_IN<3> | GPIO04 |
| 5 | ADC\_PAD\_IN<4> | GPIO50 |
| 6 | ADC\_PAD\_IN<5> | GPIO49 |
| 7 | ADC\_PAD\_IN<6> | GPIO48 |
| 8 | ADC\_PAD\_IN<7> | GPIO47 |
| 9 | OPA0\_ADC\_OUT | Internal channel |
| 10 | OPA1\_ADC\_OUT | Internal channel |
| 11 | OPA2\_ADC\_OUT | Internal channel |
| 12 | DCTEST\_OUT | Internal channel |
| 13 | TD\_OUT\_TEST | Internal channel |
| 14 | DAC\_CORE\_AOUT | Internal channel |
| 15 | VBAT31 | Internal channel |

To generate VBAT31 signal, it is necessary to enable VBAT/3 voltage division circuit by setting

the D\_VBAT\_DIV3\_EN bit in the *RESV1* register of the analog part. This channel is nominally

1/3 of VBAT and it is 1/3.06 of VBAT actually.

**16.4 Trigger Source**

* **Software trigger:** The conversion starts immediately when a rising edge on the START bit of ADC\_CR is detected.
* **Hardware trigger:** The conversion is triggered by Timer or IO, containing 10 selectable trigger sources with a configurable level.

The trigger mode is selected through the TRIG\_SEL bit in register *ADC\_CFGR* and the external trigger source is selected through the EXT\_TRIG\_SEL bit in register *ADC\_CFGR*.

**16.5 Low-power Operation**

#### 

A new trigger request can only be received after the *ADC\_DR* register has been read or the

EOC flag is cleared, which can prevent overrun but might bypass some trigger requests.

**16.6 ADC Overrun**

Configure the ADC\_DR register to hold old data or update with new data when an overrun

occurs.

**16.7 Conversion Modes**

#### 

The sampling mode is configured by the CONV\_MODE bit in register *ADC\_CFGR*:

The ADC conversion supports a programmable channel sequence with a length between 1 to

16, and the channels can be configured in single-ended or differential mode. In differential

mode, only the P input of the channels in the sequence need to be configured. A channel can

be selected more than once in the sequence, and thus the conversion of the same channel will

be performed multiple times in each sequence. The conversion sequence is configured through the *ADC\_SEQR0* and *ADC\_SEQR1* registers, and every 4 bits configures one channel number.

The two 32-bit registers have 64 bits in total, and thus up to 16 channels can be configured to

be converted.

* **Continuous Mode:** When a software or hardware trigger event occurs, the ADC performs

a sequence of conversions. After the conversions are completed, the ADC automatically

re-starts and continuously performs the same sequence of conversions until a STOP

command is issued by software.

* **Single Mode:** When a software or hardware trigger event occurs, the ADC performs a

single sequence of conversions and then stops automatically after the conversions are

completed.

* **Discontinuous Mode:** Each conversion defined in the sequence requires a hardware or

software trigger event. When a sequence of conversions is completed, a new trigger event

restarts the conversion of the first channel defined in the sequence. While in continuous

and single modes, the complete sequence is converted upon a single trigger event.

**16.8 Voltage Reference**

#### 

The reference voltage is configured through the D\_ADC\_SEL\_VREF bit in the RST register of

the analog part. The external or internal reference voltage is configured by clearing or setting

this bit, and the default value is 1.

* **Internal Voltage Reference:** VRef, 1.2V.
* **External Voltage Reference:** VREFP/3, VREFP≤3.6V. VREFP is connected to VDDA

in the ASR6601CB (48-pin) chip.

**16.9 Data Buffer**

##### 

For the 12-bit data buffer, the most significant bit is the sign bit in differential input mode.

|  |  |  |
| --- | --- | --- |
| ADC Value | Definition (differential) | Definition (single-ended) |
| 1111\_1111\_1111 | +Vref**(1)** | +Vref**(1)** |
| … | … | … |
| … | … | … |
| … | … | … |
| … | … | … |
| … | … | … |
| 1000\_0000\_0001 | +Vref/2048**(1)** | +Vref/2+Vref/4096**(1)** |
| 1000\_0000\_0000 | 0 | +Vref/2**(1)** |
| 0111\_1111\_1111 | -Vref/2048**(1)** | +Vref/2-Vref/4096**(1)** |
| … | … | … |
| … | … | … |
| … | … | … |
| … | … | … |
| … | … | … |
| 0000\_0000\_0000 | -Vref**(1)** | 0 |

***(1)*** *This value should be calibrated by software to correct error on the ADC hardware.*

The measure range in differential mode is -1.0~1.0V, and the measure range in single-ended

mode is 0.1~1.1V. In order to correct the error on the ADC hardware, ASR6601 is calibrated

before leaving the factory. The calibration data (Offset and Gain) are stored in Flash. The user

needs to convert the data read from register *ADC\_DR* to get the final AD value. The formula is

as follows:

***V = (Vout – Offset) / Gain***

where **Vout** is the value readed from the data buffer.

##### 16.10 DMA Request

When the 12-bit data buffer is full, the DMA request is genetated if the DMA\_EN bit in register

ADC\_CFGR is set. And the DMA request is disabled by writing ‘0’ to the DMA\_EN bit.

##### 16.11 Interrupts

The interrupt sources include the end of conversion (EOC), end of a sequence of conversions

(EOS), and a data overrun (OVERRUN). The interrupts are enabled through register *ADC\_IER*,

and the interrupt status is inquired through the *ADC\_ISR* register.

**16.12 Wakeup**

The MCU wakes up from the Sleep mode if an interrupt or event is generated.

**16.13 ADC Clock and Reset**

#### 

The ADC bus reset and the ADC clock reset are independent. The ADC module supports the

APB bus clock. The ADC interface clock source can be one of the following sources (divided

or not): sys\_clk, apb\_x\_pclk, pll\_clk or rco48m\_clk.

##### 16.14 ADC Registers

Base Address: 0x40017000

**Table 16-2 ADC Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| ADC\_CR | 0x00 | ADC Control Register |
| ADC\_CFGR | 0x04 | ADC Configuration Register |
| ADC\_SEQR0 | 0x08 | ADC Sequence Register 0 |
| ADC\_SEQR1 | 0x0C | ADC Sequence Register 1 |
| ADC\_DIFFSEL | 0x10 | ADC Differential Mode Selection Register |
| ADC\_ISR | 0x14 | ADC Interrupt and Status Register |
| ADC\_IER | 0x18 | ADC Interrupt Enable Register |
| ADC\_DR | 0x1C | ADC Data Register |

###### 16.14.1 ADC\_CR

Offset: 0x00

Reset Value: 0x00000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **31-4** | **3** | **2** | **1** | **0** |
| RESERVED | STOP | START | DIS | EN |
| r-0h | rw-0h | rw-0h | w-0h | rw-0h |

**Bits 31-4 RESERVED**: Must be kept, and cannot be modified.

**Bit 3 STOP:** ADC stop conversion command.

* 0: no action
* 1: Stop the ADC. Read 1 means that the STOP command is in progress

***Notes:***

1. *Software writes 1 to this bit to stop and discard an ongoing conversion, thus the conversion sequence is reset; this bit is cleared automatically by hardware.*
2. *After the START bit is cleared, software must wait for 3 ADCCLK ticks before reconfigure the START bit; or wait for 1 CLK\_DIV (set in register ADC\_CFGR) tick to set the DIS bit to disable the ADC.*
3. *Software is allowed to set this bit only when START=1 and STOP=0.*
4. *Before setting the STOP bit, it is recommended to disable the trigger source first, or keep the trigger level in an invalid state.*

**Bit 2 START:** ADC start conversion command.

* 0: no action
* 1: start the ADC. Read 1 means that the ADC conversion is being performed

This bit is set by software to start the ADC conversion. Software is allowed to set this bit only when EN=1 and DIS=0. Whether an ADC conversion starts immediately (software trigger mode) or won’t start until a hardware trigger event occurs depends on the TRIG\_SEL[18:17] configuration bits in register *ADC\_CFGR*.

This bit is automatically cleared by hardware in the following the following circumstances:

* In single conversion mode, if software trigger is selected (TRIG\_SEL=00 in register *ADC\_CFGR*), the START bit is cleared when the EOS flag in register *ADC\_ISR* is set.
* In discontinuous conversion mode, if software trigger is selected, the START bit is cleared when the EOC flag in register *ADC\_ISR* is set.
* In any case, after the execution of the STOP command, the START and STOP bits are cleared by hardware at the same time.

**Bit 1 DIS:** ADC disable.

* 0: no action
* 1: disable the ADC

Software is allowed to set this bit only when EN=1 and START=0 (no conversion in progress).

**Bit 0 EN:** ADC enable.

* 0: no action
* 1: enable the ADC. Read 1 means that the ADC is enabled

This bit is set by software to enable the ADC module. The software is allowed to set this bit only when all bits of register *ADC\_CR* equal 0. Reading this bit reflects whether the ADC is enabled or not. The software must wait at least 100us for the ADC analog circuit to stabilize after initialization before it enables the ADC conversion.

###### 16.14.2 ADC\_CFGR

Offset: 0x004

Reset Value: 0x00000002

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-24** | **23** | | **22** | **21-20** | **19** |  | **18-17** |
| RESERVED | RESERVED | | WAIT\_MODE | CONV\_MODE | OVERRUN\_MO | DE | TRIG\_SEL |
| r-0h | r-0h | | r-0h | r-0h | r-0h |  | rw-0h |
| **16** | | **15-13** | | **12** | **11-8** | **7-0** | |
| EXT\_TRIG\_SEL[3] | | EXT\_TRIG\_SEL[2:0] | | DMA\_EN | CLK\_DIV[11:8] | CLK\_DIV[7:0] | |
| rw-0h | | rw-0h | | rw-0h | rw-0h | rw-2h | |

**Bits 31-23 RESERVED:** Must be kept, and cannot be modified.

**Bit 22 WAIT\_MODE:** Wait conversion mode.

* 0: wait conversion mode disabled
* 1: wait conversion mode enabled

Wait for the conversion mode, that is, a new trigger request can only be received after register ADC\_DR has been read or the EOC flag (in ADC\_ISR) is cleared, which can prevent overrun but may bypass some trigger requests.

Software is allowed to write this bit only when START=0 (in register *ADC\_CR*).

**Bits 21-20 CONV\_MODE:** ADC conversion mode selection.

* 00: single conversion mode
* 01: continuous conversion mode
* 1x: discontinuous conversion mode

Software is allowed to write this bit only when START=0 (in register *ADC\_CR*).

***Note:***

1. *In single conversion mode, when a software or hardware trigger event occurs, the ADC performs a single sequence of conversions (set by ADC\_SEQR0/1). After the conversions are completed, the ADC stops until a new trigger occurs.*
2. *In continuous conversion mode, when a software or hardware trigger event occurs, the ADC performs a sequence of conversions (set by ADC\_SEQR0/1). After the conversions are completed, the ADC automatically re-starts and continuously performs the same sequence of conversions until a STOP command is issued by software.*
3. *In discontinuous conversion mode, each conversion defined in the sequence (set by ADC\_SEQR0/1) requires a hardware or software trigger event. When a sequence of conversions is completed, a new trigger event restarts the conversion of the first channel defined in the sequence.*

**Bit 19 OVERRUN\_MODE:** Overrun management mode.

* 0: the old data in the ADC\_DR register is hold when an overrun is occurred
* 1: the ADC\_DR register is overwritten with the newly converted data when an overrun is occurred

Software is allowed to write this bit only when START=0 (in register *ADC\_CR*).

**Bits 18-17 TRIG\_SEL:** Trigger mode and polarity selection.

* 00: software trigger. The conversion starts immediately when a rising edge on the START bit of ADC\_CR is detected
* 01: hardware trigger detection on the rising edge
* 10: hardware trigger detection on the falling edge
* 11: hardware trigger detection on both edges

Software is allowed to write this bit only when START=0 (in register *ADC\_CR*).

When a hardware trigger is selected, after the START bit is configured, software must wait for 3 ADCCLK ticks before receiving the trigger signal.

**Bits 16-13 EXT\_TRIG\_SEL:** External trigger selection for the start of ADC conversion.

* 0000~0100: reserved
* 0101: GPIO47
* 0110: GPIO31
* 0111: GPIO19
* 1000: GPIO10
* 1001: GPTIM1\_TRGO
* 1010: GPTIM0\_CH2\_OUT
* 1011: GPTIM3\_TRGO
* 1100: GPTIM0\_CH3\_OUT
* 1101: GPTIM0\_TRGO
* 1110: GPTIM2\_CH1\_OUT
* 1111: reserved

***Notes:***

1. *Software is allowed to write this bit only when START=0 (in register ADC\_CR).*
2. *If the TRGO signal of GPTIMx is used as the trigger source for the ADC conversion, the MMS bit in the GPTIM0\_CR2 and GPTIM1\_CR2 registers can only be configured as 0b100 (OC0REF), 0b101 (OC1REF), 0b110 (OC2REF) or 0b111 (OC3REF). For GPTIM2\_CR2 and GPTIM3\_CR2, only 0b100 (OC0REF) or 0b101 (OC1REF) can be selected.*
3. *To achieve timed trigger or periodic trigger, you need to configure the selected channel as output mode, select the corresponding output mode, and configure the corresponding GPTIMx\_ARR and GPTIMx\_CCRx according to the required time.*

**Bit 12 DMA\_EN:** DMA enable.

* 0: DMA disabled
* 1: DMA enabled

**Bits 11-0 CLK\_DIV:** ADCCLK prescale.

* 000: not divided
* 001: not divided
* n: ADC\_IP\_CLK=ADCCLK/n, 50% duty cycle

***Notes:***

1. *This bit can only be configured when all bits of the ADC\_CR register are 0; the clock source selection for ADCCLK is configured in the RCC\_CR2 register.*
2. *The clock division and clock source selection need to consider the data readout speed. The ADC samples every 16 ADC clock cycles, if a high-speed ADC clock source is chosen, the converted data cannot be read in time by the software or the DMA, which may cause overflow.*

###### 16.14.3 ADC\_SEQR0

Offset: 0x008

Reset Value: 0x00000000

***Note:*** *Software is allowed to configure this register only when START=0 and EN=0 (in ADC\_CR).*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-28** | **27-24** | **23-20** | **19-16** | **15-12** | **11-8** | **7-4** | **3-0** |
| SEL7 | SEL6 | SEL5 | SEL4 | SEL3 | SEL2 | SEL1 | SEL0 |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-28 SEL7:** Select the channel number from 1 to 15 as the 7th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 27-24 SEL6:** Select the channel number from 1 to 15 as the 6th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 23-20 SEL5:** Select the channel number from 1 to 15 as the 5th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 19-16 SEL4:** Select the channel number from 1 to 15 as the 4th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 15-12 SEL3:** Select the channel number from 1 to 15 as the 3th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 11-8 SEL2:** Select the channel number from 1 to 15 as the 2nd in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 7-4 SEL1:** Select the channel number from 1 to 15 as the 1st in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 3-0 SEL0:** Select the channel number from 1 to 15 as the 0th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

###### 16.14.4 ADC\_SEQR1

Offset: 0x00C

Reset Value: 0x00000000

***Note:*** *Software is allowed to configure this register only when START=0 and EN=0 (in ADC\_CR).*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-28** | **27-24** | **23-20** | **19-16** | **15-12** | **11-8** | **7-4** | **3-0** |
| SEL15 | SEL14 | SEL13 | SEL12 | SEL11 | SEL10 | SEL9 | SEL8 |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-28 SEL15:** Select the channel number from 1 to 15 as the 15th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 27-24 SEL14:** Select the channel number from 1 to 15 as the 14th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 23-20 SEL13:** Select the channel number from 1 to 15 as the 13th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 19-16 SEL12:** Select the channel number from 1 to 15 as the 12th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 15-12 SEL11:** Select the channel number from 1 to 15 as the 11th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 11-8 SEL10:** Select the channel number from 1 to 15 as the 10th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 7-4 SEL9:** Select the channel number from 1 to 15 as the 9th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

**Bits 3-0 SEL8:** Select the channel number from 1 to 15 as the 8th in the conversion sequence.

If 0 rather than 1 to 15 is configured, it marks the end of the sequence and itself cannot be converted. If the channel numbers selected by bits SEL**x** are the same, the conversion of the same channel in a sequence will be performed multiple times.

In differential input mode, only the channel number of the positive input needs to be configured by software, and the channel number of the negative input is selected automatically by hardware according to register *ADC\_DIFFSEL*.

###### 16.14.5 ADC\_DIFFSEL

Offset: 0x010

Reset Value: 0x00000000

***Note:*** *Software is allowed to configure this register only when START=0 and EN=0 (in ADC\_CR).*

|  |  |  |  |
| --- | --- | --- | --- |
| **31-16** | **15-9** | **8-1** | **0** |
| RESERVED | SEL1 | SEL0 | RESERVED |
| r-0h | r-0h | rw-0h | r-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-9 SEL1:** Channels 9 to 15 are internal channels.

These channels can only be configured in single-ended mode. These bits are read-only.

**Bits 8-1 SEL0:** Differential or single-ended mode selection for Channels 1 to 8.

Each bit controls a channel with the same number as it:

* 0: channel x is configured in single-ended mode
* 1: channel x is configured in differential mode

In Differential mode, a group consists of two adjacent external channels, such as Group 1 consisting of

Channel 2 and Channel 3, so the corresponding two control bits of this register should be set to 1 at the

same time.

**Bit 0 RESERVED:** Must be kept, and cannot be modified.

###### 16.14.6 ADC\_ISR

Offset: 0x014

Reset Value: 0x00000000

***Note:*** *It is recommended to clear all bits of this register before software sets the START bit (in register ADC\_CR).*

|  |  |  |  |
| --- | --- | --- | --- |
| **31-3** | **2** | **1** | **0** |
| RESERVED | OVERRUN | EOS | EOC |
| r-0h | rw1c-0h | rw1c-0h | rw1c-0h |

**Bits 31-3 RESERVED:** Must be kept, and cannot be modified.

**Bit 2 OVERRUN:** ADC conversion overrun flag.

* 0: no overrun
* 1: overrun occurred

This bit is set by hardware when an overrun occurs and a new conversion is completed when the EOC flag was already set, but the *ADC\_DR* register has not been read or software writing 1 to clear this bit was not configured.

It is cleared by software writing 1 to it.

**Bit 1 EOS:** End of sequence of conversions flag.

* 0: conversion sequence in progress
* 1: conversion sequence completed

This bit is set by hardware when a sequence of conversions (set by *ADC\_SEQR0/1*) is completed.

It is cleared by software writing 1 to it.

**Bit 0 EOC:** End of conversion flag.

* 0: channel conversion in progress
* 1: channel conversion completed

This flag is set by hardware at the end of each conversion of a channel (when the newly converted data is stored in the *ADC\_DR* register).

It is cleared by software writing 1 to it or by reading the *ADC\_DR* register.

###### 16.14.7 ADC\_IER

Offset: 0x018

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-3** | **2** | **1** | **0** |
| RESERVED | OVERRUN\_INT\_EN | EOS\_INT\_EN | EOC\_INT\_EN |
| r-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-3 RESERVED:** Must be kept, and cannot be modified.

**Bit 2 OVERRUN\_INT\_EN:** ADC conversion overrun interrupt enable.

* 0: overrun interrupt disabled
* 1: overrun interrupt enabled

**Bit 1 EOS\_INT\_EN:** End of conversion sequence interrupt enable.

* 0: end of conversion sequence interrupt disabled
* 1: end of conversion sequence interrupt enabled

**Bit 0 EOC\_INT\_EN:** End of conversion interrupt enable.

* 0: end of conversion interrupt disabled
* 1: end of conversion interrupt enabled

###### 16.14.8 ADC\_DR

Offset: 0x01C

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-12** | **11-0** |
| RESERVED | DATA |
| r-0h | r-0h |

**Bits 31-12 RESERVED:** Must be kept, and cannot be modified.

**Bits 11-0 DATA:** ADC converted data. In differential mode, bit[11] is the sign bit.

## 17. Basic Timer (BSTIM)

### 17.1 Introduction

BSTIMER (Basic Timer) contains a 16bits counter, supports auto-reloading function, and supports up to 16-bits programmable frequency division counter. There are two BSTIMERs, named BSTIMER0 and BSTIMER1.

### 17.2 Main features

BSTIMER includes the following functions:

* 16bits counter, up-counting, auto-reloading
* Prescaler
* DMA control
* Single pulse mode
* Master mode
* Update event management
* Debug mode control
* Interrupt signal generation

BSTIMER structure diagram:



**u**

**\_**

**reg**

**\_**

**model**



**Master**

**C**

**ontrol**



**u**

**\_**

**psc**

**\_**

**counter**



**I**

**nterrupt**

**Control**



**DMA**

**C**

**ontrol**

**dma**

**\_**

**ack**

**dma**

**\_**

**req**

**apb**

**\_**

**write**

**apb**

**\_**

**read**

**interrupt**

**trigger**

**\_**

**output**

**rcc**

**\_**

**tim**

**\_**

**clk**



**u**

**\_**

**counter**

**reset**

**,**

**enable**

**,**

**update**



**ARR**

**\_**

**shadow**

**Figure 17-1 BSTIMER structure diagram**

* **rcc\_tim\_clk:** BSTIMER clock 
* **apb\_read:** APB bus read
* **dma\_ack:** DMA ACK 
* **trigger\_output:** BSTIMER TRGO output
* **dma\_req:** BSTIMER DMA Request 
* **interrupt:** BSTIMER interrupt
* **apb\_write:** APB bus write

### 17.3 Interface clock

The clock source of the BSTIMER interface is PCLK and cannot be set to other clock sources. Please refer to the RCC chapter for clock enable and complex bits configuration.

### 17.4 Counter

Counter only supports up-counting to ARR, so that the value of counter will change from ARR to 0, and then continue counting. At the same time, the status mark Bits UIF sets Bits. If the Update Event Interrupt Request Enable is set, an interrupt will also be generated. This The time table indicates the completion of a counting cycle. The next counting cycle counter continues to count from 0, and so on.

#### 17.5 Auto-reload

The ARPE Bits of Register BSTIM\_CR1 can be configured by software to set whether to enable the ARR Shadow Register. If ARPE=0, the Shadow Register is disabled. The value written by the software is directly updated to the ARR for counter use. If ARPE=1, the value written by the software is the value will not take effect immediately, until the update event arrives, the value will be updated to ARR for counter use.

#### 17.6 Frequency division counter

BSTIMER supports 16-bit (1~65535) programmable frequency division. This function is implemented through the frequency division counter BSTIM\_PSC. The interface clock is the clock of the frequency division counter, and the CEN of Register BSTIM\_CR1 is used as the frequency division counter Enable. When the frequency division counter counts After reaching the preloaded frequency division value, a pulse is output as the counting enable of the next level counter, and then the frequency division counter is reset to zero and counts again, and so on.

The frequency division value of the frequency division counter enables the shadow Register by default, that is, the write operation of the software will not take effect immediately. Instead, the new frequency division value will not be written to the shadow Register until an update event (UG event sets Bits, count overflow) arrives. , the frequency division value officially takes effect at this time. The software read operation reads the written Register value, not the shadow Register. If there are multiple write operations before the update event arrives, the previously written value will be overwritten. The counting and frequency division waveforms are as follows:



**Figure 17-2 Counting and Dividing Waveforms**

### 17.7 DMA control

BSTIMER supports the DMA function. After enabling the DMA function, all its Registers except BSTIM\_SR and BSTIM\_EGR can transfer data to each other and memory. BSTIM\_SR can only read data, and BSTIM\_EGR can only write data. Enable DMA through UDE Bits of Register BSTIM\_DIER , when there is an update event, a DMA Request will be generated.

The ACK signal returned by DMA clears the module's DMA Request signal.

#### 17.8 Single pulse mode

BSTIMER supports single pulse counting mode. This mode is set by setting the OPM BitsEnable of BitsRegister BSTIM\_CR1. In this mode, when the counter reaches the ARR value, it will return to zero and stop counting (CEN hardware will automatically clear it). It will not count again unless it is initialized again, as shown in the following figure:



**Figure 17-3 Single pulse waveform**

#### 17.9 Main mode selection

BSTIMER can be cascaded with other internal modules and used as a host by generating a trigger output signal (TRGO) for DAC control. The source of the TRGO signal can be selected by software configuring the MMS bit of the BSTIM\_CR2 register, as follows:

Down:

 MMS=3’b000: Reset mode, at this time the UG flag will be output to the external slave as a TRGO signal.

 MMS=3’b001: Enable mode. At this time, the counting enable CEN of the counter will be output to the outside as a TRGO signal.

Slave machine.

 MMS=3’b010: Update mode. At this time, the update event is output to the external slave as a TRGO signal.

 Other values of MMS are reserved values.

#### 17.10 Update event management

Update events include the following event sources:

1. Counter overflow event (overflow), that is, the value of counter changes from ARR to 0.

2. UG Set Bits (software Set Bits), that is, configure the UG Bits of Register BSTIM\_EGR.

The control signals related to update event management are URS and UDIS in BSTIM\_CR1 register . The specific controls are as follows:

If UDIS=0, URS=0, the overflow and UG setting Bits will initialize the counter and frequency division counter. If the shadow Register is enabled, the update event will update the written value to the shadow Register (ARR depends on ARPE).

UIF will set. If interrupt or DMA is enabled, interrupt or DMA Request will be generated.

If UDIS=0, URS=1, the overflow and UG setting Bits will initialize the counter and frequency division counter. If the shadow Register is enabled, the update event will update the written value to the shadow Register (ARR depends on ARPE).

UIF will only set Bits in the case of overflow. If interrupt or DMA is enabled, interrupt or DMA Request will be generated.

If UDIS=1 (ignoring URS), only UG setting Bits will still initialize counter and frequency division counter, but the shadow Register will not be updated, and UIF will not set Bits, so no corresponding interrupt or DMA Request will be generated.

### 17.11 Debug mode control

BSTIMER can be configured by software whether to stop counting under debug. The DEBUG mode counting control of BSTIMER0 and BSTIMER1 is implemented through the CR2 Register of SYSCFG. If this function is enabled, BSTIMER will stop counting when entering the system debug mode (the counter will not be initialized).

### 17.12 Interrupt

The interrupt signal of BSTIMER is as follows:

**Table 17-1 BSTIMER interrupt**

|  |  |
| --- | --- |
| Interrupt | Description |
| Update event interrupt | Counter overflow and UG bit setting can generate update event interrupt. |

The above interrupt is enabled by configuring the UIE Bits of Register BSTIM\_DIER. The interrupt status can be configured through Register BSTIM\_SR obtained.

### 17.13 BSTIMER Registers

BSTIMER0 Base Address: 0x4000C000

BSTIMER1 Base Address: 0x4001C000

**Table 17-2 BSTIMER Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| BSTIM\_CR1 | 0x00 | Control Register 1 |
| BSTIM\_CR2 | 0x04 | Control Register 2 |
| BSTIM\_DIER | 0x0c | DMA/Interrupt Enable Register |
| BSTIM\_SR | 0x10 | Status Register |
| BSTIM\_EGR | 0x14 | Event Register |
| BSTIM\_CNT | 0x24 | Counter Register |
| BSTIM\_PSC | 0x28 | Counter Prescaler Register |
| BSTIM\_ARR | 0x2c | Counter Auto-Reload Register |

#### 17.13.1 BSTIM\_CR1

Offset: 0x000

Reset Value: 0x00000000

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **31-8** | **7** | **6-4** | **3** | **2** | **1** | **0** |
| RESERVED | ARPE | RESERVED | OPM | URS | UDIS | CEN |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bit 7 ARPE:** Reload shadow Register enable.

* 0: BSTIM\_ARR Shadow Register disabled
* 1: BSTIM\_ARR Shadow Register enabled

**Bits 6-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 OPM:** Single pulse mode enable.

* 0: single pulse mode disabled
* 1: single pulse mode Enabled, counter stops counting at the next update event

**Bit 2 URS:** Update event source selection, this bit only affects the interrupt (UIF) and DMA flag bits, and does not affect the internal logic.

* 0: Counter overflow and UG bit can set UIF bit
* 1: Only counter overflow events can set UIF bit

**Bit 1 UDIS:** Update events are disable.

* 0: Update event enabled, update events can be generated.
* 1: The update event is disabled, the shadow Register and UIF will not be updated, but at this time the counter and prescaler can still be initialized by the UG bit Set event.

**Bit 0 CEN:** Counter enable, CEN is cleared by hardware in single pulse mode.

* 0: Counter disabled
* 1: Counter enabled

#### 17.13.2 BSTIM\_CR2

Offset: 0x004

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-7** | **6-4** | **3-0** |
| RESERVED | MMS | RESERVED |
| rw-0h | rw-0h | rw-0h |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bits 6-4 MMS:** Master mode selection, TRGO output can be configured.

000: Reset mode, UG will be output as TRGO signal

* 001: Enable mode, CEN will be output as TRGO signal
* 010: Update mode, update events (internal signals) will be output as TRGO signals
* Other values: Reserved

**Bits 3-0 RESERVED:** Must be kept, and cannot be modified.

#### 17.13.3 BSTIM\_DIER

Offset: 0x00C

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-9** | **8** | **7-1** | **0** |
| RESERVED | UDE | RESERVED | UIE |
| rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-9 RESERVED:** Must be kept, and cannot be modified.

**Bit 8 UDE:** Update event DMA Request Enable.

* 0: Disable update event DMA Request
* 1: Enable update event DMA Request

**Bits 7-1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 UIE:** Update event Interrupt Request enable.

* 0: Update event Interrupt Request disabled
* 1: Update event Interrupt Request enabled

#### 17.13.4 BSTIM\_SR

Offset: 0x010

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-1** | **0** |
| RESERVED | UIF |
| r-0h | r-0h |

**Bits 31-1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 UIF:** Update event flag.

* 0: no update event
* 1: update event occurs

#### 17.13.5 BSTIM\_EGR

Offset: 0x014

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-1** | **0** |
| RESERVED | UG |
| w-0h | w-0h |

**Bits 31-1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 UG:** Update event generation enable.

* 0: update event generation disabled
* 1: update event generation enabled

#### 17.13.6 BSTIM\_CNT

Offset: 0x024

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | CNT |
| rw-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 CNT:** Counter count value.

#### 17.13.7 BSTIM\_PSC

Offset: 0x028

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | PSC |
| rw-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 PSC:** Clock division value is PSC+1.

#### 17.13.8 BSTIM\_ARR

Offset: 0x02C

Reset Value: 0x0000ffff

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | ARR |
| rw-0h | rw-ffffh |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 ARR:** Counter auto-reload value.

## 18. RTC

### 18.1 Introduction

The Real-time Clock is an independent BCD timer/counter. It has two 32-bit registers, which

contain the seconds, minutes, hours (12-hour or 24-hour format), day of week, date of month,

month, and year, expressed in binary coded decimal format (BCD). In addition, there is a 32-

bit register used to indicate sub-seconds value. The RTC supports operation under low-power

mode.

### 18.2 Main features

The features of RTC are as follows:

1. Calendar with the seconds, minutes, hours (12-hour or 24-hour format), day of week, date of month, month, and year, expressed in binary coded decimal format (BCD).
2. RTC frequency calibration with a resolution of about 0.5 ppm with a range from -1024 ppm to +1024 ppm.
3. Wake-up from low-power modes.
4. Tamper/wakeup IO detection at high or low level with configurable filter.
5. 32-bit counter for periodic count.
6. 2 Alarms, support calendar matching.
7. Clear retention SRAM on tamper/wakeup alarm.
8. Internal signal output by GPIO, including Alarm0 pulse, Alarm1 pulse, periodic counter pulse and second signal.
9. Calendar values reading.
10. Sub-seconds value reading.
11. Period counting value reading.
12. Interrupt signal generation.

**18.3 Interface Clock**

### 

Both XO32K and RCO32K can be RTC clock source and XO32K accuracy is higher than

RCO32K.

See *RCC* Chapter for clock configuration details.

**18.4 Calendar**

### 

The RTC calendar time and date are accessed through two types of registers, which are the

asynchronous registers and the synchronous registers.

* *RTC\_SYNDATA* and *RTC\_SYNDATA\_H* are **asynchronous registers**.

*RTC\_SYNDATA* indicates the seconds, minutes and hours; *RTC\_SYNDATA\_H* indicates the day of week, date of month, month and year.

* *RTC\_CALENDAR\_R* and *RTC\_CALENDAR\_R\_H* are **synchronous registers**.

*RTC\_CALENDAR\_R* indicates the seconds, minutes and hours; *RTC\_CALENDAR\_R\_H* indicates the day of week, date of month, month and year.

**18.4.1 Reading the Calendar**

#### 

This document only introduces reading the RTC calendar values by **synchronous registers**.

The synchronous registers should be read several times with the same result obtained to

ensure that the data is correct. Follow below steps to read the calendar：

1. Read the *RTC\_SUB\_SECOND* register to get the subsecond\_count value.
2. Read the value of the *RTC\_CALENDAR\_R* register for two consecutive times, if the values read are different, then continue reading until the values read for two consecutive times are the same.
3. Read the value of the *RTC\_CALENDAR\_R\_H* register for two consecutive times, if the values read are different, then continue reading until the values read for two consecutive times are the same.
4. Read the value of the *RTC\_SUB\_SECOND* register again, if the value is not equal to the value in Step 1, then software will restart reading the calendar from Step 1.
5. When the subseconds downcounter reaches 0, the value of the *RTC\_CALENDAR\_R* or *RTC\_CALENDAR\_R\_H* register may have no change, so if the subsecond\_count value is 0, then the software will restart reading the calendar from Step 1; if subsecond\_count value is not 0, then it indicates that the complete calendar time has been read correctly.

For converting subsecond\_count to sub-second (unit: microsecond), first obtain the frequency of the RTC interface clock (fRTCCLK) through the RTC\_CLK\_SEL bit in the *RCC\_CR1* register, then use the formula below to calculate the sub-second:

***sub-second=(1000000\*SUBSECOND\_COUNT)/fRTCCLK***

**18.4.2 Setting the Calendar**

#### 

The *RTC\_CALENDAR\_H* and *RTC\_CALENDAR* registers are used to set the calendar*.* RTC\_CALENDAR\_H sets the year, month, date of month and day of week. RTC\_CALENDAR sets the hours, minutes and seconds. Since the *RTC\_SUB\_SECOND* register is read-only, the subsecond is read-only. Follow below steps to set the calendar:

1. Read the *RTC\_SR1* register, and wait for all WRITE\_XXX\_DONE bits and the SECOND\_SR bit (bits[11:1]) to be set. After that, writing to the *RTC\_CALENDAR\_H* and *RTC\_CALENDAR* registers is allowed.
2. Configure the year, month, date of month and day of week in the *RTC\_CALENDAR\_H* register.
3. Read the *RTC\_SR1* register, and wait for all WRITE\_XXX\_DONE bits and the SECOND\_SR bit (bits[11:1]) to be set. After that, writing to the *RTC\_CALENDAR\_H* and *RTC\_CALENDAR* registers is allowed.
4. Configure the hours, minutes and seconds in the *RTC\_CALENDAR* register.

**18.5 RTC PPM Calibration**

### 

The RTC frequency can be calibrated with a resolution of about 0.5 ppm with a range from

-1024 ppm to +1024 ppm. Configure register *RTC\_PPMADJUST* to set the adjustment value.

When the value is set to 0x7FFF, it means to adjust 0 ppm, that is, no adjustment is required.

Follow below steps to conduct the PPM calibration:

1. Read the *RTC\_SR1* register, and wait for all WRITE\_XXX\_DONE bits and the SECOND\_SR bit (bits[11:1]) to be set. After that, writing to the *RTC\_PPMADJUST* register is allowed.
2. Configure the adjustment value in the *RTC\_PPMADJUST* register.

**18.6 Wake-up from Low-power Mode**

#### 

RTC can wake up the MCU from Sleep, Stop or Standby mode through an interrupt or wakeup signal.

**Table 18-1 RTC Wakeup Source**

|  |  |
| --- | --- |
| Mode | Description |
| Sleep | RTC interrupts can wake up the device from the Sleep mode. |
| Stop0/Stop1/Stop2/Stop3 | RTC wakeup, RTC tamper event, RTC alarm, and periodic count  signal can wake up the device from Stop mode. |
| Standby | RTC wakeup, RTC tamper event, RTC alarm, and periodic count  signal can wake up the device from Standby mode. |

Enable the wakeup/tamper IO, RTC alarm and periodic count signal for wake-up through the

corresponding bit in register *RTC\_CR*：

**Table 18-2 Bits to Enable Wake-up Signals**

##### 

|  |  |
| --- | --- |
| Function | Bits in Register RTC\_CR |
| WAKEUP\_IO0 | WAKEUP0\_WKEN1 |
| WAKEUP\_IO1 | WAKEUP1\_WKEN1 |
| WAKEUP\_IO2 | WAKEUP2\_WKEN1 |
| TAMPER | TAMPER\_WKEN1 |
| ALARM0 | RTC\_ALARM0\_WKEN |
| ALARM1 | RTC\_ALARM1\_WKEN |
| CYC | CYC\_WKEN |

**18.7 Tamper/Wakeup IO Detection**

### 

The tamper/wakeup IO input events can be configured for edge detection or level detection

with filtering. Edge detection means to detect the rising or falling edge of GPIO, while level

detection means to detect the high or low level of GPIO. If GPIO is active at high level, a tamper

detection event is generated when a high level is detected on GPIO input; if GPIO is active at

low level, a tamper detection event is generated when a high level is detected on GPIO input.

When an input event is detected, the following actions can be conducted:

* Erase the retention SRAM.
* Generate an interrupt, capable to wakeup from Sleep mode.
* Generate a wakeup signal (WAKEUP\_IO0/WAKEUP\_IO1/WAKEUP\_IO2/TAMPER), capable to wakeup from Stop and Standby modes.

**18.7.1 Tamper/Wakeup Initialization and Configuration**

#### 

Before Tamper/Wakeup initialization, the corresponding GPIO should be configured as tamper/

wakeup function. In addition, if it is level detection, GPIO should be configured with pull-up or

pull-down. If GPIO is active at high level, pull down GPIO; if GPIO is active at low level, pull up

GPIO.

Taking Tamper as an example, the initialization and configuration process is as follows:

1. If it is level detection, set the filter length by configuring bit TAMPER\_FILTER\_CFG in the *RTC\_CR* register, configure the active level by bit TAMPER\_LEVEL\_SEL, and then enable the tamper pin level wakeup by the TAMPER\_WKEN0 bit. ***If it is edge detection, ignore this step.***
2. Configure bit TAMPER\_WKEN1 in register *RTC\_CR* to enable TAMPER\_SR to wake up the MCU from Stop or Standby mode. ***If no such need, ignore this step***.
3. Set the TAMPER\_EN bit in the *RTC\_CR* register to enable tamper detection.

**18.7.2 Erase Operation on Retention SRAM**

##### 

When the tamper/wakeup IO input event is detected, the hardware can erase the retention SRAM. This is configured by setting the corresponding bit of RTC\_RET\_SRAM\_ERASE\_EN in register *RTC\_CR2*. Bit0 corresponds to wakeup IO0, bit1 corresponds to wakeup IO1, bit2 corresponds to wakeup IO2, and bit3 corresponds to tamper function.

**18.8 Periodic Counter**

#### 

The periodic counter generates interrupts or wakeup events at regular intervals. The regular interval is set according to the configured CYC\_MAX\_VALUE in the *RTC\_CYC\_MAX\_VALUE r*egister. Obtain the RTC interface clock frequency (fRTCCLK) through the RTC\_CLK\_SEL bit in the *RCC\_CR1* register, and then use the formula below to calculate the regular interval (in microseconds):

***Regular interval = (1000000 \* CYC\_MAX\_VALUE) / fRTCCLK***

During the periodic count, the number of elapsed cycles is read from the CYC\_CNT\_VALUE bits in the *RTC\_CYC\_CNT\_VALUE* register. On this basis, the interval (in microseconds) from the start of the ongoing counting to the current moment can be calculated by the formula below:

***Interval = (1000000 \* CYC\_CNT\_VALUE) / fRTCCLK***

Follow below steps to configure the periodic count:

1. When the regular interval is known, calculate the CYC\_MAX\_VALUE according to the above formula, and configure this value to register *RTC\_CYC\_MAX\_VALUE*.
2. Configure bit CYC\_WKEN in register *RTC\_CR* to enable CYC\_SR to wake up CPU from Stop or Standby mode. ***If no such need, ignore this step***.
3. Set bit CYC\_START\_COUNTER in register *RTC\_CR* to enable periodic counter.

**18.9 RTC Alarms**

#### 

RTC provides two alarms: Alarm 0 and Alarm 1. Both support mask selection and matching with calendar. With Mask configuration, each calendar field (sub-seconds, seconds, minutes, hours, date or day of week) can be independently selected to match the values programmed in the alarm registers. Note that for the date and the day of week, we can only choose one of them for the match.

If bit ALARM**x**\_WEEK\_SEL (Alarm**x** means Alarm 0 or Alarm 1, similarly hereinafter) is 0 in the register *RTC\_ALARM****x***, the date is selected for the match; if bit ALARM**x**\_WEEK\_SEL is 1, the day of week is selected for the match.

If the sub-seconds and seconds are not involved but the minutes are involved in Alarm**x** comparison, when Alarm**x** values match with those of the RTC Calendar, 60 interrupts or/and 60 wake-up events are generated at a one-second interval in one minute. If the sub-seconds, seconds, and minutes are not involved but the hours are involved in Alarm**x** comparison, when Alarm**x** values match with those of the RTC Calendar, 3600 interrupts or/and 3600 wake-up events are generated at a one-second interval in one hour. Whether the interrupts or/and wake-up events are generated depends on whether the alarm interrupt or/and the alarm wake-up is enabled.

The seconds, minutes, hours, date or day mask are configured through the ALARM**x**\_MASK bit field in the *RTC\_ALARM****x*** register, and the sub-seconds mask is configured through the RTC\_ALARM**x**\_SUB\_MASK bit field in the *RTC\_ALARM****x****\_SUB* register. The sub-seconds value is set by the RTC\_ALARM**x**\_SUB\_VALUE bit field in the *RTC\_ALARM****x****\_SUB* register.

The RTC\_ALARM**x**\_SUB\_VALUE indicates RTC clock cycles, and the formula for converting clock cycles to time is the same as that in periodic count.

Take Alarm 0 as an example to describe the alarm configuration process as follows:

1. Set the calendar.
2. Configure the Alarm 0 values (including the hours, minutes, seconds, date or day) by the ALARM0\_VALUE bit field in the *RTC\_ALARM0* register.
3. Configure the sub-seconds value for Alarm 0 through the RTC\_ALARM0\_SUB\_VALUE bit field in the *RTC\_ALARM0\_SUB* register.
4. Configure the seconds, minutes, hours, date or day mask for Alarm 0.
5. Configure the sub-seconds mask for Alarm 0.
6. Whether the ALARM0\_SR interrupt or ALARM0\_SR wake-up is enabled depends on the specific needs. They are configured through the ALARM0\_SR\_INT\_EN bit in register *RTC\_CR1* and the RTC\_ALARM0\_WKEN bit in register *RTC\_CR*.
7. Enable the Alarm 0 through the ALARM0\_EN bit in register *RTC\_ALARM0*.
8. Enable the calendar by setting the RTC\_START\_RTC bit in register *RTC\_CR*.

**18.10 Internal Signal Output through IO**

The internal signals that can be output through IO include Alarm 0 pulse, Alarm 1 pulse, periodic counter pulse, and the second signal. The alarm pulse and periodic counter pulse are pulses with a width of one RTC clock cycle. The Alarm pulse is output when the programmed values match with the Calendar. The periodic counter pulse is output every time the programmed count value is reached. The second signal is a square wave with a duty cycle of 50% and the frequency is 1 Hz. The RTC IO can output inverted levels. When the RTC\_OUT\_POL bit of the *RTC\_CR2* register is 0, it means that the level is non- inverted, and when this bit is 1, it means that the level is inverted. Configure the RTC\_OUT\_SEL bit of the *RTC\_CR2* register to select the RTC IO output signal.

**18.11 RTC Interrupts**

### 

The interrupt signals of RTC are as follows:

**Table 18-3 RTC interrupts**

|  |  |
| --- | --- |
| Interrupt | Description |
| Alarm 0 interrupt | Interrupt is generated when the interval set by Alarm 0 is reached. |
| Alarm 1 interrupt | Interrupt is generated when the interval set by Alarm 1 is reached. |
| Periodic wakeup interrupt | Interrupt is generated at regular intervals. |
| Tamper interrupt | Interrupt is generated when an input event is detected by tamper IO. |
| Wakeup IO0 interrupt | Interrupt is generated when an input event is detected by Wakeup IO0 IO. |
| Wakeup IO1 interrupt | Interrupt is generated when an input event is detected by Wakeup IO1 IO. |
| Wakeup IO2 interrupt | Interrupt is generated when an input event is detected by Wakeup IO2 IO. |
| Second signal interrupt | Interrupt is generated by the second signal every second. |

The above interrupts are enabled by configuring the *RTC\_CR1* register. The second signal interrupt status is indicated by the SECOND\_SR bit in the *RTC\_SR1* register, and the other interrupts’ status is indicated by the *RTC\_SR* register.

### 18.12 RTC Registers

Base Address: 0x4000E000

**Table 18-4 RTC Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| RTC\_CR | 0x00 | RTC Control Register 1 |
| RTC\_ALARM0 | 0x04 | RTC Alarm 0 Register |
| RTC\_ALARM1 | 0x08 | RTC Alarm 1 Register |
| RTC\_PPMADJUST | 0x0c | RTC PPMADJUST Register |
| RTC\_CALENDAR | 0x10 | RTC Calendar Configuration Register  (second, minute, hour) |
| RTC\_CALENDAR\_H | 0x14 | RTC Calendar Configuration Register  (date/day of week, month, year) |
| RTC\_CYC\_MAX\_VALUE | 0x18 | RTC Periodic Counter Value Configuration Register |
| RTC\_SR | 0x1c | RTC Status Register |
| RTC\_ASYNDATA | 0x20 | RTC Calendar ASYNDATA Register  (second, minute, hour) |
| RTC\_ASYNDATA\_H | 0x24 | RTC Calendar ASYNDATA Register  (date/day of week, month, year) |
| RTC\_CR1 | 0x28 | RTC Control register 1 (interrupt enable) |
| RTC\_SR1 | 0x2c | RTC Status Register 1 |
| RTC\_CR2 | 0x30 | Control Register 2 |
| RTC\_SUB\_SECOND | 0x34 | RTC Sub-second Register |
| RTC\_CYC\_CNT\_VALUE | 0x38 | RTC Periodic Counter Value Register (read-only) |
| RTC\_ALARM0\_SUB | 0x3c | RTC Alarm 0 Sub-second Register |
| RTC\_ALARM1\_SUB | 0x40 | RTC Alarm 1 Sub-second Register |
| RTC\_CALENDAR\_R | 0x44 | RTC Calendar SYNDATA Register  (second, minute, hour) |
| RTC\_CALENDAR\_R\_H | 0x48 | RTC Calendar SYNDATA Register  (date/day of week, month, year) |

#### 18.12.1 RTC\_CR

Offset: 0x00

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **31-29** |  | **28** | | **27** | | **26** | | **25** | |
| RESERVED |  | RTC\_START\_RT  C | | RTC\_ALARM0\_W  KEN | | RTC\_ALARM1\_W  KEN | | CYC\_WKEN | |
| r-0h |  | rw-0h | | rw-0h | | rw-0h | | rw-0h | |
| **24** |  | **23** | | **22** | | **21** | | **20** | |
| CYC\_START\_C  UNTER | O | TAMPER\_EN | | TAMPER\_LEVEL\_  SEL | | TAMPER\_WKEN0 | | TAMPER\_WKEN1 | |
| rw-0h |  | rw-0h | | rw-0h | | rw-0h | | rw-0h | |
| **19-18** |  | **17** | | **16** | | **15** | | **14** | |
| TAMPER\_FILT  \_CFG | ER | WAKEUP0\_EN | | WAKEUP0\_LEVE  L\_SEL | | WAKEUP0\_WKE  N0 | | WAKEUP0\_WKE  N1 | |
| rw-0h |  | rw-0h | | rw-0h | | rw-0h | | rw-0h | |
| **13-12** |  | **11** | | **10** | | **9** | | **8** | |
| WAKEUP0\_FIL  R\_CFG | TE | WAKEUP1\_EN | | WAKEUP1\_LEVE  L\_SEL | | WAKEUP1\_WKE  N0 | | WAKEUP1\_WKE  N1 | |
| rw-0h |  | rw-0h | | rw-0h | | rw-0h | | rw-0h | |
| **7-6** | **5** | | **4** | | **3** | | **2** | | **1-0** |
| WAKEUP1\_FI  LTER\_CFG | WAKEUP2\_E  N | | WAKEUP2\_LE  VEL\_SEL | | WAKEUP2\_W  KEN0 | | WAKEUP2\_W  KEN1 | | WAKEUP2\_FI  LTER\_CFG |
| rw-0h | rw-0h | | rw-0h | | rw-0h | | rw-0h | | rw-0h |

**Bits 31-29 RESERVED:** Must be kept, and cannot be modified.

**Bit 28 RTC\_START\_RTC:** RTC calendar enable.

* 0: disabled
* 1: enabled

**Bit 27 RTC\_ALARM0\_WKEN:** ALARM0\_SR wake-up enable.

* 0: disabled
* 1: enabled

**Bit 26 RTC\_ALARM1\_WKEN:** ALARM1\_SR wake-up enable.

* 0: disabled
* 1: enabled

**Bit 25 CYC\_WKEN:** CYC\_SR wake-up enable.

* 0: disabled
* 1: enabled

**Bit 24 CYC\_START\_COUNTER:** Periodic counter enable.

* 0: disabled
* 1: enabled

**Bit 23 TAMPER\_EN:** Tamper enable.

* 0: disabled
* 1: enabled

**Bit 22 TAMPER\_LEVEL\_SEL:** Tamper active level selection.

* 0: low level
* 1: high level

**Bit 21 TAMPER\_WKEN0:** Tamper level wake-up enable.

* 0: disabled
* 1: enabled

When TAMPER\_EN is set to 0, this configuration is still valid.

**Bit 20 TAMPER\_WKEN1:** TAMPER\_SR wake-up enable.

* 0: disabled
* 1: enabled

**Bits 19-18 TAMPER\_FILTER\_CFG:** Tamper filter control.

* 0: none
* 1: filter length is 1 RTC interface clock cycle
* 2: filter length is 3 RTC interface clock cycles
* 3: filter length is 7 RTC interface clock cycles

**Bit 17 WAKEUP0\_EN:** WAKEUP0 enable.

* 0: disabled
* 1: enabled

**Bit 16 WAKEUP0\_LEVEL\_SEL:** WAKEUP0 active level selection.

* 0: low level
* 1: high level

**Bit 15 WAKEUP0\_WKEN0:** WAKEUP0 level wake-up enable.

* 0: disabled
* 1: enabled

When WAKEUP0\_EN is set to 0, this configuration is still valid.

**Bit 14 WAKEUP0\_WKEN1:** WAKEUP0\_SR wake-up enable.

* 0: disabled
* 1: enabled

**Bits 13-12 WAKEUP0\_FILTER\_CFG:** WAKEUP0 filter control.

* 0: none
* 1: filter length is 1 RTC interface clock cycle
* 2: filter length is 3 RTC interface clock cycles
* 3: filter length is 7 RTC interface clock cycles

**Bit 11 WAKEUP1\_EN:** WAKEUP1 enable.

* 0: disabled
* 1: enabled

**Bit 10 WAKEUP1\_LEVEL\_SEL:** WAKEUP1 active level selection.

* 0: low level
* 1: high level

**Bit 9 WAKEUP1\_WKEN0:** WAKEUP1 level wake-up enable.

* 0: disabled
* 1: enabled

When WAKEUP1\_EN is set to 0, this configuration is still valid.

**Bit 8 WAKEUP1\_WKEN1:** WAKEUP1\_SR wake-up enable.

* 0: disabled
* 1: enabled

**Bits 7-6 WAKEUP1\_FILTER\_CFG:** WAKEUP1 filter control.

* 0: none
* 1: filter length is 1 RTC interface clock cycle
* 2: filter length is 3 RTC interface clock cycles
* 3: filter length is 7 RTC interface clock cycles

**Bit 5 WAKEUP2\_EN:** WAKEUP2 enable.

* 0: disabled
* 1: enabled

**Bit 4 WAKEUP2\_LEVEL\_SEL:** WAKEUP2 active level selection.

* 0: active at low level
* 1: active at high level

**Bit 3 WAKEUP2\_WKEN0:** WAKEUP2 level wake-up enable.

* 0: disabled
* 1: enabled

When WAKEUP2\_EN is set to 0, this configuration is still valid.

**Bit 2 WAKEUP2\_WKEN1:** WAKEUP2\_SR wake-up enable.

* 0: disabled
* 1: enabled

**Bits 1-0 WAKEUP2\_FILTER\_CFG:** WAKEUP2 filter control.

* 0: no filter
* 1: the filter length is 1 RTC interface clock cycle
* 2: the filter length is 3 RTC interface clock cycles
* 3: the filter length is 7 RTC interface clock cycles

#### 18.12.2 RTC\_ALARM0

Offset: 0x004

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31** | **30** | **29-26** | **25-0** |
| ALARM0\_EN | ALARM0\_WEEK\_SEL | ALARM0\_MASK | ALARM0\_VALUE |
| rw-0h | rw-0h | rw-0h | rw-0h |

**Bit 31 ALARM0\_EN:** Alarm 0 enable.

* 0: disabled
* 1: enabled

**Bit 30 ALARM0\_WEEK\_SEL:** Date or day of week selection for Alarm 0.

* 0: match the date
* 1: match the day of week

**Bits 29-26 ALARM0\_MASK:** Alarm 0 mask configuration.

[26] Alarm 0 seconds mask

* 0: match the seconds
* 1: seconds are not involved in Alarm 0 comparison

[27] Alarm 0 minutes mask

* 0: match the minutes
* 1: minutes are not involved in Alarm 0 comparison

[28] Alarm 0 hours mask

* 0: match the hours
* 1: hours are not involved in Alarm 0 comparison

[29] Alarm 0 date or day of week mask

* 0: match the date or day of week
* 1: date or day of week is not involved in Alarm 0 comparison

**Bits 25-0 ALARM0\_VALUE:** Alarm 0 value configuration. When the calendar sub-seconds, seconds, minutes, hours, date or day of week match the values programmed in this register and the *RTC\_ALARM0\_SUB* register, the ALARM0\_SR bit is set.

[3:0]: second units

[6:4]: second tens

[10:7]: minute units

[13:11]: minute tens

[17:14]: hour units

[19:18]: hour tens

[23:20]: bits[23:20] configure date units or bits[22:20] configure day of week

[25:24]: date tens

#### 18.12.3 RTC\_ALARM1

Offset: 0x008

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31** | **30** | **29-26** | **25-0** |
| ALARM1\_EN | ALARM1\_WEEK\_SEL | ALARM1\_MASK | ALARM1\_VALUE |
| rw-0h | rw-0h | rw-0h | rw-0h |

**Bit 31 ALARM1\_EN:** Alarm 1 enable.

* 0: disabled
* 1: enabled

**Bit 30 ALARM1\_WEEK\_SEL:** Date or day of week selection for Alarm 1.

* 0: match the date
* 1: match the day of week

**Bits 29-26 ALARM1\_MASK:** Alarm 1 mask configuration.

[26] Alarm 1 seconds mask

* 0: match the seconds
* 1: seconds are not involved in Alarm 1 comparison.

[27] Alarm 1 minutes mask

* 0: match the minutes
* 1: minutes are not involved in Alarm 1 comparison.

[28] Alarm 1 hours mask

* 0: match the hours
* 1: hours are not involved in Alarm 1 comparison.

[29] Alarm 1 date or day of week mask

* 0: match the date or day of week
* 1: date or day of week is not involved in Alarm 1 comparison

**Bits 25:0 ALARM1\_VALUE:** Alarm 1 value configuration. When the calendar sub-seconds, seconds, minutes, hours, date or day of week match the values programmed in this register and the *RTC\_ALARM1\_SUB* register, the ALARM1\_SR bit is set.

[3:0]: second units

[6:4]: second tens

[10:7]: minute units

[13:11]: minute tens

[17:14]: hour units

[19:18]: hour tens

[23:20]: bits[23:20] configure date units or bits[22:20] configure day of week

[25:24]: date tens

#### 18.12.4 RTC\_PPMADJUST

Offset: 0x00c

Reset Value: 0x00007fff

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | PPMADJUST\_VALUE |
| r-0h | rw-7fffh |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 PPMADJUST\_VALUE:** The RTC clock frequency can be calibrated with a resolution of about 0.5 ppm with a range from -1024 ppm to +1024 ppm.

* 77ff: increase frequency of RTC by 1024 ppm
* 7800: increase frequency of RTC by 1023.5 ppm
* ...
* 7ffd: increase frequency of RTC by 1 ppm
* 7ffe: increase frequency of RTC by 0.5 ppm
* 7fff: no adjustment
* 8000: decrease frequency of RTC by 0.5 ppm
* 8001: decrease frequency of RTC by 1 ppm
* …
* 87fe: decrease frequency of RTC by 1023.5 ppm
* 87ff: decrease frequency of RTC by 1024 ppm

#### 18.12.5 RTC\_CALENDAR

Offset: 0x010

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-20** | **19-0** |
| RESERVED | CALENDAR\_VALUE |
| r-0h | w-0h |

**Bits 31-20 RESERVED:** Must be kept, and cannot be modified.

**Bits 19-0 CALENDAR\_VALUE:** RTC calendar time values.

[3:0]: second units

[6:4]: second tens

[10:7]: minute units

[13:11]: minute tens

[17:14]: hour units

[19:18]: hour tens

#### 18.12.6 RTC\_CALENDAR\_H

Offset: 0x014

Reset Value: 0x00000841

|  |  |
| --- | --- |
| **31-22** | **21-0** |
| RESERVED | CALENDAR\_H\_VALUE |
| r-0h | w-841h |

**Bits 31-22 RESERVED:** Must be kept, and cannot be modified.

**Bits 21-0 CALENDAR\_H\_VALUE:** RTC calendar date values.

[3:0]: date units

[5:4]: date tens

[9:6]: month units

[10]: month tens

[13:11]: week day units

[17:14]: year units

[21:18]: year tens

#### 18.12.7 RTC\_CYC\_MAX\_VALUE

Offset: 0x018

Reset Value: 0x00008000

|  |
| --- |
| **31-0** |
| CYC\_MAX\_VALUE |
| rw-8000h |

**Bits 31-0 CYC\_MAX\_VALUE:** The programmed count value for the periodic counter to reach. When the periodic counter reaches the CYC\_MAX\_VALUE, the periodic counter status flag (bit CYC\_SR) is set. The periodic counter is clocked by the RTC interface clock.

#### 18.12.8 RTC\_SR

Offset: 0x01c

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-7** | **6** | **5** | **4** |
| RESERVED | ALARM0\_SR | ALARM1\_SR | CYC\_SR |
| r-0h | rw-0h | rw-0h | rw-0h |
| **3** | **2** | **1** | **0** |
| TAMPER\_SR | WAKEUP0\_SR | WAKEUP1\_SR | WAKEUP2\_SR |
| rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 ALARM0\_SR:** Alarm 0 flag.

This flag is set by hardware and cleared by software writing 1 to it.

* 0: Alarm 0 values doesn’t match the Calendar
* 1: Alarm 0 values match the Calendar

**Bit 5 ALARM1\_SR:** Alarm 1 flag.

This flag is set by hardware and cleared by software writing 1 to it.

* 0: Alarm 1 values doesn’t match the Calendar
* 1: Alarm 1 values match the Calendar

**Bit 4 CYC\_SR:** Periodic counter flag.

This flag is set by hardware and cleared by software writing 1 to it.

* 0: CYC\_MAX\_VALUE is not reached
* 1: CYC\_MAX\_VALUE is reached

**Bit 3 TAMPER\_SR:** Tamper flag.

This flag is set by hardware and cleared by software writing 1 to it.

* 0: tamper pin active level is not detected
* 1: tamper pin active level is detected

**Bit 2 WAKEUP0\_SR:** Wakeup0 flag.

This flag is set by hardware and cleared by software writing 1 to it.

* 0: the Wakeup0 active level is not detected
* 1: the Wakeup0 active level is detected

**Bit 1 WAKEUP1\_SR:** Wakeup1 flag.

This flag is set by hardware and cleared by software writing 1 to it.

* 0: Wakeup1 active level is not detected
* 1: Wakeup1 active level is detected

**Bit 0 WAKEUP2\_SR:** Wakeup2 flag.

This flag is set by hardware and cleared by software writing 1 to it.

* 0: Wakeup2 active level is not detected
* 1: Wakeup2 active level is detected

#### 18.12.9 RTC\_ASYNDATA

Offset: 0x020

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-20** | **19-0** |
| RESERVED | SYN\_DATA |
| r-0h | r-0h |

**Bits 31-20 RESERVED:** Must be kept, and cannot be modified.

**Bits 19-0 SYN\_DATA:** RTC calendar time values. This register is read-only by software.

[3:0]: second units

[6:4]: second tens

[10:7]: minute units

[13:11]: minute tens

[17:14]: hour units

[19:18]: hour tens

#### 18.12.10 RTC\_ASYNDATA\_H

Offset: 0x024

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-22** | **21-0** |
| RESERVED | SYN\_DATA\_H |
| r-0h | r-0h |

**Bits 31-22 RESERVED:** Must be kept, and cannot be modified.

**Bits 21-0 SYN\_DATA\_H:** RTC calendar date values. This register is read-only by software.

[3:0]: date units

[5:4]: date tens

[9:6]: month units

[10]: month tens

[13:11]: week day units

[17:14]: year units

[21:18]: year tens

#### 18.12.11 RTC\_CR1

Offset: 0x028

Reset Value: 0x00000000

|  |  |  |
| --- | --- | --- |
| **31-8** | **7** | **6** |
| RESERVED | SECOND\_SR\_INT\_EN | ALARM0\_SR\_INT\_EN |
| r-0h | rw-0h | rw-0h |
| **5** | **4** | **3** |
| ALARM1\_SR\_INT\_EN | CYC\_SR\_INT\_EN | TAMPER\_SR\_INT\_EN |
| rw-0h | rw-0h | rw-0h |
| **2** | **1** | **0** |
| WAKEUP0\_SR\_INT\_EN | WAKEUP1\_SR\_INT\_EN | WAKEUP2\_SR\_INT\_EN |
| rw-0h | rw-0h | rw-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bit 7 SECOND\_SR\_INT\_EN:** SECOND\_SR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 6 ALARM0\_SR\_INT\_EN:** ALARM0\_SR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 5 ALARM1\_SR\_INT\_EN:** ALARM1\_SR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 4 CYC\_SR\_INT\_EN:** CYC\_SR (periodic counter) interrupt enable.

* 0: disabled
* 1: enabled

**Bit 3 TAMPER\_SR\_INT\_EN:** TAMPER\_SR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 2 WAKEUP0\_SR\_INT\_EN:** WAKEUP0\_SR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 1 WAKEUP1\_SR\_INT\_EN:** WAKEUP1\_SR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 0 WAKEUP2\_SR\_INT\_EN:** WAKEUP2\_SR interrupt enable.

* 0: disabled
* 1: enabled

#### 18.12.12 RTC\_SR1

Offset: 0x02c

Reset Value: 0x00000dff

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-12** | **11** | | **10** | | **9** |
| RESERVED | WRITE\_ALARM0\_SUB\_DONE | | WRITE\_ALARM1\_SUB\_DONE | | SECOND\_SR |
| r-0h | r-1h | | r-1h | | rw-0h |
| **8** | | **7** | | **6** | |
| WRITE\_RTCCR2\_DONE | | WRITE\_RTCCR\_DONE | | WRITE\_ALARM0\_DONE | |
| r-1h | | r-1h | | r-1h | |
| **5** | | **4** | | **3** | |
| WRITE\_ALARM1\_DONE | | WRITE\_PPMADJUST\_DONE | | WRITE\_CALENDAR\_DONE | |
| r-1h | | r-1h | | r-1h | |
| **2** | | **1** | | **0** | |
| WRITE\_CYC\_MAX\_VALUE\_DONE | | WRITE\_RTCSR\_DONE | | READ\_CALENDAR\_DONE | |
| r-1h | | r-1h | | r-1h | |

**Bits 31-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 WRITE\_ALARM0\_SUB\_DONE:** The complete flag of the write operation to register *RTC\_ALARM0\_SUB*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 10 WRITE\_ALARM1\_SUB\_DONE:** The complete flag of the write operation to register *RTC\_ALARM1\_SUB*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 9 SECOND\_SR:** Second signal interrupt status. This bit is set by hardware and cleared bysoftware writing 1 to it.

* 0: no second signal interrupt generated
* 1: second signal interrupt generated

**Bit 8 WRITE\_RTCCR2\_DONE:** The complete flag of the write operation to register *RTC\_CR2*. Thisbit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 7 WRITE\_RTCCR\_DONE:** The complete flag of the write operation to register *RTC\_CR*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 6 WRITE\_ALARM0\_DONE:** The complete flag of the write operation to register *RTC\_ALARM0*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 5 WRITE\_ALARM1\_DONE:** The complete flag of the write operation to register *RTC\_ALARM1*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 4 WRITE\_PPMADJUST\_DONE:** The complete flag of the write operation to register *RTC\_PPMADJUST*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 3 WRITE\_CALENDAR\_DONE:** The complete flag of the write operations to registers *RTC\_CALENDAR* and *RTC\_CALENDAR\_H*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 2 WRITE\_CYC\_MAX\_VALUE\_DONE:** The complete flag of the write operation to register *RTC\_CYC\_MAX\_VALUE*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 1 WRITE\_RTCSR\_DONE:** The complete flag of the write operation to register *RTC\_SR*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

**Bit 0 READ\_CALENDAR\_DONE:** The complete flag of the read operations to registers *RTC\_CALENDAR\_R* and *RTC\_CALENDAR\_R\_H*. This bit is set and cleared by hardware.

* 0: write operation in progress
* 1: write operation completed

#### 18.12.13 RTC\_CR2

Offset: 0x030

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-8** | **7** | **6-4** | **3-0** |
| RESERVED | RTC\_OUT\_POL | RTC\_OUT\_SEL | RTC\_RET\_SRAM\_ERASE\_EN |
| r-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bit 7 RTC\_OUT\_POL:** RTC IO output polarity.

* 0: RTC IO output level is non-inverted
* 1: RTC IO output level is inverted

**Bits 6-4 RTC\_OUT\_SEL:** RTC IO output selection.

* 0-3: no output
* 4: alarm 0 pulse
* 5: alarm 1 pulse
* 6: cyc pulse
* 7: second signal (50% duty cycle)

**Bits 3-0 RTC\_RET\_SRAM\_ERASE\_EN:** If enabled, the Retention SRAM is erased upon a tamper or a wakeup event. [0]: wakeup0, [1]: wakeup1, [2]: wakeup2, [3]: tamper.

* 0: disabled
* 1: enabled

#### 18.12.14 RTC\_SUB\_SECOND

Offset: 0x034

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-15** | **14-0** |
| RESERVED | RTC\_SUB\_SECOND\_VALUE |
| r-0h | r-0h |

**Bits 31-15 RESERVED:** Must be kept, and cannot be modified.

**Bits 14-0 RTC\_SUB\_SECOND\_VALUE:** The subsecond count value of the RTC calendar counter. This register should be read several times with the same result obtained to ensure that the data is correct.

#### 18.12.15 RTC\_CYC\_CNT\_VALUE

Offset: 0x038

Reset Value: 0x00000000

|  |
| --- |
| **31-0** |
| CYC\_CNT\_VALUE |
| r-0h |

**Bits 31-0 CYC\_CNT\_VALUE:** Periodic counter value. This register should be read several times with the same result obtained to ensure that the data is correct.

#### 18.12.16 RTC\_ALARM0\_SUB

Offset: 0x03c

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-20** | **19-16** | **15** | **14-0** |
| RESERVED | RTC\_ALARM0\_SUB\_MASK | RESERVED | RTC\_ALARM0\_SUB\_VALUE |
| r-0h | rw-0h | r-0h | rw-0h |

**Bits 31-20 RESERVED:** Must be kept, and cannot be modified.

**Bits 19-16 RTC\_ALARM0\_SUB\_MASK:** Alarm 0 sub-second mask configuration. If sub-seconds are used in Alarm 0, it is recommended not to perform RTC PPM calibration.

* 0: No comparison on sub-seconds for Alarm 0.
* 1: RTC\_ALARM0\_SUB\_VALUE [14:1] are not involved in Alarm 0 comparison. Only bit0 is compared.
* 2: RTC\_ALARM0\_SUB\_VALUE [14:2] are not involved in Alarm 0 comparison. Only bits[1:0] are compared.
* …
* 14: RTC\_ALARM0\_SUB\_VALUE [14] are not involved in Alarm 0 comparison. Bits[13:0] are compared.
* 15: All 15 RTC\_ALARM0\_SUB\_VALUE bits are compared.

**Bit 15 RESERVED:** Must be kept, and cannot be modified.

**Bits 14-0 RTC\_ALARM0\_SUB\_VALUE:** Alarm 0 sub-seconds value. When the calendar subseconds, seconds, minutes, hours, date or day of week match the values programmed in this register and the *RTC\_ALARM0* register, the ALARM0\_SR bit is set.

#### 18.12.17 RTC\_ALARM1\_SUB

Offset: 0x040

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-20** | **19-16** | **15** | **14-0** |
| RESERVED | RTC\_ALARM1\_SUB\_MASK | RESERVED | RTC\_ALARM1\_SUB\_VALUE |
| r-0h | rw-0h | r-0h | rw-0h |

**Bits 31-20 RESERVED:** Must be kept, and cannot be modified.

**Bits 19-16 RTC\_ALARM1\_SUB\_MASK:** Alarm 1 sub-second mask configuration. If sub-seconds are used in Alarm 1, it is recommended not to perform RTC PPM calibration.

* 0: No comparison on sub-seconds for Alarm 1.
* 1: RTC\_ALARM1\_SUB\_VALUE [14:1] are not involved in Alarm 1 comparison. Only bit0 is compared.
* 2: RTC\_ALARM1\_SUB\_VALUE [14:2] are not involved in Alarm 1 comparison. Only bits[1:0] are compared.
* …
* 14: RTC\_ALARM1\_SUB\_VALUE [14] are not involved in Alarm 1 comparison. Bits[13:0] are compared.
* 15: All 15 RTC\_ALARM1\_SUB\_VALUE bits are compared.

**Bit 15 RESERVED:** Must be kept, and cannot be modified.

**Bits 14-0 RTC\_ALARM1\_SUB\_VALUE:** Alarm 1 sub-seconds value. When the calendar subseconds, seconds, minutes, hours, date or day of week match the values programmed in this register and the *RTC\_ALARM1* register, the ALARM1\_SR bit is set.

#### 18.12.18 RTC\_CALENDAR\_R

Offset: 0x044

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-20** | **19-0** |
| RESERVED | CALENDAR\_SYNC |
| r-0h | r-0h |

**Bits 31-20 RESERVED:** Must be kept, and cannot be modified.

**Bits 19-0 CALENDAR\_SYNC:** RTC\_CALENDAR\_R register values (seconds, minutes and hours). This register should be read several times with the same result obtained to ensure that the data is correct.

#### 18.12.19 RTC\_CALENDAR\_R\_H

Offset: 0x048

Reset Value: 0x00000841

|  |  |
| --- | --- |
| **31-22** | **21-0** |
| RESERVED | CALENDAR\_H\_SYNC |
| r-0h | r-841h |

**Bits 31-22 RESERVED:** Must be kept, and cannot be modified.

**Bits 21-0 CALENDAR\_H\_SYNC:** RTC\_CALENDAR\_R\_H register values (date or day of week, month and year). This register should be read several times with the same result obtained to ensure that the data is correct.

### 19. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_LPUART

#### 19.1 Introduction

LPUART (Low-power Universal Asynchronous Receiver/Transmitter) is a low-power serial port peripheral. When the 32K clock is used, the LPUART communications can be up to 9600 baud/s. Even in Deepsleep mode, the LPUART can be woken up by received data.

LPUART supports CTS (Clear To Send)/RTS (Require To Send) flow control.

DMA (direct memory access) can be used for data transmission and reception.

#### 19.2 Main features

* Programmable baud rate
* Programmable data format (support 5, 6, 7 or 8 data bits, 1 or 2 stop bits and 1 or no parity bit)
* DMA capability
* 1 byte deep TX FIFO/RX FIFO
* CTS/RTS flow control
* Interrupt generation
* Wakeup CPU from low-power modes

**19.3 Functional Description**

#### 

**19.3.1 Data Format**



**Figure 19-1 LPUART Data Format**

When LPUART is idle, its data line should be kept at high level.

For data transmission, the start bit (START), data bits (DATA), parity bit (PARITY) and stop bits (STOP) are sequentially transmitted. The meaning of each bit is as follows:

1. **Start Bit:** 0 signal is sent first to indicate the start of data transmission.
2. **Data Bits:** 5, 6, 7 or 8 data bits are transmitted in sequence.
3. **Parity Bit:** After the data bits, the parity bit is transmitted, or it can be configured as no parity bit.
4. **Stop Bit:** 1 or 2 stop bits mark the end of data transmission.

**19.3.2 Baud Rate Generation**

##### 

The LPUART baud rate divisor consists of an integer part and a fractional part. This is mainly configured through the LPUART\_BAUD\_RATE\_INT and LPUART\_BAUD\_RATE\_FRA bits in the *LPUART\_CR0* register.

Taking an LPUART interface clock frequency of 32.768kHz and 9600 baud/s as an example, the baud rate divisor is 32768/9600=3.413. Thus, set the integer part of the baud rate divisor to **3** through the LPUART\_BAUD\_RATE\_INT bit, and set the fractional part of the baud rate divisor to **7** (0.413\*16=6.608, rounded to 7) through the LPUART\_BAUD\_RATE\_FRA bit.

**19.3.3 CTS/RTS Flow Control**

##### The connection between two LPUART devices is shown in the following figure:



**RTS (Require to Send)** is an output signal used to determine whether the device is ready to

receive data. It is active low, so the low level indicates that the device is ready for data reception.

**CTS (Clear to Send)** is an input signal used to determine whether the device can send data to

the other. It is active low, so the low level indicates that the device can send data to the other.

**19.3.4 DMA Transaction**

##### 

**LPUART DMA Transmit Process:**

1. Enable the DMA\_TX\_EN bit in register *LPUART\_CR1*.
2. Configure register *LPUART\_DATA* as the destination address of DMA.
3. Configure the memory address of the data to be sent as the source address of DMA.
4. Configure the data width of DMA transfer to 8 bits by configuring the SRC\_TR\_WIDTH and DES\_TR\_WIDTH bits to 0 in the *DMA\_CTLx* register.
5. Configure the DMA burst length to 1 by configuring the SRC\_MSIZE and DEST\_MSIZE bits to 0 in the *DMA\_CTLx* register.
6. Configure the total length of DMA data transfer.
7. Configure DMA handshake type to DMA\_HANDSHAKE\_LPUART\_TX.
8. Activate the DMA.

When the DMA transfer is completed, the CH\_EN\_x bit in the DMA\_CHENREG register is cleared.

**LPUART DMA Receive Process:**

1. Enable the DMA\_RX\_EN bit in register *LPUART\_CR1*.
2. Configure register *LPUART\_DATA* as the source address of DMA.
3. Configure the memory address of the data to be received as the destination address of DMA.
4. Configure the data width of DMA transfer to 8 bits by configuring the SRC\_TR\_WIDTH and DES\_TR\_WIDTH bits to 0 in the *DMA\_CTLx* register.
5. Configure the DMA burst length to 1 by configuring the SRC\_MSIZE and DEST\_MSIZE bits to 0 in the *DMA\_CTLx* register.
6. Configure the total length of DMA data transfer.
7. Configure DMA handshake type to DMA\_HANDSHAKE\_LPUART\_RX.
8. Activate the DMA.

When the DMA transfer is completed, the CH\_EN\_x bit in the DMA\_CHENREG register is cleared.

**19.3.5 LPUART Interrupt Signals**

##### 

LPUART interrupt signals:

* TX\_DONE interrupt
* TXFIFO\_EMPTY interrupt
* RXFIFO\_NOT\_EMPTY interrupt
* RX\_OVERFLOW interrupt
* STOP\_ERR interrupt
* PARITY\_ERR interrupt
* START\_INVALID interrupt
* RX\_DONE interrupt
* START\_VALID interrupt

**19.3.6 CPU Wakeup from Low-power Mode**

##### 

RX low-level, START\_VALID and RX\_DONE signals can be used to wakeup the CPU from low power modes.

LPUART wakeup is enabled by configuring the LPUART\_WAKEUP\_EN[[24:22] bits in register *LPUART\_CR0*.

##### 19.4 LPUART Registers

Base Address:0x40005000

**Table 19-1 LPUART Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| LPUART\_CR0 | 0x00 | LPUART Control Register 0 |
| LPUART\_CR1 | 0x04 | LPUART Control Register 1 |
| LPUART\_SR0 | 0x08 | LPUART Status Register 0 |
| LPUART\_SR1 | 0x0C | LPUART Status Register 1 |
| LPUART\_DATA | 0x10 | LPUART Data Register |

###### 19.4.1 LPUART\_CR0

Offset: 0x00

Reset Value: 0x00000E13

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-27** | **26** | | **25** | **24-22** | **21-10** |
| RESERVED | LPUART\_RTS\_EN | | LPUART\_RX\_EN | LPUART\_WAKEUP\_EN | LPUART\_BAUD\_RA  TE\_INT |
| r | r/w | | r/w | r/w | r/w |
| **9-6** | | **5** | | **4-2** | **1-0** |
| LPUART\_BAUD\_RATE\_FRA | | LPUART\_STOP\_LEN | | LPUART\_PARITY\_CFG | LPUART\_DATA\_LEN |
| r/w | | r/w | | r/w | r/w |

**Bits 31-27 RESERVED:** Must be kept, and cannot be modified.

**Bit 26 LPUART\_RTS\_EN:** LPUART RTS flow control enable.

* 0: disabled
* 1: enabled

**Bit 25 LPUART\_RX\_EN:** LPUART reception enable.

* 0: disabled
* 1: enabled

**Bits 24-22 LPUART\_WAKEUP\_EN:** LPUART wakeup enable.

[22] Enable RX low-level signal as a wakeup source

* 0: disabled
* 1: enabled

[23] Enable START\_VALID signal as a wakeup source

* 0: disabled
* 1: enabled

[24] Enable RX\_DONE signal as a wakeup source

* 0: disabled
* 1: enabled

**Bits 21-10 LPUART\_BAUD\_RATE\_INT:** The integer part of the baud rate divisor.

*Baud rate divisor=UART interface clock frequency/Baud rate*

Taking an LPUART interface clock frequency of 32.768 kHz and 9600 baud/s as an example, the baud rate divisor is 32768/9600=3.413. Thus, set the integer part of the baud rate divisor to **3** through the LPUART\_BAUD\_RATE\_INT bit, and set the fractional part of the baud rate divisor to **6 or 7** (based on 0.413\*16=6.608) through the LPUART\_BAUD\_RATE\_FRA bit.

**Bits 9-6 LPUART\_BAUD\_RATE\_FRA:** The fractional part of the baud rate divisor.

**Bit 5 LPUART\_STOP\_LEN:** LPUART STOP bits configuration.

* 0: 1 stop bit
* 1: 2 stop bits

**Bits 4-2 LPUART\_PARITY\_CFG:** LPUART parity bit configuration.

* 0: even parity
* 1: odd parity
* 2: parity bit is 0
* 3: parity bit is 1
* >3: no parity

**Bits 1-0 LPUART\_DATA\_LEN:** LPUART data length.

Data width=LPUART\_DATA\_LEN+5

###### 19.4.2 LPUART\_CR1

Offset: 0x004

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-13** | **12** | | **11** | | **10** | | **9** |
| RESERVED | LPUART\_CTS\_EN | | DMA\_TX\_EN | | DMA\_RX\_EN | | LPUART\_TX\_EN |
| r | r/w | | r/w | | r/w | | r/w |
| **8** | **7** | | **6** | | **5** | | **4** |
| TX\_DONE\_INT  \_EN | TXFIFO\_EMPTY\_INT  \_EN | | RXFIFO\_NOT\_EMPTY  \_INT\_EN | | RX\_OVERFLOW  \_INT\_EN | | STOP\_ERR\_INT  \_EN |
| r/w | r/w | | r/w | | r/w | | r/w |
| **3** | | **2** | | **1** | | **0** | |
| PARITY\_ERR\_INT\_EN | | START\_INVALID\_INT\_EN | | RX\_DONE\_INT\_EN | | START\_VALID\_INT\_EN | |
| r/w | | r/w | | r/w | | r/w | |

**Bits 31:13 RESERVED:** Must be kept, and cannot be modified.

**Bit 12 LPUART\_CTS\_EN:** LPUART CTS flow control enable.

* 0: disabled
* 1: enabled

**Bit 11 DMA\_TX\_EN:** DMA transmission requests enable.

* 0: disabled
* 1: enabled

**Bit 10 DMA\_RX\_EN:** DMA reception requests enable.

* 0: disabled
* 1: enabled

**Bit 9 LPUART\_TX\_EN:** LPUART transmission enable.

* 0: disabled
* 1: enabled

**Bit 8 TX\_DONE\_INT\_EN:** TX\_DONE interrupt enable.

* 0: disabled
* 1: enabled

**Bit 7 TXFIFO\_EMPTY\_INT\_EN:** TXFIFO\_EMPTY interrupt enable.

* 0: disabled
* 1: enabled

**Bit 6 RXFIFO\_NOT\_EMPTY\_INT\_EN:** RXFIFO\_NOT\_EMPTY interrupt enable.

* 0: disabled
* 1: enabled

**Bit 5 RX\_OVERFLOW\_INT\_EN:** RX\_OVERFLOW interrupt enable.

* 0: disabled
* 1: enabled

**Bit 4 STOP\_ERR\_INT\_EN:** STOP\_ERR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 3 PARITY\_ERR\_INT\_EN:** PARITY\_ERR interrupt enable.

* 0: disabled
* 1: enabled

**Bit 2 START\_INVALID\_INT\_EN:** START\_INVALID interrupt enable.

* 0: disabled
* 1: enabled

**Bit 1 RX\_DONE\_INT\_EN:** RX\_DONE interrupt enable.

* 0: disabled
* 1: enabled

**Bit 0 START\_VALID\_INT\_EN:** START\_VALID interrupt enable.

* 0: disabled
* 1: enabled

###### 19.4.3 LPUART\_SR0

Offset: 0x008

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-6** | | **5** | **4** |
| RESERVED | | RX\_OVERFLOW\_SR | STOP\_ERR\_SR |
| r | | r/w | r/w |
| **3** | **2** | **1** | **0** |
| PARITY\_ERR\_SR | START\_INVALID\_SR | RX\_DONE\_SR | START\_VALID\_SR |
| r/w | r/w | r/w | r/w |

**Bits 31-6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 RX\_OVERFLOW\_SR:** RX\_OVERFLOW flag is used to indicate whether a RX buffer overflow has occurred. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no RX buffer overflow
* 1: RX buffer overflow occurred

**Bit 4 STOP\_ERR\_SR:** STOP\_ERR flag is used to indicate whether a Stop error has occurred. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no Stop error
* 1: Stop error occurred

**Bit 3 PARITY\_ERR\_SR:** PARITY\_ERR flag is used to indicate whether a parity error has occurred. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no parity error
* 1: parity error occurred

**Bit 2 START\_INVALID\_SR:** START\_INVALID flag is used to indicate whether an invalid Start bit has been received. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no invalid Start
* 1: invalid Start bit has been received

**Bit 1 RX\_DONE\_SR:** RX\_DONE flag is used to indicate whether the data reception is completed. This bit is set by hardware and cleared by software writing 1 to it.

* 0: data reception not completed
* 1: data reception completed

**Bit 0 START\_VALID\_SR:** START\_VALID flag is used to indicate whether a valid Start bit has been received. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no valid Start
* 1: valid Start bit has been received

###### 19.4.4 LPUART\_SR1

Offset: 0x00C

Reset Value: 0x00000016

|  |  |  |  |
| --- | --- | --- | --- |
| **31-6** | | **5** | **4** |
| RESERVED | | TX\_DONE | TXFIFO\_EMPTY |
| r | | r/w | r |
| **3** | **2** | **1** | **0** |
| RXFIFO\_NOT\_EMPTY | WRITE\_CR0\_DONE | WRITE\_SR0\_DONE | RESERVED |
| r | r | r | r |

**Bits 31-6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 TX\_DONE:** TX\_DONE flag. This bit is set by hardware and cleared by software writing 1 to it.

* 0: data transmission in progress
* 1: data transmission completed

**Bit 4 TXFIFO\_EMPTY:** TXFIFO\_EMPTY flag. This bit is set by hardware and cleared by software writing to the *LPUART\_DATA* register.

* 0: non-empty
* 1: empty

**Bit 3 RXFIFO\_NOT\_EMPTY:** RXFIFO\_NOT\_EMPTY flag. This bit is set by hardware and cleared by software reading the *LPUART\_DATA* register.

* 0: empty
* 1: non-empty

**Bit 2 WRITE\_CR0\_DONE:** The status of a write operation to the *LPUART\_CR0* register. This bit is set and cleared by hardware.

* 0: write operation to the *LPUART\_CR0* register in progress
* 1: write operation to the *LPUART\_CR0* register completed

**Bit 1 WRITE\_SR0\_DONE:** The status of a write operation to the *LPUART\_SR0* register. This bit is set and cleared by hardware.

* 0: write operation to the *LPUART\_SR0* register in progress
* 1: write operation to the *LPUART\_SR0* register completed

**Bit 0 RESERVED:** Must be kept, and cannot be modified.

###### 19.4.5 LPUART\_DATA

Offset: 0x010

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-8** | **7-0** |
| RESERVED | LPUART\_DATA |
| r | r/w |

**Bits 31-8 RESERVED:** Must be kept, and cannot be modified.

**Bits 7-0 LPUART\_DATA:** LPUART TX/RX data.

***Notes:***

1. *If the data width is less than 8 bits, the less significant bits of the LPUART\_DATA register is valid.*
2. *Before reading the LPUART\_DATA register, check the RXFIFO\_NOT\_EMPTY flag to ensure that there is data in RXFIFO; before writing to the LPUART\_DATA register, check the TXFIFO\_EMPTY flag to ensure that the TXFIFO can be written.*

## 20. LPTIM

### 20.1 Introduction

LPTIMER (Low Power Timer) is a 16-bit timer. Due to multiple clock sources, LPTIMER can run in all operating modes except standby mode and supports wake-up from all low-power operating modes. There are two separate LPTIMER, respectively LPTIMER0 and LPTIMER1.

### 20.2 Main features

LPTIMER includes the following functions:

* Selecting internal clock and external clock as counting clock
* 16 bits counter, up-counting, auto-reload
* Two counting modes, single counting and continuous counting
* Software trigger and external trigger source
* Prescaler
* PWM generation
* Single pulse, Set-once, and Timeout mode output
* DEBUG mode control
* Supports generating channel output events, match events, overflow events, trigger events, DOWN events, and UP events as wake-up signal outputs
* Quadrature decoding
* Interrupt signal generation

LPTIMER block diagram:



**Figure 20-1 LPTIMER structure**

* **lptim\_trig0~7:** External trigger source of LPTIMER
* **lptim\_in2:** LPTIMER’s IN2 pin 
* **lptim\_in1:** LPTIMER’s IN1 pin
* **lptim\_wkup:** LPTIMER wake-up signal
* **lptim\_out:** LPTIMER’s OUT pin

### 20.3 Interface clock

LPTIMER interface clock source can be internal clock and external clock. The internal clock source includes PCLK0, RCO3.6M, XO32K, and RCO32K. The external clock source is input through the GPIO of IN1. For clock configuration and selection, please refer to the RCC chapter.

### 20.4 Counter clock selection

LPTIMER In addition to the interface clock being divided into internal and external parts, the counting clock is also divided into internal and external parts. The internal and external clock sources are consistent with the interface clock. The Register bits selected to control the counting clock are the COUNTMODE of Register LPTIM\_CFGR, and the value is 0 means that the counter is controlled by the internal clock, and a value of 1 means that the counter is controlled by the external clock.

If the LPTIM1\_EXT\_CLK\_SEL bit or LPTIM\_EXT\_CLK\_SEL bit of Register RCC\_CR1 of the RCC module is 0, it means that the interface clock of LPTIMER0 or LPTIMER1 is the internal clock, then COUNTMODE The value can be 0 or 1, that is, the counting clock can be either an internal clock or an external clock; if LPTIM1\_EXT\_CLK\_SEL bit or LPTIM\_EXT\_CLK\_SEL bit is 1, then the COUNTMODE bit of Register LPTIM\_CFGR of LPTIMER0 or LPTIMER1 can only be set to 0, then 0 It does not mean that the counting clock is an internal clock, but it means that the COUNTMODE value needs to be cleared, and the counting clock can only be an external clock.

### 20.5 Counter

Except for encoding mode, the counter only supports upward counting. When counting to ARR, an ARRM interrupt is generated and the counter returns to 0 and restarts count. If the timeout mode is enabled, in addition to clearing the counter value when it increases to ARR, the trigger signal can also clear the count.

Counter again. If encoding mode is enabled, the counting direction of the counter is controlled by hardware, and is generated when counting up to ARR.

ARRM event and clears the counter. When counting down to 0, ARR is reloaded into the counter.

#### 20.6 Counting modes

LPTIMER supports two counting modes, single counting and continuous counting. In single counting mode, the first trigger signal (hardware or software) arriving during the counter stop phase will trigger the counter to start counting, and the trigger signal during the counting process will be ignored, the counter will stop counting when it reaches ARR, and will not start counting again until the next trigger signal arrives, and so on. In the continuous counting mode, once triggered (hardware or software), the counter will keep counting, from 0 to ARR. then return to 0 counts again, and so on.

The two counting modes can be switched at any time (provided that enable is set to Bits). For example, if LPTIMER is configured as single counting mode, if CNTSTRT of BitsRegister LPTIM\_CR is set, the counter will not stop counting when it reaches the ARR value; LPTIMER is configured as continuous. In counting mode, if the SNGSTRT of BitsRegister LPTIM\_CR is set, the counter will stop counting when it reaches ARR until the next trigger signal arrives. Therefore, the status figure is as follows:



IDLE



SNG



WAIT

\_

CONT



WAIT

\_

SNG



CONT

SNGSTRT



SNG

：

单次计数模式



CONT

：

连续计数模式



WAIT

\_

SNG

：

等待进入单次计数模式



WAIT

\_

CONT

：

等待进入连续计数模式

**Figure 20-2 Counting modes conversion**

#### 20.7 Software trigger and external trigger

There are two ways to trigger LPTIMER counting, one is software trigger, and the other is trigger from external trigger source. It is controlled by the TRIGEN Bits section of Register LPTIM\_CFGR. When the value is 0, it is software trigger, and when it is non-zero, it is external trigger. When it is an external trigger, you can set the external trigger signal to be valid on the rising edge, valid on the falling edge or valid on both edges. LPTIMER has 8 trigger input sources that can be selected. The external trigger sources of LPTIMER0 are as follows in Table:

**Table 20-1 LPTIMER0 external trigger sources**

|  |  |  |
| --- | --- | --- |
| TRIGSEL | External Trigger | Comment |
| lptim\_ext\_trig0 | lptim\_etr | Lptimer etr pin input |
| lptim\_ext\_trig1 | comp0 | Comp0 output |
| lptim\_ext\_trig2 | comp1 | Comp1 output |
| lptim\_ext\_trig3 | rtc\_cyc\_counter | RTC cyc counter output pulse |
| lptim\_ext\_trig4 | rtc\_alarm0 | RTC alarm0 output pulse |
| lptim\_ext\_trig5 | rtc\_alarm1 | RTC alarm1 output pulse |
| lptim\_ext\_trig6 | gpio | GPIO58 |
| lptim\_ext\_trig7 | gpio | GPIO59 |

**LPTIMER1** external trigger sources are as follows in Table:

**Table 20-2 LPTIMER1 external trigger sources**

|  |  |  |
| --- | --- | --- |
| TRIGSEL | External Trigger | Comment |
| lptim\_ext\_trig0 | lptim\_etr | Lptimer etr pin input |
| lptim\_ext\_trig1 | comp0 | Comp0 output |
| lptim\_ext\_trig2 | comp1 | Comp1 output |
| lptim\_ext\_trig3 | rtc\_cyc\_counter | RTC cyc counter output pulse |
| lptim\_ext\_trig4 | rtc\_alarm0 | RTC alarm0 output pulse |
| lptim\_ext\_trig5 | rtc\_alarm1 | RTC alarm1 output pulse |
| lptim\_ext\_trig6 | gpio | GPIO60 |
| lptim\_ext\_trig7 | gpio | GPIO61 |

#### 20.8 Frequency division counter

### The Count Enable signal can be divided by software configuration, supporting 1, 2, 4, 8, 16, 32, 64, and 128 frequency division. The prescaler is configured by configuring the PRESC Bits section of Register LPTIM\_CFGR. The prescaler is implemented through counter, that is counting enable signal generated by the upper stage circuit will be used as the counting enable of the prescaler. When the frequency division counter counts to the preloaded frequency division value, a pulse is output as the counting enable of the next level counter, and then the frequency division counter resets to zero and counts again, and so on.

### 20.9 PWM

LPTIMER can generate PWM waveforms. The polarity of the waveform can be controlled by the WAVPOL bit of Register LPTIM\_CFGR, and the duty cycle can be controlled by the values of Register LPTIM\_CMP and LPTIM\_ARR. Taking software triggering and internal clock counting as an example, the process of configuring PWM is as follows:

1. Configure the COUNTMODE of Register LPTIM\_CFGR to 0, that is, set the internal clock count.
2. The PRESC of Register LPTIM\_CFGR is the default value, that is, the prescaler is not set.
3. The value of PRELOAD in the configuration register LPTIM\_CFGR is 0, which means that the cache function of the registers LPTIM\_CMP and LPTIM\_ARR is not enabled. It can be enabled if necessary.
4. Сaching function of LPTIM\_ARR can also be enabled if needed.
5. Configure WAVPOL of Register LPTIM\_CFGR to 0, that is, the waveform output is not inverted.
6. Configure the WAVE of Register LPTIM\_CFGR to 0.
7. The value of the TRIGEN Bits section of Register LPTIM\_CFGR is 0, which is software trigger.
8. Enable LPTIMER is to set ENABLE of BitsRegister LPTIM\_CR.
9. Set the values ​​of Register LPTIM\_ARR and LPTIM\_CMP.
10. Enable the continuous counting function by setting CNTSTRT of BitsRegister LPTIM\_CR.

### 20.10 Single pulse, Set-once, Timeout mode output

In single pulse mode, when the counter is not counting, and the first trigger signal is detected, the counting Enable will set the Bits. If the ARR or enable is cleared or the module resets the Bits, the counting Enable will be cleared. The trigger signal during the counting process will will be ignored, as shown in Figure:



**Figure 20-3 Single pulse counting**

Single pulse mode is achieved by configuring the WAVE of Register LPTIM\_CFGR to 0 and the SNGSTRT of Register LPTIM\_CR to 1.

In Set-once mode, after the first trigger signal is detected, the counting Enable is set to Bits. If ARR is counted, the counting Enable is cleared. The trigger signal during the counting process will be masked. The masking signal is implemented through mask, that is, detection After reaching the first trigger signal, the mask is valid and all subsequent trigger signals are masked, as shown in the following figure:



**Figure 20-4 Set-once counting**

Set-once mode is configured by configuring Register LPTIM\_CFGR's WAVE to 1 and Register LPTIM\_CR's SNGSTRT is implemented as 1.

Timeout mode is similar to continuous counting mode. Once triggered, counting Enable is always valid. The difference is that the trigger signal during the counting process will cause the counter to count again from 0, and the output waveform will also be cleared, as shown in the following figure:

**Figure 20-5 Timeout count**

Timeout mode is implemented by configuring the WAVE of Register LPTIM\_CFGR to 0 and the CNTSTRT of Register LPTIM\_CR to 1.

### 20.11 Orthogonal coding

LPTIMER supports quadrature encoding counting function, which can input quadrature signals through IN1 and IN2 for counting and direction detection. There are three encoding modes, counting only on rising edges, counting on falling edges and counting on both edges. Enable the encoding mode through Register The ENC of LPTIM\_CFGR is controlled, and the edge control of the encoding mode is realized through the CKPOL of Register LPTIM\_CFGR. Under this function, the two channel inputs can be configured with digital filtering functions. The filtering Enable is controlled by CKFLT\_ENABLE of Register LPTIM\_CFGR, and the filter value is controlled by CKFLT of Register LPTIM\_CFGR. Configuration. Through the combination of two channel signals, the counting Enable and direction control signals can be generated to control the addition and subtraction of counter. The specific combination method is shown in the Table below:

#### Table 20-3 Orthogonal coded channel signals

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Encoding mode | IN1/IN2 level | IN1 | | IN2 | |
| rising edge | falling edge | rising edge | falling edge |
| Rising edge count | high level | Count down | - | Count up | - |
| low level | Count up | - | Count down | - |
| Falling edge count | high level | - | Count up | - | Count down |
| low leve | - | Count down | - | Count up |
| Both edges counting | high level | Count down | Count up | Count up | Count down |
| low leve | Count up | Count down | Count down | Count up |

The IN1 and IN2 input signal frequencies must be less than 1/4 of the LPTIMER clock frequency.

### 20.12 DEBUG mode control

LPTIMER can be configured by software whether to stop counting under debug. The DEBUG mode counting control of LPTIMER0 and LPTIMER1 is implemented through the CR2 Register of SYSCFG. If this function is enabled, LPTIMER stops counting when entering the system debug mode (the counter will not be initialized).

### 20.13 Wake-up signals

LPTIMER has 6 wake-up signal outputs.

* Channel output signal, at this time the channel output will be output as a wake-up signal.
* Matching event (CMPM), at this time, the matching event between counter and Register LPTIM\_CMP will be output as a wake-up signal.
* Overflow event (ARRM), at this time the overflow event will be output as a wake-up signal.
* Trigger event (EXTTRIG), the valid trigger event at this time will be output as a wake-up signal.
* DOWN event, if the counting direction changes from up counting to down counting, the DOWN event will set Bits. At this time, the DOWN event will be output as a wake-up signal.
* UP event, if the counting direction changes from down counting to up counting, the UP event bit will set. At this time, the UP event will be output as a wake-up signal.

In addition to the channel output signal, the above wake-up signals are all flag bits of the LPTIM\_ISR Register, and have independent EnableBits. The EnableBits are the OUT\_WKUP\_EN, CMPM\_WKUP\_EN, ARRM\_WKUP\_EN, EXTTRIG\_WKUP\_EN, DOWN\_WKUP\_EN, and UP\_WKUP\_EN bits of Register LPTIM\_CFGR respectively. The wake-up signal is ANDed with the corresponding enable bits. The relationship between each Wakeup Source is OR.

### 20.14 Interrupts

Interrupt signals of LPTIMER:

**Table 20-4 LPTIMER interrupt signals**

|  |  |
| --- | --- |
| Interrupt | Description |
| DOWN interrupt | In encoding mode, counting direction changes from upward to downward |
| UP interrupt | In encoding mode, counting direction changes from downward to upward |
| ARROK interrupt | ARR value loading is completed |
| CMPOK interrupt | CMP value loading is completed |
| EXTTRIG interrupt | Valid trigger edge is detected |
| ARRM interrupt | Counter value reaches ARR |
| CMPM interrupt | Counter value matches CMP |

The above interrupt is enabled by configuring Register LPTIM\_IER. The status of all interrupts can be obtained through LPTIM\_SR1 Register.

### 20.15 LPTIMER Registers Description

LPTIMER0 Base Address: 0x4000D000

LPTIMER1 Base Address: 0x4000D800

**Table 20-5 LPTIMER Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| LPTIM\_ISR | 0x00 | Status Register |
| LPTIM\_ICR | 0x04 | Status Clear Register |
| LPTIM\_IER | 0x08 | Interrupt Enable Register |
| LPTIM\_CFGR | 0x0c | Configuration Register, which needs to be modified when ENABLE of LPTIM\_CR Register is cleared. |
| LPTIM\_CR | 0x10 | Control Register |
| LPTIM\_CMP | 0x14 | Compare Register |
| LPTIM\_ARR | 0x18 | Auto-reload Register |
| LPTIM\_CNT | 0x1c | Counter Register |
| LPTIM\_CSR | 0x20 | Clear the status flag Register. Table indicates whether to clear the completion flag when using Register LPTIM\_ICR to clear LPTIM\_ISR certain status bits. |
| LPTIM\_SR1 | 0x24 | Interrupt flag Register, interrupt flag bits will be cleared immediately by Register LPTIM\_ICR |

#### 20.15.1 LPTIM\_ISR

Offset: 0x000

Reset Value: 0x00000180

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **31-9** | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | CROK | CFGROK | DOWN | UP | ARROK | CMPOK | EXTTRIG | ARRM | CMPM |
| r-0h | r-1h | r-1h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 31-9 RESERVED:** Must be kept, and cannot be modified.

**Bit 8 CROK:** The status of the last write operation to Register LPTIM\_CR. This bit is controlled by hardware, and you need to check whether the last write operation is completed before writing.

* 0: Writing operation in progress
* 1: The last write operation to LPTIM\_CR has been completed

**Bit 7 CFGROK:** The status of the last write operation to LPTIM\_CFGR. This bit is controlled by hardware, and you need to check whether the last write operation is completed before writing.

* 0: Writing operation in progress
* 1: The last write operation to LPTIM\_CFGR has been completed

**Bit 6 DOWN:** The counting direction changes from upward to downward in encoding mode.

* 0: The counting direction does not change from top to bottom.
* 1: Counting direction changes from upward to downward

It can be cleared by writing to LPTIM\_ICR Register, but it requires a time synchronization clearing pulse, so it cannot be cleared immediately.

**Bit 5 UP:** The counting direction changes from downward to upward in encoding mode.

* 0: The counting direction does not change from bottom to upward.
* 1: Counting direction changes from downward to upward

It can be cleared by writing to LPTIM\_ICR Register, but it requires a time synchronization clearing pulse, so it cannot be cleared immediately.

**Bit 4 ARROK:** ARR value loading status.

* 0: Not loaded yet
* 1: Loading completed

It can be cleared by writing to LPTIM\_ICR Register, but it requires a time synchronization clearing pulse, so it cannot be cleared immediately.

**Bit 3 CMPOK:** CMP value loading status.

* 0: Not loaded yet
* 1: Loading completed

It can be cleared by writing to LPTIM\_ICR Register, but it requires a time synchronization clearing pulse, so it cannot be cleared immediately.

**Bit 2 EXTTRIG:** Whether a valid trigger edge is detected.

* 0: No valid trigger edge detected
* 1: Valid trigger edge detected

It can be cleared by writing to LPTIM\_ICR Register, but it requires a time synchronization clearing pulse, so it cannot be cleared immediately.

**Bit 1 ARRM:** Whether the counter value reaches the ARR value.

* 0: counter value has not reached ARR
* 1: counter value reaches ARR

It can be cleared by writing to LPTIM\_ICR Register, but it requires a time synchronization clearing pulse, so it cannot be cleared immediately.

**Bit 0 CMPM:** counter value matches CMP value.

* 0: counter value does not match CMP value
* 1: counter value matches CMP value

It can be cleared by writing to LPTIM\_ICR Register, but it requires a time synchronization clearing pulse, so it cannot be cleared immediately.

#### 20.15.2 LPTIM\_ICR

Offset: 0x004

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | DOWNCF | UPCF | ARROKCF | CMPOKCF | EXTTRIGCF | ARRMCF | CMPMCF |
| w-0h | w-0h | w-0h | w-0h | w-0h | w-0h | w-0h | w-0h |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 DOWNCF:** Clear the DOWN flag. Software writes 1 to clear the flag bit, and the bit is cleared by hardware.

* 0: no action
* 1: clear flag

**Bit 5 UPCF:** Clear the UP flag. Software writes 1 to clear the flag bit, and the bit is cleared by hardware.

* 0: No operation
* 1: Clear operation

**Bit 4 ARROKCF:** Clear the ARROK flag. Software writes 1 to clear the flag bit, and the bit is cleared by hardware.

* 0: No operation
* 1: Clear operation

**Bit 3 CMPOKCF:** Clear the CMPOK flag. Software writes 1 to clear the flag bit, and the bit is cleared by hardware.

* 0: No operation
* 1: Clear operation

**Bit 2 EXTTRIGCF:** Clear the EXTTRIG flag. Software writes 1 to clear the flag bit, and the bit is cleared by hardware.

* 0: No operation
* 1: Clear operation

**Bit 1 ARRMCF:** Clear the ARRM flag. Software writes 1 to clear the flag bit, and the bit is cleared by hardware.

* 0: No operation
* 1: Clear operation

**Bit 0 CMPMCF:** Clear the CMPM flag. Software writes 1 to clear the flag Bits, which are cleared by hardware.

* 0: No operation
* 1: Clear operation

##### 20.15.3 LPTIM\_IER

##### 

Offset: 0x008

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | DOWNIE | UPIE | ARROKIE | CMPOKIE | EXTTRIGIE | ARRMIE | CMPMIE |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 DOWNIE:** DOWN interrupt enable.

* 0: disable
* 1: enable

**Bit 5 UPIE:** UP interrupt enable.

* 0: Disable interrupts
* 1: Enable interrupts

**Bit 4 ARROKIE:** ARROK interrupt enable.

* 0: Disable interrupts
* 1: Enable interrupts

**Bit 3 CMPOKIE:** CMPOK interrupt enable.

* 0: Disable interrupts
* 1: Enable interrupts

**Bit 2 EXTTRIGIE:** EXTTRIG interrupt enable.

* 0: Disable interrupts
* 1: Enable interrupts

**Bit 1 ARRMIE:** ARRM interrupt enable.

* 0: Disable interrupts
* 1: Enable interrupts

**Bit 0 CMPMIE:** CMPM interrupt enable.

* 0: Disable interrupts
* 1: Enable interrupts

#### 20.15.4 LPTIM\_CFGR

Offset: 0x00c

Reset Value: 0x00000000

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31** | **30** | **29** | **28** | **27** | **26** |
| RESERVED | OUT\_WKUP\_  EN | DOWN\_WKUP  \_EN | UP\_WKUP\_E  N | EXTTRIG\_WK  UP\_EN | ARRM\_WKUP  \_EN |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |
| **25** | **24** | **23** | **22** | **21** | **20** |
| CMPM\_WKUP  \_EN | ENC | COUNTMODE | PRELOAD | WAVPOL | WAVE |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |
| **19** | **18-17** | **16** | **15-13** | **12** | **11-9** |
| TIMEOUT | TRIGEN | RESERVED | TRIGSEL | RESERVED | PRESC |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |
| **8** | **7-6** | **5** | **4-3** | **2-1** | **0** |
| TRGLT\_ENAB  LE | TRGFLT | CKFLT\_ENAB  LE | CKFLT | CKPOL | RESERVED |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bit 31 RESERVED:** Must be kept, and cannot be modified.

**Bit 30 OUT\_WKUP\_EN:** LPTIM\_OUT wake-up Enable.

* 0: LPTIM\_OUT cannot trigger wake-up signal
* 1: LPTIM\_OUT can trigger the wake-up signal

**Bit 29 DOWN\_WKUP\_EN:** DOWN event wake-up Enable.

* 0: DOWN event cannot trigger wake-up signal
* 1: DOWN event can trigger wake-up signal

**Bit 28 UP\_WKUP\_EN:** UP event wake-up Enable.

* 0: UP event cannot trigger wake-up signal
* 1: UP event can trigger wake-up signal

**Bit 27 EXTTRIG\_WKUP\_EN:** External trigger event wake-up Enable.

* 0: External trigger events cannot trigger wake-up signal
* 1: External trigger events can trigger wake-up signal

**Bit 26 ARRM\_WKUP\_EN:** Count overflow event wake-up Enable (except ENC mode).

* 0: Count overflow cannot trigger wake-up signal
* 1: Count overflow event triggers wake-up signal

**Bit 25 CMPM\_WKUP\_EN:** Count matching event wake-up Enable.

* 0: Count match cannot trigger wake-up signal
* 1: Count matching event triggers wake-up signal

**Bit 24 ENC:** Encoding mode Enable.

* 0: Disable encoding mode
* 1: Enable encoding mode

**Bit 23 COUNTMODE:** Counting mode selection.

* 0: counter is controlled by internal clock
* 1: counter is controlled by external clock

**Bit 22 PRELOAD:** Register cache Enable.

* 0: ARR and CMP are directly operated by software
* 1: ARR and CMP are updated by update events.

**Bit 21 WAVPOL:** Output waveform polarity.

* 0: normal polarity
* 1: inverted polarity

**Bit 20 WAVE:** Waveform shape.

* 0: disable Set-once, select PWM or single pulse mode
* 1: enable Set-once mode

**Bit 19 TIMEOUT:**Timeout mode Enable.

* 0: disable Timeout mode
* 1: enable Timeout mode

**Bits 18-17 TRIGEN:** External trigger enable and polarity selection.

* 00: Software trigger
* 01: External trigger rising edge
* 10: External trigger falling edge
* 11: External trigger double-edge

**Bit 16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-13 TRIGSEL:** External trigger source selection.

* 000: lptim\_ext\_trig0
* 001: lptim\_ext\_trig1
* 010: lptim\_ext\_trig2
* 011: lptim\_ext\_trig3
* 100: lptim\_ext\_trig4
* 101: lptim\_ext\_trig5
* 110: lptim\_ext\_trig6
* 111: lptim\_ext\_trig7

**Bit 12 RESERVED:** Must be kept, and cannot be modified.

**Bits 11-9 PRESC:** clock frequency division.

* 000: /1
* 001: /2
* 010: /4
* 011: /8
* 100: /16
* 101: /32
* 110: /64
* 111: /128

**Bit 8 TRGLT\_ENABLE:** To enable the trigger input filter, the filter length must be configured first and then enabled.

* 0: disable trigger input filter
* 1: enable trigger input filter

**Bits 7-6 TRGFLT:** Trigger input filter configuration.

* 00: no action
* 01: Enable filter, filter length N=2
* 10: Enable filter, filter length N=4
* 11: Enable filter, filter length N=8

**Bit5 CKFLT\_ENABLE:** Enable the external clock filter. The filter length must be configured first and then enabled.

* 0: disable external clock filter
* 1: enable external clock filter

**Bits 4-3 CKFLT:** External clock filter configuration.

* 00: no action
* 01: enable filter, filter length N=2
* 10: enable filter, filter length N=4
* 11: enable filter, filter length N=8

**Bits 2-1 CKPOL:** Encoder mode control.

* 00: select Encoder mode 1, rising edge counting
* 01: select Encoder mode 2, falling edge counting
* 10: select Encoder mode 3, double edge counting
* 11: reserved

**Bit 0 RESERVED:** Must be kept, and cannot be modified.

#### 20.15.5 LPTIM\_CR

Offset: 0x010

Reset Value: 0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-3** | **2** | **1** | **0** |
| RESERVED | CNTSTRT | SNGSTRT | ENABLE |
| rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-3 RESERVED:** Must be kept, and cannot be modified.

**Bit 2 CNTSTRT:** Continuous counting mode Enable.

* 0: disable
* 1: Enable continuous counting mode. Write 1 to start continuous counting mode. If SNGSTRT is set during continuous counting mode, the counting will stop when ARR is counted next time (switch to single counting mode). This bit needs to be modified after ENABLE is set.

**Bit 1 SNGSTRT:** Single counting mode Enable.

* 0: disable
* 1: Enable single count mode. Write 1 to start single count mode. If CNTSTRT is set during single count mode, it will continue counting when ARR is counted next time (switch to continuous count mode). This bit needs to be modified after ENABLE is set.

**Bit 0 ENABLE:** LPTIMER Enable.

* 0: disable LPTIMER
* 1: enable LPTIMER

#### 20.15.6 LPTIM\_CMP

Offset: 0x014

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | CMP |
| rw-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 CMP:** Comparison value, which can only be modified after setting Bits in ENABLE of Register LPTIM\_CR.

#### 20.15.7 LPTIM\_ARR

Offset: 0x018

Reset Value: 0x00000001

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | ARR |
| rw-0h | rw-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 ARR:** Reload value, which can only be modified after the ENABLE bits of Register LPTIM\_CR are set.

#### 20.15.8 LPTIM\_CNT

Offset: 0x01c

Reset Value: 0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | CNT |
| r-0h | r-0h |

**Bits 31-16 RESERVED:** Must be kept, and cannot be modified.

**Bits 15-0 CNT:** The counting result; is valid only when the reading results are consistent twice.

#### 20.15.9 LPTIM\_CSR

Offset: 0x020

Reset Value 0x0000001f

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **31-5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | DOWN\_CLR\_DONE | UP\_CLR\_DONE | EXTTRIG\_CLR  \_DONE | ARRM\_CLR  \_DONE | CMPM\_CLR  \_DONE |
| r-0h | r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 31-5 RESERVED:** Must be kept, and cannot be modified.

**Bit 4 DOWN\_CLR\_DONE:** DOWN clearing completed.

* 0: clearing DOWN flag
* 1: clear successfully

**Bit 3 UP\_CLR\_DONE:** UP clearing completed.

* 0: clearing UP flag
* 1: clear successfully

**Bit 2 EXTTRIG\_CLR\_DONE:** EXTTRIG clearing completed.

* 0: clearing EXTTRIG flag
* 1: clear successfully

**Bit 1 ARRM\_CLR\_DONE:** ARRM clearing completed.

* 0: clearing ARRM flag
* 1: clear successfully

**Bit 0 CMPM \_CLR\_DONE:** CMPM clearing completed.

* 0: clearing CMPM flag
* 1: clear successfully

#### 20.15.10 LPTIM\_SR1

Offset: 0x024

Reset Value: 0x00000000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **31-7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | DOWN | UP | ARROK | CMPOK | EXTTRIG | ARRM | CMPM |
| r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 31-7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 DOWN:** Counting direction change from upward to downward in encoding mode.

* 0: counting direction does not change upward top to downward
* 1: counting direction changes from upward to downward

**Bit 5 UP:** Counting direction change from downward to upward in encoding mode.

* 0: counting direction does not change from downward to upward
* 1: counting direction changes from downward to upward

**Bit 4 ARROK:** ARR value loading status.

* 0: not loaded yet
* 1: loading completed

**Bit 3 CMPOK:** CMP value loading status.

* 0: not loaded yet
* 1: loading completed

**Bit 2 EXTTRIG:** Valid trigger edge detection.

* 0: no valid trigger edge detected
* 1: valid trigger edge is detected.

**Bit 1 ARRM:** Counter value reaching ARR value.

* 0: counter value has not reached ARR
* 1: counter value reaches ARR

**Bit 0 CMPM:** counter value matching CMP value.

* 0: counter value does not match CMP value
* 1: counter value matches CMP value

## 21. Direct Memory Access (DMA)

### 21.1 Introduction

DMA supports four data transfer methods: peripheral to peripheral, peripheral to memory, memory to peripheral, and memory to memory. It supports data width of 8 bits, 16 bits or 32 bits, and supports data auto-reloading and data chain table (LLI). There are two DMAs, named DMA0 and DMA1. Each DMA has 4 channels. Two DMAs are independent of each other and can work simultaneously. 4 channels in each DMA are also independent of each other and can run simultaneously.

### 21.2 Main features

* Configurable transfer data length
* Configurable data transfer methods
* Auto-reloading
* LLI

### 21.3 Transfer data configuration

### DMA can transmit data of multiple blocks. When transmitting the data of each block, it is first transmitted in burst mode. If there is data that is not long enough for burst, it is then sent in single mode. The data transmission of peripherals is as follows:

 **Figure 21-1 Data transfer**

The source and destination data widths of DMA are configured through the SRC\_TR\_WIDTH and DST\_TR\_WIDTH bits of the DMA\_CTLx register (x is 0, 1, 2, or 3). A value of 000 for this bit field indicates 8 bits, 001 for 16 bits, and 002 for 32 bits.

The source and destination burst data lengths of DMA are configured through the SRC\_MSIZE and DEST\_MSIZE bits of the DMA\_CTLx register. When the bit value is 000, it means 1, 001 means 4, and 002 means 8. Then the conversion to Bytes is SRC\_MSIZE (DEST\_MSIZE) \* (number of bits of data width / 8). The burst data length Bytes of DMA needs to be consistent with the input or output FIFO length of the peripheral, otherwise data loss may occur.

### The block size of DMA is configured by the BLOCK\_TS bit of the DMA\_CTLx register, which is up to 12 bits. The maximum block size is 4095, which is converted to Bytes as BLOCK\_TS \* (number of bits of data width / 8).

### 21.4 Data transfer methods

DMA supports four data transfer modes: peripheral to peripheral, peripheral to memory, memory to peripheral, and memory to memory. Peripheral to peripheral means that both the source and destination of the data are peripherals; peripheral to memory means that the source is the peripheral and the destination is memory; memory to peripheral means that the source is memory and the destination is the peripheral; memory to memory means that both the source and destination are memory.

The data transfer mode is configured through the TT\_FC bit field of the DMA\_CTLx register. Except for the memory to memory transfer mode, the other modes need to configure the handshake signal between the peripheral and DMA. The handshake value of the peripheral is shown in the following table:

**Table 21-1 Handshake value**

|  |  |  |
| --- | --- | --- |
| Handshake value | Peripheral signal | Peripheral signal description |
| 4 | lorac\_tx | LORA tx |
| 5 | lorac\_rx | LORA rx |
| 6 | dacctrl | DAC |
| 7 | adcctrl | ADC |
| 10 | i2c2\_tx | I2C2 tx |
| 11 | i2c2\_rx | I2C2 rx |
| 12 | i2c1\_tx | I2C1 tx |
| 13 | i2c1\_rx | I2C1 rx |
| 14 | i2c0\_tx | I2C0 tx |
| 15 | i2c0\_rx | I2C0 rx |
| 16 | ssp2\_tx | SSP2 tx |
| 17 | ssp2\_rx | SSP2 rx |
| 18 | ssp1\_tx | SSP1 tx |
| 19 | ssp1\_rx | SSP1 rx |
| 20 | ssp0\_tx | SSP0 tx |
| 21 | ssp0\_rx | SSP0 rx |
| 22 | lpuart\_tx | LPUAR tx |
| 23 | lpuart\_rx | LPUAR rx |
| Handshake value | Peripheral signals | Peripheral signal description |
| 24 | uart3\_tx | UART3 tx |
| 25 | uart3\_rx | UART3 rx |
| 26 | uart2\_tx | UART2 tx |
| 27 | uart2\_rx | UART2 rx |
| 28 | uart1\_tx | UART1 tx |
| 29 | uart1\_rx | UART1 rx |
| 30 | uart0\_tx | UART0 tx |
| 31 | uart0\_rx | UART0 rx |
| 32 | gptim0\_ch3 | GPTIMER0 channel3 |
| 33 | gptim0\_ch2 | GPTIMER0 channel2 |
| 34 | gptim0\_ch1 | GPTIMER0 channel1 |
| 35 | gptim0\_ch0 | GPTIMER0 channel0 |
| 36 | gptim0\_trg | GPTIMER0 trigger |
| 37 | gptim0\_up | GPTIMER0 update |
| 38 | Gptim1\_ch3 | GPTIMER1 channel3 |
| 39 | Gptim1\_ch2 | GPTIMER1 channel2 |
| 40 | Gptim1\_ch1 | GPTIMER1 hannel1 |
| 41 | Gptim1\_ch0 | GPTIMER1 channel0 |
| 42 | Gptim1\_trg | GPTIMER1 的 trigger |
| 43 | Gptim1\_up | GPTIMER1 update |
| 44 | gptim2\_ch1 | GPTIMER2 channel1 |
| 45 | gptim2\_ch0 | GPTIMER2 channel0 |
| 46 | gptim2\_trg | GPTIMER2 trigger |
| 47 | gptim2\_up | GPTIMER2 update |
| 48 | Gptim3\_ch1 | GPTIMER3 channel1 |
| 49 | Gptim3\_ch0 | GPTIMER3 channel0 |
| 50 | Gptim3\_trg | GPTIMER3 trigger |
| 51 | Gptim3\_up | GPTIMER3 update |
| 52 | basictim1\_up | BSTIMER1 update |
| 53 | basictim0\_up | BSTIMER0 的 update |

### 21.5 LLI

When there are multiple pieces of discontinuous memory data that need to be moved to peripherals or memory, LLI (chain table method) can be used, as shown in the following figure:



**Figure 21-2 LLI linked list**

LLI(0), LLI(1) Table indicates the information of configuring block0 and block1, including source and destination address, data bits width, burst length and block length. LLPx Table indicates that the current block points to the address of the next block, and the address of the first block The LLP points to the address of the second block, which is the first address of LLI(1), and so on. The LLP of the last block is 0. The length of each block can be different, and the first address of the memory is also different.

#### 21.6 Auto-reloading

Auto-reloading means that after all the data in the memory in the block is moved or written, the data is moved or written again from the starting address of the memory, and the cycle repeats until the DMA channel used is disabled. The Auto-reloading function can be used for both the source and destination of DMA, as long as it is memory.

### 21.7 interrupt

DMA interrupt signals:

**Table 21-2 DMA interrupt signals**

|  |  |
| --- | --- |
| Interrupt | Description |
| DMA block transfer completed interrupt | Interrupt generated after completion of DMA block transfer |
| DMA destination processing completed interrupt | Interrupt generated after completion of DMA destination processing |
| DMA source processing completed interrupt | Interrupt generated after DMA source processing is completed |
| DMA transfer error interrupt | Interrupt generated if error occurs during DMA transfer |
| DMA full transfer completed interrupt | Interrupt generated after DMA completes transfer |

Enable the above interrupt by configuring *DMA\_MaskBlock*, *DMA\_MaskDstTran*, *DMA\_MaskSrcTran*, *DMA\_MaskErr* and *DMA\_MaskTfr* Register.

The status of all interrupts can be obtained through *DMA\_StatusBlock*, *DMA\_StatusDstTran*, *DMA\_StatusSrcTran*, *DMA\_StatusErr* and *DMA\_StatusTfr* Register.

Clear the interrupt status by configuring *DMA\_ClearBlock*, *DMA\_ClearDstTran*, *DMA\_ClearSrcTran*, *DMA\_ClearErr* and *DMA\_ClearTfr* Register.

#### 21.8 DMA Registers

DMA0 Base Address: 0x40023000

DMA1 Base Address: 0x40024000

**Table 21-3 DMA Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| DMA\_SARx | 0x00 | Source address Register, x Table indicates channel 0, 1, 2, 3, Correspond to Offset points  0x00, 0x58, 0xb0, 0x108 |
| DMA\_DARx | 0x08 | The destination address Register, x Table indicates channel 0, 1, 2, 3, and the Offset of Correspond to are 0x08, 0x60, 0xb8, 0x110 respectively. |
| DMA\_LLPx | 0x10 | Chain Table pointer Register, x Table indicates channel 0, 1, 2, 3, Correspond to Offset are 0x10, 0x68, 0xc0, 0x118 respectively |
| DMA\_CTLx | 0x18 | Channel Control Register, x Table indicates channel 0, 1, 2, 3, Correspond to Offset are 0x18, 0x70, 0xc8, 0x120 respectively |
| DMA\_CFGx | 0x40 | Channel configuration register, x represents channel 0, 1, 2, 3, and the corresponding offsets are 0x40, 0x98, 0xf0, 0x148 respectively |
| DMA\_StatusTfr | 0x2e8 | DMA complete transfer completed Interrupt Status Register |
| DMA\_StatusBlock | 0x2f0 | DMA block transfer completed Interrupt Status Register |
| DMA\_StatusSrcTran | 0x2f8 | DMA source processing completed Interrupt Status Register |
| DMA\_StatusDstTran | 0x300 | DMA destination processing completed Interrupt Status Register |
| DMA\_StatusErr | 0x308 | DMA transfer error Interrupt Status Register |
| DMA\_MaskTfr | 0x310 | DMA full transfer completed Interrupt Enable Register |
| DMA\_MaskBlock | 0x318 | DMA block transfer completed Interrupt Enable Register |
| DMA\_MaskSrcTran | 0x320 | DMA source processing completed Interrupt Enable Register |
| DMA\_MaskDstTran | 0x328 | DMA destination processing completed Interrupt Enable Register |
| DMA\_MaskErr | 0x330 | DMA transfer error Interrupt Enable Register |
| DMA\_ClearTfr | 0x338 | DMA complete transfer completed Interrupt Status Clear Register |
| DMA\_ClearBlock | 0x340 | DMA block transfer completed Interrupt Status Clear Register |
| DMA\_ClearSrcTran | 0x348 | DMA source processing completes interrupt Status Clear Register |
| DMA\_ClearDstTran | 0x350 | DMA destination processing completes interrupt Status Clear Register |
| DMA\_ClearErr | 0x358 | DMA transfer error interrupt Status Clear Register |
| DMA\_DmaCfgReg | 0x398 | DMA Enable Register |
| DMA\_ChEnReg | 0x3a0 | DMA channel Enable Register |

##### 21.8.1 DMA\_SARx

Offset: 0x000, 0x058, 0x0b0, 0x108

Reset Value: 0x0000000000000000

|  |  |
| --- | --- |
| **63-32** | **31-0** |
| RESERVED | SAR |
| r-0h | rw-0h |

**Bits 63-32 RESERVED:** Must be kept, and cannot be modified.

**Bits 31-0 SAR:** DMA source address.

##### 21.8.2 DMA\_DARx

Offset: 0x08, 0x60, 0xb8, 0x110

Reset Value: 0x0000000000000000

|  |  |
| --- | --- |
| **63-32** | **31-0** |
| RESERVED | DAR |
| r-0h | rw-0h |

**Bits 63-32 RESERVED:** Must be kept, and cannot be modified.

**Bits 31-0 DAR:** DMA destination address.

##### 21.8.3 DMA\_LLPx

Offset: 0x10, 0x68, 0xc0, 0x118

Reset Value: 0x0000000000000000

|  |  |
| --- | --- |
| **63-32** | **31-0** |
| RESERVED | LOC |
| r-0h | rw-0h |

**Bits 63-32 RESERVED:** Must be kept, and cannot be modified.

**Bits 31-0 LOC:** The first address of the next LLI chain Table.

##### 21.8.4 DMA\_CTLx

Offset: 0x18, 0x70, 0xc8, 0x120

Reset Value: 0x0000000200308801

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **63-45** |  | **44** | **43-32** | | **31-29** | **28** |
| RESERVED |  | DONE | BLOCK\_TS | | RESERVED | LLP\_SRC\_EN |
| r-0h |  | rw-0h | rw-2h | | rw-0h | rw-0h |
| **27** |  | **26-25** | **24-23** | | **22-20** | **19** |
| LLP\_DST\_EN |  | SMS | DMS | | TT\_FC | RESERVED |
| rw-0h |  | rw-0h | rw-0h | | rw-3h | rw-0h |
| **18** |  | **17** | **16-14** | | **13-11** | **10-9** |
| DST\_SCATTER\_E | N | SRC\_GATHER\_EN | SRC\_MSIZE | | DEST\_MSIZE | SINC |
| rw-0h |  | rw-0h | rw-1h | | rw-1h | rw-0h |
| **8-7** | **6-4** | |  | **3-1** | | **0** |
| DINC | SRC\_TR\_WIDTH | |  | DST\_TR\_WIDTH | | INT\_EN |
| rw-0h | rw-0h | |  | rw-0h | | rw-1h |

**Bits 63-45 RESERVED:** Must be kept, and cannot be modified.

**Bit 44 DONE:** LLI chain Table block transfer status.

* 0: completed
* 1: uncompleted

**Bits 43-32 BLOCK\_TS:** block length.

**Bits 31-29 RESERVED:** Must be kept, and cannot be modified.

**Bit 28 LLP\_SRC\_EN:** DMA source LLI chain Table enable.

* 0: disabled
* 1: enabled

**Bit 27 LLP\_DST\_EN:** DMA destination LLI chain Table enable.

* 0: disabled
* 1: enabled

**Bits 26-25 SMS:** DMA source AHB master selection.

* 00: AHB master 1
* 01: AHB master 2
* 10: AHB master 3
* 11: AHB master 4

**Bits 24-23 SMS:** DMA destination AHB master selection.

* 00: AHB master 1
* 01: AHB master 2
* 10: AHB master 3
* 11: AHB master 4

**Bits 22-20 TT\_FC:** DMA data transfer mode selection.

* 000: memory to memory
* 001: memory to peripheral
* 010: peripheral to memory
* 011: peripheral-to-peripheral
* other values: invalid

**Bit 19 RESERVED:** Must be kept, and cannot be modified.

**Bit 18 DST\_SCATTER\_EN:** DMA destination scatter enable.

* 0: disabled
* 1: enabled

**Bit 17 SRC\_GATHER\_EN:** DMA source gather enable.

* 0: disabled
* 1: enabled

**Bits 16-14 SRC\_MSIZE:** DMA source burst length.

* 000: 1
* 001: 4
* 010: 8
* other values: invalid

**Bits 13-11 DEST\_MSIZE:** DMA destination burst length.

* 000:1
* 001:4
* 010:8
* other values: Invalid

**Bits 10-9 SINC:** DMA source address control.

* 00: increment
* 01: decrement
* 10: no change
* 11: no change

**Bits 8-7 DINC:** DMA destination address control.

* 00: Increment
* 01: Decrement
* 10: No change
* 11: Unchanged

**Bits 6-4 SRC\_TR\_WIDTH:** DMA source data width configuration.

* 000:8 bits
* 001:16 bits
* 010:32 bits
* other values: Invalid

**Bits 3-1 DST\_TR\_WIDTH:** DMA destination data width configuration.

* 000: 8 bits
* 001:16 bits
* 010: 32 bits
* other values: invalid

**Bit 0 INT\_EN:** DMA interrupt enable.

* 0: disable
* 1: enable

##### 21.8.5 DMA\_CFGx

Offset: 0x40, 0x98, 0xf0, 0x148

Reset Value: 0x0000000400020e00

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **63-47** | **46-43** | **42-39** | **38** | **37** | **36-34** |
| RESERVED | DEST\_PER | SRC\_PER | SS\_UPD\_EN | DS\_UPD\_EN | PROTCTL |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-1h |
| **33** | **32** | **31** | **30** | **29-20** | **19** |
| FIFO\_MODE | FCMODE | RELOAD\_DST | RELOAD\_SRC | RESERVED | SRC\_HS\_POL |
| rw-0h | rw-0h | rw-0h | rw-0h | r-0h | rw-0h |
| **18** | **17** | **16** | **15-14** | **13-12** | **11** |
| DST\_HS\_POL | LOCK\_B | LOCK\_CH | LOCK\_B\_L | LOCK\_CH\_L | HS\_SEL\_SRC |
| rw-0h | rw-1h | rw-0h | rw-0h | rw-0h | rw-1h |
| **10** | **9** | **8** | **7-5** | **4-0** | |
| HS\_SEL\_DST | FIFO\_EMPTY | CH\_SUSP | CH\_PRIOR | RESERVED | |
| rw-1h | r-1h | rw-0h | rw-0h | r-0h | |

**Bits 63-47 RESERVED:** Must be kept, and cannot be modified.

**Bits 46-43 DEST\_PER:** DMA destination handshake interface, valid values are 0 to 3.

**Bits 42-39 SRC\_PER:** DMA source handshake interface, valid values are 0 to 3.

**Bit 38 SS\_UPD\_EN:** DMA source status update enable.

* 0: disabled
* 1: enabled

**Bit 37 DS\_UPD\_EN:** DMA destination status update enable.

* 0: disabled
* 1: enabled

**Bits 36-34 PROTCTL:** Protection control.

**Bit 33** FIFO\_MODE: FIFO mode selection.

* 0: full FIFO can be obtained
* 1: only half of the FIFO can be obtained

**Bit 32 FCMODE:** Source flow control mode selection.

* 0: request from the source is processed as soon as it is issued
* 1: request from the source will not be processed until there is a request from the destination

**Bit 31 RELOAD\_DST:** DMA destination auto-reloading enable.

* 0: disabled
* 1: enabled

**Bit 30 RELOAD\_SRC:** DMA source auto-reloading enable.

* 0: disabled
* 1: enabled

**Bits 29-20 RESERVED:** Must be kept, and cannot be modified.

**Bit 19 SRC\_HS\_POL:** DMA source handshake interface information polarity.

* 0: active high 
* 1: active low

**Bit 18 DST\_HS\_POL:** DMA destination handshake interface information polarity.

* 0: active high 
* 1: active low

**Bit 17 LOCK\_B:** Bus lock control.

* 0: unlocked
* 1: locked

**Bit 16 LOCK\_CH:** DMA channel lock control.

* 0: unlocked
* 1: locked

**Bits 15-14 LOCK\_B\_L:** Bus lock delay.

* 00: wait until the DMA transfer is completed
* 01: wait until the block transfer is completed
* 10: wait until DMA processing is completed

**Bits 13-12 LOCK\_CH\_L:** DMA channel lock delay.

* 00: wait until the DMA transfer is completed
* 01: wait until the block transfer is completed
* 10: wait until DMA processing is completed

**Bit 11 HS\_SEL\_SRC:** DMA source handshake signal selection.

* 0: hardware handshake 
* 1: software handshake

**Bit 10 HS\_SEL\_DST:** DMA destination handshake signal selection.

* 0: hardware handshake 
* 1: software handshake

**Bit 9 FIFO\_EMPTY:** DMA Channel FIFO is empty indication.

* 0: not empty
* 1: empty

**Bit 8 CH\_SUSP:** DMA channel FIFO suspend indication.

* 0: not suspended
* 1: suspended

**Bits 7-5 CH\_PRIOR:** DMA channel priority configuration, valid values are 0 to 3, 0 is the lowest priority, 3 is the highest priority.

**Bits 4-0 RESERVED:** Must be kept, and cannot be modified.

###### 21.8.6 DMA\_StatusTfr

Offset: 0x2e8

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_STATUS | CHAN2\_STATUS | CHAN1\_STATUS | CHAN0\_STATUS |
| r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_STATUS:** Transfer completion status of DMA channel3.

* 0: Not completed
* 1: Completed

**Bit 2 CHAN2\_STATUS:** Transfer completion status of DMA channel2.

* 0: Not completed
* 1: Completed

**Bit 1 CHAN1\_STATUS:** Transfer completion status of DMA channel1.

* 0: Not completed
* 1: Completed

**Bit 0 CHAN0\_STATUS:** Transfer completion status of DMA channel0.

* 0: not completed
* 1: completed

###### 21.8.7 DMA\_StatusBlock

Offset: 0x2f0

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_STATUS | CHAN2\_STATUS | CHAN1\_STATUS | CHAN0\_STATUS |
| r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_STATUS:** Block transfer completion status of DMA channel 3.

* 0: not completed
* 1: completed

**Bit 2 CHAN2\_STATUS:** Block transfer completion status of DMA channel 2.

* 0: Not completed
* 1: Completed

**Bit 1 CHAN1\_STATUS:** Block transfer completion status of DMA channel 1.

* 0: Not completed
* 1: Completed

**Bit 0 CHAN0\_STATUS:** Block transfer completion status of DMA channel 0.

* 0: Not completed
* 1: Completed

###### 21.8.8 DMA\_StatusSrcTran

Offset: 0x2f8

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_STATUS | CHAN2\_STATUS | CHAN1\_STATUS | CHAN0\_STATUS |
| r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_STATUS:** Source transfer completion status of DMA channel 3.

* 0: not completed
* 1: completed

**Bit 2 CHAN2\_STATUS:** Source transfer completion status of DMA channel 2.

* 0: Not completed
* 1: Completed

**Bit 1 CHAN1\_STATUS:** Source transfer completion status of DMA channel 1.

* 0: Not completed
* 1: Completed

**Bit 0 CHAN0\_STATUS:** Source transfer completion status of DMA channel 0.

* 0: Not completed
* 1: Completed

###### 21.8.9 DMA\_StatusDstTran

Offset: 0x300

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_STATUS | CHAN2\_STATUS | CHAN1\_STATUS | CHAN0\_STATUS |
| r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_STATUS:** Destination transfer completion status of DMA channel 3.

* 0: not completed
* 1: completed

**Bit 2 CHAN2\_STATUS:** Destination transfer completion status of DMA channel 2.

* 0: Not completed
* 1: Completed

**Bit 1 CHAN1\_STATUS:** Destination transfer completion status of DMA channel 1.

* 0: Not completed
* 1: Completed

**Bit 0 CHAN0\_STATUS:** Destination transfer completion status of DMA channel 0.

* 0: Not completed
* 1: Completed

###### 21.8.10 DMA\_StatusErr

Offset: 0x308

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_STATUS | CHAN2\_STATUS | CHAN1\_STATUS | CHAN0\_STATUS |
| r-0h | r-0h | r-0h | r-0h | r-0h |

**Bits 63-4 RESERVED**: Must be kept, and cannot be modified.

**Bit 3 CHAN3\_STATUS:** Transmission error status of DMA channel 3.

* 0: no error
* 1: error

**Bit 2 CHAN2\_STATUS:** Transmission error status of DMA channel 2.

* 0: No error
* 1: Error

**Bit 1 CHAN1\_STATUS:** Transmission error status of DMA channel 1.

* 0: No error
* 1: Error

**Bit 0 CHAN0\_STATUS:** Transmission error status of DMA channel 0.

* 0: No error
* 1: Error

###### 

###### 21.8.11 DMA\_MaskTfr

Offset:0x310

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-12** | **11** | **10** | **9** | **8** |
| RESERVED | INT\_MASK\_WE\_3 | INT\_MASK\_WE\_2 | INT\_MASK\_WE\_1 | INT\_MASK\_WE\_0 |
|  |  |  |  |  |
| r-0h | w-0h | w-0h | w-0h | w-0h |
|  |  |  |  |  |
| **7-4** | **3** | **2** | **1** | **0** |
| RESERVED | INT\_MASK\_3 | INT\_MASK\_2 | INT\_MASK\_1 | INT\_MASK\_0 |
|  |  |  |  |  |

**Bits 63-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 INT\_MASK\_WE\_3:** DMA channel 3 transfer completion interrupt mask write enable.

* 0: disabled
* 1: enabled

**Bit 10 INT\_MASK\_WE\_2:** DMA channel 2 transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 9 INT\_MASK\_WE\_1:** DMA channel 1 transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 8 INT\_MASK\_WE\_0:** DMA channel 0 transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bits 7-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 INT\_MASK\_3:** DMA channel 3 transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 2 INT\_MASK\_2:** DMA channel 2 transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 1 INT\_MASK\_1:** DMA channel 1 transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 0 INT\_MASK\_0:** DMA channel 0 transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

###### 21.8.12 DMA\_MaskBlock

Offset: 0x318

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-12** | **11** | **10** | **9** | **8** |
| RESERVED | INT\_MASK\_WE\_3 | INT\_MASK\_WE\_2 | INT\_MASK\_WE\_1 | INT\_MASK\_WE\_0 |
|  |  |  |  |  |
| r-0h | w-0h | w-0h | w-0h | w-0h |
|  |  |  |  |  |
| **7-4** | **3** | **2** | **1** | **0** |
| RESERVED | INT\_MASK\_3 | INT\_MASK\_2 | INT\_MASK\_1 | INT\_MASK\_0 |
|  |  |  |  |  |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h |
|  |  |  |  |  |

**Bits 63-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 INT\_MASK\_WE\_3:** DMA channel 3 block transfer completion interrupt mask write enable.

* 0: disabled
* 1: enabled

**Bit 10 INT\_MASK\_WE\_2:** DMA channel 2 block transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 9 INT\_MASK\_WE\_1:** DMA channel 1 block transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 8 INT\_MASK\_WE\_0:** DMA channel 0 block transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bits 7-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 INT\_MASK\_3:** DMA channel 3 block transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 2 INT\_MASK\_2:** DMA channel 2 block transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 1 INT\_MASK\_1:** DMA channel 1 block transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 0 INT\_MASK\_0:** DMA channel 0 block transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

###### 21.8.13 DMA\_MaskSrcTran

Offset:0x320

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-12** | **11** | **10** | **9** | **8** |
| RESERVED | INT\_MASK\_WE\_3 | INT\_MASK\_WE\_2 | INT\_MASK\_WE\_1 | INT\_MASK\_WE\_0 |
| r-0h | w-0h | w-0h | w-0h | w-0h |
| **7-4** | **3** | **2** | **1** | **0** |
| RESERVED | INT\_MASK\_3 | INT\_MASK\_2 | INT\_MASK\_1 | INT\_MASK\_0 |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 63-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 INT\_MASK\_WE\_3:** DMA channel 3 destination transfer completion interrupt mask write enable.

* 0: disabled
* 1: enabled

**Bit 10 INT\_MASK\_WE\_2:** DMA channel 2 destination transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 9 INT\_MASK\_WE\_1:** DMA channel 1 destination transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 8 INT\_MASK\_WE\_0:** DMA channel 0 destination transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bits 7-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 INT\_MASK\_3:** DMA channel 3 destination transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 2 INT\_MASK\_2:** DMA channel 2 destination transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 1 INT\_MASK\_1:** DMA channel 1 destination transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 0 INT\_MASK\_0:** DMA channel 0 destination transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

###### 21.8.14 DMA\_MaskDstTran

Offset: 0x328

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-12** | **11** | **10** | **9** | **8** |
| RESERVED | INT\_MASK\_WE\_3 | INT\_MASK\_WE\_2 | INT\_MASK\_WE\_1 | INT\_MASK\_WE\_0 |
|  |  |  |  |  |
| r-0h | w-0h | w-0h | w-0h | w-0h |
|  |  |  |  |  |
| **7-4** | **3** | **2** | **1** | **0** |
| RESERVED | INT\_MASK\_3 | INT\_MASK\_2 | INT\_MASK\_1 | INT\_MASK\_0 |
|  |  |  |  |  |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h |
|  |  |  |  |  |

**Bits 63-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 INT\_MASK\_WE\_3:** DMA channel 3 destination transfer completion interrupt mask write enable.

* 0: disabled
* 1: enabled

**Bit 10 INT\_MASK\_WE\_2:** DMA channel 2 destination transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 9 INT\_MASK\_WE\_1:** DMA channel 1 destination transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 8 INT\_MASK\_WE\_1:** DMA channel 0 destination transfer completion interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bits 7-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 INT\_MASK\_3:** DMA channel 3 destination transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 2 INT\_MASK\_2:** DMA channel 2 destination transfer completion interrupt enable.

* 0: Disabled
* 1: Enabled
* **Bit 1 INT\_MASK\_1:** DMA channel 1 destination transfer completion interrupt enable.
* 0: Disabled
* 1: Enabled
* **Bit 0 INT\_MASK\_0:** DMA channel 0 destination transfer completion interrupt enable.
* 0: Disabled
* 1: Enabled

###### 21.8.15 DMA\_MaskErr

Offset:0x330

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-12** | **11** | **10** | **9** | **8** |
| RESERVED | INT\_MASK\_WE\_3 | INT\_MASK\_WE\_2 | INT\_MASK\_WE\_1 | INT\_MASK\_WE\_0 |
|  |  |  |  |  |
| r-0h | w-0h | w-0h | w-0h | w-0h |
|  |  |  |  |  |
| **7-4** | **3** | **2** | **1** | **0** |
| RESERVED | INT\_MASK\_3 | INT\_MASK\_2 | INT\_MASK\_1 | INT\_MASK\_0 |
|  |  |  |  |  |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h |
|  |  |  |  |  |

**Bits 63-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 INT\_MASK\_WE\_3:** Channel 3 transfer error interrupt mask write enable.

* 0: disabled
* 1: enabled

**Bit 10 INT\_MASK\_WE\_2:** Channel 2 transfer error interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 9 INT\_MASK\_WE\_1:** Channel 1 transfer error interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bit 8 INT\_MASK\_WE\_0:** Channel 0 transfer error interrupt mask write enable.

* 0: Disabled
* 1: Enabled

**Bits 7-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 INT\_MASK\_3:** Channel 3 transmission error interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 2 INT\_MASK\_2:** Channel 2 transmission error interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 1 INT\_MASK\_1:** Channel 1 transmission error interrupt enable.

* 0: Disabled
* 1: Enabled

**Bit 0 INT\_MASK\_0:** Channel 0 transmission error interrupt enable.

* 0: Disabled
* 1: Enabled

###### 21.8.16 DMA\_ClearTfr

Offset: 0x338

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_CLEAR | CHAN2\_CLEAR | CHAN1\_CLEAR | CHAN0\_CLEAR |
| r-0h | w-0h | w-0h | w-0h | w-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_CLEAR:** Clear DMA channel 3 transfer completion status.

* 0: no action
* 1: clear

**Bit 2 CHAN2\_CLEAR:** Clear DMA channel 2 transfer completion status.

* 0: No operation
* 1: Clear

**Bit 1 CHAN1\_CLEAR:** Clear DMA channel 1 transfer completion status.

* 0: No operation
* 1: Clear

**Bit 0 CHAN0\_CLEAR:** Clear DMA channel 0 transfer completion status.

* 0: No operation
* 1: Clear

###### 21.8.17 DMA\_ClearBlock

Offset: 0x340

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_CLEAR | CHAN2\_CLEAR | CHAN1\_CLEAR | CHAN0\_CLEAR |
| r-0h | w-0h | w-0h | w-0h | w-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_CLEAR:** Clear DMA channel 3 block transfer completion status.

* 0: no action
* 1: clear

**Bit 2 CHAN2\_CLEAR:** Clear DMA channel 2 block transfer completion status.

* 0: No operation
* 1: Clear

**Bit 1 CHAN1\_CLEAR:** Clear DMA channel 1 block transfer completion status.

* 0: No operation
* 1: Clear

**Bit 0 CHAN0\_CLEAR:** Clear DMA channel 0 block transfer completion status.

* 0: No operation
* 1: Clear

###### 21.8.18 DMA\_ClearSrcTran

Offset: 0x348

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_CLEAR | CHAN2\_CLEAR | CHAN1\_CLEAR | CHAN0\_CLEAR |
| r-0h | w-0h | w-0h | w-0h | w-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_CLEAR:** Clear DMA channel 3 source transfer completion status.

* 0: no action
* 1: clear

**Bit 2 CHAN2\_CLEAR:** Clear DMA channel 2 source transfer completion status.

* 0: No operation
* 1: Clear

**Bit 1 CHAN1\_CLEAR:** Clear DMA channel 1 source transfer completion status.

* 0: No operation
* 1: Clear

**Bit 0 CHAN0\_CLEAR:** Clear DMA channel 0 source transfer completion status.

* 0: No operation
* 1: Clear

###### 21.8.19 DMA\_ClearDstTran

Offset: 0x350

Reset Value:0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_CLEAR | CHAN2\_CLEAR | CHAN1\_CLEAR | CHAN0\_CLEAR |
| r-0h | w-0h | w-0h | w-0h | w-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_CLEAR:** Clear DMA channel 3 destination transfer completion status.

* 0: no action
* 1: clear

**Bit 2 CHAN2\_CLEAR:** Clear DMA channel 2 destination transfer completion status.

* 0: No operation
* 1: Clear

**Bit 1 CHAN1\_CLEAR:** Clear DMA channel 1 destination transfer completion status.

* 0: No operation
* 1: Clear

**Bit 0 CHAN0\_CLEAR:** Clear DMA channel 0 destination transfer completion status.

* 0: No operation
* 1: Clear

###### 21.8.20 DMA\_ClearErr

Offset: 0x358

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-4** | **3** | **2** | **1** | **0** |
| RESERVED | CHAN3\_CLEAR | CHAN2\_CLEAR | CHAN1\_CLEAR | CHAN0\_CLEAR |
| r-0h | w-0h | w-0h | w-0h | w-0h |

**Bits 63-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CHAN3\_CLEAR:** Clear DMA channel 3 transfer error status.

* 0: no action
* 1: clear

**Bit 2 CHAN2\_CLEAR:** Clear DMA channel 2 transfer error status.

* 0: No operation
* 1: Clear

**Bit 1 CHAN1\_CLEAR:** Clear DMA channel 1 transfer error status.

* 0: No operation
* 1: Clear

**Bit 0 CHAN0\_CLEAR:** Clear DMA channel 0 transfer error status.

* 0: No operation
* 1: Clear

###### 21.8.21 DMA\_DmaCfgReg

Offset: 0x398

Reset Value: 0x0000000000000000

|  |  |
| --- | --- |
| **63-1** | **0** |
| RESERVED | DMA\_EN |
| r-0h | rw-0h |

**Bits 63-1 RESERVED:** Must be kept, and cannot be modified.

**Bit 0 DMA\_EN:** DMA enable control.

* 0: disabled
* 1: enabled

###### 21.8.22 DMA\_ChEnReg

Offset: 0x3a0

Reset Value: 0x0000000000000000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **63-12** | **11** | **10** | **9** | **8** |
| RESERVED | CH\_EN\_WE\_3 | CH\_EN\_WE\_2 | CH\_EN\_WE\_1 | CH\_EN\_WE\_0 |
| r-0h | w-0h | w-0h | w-0h | w-0h |
| **7-4** | **3** | **2** | **1** | **0** |
| RESERVED | CH\_EN\_3 | CH\_EN\_2 | CH\_EN\_1 | CH\_EN\_0 |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 63-12 RESERVED:** Must be kept, and cannot be modified.

**Bit 11 CH\_EN\_WE\_3:** DMA channel 3 enable control information write enable.

* 0: disabled
* 1: enabled

**Bit 10 CH\_EN\_WE\_2:** DMA channel 2 enable control information write enable.

* 0: Disabled
* 1: Enabled

**Bit 9 CH\_EN\_WE\_1:** DMA channel 1 enable control information write enable.

* 0: Disabled
* 1: Enabled

**Bit 8 CH\_EN\_WE\_0:** DMA channel 0 enable control information write enable.

* 0: Disabled
* 1: Enabled

**Bits 7-4 RESERVED:** Must be kept, and cannot be modified.

**Bit 3 CH\_EN\_3:** DMA channel 3 enable control. When the DMA transfer is completed, the hardware automatically disables this channel.

* 0: Disabled
* 1: Enabled

**Bit 2 CH\_EN\_2:** DMA channel 2 enable control. When the DMA transfer is completed, the hardware automatically disables this channel.

* 0: Disabled
* 1: Enabled

**Bit 1 CH\_EN\_1:** DMA channel 1 enable control. When the DMA transfer is completed, the hardware automatically disables this channel.

* 0: Disabled
* 1: Enabled

**Bit 0 CH\_EN\_0:** DMA channel 0 enable control. When the DMA transfer is completed, the hardware automatically disables this channel.

* 0: Disabled
* 1: Enabled

### 22. GPTIMER

#### 22.1 Introduction

ASR6601 has a total of 4 general-purpose timers (GPTIMER), of which GPTIMER0 and GPTIMER1 have 4 channels.

GPTIMER2 and GPTIMER3 have 2 channels, that is, GPTIMER2 and GPTIMER3 do not have channels 2 and 3.

GPTIMER contains a 16-bit counter, supports auto-reloading function, and supports up to 16-bit programmable prescaler. The 4 channels can be independently configured as input or output. It supports input capture, output comparison and other functions, counting clock and counting mode. Software configurable, supports connection to Hall devices, supports encoding mode (only applicable to GPTIMER0 and GPTIMER1), supports DMA configuration, has independent interrupt output, supports encoding functions, etc. Based on rich channel configurations and functions, the GPTIMER can be used for timing counting, measuring input pulse width (us-ms level), generating PWM waveforms and other applications.

##### 22.2 Main features

* 16-bit counter, supports automatic reloading, configurable edge-aligned (up, down) counting and center-aligned (up/down) counting.
* 16-bit programmable prescaler (division coefficient 1-65535), which can be configured during the counting process.
* Up to 4 independent channels, which can complete input capture, output comparison, PWM waveform output, and single pulse waveform output.
* Support channel output polarity selection and input edge configuration.
* Supports synchronization with external input or other modules (GPTIMER, ADC, DAC).
* Independent DMA channel, up to 6 groups of DMA Request, including update events, trigger events and 4 groups of channel events (capture, comparison).
* Supports quadrature encoding function.
* Supports external trigger channel input clock for counting and supports external trigger channel input trigger signal, supports channel input clock for counting.
* Supports channel remapping, that is, mapping GPIO signals or internal signals of other modules to channels or external channels.

GPTIMER structure diagram:



**Figure 22-1 GPTIMER structure**

**Table 22-1 GPTIMER module structure**

|  |  |
| --- | --- |
| Module name | Description |
| slave control | Slave mode controller |
| master control | Master mode controller |
| u\_etr\_ctrl | ETR channel control, including polarity, frequency division, filtering and other configurations |
| u\_channel\_in\_x | Input channel x controls including polarity, filtering and edge configuration |
| u\_icx\_div | Input channel x event divider |
| u\_sampling\_clock | The sampling clock that generates the filter |
| u\_capture\_x | Input channel x capture function |
| u\_compare\_x | Output channel x compare function |
| u\_psc\_counter | 16-bit prescaler |
| u\_counter | 16-bit counter |
| u\_reg\_model | Register related configuration |
| output stage | Output control |
| interrupt control | Interrupt control |
| dma control | DMA capability |
| itr\_input | Other internal inputs to GPTIMER |
| etr\_input | External trigger channel input |
| channel\_input | Channel input |
| dma\_ack | ACK of DMA reply |
| dma\_req | Request sent to DMA |
| apb\_write | apb bus write |
| Module name | Description |
| apb\_read | apb bus read |
| trigger\_output | The signal output in master mode is an internal signal and will not be output to the outside. |
| channel\_output | Channel output |

#### 22.3 Counter

##### GPTIMER's counter has a total of 16-bit, supports upward, downward, and center-aligned counting. The counting clock is optional. Counting can be enabled or disabled by software configuration. The software can read and write at any time (it is recommended not to write during the counting process to avoid unknown errors).

##### 22.3.1 Counter clock selection

GP Timer has four counting clock sources, namely internal clock, external clock mode 1, external clock mode 2 and internal trigger signal control counting. Among them, the internal clock is the default mode (SMS==3’b000), the clock comes from RCC, as long as CEN is set, the prescaler and the counter will start counting, the other three cases use the corresponding signal as the counting enable, not as the real clock.

External clock mode 1 (SMS==3'b111, TS==3'b100/101/110), in this mode, the counter is controlled by the rising edge or falling edge or both edges of the selected channel input as the counter control, for example, if the rising edge of channel 0 is selected to control counting, then each rising edge will increase the counter by 1 (upward counting, no frequency division), and the waveform is as follows:

 **Figure 22-2 External clock mode 1 counting**

In external clock mode 2 (ECE==1) the counter is controlled by the rising edge or falling edge of ETR as the counting enable of the counter. For example, if the rising edge of ETR is configured, the waveform is as shown in the figure below.



**Figure 22-3 External clock mode 2 counting**

GPTIMER can also choose the internal trigger signal to control counting (SMS==3'b111, TS==3'b001/010/011), that is, the trigger output signal of the upper level GPTIMER can be used as the counting clock of the GPTIMER, thereby realizing GPTIMER cascade. In this case, the upper level GPTIMER is equivalent to a frequency division counter, and the waveform is as shown in the figure below.



###### Figure 22-4 Internal trigger signal for clock counting

When ETR is used as the counting clock input, there are two ways to implement it. One is external clock mode 1, configure SMS==3’b111, TS==3’b111, and the other is external clock mode 2, configure ECE==1.

###### 22.3.2 Auto-reload

GPTIMER supports the automatic reloading function. When counting upwards, after counting to the reload value (ARR), it will return to zero and start counting again. When counting downwards, it will start counting from ARR. After counting to 0, it will return to ARR and restart counting. When center-aligned counting, the counter starts counting from 0 to ARR-1, and then counts from ARR to 0.

ARR is software configurable (ARPE) whether to enable the shadow Register. If ARPE=0, the Shadow Register is disabled and the value written by the software is synchronously updated to ARR for use by the counter. If ARPE=1, the value written by the software will not be immediately effective, until the update event arrives, the value will be updated to the shadow Register for counter use.

###### 22.3.3 Counting up

If configured in up-counting mode, the counter will start incrementing from 0 to ARR after it is enabled and has a counting clock, generating an overflow event (overflow), and then reset to zero and restart counting. If UG is set (software or hardware) during the counting process, the counter including the prescaler will be initialized (reset to zero). In terms of timing, the overflow flag will be generated during the last count value. If the shadow register is enabled, the ARR, PSC, CCRx and other registers will be updated to the corresponding shadow registers at the beginning of the next round of counting. The waveform is shown in the figure below.



**Figure 22-5 Counting up**

###### 22.3.4 Counting down

If configured in down-counting mode, the counter will start to count down from ARR to 0 after it is

enabled and there is a counting clock, generating an underflow event (underflow), and then return

to ARR to restart counting. If UG is set (software or hardware) during the counting process, the

counter including the frequency division counter will be initialized (the counter returns to ARR, and

the frequency division counter returns to zero). In terms of timing, the underflow flag will be

generated during the last count value (CNT=0), but please note that if the shadow register is

enabled, the ARR register will be updated to the corresponding shadow register before the next

round of counting starts (CNT=0) to ensure that the next round of counting can use the latest load

value and frequency division value. PSC and CCRx are the same as before and will be updated to

the shadow register at the next clock of underflow. The waveform is shown in the figure below.

 **Figure 22-6 Counting down**

##### 22.3.5 Center-alignment count

If configured as the center-aligned counting mode, the counter will start incrementing from 0 to ARR-1 after it is enabled and there is a counting clock, generating an overflow event, and then decrementing from ARR to 1, generating an underflow event, and then restarting the counting from 0. If UG is set (software or hardware) during the counting process, the counter including the prescaler will be initialized (reset to zero). Please note that if the shadow register is enabled, the ARR and PSC registers will be updated to the corresponding shadow registers when counting up to the old ARR-1 to ensure that the new ARR and new PSC can be used when counting down, and the update of CCRx is the same as before. When counting down, the shadow registers of ARR, PSC and CCRx will be updated after underflow occurs. In this mode, the counting direction is controlled by hardware, and the software configuration is invalid. See figure below:



**Figure 22-7 Center-alignment count**

##### 22.4 Frequency division counter

GPTIMER supports 16-bit (1~65535) programmable frequency division, which is realized by the prescaler. The count enable signal generated by the upper circuit will be used as the enable control count of the frequency division counter. When the frequency division counter counts to the pre-loaded frequency division value, it outputs a pulse as the count enable of the next level counter, and then the frequency division counter returns to zero and counts again, and so on.

The division value of the prescaler uses the shadow register by default, that is, the software write operation will not take effect immediately, but the new division value will be written to the shadow register until the update event (UG is set, count overflow) arrives, at which time the division value will take effect. The software read operation reads the written register value, not the shadow register. If there are multiple write operations before the update event arrives, the previously written value will be overwritten.

Take an example to illustrate the prescaler. If it is configured to be divided by 4, then 4 high levels must be input to output a valid pulse. The waveform is as shown in the figure below (channel 0, no filtering, selected the rising edge of channel 0 as the valid pulse, and configure ic0 to be divided by 4).



**Figure 22-8 Frequency division counter**

##### 22.5 Sampling clock

Each input channel and external trigger channel can select the digital filtering function, which samples the input signal by using a high-frequency sampling clock (the frequency is at least 4 times that of the input signal). The clock of all flip-flops inside GPTIMER is provided by pclk. The software can configure the frequency of the sampling clock (CKD is pclk, pclk/2, pclk/4 respectively), and the frequency division is achieved by using a counter. For example, if the sampling frequency is configured to be 4 times the frequency of pclk, the counter is controlled by pclk to count, and a pulse (with a width of one cycle of pclk) is generated every 4 pclk cycles, which is used as the enable signal of the subsequent counter. In each channel, the user can also configure the sampling clock division of the digital filter again, that is, configure the value of ETF, and the filtering principle is the same as above.

#### 22.6 Thoroughfare

Each channel of each GPTIMER has multiple sources. These signal sources are asynchronous with the GPTIMER, so synchronization processing is required inside the module. The synchronized channel input signal can be filtered according to the software configuration. The sampling frequency and window length of the filter can be configured by software (ICxF). The filtered signal generates an edge signal by an edge detector. The effective level (or effective edge) can be configured by software. The processed channel signal can be used as the control signal of the slave mode controller, the encoding mode input signal, or the input capture enable signal (configurable frequency division). Each input channel can be mapped to the current channel, the adjacent channel or the internal trigger signal TRC (CCxS[1:0] configuration). The specific scheme is shown in the table (taking channel 0 as an example), where ti0fp0 is the input signal mapped to channel 0, and ti1fp0 is the input signal mapped to channel 1.

##### Table 22-2 Valid polarity configuration of input channels

|  |  |  |  |
| --- | --- | --- | --- |
| {CC0NP, CC0P} | Valid pulse (applied to input capture, reset mode, trigger mode  mode, external clock mode) | | Active level (applied to Gate mode, encoding mode) |
| ti0fp0 | ti1fp0 | ti0fp |
| 2’b00 | Channel 0 rising edge | Channel 1 rising edge | Channel 0 high level |
| 2’b01 | Channel 0 falling edge | Channel 1 falling edge | Channel 0 low level |
| 2’b10 | Reserved | Reserved | Reserved |
| 2’b11 | Channel 0 both edges | Channel 1 both edges | Channel 0 high level |

##### Table 22-3 Input channel mapping

|  |  |
| --- | --- |
| CCxS | icx mapping |
| 2’b01 | tixfpx (x represents the current channel of Table) |
| 2’b10 | tiyfpx (y represents Table adjacent channel) |
| 2’b11 | trc (only applicable to TS=3’b000, 3’b001, 3’b010, 3’b100) |

In addition, channel 0 is different from other channels. Channel 0 can be connected to the XOR output of channel 0, channel 1 and channel 2 through software configuration (TI0S is set). At this time, other functions of the channel are still valid. This function is only applicable to GPTIMER0 and GPTIMER1.

##### 22.6.1 Input capture

Input capture is activated only when the channel is configured as input mode and CCxE is set. The capture behavior can be triggered by software (CCxG) or hardware (current channel, adjacent channel or internal interconnect signal). When a valid capture trigger signal is generated, GPTIMER will latch the current counter value into the corresponding CCRx register and set the CCxIF flag bit. If the corresponding interrupt or DMA mask bit is enabled, an interrupt signal or DMA request will be generated. If more than one capture behavior occurs when CCxIF is set (not cleared by software), CCxOF is set to indicate that a capture overflow event has occurred. Reading the CCxR register (or writing 0 to the corresponding bit of the SR register) can clear CCxIF and CCxOF. The waveform is shown in the figure below.



##### **Figure 22-9 Input capture**

##### 22.6.2 Output comparison

The output compare function is activated only when the channel is configured as output mode and CCxE is set. This function controls the channel output high and low flip by comparing the counter value with the CCRx value, thereby outputting a specific waveform.

###### 22.6.2.1 CCRx Preload function

There are two ways to write to the CCRx register. If CCxPE is set, the CCRx value written by the software will not be used directly. The shadow register is the real buffer until the update event occurs. The CCRx value will be updated to the shadow register; if OCxPE is reset, the CCRx value written by the software will be used directly, and the shadow register is disabled.

###### 22.6.2.2 Output compare modes

When a match (CNT==CCR) occurs, the channel output will flip according to the configured mode, and the CCxIF flag will be set. If the corresponding interrupt or DMA mask bit is enabled, an interrupt or DMA request will be generated. The specific mode control is shown in the following table.

Table 22-4 Output comparison output waveforms in various modes description

|  |  |  |
| --- | --- | --- |
| Compare mode | Counting mode | Output waveform |
| Freeze mode | Any | No matter how the CNT changes, the output remains the same |
| SET mode | Any | After CNT==CCR, output high level |
| RESET mode | Any | After CNT==CCR, output low level |
| TOGGLE mode | Any | When CNT==CCR, toggle the current level |
| Force RESET mode | Any | After selecting this mode, output low level directly and ignore the comparison result. |
| Force SET mode | Any | After selecting this mode, output high level directly and ignore the comparison result. |
| PWM1 mode | Counting up (sides  Align pwm along) | When CNT<CCR, the output is high level; when CNT>=CCR, the output is low level. If CCR>ARR, the output is always high level (100%PWM).  CCR==0, the output is always low level (0%PWM). |
| Count down (sides  Align pwm along) | When CNT<=CCR, the output is high level; when CNT>CCR, the output is low level.  If CCR>ARR, the output is always high (100%PWM). Note: 0%PWM mode is not supported in this case. |
| middle count (center-  aligned pwm) | It is equivalent to the combination of up counting and down counting. If CCR>=ARR, the output is always high level (100%PWM). If CCR==0, the output is always low level (0%PWM). |
| PWM2 mode | Counting up (sides  Align pwm along) | When CNT<CCR, the output is low level; when CNT>=CCR, the output is high level.  If CCR>ARR, the output is always low level (0%PWM). If  CCR==0, the output is always high level (100% PWM). |
| Count down (sides  Align pwm along) | When CNT<=CCR, the output is low level; when CNT>CCR, the output is high level. If CCR>ARR, the output is always low level (0%PWM). Note:  100%PWM mode is not supported in this case. |
| middle count (center-  aligned pwm)） | It is equivalent to the combination of up counting and down counting. If CCR>=ARR, the output is always low level (0%PWM). If CCR==0, the output is always high level (100%PWM). |

The output waveforms in each mode are as follows (taking upward counting as an example).



Figure 22-10 Waveforms in various output comparison modes

Among them, the PWM mode also supports the output of 0% and 100% waveforms by configuring ARR and CCR. The PWM2 waveform of edge-aligned counting is shown in the figure below.



**Figure 22-11 Edge alignment count PWM2 center alignment count**

The PWM2 waveform of center-aligned count is shown in the figure below. **Figure 22-12 Center alignment count PWM2**

22.6.2.3 Single pulse fast output function

In single pulse mode (OPM is set), the two PWM modes can be configured as fast output mode (OCxFE is set). After enabling fast mode, the output waveform will ignore the comparison results of CNT and CCR, and the level flip will be controlled by the rising edge of the trigger signal (selected according to TS). The output signal level is equivalent to the level after the match event occurs. For example, configure GPTIMER channel 0 as output mode, select PWM1 mode, and select ETR input as the trigger signal. When ETR inputs a high level, channel 0 immediately outputs a high level (when OCxP=0). This function can effectively reduce the delay from the edge of the trigger signal to the waveform output. The single pulse output waveform when fast mode is enabled is as shown below:



**Figure 22-13 Single pulse output waveform when fast mode is enabled**

22.6.2.4 External trigger signal clears channel output function

In addition to being affected by the count value, the output waveform can also be cleared by hardware through an external trigger signal (ETR). To use this function, you need to enable the OCxCE bit in advance, and at the same time ensure that ETR disables frequency division (ETP=2’b00), and ETR cannot be used as a count clock. After enabling this function (OCxCE=1), when the level of ETR is valid (default high level), the channel output will be cleared. When changing the active level of ETR, it is achieved by configuring ETP. After turning off this function (OCxCE=0), the channel output will not be restored immediately, but will wait until the next count cycle starts to restore normal output. The comparison waveform of turning on and off the external trigger signal to clear the channel output function is as follows:



**Figure 22-14 External trigger signal clears channel output**

##### 22.7 Trigger input channel

Each GPTIMER's ETR has multiple sources, and one channel is selected to be input into the module through MUX. These signal sources are asynchronous with the GPTIMER, so synchronization processing is required inside the module. The synchronized ETR signal can select the effective level (or effective edge), configure the frequency division (1, 2, 4, 8) and filter processing according to the software configuration. The sampling frequency and window length of the filter can be configured by software (ETF).

##### 22.8 Update event management

Update events have the following event sources:

1. Counter overflow events (overflow and underflow)

2. UG set

The control signals related to update event management are mainly URS and UDIS, and the specific controls are as follows:

* If UDIS=0, URS=0, underflow, overflow, and UG are set to initialize the counter and pre-scale counter (in center-aligned mode, the counter will not be cleared by overflow, nor will ARR be loaded by underflow). If the shadow register is enabled, the update event will update the written value to the shadow register (ARR depends on ARPE, CCRx depends on OCxPE), UIF will be set, and if the interrupt or DMA mask bit is enabled, an interrupt or DMA request will be generated.
* If UDIS=0, URS=1, underflow, overflow, and UG setting will initialize the counter and pre-scale counter (in center-aligned mode, the counter will not be cleared by overflow, nor will ARR be loaded by underflow). If the shadow register is enabled, the update event will update the written value to the shadow register (ARR depends on ARPE, CCRx depends on OCxPE). UIF will only be set in the case of overflow or underflow. If the interrupt or DMA mask bit is enabled, an interrupt or DMA request will be generated. This configuration can effectively avoid the situation where the capture interrupt and update interrupt are generated at the same time when UG is set to initialize the counter in input capture mode.

If UDIS=1 (ignore URS), the underflow, overflow, and UG settings will initialize the counter and pre-scale counter (the counter will not be cleared by overflow in center-aligned mode, nor will it be loaded with ARR by underflow), but the shadow register will not be updated and UIF will not be set, so no corresponding interrupt or DMA request will be generated.

##### 22.9 Coding mode control

This GPTIMER supports the quadrature encoding counting function. Quadrature signals can be input through channel 0 and channel 1 for counting and direction detection. There are three encoding modes: counting only on the edge of channel 0, counting only on the edge of channel 1, and counting on the edges of channel 1 and channel 2. Under this function, the two channel inputs can be configured with digital filtering functions, and the polarity configuration and frequency division configuration are invalid. Through the combination of the two channel signals, the counting enable and direction control signals can be generated to control the counter addition and subtraction (if CEN is enabled), so in this mode, the software configuration of the counting direction is invalid. See the table below for specific combinations.

###### Table 22-5 Coding mode

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Encoding mode | Channel 0/1 level | Channel 0 edge | | Channel 1 level | |
| rising edge | falling edge | rising edge | falling edge |
| Encoding mode 1  (counting on channel 1 edges) | high level | - | - | count up | count down |
| low level | - | - | count down | count up |
| Encoding mode 2  (Counting edges on channel 0) | high level | count down | count up | - | - |
| low level | count up | count down | - | - |
| Encoding mode 3  (counting edges on all channels) | high level | count down | count up | count up | count down |
| low level | count up | count down | count down | count up |

In encoding mode, the counter also counts between 0-ARR. When counting up to ARR, overflow occurs, and then it returns to 0 to count again. When counting down to 0, underflow occurs, and then it returns to ARR to count again. In addition, in this mode, input capture (channel 2 and channel 3), output comparison, frequency division, and trigger output functions are still applicable. The counting waveform of encoding mode 1 is as follows:



**Figure 22-15 Counting waveform of encoding mode 1**

##### 22.10 Control from mode

GPTIMER supports cascade operation as a slave of external or internal modules. The trigger input signal TRGI of slave mode has multiple sources, which are selected by TS[2:0]. The structure is shown in the figure above, where ITRx comes from the trigger output signal (TRGO) of other internal GPTIMERs. The specific mapping relationship is shown in the table below.

###### Table 22-6 Internal trigger input mapping of each GPTIMER

|  |  |  |  |
| --- | --- | --- | --- |
| Slave GPTIMER | ITR0 | ITR1 | ITR2 |
| GPTIMER0 | GPTIMER2 | GPTIMER3 | GPTIMER1 |
| GPTIMER1 | GPTIMER0 | GPTIMER3 | GPTIMER2 |
| GPTIMER2 | GPTIMER3 | GPTIMER0 | - |
| GPTIMER3 | GPTIMER1 | GPTIMER2 | - |

There are four main ways of slave mode control:

1. **Reset mode:** The rising edge of TRGI will initialize the counter and frequency divider counter, and can update the shadow register (when UDIS=0). The reset mode waveform in slave mode is as follows:

 **Figure 22-16 Reset mode waveform in slave mode**

2. **Gated mode:** TRGI level can control the operation and stop of the counter. Under the default effective level, the counter counts when the level is high, and stops counting (not reset) when the level is low. In this mode, CEN needs to be set by software. The waveform of the gated mode in slave mode is as follows:



**Figure 22-17 Gating mode waveform in slave mode**

1. Trigger mode: The rising edge of TRGI can control the counter to start counting, but cannot control whether the counter stops. In this mode, CEN does not need to be set by software. The waveform of the trigger mode in slave mode is as follows:



**Figure 22-18 Trigger mode waveform in slave mode**

4. Clock mode (i.e. external clock mode 1): The rising edge of TRGI is used as the count enable of the counter to control the count. At this time, the frequency division circuit is still valid.

In slave mode, the rising edge of TRGI will set the TIF flag bit, and if the corresponding interrupt or DMA mask bit is enabled, an interrupt or DMA request will be generated. However, the gated mode is somewhat special. In this mode, in addition to the rising edge, the falling edge can also set TIF.

In addition, when using GPTIMER in cascade, it is necessary to ensure that the master and slave clocks have the same frequency and phase, otherwise unknown errors will occur.

##### 22.11 Master mode control

GPTIMER can also be used as a master mode to control other GPTIMERs or ADC and DAC by generating a trigger output signal (TRGO). The source of the TRGO signal can be configured by software as follows:

* MMS=3’b000: Reset mode, in which case the UG flag will be output as a TRGO signal to the external slave.
* MMS=3’b001: Enable mode, the count enable of the counter will be output as the TRGO signal to the external slave. If the current GPTIMER is also in the slave gating mode, the signal is the gating signal, otherwise CEN is directly output as the TRGO signal.
* MMS=3’b010: Update mode, in which case the update event is output as the TRGO signal.
* MMS=3’b011: Channel 0 compare pulse mode. If CC0IF is set, a pulse is output as the TRGO signal, regardless of whether CC0IF is already set.
* MMS=3’b100: Comparison mode 1, in this case OC0REF is output as the TRGO signal.
* MMS=3’b101: Comparison mode 2, in this case OC1REF is output as the TRGO signal.
* MMS=3’b110: Comparison mode 3, in this case OC2REF is output as the TRGO signal.
* MMS=3’b111: Comparison mode 4, in this case OC3REF is output as the TRGO signal.

***Note:*** *The signal OCxREF output by the last 4 modes is not the final channel output, but an internal signal.*

When GPTIMER is configured as the master enable mode, there is a special application, which is to start the master and slave counters synchronously. However, because the master's CEN is output as TRGO to the slave and enables the slave counter, it takes two clock delays (assuming that the master and slave clocks are of the same frequency and phase), so when using this function, the host's CEN signal will be delayed by 2 clock cycles using two-level registers to ensure synchronization. This function can be enabled by software configuration (MSM).

#### 22.12 Output control

GPTIMER0 and GPTIMER1 have 4 output channels, GPTIMER2 and GPTIMER3 have 2 output channels, and have corresponding output enable signals. Channel output is only valid when CCxE is set. At this time, the output polarity can be controlled by CCxP. The output polarity refers to whether the output valid level is high or low. The output enable signal is high-effective, that is, it is effective when CCxE is set. At the same time, it is necessary to ensure that the channel is correctly configured as the output mode, and the output mode is configured by CCxS.

##### 22.13 Channel remapping

Channel remapping is to map the input signal of GPTIMER channel or external trigger channel ETR from other external or internal signals. GPTIMER0's ETR channel, channel 0 and channel 3 support remapping, GPTIMER1's channel 2 supports remapping, GPTIMER2's ETR channel, channel 0 and channel 1 support remapping, GPTIMER3's ETR channel and channel 0 support remapping.

#### 22.14 Debug mode control

GPTIMER can be configured by software to stop counting in debug mode. If this function is enabled, GPTIMER will be stopped (the counter will not be initialized) when entering the system debug mode.

#### 22.15 DMA control

GPTIMER has a total of 6 DMA request sources, named update event (UIF), 4 channel events (capture event, compare Match) (CCxIF) and trigger event (TIF), whether to enable the corresponding DMA request can be configured by independent mask bits. For channel event DMA, the DMA request source of the channel can be configured by software (CCDS bit). If CCDS=0, each channel DMA requests come from events of each channel, such as capture and comparison match events; if CCDS=1, then DMA requests of each channel All come from update events, and channel events will be blocked.

Each DMA request is set only when there is no corresponding acknowledge signal, DMA enable is turned on and a DMA event occurs. When the DMA request is set, the acknowledge signal can clear the DMA request, otherwise the DMA request will remain set.

In addition to conventional DMA operations, GPTIMER also supports burst functions, that is, a DMA request can continuously read and write multiple internal registers. The DBL bit can select the burst length, up to 18, and the DBA can select the starting address of the burst. The address of the DMAR register can be used as the target address or source address of the DMA (DMA does not need to be set to increment each time). When a DMA request is set, GPTIMER calculates the actual address of each read and write operation based on the values ​​of DBL and DBA. The actual address calculation method is: CR1 + (DBA + index) x 4, where the value of index is 0 to DBL.

#### ***Note:*** *There is a reserved register address in the middle of the register group, which will also be included in the burst operation of DMA. When actually using it, please pay attention to the configured length. For example, if the starting address is the ARR register (0x2C), and the DBL is configured as 5’b00010 (3 bursts), the three registers actually operated by DMA are 0x2C, 0x30, and 0x34, of which 0x30 is a reserved register, so it cannot be written and the read value is always 0.*

#### 22.16 Interrupt

GPTIMER has 6 interrupt sources, named update event (UIF), 4-channel event (capture event, compare match) (CCxIF) and trigger event (TIF). Each interrupt can be enabled or not by an independent interrupt mask bit. The interrupt flag bit and the corresponding mask bit are in an AND relationship, and the interrupts are in an OR relationship. The interrupt signals of GPTIMER are as follows:

**Table 22-7 GPTIMER interrupt signals**

|  |  |
| --- | --- |
| Interrupt | Description |
| Trigger event interrupt | Interrupt when the trigger source generates an event |
| Channel 3 event interrupt | Channel 3 interrupt when a capture or comparison event occurs |
| Channel 2 event interrupt | Channel 2 interrupt when a capture or comparison event occurs |
| Channel 1 event interrupt | Channel 1 interrupt when a capture or comparison event occurs |
| Channel 0 event interrupt | Channel 0 interrupt when a capture or comparison event occurs |
| Update event interrupt | Interrupt when an update event occurs |

The above interrupts are enabled by configuring the TIE, CC3IE, CC2IE, CC1IE, CC0IE, and UIE bits of the DIER register respectively.

#### 22.17 GPTIMER Registers

GPTIMER0 Base Address: 0x4000A000

GPTIMER1 Base Address: 0x4001A000

GPTIMER2 Base Address: 0x4000B000

GPTIMER3 Base Address: 0x4001B000

**Table 22-8 GPTIMER Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| GPTIM\_CR1 | 0x00 | Control Register 1 |
| GPTIM\_CR2 | 0x04 | Control Register 2 |
| GPTIM\_SMCR | 0x08 | Control Register from mode |
| GPTIM\_DIER | 0x0C | DMA/Interrupt Enable Register |
| GPTIM\_SR | 0x10 | Status Register |
| GPTIM\_EGR | 0x14 | Event Register |
| GPTIM\_CCMR1 | 0x18 | Capture/compare mode Register 1 |
| GPTIM\_CCMR2 | 0x1C | Capture/compare mode Register 2 |
| GPTIM\_CCER | 0x20 | Capture/compare Enable Register |
| GPTIM\_CNT | 0x24 | Counter Register |
| GPTIM\_PSC | 0x28 | Prescaler Register |
| GPTIM\_ARR | 0x2C | Counter auto-reload value Register |
| GPTIM\_CCR0 | 0x34 | Channel 0 capture/compare Register |
| GPTIM\_CCR1 | 0x38 | Channel 1 capture/compare Register |
| GPTIM\_CCR2 | 0x3C | Channel 2 capture/compare Register |
| GPTIM\_CCR3 | 0x40 | Channel 3 capture/compare Register |
| GPTIM\_DCR | 0x48 | DMA Control Register |
| GPTIM\_DMAR | 0x4C | DMA address Register |
| GPTIM\_OR | 0x50 | Channel remapping Register |

##### 22.17.1 GPTIM\_CR1

Offset: 0x000

Reset Value: 0x0000

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **15-10** | **9-8** | **7** | **6-5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | CKD | ARPE | CMS | DIR | OPM | URS | UDIS | CEN |
| r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 15-10 RESERVED:** Must be kept, and cannot be modified.

**Bits 9-8 CKD:** Sample clock divider.

* 00: fDTS = fpclk
* 01: fDTS = fpclk
* 10: fDTS = fpclk
* 11: fDTS = reserved

**Bit 7 ARPE:** Reload shadow register enable.

* 0: ARR shadow register disabled
* 1: ARR shadow register enabled

**Bits 6-5 CMS:** Intermediate counting mode selection.

* 00: edge-aligned counting mode, DIR controls up or down counting
* 01: center alignment mode 1. The output compare interrupt flag is only set during down counting
* 10: center alignment mode 2. The output compare interrupt flag is only set during upward counting
* 11: center alignment mode 3. The output compare interrupt flag is set during both up and down counting processes

**Bit 4 DIR:** Counting direction selection. Center alignment mode and encoding mode, this bit is controlled by hardware.

* 0: count up
* 1: count down

**Bit 3 OPM:** Single Pulse Mode Enable.

* 0: single pulse mode disabled
* 1: single pulse mode enabled, the counter stops counting at the next update event

**Bit 2 URS:** Update event source selection. This bit only affects the interrupt and DMA flag bit (UIF) and does not affect the internal logic.

* 0: counter overflow, UG bit, and trigger in slave reset mode can all set UIF
* 1: only counter overflow events can set UIF

**Bit 1 UDIS:** Update events disable.

* 0: Update event enabled, middle alignment mode 1. The output compare interrupt flag can generate updates only if it is set during the downward counting process event
* 1: The update event is disabled, the shadow register and UIF will not be updated, but at this time the counter and divider counter can still be set by UG Bit event initialization

**Bit 0 CEN:** Counter enable, CEN is set by hardware in trigger mode, and CEN is cleared by hardware in single pulse mode.

* 0: counter disabled
* 1: counter enabled

##### 22.17.2 GPTIM\_CR2

Offset: 0x004

Reset Value: 0x0000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **15-8** | **7** | **6-4** | **3** | **2-0** |
| RESERVED | TI0S | MMS | CCDS | RESERVED |
| r-0h | rw-0h | rw-0h | rw-0h | r-0h |

**Bits 15-8 RESERVED:** Must be kept, and cannot be modified.

**Bit 7 TI0S:** Channel 1 source XOR selection (this feature is only supported by timer0 and timer1).

* 0: channel 0 is mapped to channel 0 input
* 1: channel 0 is the XOR output of channels 0, 1, and 2

**Bits 6-4 MMS:** Master mode selection, configurable TRGO output.

* 000: reset mode, UG will be output as TRGO signal
* 001: enable mode, CNT\_EN (not CEN) will be output as TRGO signal
* 010: update mode, update events (internal signals) will be output as TRGO signals
* 011: compare pulse mode, TRGO will output a pulse every time CC0IF is about to be set, even if CC0IF has been set
* 100: compare mode, OC0REF (internal signal) is output as TRGO signal
* 101: compare mode, OC1REF (internal signal) is output as TRGO signal
* 110: compare mode, OC2REF (internal signal) is output as TRGO signal
* 111: compare mode, OC3REF (internal signal) is output as TRGO signal

**Bit 3 CCDS:** Channel DMA request source selection (this feature is only supported by gptimer0 and gptimer1).

* 0: DMA requests of each channel (excluding update event requests and trigger event requests) are generated by channel events (capture, comparison)
* 1: DMA requests of each channel (excluding update event requests and trigger event requests) are generated by update events

**Bits 2-0 RESERVED:** Must be kept, and cannot be modified.

##### 22.17.3 GPTIM\_SMCR

Offset: 0x008

Reset Value: 0x0000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **15** | **14** | **13-12** | **11-8** | **7** | **6-4** | **3** | **2-0** |
| ETP | ECE | ETPS | ETF | MSM | TS | RESERVED | SMS |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | r-0h | rw-0h |

**Bit 15 ETP:** External trigger polarity selection (it is best not to select the mode (SMS) when configuring the polarity, in order to prevent the internal signal from flipping and triggering unknown errors).

* 0: external trigger input not inverted
* 1: external trigger input inverted

**Bit 14 ECE:** External clock mode 2 enable.

* 0: external clock mode 2 disabled
* 1: external clock mode 2 enabled

**Bit 13-12 ETPS:** External trigger input frequency division (this frequency division is mainly used for 50% duty cycle frequency reduction, such as 24M signal divided by 2 to 12M, the level is doubled).

* 00: no frequency division
* 01: frequency divided by 2
* 10: frequency divided by 4
* 11: frequency divided by 8

**Bits 11-8 ETF:** External trigger input filter configuration.

* 0000: filter disabled
* 0001: filter sampling frequency fsampling=fpclk, filter length N=2
* 0010: filter sampling frequency fsampling=fpclk, filter length N=4
* 0011: filter sampling frequency fsampling=fpclk, filter length N=8
* 0100: filter sampling frequency fsampling=fDTS/2, filter length N=6
* 0101: filter sampling frequency fsampling=fDTS/2, filter length N=8
* 0110: filter sampling frequency fsampling=fDTS/4, filter length N=6
* 0111: Filter sampling frequency fsampling=fDTS/4, filter length N=8
* 1000: filter sampling frequency fsampling=fDTS/8, filter length N=6
* 1001: filter sampling frequency fsampling=fDTS/8, filter length N=8
* 1010: filter sampling frequency fsampling=fDTS/16, filter length N=5
* 1011: Filter sampling frequency fsampling=fDTS/16, filter length N=6
* 1100: filter sampling frequency fsampling=fDTS/16, filter length N=8
* 1101: filter sampling frequency fsampling=fDTS/32, filter length N=5
* 1110: filter sampling frequency fsampling=fDTS/32, filter length N=6
* 1111: filter sampling frequency fsampling=fDTS/32, filter length N=8

**Bit 7 MSM:** Master-slave mode synchronization (when using this function, it is necessary to ensure that the clocks of the two timers are in the same frequency and phase).

* 0: no action
* 1: the TRGI trigger input will be delayed to start counting at the same time as the slave counter.

**Bit 6-4 TS:** Trigger source selection, select the source of TRGI (SMS must be cleared when configuring this bit).

* 000: ITR0
* 001: ITR1
* 010: ITR2 (timer2 and timer3 do not have this channel)
* 011: reserved
* 100: channel 0 edge detection output
* 101: channel 0 filter output
* 110: channel 1 filter output
* 111: channel trigger input

**Bit 3 RESERVED:** Must be kept, and cannot be modified.

**Bit 2-0 SMS:** Slave mode selection (it is best to configure the channel parameters before selecting the mode to prevent internal signal flipping from triggering unknown errors).

* 000: slave mode disabled
* 001: coding mode 1, the counter only counts on the edge of channel 1
* 010: coding mode 2, the counter only counts on the edge of channel 0
* 011: coding mode 3, the counter counts on the edges of channels 0 and 1
* 100: reset mode, the rising edge of TRGI will reset the counter
* 101: gating mode, the counter only counts during TRGI high level
* 110: trigger mode, the counter will start counting on the rising edge of TRGI. This mode only controls the start of counting.
* 111: external clock mode 1, the rising edge of TRGI is used as the counter counting clock

##### 22.17.4 GPTIM\_DIER

Offset: 0x00C

Reset Value: 0x0000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **15** | **14** | **13** | **12** | **11** | **10** | **9** | **8** |
| RESERVED | TDE | RESERVED | CC3DE | CC2DE | CC1DE | CC0DE | UDE |
| r-0h | rw-0h | r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |
| **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | TIE | RESERVED | CC3IE | CC2IE | CC1IE | CC0IE | UIE |
| r-0h | rw-0h | r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bit 15 RESERVED:** Must be kept, and cannot be modified.

**Bit 14 TDE:** Trigger event DMA request enable.

* 0: trigger event DMA request disabled
* 1: trigger event DMA request enabled

**Bit 13 RESERVED:** Must be kept, and cannot be modified.

**Bit 12 CC3DE:** Channel 3 event DMA request enable.

* 0: channel 3 event DMA request disabled
* 1: channel 3 event DMA request enabled

**Bit 11 CC2DE:** Channel 2 event DMA request enable.

* 0: channel 2 event DMA request disabled
* 1: channel 2 event DMA request enabled

**Bit 10 CC1DE:** Channel 1 event DMA request enable.

* 0: channel 1 event DMA request disabled
* 1: channel 1 event DMA request enabled

**Bit 9 CC0DE:** Channel 0 event DMA request enable.

* 0: channel 0 event DMA request disabled
* 1: channel 0 event DMA request enabled

**Bit 8 UDE:** Update event DMA request enable.

* 0: update event DMA request disabled
* 1: update event DMA request enabled

**Bit 7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 TIE:** Trigger event interrupt enable.

* 0: trigger event interrupt disabled
* 1: trigger event interrupt enabled

**Bit 5 RESERVED:** Must be kept, and cannot be modified.

**Bit 4 CC3IE:** Channel 3 event interrupt enable.

* 0: channel 3 event interrupt disabled
* 1: channel 3 event interrupt enabled

**Bit 3 CC2IE:** Channel 2 event interrupt enable.

* 0: channel 2 event interrupt disabled
* 1: channel 2 event interrupt enabled

**Bit 2 CC1IE:** Channel 1 event interrupt request enable.

* 0: channel 1 event interrupt disabled
* 1: channel 1 event interrupt enabled

**Bit 1 CC0IE:** Channel 0 event interrupt enable.

* 0: channel 0 event interrupt disabled
* 1: channel 0 event interrupt enabled

**Bit 0 UIE:** Update event interrupt enable.

* 0: update event interrupt disabled
* 1: update event interrupt enabled

##### 22.17.5 GPTIM\_SR

Offset: 0x010

Reset Value: 0x0000

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **15-13** | | **12** | **11** | **10** | **9** | **8-7** |
| RESERVED | | CC3OF | CC2OF | CC1OF | CC0OF | RESERVED |
| r-0h | | rw-0h | rw-0h | rw-0h | rw-0h | r-0h |
| **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| TIF | RESERVED | CC3IF | CC2IF | CC1IF | CC0IF | UIF |
| rw-0h | r-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 15-13 RESERVED:** Must be kept, and cannot be modified.

**Bit 12 CC3OF:** Channel 3 overcapture flag (cleared by writing 0).

* 0: no overcapture
* 1: at least 1 overcapture occurred

**Bit 11 CC2OF:** Channel 2 overcapture flag (cleared by writing 0).

* 0: no overcapture
* 1: at least 1 overcapture occurred

**Bit 10 CC1OF:** Channel 1 overcapture flag (cleared by writing 0).

* 0: no overcapture
* 1: at least 1 overcapture occurred

**Bit 9 CC0OF:** Channel 0 overcapture flag (cleared by writing 0).

* 0: no overcapture
* 1: at least 1 overcapture occurred

**Bits 8-7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 TIF:** Trigger event interrupt flag (cleared by writing 0).

* 0: no event
* 1: trigger event occurs

**Bit 5 RESERVED:** Must be kept, and cannot be modified.

**Bit 4 CC3IF:** Channel 3 Capture/Compare Event Flag (Compare mode: write 0 to clear; Capture mode: read the ccrx register or write 0 both can be cleared).

* 0: no event
* 1: capture or compare event occurrs

**Bit 3 CC3IF:** Channel 2 Capture/Compare Event Flag (Compare mode: write 0 to clear; Capture mode: read the ccrx register or write 0 both can be cleared).

* 0: no event
* 1: capture or compare event occurrs

**Bit 2 CC3IF:** Channel 1 Capture/Compare Event Flag (Compare mode: write 0 to clear; Capture mode: read the ccrx register or write 0 both can be cleared).

* 0: no event
* 1: capture or compare event occurrs

**Bit 1 CC3IF:** Channel 0 capture/compare event flag (compare mode: write 0 to clear; capture mode: read ccrx register or write 0 both can be cleared).

* 0: no event
* 1: capture or compare event occurrs

**Bit 0 UIF:** Update event flag (read SR or write 0 to clear this bit).

* 0: no event
* 1: update event occurs

##### 22.17.6 GPTIM\_EGR

Offset: 0x014

Reset Value: 0x0000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **15-7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| RESERVED | TG | RESERVED | CC3G | CC2G | CC1G | CC0G | UG |
| r-0h | w-0h | r-0h | w-0h | w-0h | w-0h | w-0h | w-0h |

**Bits 15-7 RESERVED:** Must be kept, and cannot be modified.

**Bit 6 TG:** generate trigger.

* 0: no action
* 1: generate a trigger event, TIF is set

**Bit 5 RESERVED:** Must be kept, and cannot be modified.

**Bit 4 CC3G:** generate Channel 3 event

* 0: no action
* 1: generate capture action in input mode and comparison action in output mode. CC3IF is set in both modes.

**Bit 3 CC2G:** generate Channel 2 event

* 0: no action

1: generate capture action in input mode and comparison action in output mode. CC2IF is set in both modes.

**Bit 2 CC1G:** generate Channel 1 event

* 0: no action

1: generate capture action in input mode and comparison action in output mode. CC1IF is set in both modes.

**Bit 1 CC0G:** generate Channel 0 event

* 0: no action

1: generate capture action in input mode and comparison action in output mode. CC0IF is set in both modes.

**Bit 0 UG:** generate update event

* 0: no action
* 1: generate update event

##### 22.17.7 GPTIM\_CCMR1

Offset: 0x018

Reset Value: 0x0000

**Output mode structure:**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **15** | **14-12** | **11** | **10** | **9-8** | **7** | **6-4** | **3** | **2** | **1-0** |
| OC1CE | OC1M | OC1PE | OC1FE | CC1S | OC0CE | OC0M | OC0PE | OC0FE | CC0S |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bit 15 OC1CE:** Channel 1 Output Compare Clear Enable.

* 0: clear function disabled
* 1: clear function enabled, ETRF high level can clear the channel output

**Bits 14-12 OC1M:** Channel 1 Output Compare Mode Select.

* 000: freeze mode, channel output does not change with the comparison result
* 001: valid mode, channel output valid level after matching
* 010: failure mode, channel output failure level after matching
* 011: flip mode, the channel output will be flipped after matching
* 100: forced valid mode. After selecting this mode, the valid level will be output directly.
* 101: forced failure mode. After selecting this mode, the failure level will be output directly.
* 110: PWM1 mode. In this mode, when counting upward, the channel outputs a valid level when CNT<CCR, otherwise the output level is invalid; When counting down, the channel outputs an invalid level when CNT>CCR, otherwise it outputs a valid level (when counting up, if CCRx>ARR, OCxREF always outputs high level. If CCRx==0, OCxREF always outputs low level; when counting down, if CCRx>ARR, OCxREF always outputs high level, and 0% PWM is not supported at this time)
* 111: PWM2 mode. In this mode, when counting upward, when CNT<CCR, the channel outputs an invalid level, otherwise it outputs a valid level; When counting down, when CNT>CCR, the channel outputs a valid level, otherwise it outputs an invalid level (0% and 100% waveforms are the same as PWM1)

**Bit 11 OC1PE:** Channel 1 Output Compare Shadow Register Enable.

* 0: shadow register disabled
* 1: shadow register enabled

**Bit 10 OC1FE:** Channel 1 fast output enable.

* 0: fast mode disabled, the output only changes when matching
* 1: fast mode enabled. The trigger input is equivalent to a matching event, which directly affects the channel output and is not affected by the comparison between the counter and CCR.

**Bits 9-8 CC1S:** Capture/Compare Select.

* 00: channel is configured in output mode
* 01: channel is configured in input mode, and the capture channel input is mapped to channel 1
* 10: channel is configured in input mode, and the capture channel input is mapped to channel 0
* 11: channel is configured in input mode, and the capture channel input is mapped to the trigger input TRC

**Bit 7 OC0CE:** Channel 0 output compare clear enable.

* 0: clear function disabled
* 1: clear function enabled, ETRF high level can clear the channel output

**Bits 6-4 OC0M:** Channel 0 output compare mode selection.

* 000: Freeze mode, channel output does not change with the comparison result
* 001: Valid mode, channel output valid level after matching
* 010: Failure mode, channel output failure level after matching
* 011: Flip mode, the channel output will be flipped after matching
* 100: Forced valid mode. After selecting this mode, the valid level will be output directly.
* 101: Forced failure mode. After selecting this mode, the failure level will be output directly.
* 110: PWM1 mode. In this mode, when counting upward, the channel outputs a valid level when CNT<CCR, otherwise the output level is invalid; When counting down, the channel outputs an invalid level when CNT>CCR, otherwise it outputs a valid level (when counting up, if CCRx>ARR, OCxREF always outputs high level. If CCRx==0, OCxREF always outputs low level; when counting down, if CCRx>ARR, OCxREF always outputs high level, and 0% PWM is not supported at this time)
* 111: PWM2 mode. In this mode, when counting upward, when CNT<CCR, the channel outputs an invalid level, otherwise it outputs a valid level; When counting down, when CNT>CCR, the channel outputs a valid level, otherwise it outputs an invalid level (0% and 100% waveforms are the same as PWM1)

**Bit 3 OC0PE:** Channel 0 output compare shadow register enable.

* 0: Disable shadow register
* 1: Enable shadow register

**Bit 2 OC0FE:** Channel 0 fast output enable.

* 0: Disable fast mode, the output only changes when matching
* 1: Enable fast mode. The trigger input is equivalent to a matching event, which directly affects the channel output and is not affected by the comparison between the counter and CCR.

**Bits 1-0 CC0S:** Capture Compare Select.

* 00: The channel is configured as output mode
* 01: The channel is configured in input mode, and the capture channel input is mapped to channel 0
* 10: The channel is configured in input mode, and the capture channel input is mapped to channel 1
* 11: The channel is configured in input mode, and the capture channel input is mapped to the trigger input TRC

**Input mode structure:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **15-12** | **11-10** | **9-8** | **7-4** | **3-2** | **1-0** |
| IC1F | IC1PSC | CC1S | IC0F | IC0PSC | CC0S |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bit 15-12 IC1F:** Channel 1 input filter configuration (CCxS!=0x0 needs to be configured for this function to take effect).

* 0000: filter disabled
* 0001: filter sampling frequency fsampling=fpclk, filter length N=2
* 0010: filter sampling frequency fsampling=fpclk, filter length N=4
* 0011: filter sampling frequency fsampling=fpclk, filter length N=8
* 0100: filter sampling frequency fsampling=fDTS/2, filter length N=6
* 0101: filter sampling frequency fsampling=fDTS/2, filter length N=8
* 0110: filter sampling frequency fsampling=fDTS/4, filter length N=6
* 0111: filter sampling frequency fsampling=fDTS/4, filter length N=8
* 1000: filter sampling frequency fsampling=fDTS/8, filter length N=6
* 1001: filter sampling frequency fsampling=fDTS/8, filter length N=8
* 1010: filter sampling frequency fsampling=fDTS/16, filter length N=5
* 1011: filter sampling frequency fsampling=fDTS/16, filter length N=6
* 1100: filter sampling frequency fsampling=fDTS/16, filter length N=8
* 1101: filter sampling frequency fsampling=fDTS/32, filter length N=5
* 1110: filter sampling frequency fsampling=fDTS/32, filter length N=6
* 1111: filter sampling frequency fsampling=fDTS/32, filter length N=8

**Bits 11-10 IC1PSC:** Channel 1 frequency division (CCxS!=0x0 needs to be configured for this function to take effect).

* 00: no frequency division
* 01: frequency divided by 2
* 10: frequency divided by 4
* 11: frequency divided by 8

**Bits 9-8 CC1S:** Capture/Compare Select.

* 00: channel is configured in output mode
* 01: channel is configured in input mode, and the capture channel input is mapped to channel 1
* 10: channel is configured in input mode, and the capture channel input is mapped to channel 0
* 11: channel is configured in input mode, and the capture channel input is mapped to the trigger input TRC

**Bit 7-4 IC0F:** Channel 0 input filter configuration (CCxS!=0x0 needs to be configured for this function to take effect).

* 0000: Disable filter
* 0001: Filter sampling frequency fsampling=fpclk, filter length N=2
* 0010: Filter sampling frequency fsampling=fpclk, filter length N=4
* 0011: Filter sampling frequency fsampling=fpclk, filter length N=8
* 0100: Filter sampling frequency fsampling=fDTS/2, filter length N=6
* 0101: Filter sampling frequency fsampling=fDTS/2, filter length N=8
* 0110: Filter sampling frequency fsampling=fDTS/4, filter length N=6
* 0111: Filter sampling frequency fsampling=fDTS/4, filter length N=8
* 1000: filter sampling frequency fsampling=fDTS/8, filter length N=6
* 1001: Filter sampling frequency fsampling=fDTS/8, filter length N=8
* 1010: Filter sampling frequency fsampling=fDTS/16, filter length N=5
* 1011: Filter sampling frequency fsampling=fDTS/16, filter length N=6
* 1100: filter sampling frequency fsampling=fDTS/16, filter length N=8
* 1101: Filter sampling frequency fsampling=fDTS/32, filter length N=5
* 1110: Filter sampling frequency fsampling=fDTS/32, filter length N=6
* 1111: Filter sampling frequency fsampling=fDTS/32, filter length N=8

**Bit 3-2 IC0PSC:** Channel 0 divider (CCxS!=0x0 needs to be configured for this function to take effect).

* 00: No frequency division
* 01: 2 frequency division
* 10: 4 frequency division
* 11: 8 frequency division

**Bits 1-0 CC0S:** Capture Compare Select.

* 00: The channel is configured as output mode
* 01: The channel is configured in input mode, and the capture channel input is mapped to channel 0
* 10: The channel is configured in input mode, and the capture channel input is mapped to channel 1
* 11: The channel is configured in input mode, and the capture channel input is mapped to the trigger input TRC

##### 22.17.8 GPTIM\_CCMR2

Offset: 0x01C

Reset Value: 0x0000

**Output mode structure:**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **15** | **14-12** | **11** | **10** | **9-8** | **7** | **6-4** | **3** | **2** | **1-0** |
| OC3CE | OC3M | OC3PE | OC3FE | CC3S | OC2CE | OC2M | OC2PE | OC2FE | CC2S |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bit 15 OC3CE:** Channel 3 Output Compare Clear Enable.

* 0: Disable clearing function
* 1: Enable the clear function, ETRF high level can clear the channel output

**Bits 14-12 OC3M:** Channel 3 Output Compare Mode Select.

* 000: Freeze mode, channel output does not change with the comparison result
* 001: Valid mode, channel output valid level after matching
* 010: Failure mode, channel output failure level after matching
* 011: Flip mode, the channel output will be flipped after matching
* 100: Forced valid mode. After selecting this mode, the valid level will be output directly.
* 101: Forced failure mode. After selecting this mode, the failure level will be output directly.
* 110: PWM1 mode. In this mode, when counting upward, the channel outputs a valid level when CNT<CCR, otherwise the output level is invalid; When counting down, the channel outputs an invalid level when CNT>CCR, otherwise it outputs a valid level (when counting up, if CCRx>ARR, OCxREF always outputs high level. If CCRx==0, OCxREF always outputs low level; when counting down, if CCRx>ARR, OCxREF always outputs high level, and 0% PWM is not supported at this time)
* 111: PWM2 mode. In this mode, when counting upward, when CNT<CCR, the channel outputs an invalid level, otherwise it outputs a valid level; When counting down, when CNT>CCR, the channel outputs a valid level, otherwise it outputs an invalid level (0% and 100% waveforms are the same as PWM1)

**Bit 11 OC3PE:** Channel 3 Output Compare Shadow Register Enable.

* 0: Disable shadow register
* 1: Enable shadow register

**Bit 10 OC3FE:** Channel 3 fast output enable.

* 0: Disable fast mode, the output only changes when matching
* 1: Enable fast mode. The trigger input is equivalent to a matching event, which directly affects the channel output and is not affected by the comparison between the counter and CCR.

**Bits 9-8 CC3S:** Capture Compare Select.

* 00: The channel is configured as output mode
* 01: The channel is configured in input mode, and the capture channel input is mapped to channel 3
* 10: The channel is configured in input mode, and the capture channel input is mapped to channel 2
* 11: The channel is configured in input mode, and the capture channel input is mapped to the trigger input TRC

**Bit 7 OC2CE:** Channel 2 Output Compare Clear Enable.

* 0: Disable clearing function
* 1: Enable the clear function, ETRF high level can clear the channel output

**Bits 6-4 OC2M:** Channel 2 Output Compare Mode Select.

* 000: Freeze mode, channel output does not change with the comparison result
* 001: Valid mode, channel output valid level after matching
* 010: Failure mode, channel output failure level after matching
* 011: Flip mode, the channel output will be flipped after matching
* 100: Forced valid mode. After selecting this mode, the valid level will be output directly.
* 101: Forced failure mode. After selecting this mode, the failure level will be output directly.
* 110: PWM1 mode. In this mode, when counting upward, the channel outputs a valid level when CNT<CCR, otherwise the output level is invalid; When counting down, the channel outputs an invalid level when CNT>CCR, otherwise it outputs a valid level (when counting up, if CCRx>ARR, OCxREF always outputs high level. If CCRx==0, OCxREF always outputs low level; when counting down, if CCRx>ARR, OCxREF always outputs high level, and 0% PWM is not supported at this time)
* 111: PWM2 mode. In this mode, when counting upward, when CNT<CCR, the channel outputs an invalid level, otherwise it outputs a valid level; When counting down, when CNT>CCR, the channel outputs a valid level, otherwise it outputs an invalid level (0% and 100% waveforms are the same as PWM1)

**Bit 3 OC2PE:** Channel 2 Output Compare Shadow Register Enable.

* 0: Disable shadow register
* 1: Enable shadow register

**Bit 2 OC2FE:** Channel 2 fast output enable.

* 0: Disable fast mode, the output only changes when matching
* 1: Enable fast mode. The trigger input is equivalent to a matching event, which directly affects the channel output and is not affected by the comparison between the counter and CCR.

**Bits 1-0 CC2S:** Capture Compare Select.

* 00: The channel is configured as output mode
* 01: The channel is configured in input mode, and the capture channel input is mapped to channel 2
* 10: The channel is configured in input mode, and the capture channel input is mapped to channel 3
* 11: The channel is configured in input mode, and the capture channel input is mapped to the trigger input TRC

**The structure of the input mode is as follows:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **15-12** | **11-10** | **9-8** | **7-4** | **3-2** | **1-0** |
| IC3F | IC3PSC | CC3S | IC2F | IC2PSC | CC2S |
| rw-0h | rw-0h | rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 15-12 IC3F:** Channel 3 input filter configuration (CCxS!=0x0 needs to be configured for this function to take effect).

* 0000: Disable filter
* 0001: Filter sampling frequency fsampling=fpclk, filter length N=2
* 0010: Filter sampling frequency fsampling=fpclk, filter length N=4
* 0011: Filter sampling frequency fsampling=fpclk, filter length N=8
* 0100: Filter sampling frequency fsampling=fDTS/2, filter length N=6
* 0101: Filter sampling frequency fsampling=fDTS/2, filter length N=8
* 0110: Filter sampling frequency fsampling=fDTS/4, filter length N=6
* 0111: Filter sampling frequency fsampling=fDTS/4, filter length N=8
* 1000: filter sampling frequency fsampling=fDTS/8, filter length N=6
* 1001: Filter sampling frequency fsampling=fDTS/8, filter length N=8
* 1010: Filter sampling frequency fsampling=fDTS/16, filter length N=5 (not finished, continued on next page)
* 1011: Filter sampling frequency fsampling=fDTS/16, filter length N=6
* 1100: filter sampling frequency fsampling=fDTS/16, filter length N=8
* 1101: Filter sampling frequency fsampling=fDTS/32, filter length N=5
* 1110: Filter sampling frequency fsampling=fDTS/32, filter length N=6
* 1111: Filter sampling frequency fsampling=fDTS/32, filter length N=8

**Bits 11-10 IC3PSC:** Channel 3 divider (CCxS!=0x0 needs to be configured for this function to take effect).

* 00: No frequency division
* 01: 2 frequency division
* 10: 4 frequency division
* 11: 8 frequency division

**Bits 9-8 CC3S:** Capture Compare Select.

* 00: The channel is configured as output mode
* 01: The channel is configured in input mode, and the capture channel input is mapped to channel 3
* 10: The channel is configured in input mode, and the capture channel input is mapped to channel 2
* 11: The channel is configured in input mode, and the capture channel input is mapped to the trigger input TRC

**Bits 7-4 IC2F:** Channel 2 input filter configuration (CCxS!=0x0 needs to be configured for this function to take effect).

* 0000: Disable filter
* 0001: Filter sampling frequency fsampling=fpclk, filter length N=2
* 0010: Filter sampling frequency fsampling=fpclk, filter length N=4
* 0011: Filter sampling frequency fsampling=fpclk, filter length N=8
* 0100: Filter sampling frequency fsampling=fDTS/2, filter length N=6
* 0101: Filter sampling frequency fsampling=fDTS/2, filter length N=8
* 0110: Filter sampling frequency fsampling=fDTS/4, filter length N=6
* 0111: Filter sampling frequency fsampling=fDTS/4, filter length N=8
* 1000: filter sampling frequency fsampling=fDTS/8, filter length N=6
* 1001: Filter sampling frequency fsampling=fDTS/8, filter length N=8
* 1010: Filter sampling frequency fsampling=fDTS/16, filter length N=5
* 1011: Filter sampling frequency fsampling=fDTS/16, filter length N=6
* 1100: filter sampling frequency fsampling=fDTS/16, filter length N=8
* 1101: Filter sampling frequency fsampling=fDTS/32, filter length N=5
* 1110: Filter sampling frequency fsampling=fDTS/32, filter length N=6
* 1111: Filter sampling frequency fsampling=fDTS/32, filter length N=8

**Bit 3-2 IC2PSC:** Channel 2 frequency division (CCxS!=0x0 needs to be configured for this function to take effect).

* 00: No frequency division
* 01: 2 frequency division
* 10: 4 frequency division
* 11: 8 frequency division

**Bits 1-0 CC2S:** Capture Compare Select.

* 00: The channel is configured as output mode
* 01: The channel is configured in input mode, and the capture channel input is mapped to channel 2
* 10: The channel is configured in input mode, and the capture channel input is mapped to channel 3
* 11: The channel is configured in input mode, and the capture channel input is mapped to the trigger input TRC

##### 22.17.9 GPTIM\_CCER

Offset: 0x020

Reset Value: 0x0000

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **15** | **14** | **13** | **12** | **11** | **10** | **9** | **8** |
| CC3NP | RESERVED | CC3P | CC3E | CC2NP | RESERVED | CC2P | CC2E |
| rw-0h | r-0h | rw-0h | rw-0h | rw-0h | r-0h | rw-0h | rw-0h |
| **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| CC1NP | RESERVED | CC1P | CC1E | CC0NP | RESERVED | CC0P | CC0E |
| rw-0h | r-0h | rw-0h | rw-0h | rw-0h | r-0h | rw-0h | rw-0h |

**Bit 15 CC3NP:** Output reverse polarity, this bit must be set to 0 in output mode, see CC3P in input mode.

**Bit 14 RESERVED:** Must be kept, and cannot be modified.

**Bit 13 CC3P:** Output polarity, must work together with CC3NP (it is best to configure the polarity before mode selection to prevent internal signal inversion. Redirect triggers an unknown error).

**Output mode:**

* 0: high level output polarity
* 1: low level output polarity

**Input mode, {CC3NP, CC3P}:**

* 00: channel input active rising edge is active (capture, trigger, reset, clock mode), high level is active (gating, encoding mode)
* 01: channel input falling edge is active (capture, trigger, reset, clock mode), low level is active (gating, encoding mode)
* 10: reserved
* 11: both rising and falling edges of channel input are active (capture, trigger, reset, clock mode), high level is active (gating, encoding model)

**Bit 12 CC3E:** Channel enable.

**Input mode:**

* 0: capture disabled
* 1: capture enabled

**Output mode:**

* 0: output disabled
* 1: output enabled

**Bit 11 CC2NP:** Output reverse polarity, this bit must be set to 0 in output mode, see CC2P in input mode.

**Bit 10 RESERVED:** Must be kept, and cannot be modified.

**Bit 9 CC2P:** Output polarity, must work together with CC2NP (it is best to configure the polarity before mode selection to prevent internal signal flipping triggers an unknown error).

**Output mode:**

* 0: Output valid polarity bit high level
* 1: Output valid polarity bit low level

**Input mode, {CC2NP, CC2P}:**

* 00: Channel input rising edge is valid (capture, trigger, reset, clock mode), high level is valid (gating, encoding mode)
* 01: Channel input falling edge is valid (capture, trigger, reset, clock mode), low level is valid (gating, encoding mode)
* 10: Reserved
* 11: Both rising and falling edges of channel input are valid (capture, trigger, reset, clock mode), high level is valid (gating, encoding model)

**Bit 8 CC2E:** Channel enable.

Input mode:

* 0: Disable capture
* 1: Enable capture

Output mode:

* 0: Disable output
* 1: Enable output

**Bit 7 CC1NP:** Output reverse polarity, this bit must be set to 0 in output mode, see CC1P in input mode.

**Bit 6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 CC1P:** Output polarity, must work together with CC3NP (it is best to configure the polarity before mode selection to prevent internal signal flipping triggers an unknown error).

**Output mode:**

* 0: Output valid polarity bit high level
* 1: Output valid polarity bit low level

**Input mode, {CC1NP, CC1P}:**

* 00: Channel input rising edge is valid (capture, trigger, reset, clock mode), high level is valid (gating, encoding mode)
* 01: Channel input falling edge is valid (capture, trigger, reset, clock mode), low level is valid (gating, encoding mode)
* 10: Reserved
* 11: Both rising and falling edges of channel input are valid (capture, trigger, reset, clock mode), high level is valid (gating, encoding model)

**Bit 4 CC1E:** Channel enable.

**Input mode:**

* 0: Disable capture
* 1: Enable capture

**Output mode:**

* 0: Disable output
* 1: Enable output

**Bit 3 CC0NP:** Output reverse polarity. This bit must be set to 0 in output mode. Refer to CC0P in input mode.

**Bit 2 RESERVED:** Must be kept, and cannot be modified.

**Bit 1 CC0P:** Output polarity, must work together with CC0NP (it is best to configure the polarity before mode selection to prevent internal signal inversion triggers an unknown error).

**Output mode:**

* 0: Output valid polarity bit high level
* 1: Output valid polarity bit low level

**Input mode, {CC0NP, CC0P}:**

* 00: Channel input rising edge is valid (capture, trigger, reset, clock mode), high level is valid (gating, encoding mode)
* 01: Channel input falling edge is valid (capture, trigger, reset, clock mode), low level is valid (gating, encoding mode)
* 10: Reserved
* 11: Both rising and falling edges of channel input are valid (capture, trigger, reset, clock mode), high level is valid (gating, encoding model)

**Bit 0 CC0E:** Channel enable.

**Input mode:**

* 0: Disable capture
* 1: Enable capture

**Output mode:**

* 0: Disable output
* 1: Enable output

##### 22.17.10 GPTIM\_CNT

Offset: 0x024

Reset Value: 0x0000

|  |
| --- |
| **15-0** |
| CNT |
| rw-0h |

**Bits 15-0 CNT:** counter count value.

##### 22.17.11 GPTIM\_PSC

Offset: 0x028

Reset Value: 0x0000

|  |
| --- |
| **15-0** |
| PSC |
| rw-0h |

**Bits 15-0 PSC:** Prescaler value is PSC+1.

##### 22.17.12 GPTIM\_ARR

Offset: 0x02C

Reset Value: 0xFFFF

|  |
| --- |
| **15-0** |
| PSC |
| rw-FFFFh |

**Bits 15-0 ARR:** counter reload value.

##### 22.17.13 GPTIM\_CCR0

Offset: 0x034

Reset Value: 0x0000

|  |
| --- |
| **15-0** |
| CCR0 |
| rw-0h |

**Bits 15-0 CCR0:** In output mode this register saves the comparison value written by the user for comparison with CNT; in input mode this register holds the captured value and is read-only.

##### 22.17.14 GPTIM\_CCR1

Offset: 0x038

Reset Value: 0x0000

|  |
| --- |
| **15-0** |
| CCR1 |
| rw-0h |

**Bits 15-0 CCR1:** In output mode this register saves the comparison value written by the user for comparison with CNT; in input mode this register holds the captured value and is read-only.

##### 22.17.15 GPTIM\_CCR2

Offset: 0x03C

Reset Value: 0x0000

|  |
| --- |
| **15-0** |
| CCR2 |
| rw-0h |

**Bits 15-0 CCR2:** In output mode this register saves the comparison value written by the user for comparison with CNT; in input mode this register holds the captured value and is read-only.

##### 22.17.16 GPTIM\_CCR3

Offset: 0x040

Reset Value: 0x0000

|  |
| --- |
| **15-0** |
| CCR3 |
| rw-0h |

**Bits 15-0 CCR3:** In output mode this register saves the comparison value written by the user for comparison with CNT; in input mode this register holds the captured value and is read-only.

##### 22.17.17 GPTIM\_DCR

Offset: 0x048

Reset Value: 0x0000

|  |  |  |  |
| --- | --- | --- | --- |
| **15-13** | **12-8** | **7-5** | **4-0** |
| RESERVED | DBL | RESERVED | DBA |
| r-0h | rw-0h | r-0h | rw-0h |

##### **Bits 15-13 RESERVED:** Must be kept, and cannot be modified.

##### **Bits 12-8 DBL:** DMA continuous read and write length.

##### 00000: 1 transfer

##### 00001: 2 transfers

##### 00010: 3 transfers

##### 00011: 4 transfers

##### 00100: 5 transfers

##### 00101: 6 transfers

##### 00110: 7 transfers

##### 00111: 8 transfers

##### 01000: 9 transfers

##### 01001: 10 transfers

##### 01010: 11 transfers

##### 01011: 12 transfers

##### 01100: 13 transfers

##### 01101: 14 transfers

##### 01110: 15 transfers

##### 01111: 16 transfers

##### 10000: 17 transfers

##### 10001: 18 transfers

##### **Bits 7-5 RESERVED:** Must be kept, and cannot be modified.

##### **Bits 4-0 DBA:** DMA base address for continuous reading and writing.

##### 00000: CR1 register

##### 00001: CR2 register

##### 00010: SMCR register

##### 00011: DIER register

##### 00100: SR register

##### 00101: EGR register

##### 00110: CCMR1 register

##### 00111: CCMR2 register

##### 01000: CCER register

##### 01001: CNT register

##### 01010: PSC register

##### 01011: ARR register

##### 01100: reserved register with offset 0X30

##### 01101: CCR0 register

##### 01110: CCR1 register

##### 01111: CCR2 register

##### 10000: CCR3 register

##### 10001: reserved register with offset 0x44

##### 10010: DCR register

##### 10011: DMAR register

##### 10100: OR register

##### 10101: reserved

##### 10110: reserved

##### 10111: reserved

##### 11000: reserved

##### 11001: reserved

##### 11010: reserved

##### 11011: reserved

##### 11100: reserved

##### 11101: reserved

##### 11110: reserved

##### 11111: reserved

##### 22.17.18 GPTIM\_DMAR

Offset: 0x04C

Reset Value: 0x0000

|  |
| --- |
| **15-0** |
| DMAR |
| rw-0h |

**Bits 15-0 DMAR:** This Register saves the value of the Register of the current DMA operation. For example, the current DMA needs to operate the TIM\_CR2 Register, then directly operating the address is equivalent to operating the TIM\_CR2 Register. Please refer to the specific Register of the Table. Values ​​ for DSTEP, DBL and DBA.

**22.17.19 GPTIM\_OR**

Offset: 0x050

Reset Value: 0x0000

**GPTIMER0 Register structure:**

|  |  |  |  |
| --- | --- | --- | --- |
| **15-11** | **10-7** | **6-4** | **3-0** |
| RESERVED | ETR\_RMP | TI3\_RMP | TI0\_RMP |
| r-0h | rw-0h | rw-0h | rw-0h |

**Bits 15-11 RESERVED:** Must be kept, and cannot be modified.

**Bits 10-7 ETR\_RMP:** ETR remapping.

* 0000：iom
* 0001: comp0
* 0010: comp1
* 0011: xo32k
* 0100: rco48m
* 0101: adcctrl\_awd0
* 0110: adcctrl\_awd1
* 0111: adcctrl\_awd2
* 1000: uart\_rx[0]
* 1001: uart\_rx[1]
* 1010: uart\_rx[2]
* 1011: uart\_rx[3]
* 1100: uart\_rx[4]
* 1101: reserved
* 1110: reserved
* 1111: reserved

**Bits 6-4 TI3\_RMP:** Channel 3 remapping.

* 000：iom
* 001:comp0
* 010: comp1
* 011: reserved
* 100: reserved
* 101: reserved
* 110: reserved
* 111: reserved

**Bits 3-0 TI0\_RMP:** Channel 0 remapping.

* 0000：iom
* 0001: uart\_rx[0]
* 0010: uart\_rx[1]
* 0011: uart\_rx[2]
* 0100: uart\_rx[3]
* 0101: uart\_rx[4]
* 0110: reserved
* 0111: reserved
* 1000: reserved
* 1001: reserved
* 1010: reserved
* 1011: reserved
* 1100: reserved
* 1101: reserved
* 1110: reserved
* 1111: reserved

###### **GPTIMER1 Register structure:**

|  |  |
| --- | --- |
| **15-2** | **1-0** |
| RESERVED | TI2\_RMP |
| r-0h | rw-0h |

**Bit 15-2 RESERVED:** Must be kept, and cannot be modified.

**Bits 1-0 TI2\_RMP:** Channel 2 remapping.

* 00： iom
* 01: TIM3\_CH1
* 10: reserved
* 11: reserved

**GPTIMER2 Register structure:**

|  |  |  |  |
| --- | --- | --- | --- |
| **15-10** | **9-7** | **6-5** | **4-0** |
| RESERVED | ETR\_RMP | TI1\_RMP | TI0\_RMP |
| r-0h | rw-0h | rw-0h | rw-0h |

**Bits 15-11 RESERVED:** Must be kept, and cannot be modified.

**Bits 10-7 ETR\_RMP:** ETR remapping.

* 0000: ion
* 0001: comp0
* 0010: comp1
* 0011: xo32k
* 0100: reserved
* 0101: reserved
* 0110: reserved
* 0111: reserved
* 1000: reserved
* 1001: reserved
* 1010: reserved
* 1011: reserved
* 1100: reserved
* 1101: reserved
* 1110: reserved
* 1111: reserved

**Bits 6-5 TI1\_RMP:** Channel 1 remapping.

* 00: iom
* 01: comp1
* 10: reserved
* 11: reserved

**Bits 4-0 TI0\_RMP:** Channel 0 remapping.

* 00000: iom
* 00001: xo24m
* 00010: xo32m
* 00011: rco48m
* 00100: xo32k
* 00101: rco32k
* 00110: mco
* 00111: comp0
* 01000: rco3.6m
* 01001: rtc\_alarm1\_happen\_pulse
* 01010: rtc\_alarm0\_happen\_pulse
* 01011: rtc\_cyc\_counter\_pulse
* 01100: reserved
* 01101: reserved
* 01110: reserved
* 01111: reserved
* 10000: reserved
* 10001: reserved
* 10010: reserved
* 10011: reserved
* 10100: reserved
* 10101: reserved
* 10110: reserved
* 10111: reserved
* 11000: reserved
* 11001: reserved
* 11010: reserved
* 11011: reserved
* 11100: reserved
* 11101: reserved
* 11110: reserved
* 11111: reserved

###### **GPTIMER3 Register structure:**

|  |  |  |
| --- | --- | --- |
| **15-7** | **6-3** | **2-0** |
| RESERVED | ETR\_RMP | TI0\_RMP |
| r-0h | rw-0h | rw-0h |

**Bits 15-7 RESERVED:** Must be kept, and cannot be modified.

**Bits 6-3 ETR\_RMP:** ETR remapping.

* 0000：iom
* 0001: comp0
* 0010: comp1
* 0011: xo32k
* 0100: uart\_rx[0]
* 0101: uart\_rx[1]
* 0110: uart\_rx[2]
* 0111: uart\_rx[3]
* 1000: uart\_rx[4]
* 1001: reserved
* 1010: reserved
* 1011: reserved
* 1100: reserved
* 1101: reserved
* 1110: reserved
* 1111: reserved

**Bits 2-0 TI0\_RMP:** Channel 0 remapping.

* 000： iom
* 001: comp0
* 010: comp1
* 011: uart\_rx[0]
* 100: uart\_rx[1]
* 101: uart\_rx[2]
* 110: uart\_rx[3]
* 111: uart\_rx[4]