

**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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1 Overview

## 1. 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.

## 2. 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 can support 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 transmission. When powered by 3.3 V power supply, the maximum output power of 22 dBm can be transmitted through 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

### 3. 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 |
|  |  | Supports programmable FIFO Threshold |
| 10. | Support 1 interrupt signal generation |
| UART |  | Support IrDA, support 3/16 and low-power (1.41-2.23us) Bit width |
|  | Support FIFO transmission and reception, 16x8bits transmission FIFO, 16x10bits reception FIFO |
|  | Supports Buffer sending and receiving, 1 deep sending and receiving buffer |
|  | 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, using BCD format, supports seconds, minutes, hours, days, months, years, and days of the week | |
|  | Support ppm adjustment, adjustment step size is 0.5ppm, support +/-1024 ppm adjustment | |
|  | Support low power wake-up | |
|  | Tamper/wakeup IO detection function, supports effective 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 | |
|  | Tamper/wakeup alarm clear retention sram function | |
|  | Some registers support Safety lockControl | |
|  | Internal signal IO output, including alarm0 matching pulse, alarm1 matching pulse, cycle count configuration pulse, seconds signal output | |
|  | Support calendar count value reading | |
|  | Support sub-second count value reading | |
|  | Supports count value reading of cycle counting | |
|  | Support interrupt signal generation | |
| IWDG | 1. | | Watchdog counting function, subtraction counting, counting clock supports prescaler (4-256 divider) |
| 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. | | Supports generating interrupt signals |
|  | 4. | | Support dog feeding window configuration |
|  | 5. | | Support count value reading |
|  | 6. | | Support low power wake-up |
| QSPI | 1. | | Supports master interface only |
| 2. | | Supports 1-wire, 2-wire, 4-wire modes |
| 3. | | Supports 3 working modes, including indirect access, status query and Memory-mapping |
|  | 4. | | Supports baud rate division, up to interface clock frequency/2 |
|  | 5. | | Supports generating interrupt signals |
| CRC | 1. | | Configurable polynomial bit width, supports 7, 8, 16, 32 bits |
| 2. | | Supports different hsize accesses, the lower byte is calculated first and can be edited |
| 3. | | Programmable crc initial value |
|  | 4. | | Support input data reverse, support byte, halfword and word |
|  | 5. | | Support output data reverse, support word |
| DMA | 1. | | Supports 1 master interface AHB bus |
| 2. | | The AHB interface only supports little-endian structure |
| 3. | | Support interrupt signal generation |
| 4. | | Transmission mode, supports M2M, P2M, M2P, P2P |
| 5. | | Support software triggering handshake signal |
|  | 6. | | Supports 4 sets of hardware handshake signals, including burst and single requests |
|  | 7. | | Supports hardware handshake signal sources, each group supports 64 source selections |
|  | 8. | | Supports 4 logical channels |
|  | 9. | | Channel 0 configutation:  (1) 8 bytes deep FIFO   1. Maximum burst length is 8 2. The maximum transfer length is 2047 3. Only supports dmac flow control 4. Source address data bit width configurable 5. Destination address data bit width configurable 6. The address supports increment, decrement, and unchanged 7. Support block transfer, including continuous address, automatic loading and linked list 8. Support scatter and gather |

|  |  |  |
| --- | --- | --- |
|  | 10. | Channel 1-3 configuration:   1. 8 bytes deep FIFO 2. Maximum burst length is 8 3. The maximum transfer length is 2047 4. Only supports dmac flow control 5. Source address data bit width configurable 6. Destination address data bit width configurable 7. The address supports increment, decrement, and unchanged 8. Supports block transfer, including continuous addresses and automatic loading, but does not support linked lists 9. Scatter and gather are not supported |
| GPIO | 1. | IO output configuration, supports push-pull, open drain, output high impedance |
| 2. | IO input configuration, supports floating, input pull-up, input pull-down, analog input |
| 3. | IO other configurations, pull-up configuration, pull-down configuration, drive capability Control |
|  | 4. | Supports generating interrupt signals, including rising edge interrupt, falling edge interrupt, and double edge interrupt |
|  | 5. | Supports generating wake-up signals, including high level and low level |
| SAE | 1. | Support AES128/192/256 |
| 2. | Supports DES and 3DES |
| 3. | Support SM2, SM3, SM4 (ASR6601SE) |
| 4. | Support RSA1024/2048 |
|  | 5. | Support ECC224/256/384/512 |
|  | 6. | Support SHA1, SHA-224, SHA256, SHA384, SHA512 |
|  | 7. | Support random number generator |
| BSTIMER | 1. | 32bits counter, supports automatic loading, supports addition, subtraction, addition and subtraction counting |
| 2. | 16bits count clock prescaler |
| 3. | Supports DMA requests |
|  | 4. | Supports generating interrupt signals |
| GPTIMER | 1. | 32bits counter, supports automatic loading, supports addition, subtraction, addition and subtraction counting |
| 2. | 16bits count clock prescaler |
| 3. | gptimer0 and gptimer1 support 4 Channels, gptimer2 and gptimer3 support 2 Channels, each Channel can support |
|  | 4. | Channel can support input capture, output comparison, PWM generation, single pulse output |
|  | 5. | Supports generating interrupt signals |
|  | 6. | Supports DMA requests |
| LPTIMER | 1. | Supports selecting internal clock and IO clock as counting clock |
| 2. | 16bits counter, additive counting, supports automatic loading |
| 3. | Support count clock prescaler |
| 4. | Supports counting clock prescaler and supports quadrature decoding |
|  | 5. | Support input capture, output comparison, PWM generation, single pulse output |
|  | 6. | Supports generating interrupt signals |
|  | 7. | Supports DMA requests |
| ADC | 1. | Sampling accuracy 12 bits |
| 2. | Configurable sampling speed up to 1 MHz |
| 3. | Supports single-ended and differential sampling |
| 4. | Data alignment only supports right alignment |
| 5. | Supports 8 external channels |
| 6. | Supports 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. | Sampling mode, supports sampling sequence, continuous, single, and non-continuous |
|  |  | Supports analog watchdog function, 3 channels in total, configurable Channel selection and high and low thresholds |
|  | Supports DMA requests |
|  | Supports generating interrupt signals |
| DAC | 1. | Output accuracy 10 bits |
| 2. | Configurable output speed up to 1 MHz |
| 3. | Data alignment only supports right alignment |
| 4. | Special waveform output, supports triangle wave |
|  | 5. | Trigger mode, supports software trigger and hardware trigger |
|  | 6. | Supports DMA requests |
|  | 7. | Supports generating interrupt signals |
| LCDCTRL | 1. | Frame rate division 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, the blinking frequency is configurable |
|  | 6. | Supports large and small 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, which 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.

1. **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.
2. **Aon** (always 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.
3. **Aonr** (Always on and retention) 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 strong.

**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 Mode

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:

1. 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.
2. When entering a low-power mode, developers need to configure below items to achieve specified power consumption:
3. Configure unused GPIOs to ANALOG mode (high impedance)
4. If the GPIOs are in input mode, users should configure them pull-up or pull-down
5. In output mode, configure the connected peripherals pull-up or pull-down according to the output level.
6. 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.
7. 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.
8. 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 above table：

* **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 Function**1** 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 | Flash Main | 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:** Whether the LPTIM1 counter is stopped when 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

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

**Bit 27 SYSCFG\_HALTED\_LPTIM0\_EN:** Whether the LPTIM0 counter is stopped when 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:** Whether the independent watchdog counter is stopped when 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:** Whether the window watchdog counter is stopped when 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:** Whether the GPTIM0 counter is stopped when 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:** Whether the GPTIM1 counter is stopped when 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:** Whether the GPTIM2 counter is stopped when 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:** Whether the GPTIM3 counter is stopped when 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:** Whether the BASICTIM0 counter is stopped when 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:** Whether the BASICTIM1 counter is stopped when 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:** Whether to allow a debug connection in Deepsleep mode

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

* 0: not allowed
* 1: allowed

**Bit 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:** Whether to allow a debug connection in Stop mode. It is only used in debug and it will affect the implementation of Stop mode.

* 0: not allowed
* 1: allowed

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

* 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: no security lock
* 1: security lock enabled

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

[5] Correspond to VD

* 0: no security lock
* 1: security lock enabled

[6] Correspond to TD

* 0: no security lock
* 1: security lock enabled

[7] Correspond to LD

* 0: no security lock
* 1: security lock enabled

[8] Correspond to FD24M

* 0: no security lock
* 1: security lock enabled

[9] Correspond to FD32M

* 0: no security lock
* 1: security lock enabled

[10] Correspond to RNG

* 0: no security lock
* 1: security lock enabled

[11] Correspond to TEST

* 0: no security lock
* 1: security lock enabled

[14:12]: Unused

* 0: no security lock
* 1: security lock enabled

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

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

* 0: no security lock
* 1: security lock enabled

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

* 0: no security lock
* 1: security lock enabled

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

* 0: no security lock
* 1: security lock enabled

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

* 0: no security lock
* 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 can't be modified.

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

[5] Correspond to LPLDO

* + 0: no security lock
  + 1: security lock

1. Correspond to RCO3.6M
   * 0: no security lock
   * 1: security lock
2. Correspond to PWRSW
   * 0: no security lock
   * 1: security lock
3. Correspond to RCO32K
   * 0: no security lock
   * 1: security lock
4. Correspond to XO32K
   * 0: no security lock
   * 1: security lock
5. Correspond to LDO12
   * 0: no security lock
   * 1: security lock
6. Correspond to FD32K
   * 0: no security lock
   * 1: security lock

[14:12] unused

* + 0: no security lock
  + 1: security lock

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

* + 0: no security lock
  + 1: security lock

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

* + 0: no security lock
  + 1: security lock

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

* + 0: no security lock
  + 1: security lock

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

* + 0: no security lock
  + 1: security lock

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

* + 0: no security lock
  + 1: security lock

##### 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:** QSPI memory encryption key.

##### 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 can't 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 can't be modified.

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

* 0: Disable
* 1: Enable

***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: Disable
* 1: Enable

***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 master interface resolution configuration.

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

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

**Bit 14 I2S\_MODE\_SEL:** I2S mode select.

* 0: slave mode
* 1: master mode

***Note:*** In addition to this Register, you also need to configure I2S\_CLK\_DIV and I2S\_CLK\_SEL in RCC\_CR3 and RCC\_CR2 registers, as well as GPIO multiplexing configuration.

**Bit 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 |
| No. | Source |
| 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

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.

##### 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 can't be modified.

**Bits 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 is 1
* 4: division factor is 2
* 5: division factor is 4
* 6: division factor is 8
* 7: division factor is 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: Disable
* 1: Enable

**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 can't 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 can't 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 or 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 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 LCDCTRL interface clock source selection.

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

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

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

**Bit 1 RTC\_CLK\_SEL:** 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 can't 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:** 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 can't 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:*

###### *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.*

###### *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:** 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 |

**Bits 31 PWR\_CLK\_EN:**PWR clock Enable.

* 0: Disable
* 1: Enable

**Bit 30 DMAC0\_CLK\_EN:**DMAC0 clock Enable.

* 0: Disable
* 1: Enable

**Bit 29 DMAC1\_CLK\_EN:**DMAC1 clock Enable.

* 0: Disable
* 1: Enable

**Bit 28 CRC\_CLK\_EN:**CRC clock Enable.

* 0: Disable
* 1: Enable

**Bit 27 BASICTIM0\_CLK\_EN:**BASICTIM0 clock Enable.

* 0: Disable
* 1: Enable

**Bit 26 BASICTIM1\_CLK\_EN:**BASICTIM1 clock Enable.

* 0: Disable
* 1: Enable

**Bit 25 IOM0\_CLK\_EN:**IOM0 clock Enable.

* 0: Disable
* 1: Enable

**Bit 24 IOM1\_CLK\_EN:**IOM1 clock Enable.

* 0: Disable
* 1: Enable

**Bit 23 IOM2\_CLK\_EN:**IOM2 clock Enable.

* 0: Disable
* 1: Enable

**Bit 22 IOM3\_CLK\_EN:**IOM3 clock Enable.

* 0:Disable
* 1:Enable

**Bit 21 SYSCFG\_CLK\_EN:**SYSCFG clock Enable.

* 0: Disable
* 1: Enable

**Bit 20 UART0\_CLK\_EN:**UART0 clock Enable.

* 0: Disable
* 1: Enable

**Bit 19 UART1\_CLK\_EN:**UART1 clock Enable.

* 0: Disable
* 1: Enable

**Bit 18 UART2\_CLK\_EN:**UART2 clock Enable.

* 0: Disable
* 1: Enable

**Bit 17 UART3\_CLK\_EN:**UART3 clock Enable.

* 0: Disable
* 1: Enable

**Bit 16 LPUART\_CLK\_EN:**LPUART clock Enable.

* 0: Disable
* 1: Enable

**Bit 15 SSP0\_CLK\_EN:**SSP0 clock Enable.

* 0: Disable
* 1: Enable

**Bit 14 SSP1\_CLK\_EN:**SSP1 clock Enable.

* 0: Disable
* 1: Enable

**Bit 13 SSP2\_CLK\_EN:**SSP2 clock Enable.

* 0: Disable
* 1: Enable

**Bit 12 I2C0\_CLK\_EN:**I2C0 clock Enable.

* 0: Disable
* 1: Enable

**Bit 11 I2C1\_CLK\_EN:**I2C1 clock Enable.

* 0: Disable
* 1: Enable

**Bit 10 I2C2\_CLK\_EN:**I2C2 clock Enable.

* 0: Disable
* 1: Enable

**Bit 9 RESERVED:** Must be kept, and can't be modified.

**Bit 8 ADCCTRL\_CLK\_EN:**ADCCTRL clock Enable.

* 0: Disable
* 1: Enable

**Bit 7 AFEC\_CLK\_EN:**AFEC clock Enable.

* 0: Disable
* 1: Enable

**Bit 6 LCDCTRL\_CLK\_EN:**LCDCTRL clock Enable.

* 0: Disable
* 1: Enable

**Bit 5 DACCTRL\_CLK\_EN:**DACCTRL clock Enable.

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

##### 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 can't be modified.

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

***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: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

***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: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

##### 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 can't be modified.

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1:Enable

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

* 0: Disable
* 1: Enable

##### 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 reset

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

* 0: reset
* 1: no reset

**Bit 29 UART2\_RST\_N:** UART1reset control**.**

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

**Bits 21 I2C1\_RST\_N:** I2C1 复Bits控制.

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

**Bit 19 RESERVED:** Must be kept, and can't be modified.

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no 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 can't be modified.

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no reset

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

* 0: reset
* 1: no 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 can't be modified.

**Bit 6 BOR\_RESET\_SR:** BOR reset status. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no BOR reset occurred
* an BOR reset occurred

**Bit 5 IWDG\_RESET\_SR:** IWDG reset status. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no IWDG reset occurred
* an IWDG reset occurred

**Bit 4 WWDG\_RESET\_SR:** WWDG reset status. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no WWDG reset occurred
* an WWDG reset occurred

**Bit 3 EFC\_RESET\_SR:** EFC reset status. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no EFC reset occurred
* an EFC reset occurred

**Bit 2 CPU\_RESET\_SR:** CPU reset status. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no CPU reset occurred
* an CPU reset occurred

**Bit 1 SEC\_RESET\_SR:** SEC reset status. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no SEC reset occurred
* an SEC reset occurred

**Bit 0 STANDBY\_RESET\_SR:** MPU reset status. This bit is set by hardware and cleared by software writing 1 to it.

* 0: no MPU reset occurred
* an 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 can't be modified.

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

**Bit 0 RESERVED:** Must be kept, and can't 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 can't 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 is in progress
* 1: configuration is complete

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

* 0: configuration is in progress
* 1: configuration is 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 is in progress
* 1: configuration is 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 is in progress
* 1: configuration is 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 is in progress
* 1: configuration is 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 is in progress
* 1: configuration is 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 can't 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: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

**Bit 14 RESERVED:** Must be kept, and can't be modified.

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

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

* 0: disabled
* 1: enabled

##### 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 can't 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.*

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

9 interrupt (Interrupt)

## 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 (4KB), Mass erase (all flash main)

### 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 register

#### 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:

* When SYS\_CLK is 48MHz frequency, READ\_NUM must ≥ 2.
* When SYS\_CLK is 32MHz frequency, READ\_NUM must ≥ 1.
* When SYS\_CLK is 24MHz frequency, READ\_NUM must ≥ 1.
* When SYS\_CLK is 3.6MHz frequency, READ\_NUM must ≥ 0.
* When SYS\_CLK is 32KHz 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\_CL 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**

Page erase unit size is 4KB.

* **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 can't be modified.

**Bits 49-44 WR\_PROTECT\_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 can't 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 can't be modified.

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

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

**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

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

It must be enabled within the FlashSecure area, and the area range starts from FlashHideStart and ends at FlashSecureEnd; it is only valid when the FlashSecure area is Enabled.

**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 can't 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 | 0x00 | Control Register |
| EFC\_INT\_EN | 0x04 | Interrupt enable register |
| EFC\_SR | 0x08 | Status Register |
| EFC\_PROG\_DATA0 | 0x0C | Program Data 0 |
| EFC\_PROG\_DATA1 | 0x10 | Program Data 1 |
| EFC\_TIMING\_CFG | 0x14 | Timing configuration register |
| EFC\_PROTECT\_SEQ | 0x18 | Protection Sequence |
| RESERVED | 0x1C-0x28 | Reserved |
| SERIAL\_NUM\_LOW | 0x2C | Less Significant 32 bits of the  Chip Serial Number |
| SERIAL\_NUM\_HIGH | 0x30 | More Significant 32 bits of the  Chip Serial Number |
| RESERVED | 0x34-0x38 | Reserved |
| OPTION\_CSR\_BYTES | 0x3C | OPTION control and status data |
| OPTION\_EXE\_ONLY\_BYTES | 0x40 | OPTION Execution-only data |
| OPTION\_WR\_PROTECT\_BYTES | 0x44 | OPTION Write-protection data |
| OPTION\_SECURE\_BYTES0 | 0x48 | OPTION Secure Data 0 |
| OPTION\_SECURE\_BYTES1 | 0x4C | 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

* 0: invalid
* 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 can't 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 can't 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 (in hold mode)
* 1: read acceleration enabled (in 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: a write to the Flash memory does not trigger Flash programming operation
* 1: a 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: a write to the Flash memory does not trigger Flash page erasing operation
* 1: a write to the Flash memory triggers Flash page erasing operation

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

* 0: a write to the Flash memory does not trigger Flash mass erasing operation
* 1: a 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 can't be modified.

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

* 0: Disable
* 1: Enable

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

* 0: Disable
* 1: Enable

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

* 0:Disable
* 1:Enable

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

* 0:Disable
* 1:Enable

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

* 0:Disable
* 1:Enable

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

* 0:Disable
* 1:Enable

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

* 0:Disable
* 1:Enable

**Bit 1 Reserved:** Must be kept, and can't be modified.

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

* 0:Disable
* 1:Enable

#### 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 can't 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: a 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 writing1 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: a 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 *EFC\_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: not complete
* 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 can't 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.
* When SYS\_CLK is 48 MHz frequency, READ\_NUM must ≥ 2.
* When SYS\_CLK is 32 MHz frequency, READ\_NUM must ≥ 1.
* When SYS\_CLK is 24 MHz frequency, READ\_NUM must ≥ 1.
* When SYS\_CLK is 4 MHz frequency, READ\_NUM must ≥ 0.
* When SYS\_CLK is 32 kHz 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 can't 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 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
2. Then write 0x13141516
3. Then 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 can't 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 is disabled
* 1: secure area is enabled

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

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

**Bit 2 FLASH\_BOOT1:** Boot memory selection. See *Table 7-7* for more

details.

* 1: BootLoader 
* 0: System SRAM boot

**Bit 1 USE\_FLASH\_BOOT0:** This bit can be used to identify the boot mode, and the configuration is only

valid when USE\_FLASH\_BOOT0=1. See *Table 7-7* for more details.

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

**Bit 0 FLASH\_BOOT0:** Valid when USE\_FLASH\_BOOT0=1, used for Boot mode selection.

* 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 can't be modified.

**Bit 24 EXE\_ONLY\_KEEP:** Whether Exe\_Only area is kept when the Debug\_Level changes from 1

to 0

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

This bit can only be set to 0 by software.

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

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

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

When *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

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

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

When *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 can't be modified.

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

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

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

When *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

When *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

When *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

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

**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 enabled, the SECURE\_AREA\_EN bit is set, which means all the other

secure areas can be enabled.

When 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

When *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

When *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 | 0x00 | General output enable register |
| GPIOx\_OTYPER | 0x04 | General output type control register |
| GPIOx\_IER | 0x08 | General input enable register |
| GPIOx\_PER | 0x0C | Pull-up/pull-down enable register |
| GPIOx\_PSR | 0x10 | Pull-up/pull-down selection register |
| GPIOx\_IDR | 0x14 | Input data register |
| GPIOx\_ODR | 0x18 | Output data register |
| GPIOx\_BRR | 0x1C | Bit reset register |
| GPIOx\_BSRR | 0x20 | Bit set or reset register |
| GPIOx\_DSR | 0x24 | Output drive strength register |
| GPIOx\_INT\_CR | 0x28 | Interrupt enable register |
| GPIOx\_FR | 0x2C | Interrupt edge flag register |
| GPIOx\_WU\_EN | 0x30 | Wake-up enable resigter for Sleep/Stop0~2 mode |
| GPIOx\_WU\_LVL | 0x34 | Wake-up level control register for Sleep/Stop0~2 mode |
| GPIOx\_AFRL | 0x38 | GPIO alternate function low register |
| GPIOx\_AFRH | 0x3C | GPIO alternate function high register |
| GPIOx\_STOP3\_WU\_CR | 0x40 | 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: invalid
* 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: disabled
* 1: clear the corresponding bit of the GPIOx\_ODR register

**Bits 15-0 BSR:** Portx Pin[15:0] output data set

* 0: disabled
* 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\_EN: 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 mode

* 0: disabled
* 1: enabled

###### 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 the Portx Pin[15:0] to wakeup CPU from Sleep/Stop0~2 mode in

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
* 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

**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: 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: disabled
* 1: enabled

**Bit 14 STOP3\_WU\_LVL\_G3:** PortA Group3 wake-up pin level selection in Stop3 mode

* 0: wake-up at low level
* 1: wake-up at 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 mainly used to control the internal RF TRX to transmit and reception LoRa

signal.

### 12.2 Main features

* Support SPI interface to connect with RF TRX
* Support 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 whether 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. Write the REG\_NSS bit in register *LORAC\_NSS\_CR* to 0.
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. Write the REG\_NSS bit in register *LORAC\_NSS\_CR* to 1.

**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 the NRESET\_BAT bit in register *LORAC\_CR1* to 1.
2. Set the POR\_BAT bit in register *LORAC\_CR1* to 0.
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 this 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 all the time.

#### 12.4 LoRaC Registers

LORAC Base Address:0x40009000

**Table 12-1 LORAC Register Summary**

|  |  |  |
| --- | --- | --- |
| **Register** | **Offset** | **Description** |
| SSP\_CR0 | 0x00 | LORAC Internal SSP Control Register 0 |
| SSP\_CR1 | 0x04 | LORAC Internal SSP Control Register 1 |
| SSP\_DR | 0x08 | LORAC Internal SSP Data Register |
| SSP\_SR | 0x0C | LORAC Internal SSP Status Register |
| SSP\_CPSR | 0x10 | LORAC Internal SSP Clock Prescaler Register |
| SSP\_IMSC | 0x14 | LORAC Internal SSP Interrupt Mask Set/Clear Register |
| SSP\_RIS | 0x18 | LORAC Internal SSP Raw Interrupt Status register |
| SSP\_MIS | 0x1C | LORAC Internal SSP Masked Interrupt Status register |
| SSP\_ICR | 0x20 | LORAC Internal SSP Interrupt Clear Register |
| SSP\_DMACR | 0x24 | LORAC Internal SSP DMA Control Register |
| RESERVED | 0x28-0xFC | 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 bit
* 4: 5 bit
* 5: 6 bit
* 6: 7 bit
* 7: 8 bit
* 8: 9 bit
* 9: 10 bit
* 10: 11 bit
* 11: 12 bit
* 12: 13 bit
* 13: 14 bit
* 14: 15 bit
* 15: 16 bit

##### 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 is on going

**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: 0x0C

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: 0x00

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: 0x00

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: 0x00

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: 0x00

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.

##### 12.4.10 SSP\_DMACR

Offset: 0x00

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: not reset
* 1: reset

**Bit 6 RESERVED:** Must be kept, and cannot be modified.

**Bit 5 NRESET\_BAT:** NRESET\_BAT control

* 0: reset
* 1: not 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 all the time.

* 0: no interrupt
* 1: an 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*

where BRDI is the integer part and BRDF is the fractional part separated by a decimal point as

shown below.

|  |  |  |
| --- | --- | --- |
| 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 Data Register (*UARTx\_CR*) and configure

the data bit, 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 electronics

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 effect of 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 | 0x00 | Data Register |
| UARTx\_RSR\_ECR | 0x04 | Receive Status Register/Error Clear Register |
| UARTx\_RSV0[4] | 0x08 | 4 x 4 Bytes reserved |
| UARTx\_FR | 0x18 | Flag Register |
| UARTx\_RSV1 | 0x1C | 4 Bytes reserved |
| UARTx\_ILPR | 0x20 | IrDA Low-Power Counter Register |
| UARTx\_IBRD | 0x24 | Integer Baud Rate Register |
| UARTx\_FBRD | 0x28 | Fractional Baud Rate Register |
| UARTx\_LCR\_H | 0x2C | Line Control Register |
| UARTx\_CR | 0x30 | Control Register |
| UARTx\_IFLS | 0x34 | Interrupt FIFO Level Selection Register |
| UARTx\_IMSC | 0x38 | Interrupt Mask Set/Clear Register |
| UARTx\_RIS | 0x3C | Raw Interrupt Status Register |
| UARTx\_MIS | 0x40 | Masked Interrupt Status Register |
| UARTx\_ICR | 0x44 | Interrupt Clear Register |
| UARTx\_DMACR | 0x48 | DMA Control Register |
| UARTx\_RSV2[997] | 0x4C | 4 x 997 Bytes reserved |

###### 13.13.1 UARTx\_DR (x=0, 1, 2, 3)

Offset: 0x00

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: 0x04

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: 0x18

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 transmission
* 1: transmission on going

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: 0x20

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: 0x24

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: 0x28

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: 0x2C

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:** Even parity selection

* 0: odd parity
* 1: even parity

This bit has no effect when 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: 0x30

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:** Receive enable

* 0: reception disabled. If the UART is disabled in the middle of reception, then it completes the current character before stopping.
* 1: reception enabled

**Bit 8 TXE:** Transmit enable

* 0: transmission disabled. If the UART is disabled in the middle of transmission, then it completes the current character before stopping.
* 1: transmission 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 in the middle of 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: 0x34

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: 0x38

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: 0x3C

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:0x40 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: 0x44

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:** Overrun error interrupt clear

* 0: a write of 0 has no effect
* 1: write 1 to clear overrun error interrupt

**Bit 9 BEIC:** Break error interrupt clear

* 0: a write of 0 has no effect
* 1: write 1 to clear break error interrupt

**Bit 8 PEIC:** Parity error interrupt clear

* 0: a write of 0 has no effect
* 1: write 1 to clear parity error interrupt

**Bit 7 FEIC:** Framing error interrupt clear

* 0: a write of 0 has no effect
* 1: write 1 to clear framing error interrupt

**Bit 6 RTIC:** Receive timeout interrupt clear

* 0: a write of 0 has no effect
* 1: write 1 to clear receive timeout interrupt

**Bit 5 TXIC:** Transmission completion interrupt clear

* 0: a write of 0 has no effect
* 1: write 1 to clear transmission completion interrupt

**Bit 4 RXIC:** Reception completion interrupt clear

* 0: a write of 0 has no effect
* 1: write 1 to 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: 0x48

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 transmission rate.

#### 14.2 Main features

* Master or slave operation
* Support up to 16 MHz output
* Support 16-bit wide TX/RX FIFO with a depth of 8
* Support multiple frame formats
* Support 4-bit to 16-bit data width
* Support DMA
* Support 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 acts 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. Support 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 as follows:



**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 support three frame formats:

* Motorola SPI
* Texas Instruments SPI
* National Semiconductor Microwire

**14.3.4 DMA Transaction**

**SSP DMA Transmission Process**

1. Enable the TXDMAE bit in register *SSP\_DMACR*.
2. Configure register *SSP\_DR* 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.

1. 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 RX type (for example, for

SSP0, configure it to DMA\_HANDSHAKE\_SSP\_0\_RX).

1. 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: 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 bit
* 4: 5 bit
* 5: 6 bit
* 6: 7 bit
* 7: 8 bit
* 8: 9 bit
* 9: 10 bit
* 10: 11 bit
* 11: 12 bit
* 12: 13 bit
* 13: 14 bit
* 14: 15 bit
* 15: 16 bit

##### 14.4.2 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

##### 14.4.3 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

##### 14.4.4 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 is on going

**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: 0x0C

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: 0x00

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 interrup

##### 14.4.7 SSP\_RIS

Offset: 0x00

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: 0x00

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: 0x00

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: 0x00

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 follows below sequence:

1. Start
2. 7-bit slave address
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. **When the 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. **When the 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 target 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  initiat 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 | * Eight 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: 0x00

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: a Stop condition is generated when the STOP bit in this register is set
* 1: a 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: invalid
* 1: I2C bus reset, and this bit is cleared automatically

**Bit 10 UR:** Unit reset

* 0: no reset
* 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 transaction begins
* 1: a 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 a ACK after receiving a data byte
* 1: send a 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 Stop condition is generated
* 1: generate a 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 Start condition is generated
* 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: 0x04

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 is not done
* 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 was detected
* 1: a master Stop was 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 was detected
* 1: a 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 was detected
* 1: the matching slave address was detected, and it is cleared by software writing 1 to it.

**Bit 22 BED:** Bus error detection flag

* 0: no bus error was detected
* 1: a bus error was 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 is still being transmitted.
* 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: the I2C wins the arbitration or no arbitration took place
* 1: the 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: the I2C received or sent an ACK
* 1: the 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: 0x08

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: 0x0C

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: 0x10

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: 0x18

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: 0x1C

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: 0x20

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: 0x24

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: 0x28

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: 0x2C

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: 0x30

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: 0x34

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: 0x40

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: 0x44

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**

* **By software:** The conversion starts immediately when a rising edge on the START bit of ADC\_CR is detected.
* **By hardware:** 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 read 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: A write of 0 has no effect.
* 1: Write 1 to stop the ADC. Read 1 means that the STOP command is under execution.

***Note:***

1. *Software writes 1 to this bit to stop and discard an ongoing conversion, thus the conversion sequence*
2. *is reset; this bit is cleared automatically by hardware.*
3. *After the START bit is cleared, software must wait for 3 ADCCLK ticks before reconfigure the START*
4. *bit; or wait for 1 CLK\_DIV (set in register ADC\_CFGR) tick to set the DIS bit to disable the ADC.*
5. *Software is allowed to set this bit only when START=1 and STOP=0.*
6. *Before setting the STOP bit, it is recommended to disable the trigger source first, or keep the trigger*
7. *level in an invalid state.*

**Bit 2 START:** ADC start conversion command

* 0: A write of 0 has no effect.
* 1: Write 1 to 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: A write of 0 has no effect.
* 1: Write 1 to disable the ADC

Software is allowed to set this bit only when EN=1 and START=0 (no conversion is ongoing).

**Bit 0 EN:** ADC enable

* 0: A write of 0 has no effect.
* 1: Write 1 to 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: 0x04

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

***Note:***

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

***Note:***

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: 0x08

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: 0x0C

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: 0x10

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: 0x14

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 occurred
* 1: overrun has 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 is not complete
* 1: conversion sequence is complete

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 is not completed
* 1: channel conversion is 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: 0x18

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: 0x1C

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. 基本定时器 (BSTIM)

### 17.1 Introduction

BSTIMER（Basic Timer）包含 16bits counter,支持自动重装载功能,且支持最多 16bits 可编程的分频counter.有两个 BSTIMER,分别为 BSTIMER0 和 BSTIMER1.

### 17.2 Main features

BSTIMER 包括如下功能:

* 16bits counter,加法计数,支持自动重加载
* 分频counter
* DMA 控制
* 支持单脉冲
* 支持主模式功能
* 更新事件管理
* Debug 模式控制
* interrupt信号产生 BSTIMER 的框Figure如下:



**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 框Figure**

####  rcc\_tim\_clk:BSTIMER 的接口clock  apb\_read:APB 总线的读

* **dma\_ack:**DMA 回复的 ACK  **trigger\_output:**BSTIMER 的 TRGO 输出
* **dma\_req:**BSTIMER 对 DMA 的Request  **interrupt:**BSTIMER 的interrupt
* **apb\_write:**APB 总线的写

### 17.3 接口clock

BSTIMER 接口clock 源为 PCLK,不能设置为其它clock 源.clock Enable和复Bits配置可以参考 RCC 章节.

### 17.4 counter

counter仅支持向上计数,计数到 ARR,这样counter的值会从 ARR 变为 0,然后继续计数,同时状态标记Bits UIF 置Bits,如果更新事件interruptRequest Enable即 UIE 置Bits,则也会产生interrupt,此时Table示一个计数周期完成.下个计数周期counter继续从 0 开始计数,如此循环往复.

#### 17.5 自动重加载

可软件配置Register BSTIM\_CR1 的 ARPE Bits来设置是否启用 ARR 影子Register,如果 ARPE=0,则禁用影子Register,软件写入的值直接同步更新到 ARR 供counter使用,如果 ARPE=1,则软件写入的值不会立即生效,直到更新事件到来,才会将该值更新到 ARR 供counter使用.

#### 17.6 分频counter

BSTIMER 支持 16-bit（1~65535）可编程分频,此功能通过分频counter BSTIM\_PSC 实现.接口clock 作为分频counter的clock ,Register BSTIM\_CR1 的 CEN 作为分频counter的计数Enable,当分频counter计数到预先加载的分频值后,输出一个脉冲,作为下一级counter的计数Enable,然后分频counter归零重新计数,依次类推.

分频counter的分频值默认启用影子Register,即软件的写操作不会立即生效,而是直到更新事件（UG 事件置Bits、计数溢出）到来,才会将新的分频值写入影子Register,此时该分频值才正式生效.软件读操作读取的是写入的Register值,而不是影子Register,如果在更新事件到来前有多次写操作,则会覆盖之前写入的值.计数和分频波形如下:



**Figure 17-2 计数和分频波形**

### 17.7 DMA 控制

BSTIMER 支持 DMA 功能,Enable DMA 功能后,其所有Register除 BSTIM\_SR、BSTIM\_EGR 外与 memory 之间可以相互传递数据,BSTIM\_SR 只能被读取数据,BSTIM\_EGR 只能被写入数据.通过Register BSTIM\_DIER 的 UDE BitsEnable DMA,当有更新事件时则会产生 DMA Request ,

DMA 返回的 ACK 信号会清除模块的 DMA Request 信号.

#### 17.8 支持单脉冲

BSTIMER 支持单脉冲计数模式,通过置BitsRegister BSTIM\_CR1 的 OPM BitsEnable该模式,在该模式下,当counter计数到 ARR 值后会归零并停止计数（CEN 硬件自动清零）,除非再次初始化才会重新计数,如下Figure所示:

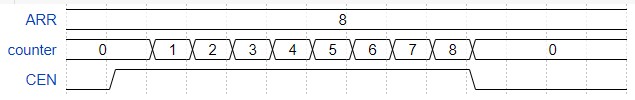
**Figure**

**17**

**-**

**3**

单脉冲波形



#### 17.9 支持主模式选择

BSTIMER 可以与其他内部模块级联,并作为主机使用,通过产生触发输出信号（TRGO）来控制 DAC.可通过软件配置 BSTIM\_CR2 Register的 MMS Bits来选择 TRGO 信号的来源,具体如下:

* MMS=3’b000:复Bits模式,此时 UG 标志Bits将作为 TRGO 信号输出给外部从机.
* MMS=3’b001:Enable模式,此时counter的计数Enable CEN 将作为 TRGO 信号输出给外部从机.
* MMS=3’b010:更新模式,此时将更新事件作为 TRGO 信号输出给外部从机.
* MMS 的其它值为保留值.

#### 17.10 更新事件管理

更新事件主要有以下事件源:

1. counter的溢出事件（overflow）,即counter的值从 ARR 变为 0.
2. UG 置Bits（软件置Bits）,即配置Register BSTIM\_EGR 的 UG Bits.

与更新事件管理相关的控制信号主要是Register BSTIM\_CR1 的 URS 和 UDIS,具体控制如下:

* 若 UDIS=0,URS=0,则 overflow、UG 置Bits会初始化counter和分频counter,如果启用影子Register,更新事件则会把写入的值更新到影子Register中（ARR 取决于 ARPE）,

UIF 会置Bits,如果Enable了interrupt或 DMA,则会产生interrupt或 DMA Request .

* 若 UDIS=0,URS=1,则 overflow、UG 置Bits会初始化counter和分频counter,如果启用影子Register,更新事件将会把写入的值更新到影子Register中（ARR 取决于 ARPE）,

UIF 只会在 overflow 情况下置Bits,如果Enable了interrupt或 DMA,则会产生interrupt或 DMA Request .

* 若 UDIS=1（忽略 URS）,则只有 UG 置Bits仍会初始化counter和分频counter,但是影子Register不会被更新,且 UIF 不会置Bits,因此也不会产生相应interrupt或 DMA Request .

### 17.11 Debug 模式控制

BSTIMER 可由软件配置 debug 下是否停止计数,通过 SYSCFG 的 CR2 Register来实现 BSTIMER0 和 BSTIMER1 的 DEBUG 模式计数控制,如果Enable该功能,则进入系统 debug 模式时,BSTIMER 停止计数（counter不会被初始化）.

### 17.12 interrupt信号

BSTIMER 的interrupt信号如下:

**Table 17-1 BSTIMER interrupt信号**

|  |  |
| --- | --- |
| interrupt名称 | Description |
| 更新事件interrupt | counter溢出、UG 置Bits均可以产生更新事件interrupt |

上述interrupt的Enable通过配置Register BSTIM\_DIER 的 UIE Bits实现,interrupt状态可以通过Register

BSTIM\_SR 获得.

### 17.13 BSTIMER 相关RegisterDescription

BSTIMER0 基地址:0x4000C000

BSTIMER1 基地址: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/interruptEnableRegister |
| BSTIM\_SR | 0x10 | 状态Register |
| BSTIM\_EGR | 0x14 | 事件Register |
| BSTIM\_CNT | 0x24 | counterRegister |
| BSTIM\_PSC | 0x28 | counter分频值 |
| BSTIM\_ARR | 0x2c | counter重装载值 |

#### 17.13.1 BSTIM\_CR1

Offset:0x00

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:**保留.

**Bits 7 ARPE:**重装载影子RegisterEnable.

* 0:BSTIM\_ARR 影子Register除能
* 1:BSTIM\_ARR 影子RegisterEnable**Bits 6-4 RESERVED:**保留.

**Bits 3 OPM:**单脉冲模式Enable.

* 0:单脉冲模式除能
* 1:单脉冲模式Enable,counter在下一次更新事件停止计数

**Bits 2 URS:**更新事件源选择,该Bits仅影响interrupt（UIF）和 DMA 标志Bits,不影响内部逻辑.

* 0:counter溢出、UG Bits置Bits,均可以置Bits UIF
* 1:只有counter溢出事件可以置Bits UIF **Bits 1 UDIS:**更新事件除能.
* 0:更新事件Enable,可以产生更新事件.
* 1:更新事件除能,影子Register和 UIF 均不会被更新,但是此时counter和分频counter仍可以被 UG 置Bits事件初始化.

**Bits 0 CEN:**counterEnable,单脉冲模式下 CEN 由硬件清零.

* 0:counter除能
* 1:counterEnable

#### 17.13.2 BSTIM\_CR2

Offset:0x00 Reset Value:0x00000000

|  |  |  |
| --- | --- | --- |
| **31-7** | **6-4** | **3-0** |
| RESERVED | MMS | RESERVED |
| rw-0h | rw-0h | rw-0h |

**Bits 31-7 RESERVED:**保留.

**Bits 6-4 MMS:**主模式选择,可以配置 TRGO 输出.

* 000:复Bits模式,UG 将作为 TRGO 信号输出
* 001:Enable模式,CEN 将作为 TRGO 信号输出
* 010:更新模式,更新事件（内部信号）将作为 TRGO 信号输出
* 其它值:保留**Bits 3-0 RESERVED:**保留.

#### 17.13.3 BSTIM\_DIER

Offset:0x0c 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:**保留.**Bits 8 UDE:**更新事件 DMA Request Enable.

* 0:禁用更新事件 DMA Request
* 1:Enable更新事件 DMA Request **Bits 7-1 RESERVED:**保留.**Bits 0 UIE:**更新事件interruptRequest Enable.
* 0:禁用更新事件interruptRequest
* 1:Enable更新事件interruptRequest

#### 17.13.4 BSTIM\_SR

Offset:0x10 Reset Value:0x00000000

|  |  |
| --- | --- |
| **31-1** | **0** |
| RESERVED | UIF |
| r-0h | r-0h |

**Bits 31-1 RESERVED:**保留.**Bits 0 UIF:**更新事件标志.

* 0:无事件
* 1:更新事件发生

#### 17.13.5 BSTIM\_EGR

Offset:0x14 Reset Value:0x00000000

|  |  |
| --- | --- |
| **31-1** | **0** |
| RESERVED | UG |
| w-0h | w-0h |

**Bits 31-1 RESERVED:**保留.**Bits 0 UG:**更新事件产生.

* 0:无动作
* 1:产生一次更新事件

#### 17.13.6 BSTIM\_CNT

Offset:0x24 Reset Value:0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | CNT |
| rw-0h | rw-0h |

**Bits 31-16 RESERVED:**保留.**Bits 15-0 CNT:**counter计数值.

#### 17.13.7 BSTIM\_PSC

Offset:0x28 Reset Value:0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | PSC |
| rw-0h | rw-0h |

**Bits 31-16 RESERVED:**保留.

**Bits 15-0 PSC:**clock 分频值为 PSC+1.

#### 17.13.8 BSTIM\_ARR

Offset:0x2c

Reset Value:0x0000ffff

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | ARR |
| rw-0h | rw-ffffh |

**Bits 31-16 RESERVED:**保留.

**Bits 15-0 ARR:**counter重装载值.

## 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 main 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. Support RTC frequency calibration with a resolution of about 0.5 ppm with a range from -1024 ppm to +1024 ppm.
3. Support wake-up from low-power mode
4. Tamper/wakeup IO detection is activated at high or low level with configurable filter
5. 32-bit counter for periodic count
6. 2 Alarms support calendar matching
7. Retention SRAM is cleared once tamper/wakeup alarm occurs
8. Internal signal is output by GPIO, including Alarm0 pulse, Alarm1 pulse, periodic counter pulse and second signal
9. Support reading calendar values
10. Support reading the sub-seconds value
11. Support reading the period counting value
12. Support interrupt signal generation

**18.3 Interface Clock**

### 

Both XO32K and RCO32K can be RTC clock source and XO32K accuracy is higher than

RCO32K.

See Chapter *RCC* 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:** Reserved.

**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: active at low level
* 1: active at 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: 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

**Bit 17 WAKEUP0\_EN:** WAKEUP0 enable

* 0: disabled
* 1: enabled

**Bit 16 WAKEUP0\_LEVEL\_SEL:** WAKEUP0 active level selection

* 0: active at low level
* 1: active at 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: 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

**Bit 11 WAKEUP1\_EN:** WAKEUP1 enable

* 0: disabled
* 1: enabled

**Bit 10 WAKEUP1\_LEVEL\_SEL:** WAKEUP1 active level selection

* 0: active at low level
* 1: active at 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: 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

**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: 0x04

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: 0x08

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: 0x0c

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: 0x10

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: 0x14

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: 0x18

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: 0x1c

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: the Alarm 0 values doesn’t match the Calendar
* 1: the 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: the Alarm 1 values doesn’t match the Calendar
* 1: the 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: the CYC\_MAX\_VALUE is not reached
* 1: the 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: the tamper pin active level is not detected
* 1: the 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: the Wakeup1 active level is not detected
* 1: the 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: the Wakeup2 active level is not detected
* 1: the Wakeup2 active level is detected

#### 18.12.9 RTC\_ASYNDATA

Offset: 0x20

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: 0x24

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: 0x28

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: 0x2c

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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is 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 is generated
* 1: a second signal interrupt is 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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is 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: a write operation is ongoing
* 1: a write operation is completed

#### 18.12.13 RTC\_CR2

Offset: 0x30

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: 0x34

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: 0x38

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: 0x3c

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: 0x40

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: 0x44

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: 0x48

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.

In addition, 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)
* Support DMA request
* 1-deep TX FIFO/RX FIFO
* Support CTS/RTS flow control
* Support LPUART 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 Transmitter 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 Reception 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**

##### 

The interrupt signals of LPUART are:

* 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: 0x04

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: 0x08

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 occurred
* 1: an 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 occurred
* 1: a 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 occurred
* 1: a 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: an 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 is not completed
* 1: data reception is 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: a valid Start bit has been received

###### 19.4.4 LPUART\_SR1

Offset: 0x0C

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 is on-going
* 1: data transmission is 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: a write operation to the *LPUART\_CR0* register is on-going
* 1: a write operation to the *LPUART\_CR0* register has been 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: a write operation to the *LPUART\_SR0* register is on-going
* 1: a write operation to the *LPUART\_SR0* register has been completed

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

###### 19.4.5 LPUART\_DATA

Offset: 0x10

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

***Note:***

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）是一个 16 Bits的计时器,由于其有多种clock 源,LPTIMER 能够在除 standby 模式外的所有工作模式下运行,并且支持从所有低功耗工作模式中唤醒.有两个

LPTIMER,分别为 LPTIMER0 和 LPTIMER1.

### 20.2 Main features

LPTIMER 包括如下功能:

* 支持选择内部clock 与外部clock 作为计数clock
* 16bits counter,加法计数,支持自动加载
* 支持两种计数模式,单次计数和连续计数
* 支持软件触发和外部触发源触发计数
* 分频counter
* 支持产生 PWM
* 支持单脉冲、Set-once、Timeout 模式输出
* 支持 DEBUG 模式控制
* 支持产生通道输出事件、匹配事件、溢出事件、触发事件、DOWN 事件、UP 事件作为唤醒信号输出
* 正交解码
* interrupt信号产生

LPTIMER 的框Figure如下:



**Figure 20-1 LPTIMER 框Figure**

####  lptim\_trig0~7:LPTIMER 的外部触发源

* **lptim\_in2:**LPTIMER 的 IN2 pin 脚  **lptim\_in1:**LPTIMER 的 IN1 pin 脚
* **lptim\_wkup:**LPTIMER 的唤醒信号
* **lptim\_out:**LPTIMER 的 OUT pin 脚

### 20.3 接口clock

LPTIMER 接口clock 源分内部clock 和外部clock ,内部clock 源有 PCLK0、RCO3.6M、XO32K、 RCO32K,外部clock 源通过 IN1 的 GPIO 输入.clock 配置和选择可以参考 RCC 章节.

### 20.4 计数clock 选择

LPTIMER 除了接口clock 有内部和外部之分外,计数clock 也有内部和外部之分,其内部与外部的clock 源与接口clock 的一致.控制计数clock 选择的Register bit Bits为Register LPTIM\_CFGR 的 COUNTMODE,值为 0 Table示counter由内部clock 控制,值为 1 Table示counter由外部clock 控制,如果 RCC 模块的Register RCC\_CR1 的 LPTIM1\_EXT\_CLK\_SEL Bits或 LPTIM\_EXT\_CLK\_SEL Bits为 0,即Table示 LPTIMER0 或 LPTIMER1 的接口clock 为内部clock ,则 COUNTMODE 的值可以为 0 或 1,即计数clock 既可以为内部clock 也可以为外部clock ；如果 LPTIM1\_EXT\_CLK\_SEL Bits或 LPTIM\_EXT\_CLK\_SEL Bits为 1,则 LPTIMER0 或 LPTIMER1 的Register LPTIM\_CFGR 的 COUNTMODE Bits只能设置为 0,这时 0 不是Table示计数clock 为内部clock ,是Table示 COUNTMODE 值需要清零,计数clock 只能为外部clock .

### 20.5 counter

除编码模式外,counter仅支持向上计数,计数到 ARR 时产生 ARRM interrupt,counter回到 0 重新计数.若Enable timeout 模式,则除了counter值增加到 ARR 时清零外,触发信号也可以清零counter重新计数.若Enable编码模式,则counter的计数方向由硬件控制,向上计数到 ARR 时产生

ARRM 事件并清零counter,向下计数到 0 时则重新加载 ARR 到counter.

#### 20.6 计数模式

LPTIMER 支持两种计数模式,单次计数和连续计数.单次计数模式下,counter停止阶段第一个到来的触发信号（硬件或软件）会触发counter开始计数,计数过程中的触发信号将会被忽略,计数到 ARR 时counter会停止计数,直到下一次触发信号到来才会再次开始计数,依次类推.连续计数模式下,一旦触发（硬件或软件）,counter会一直计数下去,从 0 到 ARR,然后回到

0 再次计数,如此循环往复.

两种计数模式可以在任意时刻切换（前提是 enable 置Bits）,例如,配置 LPTIMER 为单次计数模式,若置BitsRegister LPTIM\_CR 的 CNTSTRT,则counter计数到 ARR 值将不会停止计数；配置 LPTIMER 为连续计数模式,若置BitsRegister LPTIM\_CR 的 SNGSTRT,则counter计数到 ARR 时将会停止计数,直到下一次触发信号到来.因此状态Figure如下:



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 计数模式转换Figure**

#### 20.7 软件触发和外部触发

触发 LPTIMER 计数有两种方式,一种是软件触发,另一种是外部触发源触发.通过Register LPTIM\_CFGR 的 TRIGEN Bits段进行控制,当值为 0 时为软件触发,非零时为外部触发,当为外部触发时,可以设置外部触发信号上升沿有效、下降沿有效或双沿有效.LPTIMER 有 8 种触发输入源可以选择使用,**LPTIMER0** 的外部触发源如下Table:

**Table 20-1 LPTIMER0 的外部触发源**

|  |  |  |
| --- | --- | --- |
| 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** 的外部触发源如下Table:

**Table 20-2 LPTIMER1 的外部触发源**

|  |  |  |
| --- | --- | --- |
| 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 分频counter

计数Enable信号可以被软件配置分频,支持 1、2、4、8、16、32、64、128 分频,通过配置Register LPTIM\_CFGR 的 PRESC Bits段进行分频配置.该分频通过counter实现,即上一级电路产生的计数Enable信号将作为该分频counter的计数Enable,当分频counter计数到预先加载的分频值后,输出一个脉冲,作为下一级counter的计数Enable,然后分频counter归零重新计数,依次类推.

### 20.9 PWM

LPTIMER 可以产生 PWM 波形,波形的极性可以通过Register LPTIM\_CFGR 的 WAVPOL 比特控制,占空比可以通过Register LPTIM\_CMP 和 LPTIM\_ARR 的值进行控制.以软件触发和内部clock 计数为例,配置 PWM 的流程如下:

1. 配置Register LPTIM\_CFGR 的 COUNTMODE 为 0,即设置内部clock 计数.
2. Register LPTIM\_CFGR 的 PRESC 为默认值,即不设置counter分频.
3. 配置Register LPTIM\_CFGR 的 PRELOAD 的值为 0,即DisableRegister LPTIM\_CMP 和

LPTIM\_ARR 的缓存功能.如果需要也可以Enable.

1. 配置Register LPTIM\_CFGR 的 WAVPOL 为 0,即波形输出不反相.
2. 配置Register LPTIM\_CFGR 的 WAVE 为 0.
3. Register LPTIM\_CFGR 的 TRIGEN Bits段的值为 0,即软件触发.
4. Enable LPTIMER,就是置BitsRegister LPTIM\_CR 的 ENABLE.
5. 设置Register LPTIM\_ARR 和 LPTIM\_CMP 的值.
6. Enable连续计数功能,通过置BitsRegister LPTIM\_CR 的 CNTSTRT 实现.

### 20.10 支持单脉冲、Set-once、Timeout 模式输出

单脉冲模式下,counter未计数时,检测到第一个触发信号,则计数Enable置Bits,若计数到ARR或 enable 清零或模块复Bits,则计数Enable清零,计数过程中的触发信号将会被忽略,如下Figure:

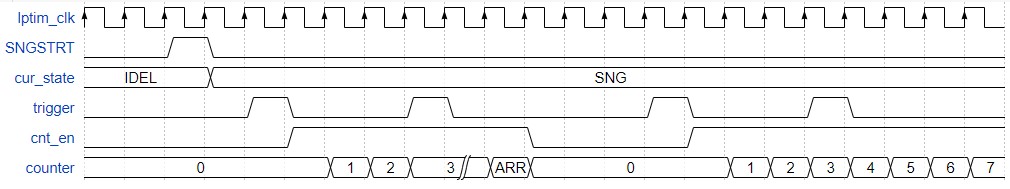
**Figure**

**20**

**-**

**3**

单脉冲计数



单脉冲模式通过配置Register LPTIM\_CFGR 的WAVE 为 0 以及Register LPTIM\_CR 的 SNGSTRT 为 1 实现.

Set-once 模式下,检测到第一个触发信号后,计数Enable置Bits,若计数到 ARR,则计数Enable清零,计数过程中的触发信号将会被屏蔽,屏蔽信号通过 mask 实现,即检测到第一个触发信号后,mask 有效,屏蔽之后的所有触发信号,如下Figure:

**Figure**

**20**

**-**

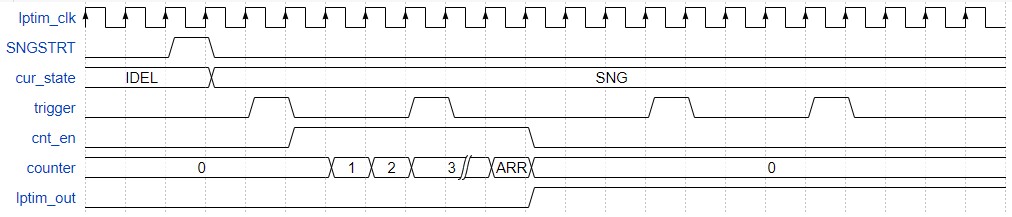
**4**

**Set**

**-**

**once**

计数



Set-once 模式通过配置Register LPTIM\_CFGR 的 WAVE 为 1 以及Register LPTIM\_CR 的

SNGSTRT 为 1 实现.

Timeout 模式与连续计数模式类似,一旦被触发,计数Enable一直有效,区别是,计数过程中的触发信号会让counter从 0 开始重新计数,且输出波形也会被清除,如下Figure:

**Figure**

**20**

**-**

**5**

**Timeout**

计数



Timeout模式通过配置RegisterLPTIM\_CFGR的WAVE为0以及RegisterLPTIM\_CR的CNTSTRT 为 1 实现.

### 20.11 正交编码

LPTIMER 支持正交编码计数功能,可以通过 IN1和 IN2输入正交信号,进行计数和方向检测.编码模式共有三种,仅在上升沿计数、下降沿计数以及双边沿计数,编码模式的Enable通过Register LPTIM\_CFGR 的 ENC 控制,编码模式的边沿控制通过Register LPTIM\_CFGR 的 CKPOL 来实现.在此功能下,两个通道输入可以配置数字滤波功能,滤波Enable通过Register LPTIM\_CFGR 的 CKFLT\_ENABLE 控制,滤波值通过Register LPTIM\_CFGR 的 CKFLT 进行配置.通过两个通道信号的组合,可以产生计数Enable和方向控制信号,控制counter加减.具体的组合方式见下Table:

#### Table 20-3 正交编码通道信号

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 编码模式 | IN1/IN2电平 | IN1 | | IN2 | |
| 上升沿 | 下降沿 | 上升沿 | 下降沿 |
| 上升沿计数 | 高电平 | 向下计数 | - | 向上计数 | - |
| 低电平 | 向上计数 | - | 向下计数 | - |
| 下降沿计数 | 高电平 | - | 向上计数 | - | 向下计数 |
| 低电平 | - | 向下计数 | - | 向上计数 |
| 双沿计数 | 高电平 | 向下计数 | 向上计数 | 向上计数 | 向下计数 |
| 低电平 | 向上计数 | 向下计数 | 向下计数 | 向上计数 |

IN1 和 IN2 输入信号频率必须小于 LPTIMER clock 频率的 1/4.

### 20.12 支持 DEBUG 模式控制

LPTIMER 可由软件配置 debug 下是否停止计数,通过 SYSCFG 的 CR2 Register来实现 LPTIMER0 和 LPTIMER1 的 DEBUG 模式计数控制,如果Enable该功能,则进入系统 debug 模式时,LPTIMER 停止计数（counter不会被初始化）.

### 20.13 唤醒信号

LPTIMER 有 6 种唤醒信号输出,分别是,

* **通道输出信号**,此时通道输出将作为唤醒信号输出.
* **匹配事件（CMPM）**,此时counter与Register LPTIM\_CMP 的匹配事件将作为唤醒信号输出.
* **溢出事件（ARRM）**,此时 overflow 事件将作为唤醒信号输出.
* **触发事件（EXTTRIG）**,此时有效的触发事件将作为唤醒信号输出.
* **DOWN 事件**,若计数方向由向上计数变为向下计数,DOWN 事件会置Bits,此时 DOWN 事件会作为唤醒信号输出.
* **UP 事件**,若计数方向由向下计数变为向上计数,UP 事件会置Bits,此时 UP 事件会作为唤醒信号输出.

以上唤醒信号除了通道输出信号,均为 LPTIM\_ISR Register的标志Bits,且有独立的EnableBits,EnableBits分别为Register LPTIM\_CFGR 的 *OUT\_WKUP\_EN*、*CMPM\_WKUP\_EN*、*ARRM\_WKUP\_ EN*、*EXTTRIG\_WKUP\_EN*、*DOWN\_WKUP\_EN*、*UP\_WKUP\_EN* 比特Bits,唤醒信号与相应EnableBits是 AND 的关系,各Wakeup Source之间是 OR 的关系.

### 20.14 interrupt信号

LPTIMER 的interrupt信号如下:

**Table 20-4 LPTIMER interrupt信号**

|  |  |
| --- | --- |
| interrupt名称 | Description |
| DOWN interrupt | 编码模式下,Table示计数方向由向上变为向下 |
| UP interrupt | 编码模式下,Table示计数方向由向下变为向上 |
| ARROK interrupt | Table示 ARR 值加载完成 |
| CMPOK interrupt | Table示 CMP 值加载完成 |
| EXTTRIG interrupt | Table示检测到有效触发边沿 |
| ARRM interrupt | Table示counter值到达 ARR |
| CMPM interrupt | Table示counter值与 CMP 匹配 |

上述interrupt的Enable通过配置Register LPTIM\_IER 实现,所有interrupt的interrupt状态都可以通过Register

LPTIM\_SR1 获得.

### 20.15 LPTIMER 相关RegisterDescription

LPTIMER0 基地址:0x4000D000

LPTIMER1 基地址:0x4000D800

**Table 20-5 LPTIMER Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| LPTIM\_ISR | 0x00 | 状态Register |
| LPTIM\_ICR | 0x04 | 状态清除Register |
| LPTIM\_IER | 0x08 | interruptEnableRegister |
| LPTIM\_CFGR | 0x0c | 配置Register,该Register需在 LPTIM\_CR Register的 ENABLE 清零时修改 |
| LPTIM\_CR | 0x10 | Control Register |
| LPTIM\_CMP | 0x14 | 比较Register |
| LPTIM\_ARR | 0x18 | 重装载Register |
| LPTIM\_CNT | 0x1c | counterRegister |
| LPTIM\_CSR | 0x20 | 清除状态标志Register,Table示使用Register LPTIM\_ICR 清除 LPTIM\_ISR 某些状态Bits时的是否清除完成标志 |
| LPTIM\_SR1 | 0x24 | interrupt标志Register,interrupt标志Bits会被Register LPTIM\_ICR 立即清零 |

#### 20.15.1 LPTIM\_ISR

Offset:0x00

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:**保留.

**Bits 8 CROK:**上一次对Register LPTIM\_CR 的写操作状态.该Bits由硬件控制,写操作前需要检查上一次写操作是否完成.

* 0:正在进行写操作
* 1:上一次对 LPTIM\_CR 的写操作已经完成

**Bits 7 CFGROK:**上一次对 LPTIM\_CFGR 的写操作状态.该Bits由硬件控制,写操作前需要检查上一次写操作是否完成.

* 0:正在进行写操作
* 1:上一次对 LPTIM\_CFGR 的写操作已经完成

**Bits 6 DOWN:**编码模式下计数方向由向上变为向下.

* 0:计数方向未发生由上向下的变化
* 1:计数方向由向上变为向下

可以通过写 LPTIM\_ICR Register清零,但是需要时间同步清零脉冲,因此无法立即清除.

**Bits 5 UP:**编码模式下计数方向由向下变为向上.

* 0:计数方向未发生由下向上的变化
* 1:计数方向由向下变为向上

可以通过写 LPTIM\_ICR Register清零,但是需要时间同步清零脉冲,因此无法立即清除.

**Bits 4 ARROK:**ARR 值加载状态.

* 0:未加载完成
* 1:加载完成

可以通过写 LPTIM\_ICR Register清零,但是需要时间同步清零脉冲,因此无法立即清除.

**Bits 3 CMPOK:**CMP 值加载状态.

* 0:未加载完成
* 1:加载完成

可以通过写 LPTIM\_ICR Register清零,但是需要时间同步清零脉冲,因此无法立即清除.

**Bits 2 EXTTRIG:**是否检测到有效触发边沿.

* 0:未检测到有效触发边沿
* 1:检测到有效触发边沿

可以通过写 LPTIM\_ICR Register清零,但是需要时间同步清零脉冲,因此无法立即清除.

**Bits 1 ARRM:**counter值是否到达 ARR 值.

* 0:counter值未到达 ARR
* 1:counter值到达 ARR

可以通过写 LPTIM\_ICR Register清零,但是需要时间同步清零脉冲,因此无法立即清除.

**Bits 0 CMPM:**counter值与 CMP 值匹配状态.

* 0:counter值与 CMP 值未匹配
* 1:counter值与 CMP 值匹配

可以通过写 LPTIM\_ICR Register清零,但是需要时间同步清零脉冲,因此无法立即清除.

#### 20.15.2 LPTIM\_ICR

Offset:0x04

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:**保留.

**Bits 6 DOWNCF:**清除 DOWN 标志Bits.软件写 1 清除标记Bits,该Bits由硬件清零.

* 0:无操作
* 1:清除操作

**Bits 5 UPCF:**清除 UP 标志Bits.软件写 1 清除标记Bits,该Bits由硬件清零.

* 0:无操作
* 1:清除操作

**Bits 4 ARROKCF:**清除 ARROK 标志Bits.软件写 1 清除标记Bits,该Bits由硬件清零.

* 0:无操作
* 1:清除操作

**Bits 3 CMPOKCF:**清除 CMPOK 标志Bits.软件写 1 清除标记Bits,该Bits由硬件清零.

* 0:无操作
* 1:清除操作

**Bits 2 EXTTRIGCF:**清除 EXTTRIG 标志Bits.软件写 1 清除标记Bits,该Bits由硬件清零.

* 0:无操作
* 1:清除操作

**Bits 1 ARRMCF:**清除 ARRM 标志Bits.软件写 1 清除标记Bits,该Bits由硬件清零.

* 0:无操作
* 1:清除操作

**Bits 0 CMPMCF:**清除 CMPM 标志Bits.软件写 1 清除标记Bits,该Bits由硬件清零.

* 0:无操作
* 1:清除操作

##### 20.15.3 LPTIM\_IER

Offset:0x08 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:**保留.**Bits 6 DOWNIE:**DOWN interruptEnable.

* 0:禁用interrupt
* 1:Enableinterrupt**Bits 5 UPIE:**UP interruptEnable.
* 0:禁用interrupt
* 1:Enableinterrupt**Bits 4 ARROKIE:**ARROK interruptEnable.
* 0:禁用interrupt
* 1:Enableinterrupt**Bits 3 CMPOKIE:**CMPOK interruptEnable.
* 0:禁用interrupt
* 1:Enableinterrupt**Bits 2 EXTTRIGIE:**EXTTRIG interruptEnable.
* 0:禁用interrupt
* 1:Enableinterrupt**Bits 1 ARRMIE:**ARRM interruptEnable.
* 0:禁用interrupt
* 1:Enableinterrupt**Bits 0 CMPMIE:**CMPM interruptEnable.
* 0:禁用interrupt
* 1:Enableinterrupt

#### 20.15.4 LPTIM\_CFGR

Offset:0x0c 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 |

**Bits 31 RESERVED:**保留.

**Bits 30 OUT\_WKUP\_EN:**LPTIM\_OUT 唤醒Enable.

* 0:LPTIM\_OUT 不能触发唤醒信号
* 1:LPTIM\_OUT 可以触发唤醒信号**Bits 29 DOWN\_WKUP\_EN:**DOWN 事件唤醒Enable.
* 0:DOWN 事件不能触发唤醒信号
* 1:DOWN 事件可以触发唤醒信号**Bits 28 UP\_WKUP\_EN:**UP 事件唤醒Enable.
* 0:UP 事件不能触发唤醒信号
* 1:UP 事件可以触发唤醒信号**Bits 27 EXTTRIG\_WKUP\_EN:**外部触发事件唤醒Enable.
* 0:外部触发事件不能触发唤醒信号
* 1:外部触发事件可以触发唤醒信号**Bits 26 ARRM\_WKUP\_EN:**计数溢出事件唤醒Enable（ENC 模式除外）.
* 0:计数溢出不能触发唤醒信号
* 1:计数溢出事件触发唤醒信号**Bits 25 CMPM\_WKUP\_EN:**计数匹配事件唤醒Enable.
* 0:计数匹配不能触发唤醒信号
* 1:计数匹配事件触发唤醒信号**Bits 24 ENC:**编码模式Enable.
* 0:禁用编码模式
* 1:Enable编码模式**Bits 23 COUNTMODE:**计数模式选择.
* 0:counter由内部clock 控制
* 1:counter由外部clock 控制**Bits 22 PRELOAD:**Register缓存Enable.
* 0:ARR 和 CMP 直接由软件操作
* 1:ARR 和 CMP 由更新事件更新**Bits 21 WAVPOL:**输出波形极性.
* 0:输出不反相
* 1:输出反相**Bits 20 WAVE:**波形形状.
* 0:禁用 Set-once,选择 PWM 或单脉冲模式
* 1:Enable Set-once 模式**Bits 19 TIMEOUT:**Timeout 模式Enable.
* 0:禁用 Timeout 模式
* 1:Enable Timeout 模式**Bits 18-17 TRIGEN:**外部触发Enable及极性选择.
* 00:软件触发
* 01:外部触发上升沿有效
* 10:外部触发下降沿有效
* 11:外部触发双沿有效**Bits 16 RESERVED:**保留.

**Bits 15-13 TRIGSEL:**外部触发源选择.

* 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 **Bits 12 RESERVED:**保留.**Bits 11-9 PRESC:**clock 分频.
* 000:/1
* 001:/2
* 010:/4
* 011:/8
* 100:/16
* 101:/32
* 110:/64
* 111:/128

**Bits 8 TRGLT\_ENABLE:**触发输入滤波器Enable,必须先配置滤波器长度,再Enable.

* 0:禁用触发输入滤波器
* 1:Enable触发输入滤波器

**Bits 7-6 TRGFLT:**触发输入滤波器配置.

* 00:无操作
* 01:Enable滤波器,滤波器长度 N=2
* 10:Enable滤波器,滤波器长度 N=4
* 11:Enable滤波器,滤波器长度 N=8

**Bits 5 CKFLT\_ENABLE:**外部clock 滤波器Enable,必须先配置滤波器长度,再Enable.

* 0:禁用外部clock 滤波器
* 1:Enable外部clock 滤波器

**Bits 4-3 CKFLT:**外部clock 滤波器配置.

* 00:无操作
* 01:Enable滤波器,滤波器长度 N=2
* 10:Enable滤波器,滤波器长度 N=4
* 11:Enable滤波器,滤波器长度 N=8 **Bits 2-1 CKPOL:**Encoder 模式控制.
* 00:选择 Encoder 模式 1,上升沿计数
* 01:选择 Encoder 模式 2,下降沿计数
* 10:选择 Encoder 模式 3,双沿计数
* 11:保留

**Bits 0 RESERVED:**保留.

#### 20.15.5 LPTIM\_CR

Offset:0x10

Reset Value:0x00000000

|  |  |  |  |
| --- | --- | --- | --- |
| **31-3** | **2** | **1** | **0** |
| RESERVED | CNTSTRT | SNGSTRT | ENABLE |
| rw-0h | rw-0h | rw-0h | rw-0h |

**Bits 31-7 RESERVED:**保留.

**Bits 2 CNTSTRT:**连续计数模式Enable.

* 0:Disable
* 1:Enable连续计数模式,写 1 开始连续计数模式,若在连续计数模式过程中置Bits SNGSTRT,则在下一次计数到 ARR 时停止计数（切换到单次计数模式）.该比特Bits需在 ENABLE 置Bits后修改.

**Bits 1 SNGSTRT:**单次计数模式Enable.

* 0:Disable
* 1:Enable单次计数模式,写 1 开始单次计数模式,若在单次计数模式过程中置Bits CNTSTRT,则在下一次计数到 ARR 时继续计数（切换到连续计数模式）.该比特Bits需在 ENABLE 置Bits后修改.

**Bits 0 ENABLE:**LPTIMER Enable.

* 0:禁用 LPTIMER
* 1:Enable LPTIMER

#### 20.15.6 LPTIM\_CMP

Offset:0x14 Reset Value:0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | CMP |
| rw-0h | rw-0h |

**Bits 31-16 RESERVED:**保留.

**Bits 15-0 CMP:**比较值,需在Register LPTIM\_CR 的 ENABLE 置Bits后才能修改.

#### 20.15.7 LPTIM\_ARR

Offset:0x18 Reset Value:0x00000001

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | ARR |
| rw-0h | rw-0h |

**Bits 31-16 RESERVED:**保留.

**Bits 15-0 ARR:**重装载值,需在Register LPTIM\_CR 的 ENABLE 置Bits后才能修改.

#### 20.15.8 LPTIM\_CNT

Offset:0x1c Reset Value:0x00000000

|  |  |
| --- | --- |
| **31-16** | **15-0** |
| RESERVED | CNT |
| r-0h | r-0h |

**Bits 31-16 RESERVED:**保留.**Bits 15-0 CNT:**计数结果,读该值时,连续两次读到的结果一致才算有效.

#### 20.15.9 LPTIM\_CSR

Offset:0x20 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:**保留.

**Bits 4 DOWN\_CLR\_DONE:**DOWN 清除完成.

* 0:正在清除 DOWN 标志Bits
* 1:清除成功**Bits 3 UP\_CLR\_DONE:**UP 清除完成.
* 0:正在清除 UP 标志Bits
* 1:清除成功**Bits 2 EXTTRIG\_CLR\_DONE:**EXTTRIG 清除完成.
* 0:正在清除 EXTTRIG 标志Bits
* 1:清除成功**Bits 1 ARRM\_CLR\_DONE:**ARRM 清除完成.
* 0:正在清除 ARRM 标志Bits
* 1:清除成功**Bits 0 CMPM \_CLR\_DONE:**CMPM 清除完成.
* 0:正在清除 CMPM 标志Bits
* 1:清除成功

#### 20.15.10 LPTIM\_SR1

Offset:0x24

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:**保留.

**Bits 6 DOWN:**编码模式下计数方向由向上变为向下.

* 0:计数方向未发生由上向下的变化
* 1:计数方向由向上变为向下

**Bits 5 UP:**编码模式下计数方向由向下变为向上.

* 0:计数方向未发生由下向上的变化
* 1:计数方向由向下变为向上

**Bits 4 ARROK:**ARR 值加载状态.

* 0:未加载完成
* 1:加载完成

**Bits 3 CMPOK:**CMP 值加载状态.

* 0:未加载完成
* 1:加载完成

**Bits 2 EXTTRIG:**是否检测到有效触发边沿.

* 0:未检测到有效触发边沿
* 1:检测到有效触发边沿**Bits 1 ARRM:**counter值是否到达 ARR 值.
* 0:counter值未到达 ARR
* 1:counter值到达 ARR

**Bits 0 CMPM:**counter值与 CMP 值匹配状态.

* 0:counter值与 CMP 值未匹配
* 1:counter值与 CMP 值匹配

## 21. 直接存储器访问控制器 (DMA)

### 21.1 Introduction

DMA 支持外设到外设,外设到 memory,memory 到外设,memory 到 memory 这四种数据搬移方式,支持数据Bits宽为 8 Bits、16 Bits或 32 Bits,并支持数据的 Auto-reloading 以及数据的链Table（LLI）.共有两个 DMA,分别为 DMA0 和 DMA1,每个 DMA 有 4 个 channel.两个 DMA 相互独立,可以同时工作,每个 DMA 中的 4 个 channel 也是相互独立的,可以同时运行.

### 21.2 Main features

* 传输数据长度的配置
* 支持数据搬移方式的配置
* 支持 Auto-reloading
* 支持 LLI

### 21.3 配置传输数据长度

DMA 可以传输多个 block 的数据,传输每个 block 的数据时先以 burst 方式传送,后面有不够 burst 的数据长度的数据时再以 single 方式发送.外设的数据传输如下Figure:

 **Figure 21-1 数据传输**

DMA 的源和目的数据Bits宽通过 *DMA\_CTLx* Register的 *SRC\_TR\_WIDTH* 和 *DST\_TR\_WIDTH* Bits段进行配置（x 为 0、1、2 或 3）,此Bits段值为 000 时Table示 8bit,为 001 Table示 16bit,为 002 Table示 32bit.

DMA 的源和目的 burst 数据长度通过 *DMA\_CTLx* Register的 *SRC\_MSIZE* 和 *DEST\_MSIZE*

Bits段进行配置,此Bits段值为 000 时Table示 1,为 001 Table示 4,为 002 Table示 8,那么转化为 Bytes 就是 *SRC\_MSIZE (DEST\_MSIZE) \* (*数据Bits宽的*bit*数 */ 8)*.DMA 的 burst 数据长度 Bytes 需要与外设的输入或输出 FIFO 长度一致,否则可能导致数据丢失.

DMA 的 block size 通过 *DMA\_CTLx* Register的 *BLOCK\_TS* Bits进行配置,最多为 12 个 bit,那么 block size 最大为 4095,转换为 Bytes 时为 *BLOCK\_TS \* (*数据Bits宽的*bit*数 */ 8)*.

### 21.4 数据搬移方式

DMA 支持外设到外设,外设到 memory,memory 到外设,memory 到 memory 四种数据搬移方式.外设到外设指数据的源和目的都为外设；外设到 memory 指源为外设,目的为 memory； memory 到外设指源为 memory,目的为外设；memory 到 memory 指源和目的都为 memory.数据搬移方式通过 *DMA\_CTLx* Register的 *TT\_FC* Bits段进行配置.除了 memory 到 memory 的搬移方式,其他几种方式都要配置外设与 DMA 之间的握手信号即 handshake.外设的 handshake 的值如下Table所示:

**Table 21-1 Handshake 值**

|  |  |  |
| --- | --- | --- |
| Handshake值 | 外设信号 | 外设信号Description |
| 4 | lorac\_tx | LORA 的 tx |
| 5 | lorac\_rx | LORA 的 rx |
| 6 | dacctrl | DAC |
| 7 | adcctrl | ADC |
| 10 | i2c2\_tx | I2C2 的 tx |
| 11 | i2c2\_rx | I2C2 的 rx |
| 12 | i2c1\_tx | I2C1 的 tx |
| 13 | i2c1\_rx | I2C1 的 rx |
| 14 | i2c0\_tx | I2C0 的 tx |
| 15 | i2c0\_rx | I2C0 的 rx |
| 16 | ssp2\_tx | SSP2 的 tx |
| 17 | ssp2\_rx | SSP2 的 rx |
| 18 | ssp1\_tx | SSP1 的 tx |
| 19 | ssp1\_rx | SSP1 的 rx |
| 20 | ssp0\_tx | SSP0 的 tx |
| 21 | ssp0\_rx | SSP0 的 rx |
| 22 | lpuart\_tx | LPUAR 的 tx |
| 23 | lpuart\_rx | LPUAR 的 rx |
| Handshake值 | 外设信号 | 外设信号Description |
| 24 | uart3\_tx | UART3 的 tx |
| 25 | uart3\_rx | UART3 的 rx |
| 26 | uart2\_tx | UART2 的 tx |
| 27 | uart2\_rx | UART2 的 rx |
| 28 | uart1\_tx | UART1 的 tx |
| 29 | uart1\_rx | UART1 的 rx |
| 30 | uart0\_tx | UART0 的 tx |
| 31 | uart0\_rx | UART0 的 rx |
| 32 | gptim0\_ch3 | GPTIMER0 的 channel3 |
| 33 | gptim0\_ch2 | GPTIMER0 的 channel2 |
| 34 | gptim0\_ch1 | GPTIMER0 的 channel1 |
| 35 | gptim0\_ch0 | GPTIMER0 的 channel0 |
| 36 | gptim0\_trg | GPTIMER0 的 trigger |
| 37 | gptim0\_up | GPTIMER0 的 update |
| 38 | Gptim1\_ch3 | GPTIMER1 的 channel3 |
| 39 | Gptim1\_ch2 | GPTIMER1 的 channel2 |
| 40 | Gptim1\_ch1 | GPTIMER1 的 channel1 |
| 41 | Gptim1\_ch0 | GPTIMER1 的 channel0 |
| 42 | Gptim1\_trg | GPTIMER1 的 trigger |
| 43 | Gptim1\_up | GPTIMER1 的 update |
| 44 | gptim2\_ch1 | GPTIMER2 的 channel1 |
| 45 | gptim2\_ch0 | GPTIMER2 的 channel0 |
| 46 | gptim2\_trg | GPTIMER2 的 trigger |
| 47 | gptim2\_up | GPTIMER2 的 update |
| 48 | Gptim3\_ch1 | GPTIMER3 的 channel1 |
| 49 | Gptim3\_ch0 | GPTIMER3 的 channel0 |
| 50 | Gptim3\_trg | GPTIMER3 的 trigger |
| 51 | Gptim3\_up | GPTIMER3 的 update |
| 52 | basictim1\_up | BSTIMER1 的 update |
| 53 | basictim0\_up | BSTIMER0 的 update |

### 21.5 LLI

当有多块不连续的memory的数据需要搬移到外设或memory时,可以使用LLI（即链Table方式）,如下Figure所示:



**Figure 21-2 LLI 链Table**

LLI(0)、LLI(1)Table示配置 block0、block1 的信息,包括源目的地址、数据Bits宽、burst 长度和 block 长度.LLPx Table示当前 block 指向下个 block 的地址,第一个 block 的 LLP 指向第二个 block 的地址即 LLI(1)的首地址,依次类推,最后一个 block 的 LLP 为 0.每个 block 长度是可以不一样的,并且 memory 的首地址也是不一样的.

#### 21.6 Auto-reloading

Auto-reloading 指 block 中的 memory 的数据被搬完或 memory 都被写入完成,然后重新从此 memory 的起始地址开始搬送或写入数据,如此循环往复,直至把所用的 DMA 的 channel 去Enable后才会停止.DMA 的源和目的都可以使用 Auto-reloading 功能,只要其为 memory 就可以.

### 21.7 interrupt

DMA 的interrupt信号如下:

**Table 21-2 DMA interrupt信号**

|  |  |
| --- | --- |
| interrupt名称 | Description |
| DMA 块传输完成interrupt | DMA 块传输完成后产生的interrupt |
| DMA 目的端处理完成interrupt | DMA 目的端处理完成后产生的interrupt |
| DMA 源端处理完成interrupt | DMA 源端处理完成后产生的interrupt |
| DMA 传输出错interrupt | DMA 传输过程中产生错误时发生的interrupt |
| DMA 完全传输完成interrupt | DMA 完全传输完成后产生的interrupt |

通过配置 *DMA\_MaskBlock*,*DMA\_MaskDstTran*,*DMA\_MaskSrcTran*,*DMA\_MaskErr* 和 *DMA\_MaskTfr* Register来Enable上述interrupt.

通过 *DMA\_StatusBlock*,*DMA\_StatusDstTran*,*DMA\_StatusSrcTran*,*DMA\_StatusErr* 和 *DMA\_StatusTfr* Register可以获得所有interrupt的状态.

通过配置 *DMA\_ClearBlock*、*DMA\_ClearDstTran*、*DMA\_ClearSrcTran*、*DMA\_ClearErr* 和 *DMA\_ClearTfr* Register来清除interrupt状态.

#### 21.8 DMA 相关RegisterDescription

DMA0 基地址:0x40023000

DMA1 基地址:0x40024000

**Table 21-3 DMA Register Summary**

|  |  |  |
| --- | --- | --- |
| Register | Offset | Description |
| DMA\_SARx | 0x00 | 源地址Register,x Table示 channel 0、1、2、3,Correspond to 的Offset分  别为 0x00、0x58、0xb0、0x108 |
| DMA\_DARx | 0x08 | 目的地址Register,x Table示 channel 0、1、2、3,Correspond to 的Offset分别为 0x08、0x60、0xb8、0x110 |
| DMA\_LLPx | 0x10 | 链Table指针Register,x Table示 channel 0、1、2、3,Correspond to 的Offset分别为 0x10、0x68、0xc0、0x118 |
| DMA\_CTLx | 0x18 | 通道Control Register,x Table示 channel 0、1、2、3,Correspond to 的Offset分别为 0x18、0x70、0xc8、0x120 |
| DMA\_CFGx | 0x40 | 通道配置Register,x Table示 channel 0、1、2、3,Correspond to 的Offset  分别为 0x40、0x98、0xf0、0x148 |
| DMA\_StatusTfr | 0x2e8 | DMA 完全传输完成interrupt状态Register |
| DMA\_StatusBlock | 0x2f0 | DMA 块传输完成interrupt状态Register |
| DMA\_StatusSrcTran | 0x2f8 | DMA 源端处理完成interrupt状态Register |
| DMA\_StatusDstTran | 0x300 | DMA 目的端处理完成interrupt状态Register |
| DMA\_StatusErr | 0x308 | DMA 传输出错interrupt状态Register |
| DMA\_MaskTfr | 0x310 | DMA 完全传输完成interruptEnableRegister |
| DMA\_MaskBlock | 0x318 | DMA 块传输完成interruptEnableRegister |
| DMA\_MaskSrcTran | 0x320 | DMA 源端处理完成interruptEnableRegister |
| DMA\_MaskDstTran | 0x328 | DMA 目的端处理完成interruptEnableRegister |
| DMA\_MaskErr | 0x330 | DMA 传输出错interruptEnableRegister |
| DMA\_ClearTfr | 0x338 | DMA 完全传输完成interrupt状态清除Register |
| DMA\_ClearBlock | 0x340 | DMA 块传输完成interrupt状态清除Register |
| DMA\_ClearSrcTran | 0x348 | DMA 源端处理完成interrupt状态清除Register |
| DMA\_ClearDstTran | 0x350 | DMA 目的端处理完成interrupt状态清除Register |
| DMA\_ClearErr | 0x358 | DMA 传输出错interrupt状态清除Register |
| DMA\_DmaCfgReg | 0x398 | DMA EnableRegister |
| DMA\_ChEnReg | 0x3a0 | DMA channel EnableRegister |

##### 21.8.1 DMA\_SARx

Offset:0x00、0x58、0xb0、0x108 Reset Value:0x0000000000000000

|  |  |
| --- | --- |
| **63-32** | **31-0** |
| RESERVED | SAR |
| r-0h | rw-0h |

**Bits 63-32 RESERVED:**保留.

**Bits 31-0 SAR:**DMA 源地址Register.

##### 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:**保留.

**Bits 31-0 DAR:**DMA 目的地址Register.

##### 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:**保留.

**Bits 31-0 LOC:**下一个 LLI 链Table的首地址.

##### 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:**保留.

**Bits 44 DONE:**LLI 链Table中一个 block 是否传输完成.

* 0:完成
* 1:未完成**Bits 43-32 BLOCK\_TS:**block 的长度.**Bits 31-29 RESERVED:**保留.

**Bits 28 LLP\_SRC\_EN:**DMA 源Enable LLI 链Table.

* 0:去Enable
* 1:Enable**Bits 27 LLP\_DST\_EN:**DMA 目的Enable LLI 链Table.
* 0:去Enable
* 1:Enable**Bits 26-25 SMS:**DMA 源的 AHB master 选择.
* 00:AHB master 1
* 01:AHB master 2
* 10:AHB master 3
* 11:AHB master 4

**Bits 24-23 SMS:**DMA 目的的 AHB master 选择.

* 00:AHB master 1
* 01:AHB master 2
* 10:AHB master 3
* 11:AHB master 4

**22-20 TT\_FC:**DMA 数据搬移方式选择.

* 000:DMA 流控的 Memory 到 Memory 方式
* 001:DMA 流控的 Memory 到外设方式
* 010:DMA 流控的外设到 Memory 方式
* 011:DMA 流控的外设到外设方式
* 其它值:无效**Bits 19 RESERVED:**保留.

**Bits 18 DST\_SCATTER\_EN:**DMA 目的Enable Scatter.

* 0:去Enable
* 1:Enable**Bits 17 SRC\_GATHER\_EN:**DMA 源Enable Gather.
* 0:去Enable
* 1:Enable**Bits 16-14 SRC\_MSIZE:**DMA 源的 Burst 长度配置.
* 000:1
* 001:4
* 010:8
* 其它值:无效**Bits 13-11 DEST\_MSIZE:**DMA 目的的 Burst 长度配置.
* 000:1
* 001:4
* 010:8
* 其它值:无效**Bits 10-9 SINC:**DMA 源地址控制.
* 00:递增
* 01:递减
* 10:不变化
* 11:不变化**Bits 8-7 DINC:**DMA 目的地址控制.
* 00:递增
* 01:递减
* 10:不变化
* 11:不变化**Bits 6-4 SRC\_TR\_WIDTH:**DMA 源数据Bits宽配置.
* 000:8bit
* 001:16bit
* 010:32bit
* 其它值:无效**Bits 3-1 DST\_TR\_WIDTH:**DMA 目的数据Bits宽配置.
* 000:8bit
* 001:16bit
* 010:32bit
* 其它值:无效**Bits 0 INT\_EN:**DMA interruptEnable.
* 0:去Enable
* 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:**保留.**Bits 46-43 DEST\_PER:**DMA 目的握手接口,有效值为 0 至 3. **Bits 42-39 SRC\_PER:**DMA 源握手接口,有效值为 0 至 3.

**Bits 38 SS\_UPD\_EN:**DMA 源状态更新Enable.

* 0:去Enable
* 1:Enable**Bits 37 DS\_UPD\_EN:**DMA 目的状态更新Enable.
* 0:去Enable
* 1:Enable**Bits 36-34 PROTCTL:**保护控制.**Bits 33 FIFO\_MODE:**FIFO 模式选择.
* 0:可以获取全部 FIFO
* 1:只能获得一半 FIFO **Bits 32 FCMODE:**源端流控模式选择.
* 0:源端的Request 发出就处理
* 1:直到目的端有Request 发生才会处理源端的Request

**31 RELOAD\_DST:**DMA 目的Enable Auto-reloading.

* 0:去Enable
* 1:Enable**Bits 30 RELOAD\_SRC:**DMA 源Enable Auto-reloading.
* 0:去Enable
* 1:Enable**Bits 29-20 RESERVED:**保留.

**Bits 19 SRC\_HS\_POL:**DMA 源握手接口信息极性.

* 0:高有效  1:低有效**Bits 18 SRC\_HS\_POL:**DMA 目的握手接口信息极性.
* 0:高有效  1:低有效**Bits 17 LOCK\_B:**总线锁定控制.
* 0:不锁定
* 1:锁定**Bits 16 LOCK\_CH:**DMA channel 锁定控制.
* 0:不锁定
* 1:锁定**Bits 15-14 LOCK\_B\_L:**总线锁定延时.
* 00:等到 DMA 传输完成
* 01:等到 block 传输完成
* 10:等到 DMA 处理完成**Bits 13-12 LOCK\_CH\_L:**DMA channel 锁定延时.
* 00:等到 DMA 传输完成
* 01:等到 block 传输完成
* 10:等到 DMA 处理完成**Bits 11 HS\_SEL\_SRC:**DMA 源握手信号选择.
* 0:硬件握手  1:软件握手**Bits 10 HS\_SEL\_DST:**DMA 目的握手信号选择.
* 0:硬件握手  1:软件握手**Bits 9 FIFO\_EMPTY:**DMA channel FIFO 是否为空.
* 0:非空
* 1:空**Bits 8 CH\_SUSP:**DMA channel FIFO 是否暂停.
* 0:非暂停
* 1:暂停

**7-5 CH\_PRIOR:**DMA channel 优先级配置,有效值为 0 至 3,0 为最低优先级,3 为最高优先级.

**Bits 4-0 RESERVED:**保留.

###### 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:**保留.

**Bits 3 CHAN3\_STATUS:**DMA channel3 的传输完成状态.

* 0:未完成
* 1:完成 **Bits 2 CHAN2\_STATUS:**DMA channel2 的传输完成状态.
* 0:未完成
* 1:完成**Bits 1 CHAN1\_STATUS:**DMA channel1 的传输完成状态.
* 0:未完成
* 1:完成**Bits 0 CHAN0\_STATUS:**DMA channel0 的传输完成状态.
* 0:未完成
* 1:完成

###### 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:**保留.

**Bits 3 CHAN3\_STATUS:**DMA channel3 的块传输完成状态.

* 0:未完成
* 1:完成

**2 CHAN2\_STATUS:**DMA channel2 的块传输完成状态.

* 0:未完成
* 1:完成**Bits 1 CHAN1\_STATUS:**DMA channel1 的块传输完成状态.
* 0:未完成
* 1:完成**Bits 0 CHAN0\_STATUS:**DMA channel0 的块传输完成状态.
* 0:未完成
* 1:完成

###### 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:**保留.

**Bits 3 CHAN3\_STATUS:**DMA channel3 的源端传输完成状态.

* 0:未完成
* 1:完成 **Bits 2 CHAN2\_STATUS:**DMA channel2 的源端传输完成状态.
* 0:未完成
* 1:完成**Bits 1 CHAN1\_STATUS:**DMA channel1 的源端传输完成状态.
* 0:未完成
* 1:完成**Bits 0 CHAN0\_STATUS:**DMA channel0 的源端传输完成状态.
* 0:未完成
* 1:完成

###### 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 |

**63-4 RESERVED:**保留.

**Bits 3 CHAN3\_STATUS:**DMA channel3 的目的端传输完成状态.

* 0:未完成
* 1:完成 **Bits 2 CHAN2\_STATUS:**DMA channel2 的目的端传输完成状态.
* 0:未完成
* 1:完成**Bits 1 CHAN1\_STATUS:**DMA channel1 的目的端传输完成状态.
* 0:未完成
* 1:完成**Bits 0 CHAN0\_STATUS:**DMA channel0 的目的端传输完成状态.
* 0:未完成
* 1:完成

###### 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:**保留.

**Bits 3 CHAN3\_STATUS:**DMA channel3 的传输错误状态.

* 0:未出错
* 1:出错 **Bits 2 CHAN2\_STATUS:**DMA channel2 的传输错误状态.
* 0:未出错
* 1:出错**Bits 1 CHAN1\_STATUS:**DMA channel1 的传输错误状态.
* 0:未出错
* 1:出错**Bits 0 CHAN0\_STATUS:**DMA channel0 的传输错误状态.
* 0:未出错
* 1:出错

###### 21.8.11 DMA\_MaskTfr

Offset:0x310



**Bits 63-12 RESERVED:**保留.

**Bits 11 INT\_MASK\_WE\_3:**DMA channel3 的传输完成interrupt掩码写Enable.

* 0:去Enable
* 1:Enable **Bits 10 INT\_MASK\_WE\_2:**DMA channel2 的传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 9 INT\_MASK\_WE\_1:**DMA channel1 的传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 8 INT\_MASK\_WE\_0:**DMA channel0 的传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 7-4 RESERVED:**保留.

**Bits 3 INT\_MASK\_3:**DMA channel3 的传输完成interruptEnable.

* 0:去Enable
* 1:Enable **Bits 2 INT\_MASK\_2:**DMA channel2 的传输完成interruptEnable.
* 0:去Enable
* 1:Enable**Bits 1 INT\_MASK\_1:**DMA channel1 的传输完成interruptEnable.
* 0:去Enable
* 1:Enable**Bits 0 INT\_MASK\_0:**DMA channel0 的传输完成interruptEnable.
* 0:去Enable

###### 21.8.12 DMA\_MaskBlock

Offset:0x318



**Bits 63-12 RESERVED:**保留.

**Bits 11 INT\_MASK\_WE\_3:**DMA channel3 的块传输完成interrupt掩码写Enable.

* 0:去Enable
* 1:Enable **Bits 10 INT\_MASK\_WE\_2:**DMA channel2 的块传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 9 INT\_MASK\_WE\_1:**DMA channel1 的块传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 8 INT\_MASK\_WE\_0:**DMA channel0 的块传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 7-4 RESERVED:**保留.

**Bits 3 INT\_MASK\_3:**DMA channel3 的块传输完成interruptEnable.

* 0:去Enable
* 1:Enable **Bits 2 INT\_MASK\_2:**DMA channel2 的块传输完成interruptEnable.
* 0:去Enable
* 1:Enable**Bits 1 INT\_MASK\_1:**DMA channel1 的块传输完成interruptEnable.
* 0:去Enable
* 1:Enable**Bits 0 INT\_MASK\_0:**DMA channel0 的块传输完成interruptEnable.
* 0:去Enable

###### 21.8.13 DMA\_MaskSrcTran

Offset:0x320



**Bits 63-12 RESERVED:**保留.

**Bits 11 INT\_MASK\_WE\_3:**DMA channel3 的源端传输完成interrupt掩码写Enable.

* 0:去Enable
* 1:Enable **Bits 10 INT\_MASK\_WE\_2:**DMA channel2 的源端传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 9 INT\_MASK\_WE\_1:**DMA channel1 的源端传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 8 INT\_MASK\_WE\_0:**DMA channel0 的源端传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 7-4 RESERVED:**保留.

**Bits 3 INT\_MASK\_3:**DMA channel3 的源端传输完成interruptEnable.

* 0:去Enable
* 1:Enable **Bits 2 INT\_MASK\_2:**DMA channel2 的源端传输完成interruptEnable.
* 0:去Enable
* 1:Enable**Bits 1 INT\_MASK\_1:**DMA channel1 的源端传输完成interruptEnable.
* 0:去Enable
* 1:Enable**Bits 0 INT\_MASK\_0:**DMA channel0 的源端传输完成interruptEnable.
* 0:去Enable

###### 21.8.14 DMA\_MaskDstTran

Offset:0x328



**Bits 63-12 RESERVED:**保留.

**Bits 11 INT\_MASK\_WE\_3:**DMA channel3 的目的端传输完成interrupt掩码写Enable.

* 0:去Enable
* 1:Enable **Bits 10 INT\_MASK\_WE\_2:**DMA channel2 的目的端传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 9 INT\_MASK\_WE\_1:**DMA channel1 的目的端传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 8 INT\_MASK\_WE\_0:**DMA channel0 的目的端传输完成interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 7-4 RESERVED:**保留.

**Bits 3 INT\_MASK\_3:**DMA channel3 的目的端传输完成interruptEnable.

* 0:去Enable
* 1:Enable **Bits 2 INT\_MASK\_2:**DMA channel2 的目的端传输完成interruptEnable.
* 0:去Enable
* 1:Enable**Bits 1 INT\_MASK\_1:**DMA channel1 的目的端传输完成interruptEnable.
* 0:去Enable
* 1:Enable**Bits 0 INT\_MASK\_0:**DMA channel0 的目的端传输完成interruptEnable.
* 0:去Enable

###### 21.8.15 DMA\_MaskErr

Offset:0x330



**Bits 63-12 RESERVED:**保留.

**Bits 11 INT\_MASK\_WE\_3:**DMA channel3 的传输出错interrupt掩码写Enable.

* 0:去Enable
* 1:Enable **Bits 10 INT\_MASK\_WE\_2:**DMA channel2 的传输出错interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 9 INT\_MASK\_WE\_1:**DMA channel1 的传输出错interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 8 INT\_MASK\_WE\_0:**DMA channel0 的传输出错interrupt掩码写Enable.
* 0:去Enable
* 1:Enable**Bits 7-4 RESERVED:**保留.

**Bits 3 INT\_MASK\_3:**DMA channel3 的传输出错interruptEnable.

* 0:去Enable
* 1:Enable **Bits 2 INT\_MASK\_2:**DMA channel2 的传输出错interruptEnable.
* 0:去Enable
* 1:Enable**Bits 1 INT\_MASK\_1:**DMA channel1 的传输出错interruptEnable.
* 0:去Enable
* 1:Enable**Bits 0 INT\_MASK\_0:**DMA channel0 的传输出错interruptEnable.
* 0:去Enable

###### 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:**保留.

**Bits 3 CHAN3\_CLEAR:**DMA channel3 的传输完成状态清除.

* 0:不操作
* 1:清除 **Bits 2 CHAN2\_CLEAR:**DMA channel2 的传输完成状态清除.
* 0:不操作
* 1:清除**Bits 1 CHAN1\_CLEAR:**DMA channel1 的传输完成状态清除.
* 0:不操作
* 1:清除**Bits 0 CHAN0\_CLEAR:**DMA channel0 的传输完成状态清除.
* 0:不操作
* 1:清除

###### 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:**保留.

**Bits 3 CHAN3\_CLEAR:**DMA channel3 的块传输完成状态清除.

* 0:不操作
* 1:清除 **Bits 2 CHAN2\_CLEAR:**DMA channel2 的块传输完成状态清除.
* 0:不操作
* 1:清除**Bits 1 CHAN1\_CLEAR:**DMA channel1 的块传输完成状态清除.
* 0:不操作
* 1:清除

**Bits 0 CHAN0\_CLEAR:**DMA channel0 的块传输完成状态清除.

* 0:不操作
* 1:清除

###### 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:**保留.

**Bits 3 CHAN3\_CLEAR:**DMA channel3 的源端传输完成状态清除.

* 0:不操作
* 1:清除 **Bits 2 CHAN2\_CLEAR:**DMA channel2 的源端传输完成状态清除.
* 0:不操作
* 1:清除**Bits 1 CHAN1\_CLEAR:**DMA channel1 的源端传输完成状态清除.
* 0:不操作
* 1:清除**Bits 0 CHAN0\_CLEAR:**DMA channel0 的源端传输完成状态清除.
* 0:不操作
* 1:清除

###### 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:**保留.

**Bits 3 CHAN3\_CLEAR:**DMA channel3 的目的端传输完成状态清除.

* 0:不操作
* 1:清除 **Bits 2 CHAN2\_CLEAR:**DMA channel2 的目的端传输完成状态清除.
* 0:不操作
* 1:清除**Bits 1 CHAN1\_CLEAR:**DMA channel1 的目的端传输完成状态清除.
* 0:不操作
* 1:清除**Bits 0 CHAN0\_CLEAR:**DMA channel0 的目的端传输完成状态清除.
* 0:不操作
* 1:清除

###### 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:**保留.

**Bits 3 CHAN3\_CLEAR:**DMA channel3 的传输出错状态清除.

* 0:不操作
* 1:清除 **Bits 2 CHAN2\_CLEAR:**DMA channel2 的传输出错状态清除.
* 0:不操作
* 1:清除**Bits 1 CHAN1\_CLEAR:**DMA channel1 的传输出错状态清除.
* 0:不操作
* 1:清除**Bits 0 CHAN0\_CLEAR:**DMA channel0 的传输出错状态清除.
* 0:不操作
* 1:清除

###### 21.8.21 DMA\_DmaCfgReg

Offset:0x398 Reset Value:0x0000000000000000

|  |  |
| --- | --- |
| **63-1** | **0** |
| RESERVED | DMA\_EN |
| r-0h | rw-0h |

**Bits 63-1 RESERVED:**保留.**Bits 0 DMA\_EN:**DMA Enable控制.

* 0:去Enable
* 1:Enable

###### 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:**保留.

**Bits 11 CH\_EN\_WE\_3:**DMA channel3 的Enable控制信息的写Enable.

* 0:去Enable
* 1:Enable **Bits 10 CH\_EN\_WE\_2:**DMA channel2 的Enable控制信息的写Enable.
* 0:去Enable
* 1:Enable**Bits 9 CH\_EN\_WE\_1:**DMA channel1 的Enable控制信息的写Enable.
* 0:去Enable
* 1:Enable**Bits 8 CH\_EN\_WE\_0:**DMA channel0 的Enable控制信息的写Enable.
* 0:去Enable
* 1:Enable**Bits 7-4 RESERVED:**保留.

**Bits3 CH\_EN\_3:**DMA channel3的Enable控制,当DMA传输完成后,硬件自动将此channel去Enable.

* 0:去Enable
* 1:Enable **Bits2 CH\_EN\_2:**DMA channel2的Enable控制,当DMA传输完成后,硬件自动将此channel去Enable.
* 0:去Enable
* 1:Enable**Bits1 CH\_EN\_1:**DMA channel1的Enable控制,当DMA传输完成后,硬件自动将此channel去Enable.
* 0:去Enable
* 1:Enable**Bits0 CH\_EN\_0:**DMA channel0的Enable控制,当DMA传输完成后,硬件自动将此channel去Enable.
* 0:去Enable
* 1:Enable

### 22. 通用定时器 (GPTIMER)

#### 22.1 Introduction

ASR6601 共有 4 个通用定时器（GPTIMER）,其中 GPTIMER0 和 GPTIMER1 有 4 路通道,

GPTIMER2 和 GPTIMER3 有 2 路通道,即 GPTIMER2 和 GPTIMER3 没有通道 2 和 3.

GPTIMER包含16-bitcounter,支持自动重装载功能,且支持最多16-bit可编程的分频counter, 4 路通道可独立配置为输入或输出,支持输入捕获、输出比较等功能,计数clock 和计数模式可软件配置,支持连接霍尔器件即支持编码模式（仅适用于 GPTIMER0 和 GPTIMER1）,支持 DMA 配置,有独立interrupt输出,支持编码功能等.基于丰富的通道配置和功能,该 GPTIMER 可用于定时计数、测量输入脉冲宽度（us-ms 级）、产生 PWM 波形等应用.

##### 22.2 Main features

* 16-bit counter,支持自动重装载,可配置边沿对齐（向上、向下）计数和中间对齐（向上/ 向下）计数
* 16-bit 可编程分频counter（分频系数 1-65535）,可在计数过程中配置
* 最多 4 路独立通道,可完成输入捕获、输出比较、PWM 波形输出、单脉冲波形输出
* 支持通道输出极性选择,和输入边沿配置
* 支持与外部输入或其他模块（GPTIMER、ADC、DAC）同步
* 独立的 DMA 通道,最多 6 组 DMA Request ,包括更新事件、触发事件以及 4 组通道事件（捕获、比较）
* 支持正交编码功能
* 支持外部触发通道输入clock 用于计数并且支持外部触发通道输入触发信号,支持通道输入clock 用于计数
* 支持通道重映射,即把其它模块的 GPIO 信号或内部信号映射到通道或外部通道

GPTIMER 的架构框Figure如下:



**Figure 22-1 GPTIMER 框Figure**

**Table 22-1 GPTIMER 模块介绍**

|  |  |
| --- | --- |
| Module name | Description |
| slave control | 从模式控制器 |
| master control | 主模式控制器 |
| u\_etr\_ctrl | ETR 通道控制,包括极性、分频、滤波等配置 |
| u\_channel\_in\_x | 输入通道 x 控制,包括极性、滤波及边沿配置 |
| u\_icx\_div | 输入通道 x 事件分频器 |
| u\_sampling\_clock | 产生滤波器的采样clock |
| u\_capture\_x | 输入通道 x 捕获功能 |
| u\_compare\_x | 输出通道 x 比较功能 |
| u\_psc\_counter | 16-bit 分频counter |
| u\_counter | 16-bit counter |
| u\_reg\_model | Register相关配置 |
| output stage | 输出控制 |
| interrupt control | interrupt控制 |
| dma control | DMA 功能控制 |
| itr\_input | 其它 GPTIMER 的内部输入 |
| etr\_input | 外部触发通道的输入 |
| channel\_input | 通道输入 |
| dma\_ack | DMA 回复的 ACK |
| dma\_req | 向 DMA 发送的Request |
| apb\_write | apb 总线写 |
| Module name | Description |
| apb\_read | apb 总线读 |
| trigger\_output | 主模式下的信号输出,为内部信号,不会输出到外部 |
| channel\_output | 通道输出 |

#### 22.3 counter

GPTIMER的counter共16-bit,支持向上、向下、中间对齐计数,计数clock 可选,可软件配置计数Enable与关闭,软件可随时读写（建议不要在计数过程中写入,以免发生未知错误）.

##### 22.3.1 计数clock 选择

GPTimer 共有四种计数clock 源,分别是内部clock 、外部clock 模式 1、外部clock 模式 2 以及内部触发信号控制计数.其中,内部clock 为默认方式（SMS==3’b000）,clock 来自 RCC,只要 CEN 置Bits,则分频counter和该counter便开始计数,其他三种情况,均使用相应信号作为计数Enable,并不是作为真正的clock .

外部clock 模式 1（SMS==3’b111,TS==3’b100/101/110）,该模式下,counter由所选择的通道输入的上升沿或下降沿或双沿作为counter的计数Enable控制计数,例如选择通道 0 的上升沿控制计数,则每个上升沿都会让counter加 1（向上计数、不分频）,波形如下Figure:

 **Figure 22-2 外部clock 模式 1 计数**

外部clock 模式2（ECE==1）,该模式下,counter由ETR 的上升沿或下降沿作为counter的计数Enable控制计数,例如配置 ETR 的上升沿有效,则波形如下Figure所示.

 **Figure 22-3 外部clock 模式 2 计数**

GPTIMER 还可以选择内部触发信号控制计数（SMS==3’b111,TS==3’b001/010/011）,即可以由上一级 GPTIMER 的触发输出信号作为该 GPTIMER 的计数clock ,从而实现 GPTIMER 的级联,该情况下,上一级 GPTIMER 相当于一个分频counter,波形如下Figure所示.



###### Figure 22-4 内部触发信号做clock 计数

当ETR做为计数clock 输入时可以有两种方式实现,一种是外部clock 模式1,配置SMS==3’b111,

TS==3’b111,另一种是外部clock 模式 2,配置 ECE==1

###### 22.3.2 自动重装载

GPTIMER 支持自动重装载功能,向上计数时,计数到重装载值（ARR）后,将会归零重新计数,向下计数时,会从 ARR 开始计数,计数到 0 后回到 ARR 重新计数,中间对齐计数时,counter从 0 开始计数到 ARR-1,接着从 ARR 计数到 0.

ARR 可软件配置（ARPE）是否使用启用影子Register,如果 ARPE=0,则禁用影子Register,软件写入的值同步更新到 ARR 供counter使用,如果 ARPE=1,则软件写入的值不会立即生效,直到更新事件到来,才会将该值更新到影子Register中供counter使用.

###### 22.3.3 向上计数

若配置为向上计数模式,则counterEnable且有计数clock 后,会从 0 开始递加到 ARR,产生向上溢出事件（overflow）,然后归零重新开始计数.计数过程中如果 UG 置Bits（软件或硬件）,则counter包括分频counter会被初始化（归零）.时序上,overflow标志将在最后一个计数值期间产生,如果启用影子Register,则 ARR、PSC、CCRx 等Register将会在下一轮计数开始时更新到相应的影子Register,波形如下Figure所示.



**Figure 22-5 向上计数**

###### 22.3.4 向下计数

若配置为向下计数模式,则counterEnable且有计数clock 后,会从 ARR 开始递减到 0,产生向下溢

出事件（underflow）,然后回到 ARR 重新开始计数.计数过程中如果 UG 置Bits（软件或硬件）,则counter包括分频counter会被初始化（counter回到 ARR,分频counter归零）.时序上,

underflow 标志将在最后一个计数值（CNT=0）期间产生,但是请注意,如果启用影子Register,则 ARR Register将会在下一轮计数开始之前（CNT=0）更新到相应的影子Register,以保证下一轮计数过程可以使用最新的装载值和分频值,PSC 和 CCRx 则与之前相同,将在 underflow 下一clock 更新到影子Register,波形如下Figure所示.

 **Figure 22-6 向下计数**

##### 22.3.5 中间对齐计数

若配置为中间对齐计数模式,则counterEnable且有计数clock 后,会从 0 开始递增到 ARR-1,产生 overflow 事件,然后从 ARR 递减到 1,产生 underflow 事件,再从 0 开始重新计数.计数过程中如果 UG 置Bits（软件或硬件）,则counter包括分频counter会被初始化（归零）.请注意,如果启用影子Register,则 ARR 和 PSC Register将会在向上计数到老的 ARR-1 时更新到相应的影子Register,以保证在向下计数时可以使用新的 ARR 和新的 PSC,CCRx 的更新与之前情况相同.向下计数时,将会在产生 underflow 后更新 ARR、PSC 和 CCRx 的影子Register.在该模式下,计数方向由硬件控制,软件配置无效.波形如Figure,



**Figure 22-7 中间对齐计数**

##### 22.4 分频counter

GPTIMER 支持 16-bit（1~65535）可编程分频,这一功能通过该分频counter实现.上一级电路产生的计数Enable信号将作为该分频counter的Enable控制计数,当分频counter计数到预先加载的分频值后,输出一个脉冲,作为下一级counter的计数Enable,然后分频counter归零重新计数,如此循环.

分频counter的分频值默认启用影子Register,即软件的写操作不会立即生效,而是直到更新事件

（UG 置Bits、计数溢出）到来,才会将新的分频值写入影子Register,此时该分频值才正式生效.

软件读操作读取的是写入的Register值,而不是影子Register,如果在更新事件到来前有多次写操作,则会覆盖之前写入的值.

举一个例子说明分频counter,如配置为 4 分频,则输入 4 个高电平,才会输出一个有效的脉冲,波形如下Figure（通道 0,无滤波,选择通道 0 上升沿作为有效脉冲,配置 ic0 为 4 分频）.



**Figure 22-8 分频counter**

##### 22.5 采样clock

各输入通道和外部触发通道均可以选择数字滤波功能,该数字滤波功能通过使用高频的采样clock （频率至少是输入信号的 4 倍）对输入信号采样.GPTIMER 内部所有 Flip-Flop 的clock 均由 pclk 提供.软件可以配置采样clock 的频率（CKD 分别为 pclk、pclk/2,pclk/4）,通过采用counter实现分频,如配置采样频率为 pclk 的 4 分频,则counter由 pclk 控制计数,每 4 个 pclk 周期产生一个脉冲（宽度为 pclk 的一个周期）,用于后级counter的Enable信号.在各通道内,用户还可以再次配置数字滤波器的采样clock 分频,即配置 ETF 的值,滤波原理上述相同.

#### 22.6 通道

每个 GPTIMER 的各个通道有多路来源,这些信号来源与 GPTIMER 均为异步关系,因此在模块内部需要做同步处理.同步后的通道输入信号,可以根据软件配置进行滤波处理,滤波的采样频率和窗口长度均可以软件配置（ICxF）,滤波后的信号由一个边沿检测器产生边沿信号,可以由软件配置有效电平（或有效边沿）.处理后的通道信号可以作为从模式控制器的控制信号,编码模式输入信号,也可以作为输入捕获Enable信号（可配置分频）.每个输入通道可映射到当前通道、相邻通道或内部触发信号 TRC（CCxS[1:0]配置）,具体方案见Table格（以通道 0 为例）,其中 ti0fp0 为映射到通道 0 的输入信号,ti1fp0 为映射到通道 1 的输入信号.

##### Table 22-2 输入通道有效极性配置

|  |  |  |  |
| --- | --- | --- | --- |
| {CC0NP, CC0P} | 有效脉冲（应用于输入捕获、复Bits模式、触发模式、外部clock 模式） | | 有效电平（应用于Gate 模式、编码模式） |
| ti0fp0 | ti1fp0 | ti0fp |
| 2’b00 | 通道 0 上升沿 | 通道 1 上升沿 | 通道 0 高电平 |
| 2’b01 | 通道 0 下降沿 | 通道 1 下降沿 | 通道 0 低电平 |
| 2’b10 | 保留 | 保留 | 保留 |
| 2’b11 | 通道 0 双沿 | 通道 1 双沿 | 通道 0 高电平 |

##### Table 22-3 输入通道映射

|  |  |
| --- | --- |
| CCxS | icx映射 |
| 2’b01 | tixfpx（x 代Table当前通道） |
| 2’b10 | tiyfpx（y 代Table相邻通道） |
| 2’b11 | trc（仅适用于 TS=3’b000、3’b001、3’b010、3’b100） |

此外,通道 0 与其他通道不同,可以软件配置（TI0S 置Bits）通道 0 连接到通道 0、通道 1 和通

道2的异或输出,此时该通道的其他功能依然有效,该功能仅适用于GPTIMER0和GPTIMER1.

##### 22.6.1 输入捕获

输入捕获仅在通道被配置为输入模式且 CCxE 置Bits时被激活,可以由软件（CCxG）或硬件

（当前通道、相邻通道或内部互联信号）触发捕获行为.当有效的捕获触发信号产生时, GPTIMER 会把当前 counter 的值锁存到相应的 CCRx Register中,并且置Bits CCxIF 标志Bits,如果Enable了相应interrupt或 DMA 屏蔽Bits,则会产生interrupt信号或 DMA Request .如果 CCxIF 置Bits时（未被软件清除）又发生了不止一次捕获行为,则 CCxOF 置Bits,指示发生了捕获溢出事件,读取

CCxR Register（或 SR Register相应Bits写 0）可以清除 CCxIF 和 CCxOF.波形如下Figure所示.

 **Figure 22-9 输入捕获**

##### 22.6.2 输出比较

输出比较功能仅在通道被配置为输出模式且 CCxE 置Bits时被激活,该功能通过比较 counter 值与 CCRx 的值,控制通道输出高低翻转,进而输出特定的波形.

###### 22.6.2.1 CCRx 预装载功能

CCRx Register的写入有两种方式,若 CCxPE 置Bits,则软件写入的 CCRx 值不会直接被使用,真正起作用的是影子Register,作为缓冲,直到更新事件发生后,才会将 CCRx 的值更新到影子Register中；若 OCxPE 复Bits,则软件写入的 CCRx 值会直接被使用,影子Register禁用.

###### 22.6.2.2 输出比较模式

当匹配（CNT==CCR）发生时,通道输出会根据配置的模式进行翻转,且 CCxIF 标志Bits会置Bits,若Enable了相应的interrupt或 DMA 屏蔽Bits,则会产生interrupt或 DMA Request ,具体的模式控制如下Table格所示.

Table 22-4 输出比较各种模式下的输出波形Description

|  |  |  |
| --- | --- | --- |
| 比较模式 | 计数模式 | 输出波形 |
| 冻结模式 | Any | 无论 CNT 如何变化,输出维持不变 |
| SET 模式 | Any | 在 CNT==CCR 后,输出高电平 |
| RESET 模式 | Any | 在 CNT==CCR 后,输出低电平 |
| TOGGLE 模式 | Any | 在 CNT==CCR 时,翻转当前电平 |
| 强制 RESET 模式 | Any | 选择该模式后,直接输出低电平,忽略比较结果 |
| 强制 SET 模式 | Any | 选择该模式后,直接输出高电平,忽略比较结果 |
| PWM1 模式 | 向上计数（边  沿对齐 pwm） | CNT<CCR 时,输出高电平,CNT>=CCR 时,输出低电平.如果 CCR>ARR,则输出一直为高电平（100%PWM）,如果  CCR==0,则输出一直为低电平（0%PWM）. |
| 向下计数（边  沿对齐 pwm） | CNT<=CCR 时,输出高电平,CNT>CCR 时,输出低电平.  如果 CCR>ARR,则输出一直为高电平（100%PWM）.Note: 0%PWM 模式在该情况下不支持. |
| 中间计数（中  间对齐 pwm） | 相当于向上计数与向下计数相结合.如果 CCR>=ARR,则输出一直为高电平（100%PWM）,如果 CCR==0,则输出一直为低电平（0%PWM）. |
| PWM2 模式 | 向上计数（边  沿对齐 pwm） | CNT<CCR 时,输出低电平,CNT>=CCR 时,输出高电平.  如果 CCR>ARR,则输出一直为低电平（0%PWM）,如果  CCR==0,则输出一直为高电平（100%PWM）. |
| 向下计数（边  沿对齐 pwm） | CNT<=CCR 时,输出低电平,CNT>CCR 时,输出高电平.如果 CCR>ARR,则输出一直为低电平（0%PWM）.Note:  100%PWM 模式在该情况下不支持. |
| 中间计数（中  间对齐 pwm） | 相当于向上计数与向下计数相结合.如果 CCR>=ARR,则输出一直为低电平（0%PWM）,如果 CCR==0,则输出一直为高电平（100%PWM）. |

**各模式下输出波形**如下所示（以向上计数为例）:



Figure 22-10 各种输出比较模式下的波形

其中,PWM 模式下还支持通过配置 ARR 和 CCR 控制输出 0%和 100%波形,边沿对齐计数的

PWM2 波形如下Figure所示.



**Figure 22-11 边沿对齐计数 PWM2** 中间对齐计数的 PWM2 波形如下Figure所示.

 **Figure 22-12 中间对齐计数 PWM2**

22.6.2.3 单脉冲快速输出功能

单脉冲模式下（OPM 置Bits）,两个 PWM 模式可以配置为快速输出模式（置Bits OCxFE）,Enable快速模式后,输出波形将忽略 CNT 和 CCR 的比较结果,改为由触发信号（根据 TS 选择）上升沿控制电平翻转,输出信号电平等同于匹配事件发生后的电平,例如,配置 GPTIMER 通道 0 为输出模式,选择 PWM1 模式,触发信号选择 ETR 输入,则当 ETR 输入高电平后,通道 0 立刻输出高电平（OCxP=0 情况下）,该功能可以有效减少从触发信号边沿到波形输出之间的延迟.Enable快速模式时的单脉冲输出波形如下Figure:

 **Figure 22-13 Enable快速模式时的单脉冲输出波形**

22.6.2.4 外部触发信号清除通道输出功能

输出波形除了受计数值的影响,还可以通过外部触发信号（ETR）硬件清零,若要使用该功能,需提前Enable OCxCE Bits,同时保证 ETR 禁用分频（ETP=2’b00）,且 ETR 不得作为计数clock .Enable该功能后（OCxCE=1）,ETR 的电平有效（默认高电平）时,通道输出将被清除,更改 ETR的有效电平时通过配置ETP实现.关闭该功能后（OCxCE=0）,通道输出不会立刻恢复,而是等到下一次计数周期开始才会恢复正常输出.开启和关闭外部触发信号清除通道输出功能的对比波形如下Figure:

 **Figure 22-14 外部触发信号清除通道输出**

##### 22.7 触发输入通道

每个 GPTIMER 的 ETR 有多路来源,通过 MUX 选择一路输入到模块内,这些信号来源与 GPTIMER 均为异步关系,因此在模块内部需要做同步处理.同步后的 ETR 信号,可以根据软件配置选择有效电平（或有效边沿）、配置分频（1、2、4、8）以及滤波处理,滤波的采样频率和窗长度均可以软件配置（ETF）.

##### 22.8 更新事件管理

更新事件主要有以下事件源:

1. counter的溢出事件（overflow 和 underflow）
2. UG 置Bits

与更新事件管理相关的控制信号主要是 URS 和 UDIS,具体控制如下:

* 若 UDIS=0,URS=0,则 underflow、overflow、UG 置Bits会初始化 counter 和 pre-scale counter（center-aligned 模式下 counter 不会被 overflow 清零,也不会被 underflow 加载 ARR）,如果启用影子Register,更新事件将会把写入的值更新到影子Register中（ARR 取决于 ARPE,CCRx 取决于 OCxPE）,UIF 会置Bits,如果Enable了interrupt或 DMA 屏蔽Bits,则会产生interrupt或 DMA Request .
* 若 UDIS=0,URS=1,则 underflow、overflow、UG 置Bits会初始化 counter 和 pre-scale counter（center-aligned 模式下 counter 不会被 overflow 清零,也不会被 underflow 加载 ARR）,如果启用影子Register,更新事件将会把写入的值更新到影子Register中（ARR 取决于ARPE,CCRx取决于 OCxPE）,UIF 只会在 overflow或underflow情况下置Bits,如果Enable了interrupt或 DMA 屏蔽Bits,则会产生interrupt或 DMA Request ,该配置可以有效避免输入捕获模式下 UG 置Bits初始化counter时,同时产生捕获interrupt和更新interrupt的情况.
* 若 UDIS=1（忽略 URS）,则 underflow、overflow、UG 置Bits会初始化 counter 和 prescale counter（center-aligned模式下counter不会被overflow清零,也不会被underflow 加载 ARR）,但是影子Register不会被更新,且 UIF 不会置Bits,因此不会产生相应interrupt或

DMA Request .

##### 22.9 编码模式控制

该 GPTIMER 支持正交编码计数功能,可以通过通道 0 和通道 1 输入正交信号,进行计数和方向检测.编码模式共有三种,仅在通道 0 边沿计数、仅在通道 1 边沿计数以及在通道 1 和通道 2 边沿计数.在此功能下,两个通道输入可以配置数字滤波功能,极性配置和分频配置无效.通过两个通道信号的组合,可以产生计数Enable和方向控制信号,控制counter加减（如果CENEnable）,因此在该模式下,软件配置计数方向无效.具体的组合方式见下Table,

###### Table 22-5 编码模式

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 编码模式 | 通道0/1电平 | 通道0边沿 | | 通道1电平 | |
| 上升沿 | 下降沿 | 上升沿 | 下降沿 |
| 编码模式 1  （在通道 1 边沿计数） | 高电平 | - | - | 向上计数 | 向下计数 |
| 低电平 | - | - | 向下计数 | 向上计数 |
| 编码模式 2  （在通道 0 边沿计数） | 高电平 | 向下计数 | 向上计数 | - | - |
| 低电平 | 向上计数 | 向下计数 | - | - |
| 编码模式 3  （在所有通道边沿计数） | 高电平 | 向下计数 | 向上计数 | 向上计数 | 向下计数 |
| 低电平 | 向上计数 | 向下计数 | 向下计数 | 向上计数 |

在编码模式下,counter同样是在 0-ARR 之间计数,向上计数到 ARR 时会产生 overflow,然后回到 0 重新计数,向下计数到 0 时会产生 underflow,然后回到 ARR 重新计数.此外,在该模式下,输入捕获（通道 2 和通道 3）、输出比较、分频、触发输出功能依然适用.编码模式 1 的计数波形Figure如下:



**Figure 22-15 编码模式 1 的计数波形**

##### 22.10 从模式控制

GPTIMER 支持级联操作,作为外部或内部模块的从机.从模式的触发输入信号 TRGI 有多路来源,通过 TS[2:0] 进行选择,结构如上Figure,其中 ITRx 来自于内部其他 GPTIMER 的触发输出信号（TRGO）,具体映射关系见下Table.

###### Table 22-6 各 GPTIMER 的内部触发输入映射

|  |  |  |  |
| --- | --- | --- | --- |
| 从机GPTIMER | ITR0 | ITR1 | ITR2 |
| GPTIMER0 | GPTIMER2 | GPTIMER3 | GPTIMER1 |
| GPTIMER1 | GPTIMER0 | GPTIMER3 | GPTIMER2 |
| GPTIMER2 | GPTIMER3 | GPTIMER0 | - |
| GPTIMER3 | GPTIMER1 | GPTIMER2 | - |

从模式控制主要有以下四种方式:

1. **复Bits模式**:TRGI 的上升沿将会初始化counter和分频counter,并且可以更新影子Register

（UDIS=0 时）,从模式下复Bits模式波形Figure如下:

 **Figure 22-16 从模式下的复Bits模式波形**

1. **门控模式**:TRGI 电平可以控制counter的运行和停止,默认有效电平下,高电平时counter计数,低电平时counter停止计数（不是复Bits）,在该模式下,CEN 需要软件置Bits.从模式下门控模式波形Figure如下:

 **Figure 22-17 从模式下的门控模式波形**

1. **触发模式**:TRGI 的上升沿可以控制counter开始计数,但是无法控制counter是否停止,在该模式下,CEN 不需要软件置Bits.从模式下触发模式波形Figure如下:

 **Figure 22-18 从模式下的触发模式波形**

1. **clock 模式（即外部clock 模式 1）**:TRGI 的上升沿作为counter的计数Enable控制计数,此时分频电路依然有效.

在从模式下,TRGI 的上升沿会置Bits TIF 标志Bits,如果Enable了相应interrupt或 DMA 屏蔽Bits,则会产生interrupt或 DMA Request .但是门控模式有一些特殊,在该模式下,除上升沿外,下降沿也可以置Bits TIF.

另外使用 GPTIMER 级联时,需要保证主从的clock 同频同相,否则会发生未知错误.

##### 22.11 主模式控制

GPTIMER也可以作为主模式使用,通过产生触发输出信号（TRGO）来控制其他GPTIMER或

ADC 和 DAC.TRGO 信号的来源可以由软件配置,具体如下:

* MMS=3’b000:复Bits模式,此时 UG 标志Bits将作为 TRGO 信号输出给外部从机.
* MMS=3’b001:Enable模式,此时counter的计数Enable将作为 TRGO 信号输出给外部从机.如果当前GPTIMER同时处于从机门控模式,则该信号为门控信号,否则直接将CEN作为 TRGO 信号输出.
* MMS=3’b010:更新模式,此时将更新事件作为 TRGO 信号输出.
* MMS=3’b011:通道 0 比较脉冲模式,此时如果 CC0IF 将置Bits,则输出一个脉冲作为

TRGO 信号,无论此时 CC0IF 是否已经置Bits.

* MMS=3’b100:比较模式 1,此时将 OC0REF 作为 TRGO 信号输出.  MMS=3’b101:比较模式 2,此时将 OC1REF 作为 TRGO 信号输出.
* MMS=3’b110:比较模式 3,此时将 OC2REF 作为 TRGO 信号输出.
* MMS=3’b111:比较模式 4,此时将 OC3REF 作为 TRGO 信号输出.

**Note:** 后*4*种模式输出的信号*OCxREF*,并不是最终的通道输出,而是内部信号.

GPTIMER 配置为主机Enable模式时,有一种特殊应用,即同步启动主机和从机的counter.但是因为主机的 CEN 作为 TRGO 输出到从机并Enable从机counter需要两个clock 的延迟（假定主从clock 同频同相）,因此在使用这一功能时,内部会把主机的 CEN 信号用两级Register延迟 2 个clock 周期,以保证同步,该功能可以软件配置是否Enable（MSM）.

#### 22.12 输出控制

GPTIMER0 和 GPTIMER1 共 4 路通道输出,GPTIMER2 和 GPTIMER3 共 2 路通道输出,同时有相应的输出Enable信号,通道输出仅在 CCxE 置Bits时有效,此时可以通过 CCxP 控制输出极性,输出极性指输出有效电平为高电平还是低电平.输出Enable信号为高有效,即在 CCxE 置Bits时有效,同时需保证通道被正确配置为输出模式,输出模式通过 CCxS 配置.

##### 22.13 通道重映射

通道重映射就是把 GPTIMER 的通道或外部触发通道 ETR 的输入信号从其他外部或内部信号映射过来.GPTIMER0 的 ETR 通道、通道 0 和通道 3 支持重映射,GPTIMER0 的通道 2 支持重映射,GPTIMER2 的 ETR 通道、通道 0 和通道 1 支持重映射,GPTIMER3 的 ETR 通道、通道 0 支持重映射.

#### 22.14 Debug 模式控制

GPTIMER 可由软件配置 debug 下是否停止计数,如果Enable该功能,则进入系统 debug 模式时,

GPTIMER 停止计数（counter不会初始化）.

#### 22.15 DMA 控制

GPTIMER 共有 6 个 DMA Request 源,分别是 update 事件（UIF）、4 路通道事件（捕获事件、比较匹配）（CCxIF）以及触发事件（TIF）,可以由独立的屏蔽Bits配置是否Enable相应的 DMA Request .

对于通道事件 DMA,可以软件（CCDS Bits）配置通道的 DMA Request 源,若 CCDS=0,各通道 DMA Request 来自于各通道的事件,如捕获、比较匹配事件；若 CCDS=1,则各通道的 DMA Request 均来自于更新事件,通道事件将被屏蔽.

各 DMA Request 仅在无相应应答信号、DMA Enable开启且 DMA 事件发生时置Bits,在 DMA Request 置Bits时,应答信号可以清除 DMA Request ,否则 DMA Request 将一直保持置Bits状态.

除常规的 DMA 操作外,GPTIMER 还支持 burst 功能,即一个 DMA Request 可以连续读写多个内部Register.DBL Bits可以选择 burst 长度,最多 18 个,DBA 可以选择 burst 的起始地址,DMAR Register的地址可以作为 DMA 的目标地址或源地址（DMA 内部不需要设置每次递增）.当某一个 DMA Request 置Bits时,GPTIMER 根据 DBL 和 DBA 的值,计算出每一次读写操作的实际地址,实际地址计算方法为:*CR1 + (DBA + index) x 4*,其中 index 的值为 0 至 DBL.

**Note:** Register组中间有保留Register地址,该地址也将包含在*DMA*的*burst*操作中,实际使用时需注意配置的长度.例如,起始地址选择*ARR* Register（*0x2C*）,*DBL* 配置为*5’b00010*（*3* 个

*burst*）,则*DMA* 实际操作的三个Register分别是*0x2C*、 *0x30*、 *0x34*,其中*0x30* 为保留Register,因此无法写入且读出永远为*0*.

#### 22.16 interrupt

GPTIMER 共有 6 个interrupt源,分别是 update 事件（UIF）、4 路通道事件（捕获事件、比较匹配）（CCxIF）以及触发事件（TIF）,各interrupt可以由独立的interrupt屏蔽Bits选择是否Enable,interrupt标志Bits与相应屏蔽Bits是 AND 的关系,interrupt之间是 OR 的关系.GPTIMER 的interrupt信号如下Table:

**Table 22-7 GPTIMER interrupt信号**

|  |  |
| --- | --- |
| interrupt名称 | Description |
| 触发事件interrupt | 触发源产生事件时的interrupt |
| 通道 3 事件interrupt | 通道 3 产生捕获或比较事件时的interrupt |
| 通道 2 事件interrupt | 通道 2 产生捕获或比较事件时的interrupt |
| 通道 1 事件interrupt | 通道 1 产生捕获或比较事件时的interrupt |
| 通道 0 事件interrupt | 通道 0 产生捕获或比较事件时的interrupt |
| 更新事件interrupt | 产生更新事件时的interrupt |

上述interrupt的Enable分别通过配置Register DIER 的 TIE、CC3IE、CC2IE、CC1IE、CC0IE、UIE Bits实现.

#### 22.17 GPTIMER 相关RegisterDescription

GPTIMER0 基地址:0x4000A000

GPTIMER1 基地址:0x4001A000

GPTIMER2 基地址:0x4000B000

GPTIMER3 基地址: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 | 从模式Control Register |
| GPTIM\_DIER | 0x0C | DMA/interruptEnableRegister |
| GPTIM\_SR | 0x10 | 状态Register |
| GPTIM\_EGR | 0x14 | 事件Register |
| GPTIM\_CCMR1 | 0x18 | 捕获比较模式Register 1 |
| GPTIM\_CCMR2 | 0x1C | 捕获比较模式Register 2 |
| GPTIM\_CCER | 0x20 | 捕获比较EnableRegister |
| GPTIM\_CNT | 0x24 | 计数Register |
| GPTIM\_PSC | 0x28 | counter分频值Register |
| GPTIM\_ARR | 0x2C | counter重装载值Register |
| GPTIM\_CCR0 | 0x34 | 通道 0 捕获比较Register |
| GPTIM\_CCR1 | 0x38 | 通道 1 捕获比较Register |
| GPTIM\_CCR2 | 0x3C | 通道 2 捕获比较Register |
| GPTIM\_CCR3 | 0x40 | 通道 3 捕获比较Register |
| GPTIM\_DCR | 0x48 | DMA Control Register |
| GPTIM\_DMAR | 0x4C | DMA 地址Register |
| GPTIM\_OR | 0x50 | 通道重映射Register |

##### 22.17.1 GPTIM\_CR1

Offset:0x00

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:**保留.**Bits 9-8 CKD:**采样clock 分频.

* 00:fDTS = fpclk
* 01:fDTS = fpclk
* 10:fDTS = fpclk
* 11:fDTS = reserved

**Bits 7 ARPE:**重装载影子RegisterEnable.

* 0:ARR 影子Register除能
* 1:ARR 影子RegisterEnable

**Bits 6-5 CMS:**中间计数模式选择.

* 00:边沿对齐计数模式,DIR 控制向上或向下计数
* 01:中间对齐模式 1.输出比较interrupt标志Bits仅在向下计数过程中置Bits
* 10:中间对齐模式 2.输出比较interrupt标志Bits仅在向上计数过程中置Bits
* 11:中间对齐模式 3.输出比较interrupt标志Bits在向上和向下计数过程中均置Bits**Bits 4 DIR:**计数方向选择.中间对齐模式和编码模式,该Bits由硬件控制.
* 0:向上计数
* 1:向下计数

**Bits 3 OPM:**单脉冲模式Enable.

* 0:单脉冲模式除能
* 1:单脉冲模式Enable,counter在下一次更新事件停止计数

**Bits 2 URS:**更新事件源选择,该Bits仅影响interrupt和 DMA 标志Bits（UIF）,不影响内部逻辑.

* 0:counter溢出、UG Bits置Bits、从模式 reset 模式下的触发,均可以置Bits UIF
* 1:只有counter溢出事件可以置Bits UIF **Bits 1 UDIS:**更新事件除能.
* 0:更新事件Enable,中间对齐模式 1.输出比较interrupt标志Bits仅在向下计数过程中置Bits均可以产生更新事件
* 1:更新事件除能,影子Register和 UIF 均不会被更新,但是此时counter和分频counter仍可以被 UG 置Bits事件初始化**Bits 0 CEN:**counterEnable,触发模式下 CEN 由硬件置Bits,单脉冲模式下 CEN 由硬件清零.
* 0:counter除能
* 1:counterEnable

##### 22.17.2 GPTIM\_CR2

Offset:0x04

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:**保留.

**Bits 7 TI0S:**通道 1 源异或选择（该功能仅 timer0 和 timer1 支持）.

* 0:通道 0 映射到通道 0 输入
* 1:通道 0 为通道 0、1、2 的异或输出

**Bits 6-4 MMS:**主模式选择,可以配置 TRGO 输出.

* 000:复Bits模式,UG 将作为 TRGO 信号输出
* 001:Enable模式,CNT\_EN（不是 CEN）将作为 TRGO 信号输出
* 010:更新模式,更新事件（内部信号）将作为 TRGO 信号输出
* 011:比较脉冲模式,每次 CC0IF 将要置Bits时 TRGO 会输出一个脉冲,即使 CC0IF 已经置Bits
* 100:比较模式,OC0REF（内部信号）作为 TRGO 信号输出
* 101:比较模式,OC1REF（内部信号）作为 TRGO 信号输出
* 110:比较模式,OC2REF（内部信号）作为 TRGO 信号输出
* 111:比较模式,OC3REF（内部信号）作为 TRGO 信号输出

**Bits 3 CCDS:**通道 DMA Request 源选择（该功能仅 gptimer0 和 gptimer1 支持）.

* 0:各通道的 DMA Request （不包含更新事件Request 和触发事件Request ）由通道事件（捕获、比较）产生
* 1:各通道的 DMA Request （不包含更新事件Request 和触发事件Request ）由更新事件产生

**Bits 2-0 RESERVED:**保留.

##### 22.17.3 GPTIM\_SMCR

Offset:0x08 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 |

**Bits 15 ETP:**外部触发极性选择（配置极性时最好先不要选择模式（SMS）,以防内部信号翻转触发未知错误）.

* 0:外部触发输入不反相
* 1:外部触发输入反相**Bits 14 ECE:**外部clock 模式 2 Enable.
* 0:禁用外部clock 模式 2
* 1:Enable外部clock 模式 2 **Bits 13-12 ETPS:**外部触发输入分频（该分频主要用于 50%占空比降频,如 24M 信号 2 分频为 12M,电平延展一倍）择.
* 00:不分频
* 01:2 分频
* 10:4 分频
* 11:8 分频**Bits 11-8 ETF:**外部触发输入滤波器配置.
* 0000:禁用滤波器
* 0001:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=2
* 0010:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=4
* 0011:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=8
* 0100:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=6
* 0101:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=8
* 0110:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=6
* 0111:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=8
* 1000:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=6
* 1001:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=8
* 1010:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=5
* 1011:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=6
* 1100:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=8
* 1101:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=5
* 1110:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=6
* 1111:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=8

**Bits 7 MSM:**主从模式同步（使用该功能时,需保证两个 timer 的clock 同频同相）.

* 0:无动作
* 1:TRGI 触发输入将延迟产生作用,以便与从counter同时开始计数**Bits 6-4 TS:**触发源选择,选择 TRGI 的来源（配置该Bits时 SMS 必须处于清零状态）.
* 000:ITR0
* 001:ITR1
* 010:ITR2（timer2 和 timer3 无此通道）
* 011:保留
* 100:通道 0 边沿检测输出
* 101:通道 0 滤波器输出
* 110:通道 1 滤波器输出
* 111:外部触发输入**Bits 3 RESERVED:**保留.

**Bits 2-0 SMS:**从模式选择（选择模式前最好先配置好通道参数,以防内部信号翻转触发未知错误）.

* 000:禁用从模式
* 001:编码模式 1,counter仅在通道 1 边沿计数
* 010:编码模式 2,counter仅在通道 0 边沿计数
* 011:编码模式 3,counter在通道 0 和 1 的边沿计数
* 100:复Bits模式,TRGI 的上升沿将复Bitscounter
* 101:门控模式,counter仅在 TRGI 高电平期间计数
* 110:触发模式,counter在 TRGI 上升沿将开始计数,该模式仅控制计数的开始
* 111:外部clock 模式 1,TRGI 的上升沿作为counter计数clock

##### 22.17.4 GPTIM\_DIER

Offset:0x0C

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 |

**Bits 15 RESERVED:**保留.

**Bits 14 TDE:**触发事件 DMA Request Enable.

* 0:禁用触发事件 DMA Request
* 1:Enable触发事件 DMA Request **Bits 13 RESERVED:**保留.

**Bits 12 CC3DE:**通道 3 事件 DMA Request Enable.

* 0:禁用通道 3 事件 DMA Request
* 1:Enable通道 3 事件 DMA Request **Bits 11 CC3DE:**通道 2 事件 DMA Request Enable.
* 0:禁用通道 2 事件 DMA Request
* 1:Enable通道 2 事件 DMA Request

**Bits 10 CC3DE:**通道 1 事件 DMA Request Enable.

* 0:禁用通道 1 事件 DMA Request
* 1:Enable通道 1 事件 DMA Request **Bits 9 CC3DE:**通道 0 事件 DMA Request Enable.
* 0:禁用通道 0 事件 DMA Request
* 1:Enable通道 0 事件 DMA Request

**Bits 8 UDE:**更新事件 DMA Request Enable.

* 0:禁用更新事件 DMA Request
* 1:Enable更新事件 DMA Request **Bits 7 RESERVED:**保留.

**Bits 6 TIE:**触发事件interruptRequest Enable.

* 0:禁用触发事件interruptRequest
* 1:Enable触发事件interruptRequest **Bits 5 RESERVED:**保留.

**Bits 4 CC3IE:**通道 3 事件interruptRequest Enable.

* 0:禁用通道 3 事件interruptRequest
* 1:Enable通道 3 事件interruptRequest **Bits 3 CC2IE:**通道 2 事件interruptRequest Enable.
* 0:禁用通道 2 事件interruptRequest
* 1:Enable通道 2 事件interruptRequest **Bits 2 CC1IE:**通道 1 事件interruptRequest Enable.
* 0:禁用通道 1 事件interruptRequest
* 1:Enable通道 1 事件interruptRequest **Bits 1 CC0IE:**通道 0 事件interruptRequest Enable.
* 0:禁用通道 0 事件interruptRequest
* 1:Enable通道 0 事件interruptRequest **Bits 0 UIE:**通道 0 事件interruptRequest Enable.
* 0:禁用通道 0 事件interruptRequest
* 1:Enable通道 0 事件interruptRequest

##### 22.17.5 GPTIM\_SR

Offset:0x10 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:**保留.

**Bits 12 CC3OF:**通道 3 overcapture 标志（写 0 清零）.

* 0:无 overcapture
* 1:发生了至少 1 次 overcapture **Bits 11 CC2OF:**通道 2 overcapture 标志（写 0 清零）.
* 0:无 overcapture
* 1:发生了至少 1 次 overcapture **Bits 10 CC1OF:**通道 1 overcapture 标志（写 0 清零）.
* 0:无 overcapture
* 1:发生了至少 1 次 overcapture **Bits 9 CC0OF:**通道 0 overcapture 标志（写 0 清零）.
* 0:无 overcapture
* 1:发生了至少 1 次 overcapture **Bits 8-7 RESERVED:**保留.

**Bits 6 TIF:**触发事件interrupt标志（写 0 清零）.

* 0:无触发事件
* 1:触发事件发生**Bits 5 RESERVED:**保留.

**Bits 4 CC3IF:**通道 3 捕获/比较事件标志（比较模式:写 0 清零；捕获模式:读 ccrx Register或写 0 均可清零）.

* 0:无事件
* 1:捕获或比较事件发生**Bits 3 CC3IF:**通道 2 捕获/比较事件标志（比较模式:写 0 清零；捕获模式:读 ccrx Register或写 0 均可清零）.
* 0:无事件
* 1:捕获或比较事件发生**Bits 2 CC3IF:**通道 1 捕获/比较事件标志（比较模式:写 0 清零；捕获模式:读 ccrx Register或写 0 均可清零）.
* 0:无事件
* 1:捕获或比较事件发生

**Bits 1 CC3IF:**通道 0 捕获/比较事件标志（比较模式:写 0 清零；捕获模式:读 ccrx Register或写 0 均可清零）.

* 0:无事件
* 1:捕获或比较事件发生

**Bits 0 UIF:**更新事件标志（读 SR 或写 0 可清零该Bits）.

* 0:无事件
* 1:更新事件发生

##### 22.17.6 GPTIM\_EGR

Offset:0x14

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:**保留.

**Bits 6 TG:**触发产生.

* 0:无动作
* 1:产生一次触发事件,TIF 置Bits**Bits 5 RESERVED:**保留.

**Bits 4 CC3G:**通道 3 事件产生.

* 0:无动作
* 1:输入模式时产生捕获动作,输出模式时产生比较动作,两种模式下 CC3IF 置Bits**Bits 3 CC2G:**通道 2 事件产生.
* 0:无动作
* 1:输入模式时产生捕获动作,输出模式时产生比较动作,两种模式下 CC2IF 置Bits**Bits 2 CC1G:**通道 1 事件产生.
* 0:无动作
* 1:输入模式时产生捕获动作,输出模式时产生比较动作,两种模式下 CC1IF 置Bits**Bits 1 CC0G:**通道 0 事件产生.
* 0:无动作
* 1:输入模式时产生捕获动作,输出模式时产生比较动作,两种模式下 CC0IF 置Bits**Bits 0 UG:**更新事件产生.
* 0:无动作
* 1:产生一次更新事件

##### 22.17.7 GPTIM\_CCMR1

Offset:0x18

Reset Value:0x0000

**输出模式时结构如下:**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 |

**Bits 15 OC1CE:**通道 1 输出比较清除Enable.

* 0:禁用清除功能
* 1:Enable清除功能,ETRF 高电平可以清除通道输出**Bits 14-12 OC1M:**通道 1 输出比较模式选择.
* 000:冻结模式,通道输出不随比较结果变化
* 001:有效模式,匹配后通道输出有效电平
* 010:失效模式,匹配后通道输出失效电平
* 011:翻转模式,匹配后将翻转通道输出
* 100:强制有效模式,选择该模式后,直接输出有效电平
* 101:强制失效模式,选择该模式后,直接输出失效电平
* 110:PWM1 模式,该模式下,向上计数时,CNT<CCR 时通道输出有效电平,否则输出失效电平；向下计数时,CNT>CCR 时通道输出失效电平,否则输出有效电平（向上计数时,若 CCRx>ARR,

OCxREF 一直输出高电平,若 CCRx==0,OCxREF 一直输出低电平；向下计数时,若 CCRx>ARR,

OCxREF 一直输出高电平,此时 0% PWM 不支持）

* 111:PWM2 模式,该模式下,向上计数时,CNT<CCR 时通道输出失效电平,否则输出有效电平；

向下计数时,CNT>CCR 时通道输出有效电平,否则输出失效电平（0%与 100%波形与 PWM1 同理）**Bits 11 OC1PE:**通道 1 输出比较影子RegisterEnable.

* 0:禁用影子Register
* 1:Enable影子Register

**Bits 10 OC1FE:**通道 1 快速输出Enable.

* 0:禁用快速模式,输出仅在匹配时变化
* 1:Enable快速模式,触发输入相当于匹配事件,直接影响通道输出,不受counter与 CCR 的比较影响**Bits 9-8 CC1S:**捕获比较选择.
* 00:通道配置为 输出模式
* 01:通道配置为输入模式,捕获通道输入映射至通道 1
* 10:通道配置为输入模式,捕获通道输入映射至通道 0
* 11:通道配置为输入模式,捕获通道输入映射至触发输入 TRC **Bits 7 OC0CE:**通道 0 输出比较清除Enable.
* 0:禁用清除功能
* 1:Enable清除功能,ETRF 高电平可以清除通道输出

**Bits 6-4 OC0M:**通道 0 输出比较模式选择.

* 000:冻结模式,通道输出不随比较结果变化
* 001:有效模式,匹配后通道输出有效电平
* 010:失效模式,匹配后通道输出失效电平
* 011:翻转模式,匹配后将翻转通道输出
* 100:强制有效模式,选择该模式后,直接输出有效电平
* 101:强制失效模式,选择该模式后,直接输出失效电平
* 110:PWM1 模式,该模式下,向上计数时,CNT<CCR 时通道输出有效电平,否则输出失效电平；向下计数时,CNT>CCR 时通道输出失效电平,否则输出有效电平（向上计数时,若 CCRx>ARR,

OCxREF 一直输出高电平,若 CCRx==0,OCxREF 一直输出低电平；向下计数时,若 CCRx>ARR,

OCxREF 一直输出高电平,此时 0% PWM 不支持）

* 111:PWM2 模式,该模式下,向上计数时,CNT<CCR 时通道输出失效电平,否则输出有效电平；

向下计数时,CNT>CCR 时通道输出有效电平,否则输出失效电平（0%与 100%波形与 PWM1 同理）**Bits 3 OC0PE:**通道 0 输出比较影子RegisterEnable.

* 0:禁用影子Register
* 1:Enable影子Register

**Bits 2 OC0FE:**通道 0 快速输出Enable.

* 0:禁用快速模式,输出仅在匹配时变化
* 1:Enable快速模式,触发输入相当于匹配事件,直接影响通道输出,不受counter与 CCR 的比较影响**Bits 1-0 CC0S:**捕获比较选择.
* 00:通道配置为 输出模式
* 01:通道配置为输入模式,捕获通道输入映射至通道 0
* 10:通道配置为输入模式,捕获通道输入映射至通道 1
* 11:通道配置为输入模式,捕获通道输入映射至触发输入 TRC

**输入模式时结构如下:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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 |

**Bits 15-12 IC1F:**通道 1 输入滤波器配置（需配置 CCxS！=0x0 该功能才能生效）.

* 0000:禁用滤波器
* 0001:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=2
* 0010:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=4
* 0011:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=8
* 0100:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=6
* 0101:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=8
* 0110:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=6
* 0111:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=8
* 1000:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=6
* 1001:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=8
* 1010:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=5**（未完,接下页）**
* 1011:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=6
* 1100:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=8
* 1101:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=5
* 1110:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=6
* 1111:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=8 **Bits 11-10 IC1PSC:**通道 1 分频（需配置 CCxS！=0x0 该功能才能生效）.
* 00:不分频
* 01:2 分频
* 10:4 分频
* 11:8 分频**Bits 9-8 CC1S:**捕获比较选择.
* 00:通道配置为 输出模式
* 01:通道配置为输入模式,捕获通道输入映射至通道 1
* 10:通道配置为输入模式,捕获通道输入映射至通道 0
* 11:通道配置为输入模式,捕获通道输入映射至触发输入 TRC **Bits 7-4 IC0F:**通道 0 输入滤波器配置（需配置 CCxS！=0x0 该功能才能生效）.
* 0000:禁用滤波器
* 0001:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=2
* 0010:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=4
* 0011:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=8
* 0100:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=6
* 0101:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=8
* 0110:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=6
* 0111:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=8
* 1000:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=6
* 1001:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=8
* 1010:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=5
* 1011:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=6
* 1100:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=8
* 1101:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=5
* 1110:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=6
* 1111:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=8 **Bits 3-2 IC0PSC:**通道 0 分频（需配置 CCxS！=0x0 该功能才能生效）.
* 00:不分频
* 01:2 分频
* 10:4 分频
* 11:8 分频**Bits 1-0 CC0S:**捕获比较选择.
* 00:通道配置为 输出模式
* 01:通道配置为输入模式,捕获通道输入映射至通道 0
* 10:通道配置为输入模式,捕获通道输入映射至通道 1
* 11:通道配置为输入模式,捕获通道输入映射至触发输入 TRC

##### 22.17.8 GPTIM\_CCMR2

Offset:0x1C

Reset Value:0x0000

**输出模式时结构如下:**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 |

**Bits 15 OC3CE:**通道 3 输出比较清除Enable.

* 0:禁用清除功能
* 1:Enable清除功能,ETRF 高电平可以清除通道输出**Bits 14-12 OC3M:**通道 3 输出比较模式选择.
* 000:冻结模式,通道输出不随比较结果变化
* 001:有效模式,匹配后通道输出有效电平
* 010:失效模式,匹配后通道输出失效电平
* 011:翻转模式,匹配后将翻转通道输出
* 100:强制有效模式,选择该模式后,直接输出有效电平
* 101:强制失效模式,选择该模式后,直接输出失效电平
* 110:PWM1 模式,该模式下,向上计数时,CNT<CCR 时通道输出有效电平,否则输出失效电平；向下计数时,CNT>CCR 时通道输出失效电平,否则输出有效电平（向上计数时,若 CCRx>ARR,

OCxREF 一直输出高电平,若 CCRx==0,OCxREF 一直输出低电平；向下计数时,若 CCRx>ARR,

OCxREF 一直输出高电平,此时 0% PWM 不支持）

* 111:PWM2 模式,该模式下,向上计数时,CNT<CCR 时通道输出失效电平,否则输出有效电平；

向下计数时,CNT>CCR 时通道输出有效电平,否则输出失效电平（0%与 100%波形与 PWM1 同理）**Bits 11 OC3PE:**通道 3 输出比较影子RegisterEnable.

* 0:禁用影子Register
* 1:Enable影子Register

**Bits 10 OC3FE:**通道 3 快速输出Enable.

* 0:禁用快速模式,输出仅在匹配时变化
* 1:Enable快速模式,触发输入相当于匹配事件,直接影响通道输出,不受counter与 CCR 的比较影响**Bits 9-8 CC3S:**捕获比较选择.
* 00:通道配置为 输出模式
* 01:通道配置为输入模式,捕获通道输入映射至通道 3
* 10:通道配置为输入模式,捕获通道输入映射至通道 2
* 11:通道配置为输入模式,捕获通道输入映射至触发输入 TRC **Bits 7 OC2CE:**通道 2 输出比较清除Enable.
* 0:禁用清除功能
* 1:Enable清除功能,ETRF 高电平可以清除通道输出

**Bits 6-4 OC2M:**通道 2 输出比较模式选择.

* 000:冻结模式,通道输出不随比较结果变化
* 001:有效模式,匹配后通道输出有效电平
* 010:失效模式,匹配后通道输出失效电平
* 011:翻转模式,匹配后将翻转通道输出
* 100:强制有效模式,选择该模式后,直接输出有效电平
* 101:强制失效模式,选择该模式后,直接输出失效电平
* 110:PWM1 模式,该模式下,向上计数时,CNT<CCR 时通道输出有效电平,否则输出失效电平；向下计数时,CNT>CCR 时通道输出失效电平,否则输出有效电平（向上计数时,若 CCRx>ARR,

OCxREF 一直输出高电平,若 CCRx==0,OCxREF 一直输出低电平；向下计数时,若 CCRx>ARR,

OCxREF 一直输出高电平,此时 0% PWM 不支持）

* 111:PWM2 模式,该模式下,向上计数时,CNT<CCR 时通道输出失效电平,否则输出有效电平；

向下计数时,CNT>CCR 时通道输出有效电平,否则输出失效电平（0%与 100%波形与 PWM1 同理）  **Bits 3 OC2PE:**通道 2 输出比较影子RegisterEnable.

* 0:禁用影子Register
* 1:Enable影子Register

**Bits 2 OC2FE:**通道 2 快速输出Enable.

* 0:禁用快速模式,输出仅在匹配时变化
* 1:Enable快速模式,触发输入相当于匹配事件,直接影响通道输出,不受counter与 CCR 的比较影响  **Bits 1-0 CC2S:**捕获比较选择.
* 00:通道配置为输出模式
* 01:通道配置为输入模式,捕获通道输入映射至通道 2
* 10:通道配置为输入模式,捕获通道输入映射至通道 3
* 11:通道配置为输入模式,捕获通道输入映射至触发输入 TRC

**输入模式时结构如下:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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:**通道 3 输入滤波器配置（需配置 CCxS！=0x0 该功能才能生效）.

* 0000:禁用滤波器
* 0001:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=2
* 0010:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=4
* 0011:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=8
* 0100:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=6
* 0101:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=8
* 0110:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=6
* 0111:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=8
* 1000:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=6
* 1001:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=8
* 1010:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=5**（未完,接下页）**
* 1011:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=6
* 1100:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=8
* 1101:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=5
* 1110:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=6
* 1111:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=8 **Bits 11-10 IC3PSC:**通道 3 分频（需配置 CCxS！=0x0 该功能才能生效）.
* 00:不分频
* 01:2 分频
* 10:4 分频
* 11:8 分频**Bits 9-8 CC3S:**捕获比较选择.
* 00:通道配置为 输出模式
* 01:通道配置为输入模式,捕获通道输入映射至通道 3
* 10:通道配置为输入模式,捕获通道输入映射至通道 2
* 11:通道配置为输入模式,捕获通道输入映射至触发输入 TRC **Bits 7-4 IC2F:**通道 2 输入滤波器配置（需配置 CCxS！=0x0 该功能才能生效）.
* 0000:禁用滤波器
* 0001:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=2
* 0010:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=4
* 0011:滤波器采样频率 fsampling=fpclk, 滤波器长度 N=8
* 0100:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=6
* 0101:滤波器采样频率 fsampling=fDTS/2, 滤波器长度 N=8
* 0110:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=6
* 0111:滤波器采样频率 fsampling=fDTS/4, 滤波器长度 N=8
* 1000:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=6
* 1001:滤波器采样频率 fsampling=fDTS/8, 滤波器长度 N=8
* 1010:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=5
* 1011:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=6
* 1100:滤波器采样频率 fsampling=fDTS/16, 滤波器长度 N=8
* 1101:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=5
* 1110:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=6
* 1111:滤波器采样频率 fsampling=fDTS/32, 滤波器长度 N=8 **Bits 3-2 IC2PSC:**通道 2 分频（需配置 CCxS！=0x0 该功能才能生效）.
* 00:不分频
* 01:2 分频
* 10:4 分频
* 11:8 分频**Bits 1-0 CC2S:**捕获比较选择.
* 00:通道配置为 输出模式
* 01:通道配置为输入模式,捕获通道输入映射至通道 2
* 10:通道配置为输入模式,捕获通道输入映射至通道 3
* 11:通道配置为输入模式,捕获通道输入映射至触发输入 TRC

##### 22.17.9 GPTIM\_CCER

Offset:0x20

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 |

**Bits 15 CC3NP:**输出反相极性,输出模式时该Bits必须Bits 0,输入模式时参看 CC3P.

**Bits 14 RESERVED:**保留.

**Bits 13 CC3P:**输出极性,须与 CC3NP 共同作用（配置极性最好在模式选择之前,防止内部信号翻转触发未知错误）.

**输出模式:**

* 0:输出有效极性Bits高电平
* 1:输出有效极性Bits低电平

**输入模式,{CC3NP,CC3P}:**

* 00:通道输入上升沿有效（捕获、触发、复Bits、clock 模式）,高电平有效（门控、编码模式）
* 01:通道输入下降沿有效（捕获、触发、复Bits、clock 模式）,低电平有效（门控、编码模式）
* 10:保留
* 11:通道输入上升沿和下降沿均有效（捕获、触发、复Bits、clock 模式）,高电平有效（门控、编码模式）**Bits 12 CC3E:**通道Enable.

**输入模式:**

* 0:禁用捕获
* 1:Enable捕获**输出模式:**
* 0:禁用输出
* 1:Enable输出**Bits 11 CC2NP:**输出反相极性,输出模式时该Bits必须Bits 0,输入模式时参看 CC2P.

**Bits 10 RESERVED:**保留.

**Bits 9 CC2P:**输出极性,须与 CC2NP 共同作用（配置极性最好在模式选择之前,防止内部信号翻转触发未知错误）.

**输出模式:**

* 0:输出有效极性Bits高电平
* 1:输出有效极性Bits低电平

**输入模式,{CC2NP,CC2P}:**

* 00:通道输入上升沿有效（捕获、触发、复Bits、clock 模式）,高电平有效（门控、编码模式）
* 01:通道输入下降沿有效（捕获、触发、复Bits、clock 模式）,低电平有效（门控、编码模式）
* 10:保留
* 11:通道输入上升沿和下降沿均有效（捕获、触发、复Bits、clock 模式）,高电平有效（门控、编码模式）**Bits 8 CC2E:**通道Enable.

**输入模式:**

* 0:禁用捕获
* 1:Enable捕获**输出模式:**
* 0:禁用输出
* 1:Enable输出**Bits 7 CC1NP:**输出反相极性,输出模式时该Bits必须Bits 0,输入模式时参看 CC1P.

**Bits 6 RESERVED:**保留.

**Bits 5 CC1P:**输出极性,须与 CC3NP 共同作用（配置极性最好在模式选择之前,防止内部信号翻转触发未知错误）.

**输出模式:**

* 0:输出有效极性Bits高电平
* 1:输出有效极性Bits低电平

**输入模式,{CC1NP,CC1P}:**

* 00:通道输入上升沿有效（捕获、触发、复Bits、clock 模式）,高电平有效（门控、编码模式）
* 01:通道输入下降沿有效（捕获、触发、复Bits、clock 模式）,低电平有效（门控、编码模式）
* 10:保留
* 11:通道输入上升沿和下降沿均有效（捕获、触发、复Bits、clock 模式）,高电平有效（门控、编码模式）**Bits 4 CC1E:**通道Enable.

**输入模式:**

* 0:禁用捕获
* 1:Enable捕获**输出模式:**
* 0:禁用输出
* 1:Enable输出

**Bits 3 CC0NP:**输出反相极性,输出模式时该Bits必须Bits 0,输入模式时参看 CC0P.

**Bits 2 RESERVED:**保留.

**Bits 1 CC0P:**输出极性,须与 CC0NP 共同作用（配置极性最好在模式选择之前,防止内部信号翻转触发未知错误）.

**输出模式:**

* 0:输出有效极性Bits高电平
* 1:输出有效极性Bits低电平

**输入模式,{CC0NP,CC0P}:**

* 00:通道输入上升沿有效（捕获、触发、复Bits、clock 模式）,高电平有效（门控、编码模式）
* 01:通道输入下降沿有效（捕获、触发、复Bits、clock 模式）,低电平有效（门控、编码模式）
* 10:保留
* 11:通道输入上升沿和下降沿均有效（捕获、触发、复Bits、clock 模式）,高电平有效（门控、编码模式）**Bits 0 CC0E:**通道Enable.

**输入模式:**

* 0:禁用捕获
* 1:Enable捕获**输出模式:**
* 0:禁用输出  1:Enable输出

##### 22.17.10 GPTIM\_CNT

Offset:0x24

Reset Value:0x0000

|  |
| --- |
| **15-0** |
| CNT |
| rw-0h |

**Bits 15-0 CNT:**counter计数值.

##### 22.17.11 GPTIM\_PSC

Offset:0x28

Reset Value:0x0000

|  |
| --- |
| **15-0** |
| PSC |
| rw-0h |

**Bits 15-0 PSC:**clock 分频值为 PSC+1.

##### 22.17.12 GPTIM\_ARR

Offset:0x2C

Reset Value:0xFFFF

|  |
| --- |
| **15-0** |
| PSC |
| rw-FFFFh |

**Bits 15-0 ARR:**counter重装载值.

##### 22.17.13 GPTIM\_CCR0

Offset:0x34

Reset Value:0x0000

|  |
| --- |
| **15-0** |
| CCR0 |
| rw-0h |

**Bits 15-0 CCR0:**输出模式时,该Register保存用户写入的比较值,用于与 CNT 进行比较；输入模式时,该Register保存捕获的值,只读.

##### 22.17.14 GPTIM\_CCR1

Offset:0x38

Reset Value:0x0000

|  |
| --- |
| **15-0** |
| CCR1 |
| rw-0h |

**Bits 15-0 CCR1:**输出模式时,该Register保存用户写入的比较值,用于与 CNT 进行比较；输入模式时,该Register保存捕获的值,只读.

##### 22.17.15 GPTIM\_CCR2

Offset:0x3C Reset Value:0x0000

|  |
| --- |
| **15-0** |
| CCR2 |
| rw-0h |

**Bits 15-0 CCR2:**输出模式时,该Register保存用户写入的比较值,用于与 CNT 进行比较；输入模式时,该Register保存捕获的值,只读.

##### 22.17.16 GPTIM\_CCR3

Offset:0x40 Reset Value:0x0000

|  |
| --- |
| **15-0** |
| CCR3 |
| rw-0h |

**Bits 15-0 CCR3:**输出模式时,该Register保存用户写入的比较值,用于与 CNT 进行比较；输入模式时,该Register保存捕获的值,只读.

##### 22.17.17 GPTIM\_DCR

Offset:0x48 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:**保留.

**Bits 12-8 DBL:**DMA 连续读写长度.

* 00000:1 个传输
* 00001:2 个传输
* 00010:3 个传输
* 00011:4 个传输
* 00100:5 个传输
* 00101:6 个传输
* 00110:7 个传输
* 00111:8 个传输
* 01000:9 个传输**（未完,接下页）**
* 01001:10 个传输
* 01010:11 个传输
* 01011:12 个传输
* 01100:13 个传输
* 01101:14 个传输
* 01110:15 个传输
* 01111:16 个传输
* 10000:17 个传输
* 10001:18 个传输**Bits 7-5 RESERVED:**保留.**Bits 4-0 DBA:**DMA 连续读写基地址.
* 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:偏移地址为 0X30 的保留Register
* 01101:CCR0 Register
* 01110:CCR1 Register
* 01111:CCR2 Register
* 10000:CCR3 Register
* 10001:偏移地址为 0X44 的保留Register
* 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:0x4C Reset Value:0x0000

|  |
| --- |
| **15-0** |
| DMAR |
| rw-0h |

**Bits 15-0 DMAR:**该Register保存当前 DMA 操作的Register的值,例如当前 DMA 需要操作 TIM\_CR2 Register,那么直接操作该地址,便相当于操作 TIM\_CR2 Register.具体代Table那个Register需要参考

DSTEP、DBL 和 DBA 的值.

22.17.19 GPTIM\_OR Offset:0x50 Reset Value:0x0000

**GPTIMER0 时此Register的结构如下:**

|  |  |  |  |
| --- | --- | --- | --- |
| **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:**保留.

**Bits 10-7 ETR\_RMP:**ETR 重映射.

* 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:**通道 3 重映射.

* 000:iom
* 001:comp0
* 010:comp1
* 011:reserved
* 100:reserved
* 101:reserved
* 110:reserved
* 111:reserved

**Bits 3-0 TI0\_RMP:**通道 0 重映射.

* 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 时此Register的结构如下:

|  |  |
| --- | --- |
| **15-2** | **1-0** |
| RESERVED | TI2\_RMP |
| r-0h | rw-0h |

**Bits 15-2 RESERVED:**保留.**Bits 1-0 TI2\_RMP:**通道 2 重映射.

* 00:iom
* 01:TIM3\_CH1
* 10:reserved
* 11:reserved

**GPTIMER2 时此Register的结构如下:**

|  |  |  |  |
| --- | --- | --- | --- |
| **15-10** | **9-7** | **6-5** | **4-0** |
| RESERVED | ETR\_RMP | TI1\_RMP | TI0\_RMP |
| r-0h | rw-0h | rw-0h | rw-0h |

**Bits 15-10 RESERVED:**保留.**Bits 9-7 ETR\_RMP:**ETR 重映射.

* 0000:iom
* 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:**通道 1 重映射.

* 00:iom
* 01:comp1
* 10:reserved
* 11:reserved

**Bits 4-0 TI0\_RMP:**通道 0 重映射.

* 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**（未完,接下页）**
* 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 时此Register的结构如下:

|  |  |  |
| --- | --- | --- |
| **15-7** | **6-3** | **2-0** |
| RESERVED | ETR\_RMP | TI0\_RMP |
| r-0h | rw-0h | rw-0h |

**Bits 15-7 RESERVED:**保留.**Bits 6-3 ETR\_RMP:**ETR 重映射.

* 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:**通道 0 重映射.

* 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]