
AT32F423 Firmware BSP&Pack

Introduction

This application note is written to give a brief description of how to use AT32F423 BSP (Board Support Package) and install AT32 pack.

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1 Overview

In order to help users make efficient use of Artery MCU, we provide a complete set of BSP & Pack tools to speed up development. They include peripheral driver library, core-related documents and application cases as well as Pack documents supporting a variety of development environments such as Keil_v5, Keil_v4, IAR_v6, IAR_v7 and IAR_v8. The BSP and Pack are available on Artery official website.

This application note is written to present how to use BSP and Pack.

2 How to install Pack

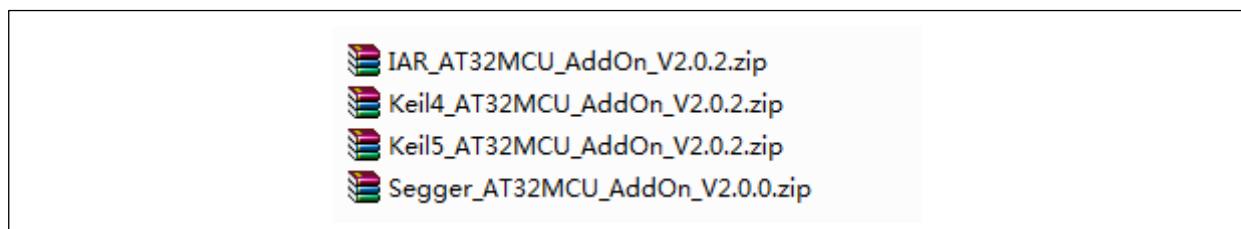
Artery Pack supports various development environment such as Keil_v5, Keil_v4, IAR_v6, IAR_v7 and IAR_v8.

Double click on the corresponding Pack to finish installation.

Note: This section takes AT32F403A as an example, and other AT32 MCUs have similar Pack installation methods.

The installation package is shown in Figure 1 (the specific version information is subject to the actual conditions).

Figure 1. Pack kit

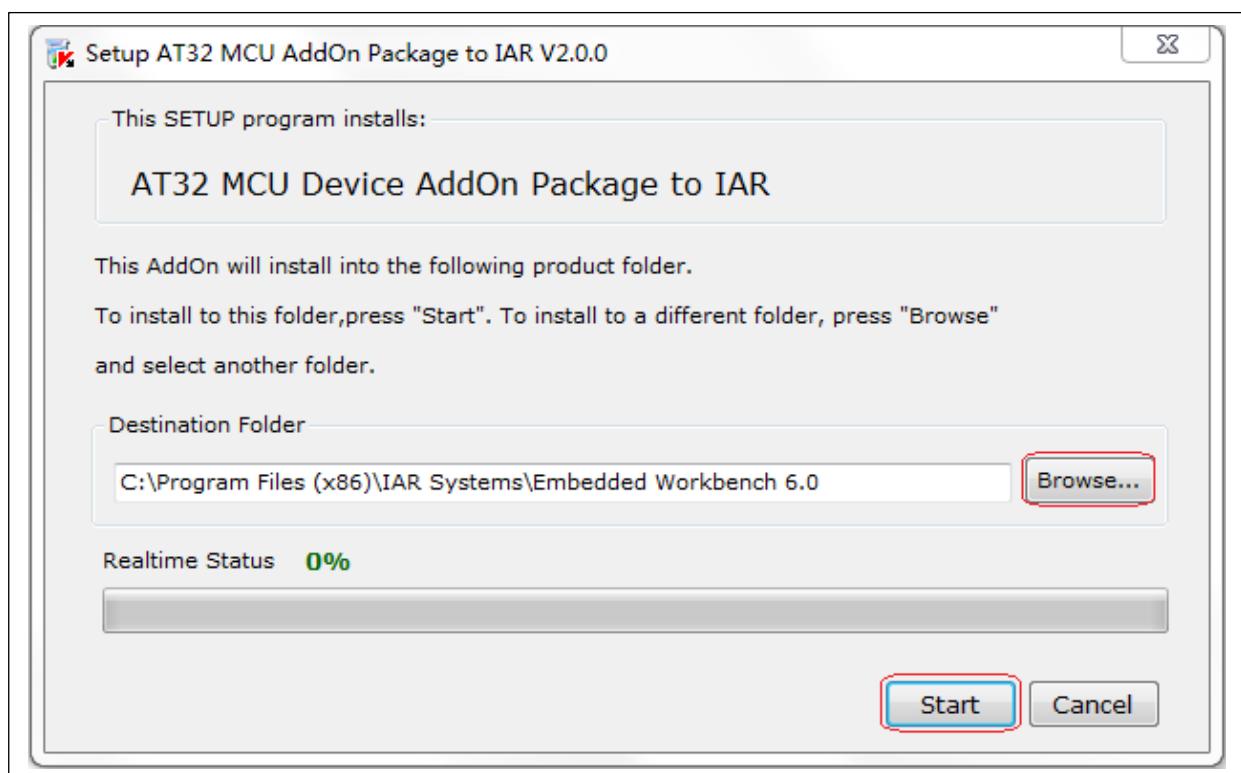


2.1 IAR Pack installation

IAR_AT32MCU_AddOn.zip: This is a zip file supporting IAR_V6, IAR_V7 and IAR_V8. Follow the steps below to install:

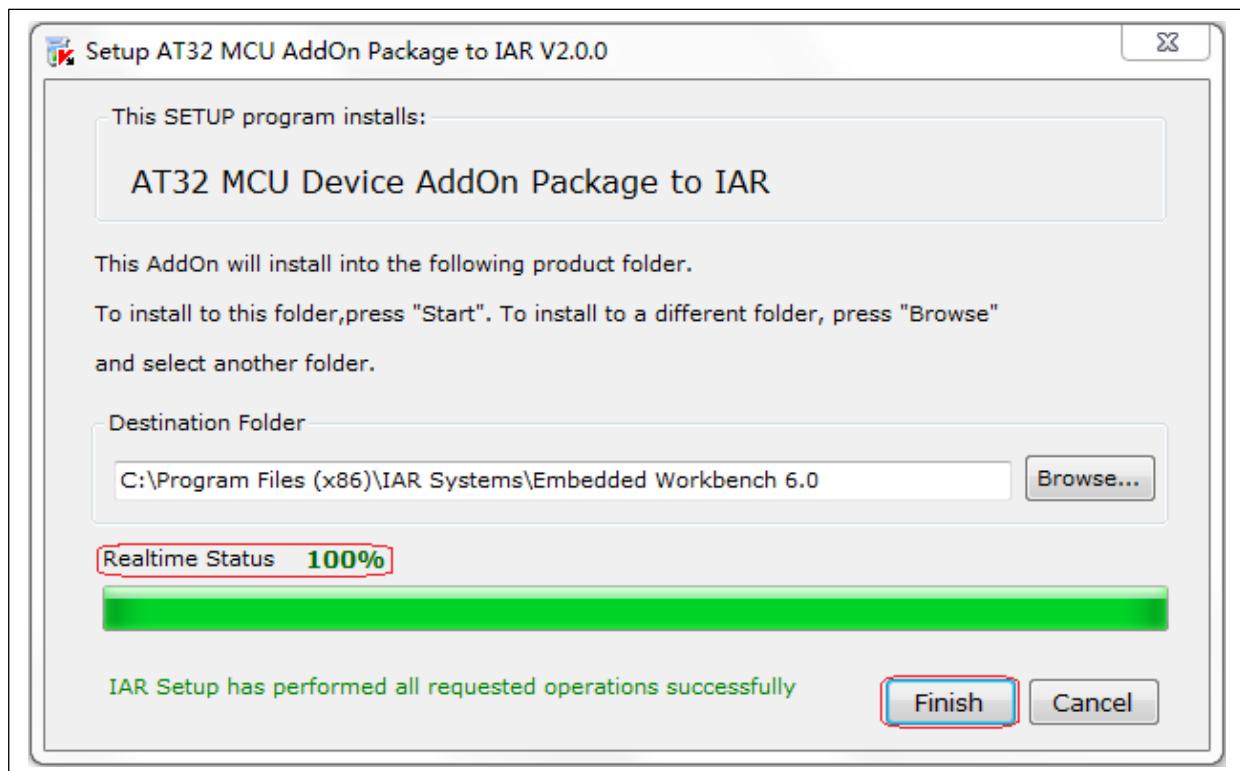
- ① Unzip *IAR_AT32MCU_AddOn.zip*;
- ② Double click on *IAR_AT32MCU_AddOn.exe*, and a dialog box pops up below (the specific version information is subject to the actual conditions).

Figure 2. IAR Pack installation window



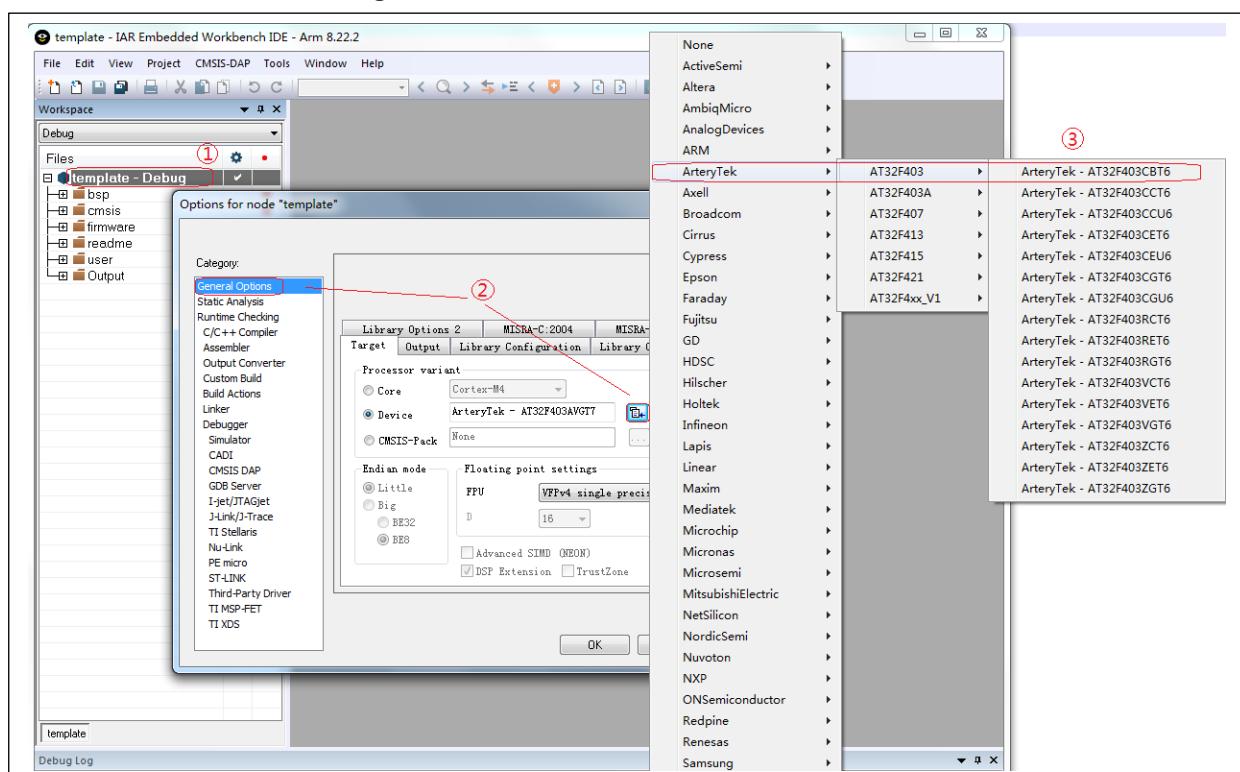
Note: If the installation path of IAR does not match the Destination Folder, click on "Browse" to select a correct path, then click on "Start", as shown below.

Figure 3. IAR Pack installation window



- ③ Click on “Finish”;
- ④ To check whether the IAR Pack is installed successfully or not, open an IAR project and follow the steps below:
 - Right click on a project name, and select “Options...”;
 - Select “General Options”, and click on the check box;
 - Click on “ArteryTek” and view AT32 MCU-related information.

Figure 4. View IAR Pack installation status

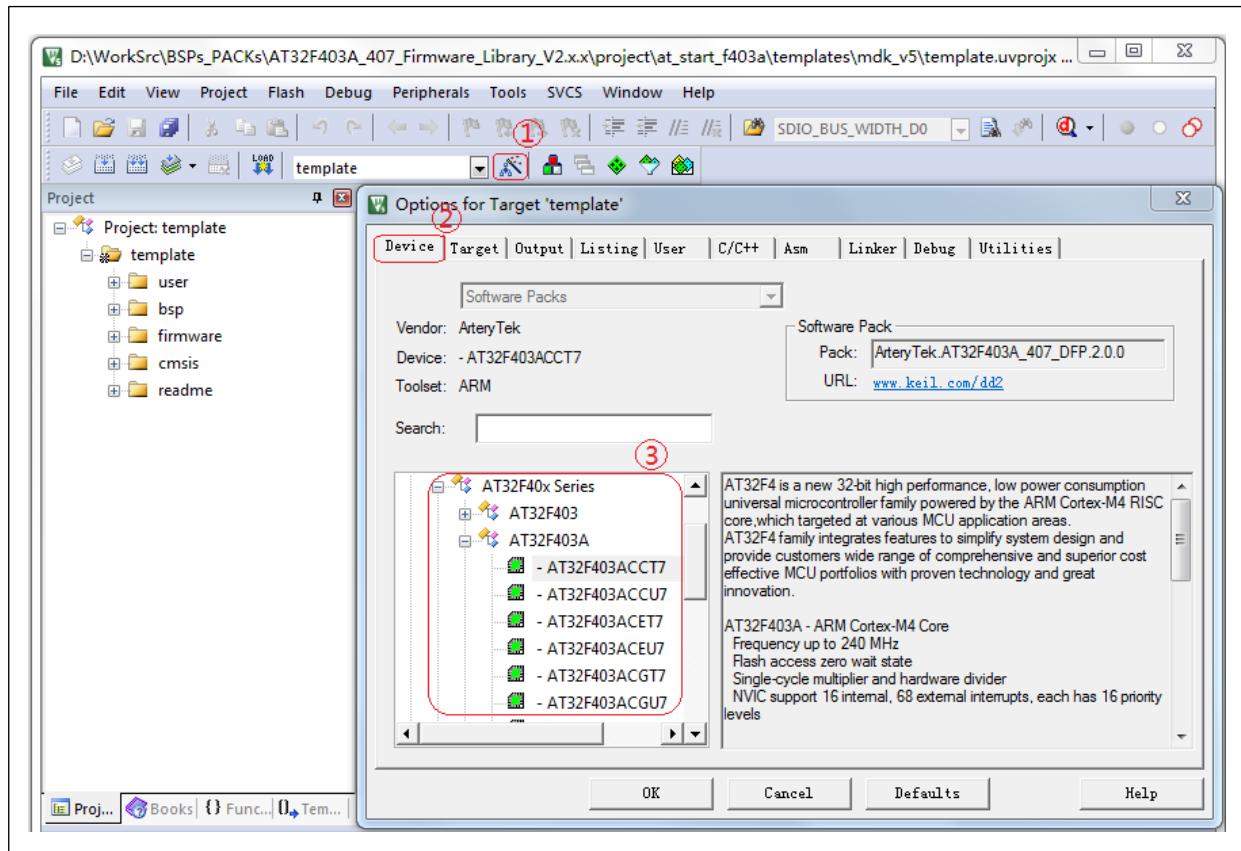


2.2 Keil_v5 Pack installation

Keil5_AT32MCU_AddOn.zip: This is a zip file supporting Keil_v5. Follow the steps below to install:

- ① Unzip *Keil5_AT32MCU_AddOn.zip*. This zip file includes all Keil5 packs supported, all of which are standard Keil_v5 DFP installation files.
- ② Select the desired Pack, and double click on *ArteryTek.AT32xxxx_DFP.2.x.x.pack* to get one-stop installation.
- ⑤ To check whether the Keil_v5 Pack is installed successfully or not, follow the steps below:
 - Click on wand;
 - Select “Device”;
 - View AT32 MCU-related information.

Figure 5. View Keil_v5 Pack installation status

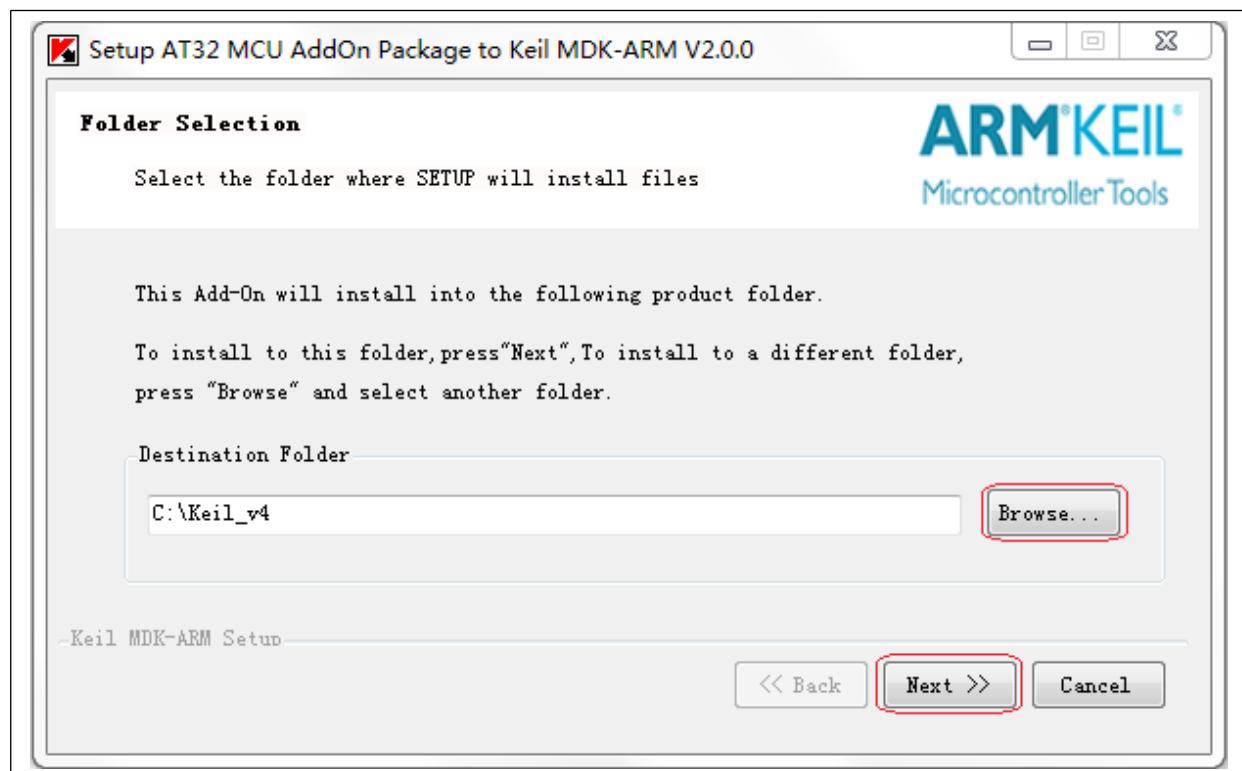


2.3 Keil_v4 Pack installation

Keil4_AT32MCU_AddOn.zip: This is a zip file supporting Keil_v4. Follow the steps below to install:

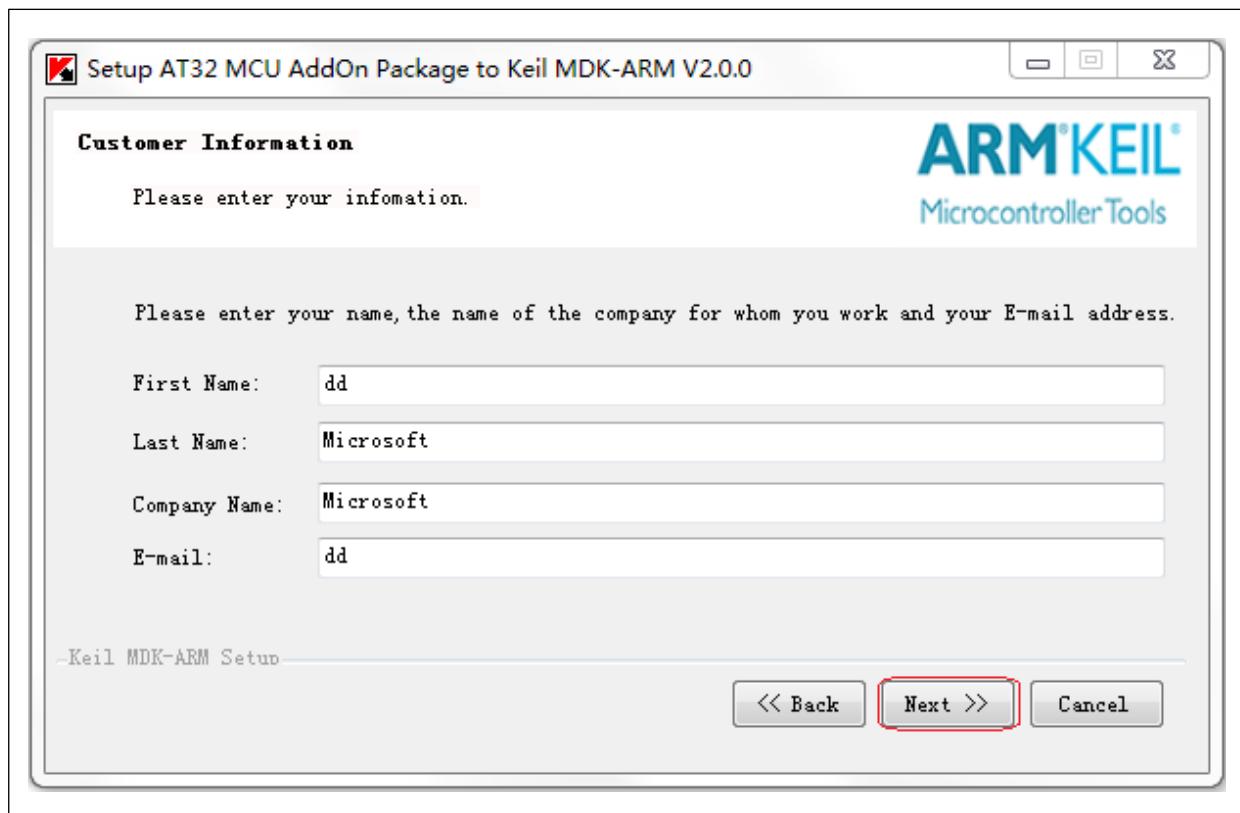
- ① Unzip *Keil4_AT32MCU_AddOn.zip*;
- ② Double click on *Keil4_AT32MCU_AddOn.exe*, and a dialog box pops up below (the specific version information is subject to the actual conditions).

Figure 6. Keil_v4 Pack installation



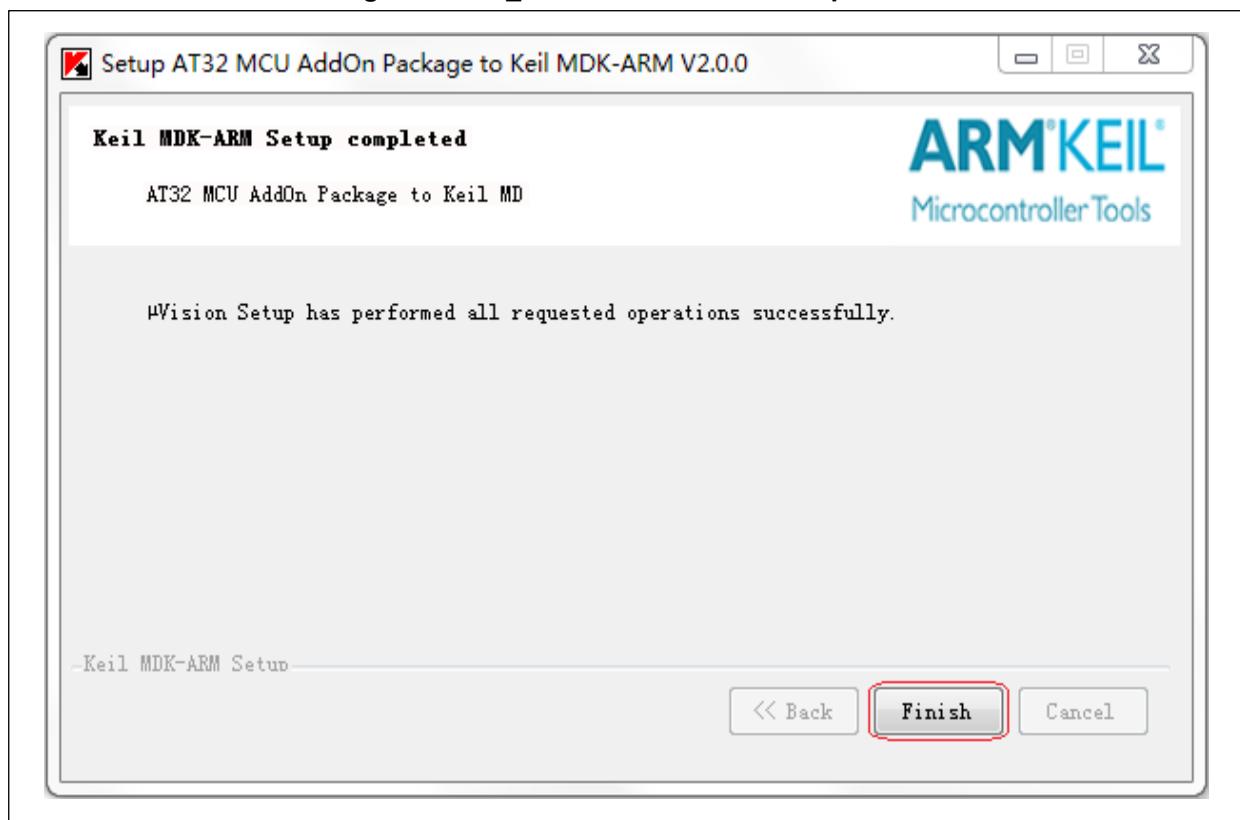
- ③ If the installation path of Keil_v4 does not match the “Destination Folder”, click on “Browse” to select the actual correct path, then click on “Next”, as shown below.

Figure 7. Keil_v4 Pack installation process



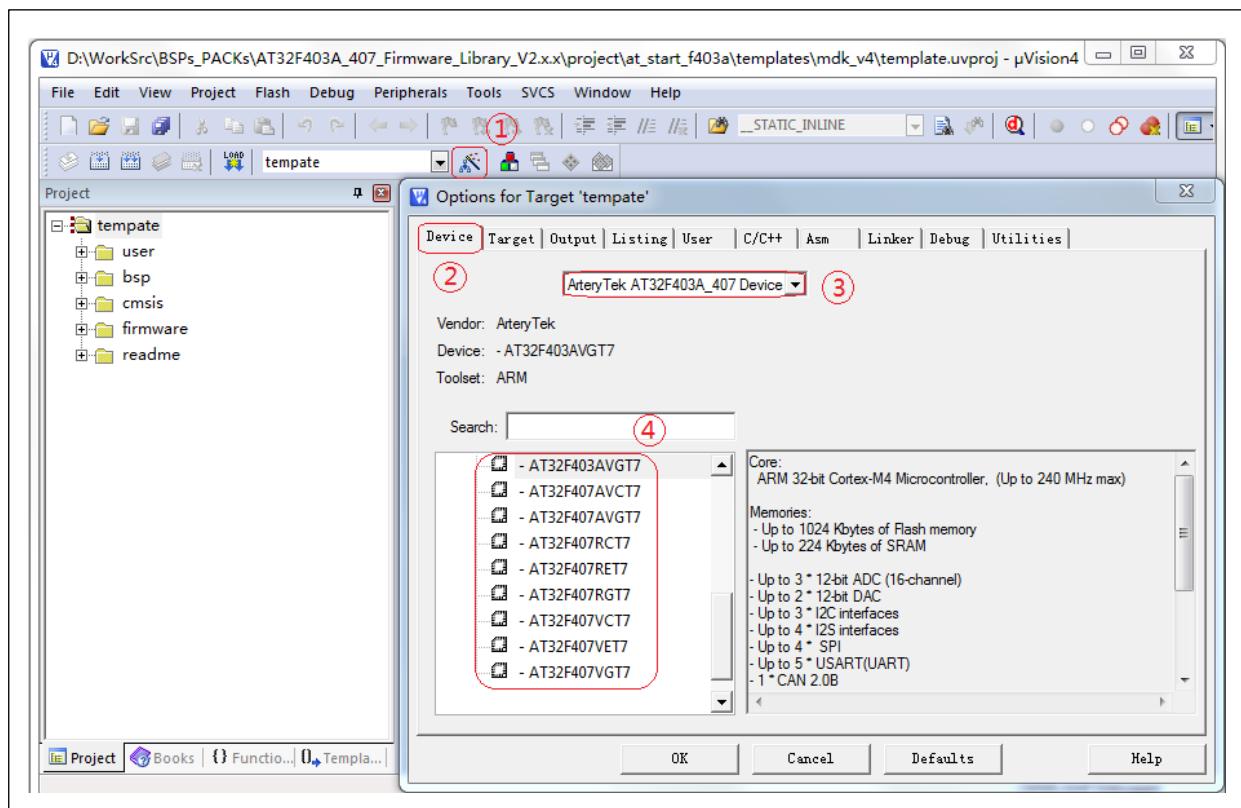
- ④ In the above “Customer Information” window, you can make some changes, but usually it is unnecessary. Then click on “Next” to start installation. The installation result is as follows.

Figure 8. Keil_v4 Pack installation complete



- ⑤ Click on “Finish”. To check whether Keil_v4 Pack is installed successfully or not, follow the below steps:
- Click on wand;
 - Select “Device”;
 - Select the desired pack file;
 - View ArteryTek-related information.

Figure 9. View Keil_v4 Pack installation status

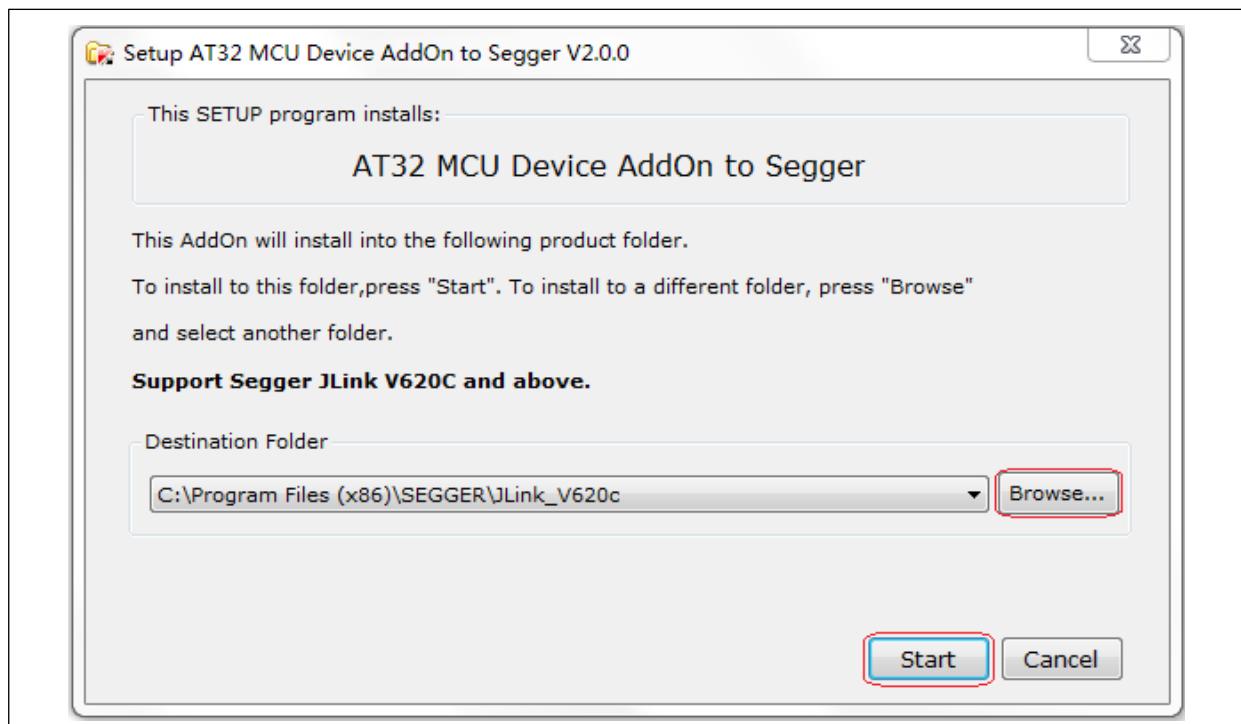


2.4 Segger Pack installation

Segger_AT32MCU_AddOn.zip: This is used to download J-Flash. Follow the steps below to install:

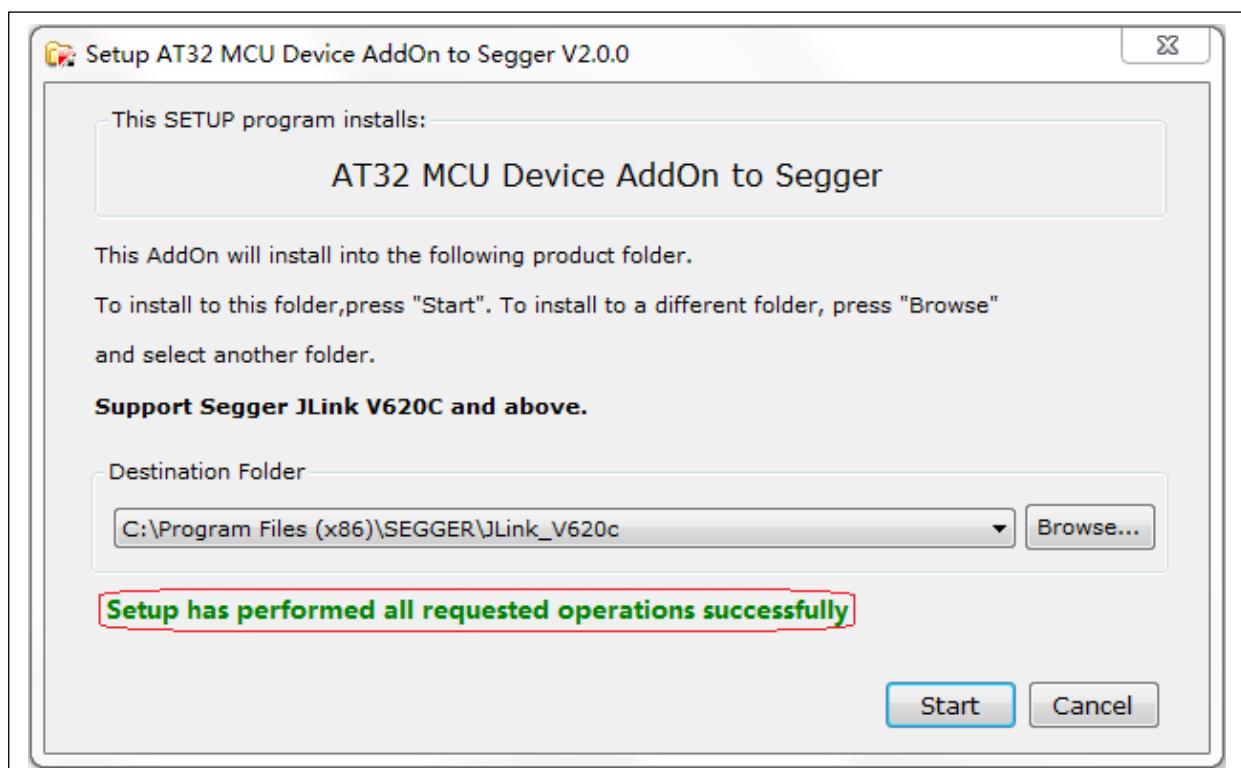
- ① Unzip Segger_AT32MCU_AddOn.zip;
- ② Double click on Segger_AT32MCU_AddOn.exe, and a dialog box pops up below (the specific version information is subject to the actual conditions).

Figure 10. Segger pack installation window



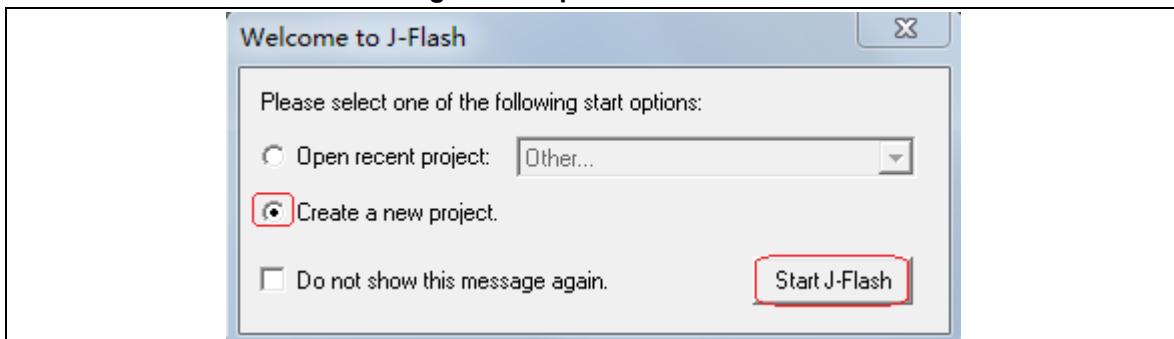
Note: If the installation path of Segger does not match the “Destination Folder”, click on “Browse” to select a correct path, then click on “Start”, as shown below.

Figure 11. Segger pack installation process



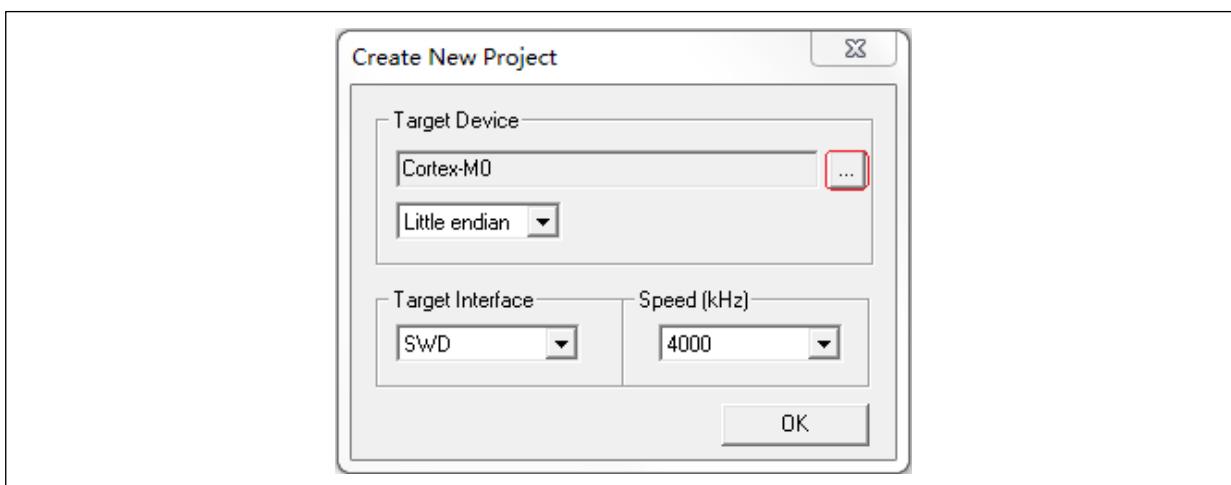
- ③ If the “Setup has performed all requested operations successfully” appears, it indicates successful installation. To check whether the installation is successful or not, follow the steps below:
- Open J-Flash.exe, a dialog box appears; tick “Create a new project” and click on “Start J-Flash”:

Figure 12. Open J-Flash



- After “Start J-Flash”, click on the check box under “Target Device”.

Figure 13. Create a new project using J-Flash



- Drag the scroll bar up and down in the check box. If the ArteryTek-related information and algorithm documents can be found, the installation is successful, as shown below:

Figure 14. View Device information

Select device					
Manufacturer	Device	Core	Flash size	RAM size	
ArteryTek	AT32F403_EXT_TYPE1_1MB	Cortex-M4	1024 KB	224 KB	
ArteryTek	AT32F403_EXT_TYPE1_2MB	Cortex-M4	2048 KB	224 KB	
ArteryTek	AT32F403_EXT_TYPE1_4MB	Cortex-M4	4096 KB	224 KB	
ArteryTek	AT32F403_EXT_TYPE1_8MB	Cortex-M4	8192 KB	224 KB	
ArteryTek	AT32F403_EXT_TYPE2_16MB	Cortex-M4	16 MB	224 KB	
ArteryTek	AT32F403_EXT_TYPE2_1MB	Cortex-M4	1024 KB	224 KB	
ArteryTek	AT32F403_EXT_TYPE2_2MB	Cortex-M4	2048 KB	224 KB	
ArteryTek	AT32F403_EXT_TYPE2_4MB	Cortex-M4	4096 KB	224 KB	
ArteryTek	AT32F403_EXT_TYPE2_8MB	Cortex-M4	8192 KB	224 KB	
ArteryTek	AT32F403_UNIVERSAL_TYPE1_1...	Cortex-M4	128 KB + 16 MB	224 KB	
ArteryTek	AT32F403_UNIVERSAL_TYPE1_2...	Cortex-M4	1024 KB + 16 MB	224 KB	
ArteryTek	AT32F403_UNIVERSAL_TYPE2_1...	Cortex-M4	128 KB + 16 MB	224 KB	
ArteryTek	AT32F403_UNIVERSAL_TYPE2_2...	Cortex-M4	1024 KB + 16 MB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	16 MB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	1024 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	2048 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	4096 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	8192 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	16 MB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	1024 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	2048 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	4096 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE1_REAMP...	Cortex-M4	8192 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE2_REAMP...	Cortex-M4	16 MB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE2_REAMP...	Cortex-M4	1024 KB	224 KB	
ArteryTek	AT32F403A_EXT_TYPE2_REAMP...	Cortex-M4	2048 KB	224 KB	
ArteryTek	AT32F403A_FXT_TYPE2_RFAMP	Cortex-M4	2048 KB	224 KB	

3 Flash algorithm file

Flash algorithm files are included in the Pack for online download through IDE tools such as KEIL/IAR. This section describes how to use Flash algorithm files.

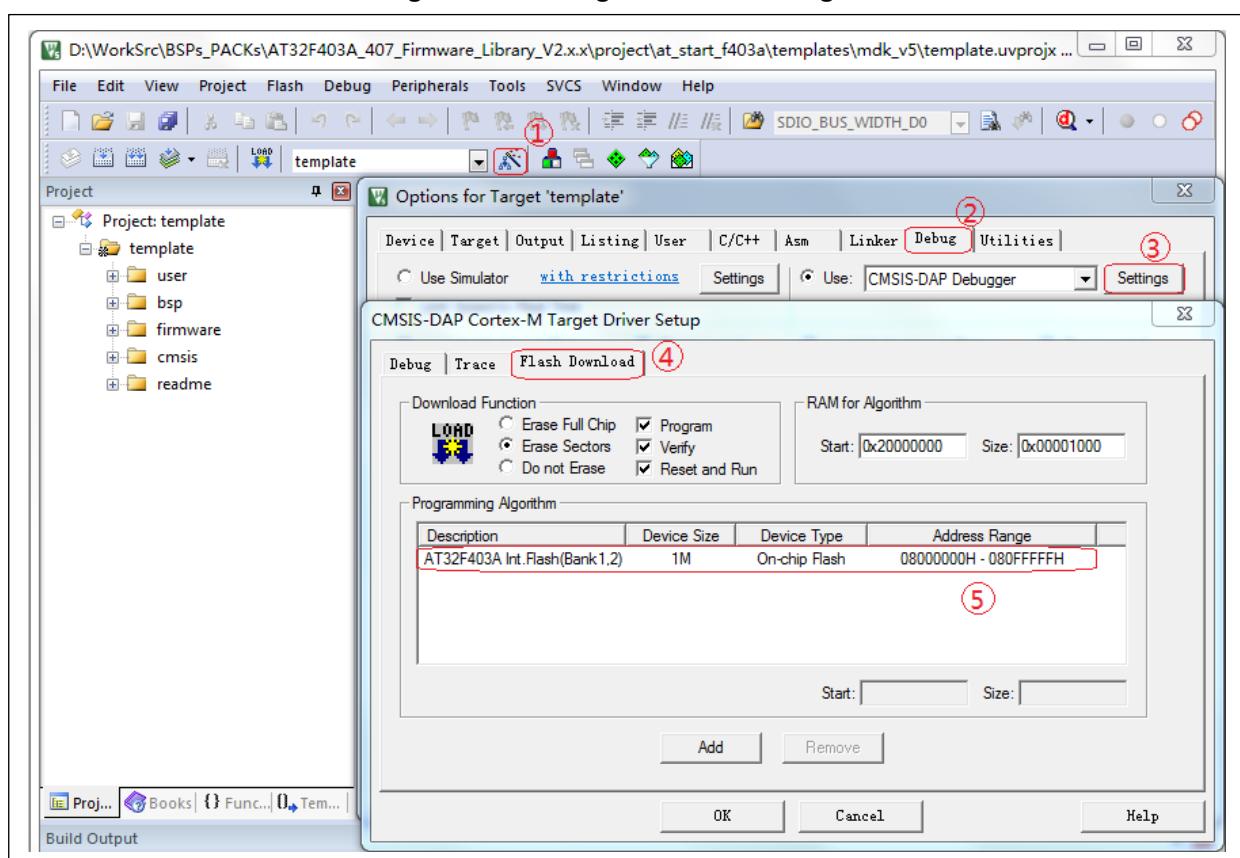
Note: AT32 MCUs have similar Flash algorithms, and this section uses AT32F403A as an example.

3.1 How to use Keil algorithm file

Common IDE tools such as Keil_v4 and Keil_v5 adopt a similar method to select and use the algorithm files. Here we take Keil_v5 as an example.

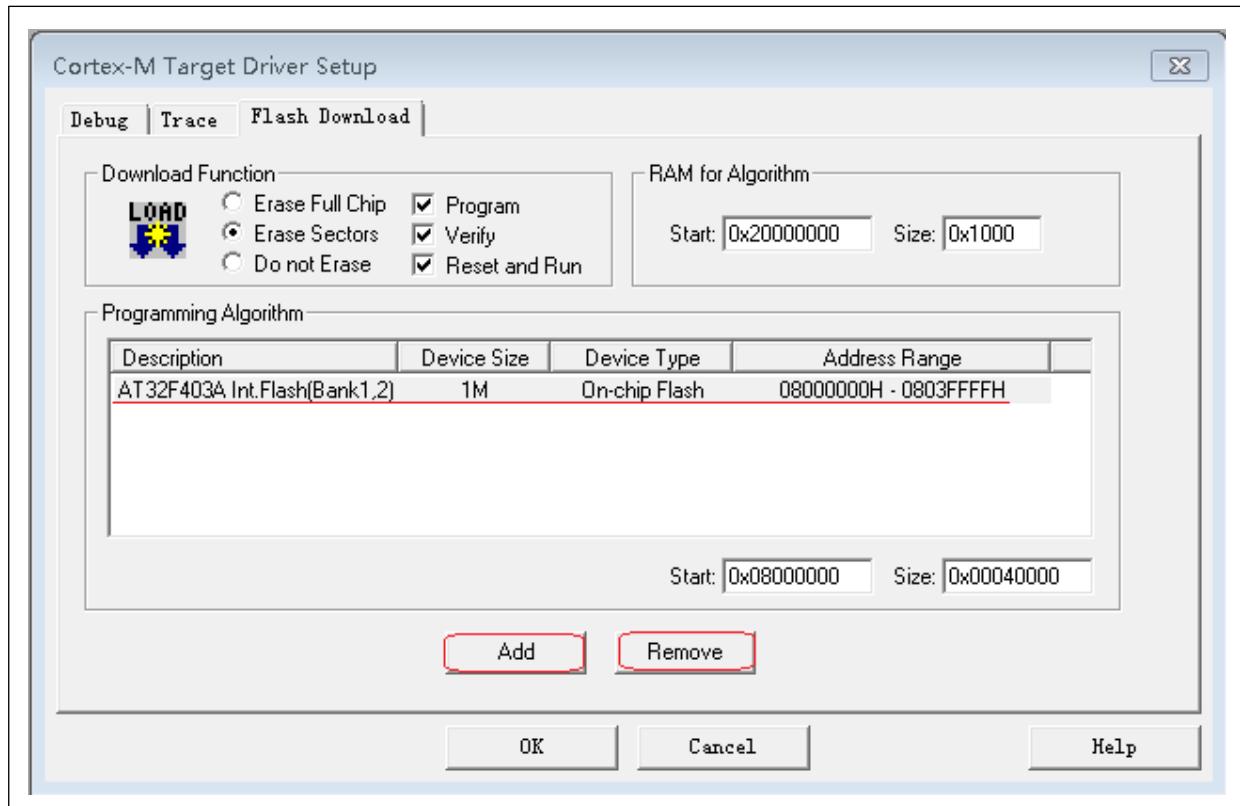
After creating a Keil IDE development tool project, the user can start Debug configuration and select the Flash algorithms. Go to *wand*—>*Debug*—>*Settings*—>*Flash Download*, as shown below:

Figure 15. Keil algorithm file settings



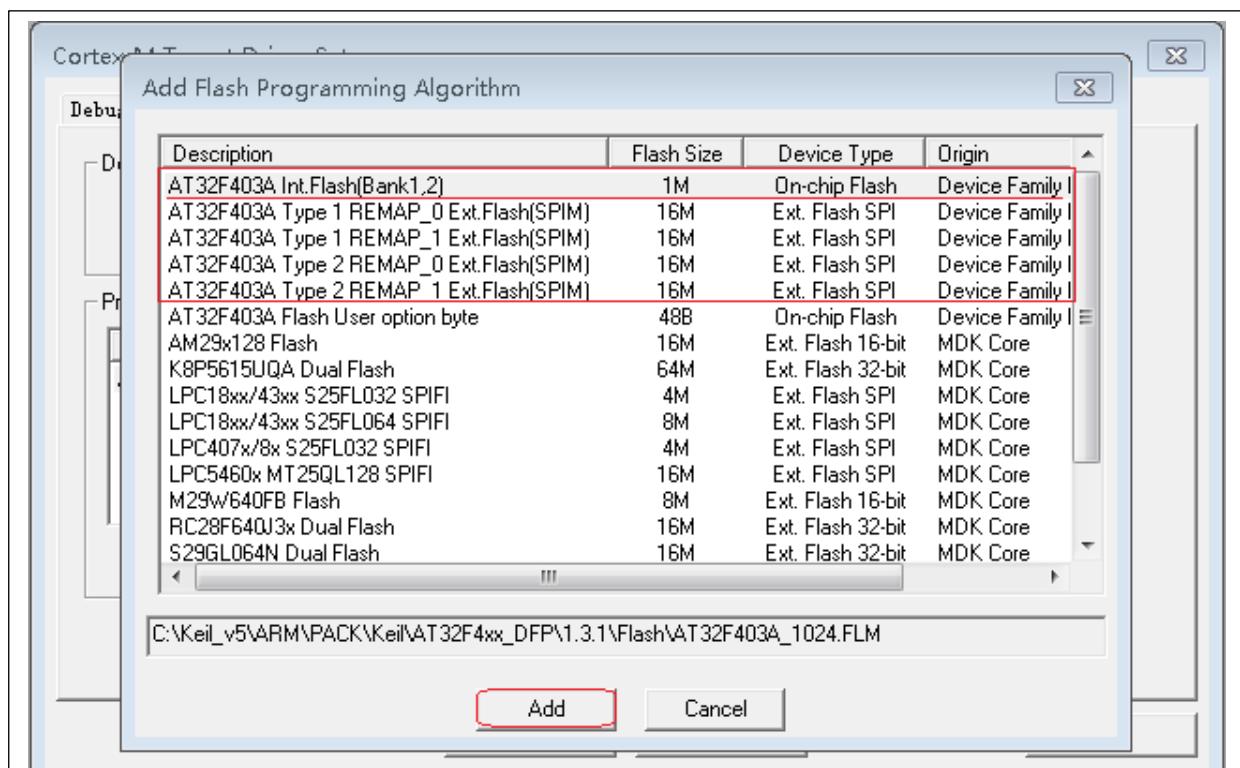
In this example, the selected Flash algorithm file is the default one. To change or remove it, click on this algorithm file, then click on *Add* or *Remove*. If the selected algorithm does not match the MCU, please follow the method below to modify.

Figure 16. Keil algorithm file configuration



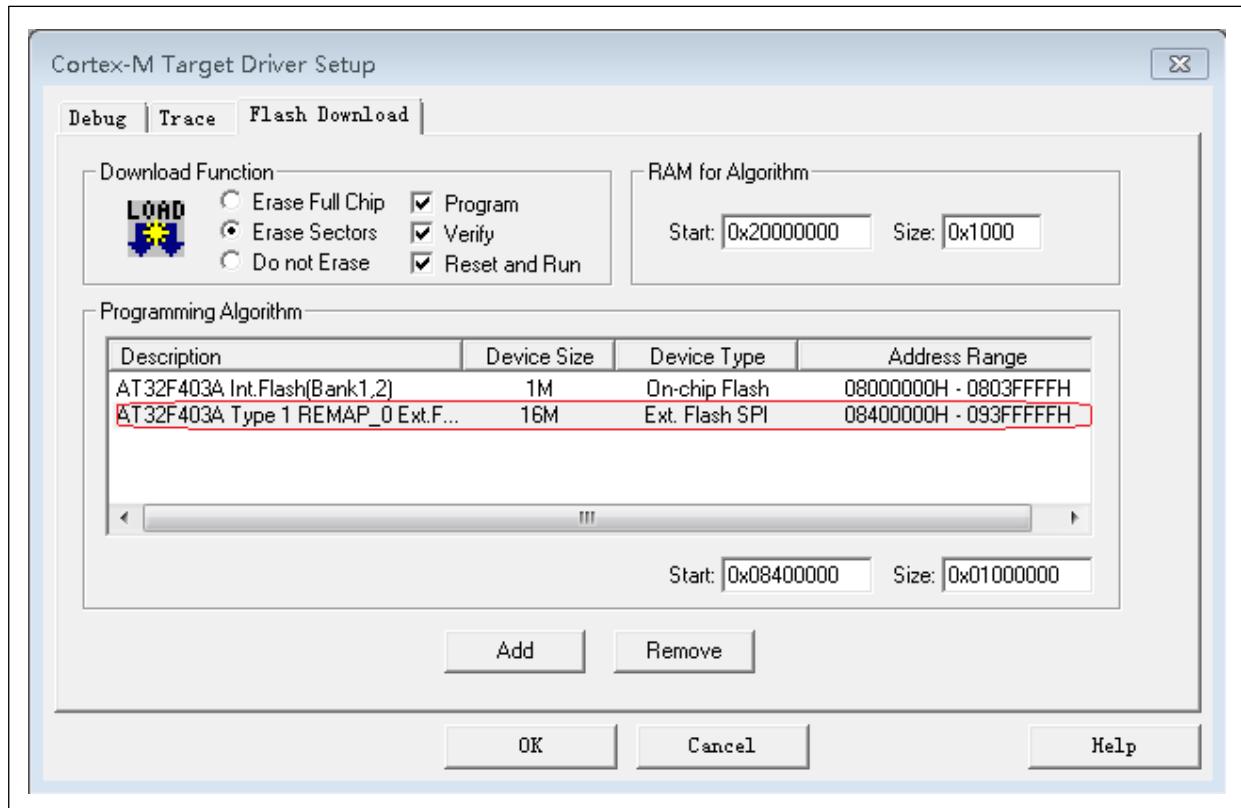
Click on *Remove* to remove the existing algorithm from the configuration, then click on *Add* to view the algorithm files associated with a MCU model and select them, as shown below:

Figure 17. Select algorithm files using Keil



After selection, click on *Add* to add the selected algorithm files into the current configuration. For example, a new SPIFI algorithm is added into the project.

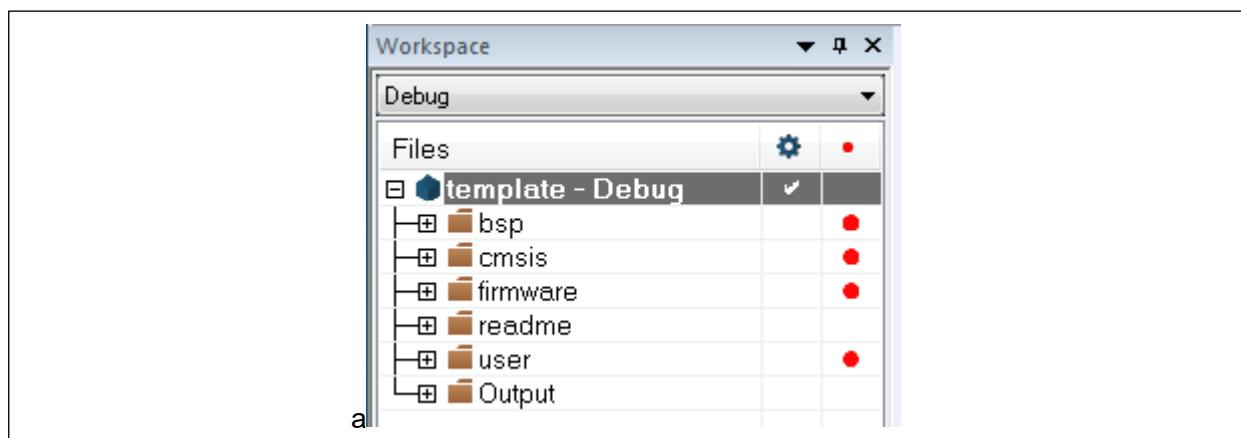
Figure 18. Add algorithm files using Keil



3.2 How to use IAR algorithm files

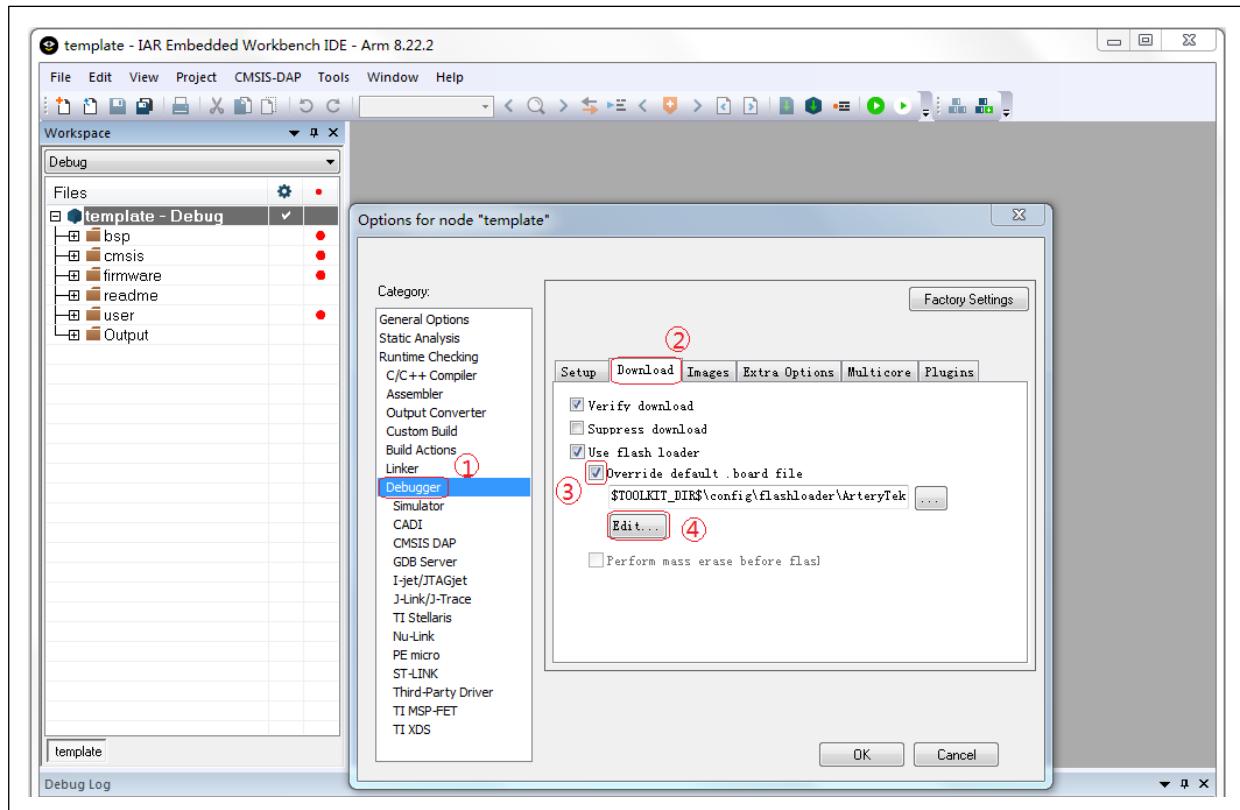
In IAR environment, the Flash algorithm files are automatically selected according to the selected MCU model during a new project configuration. To configure/modify an algorithm file manually, right-click on the file name (after an IAR project is created) in the following gray box:

Figure 19. IAR project name



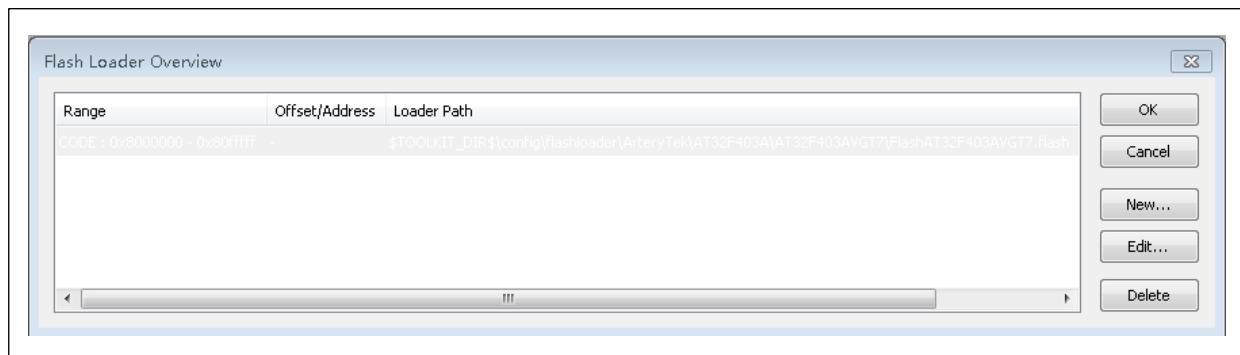
Go to Options—>Debugger—>Download—>Tick Override default .board file—>Click on Edit, as shown below:

Figure 20. IAR algorithm file configuration



Then the following window will be displayed.

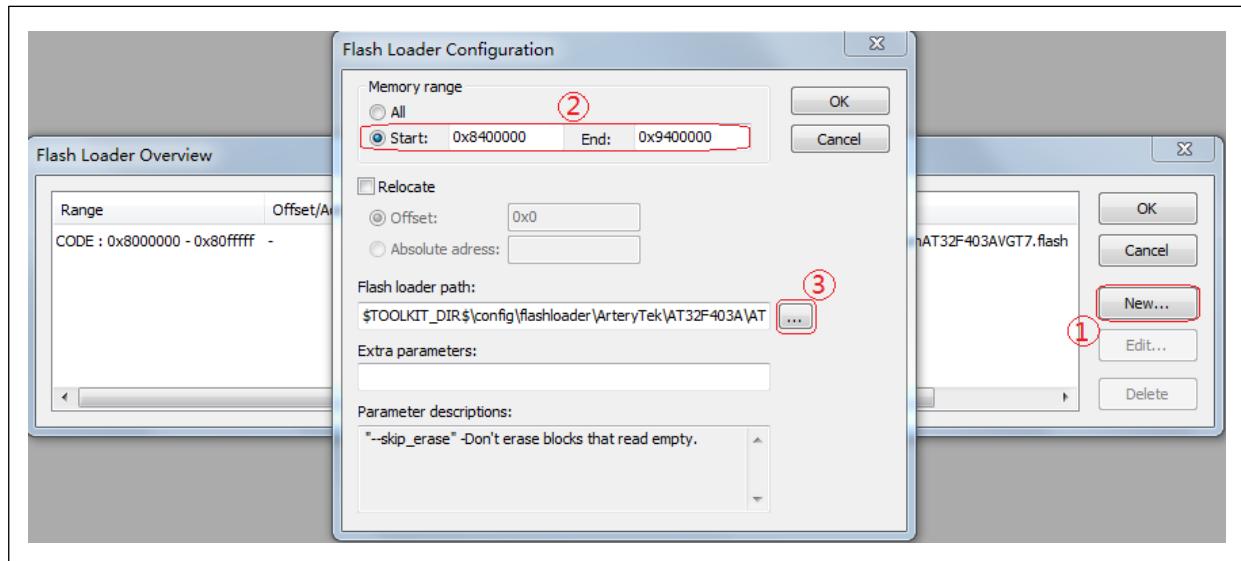
Figure 21. IAR Flash Loader overview



Flash algorithm configuration is designated by default after selecting a MCU part number. To modify it, click on *New/Edit/Delete*.

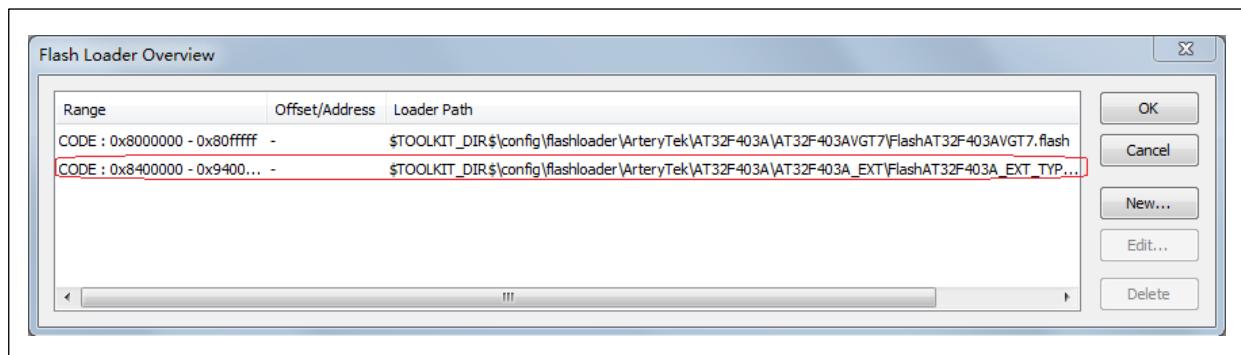
For example, click on *New*—>*Memory range*—> Select a Flash algorithm file, as shown below:

Figure 22. IAR Flash Loader configuration



This example shows how to add a SPIM Flash algorithm file. The user needs to select the corresponding MCU part number and a correct Flash algorithm file. The selected Flash algorithm configuration file is installed into IAR development environment using IAR_AT32MCU_AddOn tool. After a successful configuration, a new SPIM Flash algorithm is shown below:

Figure 23. IAR Flash Loader configuration success



1. Description of SPIM algorithms

Some Artery MCUs support Bank3 (refer to the Reference Manual or Datasheet on Artery official website for details), which can be used as an expansion of Flash memory in case of insufficient internal Flash or special application requirements. When the compiling addresses of some code or data are stored in the SPIM, these algorithm files are used for external Flash programming during online IDE tool download.

Naming rules of Artery SPIM algorithm file: AT32F4xxTypeNREMAP_P Ext.Flash.

N=1,2

P=0,1

TYPEN: External SPI Flash. Select it according to the external Flash type and part number. Refer to the FLASH_SELECT register section of the corresponding MCU Reference Manual.

REMAP_P: Select multiplex-function MCU SPIM PIN. Select it according to the connection method of pins connected to external Flash. Refer to the external SPIF remapping section in the corresponding MCU reference manual.

REMAP0: EXT_SPIF_GRMP=000

REMAP1: EXT_SPIF_GRMP=001

4 BSP introduction

4.1 Quick start

4.1.1 Template project

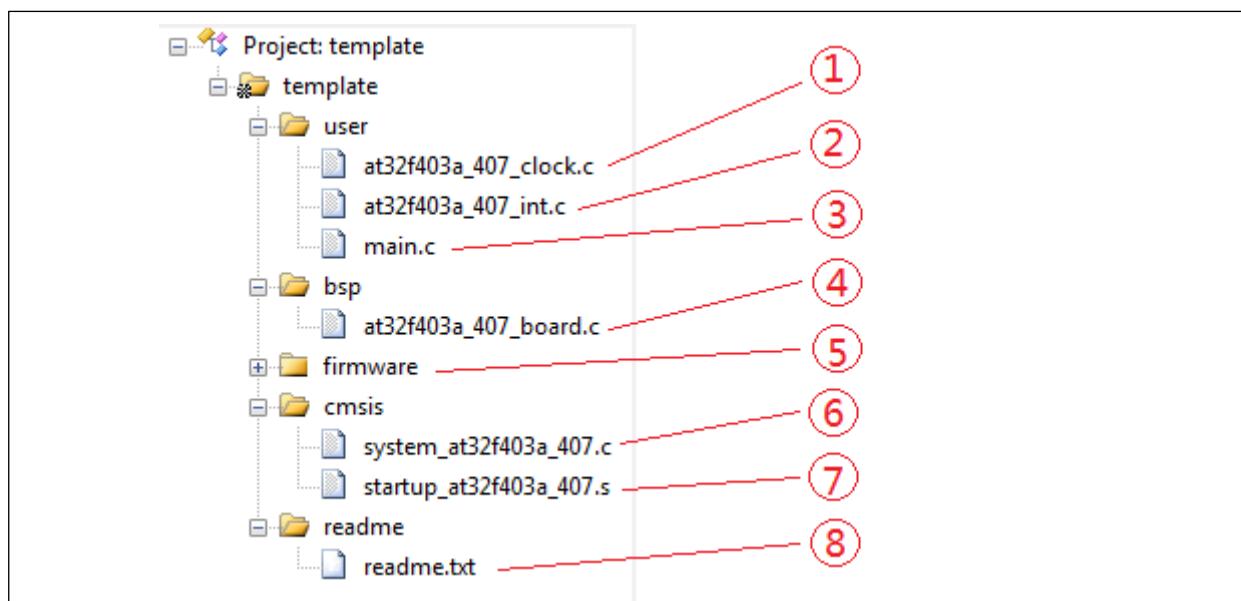
Artery firmware library BSP comes with a series of template projects built around Keil and IAR. For example, the template project of AT32F403A/407 is located in `AT32F403A_407_Firmware_Library_V2.x.x/project/at_start_xxx/templates`.

Figure 24. Template content

iar_v6.10	21/05/24 16:03	文件夹
iar_v7.4	21/05/24 16:03	文件夹
iar_v8.2	21/05/24 16:03	文件夹
inc	21/05/24 16:03	文件夹
mdk_v4	21/05/24 16:03	文件夹
mdk_v5	21/05/24 16:03	文件夹
src	21/05/24 16:03	文件夹
readme.txt	21/05/21 11:15	TXT 文件

The above template project includes various versions such as Keil_v5, Keil_v4, IAR_6.10, IAR_7.4 and IAR_8.2. Of those, “inc” and “src” folders contain header files and source code files, respectively. Open a corresponding folder and click on the corresponding file to open an IDE project. Figure 25 presents an example of Keil_v5 template project (its details and version are subject to the actual firmware library).

Figure 25. Keil_v5 template project example



The contents in a project include: (using AT32F403A/407 as an example, other products are similar)

- ① `at32f403a_407_clock.c` (clock configuration file) defines the default clock frequency and clock paths.
- ② `at32f403a_407_int.c` (interrupt file) contains some interrupt handling codes.
- ③ `main.c` contains the main code files.

- ④ at32f403a_407_board.c (board configuration file) contains common hardware configurations such as buttons and LEDs on the AT-START-Evaluation Board.
- ⑤ at32f403a_407_xx.c under firmware folder contains driver files of on-chip peripherals.
- ⑥ system_at32f403a_407.c is the system initialization file.
- ⑦ startup_at32f403a_407.s is a startup file.
- ⑧ readme.txt is a readme file, containing functional description and configuration information.

Note: AT32 MUCs share similar BSP usage method, and this section uses AT32F403A as an example.

4.1.2 BSP macro definitions

- ① To create a project, it is necessary to enable a startup code (startup_at32f403a_407.s) and open the appropriate macro definitions according to MCU part number before compiling code. Table 1 presents the correspondence between the MCU and their macro definitions.

Table 1. Summary of macro definitions

MCU part numbers	Macro definitions	PINs	Flash size (KB)
AT32F403ACCT7	AT32F403ACCT7	48	256
AT32F403ACET7	AT32F403ACET7	48	512
AT32F403ACGT7	AT32F403ACGT7	48	1024
AT32F403ACCU7	AT32F403ACCU7	48	256
AT32F403ACEU7	AT32F403ACEU7	48	512
AT32F403ACGU7	AT32F403ACGU7	48	1024
AT32F403ARCT7	AT32F403ARCT7	64	256
AT32F403ARET7	AT32F403ARET7	64	512
AT32F403ARGT7	AT32F403ARGT7	64	1024
AT32F403AVCT7	AT32F403AVCT7	100	256
AT32F403AVET7	AT32F403AVET7	100	512
AT32F403AVGT7	AT32F403AVGT7	100	1024
AT32F407RCT7	AT32F407RCT7	64	256
AT32F407RET7	AT32F407RET7	64	512
AT32F407RGT7	AT32F407RGT7	64	1024
AT32F407VCT7	AT32F407VCT7	100	256
AT32F407VET7	AT32F407VET7	100	512
AT32F407VGT7	AT32F407VGT7	100	1024
AT32F407AVCT7	AT32F407AVCT7	100	256
AT32F407AVGT7	AT32F407AVGT7	100	1024

- ② In the header file (at32f403a_407.h), USE_STDPERIPH_DRIVER (macro definition) is used to determine whether the Keil RTE feature is used or not. Enabling this definition while Keil RTE is unused can prevent some versions of Keil-MDK from opening _RTE_ accidentally.
- ③ The configuration header file (at32f403a_407_conf.h) defines macro definitions that enable peripherals. The file can be used to control the use of peripherals. The peripherals can be disabled simply by masking _MODULE_ENABLED pertaining to peripherals, as shown below:

Figure 26. Peripheral enable macro definitions

```
#define CRM_MODULE_ENABLED  
#define TMR_MODULE_ENABLED  
#define RTC_MODULE_ENABLED  
#define BPR_MODULE_ENABLED  
#define GPIO_MODULE_ENABLED  
#define I2C_MODULE_ENABLED  
#define USART_MODULE_ENABLED  
#define PWC_MODULE_ENABLED  
#define CAN_MODULE_ENABLED  
#define ADC_MODULE_ENABLED  
#define DAC_MODULE_ENABLED  
#define SPI_MODULE_ENABLED  
#define DMA_MODULE_ENABLED  
#define DEBUG_MODULE_ENABLED  
#define FLASH_MODULE_ENABLED  
#define CRC_MODULE_ENABLED  
#define WWDT_MODULE_ENABLED  
#define WDT_MODULE_ENABLED  
#define EXINT_MODULE_ENABLED  
#define SDIO_MODULE_ENABLED  
#define XMC_MODULE_ENABLED  
#define USB_MODULE_ENABLED  
#define ACC_MODULE_ENABLED  
#define MISC_MODULE_ENABLED  
#define EMAC_MODULE_ENABLED
```

at32f403a_407_conf.h also defines the HEXT_VALUE (high-speed external clock value), which should be modified accordingly when changing an external high-speed crystal oscillator.

- ④ The system clock configuration file (*at32f403a_407_clock.c/.h*) defines the default system clock frequency and clock paths. The user, if needed, can customize the frequency multiplication process and factors, or generate corresponding clock configuration files using the clock configuration host of ArteryTek.

4.2 BSP specifications

The subsequent sections give a description of BSP specifications.

4.2.1 List of abbreviations for peripherals

Table 2. List of abbreviations for peripherals

Abbreviations	Description
ADC	Analog-to-digital converter
BPR	Battery powered register
CAN	Controller area network
CRC	CRC calculation unit
CRM	Clock and reset manage
DAC	Digital-to-analog converter
DMA	Direct memory access
DEBUG	Debug
EXINT	External interrupt/event controller
GPIO	General-purpose I/Os
IOMUX	Multiplexed I/Os
I2C	Inter-integrated circuit interface
NVIC	Nested vectored interrupt controller
PWC	Power controller
RTC	Real-time clock
SPI	Serial peripheral interface
I2S	Inter-IC Sound
SysTick	System tick timer
TMR	Timer
USART	Universal synchronous/asynchronous receiver transmitter
WDT	Watchdog timer
WWDT	Window watchdog timer
XMC	External memory controller

4.2.2 Naming rules

The naming rules for BSP are described as follows:

“ip” indicates an abbreviation of a peripheral, for example, ADC, TMR, GPIO, etc., regardless of upper and lower case letters, such as, adc, tmr, gpio...

- **Source code file**

The file name starts with “at32fxxx_ip.c”, for example, at32f403a_407_adc.c

- **Header file**

The file name starts with “at32fxxx_ip.h”, such as, at32f403a_407_adc.h

- **Constant**

If it is used in a single one file, the constant is then defined in this file; if it is used in multiple files, the constant is defined in corresponding header file.

All constants are in written in English capital letters.

- **Variable**

If it is used in a single one file, the variable is then defined in this file; if it is used in multiple files, the variable is declared with extern in the corresponding header file.

- **Naming rules for functions**

The peripheral functions are named based on the rule of “**peripheral abbreviatio_attribute_action**” or “**peripheral abbreviation_attribute_action**”.

The commonly used functions are as follows:

Function type	Naming rule	Example
Peripheral reset	ip_reset	adc_reset
Peripheral enable	ip_enable	adc_enable
Peripheral structure parameter initialize	ip_default_para_init	spi_default_para_init
Peripheral initialize	ip_init	spi_init
Peripheral interrupt enable	ip_interrupt_enable	adc_interrupt_enable
Peripheral flag get	ip_flag_get	adc_flag_get
Peripheral flag clear	ip_flag_clear	adc_flag_clear

4.2.3 Encoding rules

This section describes the encoding rules related to firmware function library.

Type of variables:

```

typedef int32_t INT32;
typedef int16_t INT16;
typedef int8_t INT8;
typedef uint32_t UINT32;
typedef uint16_t UINT16;
typedef uint8_t UINT8;

typedef int32_t s32;
typedef int16_t s16;
typedef int8_t s8;

typedef const int32_t sc32; /*!< read only */
typedef const int16_t sc16; /*!< read only */
typedef const int8_t sc8; /*!< read only */

typedef __IO int32_t vs32;
typedef __IO int16_t vs16;
typedef __IO int8_t vs8;

typedef __I int32_t vsc32; /*!< read only */
typedef __I int16_t vsc16; /*!< read only */
typedef __I int8_t vsc8; /*!< read only */

typedef uint32_t u32;
typedef uint16_t u16;
typedef uint8_t u8;

typedef const uint32_t uc32; /*!< read only */
typedef const uint16_t uc16; /*!< read only */
typedef const uint8_t uc8; /*!< read only */

```

```

typedef __IO uint32_t vu32;
typedef __IO uint16_t vu16;
typedef __IO uint8_t vu8;

typedef __I uint32_t vuc32; /*!< read only */
typedef __I uint16_t vuc16; /*!< read only */
typedef __I uint8_t vuc8; /*!< read only */

```

4.2.3.1 Flag type

```
typedef enum {RESET = 0, SET = !RESET} flag_status;
```

4.2.3.2 Function status type

```
typedef enum {FALSE = 0, TRUE = !FALSE} confirm_state;
```

4.2.3.3 Error status type

```
typedef enum {ERROR = 0, SUCCESS = !ERROR} error_status;
```

4.2.3.4 Peripheral type

① Peripherals

Define the base address of peripheral in the at32fxxx_ip.h, for example, in the at32f403a_407.h:

#define ADC1_BASE	(APB2PERIPH_BASE + 0x2400)
#define ADC2_BASE	(APB2PERIPH_BASE + 0x2800)

Define the type of a peripheral in the at32fxxx_ip.h, for example, in the at32f403a_407_adc.h:

#define ADC1	((adc_type *) ADC1_BASE)
#define ADC2	((adc_type *) ADC2_BASE)

② Peripheral registers and bits

Define the type of a peripheral in the at32fxxx_ip.h, for example, in the at32f403a_407_adc.h

```

/*
 * @brief type define adc register all
 */
typedef struct
{

    /**
     * @brief adc sts register, offset:0x00
     */
    union
    {
        __IO uint32_t sts;
        struct
        {
            __IO uint32_t vmor : 1; /* [0] */

```

```

    __IO uint32_t cce          : 1; /* [1] */
    __IO uint32_t pcce         : 1; /* [2] */
    __IO uint32_t pccs         : 1; /* [3] */
    __IO uint32_t occs         : 1; /* [4] */
    __IO uint32_t reserved1    : 27; /* [31:5] */

} sts_bit;

};

...
...
...
...

/***
 * @brief adc odt register, offset:0x4C
 */
union
{
    __IO uint32_t odt;
    struct
    {
        __IO uint32_t odt          : 16; /* [15:0] */
        __IO uint32_t adc2odt      : 16; /* [31:16] */
    } odt_bit;
};

} adc_type;

```

③ Examples of peripheral register access

Read peripheral	i = ADC1->ctrl1;
Write peripheral	ADC1->ctrl1 = i;
Read bit 5 in bit-field mode	i = ADC1->ctrl1.cceien;
Write 1 to bit 5 in bit-field mode	ADC1->ctrl1.cceien= TRUE;
Write 1 to bit 5	ADC1->ctrl1 = 1<<5;
Write 0 to bit 5	ADC1->ctrl1&= ~(1<<5);

4.3 BSP structure

4.3.1 BSP folder structure

BSP(Board Support Package) structure is shown in Figure 27.

Figure 27. BSP folder structure

 document	21/05/18 10:32	文件夹
 libraries	21/05/18 10:32	文件夹
 middlewares	21/05/18 10:32	文件夹
 project	21/05/18 10:32	文件夹
 utilities	21/05/14 11:35	文件夹

Document:

- AT32Fxxx firmware library BSP&Pack user guide.pdf: refer to BSP/Pack user manual
- ReleaseNotes_AT32F403A_407_Firmware_Library.pdf: document revision history

Libraries:

- **Drivers:** driver library for peripherals
Src folder: low-level driver source file for peripherals, such as, at32fxxx_ip.c
inc folder: low-level driver header file for peripherals, such as, at32fxxx_ip.h
- **Cmsis:** Core-related files
cm4 folder: core-related files, including cortex-m4 library, system initialization file, startup file, etc.
dsp folder: dsp-related files

Middlewares:

Third-party software or public protocols, including USB protocol layer driver, network protocol driver, operating system source code, etc.

Project:

Examples: demo

Templates: template projects, including Keil4, keil5, IAR6, IAR7, IAR8 and eclipse_gcc

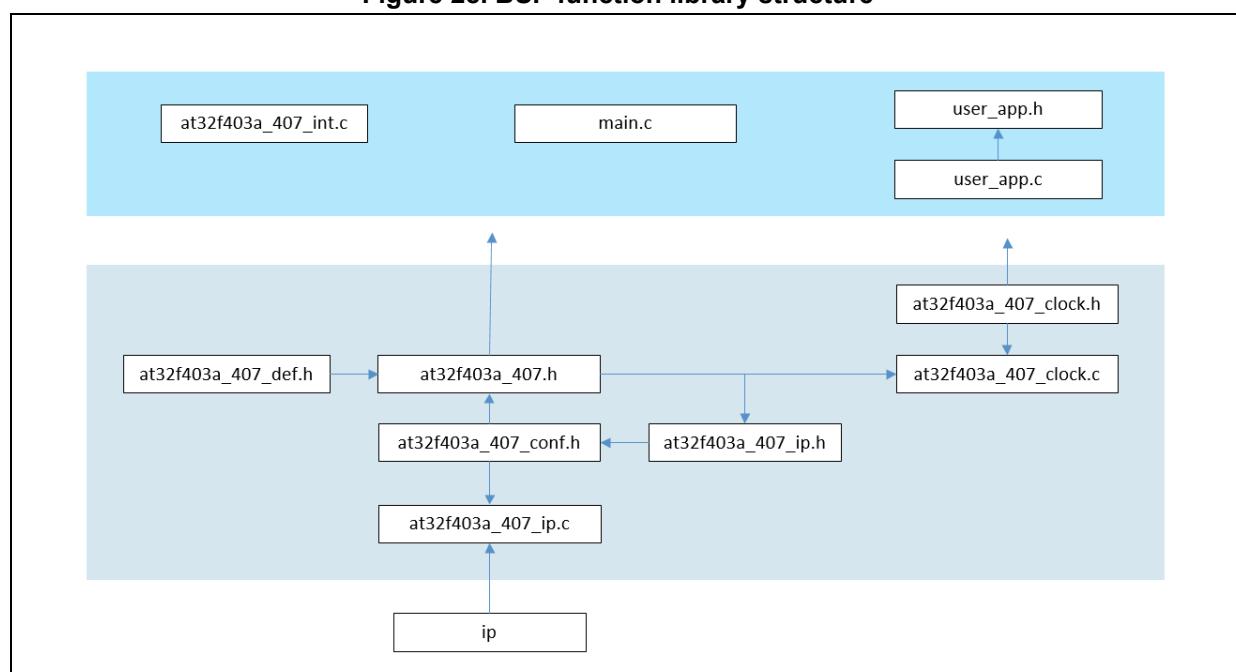
Utilities:

Store application cases

4.3.2 BSP function library structure

Figure 28 shows the architecture of BSP function library.

Figure 28. BSP function library structure



BSP function library files are described in Table 3.

Table 3. Summary of BSP function library files

File name	Description
at32f403a_407_conf.h	Macro definition for peripheral enable, and external high-speed clock HEXT_VALUE
main.c	Main function
at32f403a_407_ip.c	Driver source file for a peripheral, for example, at32f403a_407_adc.c
at32f403a_407_ip.h	Driver header file for a peripheral, for example, at32f403a_407_adc.h
at32f403a_407.h	In the header file (at32f403a_407.h), the definition USE_STDPERIPH_DRIVER is used to determine whether the Keil RTE is used or not. Enabling the definition while Keil RTE is unused can prevent Keil-MDK from enabling _RTE_ accidentally.
at32f403a_407_clock.c	This is a clock configuration file used to configure default clock frequency and clock path.
at32f403a_407_clock.h	This is a clock configure header file.
at32f403a_407_int.c	This is a source file for interrupt functions that programs interrupt handling code.
at32f403a_407_int.h	This is a header file for interrupt functions.
at32f403a_407_misc.c	This is a source file for other configurations, such as, nvic configuration function, systick clock source selection.
at32f403a_407_misc.h	This is a header file for other configurations.
startup_at32f403a_407.s	This is a startup file.

4.3.3 Initialization and configuration for peripherals

This section describes how to initialize and configure peripherals using GPIO as an example.

GPIO initialization

- Step 1: Define the gpio_init_type, for example, gpio_init_type gpio_init_struct;
- Step 2: Enable GPIO clock using the function crm_periph_clock_enable;
- Step 3: De-initialize the structure gpio_init_struct to allow the values of other members (mostly default values) to be correctly written, for example, gpio_default_para_init(&gpio_init_struct);
- Step 4: Configure member of the structure, and write structure parameters into GPIO registers through the gpio_init, for example,

```
gpio_init_struct.gpio_pins = GPIO_PINS_2 | GPIO_PINS_3;
gpio_init_struct.gpio_mode = GPIO_MODE_OUTPUT;
gpio_init_struct.gpio_out_type = GPIO_OUTPUT_PUSH_PULL;
gpio_init_struct.gpio_pull = GPIO_PULL_NONE;
gpio_init_struct.gpio_drive_strength = GPIO_DRIVE_STRENGTH_STRONGER;
gpio_init(GPIOA, &gpio_init_struct);
```

For more information on peripheral initialization procedure, refer to the section of peripherals of the reference manual, and the section of peripherals of the AT32Fxxx_Firmware_Library_V2.x.x.zip\project\at_start_fxxx\examples.

4.3.4 Peripheral functions format description

Table 4. Function format description for peripherals

Name	Description
Function name	The name of a peripheral function
Function prototype	Prototype declaration
Function description	Brief description of how the function is executed
Input parameter (n)	Description of the input parameters
Output parameter (n)	Description of the output parameters
Return value	Value returned by the function
Required preconditions	Requirements before calling the function
Called functions	Other library functions called

5 AT32F423 peripheral library functions

5.1 HICK automatic clock calibration (ACC)

The ACC register structure acc_type is defined in the “at32f423_acc.h”:

```
/*
 * @brief type define acc register all
 */
typedef struct
{
    .....
} acc_type;
```

The table below gives a list of the ACC registers.

Table 5. Summary of ACC registers

Register	Description
acc_sts	ACC status register
acc_ctrl1	ACC control register 1
acc_ctrl2	ACC control register 2
acc_c1	ACC compare value 1
acc_c2	ACC compare value 2
acc_c3	ACC compare value 3

The table below gives a list of the ACC library functions.

Table 6. Summary of ACC library functions

Function name	Description
acc_calibration_mode_enable	ACC calibration mode enable
acc_step_set	Configure ACC calibration step length
acc_interrupt_enable	ACC interrupt enable
acc_hicktrim_get	Get ACC trimming calibration value
acc_hickcal_get	Get ACC coarse calibration value
acc_write_c1	Write ACC C1 register value
acc_write_c2	Write ACC C2 register value
acc_write_c3	Write ACC C3 register value
acc_read_c1	Read ACC C1 register value
acc_read_c2	Read ACC C2 register value
acc_read_c3	Read ACC C3 register value
acc_flag_get	Get ACC interrupt flag
acc_flag_clear	Clear ACC interrupt flag

5.1.1 acc_calibration_mode_enable function

The table below describes the function acc_calibration_mode_enable.

Table 7. acc_calibration_mode_enable function

Name	Description
Function name	acc_calibration_mode_enable
Function prototype	void acc_calibration_mode_enable(uint16_t acc_trim, confirm_state new_state);
Function description	ACC calibration mode enable
Input parameter 1	acc_trim: calibration mode selection This parameter can be ACC_CAL_HICKCAL or ACC_CAL_HICKTRIM.
Input parameter 2	new_state: Enable or disable ACC
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

acc_trim

Calibration mode selection

ACC_CAL_HICKCAL: Coarse calibration mode

ACC_CAL_HICKTRIM: Fine calibration mode

new_state

Enable or disable ACC

FALSE: Disabled

TRUE: Enabled

Example:

```
/* open acc calibration */
acc_calibration_mode_enable(ACC_CAL_HICKTRIM, TRUE);
```

5.1.2 acc_step_set function

The table below describes the function acc_step_set.

Table 8. acc_step_set function

Name	Description
Function name	acc_step_set
Function prototype	void acc_step_set(uint8_t step_value);
Function description	Configure ACC calibration step length
Input parameter 1	step_value: step value for calibration
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

step_value

This 4-bit field defines the value to be changed for each calibration.

Note: To obtain better calibration accuracy, it is recommended to set the step value to 1.

When ENTRIM=0 only the HICKCAL is calibrated. If the step value is incremented or decremented

by one, the corresponding HICKCAL follows the change rule (increased or decreased by one), and the HICK frequency will increase or decrease by 40 KHz (design value), meaning a positive correlation between them.

When ENTRIM=1, only the HICKTRIM is calibrated. If the step value is incremented or decremented by one, the corresponding HICKTRIM follows the change rule (increased or decreased by one), and the HICK frequency will increase or decrease by 20KHz (design value), meaning a positive correlation between them.

Example:

```
/* set acc step value */  
acc_step_set(0x1);
```

5.1.3 acc_interrupt_enable function

The table below describes the function acc_interrupt_enable.

Table 9. acc_interrupt_enable function

Name	Description
Function name	dma_interrupt_enable
Function prototype	void acc_interrupt_enable(uint16_t acc_int, confirm_state new_state);
Function description	Enable acc interrupts
Input parameter 1	acc_int: interrupt source selection
Input parameter 2	new_state: enable or disable interrupts
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

acc_int

interrupt source selection

ACC_CALRDYIEN_INT: Calibration complete interrupt

ACC_EIEN_INT: Reference signal lost interrupt

new_state

Enable or disable interrupts.

FALSE: Interrupt disabled

TRUE: Interrupt enabled

Example:

```
/* enable the acc reference signal lost interrupt */  
acc_interrupt_enable(ACC_EIEN_INT, TRUE);
```

5.1.4 acc_hicktrim_get function

The table below describes the function acc_hicktrim_get.

Table 10. acc_hicktrim_get function

Name	Description
Function name	acc_hicktrim_get
Function prototype	uint8_t acc_hicktrim_get(void);
Function description	Get ACC trimming value
Input parameter	NA
Output parameter	NA
Return value	Return ACC trimming value
Required preconditions	NA
Called functions	NA

Example:

```
/* get trim value*/  
uint8_t trim_value;  
trim_value = acc_hicktrim_get();
```

5.1.5 acc_hickcal_get function

The table below describes the function acc_hickcal_get.

Table 11. acc_hickcal_get function

Name	Description
Function name	acc_hickcal_get
Function prototype	uint8_t acc_hickcal_get(void);
Function description	Get ACC coarse calibration value
Input parameter	NA
Output parameter	NA
Return value	Return ACC coarse calibration value
Required preconditions	NA
Called functions	NA

Example:

```
/* get cal value*/  
uint8_t cal_value;  
cal_value = acc_hickcal_get();
```

5.1.6 acc_write_c1 function

The table below describes the function acc_write_c1.

Table 12. acc_write_c1 function

Name	Description
Function name	acc_write_c1
Function prototype	void acc_write_c1(uint16_t acc_c1_value);
Function description	Write ACC C1 register value
Input parameter	acc_c1_value: the value to be written in ACC C1 register
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* update the c1 value */  
acc_c2_value = 8000;  
acc_write_c1(acc_c2_value - 10);
```

5.1.7 acc_write_c2 function

The table below describes the function acc_write_c2.

Table 13. acc_write_c2 function

Name	Description
Function name	acc_write_c2
Function prototype	void acc_write_c2(uint16_t acc_c2_value);
Function overview	Write ACC C2 register value
Input parameter	acc_c2_value: the value to be written in ACC C2 register
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* update the c2 value */  
acc_c2_value = 8000;  
acc_write_c2(acc_c2_value - 10);
```

5.1.8 acc_write_c3 function

The table below describes the function acc_write_c3.

Table 14. acc_write_c3 function

Name	Description
Function name	acc_write_c3
Function prototype	void acc_write_c3(uint16_t acc_c3_value);
Function description	Write ACC C3 register value
Input parameter	acc_c3_value: the value to be written in ACC C3 register
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* update the c3 value */  
acc_c2_value = 8000;  
acc_write_c3(acc_c2_value - 10);
```

5.1.9 acc_read_c1 function

The table below describes the function acc_read_c1.

Table 15. acc_read_c1 function

Name	Description
Function name	acc_read_c1
Function prototype	uint16_t acc_read_c1(void);
Function description	Read ACC C1 register value
Input parameter	NA
Output parameter	NA
Return value	ACC C1 register value
Required preconditions	NA
Called functions	NA

Example:

```
/* get the c1 value */  
uint16_t acc_c1_value;  
acc_c1_value = acc_read_c1();
```

5.1.10 acc_read_c2 function

The table below describes the function acc_read_c2.

Table 16. acc_read_c2 function

Name	Description
Function name	acc_read_c2
Function prototype	uint16_t acc_read_c2(void);
Function description	Read ACC C2 register value
Input parameter	NA
Output parameter	NA
Return value	ACC C2 register value
Required preconditions	NA
Called functions	NA

Example:

```
/* get the c2 value */  
uint16_t acc_c2_value;  
acc_c2_value = acc_read_c2();
```

5.1.11 acc_read_c3 function

The table below describes the function acc_read_c3.

Table 17. acc_read_c3 function

Name	Description
Function name	acc_read_c3
Function prototype	uint16_t acc_read_c3(void);
Function description	Read ACC C3 register value
Input parameter	NA
Output parameter	NA
Return value	ACC C3 register value
Required preconditions	NA
Called functions	NA

Example:

```
/* get the c3 value */  
uint16_t acc_c3_value;  
acc_c3_value = acc_read_c3();
```

5.1.12 acc_flag_get function

The table below describes the function acc_flag_get.

Table 18. acc_flag_get function

Name	Description
Function name	acc_flag_get
Function prototype	flag_status acc_flag_get(uint16_t acc_flag);
Function description	Get ACC flag status
Input parameter 1	acc_flag: ACC flag selection
Output parameter	NA
Return value	flag_status: indicates whether or not the flag has been set
Required preconditions	NA
Called functions	NA

acc_flag

The acc_flag is used for flag selection, including:

ACC_RSLOST_FLAG: Reference signal lost interrupt

ACC_CALRDY_FLAG: Calibration complete interrupt

flag_status

RESET: Corresponding flag bit is not set

SET: Corresponding flag bit is set

Example:

```
if(acc_flag_get(ACC_CALRDY_FLAG) != RESET)
{
    at32_led_toggle(LED2);
    /* clear acc calibration ready flag */
    acc_flag_clear(ACC_CALRDY_FLAG);
}
```

5.1.13 acc_interrupt_flag_get function

The table below describes the function acc_interrupt_flag_get.

Table 19. acc_interrupt_flag_get function

Name	Description
Function name	Acc_interrupt_flag_get
Function prototype	flag_status acc_interrupt_flag_get(uint16_t acc_flag);
Function description	Get ACC interrupt flag status
Input parameter 1	acc_flag: ACC flag selection
Output parameter	NA
Return value	flag_status: Set or Reset
Required preconditions	NA
Called functions	NA

acc_flag

The acc_flag is used for flag selection, including:

ACC_RSLOST_FLAG: Reference signal lost interrupt

ACC_CALRDY_FLAG: Calibration complete interrupt

flag_status

RESET: Corresponding flag bit is not set

SET: Corresponding flag bit is set

Example:

```
if(acc_interrupt_flag_get(ACC_CALRDY_FLAG) != RESET)
{
    at32_led_toggle(LED2);
    /* clear acc calibration ready flag */
    acc_flag_clear(ACC_CALRDY_FLAG);
}
```

5.1.14 acc_flag_clear function

The table below describes the function acc_flag_clear.

Table 20. acc_flag_clear function

Name	Description
Function name	acc_flag_clear
Function prototype	void acc_flag_clear(uint16_t acc_flag);
Function description	Clear ACC flag
Input parameter 1	acc_flag: ACC flag selection
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

acc_flag

The acc_flag is used for flag selection, including:

ACC_RSLOST_FLAG: Reference signal lost interrupt

ACC_CALRDY_FLAG: Calibration complete interrupt

Example:

```
if(acc_flag_get(ACC_CALRDY_FLAG) != RESET)
{
    at32_led_toggle(LED2);
    /* clear acc calibration ready flag */
    acc_flag_clear(ACC_CALRDY_FLAG);
}
```

5.2 Analog-to-digital converter (ADC)

ADC register structure adc_type is defined in the “at32f423_adc.h”.

```
/**
 * @brief type define adc register all
 */
typedef struct
{
    .....
} adc_type;
```

The table below gives a list of the ADC registers.

Table 21. Summary of ADC registers

Register	Description
sts	ADC status register
ctrl1	ADC control register 1
ctrl2	ADC control register 2
spt1	ADC sample time register 1
spt2	ADC sample time register 2
pcdto1	ADC preempted channel data offset register 1
pcdto2	ADC preempted channel data offset register 2
pcdto3	ADC preempted channel data offset register 3
pcdto4	ADC preempted channel data offset register 4
vmhb	ADC voltage monitor high boundary register
vmlb	ADC voltage monitor low boundary register
osq1	ADC ordinary sequence register 1
osq2	ADC ordinary sequence register 2
osq3	ADC ordinary sequence register 3
psq	ADC preempted sequence register
pdt1	ADC preempted data register 1
pdt2	ADC preempted data register 2
pdt3	ADC preempted data register 3
pdt4	ADC preempted data register 4
odt	ADC ordinary data register
spt3	ADC sample time register 3
osq4	ADC ordinary sequence register 4
osq5	ADC ordinary sequence register 5

Register	Description
osq6	ADC ordinary sequence register 6
ovsp	ADC oversampling register
calval	ADC calibration value register
cctrl	ADC common control register

The table below gives a list of ADC library functions.

Table 22. Summary of ADC library functions

Function name	Description
adc_reset	Reset all ADC registers to their reset values
adc_enable	Enable A/D converter
adc_base_default_para_init	Define an initial value for adc_base_struct
adc_base_config	Configure ADC registers with the initialized parameters of the adc_base_struct
adc_common_default_para_init	Define an initial value for the adc_common_struct
adc_common_config	Configure ADC common register with the initialized parameters of the adc_common_struct
adc_resolution_set	Set ADC conversion resolution
adc_dma_mode_enable	Enable DMA transfer for ordinary group
adc_dma_request_repeat_enable	Enable DMA request repetition mode for ordinary group conversion
adc_interrupt_enable	Enable the selected ADC event interrupt
adc_calibration_value_set	Set calibration value by software
adc_calibration_init	Initialization calibration
adc_calibration_init_status_get	Get initialization calibration status
adc_calibration_start	Start calibration
adc_calibration_status_get	Get calibration status
adc_voltage_monitor_enable	Enable voltage monitoring for ordinary/preempted channels and a single channel
adc_voltage_monitor_threshold_value_set	Set the threshold of voltage monitoring
adc_voltage_monitor_single_channel_select	Select a single channel for voltage monitoring
adc_ordinary_channel_set	Configure ordinary channels, including channel selection, conversion sequence number and sampling time
adc_preempt_channel_length_set	Configure the length of preempted group conversion sequence
adc_preempt_channel_set	Configure preempted channels, including channel selection, conversion sequence number and sampling time
adc_ordinary_conversion_trigger_set	Enable trigger mode and trigger event selection for ordinary conversion
adc_preempt_conversion_trigger_set	Enable trigger mode and trigger event selection for preempted conversion
adc_preempt_offset_value_set	Set data offset for preempted conversion
adc_ordinary_part_count_set	Set the number of ordinary channels for each triggered conversion in partition mode
adc_ordinary_part_mode_enable	Enable partition mode for ordinary channels

Function name	Description
adc_preempt_part_mode_enable	Enable partition mode for preempted channels
adc_preempt_auto_mode_enable	Enable auto conversion of preempted group at the end of ordinary conversion
adc_conversion_stop	Stop on-going ADC conversion
adc_conversion_stop_status_get	Get the status of stop conversion command
adc_occe_each_conversion_enable	Enable OCCE flag for each ordinary channel conversion
adc_ordinary_software_trigger_enable	Software trigger ordinary group conversion
adc_ordinary_software_trigger_status_get	Get the status of ordinary group conversion triggered by software
adc_preempt_software_trigger_enable	Software trigger preempted group conversion
adc_preempt_software_trigger_status_get	Get the status of preempted group conversion triggered by software
adc_ordinary_conversion_data_get	Get data of ordinary group conversion in non-master-slave mode
adc_preempt_conversion_data_get	Get the converted data of preempted group
adc_flag_get	Get the status of flag bits
adc_flag_clear	Clear flag bits
adc_ordinary_oversample_enable	Enable oversampling of ordinary group
adc_preempt_oversample_enable	Enable oversampling of preempted group
adc_oversample_ratio_shift_set	Set oversampling ratio and its shift length
adc_ordinary_oversample_trig_enable	Enable oversampling trigger mode of ordinary group
adc_ordinary_oversample_restart_set	Enable oversampling restart mode of ordinary group

5.2.1 adc_reset function

The table below describes the function adc_reset.

Table 23. adc_reset function

Name	Description
Function name	adc_reset
Function prototype	void adc_reset(adc_type *adc_x)
Function description	Reset all ADC registers to their reset values
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	crm_periph_reset()

Example:

```
/* deinitialize adc1 */
adc_reset();
```

5.2.2 adc_enable function

The table below describes the function adc_enable.

Table 24. adc_enable function

Name	Description
Function name	adc_enable
Function prototype	void adc_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable/disable A/D converter
Input parameter 1	adc_x: indicates the selected ADC This parameter is used to select ADC1.
Input parameter 2	new_state: indicates the pre-configured status of A/D converter This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable adc1 */
adc_enable(ADC1, TRUE);
```

5.2.3 adc_base_default_para_init function

The table below describes the function adc_base_default_para_init.

Table 25. adc_base_default_para_init function

Name	Description
Function name	adc_base_default_para_init
Function prototype	void adc_base_default_para_init(adc_base_config_type *adc_base_struct)
Function description	Set the initial value for the adc_base_struct.
Input parameter	adc_base_struct: adc_base_config_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

The default values of members in the adc_base_struct:

sequence_mode:	FALSE
repeat_mode:	FALSE
data_align:	ADC_RIGHT_ALIGNMENT
ordinary_channel_length:	1

Example:

```
/* initialize a adc_base_config_type structure */
adc_base_config_type adc_base_struct;
adc_base_default_para_init(&adc_base_struct);
```

5.2.4 adc_base_config function

The table below describes the function adc_base_config.

Table 26. adc_base_config function

Name	Description
Function name	adc_base_config
Function prototype	void adc_base_config(adc_type *adc_x, adc_base_config_type *adc_base_struct);
Function description	Initialize ADC registers with the specified parameters in the adc_base_struct.
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	adc_base_struct: adc_base_config_type structure pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_base_config_type structure

The adc_base_config_type is defined in the at32f423_adc.h:

typedef struct

```
{
    confirm_state      sequence_mode;
    confirm_state      repeat_mode;
    adc_data_align_type data_align;
    uint8_t            ordinary_channel_length;
}
```

adc_base_config_type; the member parameters are described as follows

sequence_mode

Set ADC sequence mode.

FALSE: Select a single channel for conversion

TRUE: Select multiple channels for conversion

repeat_mode

Set ADC repeat mode.

FALSE: when SQEN=0, trigger a single channel conversion each time; when SQEN=1, trigger the conversion of a group of channels each time

TRUE: when SQEN =0, repeatedly convert a single channel at each trigger; when SQEN=1, repeatedly convert a group of channels at each trigger until the ADCEN bit is cleared.

data_align

Set data alignment of ADC

ADC_RIGHT_ALIGNMENT: right-aligned

ADC_LEFT_ALIGNMENT: left-aligned

ordinary_channel_length

Set the length of ordinary group ADC conversion

Example:

```
adc_base_config_type adc_base_struct;
adc_base_struct.sequence_mode = TRUE;
adc_base_struct.repeat_mode = FALSE;
adc_base_struct.data_align = ADC_RIGHT_ALIGNMENT;
```

```
adc_base_struct.ordinary_channel_length = 3;
adc_base_config(ADC1, &adc_base_struct);
```

5.2.5 adc_common_default_para_init function

The table below describes the function adc_common_default_para_init.

Table 27. adc_common_default_para_init function

Name	Description
Function name	adc_common_default_para_init
Function prototype	void adc_common_default_para_init(adc_common_config_type *adc_common_struct)
Function description	Set the initial value for the adc_common_struct
Input parameter	adc_common_struct: adc_common_config_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

The devalue values of members in the adc_common_struct:

div: ADC_HCLK_DIV_2
 tempervintrv_state: FALSE

Example:

```
/* initialize a adc_common_config_type structure */
adc_common_config_type adc_common_struct;
adc_common_default_para_init(&adc_common_struct);
```

5.2.6 adc_common_config function

The table below describes the function adc_common_config.

Table 28. adc_common_config function

Name	Description
Function name	adc_common_config
Function prototype	void adc_common_config(adc_common_config_type *adc_common_struct)
Function description	Initialize ADC common register with the parameters programmed in the adc_common_struct
Input parameter	adc_common_struct: adc_common_config_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_common_config_type structure

The adc_common_config_type is defined in the at32f423_adc.h:

```
typedef struct
{
    adc_div_type           div;
    confirm_state          tempervintrv_state;
} adc_common_config_type; see the descriptions below for its members;
```

div

Set ADC frequency division factor.

- ADC_HCLK_DIV_2: ADCCLK is clocked by HCLK/2
- ADC_HCLK_DIV_3: ADCCLK is clocked by HCLK/3
- ADC_HCLK_DIV_4: ADCCLK is clocked by HCLK/4
- ADC_HCLK_DIV_5: ADCCLK is clocked by HCLK/5
- ADC_HCLK_DIV_6: ADCCLK is clocked by HCLK/6
- ADC_HCLK_DIV_7: ADCCLK is clocked by HCLK/7
- ADC_HCLK_DIV_8: ADCCLK is clocked by HCLK/8
- ADC_HCLK_DIV_9: ADCCLK is clocked by HCLK/9
- ADC_HCLK_DIV_10: ADCCLK is clocked by HCLK/10
- ADC_HCLK_DIV_11: ADCCLK is clocked by HCLK/11
- ADC_HCLK_DIV_12: ADCCLK is clocked by HCLK/12
- ADC_HCLK_DIV_13: ADCCLK is clocked by HCLK/13
- ADC_HCLK_DIV_14: ADCCLK is clocked by HCLK/14
- ADC_HCLK_DIV_15: ADCCLK is clocked by HCLK/15
- ADC_HCLK_DIV_16: ADCCLK is clocked by HCLK/16
- ADC_HCLK_DIV_17: ADCCLK is clocked by HCLK/17

tempervintrv_state

Enable or disable ADC internal temperature sensor and V_{INTRV}

FALSE: Internal temperature sensor and V_{INTRV} disabled

TRUE: Internal temperature sensor and V_{INTRV} enabled

Example:

```
adc_common_config_type adc_common_struct;  
adc_common_struct.div = ADC_HCLK_DIV_4;  
adc_common_struct.tempervintrv_state = TRUE;  
adc_common_config(&adc_common_struct);
```

5.2.7 adc_resolution_set function

The table below describes the function adc_resolution_set.

Table 29. adc_resolution_set function

Name	Description
Function name	adc_resolution_set
Function prototype	void adc_resolution_set(adc_type *adc_x, adc_resolution_type resolution)
Function description	Set ADC conversion resolution
Input parameter 1	adc_x: indicates the selected ADC This parameter is used to select ADC1.
Input parameter 2	Resolution: ADC conversion resolution selection This parameter can be any enumerated value in the adc_resolution_type.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

resolution

The resolution is used to select ADC conversion resolution, including:

- ADC_RESOLUTION_12B: 12-bit resolution
- ADC_RESOLUTION_10B: 10-bit resolution
- ADC_RESOLUTION_8B: 8-bit resolution
- ADC_RESOLUTION_6B: 6-bit resolution

Example:

```
/* set conversion resolution */
adc_resolution_set(ADC1, ADC_RESOLUTION_12B);
```

5.2.8 adc_dma_mode_enable function

The table below describes the function adc_dma_mode_enable.

Table 30. adc_dma_mode_enable function

Name	Description
Function name	adc_dma_mode_enable
Function prototype	void adc_dma_mode_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable DMA transfer for ordinary group conversion
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	new_state: pre-configured status of ordinary group in DMA transfer mode This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable dma transfer adc ordinary conversion data */
adc_dma_mode_enable(ADC1, TRUE);
```

5.2.9 adc_dma_request_repeat_enable function

The table below describes the function adc_dma_request_repeat_enable.

Table 31. adc_dma_request_repeat_enable function

Name	Description
Function name	adc_dma_request_repeat_enable
Function prototype	void adc_dma_request_repeat_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable DMA request repetition mode for ordinary group conversion
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status of DMA request repetition mode This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* config dma request repeat,it's not useful when common dma mode is use */  
adc_dma_request_repeat_enable(ADC1, TRUE);
```

5.2.10 adc_interrupt_enable function

The table below describes the function adc_interrupt_enable.

Table 32. adc_interrupt_enable function

Name	Description
Function name	adc_interrupt_enable
Function prototype	void adc_interrupt_enable(adc_type *adc_x, uint32_t adc_int, confirm_state new_state)
Function description	Enable the selected ADC event interrupt
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	adc_int: ADC event interrupt selection This parameter is used to select any event interrupt supported by ADC.
Input parameter3	new_state: indicates the pre-configured status of ADC event interrupts This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_int

The adc_int is used to select and set event interrupts, with the following parameters:

ADC_OCCE_INT: Interrupt enabled at the end of ordinary group conversion

ADC_VMOR_INT: Interrupt enabled when voltage monitor is outside a threshold

ADC_PCCE_INT: Interrupt enabled at the end of preempted group conversion

ADC_OCCO_INT: Overflow interrupt for ordinary group conversion

Example:

```
/* enable voltage monitoring out of range interrupt */
adc_interrupt_enable(ADC1, ADC_VMOR_INT, TRUE);
```

5.2.11 adc_calibration_value_set function

The table below describes the function adc_calibration_value_set.

Table 33. adc_calibration_value_set function

Name	Description
Function name	adc_calibration_value_set
Function prototype	void adc_calibration_value_set(adc_type *adc_x, uint8_t adc_calibration_value)
Function description	Set calibration value by software
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	adc_calibration_value: indicates the pre-configured calibration value This parameter can be any enumerated value in the 0x00~0x7F.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set calibration value */
adc_calibration_value_set(ADC1, 0x3F);
```

5.2.12 adc_calibration_init function

The table below describes the function adc_calibration_init.

Table 34. adc_calibration_init function

Name	Description
Function name	adc_calibration_init
Function prototype	void adc_calibration_init(adc_type *adc_x)
Function description	Initialization calibration
Input parameter	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* initialize A/D calibration */
adc_calibration_init(ADC1);
```

5.2.13 adc_calibration_init_status_get function

The table below describes the function adc_calibration_init_status_get.

Table 35. adc_calibration_init_status_get function

Name	Description
Function name	adc_calibration_init_status_get
Function prototype	flag_status adc_calibration_init_status_get(adc_type *adc_x)
Function description	Get the status of initialization calibration
Input parameter	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Output parameter	NA
Return value	flag_status: indicates the status of calibration initialization Return SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
/* wait initialize A/D calibration success */
while(adc_calibration_init_status_get(ADC1));
```

5.2.14 adc_calibration_start function

The table below describes the function adc_calibration_start.

Table 36. adc_calibration_start function

Name	Description
Function name	adc_calibration_start
Function prototype	void adc_calibration_start(adc_type *adc_x)
Function description	Start calibration
Input parameter	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* start calibration process */  
adc_calibration_start(ADC1);
```

5.2.15 adc_calibration_status_get function

The table below describes the function adc_calibration_status_get.

Table 37. adc_calibration_status_get function

Name	Description
Function name	adc_calibration_status_get
Function prototype	flag_status adc_calibration_status_get(adc_type *adc_x)
Function description	Get the status of calibration
Input parameter	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Output parameter	NA
Return value	flag_status: indicates the status of calibration Return SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
/* wait calibration success */  
while(adc_calibration_status_get(ADC1));
```

5.2.16 adc_voltage_monitor_enable function

The table below describes the function adc_voltage_monitor_enable.

Table 38. adc_voltage_monitor_enable function

Name	Description
Function name	adc_voltage_monitor_enable
Function prototype	void adc_voltage_monitor_enable(adc_type *adc_x, adc_voltage_monitoring_type adc_voltage_monitoring)
Function description	Enable voltage monitor for ordinary/preempted group and a single channel
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	adc_voltage_monitoring: select ordinary group, preempted group or a single channel for voltage monitoring This parameter can be any enumerated value in the adc_voltage_monitoring_type.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_voltage_monitoring

The adc_voltage_monitoring is used to select one or more channels of ordinary group/preempted group for voltage monitoring, including:

ADC_VMONITOR_SINGLE_ORDINARY:

Select a single ordinary channel for voltage monitoring

ADC_VMONITOR_SINGLE_PREEMPT:

Select a single preempted channel for voltage monitoring

ADC_VMONITOR_SINGLE_ORDINARY_PREEMPT:

Select a single channel from ordinary or preempted group for voltage monitoring

ADC_VMONITOR_ALL_ORDINARY:

Select all ordinary channels for voltage monitoring

ADC_VMONITOR_ALL_PREEMPT:

Select all preempted channels for voltage monitoring

ADC_VMONITOR_ALL_ORDINARY_PREEMPT:

Select all ordinary and preempted channels for voltage monitoring

ADC_VMONITOR_NONE:

No channels need voltage monitoring

Example:

```
/* enable the voltage monitoring on all ordinary and preempt channels */
adc_voltage_monitor_enable(ADC1, ADC_VMONITOR_ALL_ORDINARY_PREEMPT);
```

5.2.17 adc_voltage_monitor_threshold_value_set function

The table below describes the function adc_voltage_monitor_threshold_value_set.

Table 39. adc_voltage_monitor_threshold_value_set function

Name	Description
Function name	adc_voltage_monitor_threshold_value_set
Function prototype	void adc_voltage_monitor_threshold_value_set(adc_type *adc_x, uint16_t adc_high_threshold, uint16_t adc_low_threshold)
Function description	Configure the threshold of voltage monitoring
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	adc_high_threshold: indicates the upper limit for voltage monitoring This parameter can be any value between 0x000 and 0xFFFF.
Input parameter3	adc_low_threshold: indicates the lower limit for voltage monitoring This parameter can be any value lower than that of adc_high_threshold in the range of 0x000~0xFFFF.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set voltage monitoring's high and low thresholds value */
adc_voltage_monitor_threshold_value_set(ADC1, 0xBBB, 0xAAA);
```

5.2.18 adc_voltage_monitor_single_channel_select function

The table below describes the function adc_voltage_monitor_single_channel_select.

Table 40. adc_voltage_monitor_single_channel_select function

Name	Description
Function name	adc_voltage_monitor_single_channel_select
Function prototype	void adc_voltage_monitor_single_channel_select(adc_type *adc_x, adc_channel_select_type adc_channel)
Function description	Select a single channel for voltage monitoring
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	adc_channel: select a single channel for voltage monitoring Refer to adc_channel for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_channel

The adc_channel is used to select a single channel for voltage monitoring, including:

ADC_CHANNEL_0: ADC channel 0

ADC_CHANNEL_1: ADC channel 1

.....
 ADC_CHANNEL_17: ADC channel 17
 ADC_CHANNEL_18: ADC channel 18
 ADC_CHANNEL_20: ADC channel 20

.....
 ADC_CHANNEL_27: ADC channel 27

Example:

```
/* select the voltage monitoring's channel */
adc_voltage_monitor_single_channel_select(ADC1, ADC_CHANNEL_5);
```

5.2.19 adc_ordinary_channel_set function

The table below describes the function adc_ordinary_channel_set.

Table 41. adc_ordinary_channel_set function

Name	Description
Function name	adc_ordinary_channel_set
Function prototype	void adc_ordinary_channel_set(adc_type *adc_x, adc_channel_select_type adc_channel, uint8_t adc_sequence, adc_sampletime_select_type adc_sampletime)
Function description	Configure ordinary channels, including parameters such as channel selection, conversion sequence number and sampling time
Input parameter 1	adc_x: indicates the selected ADC peripheral This parameter can be ADC1.
Input parameter 2	adc_channel: indicates the selected channel Refer to adc_channel for details.
Input parameter3	adc_sequence: defines the sequence of channel conversion This parameter can be any value from 1 to 32.
Input parameter4	adc_sampletime: defines the sampling time for channel Refer to adc_sampletime for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_sampletime

The adc_sampletime is used to configure the sampling time of channels, including:

ADC_SAMPLETIME_2_5: sampling time is 2.5 ADCCLK cycles

ADC_SAMPLETIME_6_5: sampling time is 6.5 ADCCLK cycles

ADC_SAMPLETIME_12_5: sampling time is 12.5 ADCCLK cycles

ADC_SAMPLETIME_24_5: sampling time is 24.5 ADCCLK cycles

ADC_SAMPLETIME_47_5: sampling time is 47.5 ADCCLK cycles

ADC_SAMPLETIME_92_5: sampling time is 92.5 ADCCLK cycles

ADC_SAMPLETIME_247_5: sampling time is 247.5 ADCCLK cycles

ADC_SAMPLETIME_640_5: sampling time is 640.5 ADCCLK cycles

Example:

```
/* set ordinary channel's corresponding rank in the sequencer and sample time */
```

```
adc_ordinary_channel_set(ADC1, ADC_CHANNEL_4, 1, ADC_SAMPLETIME_247_5);
adc_ordinary_channel_set(ADC1, ADC_CHANNEL_5, 2, ADC_SAMPLETIME_247_5);
```

5.2.20 adc_preempt_channel_length_set function

The table below describes the function adc_preempt_channel_length_set.

Table 42. adc_preempt_channel_length_set function

Name	Description
Function name	adc_preempt_channel_length_set
Function prototype	void adc_preempt_channel_length_set(adc_type *adc_x, uint8_t adc_channel_lenght)
Function description	Set the length of preempted channel conversion
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_channel_lenght: set the length of preempted channel conversion This parameter can be any value from 0x1 to 0x4.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set preempt channel length */
adc_preempt_channel_length_set(ADC1, 3);
```

5.2.21 adc_preempt_channel_set function

The table below describes the function adc_preempt_channel_set.

Table 43. adc_preempt_channel_set function

Name	Description
Function name	adc_preempt_channel_set
Function prototype	void adc_preempt_channel_set(adc_type *adc_x, adc_channel_select_type adc_channel, uint8_t adc_sequence, adc_sampletime_select_type adc_sampletime)
Function description	Configure preempted group, including parameters such as channel selection, conversion sequence number and sampling time
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_channel: indicates the selected channel Refer to adc_channel for details.
Input parameter3	adc_sequence: set the sequence number for channel conversion This parameter can be any value from 1 to 4.
Input parameter4	adc_sampletime: set the sampling time for channels Refer to adc_sampletime for details.
Output parameter	NA
Return value	NA

Name	Description
Required preconditions	NA
Called functions	NA

Example:

```
/* set ordinary channel's corresponding rank in the sequencer and sample time */
adc_preempt_channel_set(ADC1, ADC_CHANNEL_7, 1, ADC_SAMPLETIME_247_5);
adc_preempt_channel_set(ADC1, ADC_CHANNEL_8, 2, ADC_SAMPLETIME_247_5);
```

5.2.22 adc_ordinary_conversion_trigger_set function

The table below describes the function adc_ordinary_conversion_trigger_set.

Table 44. adc_ordinary_conversion_trigger_set function

Name	Description
Function name	adc_ordinary_conversion_trigger_set
Function prototype	void adc_ordinary_conversion_trigger_set(adc_type *adc_x, adc_ordinary_trig_select_type adc_ordinary_trig, adc_ordinary_trig_edge_type adc_ordinary_trig_edge)
Function description	Enable trigger mode and select trigger events for ordinary group conversion
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_ordinary_trig: indicates the selected trigger event for ordinary group This parameter can be any enumerated value in the adc_ordinary_trig_select_type.
Input parameter3	adc_ordinary_trig_edge: indicates the pre-configured status of external trigger edge for ordinary group This parameter can be any enumerated value in the adc_ordinary_trig_edge_type.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_ordinary_trig

The adc_ordinary_trig is used to select a trigger event for ordinary group conversion, including:

ADC_ORDINARY_TRIG_TMR1TRGOUT: TMR1 TRGOUT event

ADC_ORDINARY_TRIG_TMR1CH4: TMR1 CH4 event

ADC_ORDINARY_TRIG_TMR2TRGOUT: TMR2 TRGOUT event

ADC_ORDINARY_TRIG_TMR3TRGOUT: TMR3 TRGOUT event

ADC_ORDINARY_TRIG_TMR9TRGOUT: TMR9 TRGOUT event

ADC_ORDINARY_TRIG_TMR1CH1: TMR1 CH1 event

ADC_ORDINARY_TRIG_EXINT11: EXINT 11 event

ADC_ORDINARY_TRIG_SOFTWARE: Software trigger event

adc_ordinary_trig_edge

ADC_ORDINARY_TRIG_EDGE_NONE: Edge trigger disabled

ADC_ORDINARY_TRIG_EDGE_RISING: Rising edge

ADC_ORDINARY_TRIG_EDGE_FALLING: Falling edge

ADC_ORDINARY_TRIG_EDGE_RISING_FALLING: Any edge (Rising edge/ Falling edge)

Example:

```
/* config ordinary trigger source and trigger edge */
adc_ordinary_conversion_trigger_set(ADC1, ADC_ORDINARY_TRIG_TMR1CH1,
ADC_ORDINARY_TRIG_EDGE_NONE);
```

5.2.23 adc_preempt_conversion_trigger_set function

The table below describes the function adc_preempt_conversion_trigger_set.

Table 45. adc_preempt_conversion_trigger_set function

Name	Description
Function name	adc_preempt_conversion_trigger_set
Function prototype	void adc_preempt_conversion_trigger_set(adc_type *adc_x, adc_preempt_trig_select_type adc_preempt_trig, adc_preempt_trig_edge_type adc_preempt_trig_edge)
Function description	Enable trigger mode and trigger events for preempted group conversion
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_preempt_trig: indicates the selected trigger event for preempted group This parameter can be any enumerated value in the adc_preempt_trig_select_type.
Input parameter3	adc_preempt_trig_edge: indicates the pre-configured status of external trigger edge for preempted group This parameter can be any enumerated value in the adc_preempt_trig_edge_type.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_preempt_trig

The adc_preempt_trig is used to select a trigger event for preempted group conversion, including:

ADC_PREAMPT_TRIG_TMR1CH2:	TMR1 CH2 event
ADC_PREAMPT_TRIG_TMR1CH3:	TMR1 CH3 event
ADC_PREAMPT_TRIG_TMR2CH4:	TMR2 CH4 event
ADC_PREAMPT_TRIG_TMR3CH4:	TMR3 CH4 event
ADC_PREAMPT_TRIG_TMR9CH1:	TMR9 CH1 event
ADC_PREAMPT_TRIG_TMR6TRGOUT:	TMR6 TRGOUT event
ADC_PREAMPT_TRIG_EXINT15:	EXINT 15 event
ADC_PREAMPT_TRIG_SOFTWARE:	Software trigger event

adc_preempt_trig_edge

ADC_PREAMPT_TRIG_EDGE_NONE:	Edge trigger disabled
ADC_PREAMPT_TRIG_EDGE_RISING:	Rising edge
ADC_PREAMPT_TRIG_EDGE_FALLING:	Falling edge
ADC_PREAMPT_TRIG_EDGE_RISING_FALLING:	Any edge (Rising edge/ Falling edge)

Example:

```
/* config preempt trigger source and trigger edge */
adc_preempt_conversion_trigger_set(ADC1, ADC_PREEMPT_TRIG_TMR1CH2,
ADC_PREEMPT_TRIG_EDGE_NONE);
```

5.2.24 adc_preempt_offset_value_set function

The table below describes the function adc_preempt_offset_value_set.

Table 46. adc_preempt_offset_value_set function

Name	Description
Function name	adc_preempt_offset_value_set
Function prototype	void adc_preempt_offset_value_set(adc_type *adc_x, adc_preempt_channel_type adc_preempt_channel, uint16_t adc_offset_value)
Function description	Set the offset value of preempted group conversion
Input parameter 1	adc_x: selected ADC This parameter can be ADC1.
Input parameter 2	adc_preempt_channel: indicates the selected channel Refer to adc_preempt_channel for details.
Input parameter3	adc_offset_value: set the offset value for the selected channel This parameter can be any value from 0x000 to 0xFFFF.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_preempt_channel

The adc_preempt_channel is used to set an offset value for the selected channel, including:

ADC_PREEMPT_CHANNEL_1:	Preempted channel 1
ADC_PREEMPT_CHANNEL_2:	Preempted channel 2
ADC_PREEMPT_CHANNEL_3:	Preempted channel 3
ADC_PREEMPT_CHANNEL_4:	Preempted channel 4

Example:

```
/* set preempt channel's conversion value offset */
adc_preempt_offset_value_set(ADC1, ADC_PREEMPT_CHANNEL_1, 0x111);
adc_preempt_offset_value_set(ADC1, ADC_PREEMPT_CHANNEL_2, 0x222);
adc_preempt_offset_value_set(ADC1, ADC_PREEMPT_CHANNEL_3, 0x333);
```

5.2.25 adc_ordinary_part_count_set function

The table below describes the function adc_ordinary_part_count_set.

Table 47. adc_ordinary_part_count_set function

Name	Description
Function name	adc_ordinary_part_count_set
Function prototype	void adc_ordinary_part_count_set(adc_type *adc_x, uint8_t adc_channel_count)
Function description	Set the number of ordinary channels at each triggered conversion in partition mode
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_channel_count: indicates the number of ordinary group in partition mode This parameter can be any value from 0x1 to 0x8.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set partitioned mode channel count */
adc_ordinary_part_count_set(ADC1, 2);
```

Note: In partition mode, only the number of ordinary group is settable, and that of preempted group is fixed 1.

5.2.26 adc_ordinary_part_mode_enable function

The table below describes the function adc_ordinary_part_mode_enable.

Table 48. adc_ordinary_part_mode_enable function

Name	Description
Function name	adc_ordinary_part_mode_enable
Function prototype	void adc_ordinary_part_mode_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable partition mode for ordinary channels
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status for partition mode of ordinary channels This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable the partitioned mode on ordinary channel */
adc_ordinary_part_mode_enable(ADC1, TRUE);
```

5.2.27 adc_preempt_part_mode_enable function

The table below describes the function adc_preempt_part_mode_enable.

Table 49. adc_preempt_part_mode_enable function

Name	Description
Function name	adc_preempt_part_mode_enable
Function prototype	void adc_preempt_part_mode_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable partition mode for preempted channels
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status for partition mode of preempted channels This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable the partitioned mode on preempt channel */
adc_preempt_part_mode_enable(ADC1, TRUE);
```

5.2.28 adc_preempt_auto_mode_enable function

The table below describes the function adc_preempt_auto_mode_enable.

Table 50. adc_preempt_auto_mode_enable function

Name	Description
Function name	adc_preempt_auto_mode_enable
Function prototype	void adc_preempt_auto_mode_enable(adc_type *adc_x, confirm_state,new_state)
Function description	Enable auto preempted group conversion at the end of ordinary group conversion
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status for auto preempted group conversion This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable automatic preempt group conversion */
adc_preempt_auto_mode_enable(ADC1, TRUE);
```

5.2.29 adc_conversion_stop function

The table below describes the function adc_conversion_stop.

Table 51. adc_conversion_stop function

Name	Description
Function name	adc_conversion_stop
Function prototype	void adc_conversion_stop(adc_type *adc_x)
Function description	Stop on-going ADC conversion
Input parameter	adc_x: indicates the selected ADC This parameter can be ADC1.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* stop the ongoing conversion */
adc_conversion_stop(ADC1);
```

5.2.30 adc_conversion_stop_status_get function

The table below describes the function adc_conversion_stop_status_get.

Table 52. adc_conversion_stop_status_get function

Name	Description
Function name	adc_conversion_stop_status_get
Function prototype	flag_status adc_conversion_stop_status_get(adc_type *adc_x)
Function description	Get the status of stop conversion command
Input parameter	adc_x: indicates the selected ADC This parameter can be ADC1.
Output parameter	NA
Return value	flag_status: get the operational status of stop conversion command This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
/* wait stop conversion's */
while(adc_conversion_stop_status_get(ADC1));
```

5.2.31 adc_occe_each_conversion_enable function

The table below describes the function adc_occe_each_conversion_enable.

Table 53. adc_occe_each_conversion_enable function

Name	Description
Function name	adc_occe_each_conversion_enable
Function prototype	void adc_occe_each_conversion_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable OCCE flag for each ordinary channel conversion
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status of OCCE flag This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* each ordinary channel conversion set occe flag */
adc_occe_each_conversion_enable(ADC1, TRUE);
```

5.2.32 adc_ordinary_software_trigger_enable function

The table below describes the function adc_ordinary_software_trigger_enable.

Table 54. adc_ordinary_software_trigger_enable function

Name	Description
Function name	adc_ordinary_software_trigger_enable
Function prototype	void adc_ordinary_software_trigger_enable(adc_type *adc_x, confirm_state new_state)
Function description	Trigger ordinary group conversion by software
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status for software-triggered ordinary group conversion This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable ordinary software start conversion */
adc_ordinary_software_trigger_enable(ADC1, TRUE);
```

5.2.33 adc_ordinary_software_trigger_status_get function

The table below describes the function adc_ordinary_software_trigger_status_get

Table 55. adc_ordinary_software_trigger_status_get function

Name	Description
Function name	adc_ordinary_software_trigger_status_get
Function prototype	flag_status adc_ordinary_software_trigger_status_get(adc_type *adc_x)
Function description	Get the status of software-triggered ordinary group conversion
Input parameter	adc_x: indicates the selected ADC This parameter can be ADC1.
Output parameter	NA
Return value	flag_status: indicates the status of software-triggered ordinary group conversion This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
/* wait ordinary software start conversion */
while(adc_ordinary_software_trigger_status_get(ADC1));
```

5.2.34 adc_preempt_software_trigger_enable function

The table below describes the function adc_preempt_software_trigger_enable

Table 56. adc_preempt_software_trigger_enable function

Name	Description
Function name	adc_preempt_software_trigger_enable
Function prototype	void adc_preempt_software_trigger_enable(adc_type *adc_x, confirm_state new_state)
Function description	Preempted group conversion triggered by software
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status of software-triggered preempted group conversion This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable preempt software start conversion */
adc_preempt_software_trigger_enable(ADC1, TRUE);
```

5.2.35 adc_preempt_software_trigger_status_get function

The table below describes the function adc_preempt_software_trigger_status_get.

Table 57. adc_preempt_software_trigger_status_get function

Name	Description
Function name	adc_preempt_software_trigger_status_get
Function prototype	flag_status adc_preempt_software_trigger_status_get(adc_type *adc_x)
Function description	Get the status of software-triggered preempted group conversion
Input parameter	adc_x: indicates the selected ADC This parameter can be ADC1.
Output parameter	NA
Return value	flag_status: indicates the status of software-triggered preempted group conversion This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
/* wait preempt software start conversion */
while(adc_preempt_software_trigger_status_get(ADC1));
```

5.2.36 adc_ordinary_conversion_data_get function

The table below describes the function adc_ordinary_conversion_data_get.

Table 58. adc_ordinary_conversion_data_get function

Name	Description
Function name	adc_ordinary_conversion_data_get
Function prototype	uint16_t adc_ordinary_conversion_data_get(adc_type *adc_x)
Function description	Get the converted data of ordinary group in non-master/slave mode
Input parameter	adc_x: indicates the selected ADC This parameter can be ADC1.
Output parameter	NA
Return value	16-bit converted data by ordinary group
Required preconditions	NA
Called functions	NA

Example:

```
uint16_t adc1_ordinary_index = 0;
adc1_ordinary_index = adc_ordinary_conversion_data_get(ADC1);
```

5.2.37 adc_preempt_conversion_data_get function

The table below describes the function adc_preempt_conversion_data_get.

Table 59. adc_preempt_conversion_data_get function

Name	Description
Function name	adc_preempt_conversion_data_get
Function prototype	uint16_t adc_preempt_conversion_data_get(adc_type *adc_x, adc_preempt_channel_type adc_preempt_channel)
Function description	Get the converted data of preempted group
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_preempt_channel: the selected preempted channel Refer to adc_preempt_channel for details.
Output parameter	NA
Return value	16-bit converted data by preempted group
Required preconditions	NA
Called functions	NA

Example:

```
uint16_t adc1_preempt_valuetab[3] = {0};
adc1_preempt_valuetab[0] = adc_preempt_conversion_data_get(ADC1, ADC_PREEMPT_CHANNEL_1);
adc1_preempt_valuetab[1] = adc_preempt_conversion_data_get(ADC1, ADC_PREEMPT_CHANNEL_2);
adc1_preempt_valuetab[2] = adc_preempt_conversion_data_get(ADC1, ADC_PREEMPT_CHANNEL_3);
```

5.2.38 adc_flag_get function

The table below describes the function adc_flag_get.

Table 60. adc_flag_get function

Name	Description
Function name	adc_flag_get
Function prototype	flag_status adc_flag_get(adc_type *adc_x, uint8_t adc_flag)
Function description	Get the status of the flag bit
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_flag: indicates the selected flag Refer to adc_flag for details.
Output parameter	NA
Return value	flag_status: the status for the selected flag bit. This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

adc_flag

The adc_flag is used to select a flag to get its status, including:

ADC_VMOR_FLAG: Voltage monitor outside threshold

ADC_OCCE_FLAG: End of ordinary channel conversion

ADC_PCCE_FLAG: End of preempted channel conversion

- ADC_PCCS_FLAG: Start of preempted channel conversion
 ADC_OCCS_FLAG: Start of ordinary channel conversion
 ADC_OCCO_FLAG: Overflow flag for ordinary channel conversion
 ADC_RDY_FLAG: ADC ready to conversion flag

Example:

```
/* check if wakeup preempted channelsconversion end flag is set */
if(adc_flag_get(ADC1, ADC_PCCE_FLAG) != RESET)
```

5.2.39 adc_interrupt_flag_get function

The table below describes the function adc_interrupt_flag_get.

Table 61. adc_interrupt_flag_get function

Name	Description
Function name	adc_interrupt_flag_get
Function prototype	flag_status adc_interrupt_flag_get(adc_type *adc_x, uint8_t adc_flag)
Function description	Get ADC interrupt flag status
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_flag: select a flag to be clear Refer to adc_flag
Output parameter	NA
Return value	flag_status: SET or RESET.
Required preconditions	NA
Called functions	NA

adc_flag

The adc_flag is used to select a flag to get its status, including:

- ADC_VMOR_FLAG: Voltage monitor outside threshold
 ADC_OCCE_FLAG: End of ordinary channel conversion
 ADC_PCCE_FLAG: End of preempted channel conversion
 ADC_OCCO_FLAG: Overflow flag for ordinary channel conversion

Example:

```
/* check if wakeup preempted channelsconversion end flag is set */
if(adc_interrupt_flag_get(ADC1, ADC_PCCE_FLAG) != RESET)
```

5.2.40 adc_flag_clear function

The table below describes the function adc_flag_clear.

Table 62. adc_flag_clear function

Name	Description
Function name	adc_flag_clear
Function prototype	void adc_flag_clear(adc_type *adc_x, uint32_t adc_flag)
Function description	Clear the flag bits that have been set.
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_flag: select a flag to be clear Refer to adc_flag
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* preempted channelsconversion end flag clear */
adc_flag_clear(ADC1, ADC_PCCE_FLAG);
```

5.2.41 adc_ordinary_oversample_enable function

The table below describes the function adc_ordinary_oversample_enable.

Table 63. adc_ordinary_oversample_enable function

Name	Description
Function name	adc_ordinary_oversample_enable
Function prototype	void adc_ordinary_oversample_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable oversampling for ordinary group
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status of oversampling of ordinary group This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable ordinary oversampling */
adc_ordinary_oversample_enable(ADC1, TRUE);
```

5.2.42 adc_preempt_oversample_enable function

The table below describes the function adc_preempt_oversample_enable.

Table 64. adc_preempt_oversample_enable function

Name	Description
Function name	adc_preempt_oversample_enable
Function prototype	void adc_preempt_oversample_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable oversampling for preempted group
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status of oversampling of preempted group This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable preempt oversampling */
adc_preempt_oversample_enable(ADC1, TRUE);
```

5.2.43 adc_oversample_ratio_shift_set function

The table below describes the function adc_oversample_ratio_shift_set.

Table 65. adc_oversample_ratio_shift_set function

Name	Description
Function name	adc_oversample_ratio_shift_set
Function prototype	void adc_oversample_ratio_shift_set(adc_type *adc_x, adc_oversample_ratio_type adc_oversample_ratio, adc_oversample_shift_type adc_oversample_shift)
Function description	Set oversampling ratio and shift mode
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_oversample_ratio: indicates the oversampling rate This parameter can be any enumerated value in the adc_oversample_ratio_type.
Input parameter3	adc_oversample_shift: indicates the oversampling shift mode This parameter can be any enumerated value in the adc_oversample_shift_type.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_oversample_ratio

The adc_oversample_ratio is used for ADC oversampling ratio selection, including:

- ADC_OVERSAMPLE_RATIO_2: 2 x oversampling
- ADC_OVERSAMPLE_RATIO_4: 4 x oversampling
- ADC_OVERSAMPLE_RATIO_8: 5 x oversampling
- ADC_OVERSAMPLE_RATIO_16: 16 x oversampling
- ADC_OVERSAMPLE_RATIO_32: 32 x oversampling

ADC_OVERSAMPLE_RATIO_64: 64 x oversampling
 ADC_OVERSAMPLE_RATIO_128: 128 x oversampling
 ADC_OVERSAMPLE_RATIO_256: 256 x oversampling

adc_oversample_shift

The adc_oversample_shift is used for ADC oversampling bit width selection, including:

ADC_OVERSAMPLE_SHIFT_0: No shift
 ADC_OVERSAMPLE_SHIFT_1: 1-bit shift
 ADC_OVERSAMPLE_SHIFT_2: 2-bit shift
 ADC_OVERSAMPLE_SHIFT_3: 3-bit shift
 ADC_OVERSAMPLE_SHIFT_4: 4-bit shift
 ADC_OVERSAMPLE_SHIFT_5: 5-bit shift
 ADC_OVERSAMPLE_SHIFT_6: 6-bit shift
 ADC_OVERSAMPLE_SHIFT_7: 7-bit shift
 ADC_OVERSAMPLE_SHIFT_8: 8-bit shift

Example:

```
/* set oversampling ratio and shift */
adc_oversample_ratio_shift_set(ADC1, ADC_OVERSAMPLE_RATIO_8, ADC_OVERSAMPLE_SHIFT_3);
```

5.2.44 adc_ordinary_oversample_trig_enable function

The table below describes the function adc_ordinary_oversample_trig_enable.

Table 66. adc_ordinary_oversample_trig_enable function

Name	Description
Function name	adc_ordinary_oversample_trig_enable
Function prototype	void adc_ordinary_oversample_trig_enable(adc_type *adc_x, confirm_state new_state)
Function description	Enable oversampling trigger mode for ordinary group
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	new_state: indicates the pre-configured status of oversampling trigger mode of ordinary group This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* disable ordinary oversampling trigger mode */
adc_ordinary_oversample_trig_enable(ADC1, FALSE);
```

5.2.45 adc_ordinary_oversample_restart_set function

The table below describes the function adc_ordinary_oversample_restart_set.

Table 67. adc_ordinary_oversample_restart_set function

Name	Description
Function name	adc_ordinary_oversample_restart_set
Function prototype	void adc_ordinary_oversample_restart_set(adc_type *adc_x,

Name	Description
	adc_ordinary_oversample_restart_type adc_ordinary_oversample_restart)
Function description	Select oversampling restart mode for ordinary group
Input parameter 1	adc_x: indicates the selected ADC This parameter can be ADC1.
Input parameter 2	adc_ordinary_oversample_restart: indicates the pre-configured status of oversampling restart mode for ordinary group This parameter can be any enumerated value in the adc_ordinary_oversample_restart_type.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

adc_ordinary_oversample_restart

The adc_ordinary_oversample_restart is used to select oversampling restart mode for ordinary group ADC conversion, including:

ADC_OVERSAMPLE_CONTINUE:

Continuous mode (the oversampling buffer area of ordinary group is preserved)

ADC_OVERSAMPLE_RESTART:

Restart mode (the oversampling buffer area of ordinary group is cleared, that is, the sampling times of the current channel is cleared)

Example:

```
/* set ordinary oversample restart mode */  
adc_ordinary_oversample_restart_set(ADC1, ADC_OVERSAMPLE_CONTINUE);
```

5.3 Controller area network (CAN)

CAN register structure can_type is defined in the “at32f423_can.h”:

```
/*
 * @brief type define can register all
 */
typedef struct
{
    ...
} can_type;
```

The table below gives a list of the CAN registers.

Table 68. Summary of CAN registers

Register	Description
mctrl	CAN master control register
msts	CAN master status register
tsts	CAN transmit status register
rf0	CAN receive FIFO 0 register
fr1	CAN receive FIFO 1 register
inten	CAN interrupt enable register
ests	CAN error status register
btmg	CAN bit timing register
tmi0	Transmit mailbox 0 identifier register
tmc0	Transmit mailbox 0 data length and time stamp register
tmdtl0	Transmit mailbox 0 data byte low register
tmdth0	Transmit mailbox 0 data byte high register
tmi1	Transmit mailbox 1 identifier register
tmc1	Transmit mailbox 1 data length and time stamp register
tmdtl1	Transmit mailbox 1 data byte low register
tmdth1	Transmit mailbox 1 data byte high register
tmi2	Transmit mailbox 2 identifier register
tmc2	Transmit mailbox 2 data length and time stamp register
tmdtl2	Transmit mailbox 2 data byte low register
tmdth2	Transmit mailbox 2 data byte high register
rfi0	Receive FIFO0 mailbox identifier register
rfc0	Receive FIFO0 mailbox data length and time stamp register
rfdtl0	Receive FIFO0 mailbox data byte low register
rfdth0	Receive FIFO0 mailbox data byte high register
rfi1	Receive FIFO1 mailbox identifier register
rfc1	Receive FIFO1 mailbox data length and time stamp register
rfdtl1	Receive FIFO1 mailbox data byte low register
rfdth1	Receive FIFO1 mailbox data byte high register
fctrl	CAN filter control register
fmcfg	CAN filter mode configuration register
fscfg	CAN filter size configuration register

Register	Description
frf	CAN filter FIFO assosication register
facfg	CAN filter activate control register
fb0f1	CAN filter bank 0 filter register 1
fb0f2	CAN filter bank 0 filter register 2
fb1f1	CAN filter bank 1 filter register 1
fb1f2	CAN filter bank 1 filter register 2
...	...
Fb13f1	CAN filter bank 13 filter register 1
Fb13f2	CAN filter bank 13 filter register 2

The table below gives a list of CAN library functions.

Table 69. Summary of CAN library functions

Function name	Description
can_reset	Reset all CAN registers to their reset values
can_baudrate_default_para_init	Configure the CAN baud rate initial structure with the initial value
can_baudrate_set	Configure CAN baud rate
can_default_para_init	Configure the CAN initial structure with the initial value
can_base_init	Initialize CAN registers with the specified parameters in the can_base_struct
can_filter_default_para_init	Configure the CAN filter initial structure with the initial value
can_filter_init	Initialize CAN registers with the specified parameters in the can_filter_init_struct
can_debug_transmission_prohibit	Select to disalbe/enable message reception and transmission when debug
can_ttc_mode_enable	Enable time-triggered mode
can_message_transmit	Transmit a frame of message
can_transmit_status_get	Get the status of transmission
can_transmit_cancel	Cancel transmission
can_message_receive	Receive a frame of message
can_receive_fifo_release	Release receive FIFO
can_receive_message_pending_get	Get the count of pending messages in FIFO
can_operating_mode_set	Configure CAN operating mode
can_doze_mode_enter	Enter sleep mode
can_doze_mode_exit	Exit sleep mode
can_error_type_record_get	Read CAN error type
can_receive_error_counter_get	Read CAN receive error counter
can_transmit_error_counter_get	Read CAN transmit error counter
can_interrupt_enable	Enable the selected CAN interrupt
can_flag_get	Read the selected CAN flag
can_flag_clear	Clear the selected CAN flag

5.3.1 can_reset function

The table below describes the function can_reset.

Table 70. can_reset function

Name	Description
Function name	can_reset
Function prototype	void can_reset(can_type* can_x);
Function description	Reset CAN registers to their default values.
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	crm_periph_reset();

Example:

```
can_reset(CAN1);
```

5.3.2 can_baudrate_default_para_init function

The table below describes the function can_baudrate_default_para_init.

Table 71. can_baudrate_default_para_init function

Name	Description
Function name	can_baudrate_default_para_init
Function prototype	void can_baudrate_default_para_init(can_baudrate_type* can_baudrate_struct);
Function description	Configure the CAN baud rate initial structure with the initial value
Input parameter 1	can_baudrate_struct: can_baudrate_type pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of the can_baudrate_type before starting.
Called functions	NA

Example:

```
can_baudrate_type can_baudrate_struct;  
can_baudrate_default_para_init(&can_baudrate_struct);
```

5.3.3 can_baudrate_set function

The table below describes the function can_baudrate_set.

Table 72. can_baudrate_set function

Name	Description
Function name	can_baudrate_set
Function prototype	error_status can_baudrate_set(can_type* can_x, can_baudrate_type* can_baudrate_struct);
Function description	Set baud rate for CAN
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	can_baudrate_struct: can_baudrate_type pointer
Output parameter	NA
Return value	status_index: check if baud rate is configured successfully
Required preconditions	It is necessary to define a variable of the can_baudrate_type before starting.
Called functions	NA

The can_baudrate_type is defined in the at32f423_can.h:

typedef struct

```
{
    uint16_t      baudrate_div;
    can_rsaw_type rsaw_size;
    can_bts1_type bts1_size;
    can_bts2_type bts2_size;
} can_baudrate_type;
```

baudrate_div

CAN clock division factor

Value range: 0x001~0x400

rsaw_size

Defines the maximum of time unit that the CAN is allowed to lengthen or shorten in a bit

CAN_RSAW_1TQ: Resynchronization width is 1 time unit

CAN_RSAW_2TQ: Resynchronization width is 2 time units

CAN_RSAW_3TQ: Resynchronization width is 3 time units

CAN_RSAW_4TQ: Resynchronization width is 4 time units

bts1_size

segment1 time duration

bts1_size description

CAN_BTS1_1TQ: the bit time segment 1 has 1 time unit

.....

CAN_BTS1_16TQ: the bit time segment 1 has 16 time units

bts2_size

segment2 time duration

CAN_BTS2_1TQ: the bit time segment 2 has 1 time unit

.....

CAN_BTS2_8TQ: the bit time segment 2 has 8 time units

Example:

```

/* can baudrate, set baudrate = pclk/(baudrate_div *(1 + bts1_size + bts2_size)) */
can_baudrate_struct.baudrate_div = 10;
can_baudrate_struct.rsaw_size = CAN_RSAW_3TQ;
can_baudrate_struct.bts1_size = CAN_BTS1_8TQ;
can_baudrate_struct.bts2_size = CAN_BTS2_3TQ;
can_baudrate_set(CAN1, &can_baudrate_struct);

```

5.3.4 can_default_para_init function

The table below describes the function can_default_para_init.

Table 73. can_default_para_init function

Name	Description
Function name	can_default_para_init
Function prototype	void can_default_para_init(can_base_type* can_base_struct);
Function description	Set an initial value for CAN initial structure
Input parameter 1	can_base_struct: <i>can_base_type</i> pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of the can_base_type before starting.
Called functions	NA

Example:

```

can_base_type can_base_struct;
can_default_para_init (&can_base_struct);

```

5.3.5 can_base_init function

The table below describes the function can_base_init.

Table 74. can_base_init function

Name	Description
Function name	can_base_init
Function prototype	error_status can_base_init(can_type* can_x, can_base_type* can_base_struct);
Function description	Initialize CAN registers with the specified parameters in the can_base_struct
Input parameter 1	can_base_struct: <i>can_base_type</i> pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of the can_base_type before starting.
Called functions	NA

The can_base_type is defined in the at32f423_can.h:

```

typedef struct
{
    can_mode_type          mode_selection;
    confirm_state           ttc_enable;
    confirm_state           aebo_enable;
}

```

```
confirm_state           aed_enable;
confirm_state           prsf_enable;
can_msg_discarding_rule_type mdrsel_selection;
can_msg_sending_rule_type mmssr_selection;
} can_base_type;

mode_selection
Test mode selection
CAN_MODE_COMMUNICATE:      Communication mode
CAN_MODE_LOOPBACK:         Loopback mod
CAN_MODE_LISTENONLY:        Listen only mode
CAN_MODE_LISTENONLY_LOOPBACK: Loopback + listen only mode

ttc_enable
Enable/disable time-triggered communication mode.
FALSE: Disable time-triggered communication mode
TRUE:  Enable time-triggered communication mode (while receiving/sending messages, capture time stamp and store it into the CAN RFCx and CAN TMCx registers)

aebo_enable
Enable auto exit of bus-off mode.
FALSE: Automatic exit of bus-off mode is disabled
TRUE:  Automatic exit of bus-off mode is enabled

aed_enable
Enable auto exit of sleep mode.
FALSE: Auto exit of sleep mode is disabled
TRUE:  Auto exit of sleep mode is enabled

prsf_enable
Disable retransmission when transmit failed.
FALSE: Retransmission is enabled
TRUE:  Retransmission is disabled

mdrsel_selection
Define message discard rule when reception overflows.
CAN_DISCARDING_FIRST RECEIVED: The previous message is discarded.
CAN_DISCARDING_LAST RECEIVED: The new incoming message is discarded.

mmssr_selection
Define multiple message transmit sequence rule.
CAN_SENDING_BY_ID: The message with the smallest identifier number is first transmitted.
CAN_SENDING_BY_REQUEST: The message with the first request order is first transmitted.

Example:
/* can base init */
can_base_struct.mode_selection = CAN_MODE_COMMUNICATE;
can_base_struct.ttc_enable = FALSE;
can_base_struct.aebo_enable = TRUE;
can_base_struct.aed_enable = TRUE;
can_base_struct.prf_enable = FALSE;
can_base_struct.mdrsel_selection = CAN_DISCARDING_FIRST RECEIVED;
can_base_struct.mmssr_selection = CAN_SENDING_BY_ID;
can_base_init(CAN1, &can_base_struct);
```

5.3.6 can_filter_default_para_init function

The table below describes the function can_filter_default_para_init.

Table 75. can_filter_default_para_init function

Name	Description
Function name	can_filter_default_para_init
Function prototype	void can_filter_default_para_init(can_filter_init_type* can_filter_init_struct);
Function description	Configure CAN filter initialization structure with the initial value
Input parameter 1	can_filter_init_struct: can_filter_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of can_filter_init_type before starting.
Called functions	NA

Example:

```
can_filter_init_type can_filter_init_struct;
can_filter_default_para_init(&can_filter_init_struct);
```

5.3.7 can_filter_init function

The table below describes the function can_filter_init.

Table 76. can_filter_init function

Name	Description
Function name	can_filter_init
Function prototype	void can_filter_init(can_type* can_x, can_filter_init_type* can_filter_init_struct);
Function description	Initialize all CAN registers with the specified parameters in the can_base_struct
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	can_filter_init_struct: can_filter_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of can_filter_init_type before starting.
Called functions	NA

The can_filter_init_type is defined in the at32f423_can.h:

```
typedef struct
{
    confirm_state          filter_activate_enable;
    can_filter_mode_type   filter_mode;
    can_filter_fifo_type   filter_fifo;
    uint8_t                 filter_number;
    can_filter_bit_width_type filter_bit;
    uint16_t                filter_id_high;
    uint16_t                filter_id_low;
    uint16_t                filter_mask_high;
```

```
    uint16_t          filter_mask_low;  
} can_filter_init_type;  
filter_activate_enable  
Enable/disable filter bank  
FALSE: Disable filter bank  
TRUE: Enable filter bank  
filter_mode  
Select filter mode.  
CAN_FILTER_MODE_ID_MASK: Identifier mask mode  
CAN_FILTER_MODE_ID_LIST: Identifier list mode
```

filter_fifo
Select filter associated FIFO.
CAN_FILTER_FIFO0: Associated with FIFO0
CAN_FILTER_FIFO1: Associated with FIFO1

filter_number
Select filter bank.
Value range: 0~13

filter_bit
Select filter bit width
CAN_FILTER_16BIT: 16-bit
CAN_FILTER_32BIT: 32-bit

filter_id_high
The filter_id_high is used to configure the upper 16 bits (32-bit width, Mask/List mode) of the filter identifier 1, the filter identifier 2 (16-bit width, List mode) or the filter mask identifier 1 (16-bit width, Mask mode).
Value range: 0x0000~0xFFFF

filter_id_low
The filter_id_low is used to configure the lower 16 bits of the filter identifier 1 (32-bit width, Mask/List mode), or the filter identifier 1 (16-bit width, List mode).
Value range: 0x0000~0xFFFF

filter_mask_high
The filter_mask_high is used to configure the upper 16 bits of the filter mask identifier 1 (32-bit width, Mask mode), the filter mask identifier 2 (16-bit width, Mask mode), the upper 16 bits of the filter identifier 2 (32-bit width, List mode) or the filter identifier 4 (16-bit width, List mode).
Value range: 0x0000~0xFFFF

filter_mask_low
The filter_mask_low is used to configure the lower 16 bits of the filter mask identifier 1 (32-bit width, Mask mode), the filter identifier 2 (16-bit width, Mask mode), the lower 16 bits of the filter identifier 2 (32-bit width ,List mode) or the filter identifier 3 (16-bit width, List mode).
Value range: 0x0000~0xFFFF

Example:

```
/* can filter init */  
can_filter_init_struct.filter_activate_enable = TRUE;  
can_filter_init_struct.filter_mode = CAN_FILTER_MODE_ID_MASK;  
can_filter_init_struct.filter_fifo = CAN_FILTER_FIFO0;  
can_filter_init_struct.filter_number = 0;
```

```

can_filter_init_struct.filter_bit = CAN_FILTER_32BIT;
can_filter_init_struct.filter_id_high = 0;
can_filter_init_struct.filter_id_low = 0;
can_filter_init_struct.filter_mask_high = 0;
can_filter_init_struct.filter_mask_low = 0;
can_filter_init(CAN1, &can_filter_init_struct);

```

5.3.8 can_debug_transmission_prohibit function

The table below describes the function can_debug_transmission_prohibit.

Table 77. can_debug_transmission_prohibit function

Name	Description
Function name	can_debug_transmission_prohibit
Function prototype	void can_debug_transmission_prohibit(can_type* can_x, confirm_state new_state);
Function description	Disable/enable message transceiver when debugging
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```

/* prohibit can trans when debug*/
can_debug_transmission_prohibit(CAN1, TRUE);

```

5.3.9 can_ttc_mode_enable function

The table below describes the function can_ttc_mode_enable.

Table 78. can_ttc_mode_enable function

Name	Description
Function name	can_ttc_mode_enable
Function prototype	void can_ttc_mode_enable(can_type* can_x, confirm_state new_state);
Function description	Enable time-triggered mode
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* can time trigger operation communication mode enable*/
can_ttc_mode_enable (CAN1, TRUE);
```

Note: When the ttc_enable is enabled in the can_base_init, it indicates that only the time stamp is enabled (During message receive and transmit, the time stamp is captured and stored in the CAN_RFCx and CAN_TMCx registers). But when the can_ttc_mode_enable is enabled, not only the time stamp is enabled, and but the time stamp transmission feature is enabled (During message transmission, the time stamp is sent on the 7th and 8th data byte).

5.3.10 can_message_transmit function

The table below describes the function can_message_transmit

Table 79. can_message_transmit function

Name	Description
Function name	can_message_transmit
Function prototype	uint8_t can_message_transmit(can_type* can_x, can_tx_message_type* tx_message_struct);
Function description	Transmit a frame of message
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	tx_message_struct: message pending for transmission, refer to can_tx_message_type
Output parameter	NA
Return value	transmit_mailbox: indicates the mailbox number required to send message
Required preconditions	Write the to-be-sent message in the tx_message_struct
Called functions	NA

The can_tx_message_type is defined in the at32f423_can.h:

```
typedef struct
{
    uint32_t          standard_id;
    uint32_t          extended_id;
    can_identifier_type id_type;
    can_trans_frame_type frame_type;
    uint8_t            dlc;
    uint8_t            data[8];
} can_tx_message_type;
```

standard_id

Standard identifier (11 bits active)

Value range: 0x000~0x7FF

extended_id

Extended identifier (29 bits active)

Value range: 0x000~0x1FFFFFF

id_type

Identifier type

CAN_ID_STANDARD: Standard identifier

CAN_ID_EXTENDED: Extended identifier

frame_type

Frame type

CAN_TFT_DATA: Data frame

CAN_TFT_REMOTE: Remote frame

dlc

Data length (in byte)

Value range:0~8

data[8]

Data pending for transmission

Value range:0x00~0xFF

Example:

```
/* can transmit data */
static void can_transmit_data(void)
{
    uint8_t transmit_mailbox;
    can_tx_message_type tx_message_struct;
    tx_message_struct.standard_id = 0x400;
    tx_message_struct.extended_id = 0;
    tx_message_struct.id_type = CAN_ID_STANDARD;
    tx_message_struct.frame_type = CAN_TFT_DATA;
    tx_message_struct.dlc = 8;
    tx_message_struct.data[0] = 0x11;
    tx_message_struct.data[1] = 0x22;
    tx_message_struct.data[2] = 0x33;
    tx_message_struct.data[3] = 0x44;
    tx_message_struct.data[4] = 0x55;
    tx_message_struct.data[5] = 0x66;
    tx_message_struct.data[6] = 0x77;
    tx_message_struct.data[7] = 0x88;
    transmit_mailbox = can_message_transmit(CAN1, &tx_message_struct);
    while(can_transmit_status_get(CAN1, (can_tx_mailbox_num_type)transmit_mailbox) != CAN_TX_STATUS_SUCCESSFUL);
}
```

5.3.11 can_transmit_status_get function

The table below describes the function can_transmit_status_get.

Table 80. can_transmit_status_get function

Name	Description
Function name	can_transmit_status_get
Function prototype	can_transmit_status_type can_transmit_status_get(can_type* can_x, can_tx_mailbox_num_type transmit_mailbox);
Function description	Get the status of transmission
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	transmit_mailbox: indicates the mailbox number required to send message
Output parameter	NA
Return value	state_index: transmission status
Required preconditions	First send a frame of message and get a transmit mailbox number
Called functions	NA

Example:

```
/* can transmit data */
static void can_transmit_data(void)
{
    uint8_t transmit_mailbox;
    can_tx_message_type tx_message_struct;
    tx_message_struct.standard_id = 0x400;
    tx_message_struct.extended_id = 0;
    tx_message_struct.id_type = CAN_ID_STANDARD;
    tx_message_struct.frame_type = CAN_TFT_DATA;
    tx_message_struct.dlc = 8;
    tx_message_struct.data[0] = 0x11;
    tx_message_struct.data[1] = 0x22;
    tx_message_struct.data[2] = 0x33;
    tx_message_struct.data[3] = 0x44;
    tx_message_struct.data[4] = 0x55;
    tx_message_struct.data[5] = 0x66;
    tx_message_struct.data[6] = 0x77;
    tx_message_struct.data[7] = 0x88;
    transmit_mailbox = can_message_transmit(CAN1, &tx_message_struct);
    while(can_transmit_status_get(CAN1, (can_tx_mailbox_num_type)transmit_mailbox) != CAN_TX_STATUS_SUCCESSFUL);
}
```

5.3.12 can_transmit_cancel function

The table below describes the function can_transmit_cancel.

Table 81. can_transmit_cancel function

Name	Description
Function name	can_transmit_cancel
Function prototype	void can_transmit_cancel(can_type* can_x, can_tx_mailbox_num_type transmit_mailbox);
Function description	Cancel transmission
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	transmit_mailbox: indicates the mailbox number required to send message
Output parameter	NA
Return value	NA
Required preconditions	First send a frame of message and get a transmit mailbox number
Called functions	NA

Example:

```
/* cancel a transmit request */
uint8_t transmit_mailbox;
transmit_mailbox = can_message_transmit(CAN1, &tx_message_struct);
can_transmit_cancel(CAN1, (can_tx_mailbox_num_type)transmit_mailbox);
```

5.3.13 can_message_receive function

The table below describes the function can_message_receive.

Table 82. can_message_receive function

Name	Description
Function name	can_message_receive
Function prototype	void can_message_receive(can_type* can_x, can_rx_fifo_num_type fifo_number, can_rx_message_type* rx_message_struct);
Function description	Receive message
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	fifo_number: receive FIFO This parameter can be CAN_RX_FIFO0 or CAN_RX_FIFO1.
Output parameter	rx_message_struct: indicates the received message, refer to can_rx_message_type
Return value	NA
Required preconditions	Receive FIFO not empty (FIFO message count is not zero)
Called functions	void can_receive_fifo_release(can_type* can_x, can_rx_fifo_num_type fifo_number);

The can_rx_message_type is defined in the at32f423_can.h:

typedef struct

{

uint32_t	standard_id;
uint32_t	extended_id;

```
    can_identifier_type      id_type;
    can_trans_frame_type    frame_type;
    uint8_t                  dlc;
    uint8_t                  data[8];
    uint8_t                  filter_index;
} can_rx_message_type;
```

standard_id

Standard identifier (11 bits active)

Value range:0x000~0x7FF

extended_id

Extended identifier (29 bits active)

Value range:0x000~0x1FFFFFF

id_type

Identifier type

CAN_ID_STANDARD: Standard identifier

CAN_ID_EXTENDED: Extended identifier

frame_type

Frame type

CAN_TFT_DATA: Data frame

CAN_TFT_REMOTE: Remote frame

dlc

Data length (in byte)

Value range:0~8

data[8]

Data pending for transmission

Value range:0x00~0xFF

filter_index

Filter match index (indicating the filter number that a message has passed through)

Value range:0x00~0xFF

Example:

```
/* can receive message */
can_rx_message_type rx_message_struct;
can_message_receive(CAN1, CAN_RX_FIFO0, &rx_message_struct);
```

5.3.14 can_receive_fifo_release function

The table below describes the function can_receive_fifo_release.

Table 83. can_receive_fifo_release function

Name	Description
Function name	can_receive_fifo_release
Function prototype	void can_receive_fifo_release(can_type* can_x, can_rx_fifo_num_type fifo_number);
Function description	Release receive FIFO
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	fifo_number: receive FIFO number This parameter can be CAN_RX_FIFO0 or CAN_RX_FIFO1.
Output parameter	NA
Return value	NA
Required preconditions	Message in FIFO has already been read
Called functions	NA

Example:

```
/* can receive message */
void can_message_receive(can_type* can_x, can_rx_fifo_num_type fifo_number, can_rx_message_type*
rx_message_struct)
{
    /* get the id type */
    rx_message_struct->id_type = (can_identifier_type)can_x->fifo_mailbox[fifo_number].rfi_bit.rfidi;
    ...

    /* get the data field */
    rx_message_struct->data[0] = can_x->fifo_mailbox[fifo_number].rfdtl_bit.rfdt0;
    ...
    rx_message_struct->data[7] = can_x->fifo_mailbox[fifo_number].rfdth_bit.rfdt7;

    /* FIFO must be read before releasing FIFO */
    /* release the fifo */
    can_receive_fifo_release(can_x, fifo_number);
}
```

5.3.15 can_receive_message_pending_get function

The table below describes the function can_receive_message_pending_get.

Table 84. can_receive_message_pending_get function

Name	Description
Function name	can_receive_message_pending_get
Function prototype	uint8_t can_receive_message_pending_get(can_type* can_x, can_rx_fifo_num_type fifo_number);
Function description	Get the number of message pending for read in FIFO
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	fifo_number: receive FIFO number This parameter can be CAN_RX_FIFO0 or CAN_RX_FIFO1.
Output parameter	NA
Return value	message_pending: the count of message pending for read in FIFO
Required preconditions	NA
Called functions	NA

Example:

```
/* return the number of pending messages of */
can_receive_message_pending_get (CAN1, CAN_RX_FIFO0);
```

5.3.16 can_operating_mode_set function

The table below describes the function can_operating_mode_set.

Table 85. can_operating_mode_set function

Name	Description
Function name	can_operating_mode_set
Function prototype	error_status can_operating_mode_set(can_type* can_x, can_operating_mode_type can_operating_mode);
Function description	Configure CAN operating modes
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	<i>can_operating_mode</i> : CAN operating mode selection
Output parameter	NA
Return value	status: indicates whether configuration is successful or not
Required preconditions	NA
Called functions	NA

can_operating_mode

CAN_OPERATINGMODE_FREEZE: Freeze mode—for CAN controller initialization

CAN_OPERATINGMODE_DOZE: Sleep mode—CAN clock stopped to save power consumption

CAN_OPERATINGMODE_COMMUNICATE: Communication mode—for communication

Example:

```
/* set the operation mode —enter freeze mode*/
can_operating_mode_set (CAN1, CAN_OPERATINGMODE_FREEZE);
```

```
/* Initialize CAN controller */  
...  
  
/* set the operation mode -enter communicate mode*/  
can_operating_mode_set (CAN1, CAN_OPERATINGMODE_COMMUNICATE);  
  
/* Starts communication: send and receive message */  
...
```

5.3.17 can_doze_mode_enter function

The table below describes the function can_doze_mode_enter

Table 86. can_doze_mode_enter function

Name	Description
Function name	can_doze_mode_enter
Function prototype	can_enter_doze_status_type can_doze_mode_enter(can_type* can_x);
Function description	Enter sleep mode
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Output parameter	NA
Return value	can_enter_doze_status : indicates whether the Sleep mode is entered
Required preconditions	NA
Called functions	NA

can_enter_doze_status

Indicates whether the Sleep mode is entered or not

CAN_ENTER_DOZE_FAILED: Sleep mode entry failure

CAN_ENTER_DOZE_SUCCESSFUL: Sleep mode entry success

Example:

```
/* can enter the low power mode */  
can_enter_doze_status_type can_enter_doze_status;  
can_enter_doze_status = can_doze_mode_enter(CAN1);
```

5.3.18 can_doze_mode_exit function

The table below describes the function can_doze_mode_exit.

Table 87. can_doze_mode_exit function

Name	Description
Function name	can_doze_mode_exit
Function prototype	can_quit_doze_status_type can_doze_mode_exit(can_type* can_x);
Function description	Exit Sleep mode
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Output parameter	NA
Return value	can_quit_doze_status : indicates whether the Sleep mode has been left
Required preconditions	NA
Called functions	NA

can_quit_doze_status

Indicates whether the Sleep mode has been left successfully

CAN_QUIT_DOZE_FAILED: Sleep mode exit failure

CAN_QUIT_DOZE_SUCCESSFUL: Sleep mode exit success

Example:

```
/* can exit the low power mode */
can_quit_doze_status_type can_quit_doze_status;
can_quit_doze_status = can_doze_mode_exit (CAN1);
```

5.3.19 can_error_type_record_get function

The table below describes the function can_error_type_record_get.

Table 88. can_error_type_record_get function

Name	Description
Function name	can_error_type_record_get
Function prototype	can_error_record_type can_error_type_record_get(can_type* can_x);
Function description	Read CAN error type
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Output parameter	NA
Return value	can_error_record : Error type
Required preconditions	NA
Called functions	NA

can_error_record

CAN error record

CAN_ERRORRECORD_NOERR: No error

CAN_ERRORRECORD_STUFFERR: Bit stuffing error

CAN_ERRORRECORD_FORMERR: Format error

CAN_ERRORRECORD_ACKERR: Acknowledge error

CAN_ERRORRECORD_BITRECESSIVEERR:	Recessive bit error
CAN_ERRORRECORD_BITDOMINANTERR:	Dominant bit error
CAN_ERRORRECORD_CRCERR:	CRC error
CAN_ERRORRECORD_SOFTWARESETERR:	Set by software

Example:

```
/* get the error type record (etr) */
can_error_record_type can_error_record;
can_error_record = can_error_type_record_get (CAN1);
```

5.3.20 can_receive_error_counter_get function

The table below describes the function can_receive_error_counter_get.

Table 89. can_receive_error_counter_get function

Name	Description
Function name	can_receive_error_counter_get
Function prototype	uint8_t can_receive_error_counter_get(can_type* can_x);
Function description	Read CAN receive error counter
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Output parameter	NA
Return value	receive_error_counter: Receive error counter Value range: 0x00~0xFF
Required preconditions	NA
Called functions	NA

Example:

```
/* get the receive error counter (rec) */
uint8_t receive_error_counter;
receive_error_counter = can_receive_error_counter_get (CAN1);
```

5.3.21 can_transmit_error_counter_get function

The table below describes the function can_transmit_error_counter_get.

Table 90. can_transmit_error_counter_get function

Name	Description
Function name	can_transmit_error_counter_get
Function prototype	uint8_t can_transmit_error_counter_get(can_type* can_x);
Function description	Read CAN transmit error counter
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Output parameter	NA
Return value	transmit_error_counter: Transmit error counter Value range: 0x00~0xFF
Required preconditions	NA
Called functions	NA

Example:

```
/* get the transmit error counter (tec) */
uint8_t transmit_error_counter;
transmit_error_counter = can_transmit_error_counter_get (CAN1);
```

5.3.22 can_interrupt_enable function

The table below describes the function can_interrupt_enable.

Table 91. can_interrupt_enable function

Name	Description
Function name	can_interrupt_enable
Function prototype	void can_interrupt_enable(can_type* can_x, uint32_t can_int, confirm_state new_state);
Function description	Enable the selected CAN interrupt
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	<i>can_int</i> : Select CAN interrupts
Input parameter3	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

can_int

CAN interrupt select

CAN_TCIEN_INT:	Transmit mailbox empty interrupt enable
CAN_RF0MIEN_INT:	FIFO 0 receive message interrupt enable
CAN_RF0FIEN_INT:	Receive FIFO0 full interrupt enable
CAN_RF0OIEN_INT:	Receive FIFO0 overflow interrupt enable
CAN_RF1MIEN_INT:	FIFO 1 receive message interrupt enable
CAN_RF1FIEN_INT:	Receive FIFO1 full interrupt enable
CAN_RF1OIEN_INT:	Receive FIFO1 overflow interrupt enable
CAN_EAIEN_INT:	Error active interrupt enable
CAN_EPIEN_INT:	Error passive interrupt enable
CAN_BOIEN_INT:	Bus-off interrupt enable
CAN_ETRIEN_INT:	Error type record interrupt enable
CAN_EOEN_INT:	Error occur interrupt enable
CAN_QDZIEN_INT:	Quit Sleep mode interrupt enable
CAN_EDZIEN_INT:	Enter Sleep mode interrupt enable

Example:

```
/* can interrupt config */
nvic_irq_enable(CAN1_SE_IRQn, 0x00, 0x00);/*CAN1 error/status change interrupt */
nvic_irq_enable(USBFS_L_CAN1_RX0_IRQn, 0x00, 0x00);/*CAN1 FIFO0 receive interrupt */
```

```

/* FIFO 0 receive message interrupt enable */
can_interrupt_enable(CAN1, CAN_RF0MIEN_INT, TRUE);
/* error type record interrupt enable */
can_interrupt_enable(CAN1, CAN_ETRIEN_INT, TRUE);

/* This parameter is an error interrupt controller and it is enabled before error-related interrupts */
can_interrupt_enable(CAN1, CAN_EOIN_INT, TRUE);

```

5.3.23 can_flag_get function

The table below describes the function can_flag_get.

Table 92. can_flag_get function

Name	Description
Function name	can_flag_get
Function prototype	flag_status can_flag_get(can_type* can_x, uint32_t can_flag);
Function description	Get the status of the selected CAN flag
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	<i>can_flag</i> : indicates the selected flag Refer to the “can_flag” description below for details
Output parameter	NA
Return value	flag_status: the status of the selected flag Return value can be SET or RESET.
Required preconditions	NA
Called functions	NA

can_flag

This is used to select a flag and get its status, including:

- CAN_EAF_FLAG: Error active flag
- CAN_EPF_FLAG: Error passive flag
- CAN_BOF_FLAG: Bus-off flag
- CAN_ETR_FLAG: Error type record (non-zero error type flag)
- CAN_EOIF_FLAG: Error occur interrupt flag
- CAN_TM0TCF_FLAG: Mailbox 0 transmission complete flag
- CAN_TM1TCF_FLAG: Mailbox 1 transmission complete flag
- CAN_TM2TCF_FLAG: Mailbox 2 transmission complete flag
- CAN_RF0MN_FLAG: Receive FIFO0 non-empty flag
- CAN_RF0FF_FLAG: FIFO0 full flag
- CAN_RF0OF_FLAG: FIFO0 overflow flag
- CAN_RF1MN_FLAG: FIFO1 non-empty flag
- CAN_RF1FF_FLAG: FIFO1 full flag
- CAN_RF1OF_FLAG: FIFO1 overflow flag
- CAN_QDZIF_FLAG: Quit Sleep mode flag
- CAN_EDZC_FLAG: Enter Sleep mode flag
- CAN_TMEF_FLAG: Transmit mailbox empty flag (any one of three transmit mailboxes is empty)

Example:

```
/* get receive fifo 0 message num flag */
```

```
flag_status bit_status = RESET;
bit_status = can_flag_get (CAN1, CAN_RF0MN_FLAG);
```

5.3.24 can_interrupt_flag_get function

The table below describes the function can_interrupt_flag_get.

Table 93. can_interrupt_flag_get function

Name	Description
Function name	can_interrupt_flag_get
Function prototype	flag_status can_interrupt_flag_get(can_type* can_x, uint32_t can_flag);
Function description	Get CAN interrupt flag status
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	<i>can_flag</i> : indicates the selected flag Refer to can_flag
Output parameter	NA
Return value	flag_status: SET or RESET
Required preconditions	NA
Called functions	NA

can_flag:

This is used to clear the selected flag, including:

- CAN_EAF_FLAG: Error active flag
- CAN_EPF_FLAG: Error passive flag
- CAN_BOF_FLAG: Bus-off flag
- CAN_ETR_FLAG: Error type record (non-zero Error type flag)
- CAN_EOIF_FLAG: Error occur interrupt flag
- CAN_TM0TCF_FLAG: Mailbox 0 transmission complete flag
- CAN_TM1TCF_FLAG: Mailbox 1 transmission complete flag
- CAN_TM2TCF_FLAG: Mailbox 2 transmission complete flag
- CAN_RF0MN_FLAG: FIFO0 not-empty flag
- CAN_RF0FF_FLAG: FIFO0 full flag
- CAN_RF0OF_FLAG: FIFO0 overflow flag
- CAN_RF1MN_FLAG: FIFO1 not-empty flag
- CAN_RF1FF_FLAG: FIFO1 full flag
- CAN_RF1OF_FLAG: FIFO1 overflow flag
- CAN_QDZIF_FLAG: Quit Sleep mode flag
- CAN_EDZC_FLAG: Enter Sleep mode flag
- CAN_TMEF_FLAG: Transmit mailbox empty flag (any one of three transmit mailboxes is empty)

Example:

```
/* check receive fifo 0 message num interrupt flag */
if(can_interrupt_flag_get(CAN1, CAN_RF0MN_FLAG) != RESET)
{
}
```

5.3.25 can_flag_clear function

The table below describes the function can_flag_clear.

Table 94. can_flag_clear function

Name	Description
Function name	can_flag_clear
Function prototype	void can_flag_clear(can_type* can_x, uint32_t can_flag);
Function description	Clear the selected CAN flag
Input parameter 1	can_x: indicates the selected CAN This parameter can be CAN1 or CAN2.
Input parameter 2	<i>can_flag</i> : indicates the selected flag Refer to can_flag
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

can_flag:

This is used to clear the selected flag, including:

- CAN_EAF_FLAG: Error active flag
- CAN_EPF_FLAG: Error passive flag
- CAN_BOF_FLAG: Bus-off flag
- CAN_ETR_FLAG: Error type record (non-zero Error type flag)
- CAN_EOIF_FLAG: Error occur interrupt flag
- CAN_TM0TCF_FLAG: Mailbox 0 transmission complete flag
- CAN_TM1TCF_FLAG: Mailbox 1 transmission complete flag
- CAN_TM2TCF_FLAG: Mailbox 2 transmission complete flag
- CAN_RF0FF_FLAG: FIFO0 full flag
- CAN_RF0OF_FLAG: FIFO0 overflow flag
- CAN_RF1FF_FLAG: FIFO1 full flag
- CAN_RF1OF_FLAG: FIFO1 overflow flag
- CAN_QDZIF_FLAG: Quit Sleep mode flag
- CAN_EDZC_FLAG: Enter Sleep mode flag
- CAN_TMEF_FLAG: Transmit mailbox empty flag (any one of three transmit mailboxes is empty)

Note: The CAN_RF0MN_FLAG (FIFO0 non-empty flag) and CAN_RF1MN_FLAG (FIFO1 non-empty flag) have no clear operations since both are defined by software.

Example:

```
/* clear receive fifo 0 overflow flag */
can_flag_clear (CAN1, CAN_RF1OF_FLAG);
```

5.4 CRC calculation unit (CRC)

The CRC register structure `crc_type` is defined in the “`at32f423_crc.h`”:

```
/*
 * @brief type define crc register all
 */
typedef struct
{
    ...
} crc_type;
```

The table below gives a list of the CRC registers.

Table 95. Summary of CRC registers

Register	Description
dt	Data register
cdt	General-purpose data register
ctrl	Control register
idt	Control register
poly	Polynomial generator

The table below gives a list of CRC library functions.

Table 96. Summary of CRC library functions

Function name	Description
<code>crc_data_reset</code>	Data register reset
<code>crc_one_word_calculate</code>	Calculate the CRC value using combination of a new 32-bit data and the previous CRC value
<code>crc_block_calculate</code>	Write a data block in order into CRC check and return the calculated result
<code>crc_data_get</code>	Get the currently calculated CRC result
<code>crc_common_data_set</code>	Configure common registers
<code>crc_common_date_get</code>	Get the value of common registers
<code>crc_init_data_set</code>	Set the CRC initialization register
<code>crc_reverse_input_data_set</code>	Set CRC input data bit reverse type
<code>crc_reverse_output_data_set</code>	Set CRC output data reverse type
<code>crc_poly_value_set</code>	Set polynomial value
<code>crc_poly_value_get</code>	Get polynomial value
<code>crc_poly_size_set</code>	Set polynomial valid width
<code>crc_poly_size_get</code>	Get polynomial valid width

5.4.1 crc_data_reset function

The table below describes the function crc_data_reset.

Table 97. crc_data_reset function

Name	Description
Function name	crc_data_reset
Function prototype	void crc_data_reset(void);
Function description	When the data register is reset, the value of the initialization register is added into the data register as an initial value. The default reset value is 0xFFFFFFFF.
Input parameter 1	NA
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* reset crc data register */
crc_data_reset();
```

5.4.2 crc_one_word_calculate function

The table below describes the function crc_one_word_calculate.

Table 98. crc_one_word_calculate function

Name	Description
Function name	crc_one_word_calculate
Function prototype	uint32_t crc_one_word_calculate(uint32_t data);
Function description	Calculate the CRC value using a combination of a new 32-bit data and the previous CRC value.
Input parameter 1	data: input a 32-bit data
Input parameter 2	NA
Output parameter	NA
Return value	uint32_t: return CRC calculation result
Required preconditions	NA
Called functions	NA

Example:

```
/* calculate and return result */
uint32_t data = 0x12345678, result = 0;
result = crc_one_word_calculate (data);
```

5.4.3 crc_block_calculate function

The table below describes the function crc_block_calculate

Table 99. crc_block_calculate function

Name	Description
Function name	crc_block_calculate
Function prototype	uint32_t crc_block_calculate(uint32_t *pbuffer, uint32_t length);
Function description	Input a data block in sequence to go through CRC calculation and return a result
Input parameter 1	pbuffer: point to the data block pending for CRC check
Input parameter 2	length: data block length pending for CRC check, in terms of 32-bit
Output parameter	NA
Return value	uint32_t: return CRC calculation result
Required preconditions	NA
Called functions	NA

Example:

```
/* calculate and return result */
uint32_t pbuffer[2] = {0x12345678, 0x87654321};
uint32_t result = 0;
result = crc_block_calculate (pbuffer, 2);
```

5.4.4 crc_data_get function

The table below describes the function crc_data_get.

Table 100. crc_data_get function

Name	Description
Function name	crc_data_get
Function prototype	uint32_t crc_data_get(void);
Function description	Return the current CRC calculation result
Input parameter 1	NA
Input parameter 2	NA
Output parameter	NA
Return value	uint32_t: return CRC calculation result
Required preconditions	NA
Called functions	NA

Example:

```
/* get result */
uint32_t result = 0;
result = crc_data_get();
```

5.4.5 crc_common_data_set function

The table below describes the function crc_common_data_set.

Table 101. crc_common_data_set function

Name	Description
Function name	crc_common_data_set
Function prototype	void crc_common_data_set(uint8_t cdt_value);
Function description	Configure common data register
Input parameter 1	cdt_value: 8-bit common data that can be used as temporary storage data
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set common data */  
crc_common_data_set (0x88);
```

5.4.6 crc_common_data_get function

The table below describes the function crc_common_data_get.

Table 102. crc_common_data_get function

Name	Description
Function name	crc_common_data_get
Function prototype	uint8_t crc_common_data_get(void);
Function description	Return the value of the command data register
Input parameter 1	NA
Input parameter 2	NA
Output parameter	NA
Return value	uint8_t: return the value of the previously programmed common data register
Required preconditions	NA
Called functions	NA

Example:

```
/* get common data */  
uint8_t cdt_value = 0;  
cdt_value = crc_common_data_get();
```

5.4.7 crc_init_data_set function

The table below describes the function `crc_init_data_set`.

Table 103. `crc_init_data_set` function

Name	Description
Function name	<code>crc_init_data_set</code>
Function prototype	<code>void crc_init_data_set(uint32_t value);</code>
Function description	Set the value of the CRC initialization register
Input parameter 1	value: the value of the CRC initialization register
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

After the value of the CRC initialization register is programmed, the CRC data register is updated with this value whenever the `crc_data_reset` function is called.

Example:

```
/* set initial data */
uint32_t init_value = 0x11223344;
crc_init_data_set (init_value);
```

5.4.8 crc_reverse_input_data_set function

The table below describes the function `crc_reverse_input_data_set`.

Table 104. `crc_reverse_input_data_set` function

Name	Description
Function name	<code>crc_reverse_input_data_set</code>
Function prototype	<code>void crc_reverse_input_data_set(crc_reverse_input_type value);</code>
Function description	Define the CRC input data bit reverse type
Input parameter 1	value: input data bit reverse type. Refer to “value” below for details.
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

Define the reverse type of input data bit.

`CRC_REVERSE_INPUT_NO_AFFECTE`: No effect

`CRC_REVERSE_INPUT_BY_BYTE`: Byte reverse

`CRC_REVERSE_INPUT_BY_HALFWORD`: Half-word reverse

`CRC_REVERSE_INPUT_BY_WORD`: Word reverse

Example:

```
/* set input data reversing type */
crc_reverse_input_data_set(CRC_REVERSE_INPUT_BY_WORD);
```

5.4.9 crc_reverse_output_data_set function

The table below describes the function crc_reverse_output_data_set.

Table 105. crc_reverse_output_data_set function

Name	Description
Function name	crc_reverse_output_data_set
Function prototype	void crc_reverse_output_data_set(crc_reverse_output_type value);
Function description	Define the CRC output data reverse type
Input parameter 1	value: output data bit reverse type. Refer to “value” below for details.
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

Define the reverse type of output data bit.

CRC_REVERSE_OUTPUT_NO_AFFECTE: No effect

CRC_REVERSE_OUTPUT_DATA: Word reverse

Example:

```
/* set output data reversing type */
crc_reverse_output_data_set(CRC_REVERSE_OUTPUT_DATA);
```

5.4.10 crc_poly_value_set function

The table below describes the function crc_poly_value_set.

Table 106. crc_poly_value_set function

Name	Description
Function name	crc_poly_value_set
Function prototype	void crc_poly_value_set(uint32_t value);
Function description	Set CRC polynomial value
Input parameter 1	value: polynomial value
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set poly value */
crc_poly_value_set(0x12345671);
```

5.4.11 crc_poly_value_get function

The table below describes the function crc_poly_value_get.

Table 107. crc_poly_value_get function

Name	Description
Function name	crc_poly_value_get

Name	Description
Function prototype	uint32_t crc_poly_value_get(void);
Function description	Get CRC polynomial value
Input parameter 1	NA
Input parameter 2	NA
Output parameter	NA
Return value	uint32_t: return polynomial value
Required preconditions	NA
Called functions	NA

Example:

```
/* get poly value */
uint32_t poly = 0;
poly = crc_poly_value_get();
```

5.4.12 crc_poly_size_set function

The table below describes the function crc_poly_size_set.

Table 108. crc_poly_size_set function

Name	Description
Function name	crc_poly_size_set
Function prototype	void crc_poly_size_set(crc_poly_size_type size);
Function description	Set CRC polynomial valid width
Input parameter 1	size: polynomial valid width
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

size

Define the valid width of polynomial.

CRC_SIZE_32B: 32-bit
 CRC_SIZE_16B: 16-bit
 CRC_SIZE_8B: 8-bit
 CRC_SIZE_7B: 7-bit

Example:

```
/* set poly size 32-bit */
crc_poly_size_set(CRC_SIZE_32B);
```

5.4.13 crc_poly_size_get function

The table below describes the function crc_poly_size_get.

Table 109. crc_poly_size_get function

Name	Description
Function name	crc_poly_size_get
Function prototype	crc_poly_size_type crc_poly_size_get(void);
Function description	Get CRC polynomial valid width
Input parameter 1	NA

Name	Description
Input parameter 2	NA
Output parameter	NA
Return value	crc_poly_size_type: polynomial valid width
Required preconditions	NA
Called functions	NA

crc_poly_size_type

Define the valid width of polynomial.

CRC_POLY_SIZE_32B: 32-bit

CRC_POLY_SIZE_16B: 16-bit

CRC_POLY_SIZE_8B: 8-bit

CRC_POLY_SIZE_7B: 7-bit

Example:

```
/* get poly size */  
crc_poly_size_type size;  
size = crc_poly_size_get();
```

5.5 Clock and reset management (CRM)

The CRM register structure `crm_type` is defined in the “`at32f423_crm.h`”:

```
/*
 * @brief type define crm register all
 */
typedef struct
{
    ...
} crm_type;
```

The table below gives a list of the CRM registers.

Table 110. Summary of CRM registers

Register	Description
ctrl	Clock control register
pllcfg	PLL clock configuration register
cfg	Clock configuration register
clkint	Clock interrupt register
ahbrst1	AHB peripheral reset register 1
ahbrst2	AHB peripheral reset register 2
ahbrst3	AHB peripheral reset register 3
apb1rst	APB1 peripheral reset register
apb2rst	APB2 peripheral reset register
ahben1	AHB peripheral clock enable register 1
ahben2	AHB peripheral clock enable register 2
ahben3	AHB peripheral clock enable register 3
apb1en	APB1 peripheral clock enable register
apb2en	APB2 peripheral clock enable register
ahblpen1	AHB peripheral clock enable in low power mode register 1
ahblpen2	AHB peripheral clock enable in low power mode register 2
ahblpen3	AHB peripheral clock enable in low power mode register 3
apb1lpen	APB1 peripheral clock enable in low power mode register
apb2lpen	APB2 peripheral clock enable in low power mode register
piclks	Peripheral independent clock select register
bpdc	Battery powered domain control register
ctrlsts	Control/status register
misc1	Extra register 1
misc2	Extra register 2

The table below gives a list of CRM library functions.

Table 111. Summary of CRM library functions

Function name	Description
crm_reset	Reset clock reset management register and control status
crm_lext_bypass	Configure low-speed external clock bypass
crm_hext_bypass	Configure higded external clock bypass
crm_flag_get	Check if the selected flag is set or not
crm_hext_stable_wait	Wait HEXT to get stable
crm_hick_clock_trimming_set	High speed internal clock trimming
crm_hick_clock_calibration_set	High speed internal clock calibration
crm_periph_clock_enable	Peripheral clock enable
crm_periph_reset	Peripheral set
crm_periph_lowpower_mode_enable	Enable peripheral clock in low-power mode
crm_clock_source_enable	Clock source enable
crm_flag_clear	Clear flag
crm_erc_clock_select	ERTC clock source selection
crm_erc_clock_enable	ERTC clock enable
crm_ahb_div_set	AHB clock division
crm_apb1_div_set	APB1 clock division
crm_apb2_div_set	APB2 clock division
crm_hext_sclk_div_set	HEXT clock division
crm_hick_sclk_div_set	HICK clock division
crm_usb_clock_div_set	USB clock division
crm_clock_failure_detection_enable	Clock failure detection enable
crm_batteryPowered_domain_reset	Battery powered domain reset
crm_pll_config	PLL clock source and frequency multiplication factor
crm_sysclk_switch	System clock source switch
crm_sysclk_status_get	Get the status of system clock source
crm_clocks_freq_get	Get clock frequency
crm_clock_out_set	Clock output clock source
crm_clkout_div_set	Clock frequency division on clock out pins
crm_interrupt_enable	Interrupt enable
crm_auto_step_mode_enable	Auto step-by-step mode enable
crm_hick_sclk_frequency_select	Set system clock frequency as 8M or 48M when HICK is used as system clock
crm_usb_clock_source_select	Select PLL or interal high-speed clock (48M) as USB clock source
crm_usart_clock_select	Select USART clock source
crm_usart_clock_get	Get USART clock source status
crm_i2c1_clock_select	Select I2C1 clock source
crm_i2c1_clock_get	Get I2C1 clock source status
crm_adc_clock_select	Select ADC clock source
crm_pll_parameter_calculate	Calculate PLL parameters automatically

5.5.1 crm_reset function

The table below describes the function crm_reset.

Table 112. crm_reset function

Name	Description
Function name	crm_reset
Function prototype	void crm_reset(void);
Function description	Reset the clock reset management register and control status
Input parameter 1	NA
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

1. This function does not change the HICKTRIM[5:0] in the CRM_CTRL register;
2. Modifying the function does not reset the CRM_BPDC and CRM_CTRLSTS registers.

Example:

```
/* reset crm */
crm_reset();
```

5.5.2 crm_lext_bypass function

The table below describes the function crm_lext_bypass.

Table 113. crm_lext_bypass function

Name	Description
Function name	crm_lext_bypass
Function prototype	void crm_lext_bypass(confirm_state new_state);
Function description	Configure low-speed external clock bypass
Input parameter 1	new_state: Enable bypass (TRUE), disable bypass (FALSE)
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	The LEXT configuration must be done before being enabled.
Called functions	NA

Example:

```
/* enable lext bypass mode */
crm_lext_bypass(TRUE);
```

5.5.3 crm_hext_bypass function

The table below describes the function crm_hext_bypass.

Table 114. crm_hext_bypass function

Name	Description
Function name	crm_hext_bypass
Function prototype	void crm_hext_bypass(confirm_state new_state);
Function description	Configure high-speed external clock bypass
Input parameter 1	new_state: Enable bypass (TRUE), disable bypass (FALSE)
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	The HEXT configuration must be done before being enabled.
Called functions	NA

Example:

```
/* enable hext bypass mode */
crm_hext_bypass(TRUE);
```

5.5.4 crm_flag_get function

The table below describes the function crm_flag_get.

Table 115. crm_flag_get function

Name	Description
Function name	crm_flag_get
Function prototype	flag_status crm_flag_get(uint32_t flag);
Function description	Check if the selected flag has been set.
Input parameter 1	flag: flag selection
Input parameter 2	NA
Output parameter	NA
Return value	flag_status: check the status of the selected flag. (SET or RESET)
Required preconditions	NA
Called functions	NA

flag

Select a flag to read, including:

CRM_HICK_STABLE_FLAG:	HICK clock stable flag
CRM_HEXT_STABLE_FLAG:	HEXT clock stable flag
CRM_PLL_STABLE_FLAG:	PLL clock stable flag
CRM_LEXT_STABLE_FLAG:	LEXT clock stable flag
CRM_LICK_STABLE_FLAG:	LICK clock stable flag
CRM_NRST_RESET_FLAG:	NRST pin reset flag
CRM_POR_RESET_FLAG:	Power-on/low voltage reset flag
CRM_SW_RESET_FLAG:	Software reset flag
CRM_WDT_RESET_FLAG:	Watchdog reset flag
CRM_WWDT_RESET_FLAG:	Window watchdog reset flag
CRM_LOWPOWER_RESET_FLAG:	Low-power consumption reset flag

CRM_LICK_READY_INT_FLAG:	LICK clock ready interrupt flag
CRM_LEXT_READY_INT_FLAG:	LEXT clock ready interrupt flag
CRM_HICK_READY_INT_FLAG:	HICK clock ready interrupt flag
CRM_HEXT_READY_INT_FLAG:	HEXT clock ready interrupt flag
CRM_PLL_READY_INT_FLAG:	PLL clock ready interrupt flag
CRM_CLOCK_FAILURE_INT_FLAG:	Clock failure interrupt flag

Example:

```
/* wait till pll is ready */
while(crm_flag_get(CRM_PLL_STABLE_FLAG) != SET)
{
}
```

5.5.5 crm_interrupt_flag_get function

The table below describes the function crm_interrupt_flag_get

Table 116. crm_interrupt_flag_get function

Name	Description
Function name	crm_interrupt_flag_get
Function prototype	flag_status crm_interrupt_flag_get(uint32_t flag);
Function description	Get CRM interrupt flag status
Input parameter 1	flag: select a flag Refer to the "flag" below for details
Input parameter 2	NA
Output parameter	NA
Return value	flag_status: SET or RESET
Required preconditions	NA
Called functions	NA

flag

Select a flag to read, including:

CRM_LICK_READY_INT_FLAG:	LICK clock ready interrupt flag
CRM_LEXT_READY_INT_FLAG:	LEXT clock ready interrupt flag
CRM_HICK_READY_INT_FLAG:	HICK clock ready interrupt flag
CRM_HEXT_READY_INT_FLAG:	HEXT clock ready interrupt flag
CRM_PLL_READY_INT_FLAG:	PLL clock ready interrupt flag
CRM_CLOCK_FAILURE_INT_FLAG:	Clock failure interrupt flag

Example:

```
/* check pll ready interrupt flag */
if(crm_interrupt_flag_get(CRM_PLL_READY_INT_FLAG) != RESET)
{
}
```

5.5.6 crm_hext_stable_wait function

The table below describes the function crm_hext_stable_wait

Table 117. crm_hext_stable_wait function

Name	Description
Function name	crm_hext_stable_wait
Function prototype	error_status crm_hext_stable_wait(void);
Function description	Wait for HEXT to activate and become stable
Input parameter 1	NA
Input parameter 2	NA
Output parameter	NA
Return value	error_status: Return the status of HEXT (SUCCESS or ERROR).
Required preconditions	NA
Called functions	NA

Example:

```
/* wait till hext is ready */
while(crm_hext_stable_wait() == ERROR)
{
}
```

5.5.7 crm_hick_clock_trimming_set function

The table below describes the function crm_hick_clock_trimming_set.

Table 118. crm_hick_clock_trimming_set function

Name	Description
Function name	crm_hick_clock_trimming_set
Function prototype	void crm_hick_clock_trimming_set(uint8_t trim_value);
Function description	Trim HICK clock
Input parameter 1	trim_value: trimming value. Default value is 0x20, configurable range is from 0 to 0x3F.
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set trimming value */
crm_hick_clock_trimming_set(0x1F);
```

5.5.8 crm_hick_clock_calibration_set function

The table below describes the function crm_hick_clock_calibration_set.

Table 119. crm_hick_clock_calibration_set function

Name	Description
Function name	crm_hick_clock_calibration_set
Function prototype	void crm_hick_clock_calibration_set(uint8_t cali_value);
Function description	Set HICK clock calibration value
Input parameter 1	cali_value: calibration compensation value. The factory gate value is the default value, Its configurable range is from 0 to 0xFF.
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set trimming value */
crm_hick_clock_trimming_set(0x80);
```

5.5.9 crm_periph_clock_enable

The table below describes the function crm_periph_clock_enable.

Table 120. crm_periph_clock_enable function

Name	Description
Function name	crm_periph_clock_enable
Function prototype	void crm_periph_clock_enable(crm_periph_clock_type value, confirm_state new_state);
Function description	Enable peripheral clock
Input parameter 1	value: defines peripheral clock type
Input parameter 2	new_state: TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

The crm_periph_clock_type is defined in the at32f423_crm.h.

The naming rule of this parameter is: CRM_peripheral_PERIPH_CLOCK.

CRM_DMA1_PERIPH_CLOCK: DMA1 peripheral clock enable

CRM_DMA2_PERIPH_CLOCK: DMA2 peripheral clock enable

...

CRM_PWC_PERIPH_CLOCK: PWC peripheral clock enable

CRM_DAC_PERIPH_CLOCK: DAC peripheral clock enable

Example:

```
/* enable gpoa periph clock */
crm_periph_clock_enable(CRM_GPIOA_PERIPH_CLOCK, TRUE);
```

5.5.10 crm_periph_reset function

The table below describes the function crm_periph_reset.

Table 121. crm_periph_reset function

Name	Description
Function name	crm_periph_reset
Function prototype	void crm_periph_reset(crm_periph_reset_type value, confirm_state new_state);
Function description	Reset peripherals
Input parameter 1	value: Peripheral reset type
Input parameter 2	new_state: TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

This indicates the selected peripheral. The crm_periph_reset_type is defined in the at32f423_crm.h.

The naming rule of this parameter is: CRM_peripheral_PERIPH_RESET.

CRM_DMA1_PERIPH_RESET: DMA1 peripheral reset

CRM_DMA2_PERIPH_RESET: DMA2 peripheral reset

...

CRM_PWC_PERIPH_RESET: PWC peripheral reset

CRM_DAC_PERIPH_RESET: DAC peripheral reset

Example:

```
/* reset gpioa periph */
crm_periph_reset(CRM_GPIOA_PERIPH_RESET, TRUE);
```

5.5.11 `crm_periph_lowpower_mode_enable` function

The table below describes the function `crm_periph_lowpower_mode_enable`.

Table 122. `crm_periph_lowpower_mode_enable` function

Name	Description
Function name	<code>crm_periph_lowpower_mode_enable</code>
Function prototype	<code>void crm_periph_lowpower_mode_enable(crm_periph_clock_lowpower_type value, confirm_state new_state);</code>
Function description	Enable peripheral clock in low-power mode
Input parameter 1	value: indicates peripheral clock type in low-power mode
Input parameter 2	new_state: TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

It indicates the selected peripheral. The `crm_periph_lowpower_type` is defined in `at32f423_crm.h`.

The naming rule of this parameter is: CRM_peripheral_PERIPH_LOWPOWER.

CRM_DMA1_PERIPH_LOWPOWER: DMA1 peripheral low-power clock definition

CRM_DMA2_PERIPH_LOWPOWER: DMA2 peripheral low-power clock definition

...

CRM_PWC_PERIPH_LOWPOWER: PWC peripheral low-power clock definition

CRM_DAC_PERIPH_LOWPOWER: DAC peripheral low-power clock definition

Example:

```
/* disable gpioa periph clock at sleep mode */
crm_periph_reset(CRM_GPIOA_PERIPH_LOWPOWER, FALSE);
```

5.5.12 crm_clock_source_enable function

The table below describes the function crm_clock_source_enable function.

Table 123. crm_clock_source_enable function

Name	Description
Function name	crm_clock_source_enable
Function prototype	void crm_clock_source_enable(crm_clock_source_type source, confirm_state new_state);
Function description	Enable clock source
Input parameter 1	source: Clock type
Input parameter 2	new_state: TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

source

Clock source selection.

CRM_CLOCK_SOURCE_HICK: HICK
 CRM_CLOCK_SOURCE_HEXT: HEXT
 CRM_CLOCK_SOURCE_PLL: PLL
 CRM_CLOCK_SOURCE_LEXT: LEXT
 CRM_CLOCK_SOURCE_LICK: LICK

Example:

```
/* enable hext */
crm_clock_source_enable (CRM_CLOCK_SOURCE_HEXT, FALSE);
```

5.5.13 crm_flag_clear function

The table below describes the function crm_flag_clear function.

Table 124. crm_flag_clear function

Name	Description
Function name	crm_flag_clear
Function prototype	void crm_flag_clear(uint32_t flag);
Function description	Clear the selected flags
Input parameter 1	Flag: indicates the flag to clear
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

flag

Select a flag to clear.

CRM_NRST_RESET_FLAG: NRST pin reset flag
 CRM_POR_RESET_FLAG: Power-on/low voltage reset flag
 CRM_SW_RESET_FLAG: Software reset flag

CRM_WDT_RESET_FLAG:	Watchdog reset flag
CRM_WWDT_RESET_FLAG:	Window watchdog reset flag
CRM_LOWPOWER_RESET_FLAG:	Low-power reset flag
CRM_ALL_RESET_FLAG:	All reset flags
CRM_LICK_READY_INT_FLAG:	LICK clock ready interrupt flag
CRM_LEXT_READY_INT_FLAG:	LEXT clock ready interrupt flag
CRM_HICK_READY_INT_FLAG:	HICK clock ready interrupt flag
CRM_HEXT_READY_INT_FLAG:	HEXT clock ready interrupt flag
CRM_PLL_READY_INT_FLAG:	PLL clock ready interrupt flag
CRM_CLOCK_FAILURE_INT_FLAG:	Clock failure interrupt flag

Example:

```
/* clear clock failure detection flag */
crm_flag_clear(CRM_CLOCK_FAILURE_INT_FLAG);
```

5.5.14 crm_ertc_clock_select function

The table below describes the function crm_ertc_clock_select function.

Table 125. crm_ertc_clock_select function

Name	Description
Function name	crm_ertc_clock_select
Function prototype	void crm_ertc_clock_select(crm_ertc_clock_type value);
Function description	Select ERTC clock source
Input parameter 1	value: indicates ertc clock source type
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

ERTC clock source selection.

CRM_ERTC_CLOCK_NOCLK:	No clock source for ERTC
CRM_ERTC_CLOCK_LEXT:	LEXT selected as ERTC clock
CRM_ERTC_CLOCK_LICK:	LICK selected as ERTC clock
CRM_ERTC_CLOCK_HEXT_DIV2:	HEXT/2 selected as ERTC clock
...	
CRM_ERTC_CLOCK_HEXT_DIV31:	HEXT/31 selected as ERTC clock

Example:

```
/* config lext as ertc clock */
crm_ertc_clock_select (CRM_ERTC_CLOCK_LEXT);
```

5.5.15 crm_ertc_clock_enable function

The table below describes the function crm_ertc_clock_enable.

Table 126. crm_ertc_clock_enable function

Name	Description
Function name	crm_ertc_clock_enable
Function prototype	void crm_ertc_clock_enable(confirm_state new_state);
Function description	Enable ERTC clock
Input parameter 1	new_state: TRUE or FALSE
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable ertc clock */
crm_ertc_clock_enable (TRUE);
```

5.5.16 crm_ahb_div_set function

The table below describes the function crm_ahb_div_set.

Table 127. crm_ahb_div_set function

Name	Description
Function name	crm_ahb_div_set
Function prototype	void crm_ahb_div_set(crm_ahb_div_type value);
Function description	Configure AHB clock division
Input parameter 1	value: indicates the division factor
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

- CRM_AHB_DIV_1: SCLK/1 used as AHB clock
- CRM_AHB_DIV_2: SCLK/2 used as AHB clock
- CRM_AHB_DIV_4: SCLK/4 used as AHB clock
- CRM_AHB_DIV_8: SCLK/8 used as AHB clock
- CRM_AHB_DIV_16: SCLK/16 used as AHB clock
- CRM_AHB_DIV_64: SCLK/64 used as AHB clock
- CRM_AHB_DIV_128: SCLK/128 used as AHB clock
- CRM_AHB_DIV_256: SCLK/256 used as AHB clock
- CRM_AHB_DIV_512: SCLK/512 used as AHB clock

Example:

```
/* config ahbclk */
crm_ahb_div_set(CRM_AHB_DIV_1);
```

5.5.17 crm_apb1_div_set function

The table below describes the function crm_apb1_div_set.

Table 128. crm_apb1_div_set function

Name	Description
Function name	crm_apb1_div_set
Function prototype	void crm_apb1_div_set(crm_apb1_div_type value);
Function description	Configure APB1 clock division
Input parameter 1	value: indicates the division factor
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

- CRM_APB1_DIV_1: AHB/1 used as APB1 clock
- CRM_APB1_DIV_2: AHB/2 used as APB1 clock
- CRM_APB1_DIV_4: AHB/4 used as APB1 clock
- CRM_APB1_DIV_8: AHB/8 used as APB1 clock
- CRM_APB1_DIV_16: AHB/16 used as APB1 clock

Example:

```
/* config apb1clk */
crm_apb1_div_set(CRM_APB1_DIV_2);
```

5.5.18 crm_apb2_div_set function

The table below describes the function crm_apb2_div_set.

Table 129. crm_apb2_div_set function

Name	Description
Function name	crm_apb2_div_set
Function prototype	void crm_apb2_div_set(crm_apb2_div_type value);
Function description	Configure APB2 clock division
Input parameter 1	value: indicates the division factor
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

- CRM_APB2_DIV_1: AHB/1 used as APB2 clock
- CRM_APB2_DIV_2: AHB/2 used as APB2 clock
- CRM_APB2_DIV_4: AHB/4 used as APB2 clock
- CRM_APB2_DIV_8: AHB/8 used as APB2 clock
- CRM_APB2_DIV_16: AHB/16 used as APB2 clock

Example:

```
/* config apb2clk */
crm_apb2_div_set(CRM_APB2_DIV_2);
```

5.5.19 crm_hext_sclk_div_set function

The table below describes the function crm_hext_sclk_div_set.

Table 130. crm_hext_sclk_div_set function

Name	Description
Function name	crm_hext_sclk_div_set
Function prototype	void crm_hext_sclk_div_set(crm_hext_sclk_div_type value);
Function description	Configure HEXT clock division
Input parameter 1	value: division factor
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

- CRM_HEXT_SCLK_DIV_1: HEXT/1 used as system clock
- CRM_HEXT_SCLK_DIV_2: HEXT/2 used as system clock
- CRM_HEXT_SCLK_DIV_4: HEXT/4 used as system clock
- CRM_HEXT_SCLK_DIV_8: HEXT/8 used as system clock
- CRM_HEXT_SCLK_DIV_16: HEXT/16 used as system clock
- CRM_HEXT_SCLK_DIV_32: HEXT/32 used as system clock

Example:

```
/* config hext to sysclk div */
crm_hext_sclk_div_set(CRM_HEXT_SCLK_DIV_1);
```

5.5.20 crm_hick_sclk_div_set function

The table below describes the function crm_hick_sclk_div_set.

Table 131. crm_hick_sclk_div_set function

Name	Description
Function name	crm_hick_sclk_div_set
Function prototype	void crm_hick_sclk_div_set(crm_hick_sclk_div_type value);
Function description	Configure HICK clock division
Input parameter 1	value: division factor
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

- CRM_HICK_SCLK_DIV_1: HICK/1 used as system clock
- CRM_HICK_SCLK_DIV_2: HICK/2 used as system clock
- CRM_HICK_SCLK_DIV_4: HICK/4 used as system clock
- CRM_HICK_SCLK_DIV_8: HICK/8 used as system clock
- CRM_HICK_SCLK_DIV_16: HICK/16 used as system clock

Example:

```
/* config hick to sysclk div */  
crm_hick_sclk_div_set(CRM_HICK_SCLK_DIV_1);
```

5.5.21 crm_usb_clock_div_set function

The table below describes the function crm_usb_clock_div_set.

Table 132. crm_usb_clock_div_set function

Name	Description
Function name	crm_usb_clock_div_set
Function prototype	void crm_usb_clock_div_set(crm_usb_div_type div_value);
Function description	Configure PLL clock division
Input parameter 1	div_value: division factor
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

div_value

- CRM_USB_DIV_3: PLL/3 used as USB clock
- CRM_USB_DIV_2: PLL/2 used as USB clock
- CRM_USB_DIV_5: PLL/5 used as USB clock
- CRM_USB_DIV_4: PLL/4 used as USB clock
- CRM_USB_DIV_7: PLL/7 used as USB clock
- CRM_USB_DIV_6: PLL/6 used as USB clock
- CRM_USB_DIV_9: PLL/9 used as USB clock
- CRM_USB_DIV_8: PLL/8 used as USB clock

Example:

```
/* config usb div 2 */  
crm_usb_clock_div_set (CRM_USB_DIV_2);
```

5.5.22 crm_clock_failure_detection_enable function

The table below describes the function crm_clock_failure_detection_enable.

Table 133. crm_clock_failure_detection_enable function

Name	Description
Function name	crm_clock_failure_detection_enable
Function prototype	void crm_clock_failure_detection_enable(confirm_state new_state);
Function description	Enable clock failure detection
Input parameter 1	new_state: TRUE or FALSE
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable clock failure detection */
crm_clock_failure_detection_enable(TRUE);
```

5.5.23 crm_batteryPowered_domain_reset function

The table below describes the function crm_batteryPowered_domain_reset.

Table 134. crm_batteryPowered_domain_reset

Name	Description
Function name	crm_batteryPowered_domain_reset
Function prototype	void crm_batteryPowered_domain_reset(confirm_state new_state);
Function description	Reset battery powered domain
Input parameter 1	new_state: Reset (TRUE), Not reset (FALSE)
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

When it comes to resetting battery powered domain, it is usually necessary to reset battery powered domain through TRUE operation and then disable battery powered domain reset through FALSE operation after the completion of reset.

Example:

```
/* reset battery powered domain */
crm_batteryPowered_domain_reset (TRUE);
```

5.5.24 crm_pll_config function

The table below describes the function crm_pll_config.

Table 135. crm_pll_config function

Name	Description
Function name	crm_pll_config
Function prototype	void crm_pll_config(crm_pll_clock_source_type clock_source, uint16_t pll_ns, uint16_t pll_ms, crm_pll_fr_type pll_fr);
Function description	Configure PLL clock source and frequency multiplication and division factor
Input parameter 1	clock_source: clock source for PLL frequency multiplication
Input parameter 2	pll_ns: frequency multiplication factor from 31 to 500
Input parameter3	pll_ms: pre-division frequency factor from 1 to 15
Input parameter4	pll_fr: post-division frequency factor
Output parameter	NA
Return value	NA
Required preconditions	PLL clock source must be enabled and stabilized before configuring and enabling PLL
Called functions	NA

Frequency multiplication formula: $\text{PLLCLK} = \text{PLL input clock} / \text{PLL_MS} * \text{PLL_NS} / \text{PLL_FR}$

Requirements:

$2\text{MHz} \leq \text{PLL input clock} / \text{PLL_MS} \leq 16\text{MHz}$

$500\text{MHz} \leq \text{PLL input clock} / \text{PLL_MS} * \text{PLL_NS} \leq 1000\text{MHz}$

clock_source

CRM_PLL_SOURCE_HICK: HICK is selected as PLL clock source

CRM_PLL_SOURCE_HEXT: HEXT is selected as PLL clock source

pll_fr

CRM_PLL_FR_1: PLL/1

CRM_PLL_FR_2: PLL/2

CRM_PLL_FR_4: PLL/4

CRM_PLL_FR_8: PLL/8

CRM_PLL_FR_16: PLL/16

CRM_PLL_FR_32: PLL/32

Example:

```
/* config pll clock resource */
crm_pll_config(CRM_PLL_SOURCE_HEXT, 96, 1, CRM_PLL_FR_8);
```

5.5.25 crm_sysclk_switch function

The table below describes the function crm_sysclk_switch.

Table 136. crm_sysclk_switch function

Name	Description
Function name	crm_sysclk_switch
Function prototype	void crm_sysclk_switch(crm_sclk_type value);
Function description	Switch system clock source
Input parameter 1	value: indicates the clock source for system clock
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

CRM_SCLK_HICK: HICK as system clock

CRM_SCLK_HEXT: HEXT as system clock

CRM_SCLK_PLL: PLL as system clock

Example:

```
/* select pll as system clock source */
crm_sysclk_switch(CRM_SCLK_PLL);
```

5.5.26 crm_sysclk_switch_status_get function

The table below describes the function crm_sysclk_switch_status_get.

Table 137. crm_sysclk_switch_status_get function

Name	Description
Function name	crm_sysclk_switch_status_get
Function prototype	crm_sclk_type crm_sysclk_switch_status_get(void);
Function description	Get the clock source of system clock
Input parameter 1	NA
Input parameter 2	NA
Output parameter	NA
Return value	crm_sclk_type: return value is the clock source of system clock
Required preconditions	NA
Called functions	NA

Example:

```
/* wait till pll is used as system clock source */
while(crm_sysclk_switch_status_get() != CRM_SCLK_PLL)
{
}
```

5.5.27 crm_clocks_freq_get function

The table below describes the function crm_clocks_freq_get.

Table 138. crm_clocks_freq_get function

Name	Description
Function name	crm_clocks_freq_get
Function prototype	void crm_clocks_freq_get(crm_clocks_freq_type *clocks_struct);
Function description	Get clock frequency
Input parameter 1	clocks_struct: crm_clocks_freq_type pointer, including clock frequency
Input parameter 2	NA
Output parameter	NA
Return value	crm_sclk_type: return the clock source for system clock
Required preconditions	NA
Called functions	NA

crm_clocks_freq_type

The crm_clocks_freq_type is defined in the at32f423_crm.h:

typedef struct

```
{
    uint32_t    sclk_freq;
    uint32_t    ahb_freq;
    uint32_t    apb2_freq;
    uint32_t    apb1_freq;
} crm_clocks_freq_type;
```

sclk_freq

Get the system clock frequency, in Hz

ahb_freq

Get the clock frequency of AHB, in Hz

apb2_freq

Get the clock frequency of APB2, in Hz

apb1_freq

Get the clock frequency of APB1, in Hz

Example:

```
/* get frequency */
crm_clocks_freq_type clocks_struct;
crm_clocks_freq_get(&clocks_struct);
```

5.5.28 crm_clock_out_set function

The table below describes the function crm_clock_out_set.

Table 139. crm_clock_out_set function

Name	Description
Function name	crm_clock_out_set
Function prototype	void crm_clock_out_set(crm_clkout_select_type clkout);
Function description	Select clock source output on clkout pin
Input parameter 1	clkout: clock source output on clkout pin
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

clkout

Select clock source output on the clkout1 pin.

CRM_CLKOUT_SCLK: SCLK output on clkout pin

CRM_CLKOUT_HEXT: HEXT output on clkout pin

CRM_CLKOUT_PLL: PLL output on clkout pin

CRM_CLKOUT_USB: USB output on clkout pin

CRM_CLKOUT_ADC: ADC output on clkout pin

CRM_CLKOUT_HICK: HICK output on clkout pin

CRM_CLKOUT_LICK: LICK output on clkout pin

CRM_CLKOUT_LEXT: LEXT output on clkout pin

Example:

```
/* config clkout output hick */
crm_clock_out_set(CRM_CLKOUT_HICK);
```

5.5.29 crm_clkout_div_set function

The table below describes the function crm_clkout_div_set.

Table 140. crm_clkout_div_set function

Name	Description
Function name	crm_clkout_div_set
Function prototype	void crm_clkout_div_set(crm_clkout_div1_type div1, crm_clkout_div2_type div2)
Function description	Clock frequency division on clockout pin
Input parameter 1	div1: divider 1 clock frequency division
Input parameter 2	div2: divider 2 clock frequency division
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

div1

Divider 1 clock frequency division

CRM_CLKOUT_DIV1_1: divided by 1

CRM_CLKOUT_DIV1_2: Divided by 2
 CRM_CLKOUT_DIV1_3: Divided by 3
 CRM_CLKOUT_DIV1_4: Divided by 4
 CRM_CLKOUT_DIV1_5: Divided by 5

div2

Divider 2 clock frequency division

CRM_CLKOUT_DIV2_1: divided by 1
 CRM_CLKOUT_DIV2_2: divided by 2
 CRM_CLKOUT_DIV2_4: divided by 4
 CRM_CLKOUT_DIV2_8: divided by 8
 CRM_CLKOUT_DIV2_16: divided by 16
 CRM_CLKOUT_DIV2_64: divided by 64
 CRM_CLKOUT_DIV2_128: divided by 128
 CRM_CLKOUT_DIV2_256: divided by 256
 CRM_CLKOUT_DIV2_512: divided by 512

Example:

```
/* config clkout div */
crm_clkout_div_set(CRM_CLKOUT_DIV1_1, CRM_CLKOUT_DIV2_8);
```

5.5.30 cmm_interrupt_enable function

The table below describes the function cmm_interrupt_enable.

Table 141. cmm_interrupt_enable function

Name	Description
Function name	cmm_interrupt_enable
Function prototype	void cmm_interrupt_enable(uint32_t cmm_int, confirm_state new_state);
Function description	Enable interrupts
Input parameter 1	cmm_int: indicates the selected interrupt
Input parameter 2	new_state: Enable (TRUE), disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

cmm_int

CRM_LICK_STABLE_INT: LICK stable interrupt
 CRM_LEXT_STABLE_INT: LEXT stable interrupt
 CRM_HICK_STABLE_INT: HICK stable interrupt
 CRM_HEXT_STABLE_INT: HEXT stable interrupt
 CRM_PLL_STABLE_INT: PLL stable interrupt
 CRM_CLOCK_FAILURE_INT: Clock failure interrupt

Example:

```
/* enable pll stable interrupt */
cmm_interrupt_enable(CRM_PLL_STABLE_INT);
```

5.5.31 crm_auto_step_mode_enable function

The table below describes the function crm_auto_step_mode_enable.

Table 142. crm_auto_step_mode_enable function

Name	Description
Function name	crm_auto_step_mode_enable
Function prototype	void crm_auto_step_mode_enable(confirm_state new_state);
Function description	Enable auto step-by-step mode
Input parameter 1	new_state: Enable (TRUE), disable (FALSE)
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable auto step mode */
crm_auto_step_mode_enable(TRUE);
```

5.5.32 crm_hick_sclk_frequency_select function

The table below describes the function crm_hick_sclk_frequency_select.

Table 143. crm_hick_sclk_frequency_select function

Name	Description
Function name	crm_hick_sclk_frequency_select
Function prototype	void crm_hick_sclk_frequency_select(crm_hick_sclk_frequency_type value);
Function description	Select 8M or 48M system clock frequency when HICK is used as system clock
Input parameter 1	value: 8M or 48M HICK
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

CRM_HICK_SCLK_8MHZ: 8MHz HICK used as system clock

CRM_HICK_SCLK_48MHZ: 48MHz HICK used as system clock

Example:

```
/* config sysclk with hick 48mhz */
crm_hick_sclk_frequency_select(CRM_HICK_SCLK_48MHZ);
```

5.5.33 crm_usb_clock_source_select function

The table below describes the function crm_usb_clock_source_select.

Table 144. crm_usb_clock_source_select function

Name	Description
Function name	crm_usb_clock_source_select
Function prototype	void crm_usb_clock_source_select(crm_usb_clock_source_type value);
Function description	Select PLL or internal high-speed clock (48M) as USB clock source
Input parameter 1	value: PLL or internal high-speed clock (48M)
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

CRM_USB_CLOCK_SOURCE_PLL: PLL is used as USB clock source

CRM_USB_CLOCK_SOURCE_HICK: HICK is used as USB clock source

Example:

```
/* select hick48 as usb clock */
crm_usb_clock_source_select(CRM_USB_CLOCK_SOURCE_HICK);
```

5.5.34 crm_usart_clock_select function

The table below describes the function crm_usart_clock_select.

Table 145. crm_usart_clock_select function

Name	Description
Function name	crm_usart_clock_select
Function prototype	void crm_usart_clock_select(crm_usart_index_type usart_index, crm_usart_clock_source_type value);
Function description	Select USART clock source
Input parameter 1	usart_index: indicates the index of USART
Input parameter 2	Value: clock source type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

usart_index

CRM_USART1: USART 1

CRM_USART2: USART 2

CRM_USART3: USART 3

value

CRM_USART_CLOCK_SOURCE_PCLK: PCLK bus clock is used as USART clock

CRM_USART_CLOCK_SOURCE_SCLK: SCLK is used as USART clock

CRM_USART_CLOCK_SOURCE_HICK: HICK is used as USART clock

CRM_USART_CLOCK_SOURCE_LEXT: LEXT is used as USART clock

Example:

```
/* select pclk as usart1 clock */
crm_usart_clock_select(CRM_USART1, CRM_USART_CLOCK_SOURCE_PCLK);
```

5.5.35 crm_usart_clock_get function

The table below describes the function crm_usart_clock_get.

Table 146. crm_usart_clock_get function

Name	Description
Function name	crm_usart_clock_get
Function prototype	crm_usart_clock_source_type crm_usart_clock_get(crm_usart_index_type usart_index);
Function description	Get USART clock source status
Input parameter 1	usart_index: indicates the index of USART
Input parameter 2	NA
Output parameter	NA
Return value	crm_usart_clock_source_type: USART clock source type
Required preconditions	NA
Called functions	NA

usart_index

CRM_USART1:	USART 1
CRM_USART2:	USART 2
CRM_USART3:	USART 3

Example:

```
/* get usart1 clock */
crm_usart_clock_source_type usart_clock;
usart_clock = crm_usart_clock_get(CRM_USART1);
```

5.5.36 crm_i2c_clock_select function

The table below describes the function crm_i2c_clock_select.

Table 147. crm_i2c_clock_select function

Name	Description
Function name	crm_i2c_clock_select
Function prototype	void crm_i2c_clock_select(crm_i2c_type i2c_index, crm_i2c_clock_source_type value);
Function description	Select I2C clock source
Input parameter 1	i2c_index: I2C peripheral index
Input parameter 2	Value: clock source type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

i2c_index

CRM_I2C1: I2C1

value

CRM_I2C_CLOCK_SOURCE_PCLK: PCLK bus clock is used as I2C clock

CRM_I2C_CLOCK_SOURCE_SCLK: SCLK is used as I2C clock

CRM_I2C_CLOCK_SOURCE_HICK: HICK is used as I2C clock

Example:

```
/* select pclk as i2c1 clock */
crm_i2c_clock_select(CRM_I2C1, CRM_I2C_CLOCK_SOURCE_PCLK);
```

5.5.37 crm_i2c_clock_get function

The table below describes the function crm_i2c_clock_get.

Table 148. crm_i2c_clock_get function

Name	Description
Function name	crm_i2c_clock_get
Function prototype	crm_i2c_clock_source_type crm_i2c_clock_get(crm_i2c_type i2c_index);
Function description	Get I2C clock source status
Input parameter 1	I2c_index: I2C peripheral index
Input parameter 2	NA
Output parameter	NA
Return value	crm_i2c_clock_source_type: I2C clock source type
Required preconditions	NA
Called functions	NA

i2c_index

CRM_I2C1: I2C1

Example:

```
/* get i2c1 clock */
crm_i2c_clock_source_type i2c_clock;
i2c_clock = crm_i2c_clock_get(CRM_I2C1);
```

5.5.38 crm_adc_clock_select function

The table below describes the function crm_adc_clock_select.

Table 149. crm_adc_clock_select function

Name	Description
Function name	crm_adc_clock_select
Function prototype	void crm_adc_clock_select(crm_adc_clock_source_type value);
Function description	Select ADC clock source
Input parameter 1	Value: clock source type
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

value

CRM_I2C_CLOCK_SOURCE_HCLK: HCLK bus clock is used as ADC clock

CRM_ADC_CLOCK_SOURCE_PLLCLK: PLL is used as ADC clock

Example:

```
/* select pllclk as adc clock */
crm_adc_clock_select(CRM_ADC_CLOCK_SOURCE_PLLCLK);
```

5.5.39 crm_pll_parameter_calculate function

The table below describes the function crm_pll_parameter_calculate.

Table 150. crm_pll_parameter_calculate function

Name	Description
Function name	crm_pll_parameter_calculate
Function prototype	error_status crm_pll_parameter_calculate(crm_pll_clock_source_type pll_rcs, uint32_t target_sclk_freq, uint16_t *ret_ms, uint16_t *ret_ns, uint16_t *ret_fr);
Function description	PLL parameter auto calculation
Input parameter 1	pll_rcs: pll input clock source
Input parameter 2	target_sclk_freq: target clock frequency multiplication, for example, for 200 MHz, this parameter can be target_sclk_freq=200000000.
Output parameter1	ret_ms: return pll_ms parameter
Output parameter2	ret_ns: return pll_ns parameter
Output parameter3	ret_fr: return pll_fr parameter
Return value	error_status: Calculation status. SUCCESS: the calculated result equals the target clock PLL parameter ERROR: the calculated result is close to the target clock PLL parameter
Required preconditions	NA
Called functions	NA

Example:

```
/* pll parameter calculate automatic */
uint16_t pll_ms = 0, pll_ns = 0, pll_fr = 0;
crm_pll_parameter_calculate(CRM_PLL_SOURCE_HEXT, 200000000, &pll_ms, &pll_ns, &pll_fr);
```

5.6 Digital-to-analog converter (DAC)

The DAC register structure `dac_type` is defined in the “`at32f423_dac.h`”:

```
/*
 * @brief type define dac register all
 */
typedef struct
{
    ...
} dac_type;
```

The table below gives a list of the DAC registers.

Table 151. Summary of DAC registers

Register	Description
ctrl	DAC control register
swtrg	DAC software trigger register
d1dth12r	DAC1 12-bit right-aligned data holding register
d1dth12l	DAC1 12-bit left-aligned data holding register
d1dth8r	DAC1 8-bit right-aligned data holding register
d2dth12r	DAC2 12-bit right-aligned data holding register
d2dth12l	DAC2 12-bit left-aligned data holding register
d2dth8r	DAC2 8-bit right-aligned data holding register
ddth12r	Dual DAC 12-bit right-aligned data holding register
ddth12l	Dual DAC 12-bit left-aligned data holding register
ddth8r	Dual DAC 8-bit right-aligned data holding register
d1odt	DAC1 data output register
d2odt	DAC2 data output register
sts	DAC status register

The table below gives a list of DAC library functions.

Table 152. Summary of DAC library functions

Function name	Description
dac_reset	Reset all DAC registers to their reset values
dac_enable	Enable DAC
dac_output_buffer_enable	Enable DAC output buffer
dac_trigger_enable	Enable DAC trigger
dac_trigger_select	Select DAC trigger source
dac_software_trigger_generate	Trigger DAC by software
dac_dual_software_trigger_generate	Simultaneous trigger DAC1 and DAC2 by software
dac_wave_generate	Select DAC output waveform
dac_mask_amplitude_select	Select DAC noise /triangle-wave amplitude
dac_dma_enable	DAC DMA enable
dac_data_output_get	Get DAC output value
dac_1_data_set	Set DAC1 output value

dac_2_data_set	Set DAC2 output value
dac_dual_data_set	Set DAC1 and DAC2 output values
dac_udr_enable	Enable overflow interrupt
dac_udr_flag_get	Get overflow interrupt flag
dac_udr_flag_clear	Clear overflow interrupt flag

5.6.1 **dac_reset** function

The table below describes the function `dac_reset`.

Table 153. `dac_reset` function

Name	Description
Function name	<code>dac_reset</code>
Function prototype	<code>void dac_reset(void);</code>
Function description	Reset all DAC registers to their reset values
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	<code>crm_periph_reset();</code>

Example:

```
dac_reset();
```

5.6.2 **dac_enable** function

The table below describes the function `dac_enable`.

Table 154. `dac_enable` function

Name	Description
Function name	<code>dac_enable</code>
Function prototype	<code>void dac_enable(dac_select_type dac_select, confirm_state new_state);</code>
Function description	Enable DAC
Input parameter 1	<code>dac_select</code> : Select a DAC This parameter can be <code>DAC1_SELECT</code> or <code>DAC2_SELECT</code> .
Input parameter 2	<code>new_state</code> : Enable or disable This parameter can be <code>FALSE</code> or <code>TRUE</code>
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
dac_enable(DAC1_SELECT, TRUE);
```

5.6.3 dac_output_buffer_enable function

The table below describes the function dac_output_buffer_enable.

Table 155. dac_output_buffer_enable function

Name	Description
Function name	dac_output_buffer_enable
Function prototype	void dac_output_buffer_enable(dac_select_type dac_select, confirm_state new_state);
Function description	Enable DAC output buffer
Input parameter 1	dac_select: Select a DAC This parameter can be DAC1_SELECT or DAC2_SELECT.
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

dac_output_buffer_enable (DAC1_SELECT, TRUE);

5.6.4 dac_trigger_enable function

The table below describes the function dac_trigger_enable.

Table 156. dac_trigger_enable function

Name	Description
Function name	dac_trigger_enable
Function prototype	void dac_trigger_enable(dac_select_type dac_select, confirm_state new_state);
Function description	Enable DAC trigger
Input parameter 1	dac_select: Select a DAC This parameter can be DAC1_SELECT or DAC2_SELECT.
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

dac_trigger_enable (DAC1_SELECT, TRUE);

5.6.5 dac_trigger_select function

The table below describes the function dac_trigger_select.

Table 157. dac_trigger_select function

Name	Description
Function name	dac_trigger_select
Function prototype	void dac_trigger_select(dac_select_type dac_select, dac_trigger_type dac_trigger_source);
Function description	Select DAC trigger source
Input parameter 1	dac_select: Select a DAC This parameter can be DAC1_SELECT or DAC2_SELECT.
Input parameter 2	<i>dac_trigger_source</i> : trigger source selected
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dac_trigger_source

Trigger source selection

DAC_TMR6_TRGOUT_EVENT:	TMR6 TRGOUT event triggers DAC
DAC_TMR8_TRGOUT_EVENT:	TMR8 TRGOUT event triggers DAC
DAC_TMR7_TRGOUT_EVENT:	TMR7 TRGOUT event triggers DAC
DAC_TMR5_TRGOUT_EVENT:	TMR5 TRGOUT event triggers DAC
DAC_TMR2_TRGOUT_EVENT:	TMR2 TRGOUT event triggers DAC
DAC_TMR4_TRGOUT_EVENT:	TMR4 TRGOUT event triggers DAC
DAC_EXTERNAL_INTERRUPT_LINE_9:	EXINT LINE 9 event triggers DAC
DAC_SOFTWARE_TRIGGER:	Software triggers DAC

Example:

```
dac_trigger_select(DAC1_SELECT, DAC_TMR2_TRGOUT_EVENT);
dac_trigger_select(DAC2_SELECT, DAC_TMR2_TRGOUT_EVENT);
```

5.6.6 dac_software_trigger_generate function

The table below describes the function dac_software_trigger_generate.

Table 158. dac_software_trigger_generate function

Name	Description
Function name	dac_software_trigger_generate
Function prototype	void dac_software_trigger_generate(dac_select_type dac_select);
Function description	Trigger DAC by software
Input parameter 1	dac_select: Select a DAC This parameter can be DAC1_SELECT or DAC2_SELECT.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
dac_software_trigger_generate (DAC1_SELECT);
```

5.6.7 dac_dual_software_trigger_generate function

The table below describes the function dac_dual_software_trigger_generate.

Table 159. dac_dual_software_trigger_generate function

Name	Description
Function name	dac_dual_software_trigger_generate
Function prototype	void dac_dual_software_trigger_generate(void);
Function description	Trigger DAC1 and DAC2 by software simultaneously
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
dac_dual_software_trigger_generate();
```

5.6.8 dac_wave_generate function

The table below describes the function dac_wave_generate.

Table 160. dac_wave_generate function

Name	Description
Function name	dac_wave_generate
Function prototype	void dac_wave_generate(dac_select_type dac_select, dac_wave_type dac_wave);
Function description	DAC wave generation enable
Input parameter 1	dac_select: Select a DAC This parameter can be DAC1_SELECT or DAC2_SELECT.
Input parameter 2	<i>dac_wave</i> : wave selected
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dac_wave

Wave generation enable

DAC_WAVE_GENERATE_NONE: Wave generation disabled (output fixed register value)

DAC_WAVE_GENERATE_NOISE: Noise wave generation

DAC_WAVE_GENERATE_TRIANGLE: Triangle wave generation

Example:

```
dac_wave_generate(DAC1_SELECT, DAC_WAVE_GENERATE_NONE);
dac_wave_generate(DAC2_SELECT, DAC_WAVE_GENERATE_NOISE);
```

5.6.9 dac_mask_amplitude_select function

The table below describes the function dac_mask_amplitude_select.

Table 161. dac_mask_amplitude_select function

Name	Description
Function name	dac_mask_amplitude_select
Function prototype	void dac_mask_amplitude_select(dac_select_type dac_select, dac_mask_amplitude_type dac_mask_amplitude);
Function description	DAC noise bit width/triangle amplitude selection
Input parameter 1	dac_select: Select a DAC This parameter can be DAC1_SELECT or DAC2_SELECT.
Input parameter 2	<i>dac_mask_amplitude</i> : noise bit width/triangle amplitude selection
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dac_mask_amplitude

Noise bit width/triangle amplitude selection

- DAC_LSFR_BIT0_AMPLITUDE_1: LSFR[0] in noise mode/triangle amplitude equal to 1
- DAC_LSFR_BIT10_AMPLITUDE_3: LSFR[1:0] in noise mode/triangle amplitude equal to 3
- DAC_LSFR_BIT20_AMPLITUDE_7: LSFR[2:0] in noise mode/triangle amplitude equal to 7
- DAC_LSFR_BIT30_AMPLITUDE_15: LSFR[3:0] in noise mode/triangle amplitude equal to 15
- DAC_LSFR_BIT40_AMPLITUDE_31: LSFR[4:0] in noise mode/triangle amplitude equal to 31
- DAC_LSFR_BIT50_AMPLITUDE_63: LSFR[5:0] in noise mode/triangle amplitude equal to 63
- DAC_LSFR_BIT60_AMPLITUDE_127: LSFR[6:0] in noise mode/triangle amplitude equal to 127
- DAC_LSFR_BIT70_AMPLITUDE_255: LSFR[7:0] in noise mode/triangle amplitude equal to 255
- DAC_LSFR_BIT80_AMPLITUDE_511: LSFR[8:0] in noise mode/triangle amplitude equal to 511
- DAC_LSFR_BIT90_AMPLITUDE_1023: LSFR[9:0] in noise mode/triangle amplitude equal to 1023
- DAC_LSFR_BITA0_AMPLITUDE_2047: LSFR[10:0] in noise mode/triangle amplitude equal to 2047
- DAC_LSFR_BITB0_AMPLITUDE_4095: LSFR[11:0] in noise mode/triangle amplitude equal to 4095

Example:

```
dac_mask_amplitude_select (DAC1_SELECT, DAC_LSFR_BIT60_AMPLITUDE_127);
dac_mask_amplitude_select (DAC2_SELECT, DAC_LSFR_BIT80_AMPLITUDE_511);
```

5.6.10 dac_dma_enable function

The table below describes the function dac_dma_enable.

Table 162. dac_dma_enable function

Name	Description
Function name	dac_dma_enable
Function prototype	void dac_dma_enable(dac_select_type dac_select, confirm_state new_state);
Function description	DAC DMA enable
Input parameter 1	dac_select: Select a DAC This parameter can be DAC1_SELECT or DAC2_SELECT.
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
dac_dma_enable (DAC1_SELECT, TRUE);
```

5.6.11 dac_data_output_get function

The table below describes the function dac_data_output_get.

Table 163. dac_data_output_get function

Name	Description
Function name	dac_data_output_get
Function prototype	uint16_t dac_data_output_get(dac_select_type dac_select);
Function description	Get DAC output value
Input parameter 1	dac_select: Select a DAC This parameter can be DAC1_SELECT or DAC2_SELECT.
Output parameter	NA
Return value	dacx_data: dac1/dac2 output value
Required preconditions	NA
Called functions	NA

Example:

```
uint16_t dac1_data;  
dac1_data = dac_data_output_get (DAC1_SELECT);
```

5.6.12 dac_1_data_set function

The table below describes the function dac_1_data_set.

Table 164. dac_1_data_set function

Name	Description
Function name	dac_1_data_set
Function prototype	void dac_1_data_set(dac1_aligned_data_type dac1_aligned, uint16_t dac1_data);
Function description	Set DAC1 output data
Input parameter 1	<i>dac1_aligned</i> : data format selection
Input parameter 2	<i>dac1_data</i> : DAC output value
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dac1_aligned

Data format selector

- DAC1_12BIT_RIGHT: 12-bit right-aligned
- DAC1_12BIT_LEFT: 12-bit left-aligned
- DAC1_8BIT_RIGHT: 8-bit right-aligned

dac1_data

DAC output range settings. Value range varies from one format to another.

- DAC1_12BIT_RIGHT: 0x000~0xFFFF
- DAC1_12BIT_LEFT: 0x0000~0xFFFF0
- DAC1_8BIT_RIGHT: 0x00~0xFF

Example:

```
dac_1_data_set (DAC1_12BIT_RIGHT, 0x666);
```

5.6.13 dac_2_data_set function

The table below describes the function dac_2_data_set.

Table 165. dac_2_data_set function

Name	Description
Function name	dac_2_data_set
Function prototype	void dac_2_data_set(dac2_aligned_data_type dac2_aligned, uint16_t dac2_data);
Function description	Set DAC2 output data
Input parameter 1	<i>dac2_aligned</i> : data format selection
Input parameter 2	<i>dac2_data</i> : DAC output value
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dac2_aligned

Data format selector

- DAC2_12BIT_RIGHT: 12-bit right-aligned
- DAC2_12BIT_LEFT: 12-bit left-aligned
- DAC2_8BIT_RIGHT: 8-bit right-aligned

dac2_data

DAC output range settings. Value range varies from one format to another.

DAC2_12BIT_RIGHT: 0x000~0xFFFF

DAC2_12BIT_LEFT: 0x0000~0xFFFF0

DAC2_8BIT_RIGHT: 0x00~0xFF

Example:

```
dac_2_data_set (DAC2_12BIT_RIGHT, 0x666);
```

5.6.14 dac_dual_data_set function

The table below describes the function dac_dual_data_set.

Table 166. dac_dual_data_set function

Name	Description
Function name	dac_dual_data_set
Function prototype	void dac_dual_data_set(dac_dual_data_type dac_dual, uint16_t data1, uint16_t data2);
Function description	Set DAC1/DAC2 output data
Input parameter 1	<i>dac_dual</i> : data format selection
Input parameter 2	<i>data1</i> : DAC1 output value
Input parameter3	<i>data2</i> : DAC2 output value
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dac_dual

Data format selector

DAC_DUAL_12BIT_RIGHT: 12-bit right-aligned

DAC_DUAL_12BIT_LEFT: 12-bit left-aligned

DAC_DUAL_8BIT_RIGHT: 8-bit right-aligned

data1/data2

DAC output range settings. Value range varies from one format to another.

DAC_DUAL_12BIT_RIGHT: 0x000~0xFFFF

DAC_DUAL_12BIT_LEFT: 0x0000~0xFFFF0

DAC_DUAL_8BIT_RIGHT: 0x00~0xFF

Example:

```
dac_dual_data_set (DAC_DUAL_12BIT_RIGHT, 0x666, 0x777);
```

5.6.15 dac_udr_enable function

The table below describes the function dac_udr_enable.

Table 167. dac_udr_enable function

Name	Description
Function name	dac_udr_enable
Function prototype	void dac_udr_enable(dac_select_type dac_select, confirm_state new_state);
Function description	Set DAC1/DAC2 output data
Input parameter 1	dac_select: Select DAC1/2
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
dac_udr_enable (DAC1_SELECT, TRUE);
```

5.6.16 dac_udr_flag_get function

The table below describes the function dac_udr_flag_get.

Table 168. dac_udr_flag_get function

Name	Description
Function name	dac_udr_flag_get
Function prototype	flag_status dac_udr_flag_get(dac_select_type dac_select);
Function description	Enable DAC1/DAC2 DMA underflow interrupt
Input parameter 1	dac_select: Select DAC1/2
Output parameter	NA
Return value	Status flag
Required preconditions	NA
Called functions	NA

Example:

```
dac_udr_flag_get (DAC1_SELECT);
```

5.6.17 dac_udr_interrupt_flag_get function

The table below describes the function dac_udr_interrupt_flag_get.

Table 169. dac_udr_interrupt_flag_get function

Name	Description
Function name	dac_udr_interrupt_flag_get
Function prototype	flag_status dac_udr_interrupt_flag_get (dac_select_type dac_select);
Function description	Get DAC1 and DAC2 overflow interrupt flag status
Input parameter 1	dac_select: Select DAC1/2
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
dac_udr_interrupt_flag_get (DAC1_SELECT);
```

5.6.18 dac_udr_flag_clear function

The table below describes the function dac_udr_flag_clear.

Table 170. dac_udr_flag_clear function

Name	Description
Function name	dac_udr_flag_clear
Function prototype	void dac_udr_flag_clear(dac_select_type dac_select);
Function description	Get DAC1/DAC2 overflow flag
Input parameter 1	dac_select: Select DAC1/2
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
dac_udr_flag_clear (DAC1_SELECT);
```

5.7 Debug

The DEBUG register structure debug_type is defined in the “at32f423_debug.h”:

```
/*
 * @brief type define debug register all
 */
typedef struct
{
    ...
} debug_type;
```

The table below gives a list of the DEBUG registers.

Table 171. Summary of DEBUG registers

Register	Description
idcode	Device ID
ctrl	Control register
apb1_pause	APB1 pause control register
apb2_pause	APB2 pause control register

The table below gives a list of DEBUG library functions.

Table 172. Summary of DEBUG library functions

Function name	Description
debug_device_id_get	Read device idcode
debug_low_power_mode_set	Low-power debug mode configuration
debug_apb1_periph_mode_set	apb1 debug mode configuration
debug_apb2_periph_mode_set	apb2 debug mode configuration

5.7.1 **debug_device_id_get** function

The table below describes the function debug_device_id_get.

Table 173. debug_device_id_get function

Name	Description
Function name	debug_device_id_get
Function prototype	uint32_t debug_device_id_get(void);
Function description	Read device idcode
Input parameter 1	NA
Input parameter 2	NA
Output parameter	NA
Return value	Return 32-bit idcode
Required preconditions	NA
Called functions	NA

Example:

```
/* get idcode */
uint32_t idcode = 0;
idcode = debug_device_id_get();
```

5.7.2 debug_low_power_mode_set function

The table below describes the function debug_low_power_mode_set.

Table 174. debug_low_power_mode_set function

Name	Description
Function name	debug_low_power_mode_set
Function prototype	void debug_low_power_mode_set(uint32_t low_power_mode, confirm_state new_state)
Function description	Debug in low-power mode
Input parameter 1	periph_debug_mode: Selected peripheral or mode
Input parameter 2	new_state: enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

low_power_mode

Select a low-power mode to debug

DEBUG_SLEEP:	DEBUG in SLEEP mode
DEBUG_DEEPSLEEP:	DEBUG in DEEPSLEEP mode
DEBUG_STANDBY:	DEBUG in STANDBY mode

Example:

```
/* enable sleep debug mode */
debug_low_power_mode_set (DEBUG_SLEEP, TRUE);
```

5.7.3 debug_apb1_periph_mode_set function

The table below describes the function debug_apb1_periph_mode_set.

Table 175. debug_apb1_periph_mode_set function

Name	Description
Function name	debug_apb1_periph_mode_set
Function prototype	void debug_apb1_periph_mode_set(uint32_t apb1_periph, confirm_state new_state)
Function description	Select a peripheral to debug
Input parameter 1	apb1_periph: Select a peripheral
Input parameter 2	new_state: enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

apb1_periph

Select a peripheral or mode to debug

DEBUG_WDT_PAUSE:	Watchdog pause control bit
DEBUG_WWDT_PAUSE:	Window watchdog pause control bit
DEBUG_TMR2_PAUSE:	TMR2 pause control bit
DEBUG_TMR3_PAUSE:	TMR3 pause control bit
DEBUG_TMR4_PAUSE:	TMR4 pause control bit

DEBUG_TMR6_PAUSE:	TMR6 pause control bit
DEBUG_TMR7_PAUSE:	TMR7 pause control bit
DEBUG_TMR12_PAUSE:	TMR12 pause control bit
DEBUG_TMR13_PAUSE:	TMR13 pause control bit
DEBUG_TMR14_PAUSE:	TMR14 pause control bit
DEBUG_I2C1_SMBUS_TIMEOUT:	I2C1 SMBUS TIMEOUT pause control bit
DEBUG_I2C2_SMBUS_TIMEOUT:	I2C2 SMBUS TIMEOUT pause control bit
DEBUG_I2C3_SMBUS_TIMEOUT:	I2C3 SMBUS TIMEOUT pause control bit
DEBUG_CAN1_PAUSE:	CAN1 receive register pause control bit
DEBUG_CAN2_PAUSE:	CAN2 receive register pause control bit
DEBUG_ERTC_PAUSE:	ERTC pause control bit
DEBUG_ERTC_512_PAUSE:	ERTC 512Hz pulse output pause control bit

Example:

```
/* enable tmr2 debug mode */
debug_apb1_periph_mode_set(DEBUG_TMR2_PAUSE, TRUE);
```

5.7.4 debug_apb2_periph_mode_set function

The table below describes the function debug_apb2_periph_mode_set.

Table 176. debug_apb2_periph_mode_set function

Name	Description
Function name	debug_apb2_periph_mode_set
Function prototype	void debug_apb2_periph_mode_set(uint32_t apb2_periph, confirm_state new_state)
Function description	Select a peripheral to debug
Input parameter 1	apb2_periph: Selected peripheral or mode
Input parameter 2	new_state: enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

apb2_periph

Select a peripheral or mode to debug

DEBUG_TMR9_PAUSE:	TMR9 pause control bit
DEBUG_TMR10_PAUSE:	TMR10 pause control bit
DEBUG_TMR11_PAUSE:	TMR11 pause control bit
DEBUG_TMR1_PAUSE:	TMR9 pause control bit

Example:

```
/* enable tmr1 debug mode */
debug_apb2_periph_mode_set(DEBUG_TMR1_PAUSE, TRUE);
```

5.8 DMA controller

The DMA register structure `dma_type` is defined in the “`at32f423_dma.h`”:

```
/*
 * @brief type define dma register
 */
typedef struct
{
    ...
} dma_type;
```

DMA channel register structure `dma_channel_type` is defined in the “`at32f423_dma.h`”:

```
/*
 * @brief type define dma channel register all
 */
typedef struct
{
    ...
} dma_channel_type;
```

The table below gives a list of the DMA registers.

Table 177. Summary of DMA registers

Register	Description
<code>dma_sts</code>	DMA status register
<code>dma_clr</code>	DMA status clear register
<code>dma_c1ctrl</code>	DMA channel 1 configuration register
<code>dma_c1dtcnt</code>	DMA channel 1 number of data register
<code>dma_c1paddr</code>	DMA channel 1 peripheral address register
<code>dma_c1maddr</code>	DMA channel 1 memory address register
<code>dma_c2ctrl</code>	DMA channel 2 configuration register
<code>dma_c2dtcnt</code>	DMA channel 2 number of data register
<code>dma_c2paddr</code>	DMA channel 2 peripheral address register
<code>dma_c2maddr</code>	DMA channel 2 memory address register
<code>dma_c3ctrl</code>	DMA channel 3 configuration register
<code>dma_c3dtcnt</code>	DMA channel 3 number of data register
<code>dma_c3paddr</code>	DMA channel 3 peripheral address register
<code>dma_c3maddr</code>	DMA channel 3 memory address register
<code>dma_c4ctrl</code>	DMA channel 4 configuration register
<code>dma_c4dtcnt</code>	DMA channel 4 number of data register
<code>dma_c4paddr</code>	DMA channel 4 peripheral address register
<code>dma_c4maddr</code>	DMA channel 4 memory address register
<code>dma_c5ctrl</code>	DMA channel 5 configuration register
<code>dma_c5dtcnt</code>	DMA channel 5 number of data register

Register	Description
dma_c5paddr	DMA channel 5 peripheral address register
dma_c5maddr	DMA channel 5 memory address register
dma_c6ctrl	DMA channel 6 configuration register
dma_c6dtcnt	DMA channel 6 number of data register
dma_c6paddr	DMA channel 6 peripheral address register
dma_c6maddr	DMA channel 6 memory address register
dma_c7ctrl	DMA channel 7 configuration register
dma_c7dtcnt	DMA channel 7 number of data register
dma_c7paddr	DMA channel 7 peripheral address register
dma_c7maddr	DMA channel 7 memory address register
dma_muxsel	DMAMUX enable register
dma_muxc1ctrl	DMAMUX channel 1 control register
dma_muxc2ctrl	DMAMUX channel 2 control register
dma_muxc3ctrl	DMAMUX channel 3 control register
dma_muxc4ctrl	DMAMUX channel 4 control register
dma_muxc5ctrl	DMAMUX channel 5 control register
dma_muxc6ctrl	DMAMUX channel 6 control register
dma_muxc7ctrl	DMAMUX channel 7 control register
dma_muxg1ctrl	DMAMUX request generator 1 control register
dma_muxg2ctrl	DMAMUX request generator 2 control register
dma_muxg3ctrl	DMAMUX request generator 3 control register
dma_muxg4ctrl	DMAMUX request generator 4 control register
dma_muxsyncsts	DMAMUX synchronous status register
dma_muxsyncclr	DMAMUX synchronous status clear register
dma_muxgsts	DMAMUX request generator status register
dma_muxgclr	DMAMUX request generator status clear register

Table 169 gives a list of DMA library functions.

Table 178. Summary of DMA library functions

Function name	Description
dma_default_para_init	Initialize the parameters of the <code>dma_init_struct</code>
dma_init	Initialize the selected DMA channel
dma_reset	Reset the selected DMA channel
dma_data_number_set	Set the number of data transfer of a given channel
dma_data_number_get	Get the number of data transfer of a given channel
dma_interrupt_enable	Enable DMA channel interrupt
dma_channel_enable	Enable DMA channel
dma_flexible_config	Configure flexible DMA request mapping
dma_flag_get	Get the flag of DMA channels
dma_flag_clear	Clear the flag of DMA channels
dmamux_enable	Enable DMAMUX
dmamux_init	Initialize DMAMUX
dmamux_sync_default_para_init	Initialize DMAMUX synchronous module

dmamux_sync_config	Configure DMAMUX synchronous module
dmamux_generator_default_para_init	Initialize DMAMUX request generator
dmamux_generator_config	Configure DMAMUX request generator
dmamux_sync_interrupt_enable	Enable DMAMUX synchronous module interrupt
dmamux_generator_interrupt_enable	Enable DMAMUX request generator interrupt
dmamux_sync_flag_get	Get the flag of DMAMUX synchronous module
dmamux_sync_flag_clear	Clear the flag of DMAMUX synchronous module
dmamux_generator_flag_get	Get the flag of DMAMUX request generator
dmamux_generator_flag_clear	Clear the flag of DMAMUX request generator

5.8.1 dma_default_para_init function

The table below describes the function `dma_default_para_init`.

Table 179. `dma_default_para_init` function

Name	Description
Function name	<code>dma_default_para_init</code>
Function prototype	<code>void dma_default_para_init(dma_init_type* dma_init_struct);</code>
Function description	Initialize the parameters of the <code>dma_init_struct</code>
Input parameter 1	<code>dma_init_struct</code> : <code>dma_init_type</code> pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

The table below describes the default values of the `dma_init_struct` members.

Table 180. `dma_init_struct` default values

Member	Default values
<code>peripheral_base_addr</code>	0x0
<code>memory_base_addr</code>	0x0
<code>direction</code>	<code>DMA_DIR_PERIPHERAL_TO_MEMORY</code>
<code>buffer_size</code>	0x0
<code>peripheral_inc_enable</code>	FALSE
<code>memory_inc_enable</code>	FALSE
<code>peripheral_data_width</code>	<code>DMA_PERIPHERAL_DATA_WIDTH_BYTE</code>
<code>memory_data_width</code>	<code>DMA_MEMORY_DATA_WIDTH_BYTE</code>
<code>loop_mode_enable</code>	FALSE
<code>priority</code>	<code>DMA_PRIORITY_LOW</code>

Example:

```
/* dma init config with its default value */
dma_init_type dma_init_struct = {0};
dma_default_para_init(&dma_init_struct);
```

5.8.2 dma_init function

The table below describes the function `dma_init`.

Table 181. `dma_init` function

Name	Description
Function name	<code>dma_init</code>
Function prototype	<code>void dma_init(dma_channel_type* dmax_channely, dma_init_type* dma_init_struct)</code>
Function description	Initialize the selected DMA channel
Input parameter 1	<code>dmax_channely</code> : DMAx_CHANNELy defines a DMA channel number, x=1 or 2, y=1...7
Input parameter 2	<code>dma_init_struct</code> : <code>dma_init_type</code> pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dma_init_type structure

The `dma_init_type` is defined in the `at32f423_dma.h`:

`typedef struct`

```
{
    uint32_t          peripheral_base_addr;
    uint32_t          memory_base_addr;
    dma_dir_type      direction;
    uint16_t          buffer_size;
    confirm_state     peripheral_inc_enable;
    confirm_state     memory_inc_enable;
    dma_peripheral_data_size_type peripheral_data_width;
    dma_memory_data_size_type   memory_data_width;
    confirm_state     loop_mode_enable;
    dma_priority_level_type priority;
}
```

`} dma_init_type;`

peripheral_base_addr

Set the peripheral address of a DMA channel

memory_base_addr

Set the memory address of a DMA channel

direction

Set the transfer direction of a DMA channel

`DMA_DIR_PERIPHERAL_TO_MEMORY`: Peripheral to memory

`DMA_DIR_MEMORY_TO_PERIPHERAL`: Memory to peripheral

`DMA_DIR_MEMORY_TO_MEMORY`: Memory to memory

buffer_size

Set the number of data transfer of a DMA channel

peripheral_inc_enable

Enable/disable DMA channel peripheral address auto increment

`FALSE`: Peripheral address is not incremented

`TRUE`: Peripheral address is incremented

memory_inc_enable

Enable/disable DMA channel memory address auto increment

FALSE: Memory address is not incremented

TRUE: Memory address is incremented

peripheral_data_width

Set DMA peripheral data width

DMA_PERIPHERAL_DATA_WIDTH_BYTE: Byte

DMA_PERIPHERAL_DATA_WIDTH_HALFWORD: Half-word

DMA_PERIPHERAL_DATA_WIDTH_WORD: Word

memory_data_width

Set DMA memory data width

DMA_MEMORY_DATA_WIDTH_BYTE: Byte

DMA_MEMORY_DATA_WIDTH_HALFWORD: Half-word

DMA_MEMORY_DATA_WIDTH_WORD: Word

loop_mode_enable

Set DMA loop mode

FALSE: DMA single mode

TRUE: DMA loop mode

priority

Set DMA channel priority

DMA_PRIORITY_LOW: Low

DMA_PRIORITY_MEDIUM: Medium

DMA_PRIORITY_HIGH: High

DMA_PRIORITY VERY HIGH: Very high

Example:

```
dma_init_type dma_init_struct = {0};  
/* dma2 channel1 configuration */  
dma_init_struct.buffer_size = BUFFER_SIZE;  
dma_init_struct.direction = DMA_DIR_MEMORY_TO_PERIPHERAL;  
dma_init_struct.memory_base_addr = (uint32_t)src_buffer;  
dma_init_struct.memory_data_width = DMA_MEMORY_DATA_WIDTH_HALFWORD;  
dma_init_struct.memory_inc_enable = TRUE;  
dma_init_struct.peripheral_base_addr = (uint32_t)0x4001100C;  
dma_init_struct.peripheral_data_width = DMA_PERIPHERAL_DATA_WIDTH_HALFWORD;  
dma_init_struct.peripheral_inc_enable = FALSE;  
dma_init_struct.priority = DMA_PRIORITY_MEDIUM;  
dma_init_struct.loop_mode_enable = FALSE;  
dma_init(DMA2_CHANNEL1, &dma_init_struct);
```

5.8.3 dma_reset function

The table below describes the function dma_reset.

Table 182. dma_reset function

Name	Description
Function name	dma_reset
Function prototype	void dma_reset(dma_channel_type* dmax_channel);
Function description	Reset the selected DMA channel
Input parameter 1	dmax_channel: DMAx_CHANNELy defines a DMA channel number, x=1 or 2, y=1...7
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* reset dma2 channel1 */
dma_reset(DMA2_CHANNEL1);
```

5.8.4 dma_data_number_set function

The table below describes the function dma_data_number_set.

Table 183. dma_data_number_set function

Name	Description
Function name	dma_data_number_set
Function prototype	void dma_data_number_set(dma_channel_type* dmax_channel, uint16_t data_number);
Function description	Set the number of data transfer of the selected DMA channel
Input parameter 1	dmax_channel: DMAx_CHANNELy defines a DMA channel number, x=1 or 2, y=1...7
Input parameter 2	data_number: indicates the number of data transfer, up to 65535
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* set dma2 channel1 data count is 0x100*/
dma_data_number_set(DMA2_CHANNEL1, 0x100);
```

5.8.5 dma_data_number_get function

The table below describes the function dma_data_number_get.

Table 184. dma_data_number_get function

Name	Description
Function name	dma_data_number_get
Function prototype	uint16_t dma_data_number_get(dma_channel_type* dmax_channely);
Function description	Get the number of data transfer of the selected DMA channel
Input parameter 1	dmax_channely: DMAx_CHANNELy defines a DMA channel number, x=1 or 2, y=1...7
Output parameter	NA
Return value	Get the number of data transfer of a DMA channel
Required preconditions	NA
Called functions	NA

Example:

```
/* get dma2 channel1 data count*/
uint16_t data_counter;
data_counter = dma_data_number_set(DMA2_CHANNEL1);
```

5.8.6 dma_interrupt_enable function

The table below describes the function dma_interrupt_enable.

Table 185. dma_interrupt_enable function

Name	Description
Function name	dma_interrupt_enable
Function prototype	void dma_interrupt_enable(dma_channel_type* dmax_channely, uint32_t dma_int, confirm_state new_state);
Function description	Enable DMA channels interrupt
Input parameter 1	dmax_channely: DMAx_CHANNELy defines a DMA channel number, x=1 or 2, y=1...7
Input parameter 2	dma_int: interrupt source selection
Input parameter3	new_state: interrupt enable/disable
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dma_int

Select DMA interrupt source

DMA_FDT_INT: Transfer complete interrupt

DMA_HDT_INT: Half transfer complete interrupt

DMA_DTERR_INT: Transfer error interrupt

new_state

Enable or disable DMA channel interrupt

FALSE: Disabled

TRUE: Enabled

Example:

```
/* enable dma2 channel1 transfer full data intterrupt */
dma_interrupt_enable(DMA2_CHANNEL1, DMA_FDT_INT, TRUE);
```

5.8.7 dma_channel_enable function

The table below describes the function `dma_channel_enable`.

Table 186. `dma_channel_enable` function

Name	Description
Function name	<code>dma_channel_enable</code>
Function prototype	<code>void dma_channel_enable(dma_channel_type* dmax_channely, confirm_state new_state);</code>
Function description	Enable the selected DMA channel
Input parameter 1	dmax_channely: DMAx_CHANNELy defines a DMA channel number, x=1 or 2, y=1...7
Input parameter 2	new_state: Enable or disable the selected DMA channel
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

new_state

Enable or disable DMA channels

FALSE: Disabled

TRUE: Enabled

Example:

```
/* enable dma channel */
dma_channel_enable(DMA2_CHANNEL1, TRUE);
```

5.8.8 dma_flag_get function

The table below describes the function `dma_flag_get`.

Table 187. `dma_flag_get` function

Name	Description
Function name	<code>dma_flag_get</code>
Function prototype	<code>flag_status dma_flag_get(uint32_t dmax_flag);</code>
Function description	Get the flag of the selected DMA channel
Input parameter 1	dmax_flag: select the desired flag
Output parameter	NA
Return value	flag_status: indicates whether the desired flag is set or not
Required preconditions	NA
Called functions	NA

dmax_flag

The `dmax_flag` is used for flag section, including:

DMA1_GL1_FLAG: DMA1 channel 1 global flag

DMA1_FDT1_FLAG: DMA1 channel 1 transfer complete flag

DMA1_HDT1_FLAG:	DMA1 channel 1 half transfer complete flag
DMA1_DTERR1_FLAG:	DMA1 channel 1 transfer error flag
DMA1_GL2_FLAG:	DMA1 channel 2 global flag
DMA1_FDT2_FLAG:	DMA1 channel 2 transfer complete flag
DMA1_HDT2_FLAG:	DMA1 channel 2 half transfer complete flag
DMA1_DTERR2_FLAG:	DMA1 channel 2 transfer error flag
DMA1_GL3_FLAG:	DMA1 channel 3 global flag
DMA1_FDT3_FLAG:	DMA1 channel 3 transfer complete flag
DMA1_HDT3_FLAG:	DMA1 channel 3 half transfer complete flag
DMA1_DTERR3_FLAG:	DMA1 channel 3 transfer error flag
DMA1_GL4_FLAG:	DMA1 channel 4 global flag
DMA1_FDT4_FLAG:	DMA1 channel 4 transfer complete flag
DMA1_HDT4_FLAG:	DMA1 channel 4 half transfer complete flag
DMA1_DTERR4_FLAG:	DMA1 channel 4 transfer error flag
DMA1_GL5_FLAG:	DMA1 channel 5 global flag
DMA1_FDT5_FLAG:	DMA1 channel 5 transfer complete flag
DMA1_HDT5_FLAG:	DMA1 channel 5 half transfer complete flag
DMA1_DTERR5_FLAG:	DMA1 channel 5 transfer error flag
DMA1_GL6_FLAG:	DMA1 channel 6 global flag
DMA1_FDT6_FLAG:	DMA1 channel 6 transfer complete flag
DMA1_HDT6_FLAG:	DMA1 channel 6 half transfer complete flag
DMA1_DTERR6_FLAG:	DMA1 channel 6 transfer error flag
DMA1_GL7_FLAG:	DMA1 channel 7 global flag
DMA1_FDT7_FLAG:	DMA1 channel 7 transfer complete flag
DMA1_HDT7_FLAG:	DMA1 channel 7 half transfer complete flag
DMA1_DTERR7_FLAG:	DMA1 channel 7 transfer error flag
DMA2_GL1_FLAG:	DMA2 channel 1 global flag
DMA2_FDT1_FLAG:	DMA2 channel 1 transfer complete flag
DMA2_HDT1_FLAG:	DMA2 channel 1 half transfer complete flag
DMA2_DTERR1_FLAG:	DMA2 channel 1 transfer error flag
DMA2_GL2_FLAG:	DMA2 channel 2 global flag
DMA2_FDT2_FLAG:	DMA2 channel 2 transfer complete flag
DMA2_HDT2_FLAG:	DMA2 channel 2 half transfer complete flag
DMA2_DTERR2_FLAG:	DMA2 channel 2 transfer error flag
DMA2_GL3_FLAG:	DMA2 channel 3 global flag
DMA2_FDT3_FLAG:	DMA2 channel 3 transfer complete flag
DMA2_HDT3_FLAG:	DMA2 channel 3 half transfer complete flag
DMA2_DTERR3_FLAG:	DMA2 channel 3 transfer error flag
DMA2_GL4_FLAG:	DMA2 channel 4 global flag
DMA2_FDT4_FLAG:	DMA2 channel 4 transfer complete flag
DMA2_HDT4_FLAG:	DMA2 channel 4 half transfer complete flag
DMA2_DTERR4_FLAG:	DMA2 channel 4 transfer error flag
DMA2_GL5_FLAG:	DMA2 channel 5 global flag
DMA2_FDT5_FLAG:	DMA2 channel 5 transfer complete flag
DMA2_HDT5_FLAG:	DMA2 channel 5 half transfer complete flag
DMA2_DTERR5_FLAG:	DMA2 channel 5 transfer error flag

DMA2_GL6_FLAG:	DMA2 channel 6 global flag
DMA2_FDT6_FLAG:	DMA2 channel 6 transfer complete flag
DMA2_HDT6_FLAG:	DMA2 channel 6 half transfer complete flag
DMA2_DTERR6_FLAG:	DMA2 channel 6 transfer error flag
DMA2_GL7_FLAG:	DMA2 channel 7 global flag
DMA2_FDT7_FLAG:	DMA2 channel 7 transfer complete flag
DMA2_HDT7_FLAG:	DMA2 channel 7 half transfer complete flag
DMA2_DTERR7_FLAG:	DMA2 channel 7 transfer error flag

flag_status

RESET: Flag is reset

SET: Flag is set

Example:

```
if(dma_flag_get(DMA2_FDT1_FLAG) != RESET)
{
    /* turn led2/led3/led4 on */
    at32_led_on(LED2);
    at32_led_on(LED3);
    at32_led_on(LED4);
}
```

5.8.9 dma_flag_clear function

The table below describes the function `dma_flag_clear`.

Table 188. `dma_flag_clear` function

Name	Description
Function name	<code>dma_flag_clear</code>
Function prototype	<code>void dma_flag_clear(uint32_t dmax_flag);</code>
Function description	Clear the selected flag
Input parameter 1	<code>dmax_flag</code> : a flag that needs to be cleared
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dmax_flag

`dmax_flag` is used to select the desired flag, including:

DMA1_GL1_FLAG:	DMA1 channel 1 global flag
DMA1_FDT1_FLAG:	DMA1 channel 1 transfer complete flag
DMA1_HDT1_FLAG:	DMA1 channel 1 half transfer complete flag
DMA1_DTERR1_FLAG:	DMA1 channel 1 transfer error flag
DMA1_GL2_FLAG:	DMA1 channel 2 global flag
DMA1_FDT2_FLAG:	DMA1 channel 2 transfer complete flag
DMA1_HDT2_FLAG:	DMA1 channel 2 half transfer complete flag
DMA1_DTERR2_FLAG:	DMA1 channel 2 transfer error flag
DMA1_GL3_FLAG:	DMA1 channel 3 global flag
DMA1_FDT3_FLAG:	DMA1 channel 3 transfer complete flag

DMA1_HDT3_FLAG:	DMA1 channel 3 half transfer complete flag
DMA1_DTERR3_FLAG:	DMA1 channel 3 transfer error flag
DMA1_GL4_FLAG:	DMA1 channel 4 global flag
DMA1_FDT4_FLAG:	DMA1 channel 4 transfer complete flag
DMA1_HDT4_FLAG:	DMA1 channel 4 half transfer complete flag
DMA1_DTERR4_FLAG:	DMA1 channel 4 transfer error flag
DMA1_GL5_FLAG:	DMA1 channel 5 global flag
DMA1_FDT5_FLAG:	DMA1 channel 5 transfer complete flag
DMA1_HDT5_FLAG:	DMA1 channel 5 half transfer complete flag
DMA1_DTERR5_FLAG:	DMA1 channel 5 transfer error flag
DMA1_GL6_FLAG:	DMA1 channel 6 global flag
DMA1_FDT6_FLAG:	DMA1 channel 6 transfer complete flag
DMA1_HDT6_FLAG:	DMA1 channel 6 half transfer complete flag
DMA1_DTERR6_FLAG:	DMA1 channel 6 transfer error flag
DMA1_GL7_FLAG:	DMA1 channel 7 global flag
DMA1_FDT7_FLAG:	DMA1 channel 7 transfer complete flag
DMA1_HDT7_FLAG:	DMA1 channel 7 half transfer complete flag
DMA1_DTERR7_FLAG:	DMA1 channel 7 transfer error flag
DMA2_GL1_FLAG:	DMA2 channel 1 global flag
DMA2_FDT1_FLAG:	DMA2 channel 1 transfer complete flag
DMA2_HDT1_FLAG:	DMA2 channel 1 half transfer complete flag
DMA2_DTERR1_FLAG:	DMA2 channel 1 transfer error flag
DMA2_GL2_FLAG:	DMA2 channel 2 global flag
DMA2_FDT2_FLAG:	DMA2 channel 2 transfer complete flag
DMA2_HDT2_FLAG:	DMA2 channel 2 half transfer complete flag
DMA2_DTERR2_FLAG:	DMA2 channel 2 transfer error flag
DMA2_GL3_FLAG:	DMA2 channel 3 global flag
DMA2_FDT3_FLAG:	DMA2 channel 3 transfer complete flag
DMA2_HDT3_FLAG:	DMA2 channel 3 half transfer complete flag
DMA2_DTERR3_FLAG:	DMA2 channel 3 transfer error flag
DMA2_GL4_FLAG:	DMA2 channel 4 global flag
DMA2_FDT4_FLAG:	DMA2 channel 4 transfer complete flag
DMA2_HDT4_FLAG:	DMA2 channel 4 half transfer complete flag
DMA2_DTERR4_FLAG:	DMA2 channel 4 transfer error flag
DMA2_GL5_FLAG:	DMA2 channel 5 global flag
DMA2_FDT5_FLAG:	DMA2 channel 5 transfer complete flag
DMA2_HDT5_FLAG:	DMA2 channel 5 half transfer complete flag
DMA2_DTERR5_FLAG:	DMA2 channel 5 transfer error flag
DMA2_GL6_FLAG:	DMA2 channel 6 global flag
DMA2_FDT6_FLAG:	DMA2 channel 6 transfer complete flag
DMA2_HDT6_FLAG:	DMA2 channel 6 half transfer complete flag
DMA2_DTERR6_FLAG:	DMA2 channel 6 transfer error flag
DMA2_GL7_FLAG:	DMA2 channel 7 global flag
DMA2_FDT7_FLAG:	DMA2 channel 7 transfer complete flag
DMA2_HDT7_FLAG:	DMA2 channel 7 half transfer complete flag
DMA2_DTERR7_FLAG:	DMA2 channel 7 transfer error flag

Example:

```

if(dma_flag_get(DMA2_FDT1_FLAG) != RESET)
{
    /* turn led2/led3/led4 on */
    at32_led_on(LED2);
    at32_led_on(LED3);
    at32_led_on(LED4);
    dma_flag_clear(DMA2_FDT1_FLAG);
}

```

5.8.10 dma_flexible_config function

The table below describes the function `dma_flexible_enable`.

Table 189. `dma_flexible_config` function

Name	Description
Function name	<code>dma_flexible_config</code>
Function prototype	<code>void dma_flexible_config(dma_type* dma_x, dmamux_channel_type *dmamux_channelx, dmamux_request_id_sel_type dmamux_req_sel);</code>
Function description	Configure DMAMUX
Input parameter 1	<code>dma_x</code> : DMAx, x=1 or 2
Input parameter 2	<i>dmamux_channelx</i> :DMAMUX channel selection, x=1...7
Input parameter3	<i>dmamux_req_sel</i> :DMAMUX channel request ID
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

`dmamux_channelx`

DMAMUX channel selection, including:

DMA1MUX_CHANNEL1

DMA1MUX_CHANNEL2

DMA1MUX_CHANNEL3

DMA1MUX_CHANNEL4

DMA1MUX_CHANNEL5

DMA1MUX_CHANNEL6

DMA1MUX_CHANNEL7

DMA2MUX_CHANNEL1

DMA2MUX_CHANNEL2

DMA2MUX_CHANNEL3

DMA2MUX_CHANNEL4

DMA2MUX_CHANNEL5

DMA2MUX_CHANNEL6

DMA2MUX_CHANNEL7

dmamux_req_sel

Table 181 shows the DMAMUX channel request ID:

Table 190. DMAMUX channel request source ID

Request source ID	Description	Request source ID	Description
0x01	DMAMUX_DMAREQ_ID_REQ_G1	0x02	DMAMUX_DMAREQ_ID_REQ_G2
0x03	DMAMUX_DMAREQ_ID_REQ_G3	0x04	DMAMUX_DMAREQ_ID_REQ_G4
0x05	DMAMUX_DMAREQ_ID_ADC1	0x24	DMAMUX_DMAREQ_ID_ADC2
0x25	DMAMUX_DMAREQ_ID_ADC3	0x06	DMAMUX_DMAREQ_ID_DAC1
0x29	DMAMUX_DMAREQ_ID_DAC2	0x08	DMAMUX_DMAREQ_ID_TMR6_OVERFLOW
0x09	DMAMUX_DMAREQ_ID_TMR7_OVERFLOW	0x0A	DMAMUX_DMAREQ_ID_SPI1_RX
0x0B	DMAMUX_DMAREQ_ID_SPI1_TX	0x0C	DMAMUX_DMAREQ_ID_SPI2_RX
0x0D	DMAMUX_DMAREQ_ID_SPI2_TX	0x0E	DMAMUX_DMAREQ_ID_SPI3_RX
0x0F	DMAMUX_DMAREQ_ID_SPI3_TX	0x6A	DMAMUX_DMAREQ_ID_SPI4_RX
0x6B	DMAMUX_DMAREQ_ID_SPI4_TX	0x6E	DMAMUX_DMAREQ_ID_I2S2_EXT_RX
0x6F	DMAMUX_DMAREQ_ID_I2S2_EXT_TX	0x70	DMAMUX_DMAREQ_ID_I2S3_EXT_RX
0x71	DMAMUX_DMAREQ_ID_I2S3_EXT_TX	0x10	DMAMUX_DMAREQ_ID_I2C1_RX
0x11	DMAMUX_DMAREQ_ID_I2C1_TX	0x12	DMAMUX_DMAREQ_ID_I2C2_RX
0x13	DMAMUX_DMAREQ_ID_I2C2_TX	0x14	DMAMUX_DMAREQ_ID_I2C3_RX
0x15	DMAMUX_DMAREQ_ID_I2C3_TX	0x18	DMAMUX_DMAREQ_ID_USART1_RX
0x19	DMAMUX_DMAREQ_ID_USART1_TX	0x1A	DMAMUX_DMAREQ_ID_USART2_RX
0x1B	DMAMUX_DMAREQ_ID_USART2_TX	0x1C	DMAMUX_DMAREQ_ID_USART3_RX
0x1D	DMAMUX_DMAREQ_ID_USART3_TX	0x1E	DMAMUX_DMAREQ_ID_UART4_RX
0x1F	DMAMUX_DMAREQ_ID_UART4_TX	0x20	DMAMUX_DMAREQ_ID_UART5_RX
0x21	DMAMUX_DMAREQ_ID_UART5_TX	0x72	DMAMUX_DMAREQ_ID_USART6_RX
0x73	DMAMUX_DMAREQ_ID_USART6_TX	0x74	DMAMUX_DMAREQ_ID_UART7_RX
0x75	DMAMUX_DMAREQ_ID_UART7_TX	0x76	DMAMUX_DMAREQ_ID_UART8_RX
0x77	DMAMUX_DMAREQ_ID_UART8_TX	0x27	DMAMUX_DMAREQ_ID_SDIO1
0x67	DMAMUX_DMAREQ_ID_SDIO2	0x28	DMAMUX_DMAREQ_ID_QSPI1
0x68	DMAMUX_DMAREQ_ID_QSPI2	0x2A	DMAMUX_DMAREQ_ID_TMR1_CH1
0x2B	DMAMUX_DMAREQ_ID_TMR1_CH2	0x2C	DMAMUX_DMAREQ_ID_TMR1_CH3
0x2D	DMAMUX_DMAREQ_ID_TMR1_CH4	0x2E	DMAMUX_DMAREQ_ID_TMR1_OVERFLOW
0x2F	DMAMUX_DMAREQ_ID_TMR1_TRIG	0x30	DMAMUX_DMAREQ_ID_TMR1_HALL
0x31	DMAMUX_DMAREQ_ID_TMR8_CH1	0x32	DMAMUX_DMAREQ_ID_TMR8_CH2
0x33	DMAMUX_DMAREQ_ID_TMR8_CH3	0x34	DMAMUX_DMAREQ_ID_TMR8_CH4
0x35	DMAMUX_DMAREQ_ID_TMR8_OVERFLOW	0x36	DMAMUX_DMAREQ_ID_TMR8_TRIG
0x37	DMAMUX_DMAREQ_ID_TMR8_HALL	0x38	DMAMUX_DMAREQ_ID_TMR2_CH1
0x39	DMAMUX_DMAREQ_ID_TMR2_CH2	0x3A	DMAMUX_DMAREQ_ID_TMR2_CH3
0x3B	DMAMUX_DMAREQ_ID_TMR2_CH4	0x3C	DMAMUX_DMAREQ_ID_TMR2_OVERFLOW
0x7E	DMAMUX_DMAREQ_ID_TMR2_TRIG	0x3D	DMAMUX_DMAREQ_ID_TMR3_CH1
0x3E	DMAMUX_DMAREQ_ID_TMR3_CH2	0x3F	DMAMUX_DMAREQ_ID_TMR3_CH3

Request source ID	Description	Request source ID	Description
0x40	DMAMUX_DMAREQ_ID_TMR3_CH4	0x41	DMAMUX_DMAREQ_ID_TMR3_OVERFLOW
0x42	DMAMUX_DMAREQ_ID_TMR3_TRIG	0x43	DMAMUX_DMAREQ_ID_TMR4_CH1
0x44	DMAMUX_DMAREQ_ID_TMR4_CH2	0x45	DMAMUX_DMAREQ_ID_TMR4_CH3
0x46	DMAMUX_DMAREQ_ID_TMR4_CH4	0x47	DMAMUX_DMAREQ_ID_TMR4_OVERFLOW
0x7F	DMAMUX_DMAREQ_ID_TMR4_TRIG	0x48	DMAMUX_DMAREQ_ID_TMR5_CH1
0x49	DMAMUX_DMAREQ_ID_TMR5_CH2	0x4A	DMAMUX_DMAREQ_ID_TMR5_CH3
0x4B	DMAMUX_DMAREQ_ID_TMR5_CH4	0x4C	DMAMUX_DMAREQ_ID_TMR5_OVERFLOW
0x4D	DMAMUX_DMAREQ_ID_TMR5_TRIG	0x56	DMAMUX_DMAREQ_ID_TMR20_CH1
0x57	DMAMUX_DMAREQ_ID_TMR20_CH2	0x58	DMAMUX_DMAREQ_ID_TMR20_CH3
0x59	DMAMUX_DMAREQ_ID_TMR20_CH4	0x5A	DMAMUX_DMAREQ_ID_TMR20_OVERFLOW
0x5D	DMAMUX_DMAREQ_ID_TMR20_TRIG	0x5E	DMAMUX_DMAREQ_ID_TMR20_HALL
0x69	DMAMUX_DMAREQ_ID_DVP		

Example:

```
/* tmr20 hall dmamux function enable */
dma_flexible_config(DMA2, DMA1MUX_CHANNEL1, DMAMUX_DMAREQ_ID_TMR20_HALL);
```

5.8.11 dmamux_enable function

The table below describes the function dmamux_enable.

Table 191. dmamux_enable function

Name	Description
Function name	dmamux_enable
Function prototype	void dmamux_enable(dma_type *dma_x, confirm_state new_state);
Function description	Enable DMAMUX feature
Input parameter 1	dma_x: DMAx, x=1 or 2
Input parameter 2	new_state: enable or disable a channel
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

new_state

Enable or disable a DMA channel

FALSE: Channel disabled

TRUE: Channel enabled

Example:

```
/* dmamux function enable */
dmamux_enable(DMA2, TRUE);
```

5.8.12 dmamux_init

The table below describes the function dmamux_init.

Table 192. dmamux_init function

Name	Description
Function name	dmamux_init
Function prototype	void dmamux_init(dmamux_channel_type *dmamux_channelx, dmamux_request_id_sel_type dmamux_req_sel);
Function description	Configure DMAMUX
Input parameter 1	<i>dmamux_channelx</i> :DMAMUX channel selection, x=1...7
Input parameter 2	<i>dmamux_req_sel</i> :DMAMUX channel request ID
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* generator1 for dmamux channel4 as dma request */
dmamux_init(DMA2MUX_CHANNEL4, DMAMUX_DMAREQ_ID_REQ_G1);
```

5.8.13 dmamux_sync_default_para_init function

The table below describes the function dmamux_sync_default_para_init.

Table 193. dmamux_sync_default_para_init function

Name	Description
Function name	dmamux_sync_default_para_init
Function prototype	void dmamux_sync_default_para_init(dmamux_sync_init_type *dmamux_sync_init_struct);
Function description	Initialize the parameters in the dmamux_sync_init_struct
Input parameter 1	dmamux_sync_init_struct: dmamux_sync_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

The table below shows the default values of members in the dmamux_sync_init_struct.

Table 194. dmamux_sync_init_struct default values

Member	Default value
sync_enable	FALSE
sync_event_enable	FALSE
sync_polarity	DMAMUX_SYNC_POLARITY_DISABLE
sync_request_number	0x0
sync_signal_sel	(dmamux_sync_id_sel_type)0

Example:

```
/* dmamux sync init config with its default value */
dmamux_sync_init_type dmamux_sync_init_struct = {0};
dmamux_sync_default_para_init (&dmamux_sync_init_struct);
```

5.8.14 dmamux_sync_config function

The table below describes the function dmamux_sync_config.

Table 195. dmamux_sync_config function

Name	Description
Function name	dmamux_sync_config
Function prototype	void dmamux_sync_config(dmamux_channel_type *dmamux_channelx, dmamux_sync_init_type *dmamux_sync_init_struct);
Function description	Configure DMAMUX synchronous feature
Input parameter 1	<i>dmamux_channelx</i> :DMAMUX channel selection, x=1...7
Input parameter 2	dmamux_sync_init_struct: dmamux_sync_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dmamux_sync_init_struct

The dmamux_sync_init_type is defined in the “at32f423_dma.h”:

typedef struct

```
{
    dmamux_sync_id_sel_type      sync_signal_sel;
    uint32_t                      sync_polarity;
    uint32_t                      sync_request_number;
    confirm_state                  sync_event_enable;
    confirm_state                  sync_enable;
}
```

sync_signal_sel

Select signal source for synchronous module.

DMAMUX_SYNC_ID_EXINT0:	External extint0 signal
DMAMUX_SYNC_ID_EXINT1:	External extint1 signal
DMAMUX_SYNC_ID_EXINT2:	External extint2 signal
DMAMUX_SYNC_ID_EXINT3:	External extint3 signal
DMAMUX_SYNC_ID_EXINT4:	External extint4 signal
DMAMUX_SYNC_ID_EXINT5:	External extint5 signal
DMAMUX_SYNC_ID_EXINT6:	External extint6 signal
DMAMUX_SYNC_ID_EXINT7:	External extint7 signal
DMAMUX_SYNC_ID_EXINT8:	External extint8 signal
DMAMUX_SYNC_ID_EXINT9:	External extint9 signal
DMAMUX_SYNC_ID_EXINT10:	External extint10 signal
DMAMUX_SYNC_ID_EXINT11:	External extint11 signal
DMAMUX_SYNC_ID_EXINT12:	External extint12 signal
DMAMUX_SYNC_ID_EXINT13:	External extint13 signal

DMAMUX_SYNC_ID_EXINT14: External extint14 signal
DMAMUX_SYNC_ID_EXINT15: External extint15 signal
DMAMUX_SYNC_ID_DMAMUX_CH1_EVT: dmamux channel 1 event
DMAMUX_SYNC_ID_DMAMUX_CH2_EVT: dmamux channel 2 event
DMAMUX_SYNC_ID_DMAMUX_CH3_EVT: dmamux channel 3 event
DMAMUX_SYNC_ID_DMAMUX_CH4_EVT: dmamux channel 4 event
DMAMUX_SYNC_ID_DMAMUX_CH5_EVT: dmamux channel 5 event
DMAMUX_SYNC_ID_DMAMUX_CH6_EVT: dmamux channel 6 event
DMAMUX_SYNC_ID_DMAMUX_CH7_EVT: dmamux channel 7 event

sync_polarity

Polarity selection for synchronous signal

DMAMUX_SYNC_POLARITY_RISING:	Rising edge
DMAMUX_SYNC_POLARITY_FALLING:	Falling edge
DMAMUX_SYNC_POLARITY_RISING_FALLING:	Rising edge and falling edge

sync_request_number

The number of DMA requests that can be synchronized

Range: 1~32

sync_event_enable

Enable or disable synchronous event generation

TRUE: Synchronous event generated

FALSE: No synchronous event generated

sync_enable

Enable or disable synchronous module

FALSE: Disabled

TRUE: Enabled

Example:

```
dmamux_sync_default_para_init(&dmamux_sync_init_struct);
dmamux_sync_init_struct.sync_request_number = 4;
dmamux_sync_init_struct.sync_signal_sel = DMAMUX_SYNC_ID_EXINT1;
dmamux_sync_init_struct.sync_polarity = DMAMUX_SYNC_POLARITY_RISING;
dmamux_sync_init_struct.sync_event_enable = TRUE;
dmamux_sync_init_struct.sync_enable = TRUE;
dmamux_sync_config(DMA2MUX_CHANNEL4, &dmamux_sync_init_struct);
```

5.8.15 dmamux_generator_default_para_init function

The table below describes the function dmamux_generator_default_para_init.

Table 196. dmamux_generator_default_para_init function

Name	Description
Function name	dmamux_generator_default_para_init
Function prototype	void dmamux_generator_default_para_init(dmamux_gen_init_type *dmamux_gen_init_struct);
Function description	Initialize the parameters of the dmamux_gen_init_struct
Input parameter 1	dmamux_gen_init_struct: dmamux_gen_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Table 188 shows the default values of members in the dmamux_gen_init_struct:

Table 197. dmamux_gen_init_struct default values

Member	Default value
gen_signal_sel	(dmamux_gen_id_sel_type)0x0
gen_polarity	DMAMUX_GEN_POLARITY_DISABLE
gen_request_number	0x0
gen_enable	FALSE

Example:

```
/* dmamux gen init config with its default value */
dmamux_gen_init_type dmamux_gen_init_struct = {0};
dmamux_gen_default_para_init (&dmamux_gen_init_struct);
```

5.8.16 dmamux_generator_config function

The table below describes the function dmamux_generator_config.

Table 198. dmamux_generator_config function

Name	Description
Function name	dmamux_generator_config
Function prototype	void dmamux_generator_config(dmamux_generator_type * dmamux_gen_x, dmamux_gen_init_type *dmamux_gen_init_struct);
Function description	Configure DMAMUX request generator feature
Input parameter 1	dmamux_gen_x : request generator channel
Input parameter 2	dmamux_sync_init_struct: dmamux_sync_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dmamux_gen_x

dma request generator channel selection

DMA1MUX_GENERATOR1
DMA1MUX_GENERATOR2
DMA1MUX_GENERATOR3
DMA1MUX_GENERATOR4
DMA2MUX_GENERATOR1
DMA2MUX_GENERATOR2
DMA2MUX_GENERATOR3
DMA2MUX_GENERATOR4

dmamux_sync_init_struct

The dmamux_gen_init_type is defined in the “at32f423_dma.h”:

typedef struct

```
{  
    dmamux_gen_id_sel_type      gen_signal_sel;  
    uint32_t                   gen_polarity;  
    uint32_t                   gen_request_number;  
    confirm_state               gen_enable;  
} dmamux_gen_init_type;
```

gen_signal_sel

Select signal source for synchronous module

DMAMUX_GEN_ID_EXINT0:	External extint0 singal
DMAMUX_GEN_ID_EXINT1:	External extint1 singal
DMAMUX_GEN_ID_EXINT2:	External extint2 singal
DMAMUX_GEN_ID_EXINT3:	External extint3 singal
DMAMUX_GEN_ID_EXINT4:	External extint4 singal
DMAMUX_GEN_ID_EXINT5:	External extint5 singal
DMAMUX_GEN_ID_EXINT6:	External extint6 singal
DMAMUX_GEN_ID_EXINT7:	External extint7 singal
DMAMUX_GEN_ID_EXINT8:	External extint8 singal
DMAMUX_GEN_ID_EXINT9:	External extint9 singal
DMAMUX_GEN_ID_EXINT10:	External extint10 singal
DMAMUX_GEN_ID_EXINT11:	External extint11 singal
DMAMUX_GEN_ID_EXINT12:	External extint12 singal
DMAMUX_GEN_ID_EXINT13:	External extint13 singal
DMAMUX_GEN_ID_EXINT14:	External extint14 singal
DMAMUX_GEN_ID_EXINT15:	External extint15 singal
DMAMUX_GEN_ID_DMAMUX_CH1_EVT:	dmamux channel 1 event
DMAMUX_GEN_ID_DMAMUX_CH2_EVT:	dmamux channel 2 event
DMAMUX_GEN_ID_DMAMUX_CH3_EVT:	dmamux channel 3 event
DMAMUX_GEN_ID_DMAMUX_CH4_EVT:	dmamux channel 4 event
DMAMUX_GEN_ID_DMAMUX_CH5_EVT:	dmamux channel 5 event
DMAMUX_GEN_ID_DMAMUX_CH6_EVT:	dmamux channel 6 event
DMAMUX_GEN_ID_DMAMUX_CH7_EVT:	dmamux channel 7 event

gen_polarity

Polarity selection for request generator signal

DMAMUX_GEN_POLARITY_RISING:	Rising edge
DMAMUX_GEN_POLARITY_FALLING:	Falling edge

DMAMUX_GEN_POLARITY_RISING_FALLING: Rising edge and falling edge
gen_request_number

The number of DMA requests that are generated by request generator

Range: 1~32

gen_enable

Enable or disable request generator

FALSE: Disabled

TRUE: Enabled

Example:

```
/* generator1 configuration */
dmamux_generator_default_para_init(&dmamux_gen_init_struct);
dmamux_gen_init_struct.gen_polarity = DMAMUX_GEN_POLARITY_RISING;
dmamux_gen_init_struct.gen_request_number = 4;
dmamux_gen_init_struct.gen_signal_sel = DMAMUX_GEN_ID_EXINT1;
dmamux_gen_init_struct.gen_enable = TRUE;
dmamux_generator_config(DMA2MUX_GENERATOR1, &dmamux_gen_init_struct);
```

5.8.17 dmamux_sync_interrupt_enable function

The table below describes the function dmamux_sync_interrupt_enable.

Table 199. dmamux_sync_interrupt_enable function

Name	Description
Function name	dmamux_sync_interrupt_enable
Function prototype	void dmamux_sync_interrupt_enable(dmamux_channel_type *dmamux_channelx, confirm_state new_state);
Function description	Enable synchronous module overflow interrupt
Input parameter 1	dmamux_channelx :DMAMUX channel selection, x=1...7
Input parameter 2	new_state: enable or disable interrupts
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

new_state

Enable or disable DMA channel interrupts

FALSE: Interrupt disabled

TRUE: Interrupt enabled

Example:

```
/* enable sync overrun interrupt */
dmamux_sync_interrupt_enable (DMA2MUX_CHANNEL1, TRUE);
```

5.8.18 dmamux_generator_interrupt_enable function

The table below describes the function dmamux_generator_interrupt_enable.

Table 200. dmamux_generator_interrupt_enable function

Name	Description
Function name	dmamux_generator_interrupt_enable
Function prototype	void dmamux_generator_interrupt_enable(dmamux_generator_type *dmamux_gen_x, confirm_state new_state);
Function description	Enable request generator overflow interrupt
Input parameter 1	<i>dmamux_gen_x</i> :DMAMUX request generator channel selection, x=1...4
Input parameter 2	new_state: enable or disable interrupts
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

new_state

Enable or disable request generator channel interrupts

FALSE: Interrupt disabled

TRUE: Interrupt enabled

Example:

```
/* enable gen overrun interrupt */
dmamux_generator_interrupt_enable(DMA2MUX_GENERATOR3, TRUE);
```

5.8.19 dmamux_sync_flag_get function

The table below describes the function dmamux_sync_flag_get.

Table 201. dmamux_sync_flag_get function

Name	Description
Function name	dmamux_sync_flag_get
Function prototype	flag_status dmamux_sync_flag_get(dma_type *dma_x, uint32_t flag);
Function description	Get dmamux synchronous flag
Input parameter 1	dma_x: DMAx, x=1 or 2
Input parameter 2	Flag: flag selection
Output parameter	NA
Return value	flag_status: indicates whether or not the selected flag is set
Required preconditions	NA
Called functions	NA

flag

This is used for flag selection, including:

DMAMUX_SYNC_OV1_FLAG

DMAMUX_SYNC_OV2_FLAG

DMAMUX_SYNC_OV3_FLAG

DMAMUX_SYNC_OV4_FLAG

DMAMUX_SYNC_OV5_FLAG

DMAMUX_SYNC_OV6_FLAG

DMAMUX_SYNC_OV7_FLAG

flag_status

RESET: Corresponding flag is not set

SET: Corresponding flag is set

Example:

```
if(dmamux_sync_flag_get(DMA2, DMAMUX_SYNC_OV1_FLAG) != RESET)
{
    /* turn led2/led3/led4 on */
    at32_led_on(LED2);
    at32_led_on(LED3);
    at32_led_on(LED4);
}
```

5.8.20 dmamux_sync_flag_clear function

The table below describes the function dmamux_sync_flag_clear.

Table 202. dmamux_sync_flag_clear function

Name	Description
Function name	dmamux_sync_flag_clear
Function prototype	void dmamux_sync_flag_clear(dma_type *dma_x, uint32_t flag);
Function description	Clear synchronous module flag
Input parameter 1	dma_x: DMAx, x=1 or 2
Input parameter 2	Flag: flag selection
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

flag

This is used for flag selection, including:

DMAMUX_SYNC_OV1_FLAG

DMAMUX_SYNC_OV2_FLAG

DMAMUX_SYNC_OV3_FLAG

DMAMUX_SYNC_OV4_FLAG

DMAMUX_SYNC_OV5_FLAG

DMAMUX_SYNC_OV6_FLAG

DMAMUX_SYNC_OV7_FLAG

Example:

```
if(dmamux_sync_flag_get(DMA2, DMAMUX_SYNC_OV1_FLAG) != RESET)
{
    /* turn led2/led3/led4 on */
    at32_led_on(LED2);
    at32_led_on(LED3);
    at32_led_on(LED4);
    dmamux_sync_flag_clear(DMA2, DMAMUX_SYNC_OV1_FLAG);
}
```

5.8.21 dmamux_generator_flag_get function

The table below describes the function dmamux_generator_flag_get.

Table 203. dmamux_generator_flag_get function

Name	Description
Function name	dmamux_generator_flag_get
Function prototype	flag_status dmamux_generator_flag_get(dma_type *dma_x, uint32_t flag);
Function description	Get dmamux request generator flag
Input parameter 1	dma_x: DMAx, x=1 or 2
Input parameter 2	Flag: flag selection
Output parameter	NA
Return value	flag_status: indicates whether or not the selected flag is set
Required preconditions	NA
Called functions	NA

flag

This is used for flag selection, including:

DMAMUX_GEN_TRIG_OV1_FLAG
DMAMUX_GEN_TRIG_OV2_FLAG
DMAMUX_GEN_TRIG_OV3_FLAG
DMAMUX_GEN_TRIG_OV4_FLAG

flag_status

RESET: Corresponding flag is not set

SET: Corresponding flag is set

Example:

```
if(dmamux_generator_flag_get (DMA2, DMAMUX_GEN_TRIG_OV1_FLAG) != RESET)
{
    /* turn led2/led3/led4 on */
    at32_led_on(LED2);
    at32_led_on(LED3);
    at32_led_on(LED4);
}
```

5.8.22 dmamux_generator_flag_clear function

The table below describes the function dmamux_generator_flag_clear.

Table 204. dmamux_generator_flag_clear function

Name	Description
Function name	dmamux_generator_flag_clear
Function prototype	void dmamux_generator_flag_clear(dma_type *dma_x, uint32_t flag);
Function description	Clear request generator flag
Input parameter 1	dma_x: DMAx, x=1 or 2
Input parameter 2	Flag: flag selection
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

flag

This is used for flag selection, including:

DMAMUX_GEN_TRIG_OV1_FLAG
DMAMUX_GEN_TRIG_OV2_FLAG
DMAMUX_GEN_TRIG_OV3_FLAG
DMAMUX_GEN_TRIG_OV4_FLAG

Example:

```
if(dmamux_generator_flag_get (DMA2, DMAMUX_GEN_TRIG_OV1_FLAG) != RESET)
{
    /* turn led2/led3/led4 on */
    at32_led_on(LED2);
    at32_led_on(LED3);
    at32_led_on(LED4);
    dmamux_generator_flag_clear(DMA2, DMAMUX_GEN_TRIG_OV1_FLAG);
}
```

5.9 Real-time clock (ERTC)

The ERTC register structure ertc_type is defined in the “at32f423_ertc.h”:

```
/*
 * @brief type define ertc register all
 */
typedef struct
{

} ertc_type;
```

The table below gives a list of the ERTC registers:

Table 205. Summary of ERTC registers

Register	Description
time	ERTC time register
date	ERTC date register
ctrl	ERTC control register
sts	ERTC initialization and status register
div	ERTC divider register
wat	ERTC wakeup timer register
ccal	ERTC coarse calibration register
ala	ERTC alarm clock A register
alb	ERTC alarm clock B register
wp	ERTC write protection register
sbs	ERTC subsecond register
tadj	ERTC time adjustment register
tstm	ERTC time stamp time register
tsdt	ERTC time stamp date register
tssbs	ERTC time stamp subsecond register
scal	ERTC smooth calibration register
tamp	ERTC tamper configuration register
alasbs	ERTC alarm clock A subsecond register
albsbs	ERTC alarm clock B subsecond register
bprx	ERTC battery powered domain data register

The table below gives a list of ERTC library functions.

Table 206. Summary of ERTC library functions

Function name	Description
ertc_num_to_bcd	Convert number to BCD code
ertc_bcd_to_num	Convert BCD code to number
ertc_write_protect_enable	Enable write protection
ertc_write_protect_disable	Disable write protection
ertc_wait_update	Wait for register update complete

ertc_wait_flag	Wait flag
ertc_init_mode_enter	Enter initialization mode
ertc_init_mode_exit	Exit initialization mode
ertc_reset	Reset ERTC registers
ertc_divider_set	Divider setting
ertc_hour_mode_set	Hour mode setting
ertc_date_set	Date setting
ertc_time_set	Time setting
ertc_calendar_get	Get calendar
ertc_sub_second_get	Get the current subsecond
ertc_alarm_mask_set	Set alarm mask
ertc_alarm_week_date_select	Alarm time format selection (week/date)
ertc_alarm_set	Set alarm
ertc_alarm_sub_second_set	Set alarm subsecond
ertc_alarm_enable	Enable alarm
ertc_alarm_get	Get alarm value
ertc_alarm_sub_second_get	Get alarm subsecond
ertc_wakeup_clock_set	Select wakeup clock source
ertc_wakeup_counter_set	Set wakeup counter value
ertc_wakeup_counter_get	Get wakeup counter value
ertc_wakeup_enable	Enable wakeup timer
ertc_smooth_calibration_config	Configure smooth calibration
ertc_coarse_calibration_set	Configure coarse calibration
ertc_coarse_calibration_enable	Enable coarse calibration
ertc_cal_output_select	Calibration output source selection
ertc_cal_output_enable	Enable calibration output
ertc_time_adjust	Time adjustment
ertc_daylight_set	Set daylight saving time
ertc_daylight_bpr_get	Get daylight saving time battery powered domain data register value (BPR)
ertc_refer_clock_detect_enable	Enable reference clock detection
ertc_direct_read_enable	Enable direct read mode
ertc_output_set	Set event output
ertc_timestamp_pin_select	Time stamp detection pin selection
ertc_timestamp_valid_edge_set	Set time stamp detection valid edge
ertc_timestamp_enable	Enable time stamp
ertc_timestamp_get	Get time stamp
ertc_timestamp_sub_second_get	Get time stamp subsecond
ertc_tamper_1_pin_select	Tamper detection 1 pin selection
ertc_tamper_pull_up_enable	Enable tamper pin pull-up resistor
ertc_tamper_precharge_set	Set tamper pin precharge time
ertc_tamper_filter_set	Set tamper filter time
ertc_tamper_detect_freq_set	Set tamper detection frequency
ertc_tamper_valid_edge_set	Set tamper detection valid edge
ertc_tamper_timestamp_enable	Enable time stamp upon a tamper event
ertc_tamper_enable	Enable tamper detection

ertc_interrupt_enable	Enable interrupts
ertc_interrupt_get	Get the status of interrupt enable
ertc_flag_get	Get flag status
ertc_flag_clear	Clear flag
ertc_bpr_data_write	Write data to battery powered data register (BPR)
ertc_bpr_data_read	Read from battery powered data register (BPR)

5.9.1 ertc_num_to_bcd function

The table below describes the function ertc_num_to_bcd.

Table 207. ertc_num_to_bcd function

Name	Description
Function name	ertc_num_to_bcd
Function prototype	uint8_t ertc_num_to_bcd(uint8_t num);
Function description	Convert number into BCD format
Input parameter 1	num: number to be converted
Output parameter	NA
Return value	BCD code
Required preconditions	NA
Called functions	NA

Example:

```
ertc_num_to_bcd(12);
```

5.9.2 ertc_bcd_to_num function

The table below describes the function ertc_bcd_to_num.

Table 208. ertc_bcd_to_num function

Name	Description
Function name	ertc_bcd_to_num
Function prototype	uint8_t ertc_bcd_to_num(uint8_t bcd);
Function description	Convert BCD code into number
Input parameter 1	bcd: BCD code to be converted
Output parameter	NA
Return value	Return the number corresponding to BCD code
Required preconditions	NA
Called functions	NA

Example:

```
ertc_bcd_to_num(0x12);
```

5.9.3 ertc_write_protect_enable function

The table below describes the function ertc_write_protect_enable.

Table 209. ertc_write_protect_enable function

Name	Description
Function name	ertc_write_protect_enable
Function prototype	void ertc_write_protect_enable(void);
Function description	Write protection enable
Input parameter 1	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_write_protect_enable();
```

5.9.4 ertc_write_protect_disable function

The table below describes the function ertc_write_protect_disable.

Table 210. ertc_write_protect_disable function

Name	Description
Function name	ertc_write_protect_disable
Function prototype	void ertc_write_protect_disable(void);
Function description	Write protection disable
Input parameter 1	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_write_protect_disable();
```

5.9.5 ertc_wait_update function

The table below describes the function ertc_wait_update.

Table 211. ertc_wait_update function

Name	Description
Function name	ertc_wait_update
Function prototype	error_status ertc_wait_update(void);
Function description	Wait for register to finish update
Input parameter 1	NA
Output parameter	NA
Return value	SUCCESS: register update complete ERROR: flag wait timeout
Required preconditions	NA
Called functions	NA

Example:

ertc_wait_update();

5.9.6 ertc_wait_flag function

The table below describes the function ertc_wait_flag.

Table 212. ertc_wait_flag function

Name	Description
Function name	ertc_wait_flag
Function prototype	error_status ertc_wait_flag(uint32_t flag, flag_status status);
Function description	Wait flag
Input parameter 1	flag: flag selection Refer to the "flag" description below for details.
Input parameter 1	status: flag status. After the flag status is set, the function remains stuck here until flag status changes. This parameter can be SET or RESET.
Output parameter	NA
Return value	SUCCESS: flag state changed ERROR: flag wait timeout
Required preconditions	NA
Called functions	NA

flag

Flag selection

- ERTC_ALAWF_FLAG: Alarm A write enable flag
- ERTC_ALBWF_FLAG: Alarm B write enable flag
- ERTC_WATWF_FLAG: Wakeup timer register write enable flag
- ERTC_TADJF_FLAG: Time adjustment flag
- ERTC_CALUPDF_FLAG: Calibration value update complete flag

Example:

ertc_wait_flag(ERTC_ALAWF_FLAG, RESET);

5.9.7 ertc_init_mode_enter function

The table below describes the function ertc_init_mode_enter.

Table 213. ertc_init_mode_enter function

Name	Description
Function name	ertc_init_mode_enter
Function prototype	error_status ertc_init_mode_enter(void);
Function description	Enter initialization mode
Input parameter 1	NA
Output parameter	NA
Return value	SUCCESS: Initialization mode is entered successfully ERROR: Timeout
Required preconditions	NA
Called functions	NA

Example:

```
ertc_init_mode_enter();
```

5.9.8 ertc_init_mode_exit function

The table below describes the function ertc_init_mode_exit.

Table 214. ertc_init_mode_exit function

Name	Description
Function name	ertc_init_mode_exit
Function prototype	void ertc_init_mode_exit(void);
Function description	Exit initialization mode
Input parameter 1	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_init_mode_exit();
```

5.9.9 ertc_reset function

The table below describes the function ertc_reset.

Table 215. ertc_reset function

Name	Description
Function name	ertc_reset
Function prototype	error_status ertc_reset(void);
Function description	Reset all ERTC registers
Input parameter 1	NA
Output parameter	NA
Return value	SUCCESS: Reset successful ERROR: Reset failed
Required preconditions	NA
Called functions	NA

Example:

ertc_reset();

5.9.10 ertc_divider_set function

The table below describes the function ertc_divider_set.

Table 216. ertc_divider_set function

Name	Description
Function name	ertc_divider_set
Function prototype	error_status ertc_divider_set(uint16_t div_a, uint16_t div_b);
Function description	Divider settings, frequency division value $(div_a + 1) * (div_b + 1) = ERTC_CLK$ frequency For example, if 32768Hz is used, the frequency division should be div_a = 127, div_b = 255
Input parameter 1	div_a: divider A, range: 0~0x7F
Input parameter 2	div_b: divider B, range: 0~0x7FFF
Output parameter	NA
Return value	SUCCESS: Reset successful ERROR: Reset failed
Required preconditions	NA
Called functions	NA

Example:

ertc_divider_set(127, 255);

5.9.11 ertc_hour_mode_set function

The table below describes the function ertc_hour_mode_set.

Table 217. ertc_hour_mode_set function

Name	Description
Function name	ertc_hour_mode_set
Function prototype	error_status ertc_hour_mode_set(ertc_hour_mode_set_type mode);
Function description	Hour mode settings
Input parameter 1	mode: hour mode Refer to the following description "Mode" for details.
Output parameter	NA
Return value	SUCCESS: Setting success ERROR: Setting error
Required preconditions	NA
Called functions	NA

mode

ERTC_HOUR_MODE_24: 24-hour format

ERTC_HOUR_MODE_12: 12-hour format

Example:

```
ertc_hour_mode_set(ERTC_HOUR_MODE_24);
```

5.9.12 ertc_date_set function

The table below describes the function ertc_date_set.

Table 218. ertc_date_set function

Name	Description
Function name	ertc_date_set
Function prototype	error_status ertc_date_set(uint8_t year, uint8_t month, uint8_t date, uint8_t week);
Function description	Set date: year, month, date, weekday
Input parameter 1	year: range 0~99
Input parameter 2	month: range 1~12
Input parameter3	date: range 1~31
Input parameter4	week: range 1~7
Output parameter	NA
Return value	SUCCESS: Setting success ERROR: Setting error
Required preconditions	NA
Called functions	NA

Example:

```
ertc_date_set(22, 5, 26, 4);
```

5.9.13 ertc_time_set function

The table below describes the function ertc_time_set.

Table 219. ertc_time_set function

Name	Description
Function name	ertc_time_set
Function prototype	error_status ertc_time_set(uint8_t hour, uint8_t min, uint8_t sec, ertc_am_pm_type ampm);
Function description	Set time: hour, minute, second, AM/PM (for 12-hour format only)
Input parameter 1	hour: range 0~23
Input parameter 2	min: range 0~59
Input parameter3	sec: range 0~59
Input parameter4	ampm: AM/PM in 12-hour format (for 12-hour format only, don't care in 24-hour format) Refer to the following description "ampm" for details.
Output parameter	NA
Return value	SUCCESS: Setting success ERROR: Setting error
Required preconditions	NA
Called functions	NA

ampm

AM/PM in 12-hour format (for 12-hour format only, don't care in 24-hour format)

ERTC_24H: 24-hour format (for 24-hour format)

ERTC_AM: AM in 12-hour format

ERTC_PM: PM in 12-hour format

Example:

```
ertc_time_set(12, 1, 20, ERTC_24H);
```

5.9.14 ertc_calendar_get function

The table below describes the function ertc_calendar_get.

Table 220. ertc_calendar_get function

Name	Description
Function name	ertc_calendar_get
Function prototype	void ertc_calendar_get(ertc_time_type* time);
Function description	Get calendar, including year, month, date, weekday, hour, minute, second, AM/PM
Input parameter 1	time: ertc_time_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

ertc_time_type* time

The ertc_time_type is defined in the "at32f423_ertc.h":

typedef struct

{

```

        uint8_t          year;
        uint8_t          month;
        uint8_t          day;
        uint8_t          hour;
        uint8_t          min;
        uint8_t          sec;
        uint8_t          week;
        ertc_am_pm_type ampm;
    } ertc_time_type;
year
Range 0~99
month
Range 1~12
day
Range 1~31
week
Range 1~7
hour
Range 0~23
min
Range 0~59
sec
Range 0~59
ampm
AM/PM in 12-hour format (for 12-hour format only, doesn't care in 24 hour), including:  

ERTC_AM: AM in 12 hour format  

ERTC_PM: PM in 12 hour format

```

Example:

`ertc_calendar_get(&time);`

5.9.15 ertc_sub_second_get function

The table below describes the function ertc_sub_second_get.

Table 221. ertc_sub_second_get function

Name	Description
Function name	ertc_sub_second_get
Function prototype	uint32_t ertc_sub_second_get(void);
Function description	Get current subsecond (the current value of divider B)
Input parameter 1	NA
Output parameter	NA
Return value	Current subsecond
Required preconditions	NA
Called functions	NA

Example:

`ertc_sub_second_get();`

5.9.16 ertc_alarm_mask_set function

The table below describes the function ertc_alarm_mask_set.

Table 222. ertc_alarm_mask_set function

Name	Description
Function name	ertc_alarm_mask_set
Function prototype	void ertc_alarm_mask_set(ertc_alarm_type alarm_x, uint32_t mask);
Function description	Set alarm mask
	alarm_x: alarm selection Refer to the following description "alarm_x" for details.
Input parameter 1	mask: Set alarm mask Refer to the following description "mask" for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

alarm_x

Alarm selection

ERTC_ALA: Alarm A

ERTC_ALB: Alarm B

mask

Set alarm mask

ERTC_ALARM_MASK_NONE: No mask, alarm is relevant to all fields

ERTC_ALARM_MASK_SEC: Mask second, alarm is not relevant to second

ERTC_ALARM_MASK_MIN: Mask minute, alarm is not relevant to minute

ERTC_ALARM_MASK_HOUR: Mask hour, alarm is not relevant to hour

ERTC_ALARM_MASK_DATE_WEEK: Mask date, alarm is not relevant to date

ERTC_ALARM_MASK_ALL: Mask all. Generate an alarm per one second

Example:

```
ertc_alarm_mask_set(ERTC_ALA, ERTC_ALARM_MASK_NONE);
```

5.9.17 ertc_alarm_week_date_select function

The table below describes the function ertc_alarm_week_date_select.

Table 223. ertc_alarm_week_date_select function

Name	Description
Function name	ertc_alarm_week_date_select
Function prototype	void ertc_alarm_week_date_select(ertc_alarm_type alarm_x, ertc_week_date_select_type wk);
Function description	Alarm time format selection: week/date
Input parameter 1	alarm_x: alarm selection Refer to the following description “alarm_x” for details.
Input parameter 2	wk: alarm week/date format selection Refer to the following description “wk” for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

alarm_x

Alarm selection

ERTC_ALA: Alarm A

ERTC_ALB: Alarm B

wk

Alarm week/date format selection

ERTC_SELECT_DATE: Date mode

ERTC_SELECT_WEEK: Week mode

Example:

```
ertc_alarm_week_date_select(ERTC_ALA, ERTC_SELECT_DATE);
```

5.9.18 ertc_alarm_set function

The table below describes the function ertc_alarm_set.

Table 224. ertc_alarm_set function

Name	Description
Function name	ertc_alarm_set
Function prototype	void ertc_alarm_set(ertc_alarm_type alarm_x, uint8_t week_date, uint8_t hour, uint8_t min, uint8_t sec, ertc_am_pm_type ampm);
Function description	Set alarm
Input parameter 1	alarm_x: alarm selection Refer to the following description “alarm_x” for details.
Input parameter 2	week_date: date or week, depending on the ertc_alarm_week_date_select() Date: range 1~31 Week: range 1~7
Input parameter3	hour: range 0~23
Input parameter4	min: range 0~59
Input parameter5	sec: range 0~59
Input parameter6	ampm: AM/PM in 12-hour format (12 hour format only, doesn't care in 24-hour format) Refer to the following description “ampm” for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

alarm_x

Alarm selection

ERTC_ALA: Alarm A

ERTC_ALB: Alarm B

ampm

AM/PM in 12-hour format (for 12 hour format only, doesn't care in 24 hour)

ERTC_24H: 24-hour format (for 24 hour format)

ERTC_AM: AM in 12-hour format

ERTC_PM: PM in 12-hour format

Example:

```
ertc_alarm_set(ERTC_ALA, 15, 8, 0, 0, ERTC_24H);
```

5.9.19 ertc_alarm_sub_second_set function

The table below describes the function ertc_alarm_sub_second_set.

Table 225. ertc_alarm_sub_second_set function

Name	Description
Function name	ertc_alarm_sub_second_set
Function prototype	void ertc_alarm_sub_second_set(ertc_alarm_type alarm_x, uint32_t value, ertc_alarm_sbs_mask_type mask);
Function description	Set alarm subsecond
Input parameter 1	alarm_x: alarm selection Refer to the following description “alarm_x” for details.
Input parameter 2	value: subsecond value, range 0~0x7FFF
Input parameter3	mask: alarm mask settings Refer to the following description “mask” for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

alarm_x

Alarm selection

ERTC_ALA: Alarm A

ERTC_ALB: Alarm B

mask

Subsecond mask

ERTC_ALARM_SBS_MASK_ALL:	Mask all
ERTC_ALARM_SBS_MASK_14_1:	Only match SBS bit [0]
ERTC_ALARM_SBS_MASK_14_2:	Only match SBS bit [1:0]
ERTC_ALARM_SBS_MASK_14_3:	Only match SBS bit [2:0]
ERTC_ALARM_SBS_MASK_14_4:	Only match SBS bit [3:0]
ERTC_ALARM_SBS_MASK_14_5:	Only match SBS bit [4:0]
ERTC_ALARM_SBS_MASK_14_6:	Only match SBS bit [5:0]
ERTC_ALARM_SBS_MASK_14_7:	Only match SBS bit [6:0]
ERTC_ALARM_SBS_MASK_14_8:	Only match SBS bit [7:0]
ERTC_ALARM_SBS_MASK_14_9:	Only match SBS bit [8:0]
ERTC_ALARM_SBS_MASK_14_10:	Only match SBS bit [9:0]
ERTC_ALARM_SBS_MASK_14_11:	Only match SBS bit [10:0]
ERTC_ALARM_SBS_MASK_14_12:	Only match SBS bit [11:0]
ERTC_ALARM_SBS_MASK_14_13:	Only match SBS bit [12:0]
ERTC_ALARM_SBS_MASK_14:	Only match SBS bit [13:0]
ERTC_ALARM_SBS_MASK_NONE:	Only match SBS bit [14:0]

Example:

```
ertc_alarm_sub_second_set(ERTC_ALA, 200, ERTC_ALARM_SBS_MASK_NONE);
```

5.9.20 ertc_alarm_enable function

The table below describes the function ertc_alarm_enable.

Table 226. ertc_alarm_enable function

Name	Description
Function name	ertc_alarm_enable
Function prototype	error_status ertc_alarm_enable(ertc_alarm_type alarm_x, confirm_state new_state);
Function description	Alarm enable
Input parameter 1	alarm_x: alarm selection Refer to the following description “alarm_x” for details.
Input parameter 2	new_state: alarm enable status This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	SUCCESS: Setting success ERROR: Setting error
Required preconditions	NA
Called functions	NA

alarm_x

Alarm selection

ERTC_ALA: Alarm A

ERTC_ALB: Alarm B

Example:

```
ertc_alarm_enable(ERTC_ALA, TRUE);
```

5.9.21 ertc_alarm_get function

The table below describes the function ertc_alarm_get.

Table 227. ertc_alarm_get function

Name	Description
Function name	ertc_alarm_get
Function prototype	void ertc_alarm_get(ertc_alarm_type alarm_x, ertc_alarm_value_type* alarm);
Function description	Get alarm value
Input parameter 1	alarm_x: alarm selection Refer to the following description “alarm_x” for details.
Input parameter 2	alarm: ertc_alarm_value_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

alarm_x

Alarm selection

ERTC_ALA: Alarm A

ERTC_ALB: Alarm B

ertc_alarm_value_type* alarm

ertc_alarm_value_type is defined in the "at32f423_ertc.h":

typedef struct

```
{  
    uint8_t          day;  
    uint8_t          hour;  
    uint8_t          min;  
    uint8_t          sec;  
    ertc_am_pm_type ampm;  
    uint32_t         mask;  
    uint8_t          week_date_sel;  
    uint8_t          week;
```

} ertc_alarm_value_type;

day

Range 1~31

hour

Range 0~23

min

Range 0~59

sec

Range 0~59

ampm

AM/PM in 12-hour format (for 12-hour format only, doesn't care in 24 hour), including:

ERTC_AM: AM in 12 hour format

ERTC_PM: PM in 12 hour format

mask

Alarm mask value, including:

ERTC_ALARM_MASK_NONE:	No mask
ERTC_ALARM_MASK_SEC:	Mask second
ERTC_ALARM_MASK_MIN:	Mask minute
ERTC_ALARM_MASK_HOUR:	Mask hour
ERTC_ALARM_MASK_DATE_WEEK:	Mask date
ERTC_ALARM_MASK_ALL:	Mask all

week_date_sel

Alarm week/date format, including:

ERTC_SELECT_DATE: date mode

ERTC_SELECT_WEEK: week mode

week

Range 1~7

Example:

```
ertc_alarm_get(ERTC_ALA, &alarm);
```

5.9.22 ertc_alarm_sub_second_get function

The table below describes the function ertc_alarm_sub_second_get.

Table 228. ertc_alarm_sub_second_get function

Name	Description
Function name	ertc_alarm_sub_second_get
Function prototype	uint32_t ertc_alarm_sub_second_get(ertc_alarm_type alarm_x);
Function description	Get alarm subsecond value
Input parameter 1	alarm_x: alarm selection Refer to the following description "alarm_x" for details.
Output parameter	NA
Return value	Alarm subsecond value
Required preconditions	NA
Called functions	NA

alarm_x

Alarm selection

ERTC_ALA: Alarm A

ERTC_ALB: Alarm B

Example:

```
ertc_alarm_sub_second_get(ERTC_ALA);
```

5.9.23 ertc_wakeup_clock_set function

The table below describes the function ertc_wakeup_clock_set.

Table 229. ertc_wakeup_clock_set function

Name	Description
Function name	ertc_wakeup_clock_set
Function prototype	void ertc_wakeup_clock_set(ertc_wakeup_clock_type clock);
Function description	Select wakeup timer clock source
Input parameter 1	clock: clock source for wakeup timer Refer to the following description "clock" for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

clock

Wakeup timer clock source

ERTC_WAT_CLK_ERTCCLK_DIV16: ERTC_CLK / 16

ERTC_WAT_CLK_ERTCCLK_DIV8: ERTC_CLK / 8

ERTC_WAT_CLK_ERTCCLK_DIV4: ERTC_CLK / 4

ERTC_WAT_CLK_ERTCCLK_DIV2: ERTC_CLK / 2

ERTC_WAT_CLK_CK_B_16BITS: CK_B (1Hz calendar clock), wakeup counter value =

ERTC_WAT

ERTC_WAT_CLK_CK_B_17BITS: CK_B (1Hz calendar clock), wakeup counter value =

ERTC_WAT + 65535

Example:

```
ertc_wakeup_clock_set(ERTC_WAT_CLK_CK_B_16BITS);
```

5.9.24 ertc_wakeup_counter_set function

The table below describes the function ertc_wakeup_counter_set.

Table 230. ertc_wakeup_counter_set function

Name	Description
Function name	ertc_wakeup_counter_set
Function prototype	void ertc_wakeup_counter_set(uint32_t counter);
Function description	Set wakeup counter value
Input parameter 1	counter: counter value, range 0~0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_wakeup_counter_set(0x7FFF);
```

5.9.25 ertc_wakeup_counter_get function

The table below describes the function ertc_wakeup_counter_get.

Table 231. ertc_wakeup_counter_get function

Name	Description
Function name	ertc_wakeup_counter_get
Function prototype	uint16_t ertc_wakeup_counter_get(void);
Function description	Get the current wakeup counter value
Input parameter 1	NA
Output parameter	NA
Return value	Return the current wakeup counter value
Required preconditions	NA
Called functions	NA

Example:

```
ertc_wakeup_counter_get();
```

5.9.26 ertc_wakeup_enable function

The table below describes the function ertc_wakeup_enable.

Table 232. ertc_wakeup_enable function

Name	Description
Function name	ertc_wakeup_enable
Function prototype	error_status ertc_wakeup_enable(confirm_state new_state);
Function description	Enable wakeup timer
Input parameter 1	new_state: wakeup timer enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	SUCCESS: Set success ERROR: Set error
Required preconditions	NA
Called functions	NA

Example:

```
ertc_wakeup_enable(TRUE);
```

5.9.27 ertc_smooth_calibration_config function

The table below describes the function ertc_smooth_calibration_config.

Table 233. ertc_smooth_calibration_config function

Name	Description
Function name	ertc_smooth_calibration_config
Function prototype	error_status ertc_smooth_calibration_config(ertc_smooth_cal_period_type period, ertc_smooth_cal_clk_add_type clk_add, uint32_t clk_dec);
Function description	et smooth digital calibration
Input parameter 1	period: calibration period Refer to the following "period" descriptions for details.
Input parameter 2	clk_add: add ERTC CLK cycles Refer to the following "clk_add" descriptions for details.
Input parameter3	clk_dec: reduce ERTC CLK cycles, range 0~511
Output parameter	NA
Return value	SUCCESS: Set success ERROR: Set error
Required preconditions	NA
Called functions	NA

period

Calibration periods

ERTC_SMOOTH_CAL_PERIOD_32: 32 seconds

ERTC_SMOOTH_CAL_PERIOD_16: 16 seconds

ERTC_SMOOTH_CAL_PERIOD_8: 8 seconds

clk_add

Add ERTC CLK

ERTC_SMOOTH_CAL_CLK_ADD_0: No effect

ERTC_SMOOTH_CAL_CLK_ADD_512: Add 512 ERTC_CLK cycles

Example:

```
ertc_smooth_calibration_config(ERTC_SMOOTH_CAL_PERIOD_32, ERTC_SMOOTH_CAL_CLK_ADD_0, 511);
```

5.9.28 ertc_coarse_calibration_set function

The table below describes the function ertc_coarse_calibration_set.

Table 234. ertc_coarse_calibration_set function

Name	Description
Function name	ertc_coarse_calibration_set
Function prototype	error_status ertc_coarse_calibration_set(ertc_cal_direction_type dir, uint32_t value);
Function description	Set coarse digital calibration
Input parameter 1	dir: calibration direction Refer to the following "dir" descriptions for details.
Input parameter 2	value: calibration value, range 0~31
Output parameter	NA
Return value	SUCCESS: Set success ERROR: Set error
Required preconditions	NA
Called functions	NA

dir

Calibration direction

ERTC_CAL_DIR_POSITIVE: Positive directin calibration

ERTC_CAL_DIR_NEGATIVE: Negative directin calibration

Example:

```
ertc_coarse_calibration_set(ERTC_CAL_DIR_POSITIVE, 10);
```

5.9.29 ertc_coarse_calibration_enable function

The table below describes the function ertc_coarse_calibration_enable.

Table 235. ertc_coarse_calibration_enable function

Name	Description
Function name	ertc_coarse_calibration_enable
Function prototype	error_status ertc_coarse_calibration_enable(confirm_state new_state);
Function description	Enable coarse digital calibration
Input parameter 1	new_state: coarse digital calibration enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	SUCCESS: Set success ERROR: Set error
Required preconditions	NA
Called functions	NA

Example:

```
ertc_coarse_calibration_enable(TRUE);
```

5.9.30 ertc_cal_output_select function

The table below describes the function ertc_cal_output_select.

Table 236. ertc_cal_output_select function

Name	Description
Function name	ertc_cal_output_select
Function prototype	void ertc_cal_output_select(ertc_cal_output_select_type output);
Function description	Calibration output source selection
Input parameter 1	output: Calibration output source Refer to the following “output” descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

output

Calibration output source

ERTC_CAL_OUTPUT_512HZ: 512 Hz output

ERTC_CAL_OUTPUT_1HZ: 1 Hz output

Example:

```
ertc_cal_output_select(ERTC_CAL_OUTPUT_1HZ);
```

5.9.31 ertc_cal_output_enable function

The table below describes the function ertc_cal_output_enable.

Table 237. ertc_cal_output_enable function

Name	Description
Function name	ertc_cal_output_enable
Function prototype	void ertc_cal_output_enable(confirm_state new_state);
Function description	Calibration output enable
Input parameter 1	new_state: calibration output enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_cal_output_enable(TRUE);
```

5.9.32 ertc_time_adjust function

The table below describes the function ertc_time_adjust.

Table 238. ertc_time_adjust function

Name	Description
Function name	ertc_time_adjust
Function prototype	error_status ertc_time_adjust(ertc_time_adjust_type add1s, uint32_t decsbs);
Function description	Adjust time
Input parameter 1	add1s: add seconds Refer to the following “add1s” descriptions for details.
Input parameter 2	decsbs: reduce subseconds, range 0~0x7FFF
Output parameter	NA
Return value	SUCCESS: Set success ERROR: Set error
Required preconditions	NA
Called functions	NA

add1s

This bit is used to add seconds.

ERTC_TIME_ADD_NONE: No effect

ERTC_TIME_ADD_1S: Add 1 second

Example:

```
ertc_time_adjust(ERTC_TIME_ADD_1S, 254);
```

5.9.33 ertc_daylight_set function

The table below describes the function ertc_daylight_set.

Table 239. ertc_daylight_set function

Name	Description
Function name	ertc_daylight_set
Function prototype	void ertc_daylight_set(ertc_dst_operation_type operation, ertc_dst_save_type save);
Function description	Set daylight-saving time
Input parameter 1	operation: daylight-saving time settings Refer to the following “operation” descriptions for details.
Input parameter 2	save: save daylight time Refer to the following “save” descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

operation

Daylight-saving time settings

ERTC_DST_ADD_1H: Add 1 hour

ERTC_DST_DEC_1H: Reduce 1 hour

save

Save daylight time

ERTC_DST_SAVE_0: set BPR bit to 0 in the CTRL register

ERTC_DST_SAVE_1: set BPR bit to 1 in the CTRL register

Example:

<code>ertc_daylight_set(ERTC_DST_ADD_1H, ERTC_DST_SAVE_1);</code>

5.9.34 ertc_daylight_bpr_get function

The table below describes the function ertc_daylight_bpr_get.

Table 240. ertc_daylight_bpr_get function

Name	Description
Function name	ertc_daylight_bpr_get
Function prototype	<code>uint8_t ertc_daylight_bpr_get(void);</code>
Function description	Get the value of daylight-saving time battery powered register (BPR bit in the CTRL register)
Input parameter 1	NA
Output parameter	NA
Return value	Return the value of daylight-saving time battery powered register (BPR bit in the CTRL register)
Required preconditions	NA
Called functions	NA

Example:

<code>ertc_daylight_bpr_get();</code>

5.9.35 ertc_refer_clock_detect_enable function

The table below describes the function ertc_refer_clock_detect_enable.

Table 241. ertc_refer_clock_detect_enable function

Name	Description
Function name	ertc_refer_clock_detect_enable
Function prototype	<code>error_status ertc_refer_clock_detect_enable(confirm_state new_state);</code>
Function description	Enable reference clock detection
Input parameter 1	<code>new_state</code> : reference clock detection enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	SUCCESS: Set success ERROR: Set error
Required preconditions	NA
Called functions	NA

Example:

<code>ertc_refer_clock_detect_enable(TRUE);</code>
--

5.9.36 ertc_direct_read_enable function

The table below describes the function ertc_direct_read_enable.

Table 242. ertc_direct_read_enable function

Name	Description
Function name	ertc_direct_read_enable
Function prototype	void ertc_direct_read_enable(confirm_state new_state);
Function description	Enable direct read mode
Input parameter 1	new_state: direct read mode enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_direct_read_enable(TRUE);
```

5.9.37 ertc_output_set function

The table below describes the function ertc_output_set.

Table 243. ertc_output_set function

Name	Description
Function name	ertc_output_set
Function prototype	void ertc_output_set(ertc_output_source_type source, ertc_output_polarity_type polarity, ertc_output_type type);
Function description	Set event output, event output on PC13
Input parameter 1	source: output source selection Refer to the following "source" descriptions for details.
Input parameter 2	polarity: output polarity Refer to the following "polarity" descriptions for details.
Input parameter3	type: output type Refer to the following "type" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

source

Output source selection

- | | |
|----------------------|----------------------|
| ERTC_OUTPUT_DISABLE: | Output disabled |
| ERTC_OUTPUT_ALARM_A: | Output alarm A event |
| ERTC_OUTPUT_ALARM_B: | Output alarm B event |
| ERTC_OUTPUT_WAKEUP: | Output wakeup event |

polarity

Output polarity

- | | |
|----------------------------|------------------------------------|
| ERTC_OUTPUT_POLARITY_HIGH: | Output high when an event occurred |
|----------------------------|------------------------------------|

ERTC_OUTPUT_POLARITY_LOW: Output low when an event occurred

type

Output type

ERTC_OUTPUT_TYPE_OPEN_DRAIN: Open-drain output

ERTC_OUTPUT_TYPE_PUSH_PULL: Push-pull output

Example:

```
ertc_output_set(ERTC_OUTPUT_ALARM_A, ERTC_OUTPUT_POLARITY_HIGH,
ERTC_OUTPUT_TYPE_PUSH_PULL);
```

5.9.38 ertc_timestamp_pin_select function

The table below describes the function ertc_timestamp_pin_select.

Table 244. ertc_timestamp_pin_select function

Name	Description
Function name	ertc_timestamp_pin_select
Function prototype	void ertc_timestamp_pin_select(ertc_pin_select_type pin);
Function description	Timestamp detection pin selection
Input parameter 1	pin: Timestamp detection pin Refer to the following “pin” descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

pin

Timestampe detection pin

ERTC_PIN_PC13: PC13 is selected as timestampe detection pin

ERTC_PIN_PA0: PA0 is selected as timestampe detection pin

Example:

```
ertc_timestamp_pin_select(ERTC_PIN_PC13);
```

5.9.39 ertc_timestamp_valid_edge_set function

The table below describes the function ertc_timestamp_valid_edge_set.

Table 245. ertc_timestamp_valid_edge_set function

Name	Description
Function name	ertc_timestamp_valid_edge_set
Function prototype	void ertc_timestamp_valid_edge_set(ertc_timestamp_valid_edge_type edge);
Function description	Set timestampe detection valid edge
Input parameter 1	edge: timestampe detection valid edge Refer to the following “edge” descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

edge

Timestamp detection valid edge

ERTC_TIMESTAMP_EDGE_RISING: Rising edge

ERTC_TIMESTAMP_EDGE_FALLING: Falling edge

Example:

```
ertc_timestamp_valid_edge_set(ERTC_TIMESTAMP_EDGE_RISING);
```

5.9.40 ertc_timestamp_enable function

The table below describes the function ertc_timestamp_enable.

Table 246. ertc_timestamp_enable function

Name	Description
Function name	ertc_timestamp_enable
Function prototype	void ertc_timestamp_enable(confirm_state new_state);
Function description	Enable timestamp
Input parameter 1	new_state: timestamp enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_timestamp_enable(TRUE);
```

5.9.41 ertc_timestamp_get function

The table below describes the function ertc_timestamp_get.

Table 247. ertc_timestamp_get function

Name	Description
Function name	ertc_timestamp_get
Function prototype	void ertc_timestamp_get(ertc_time_type* time);
Function description	Get timestamp
Input parameter 1	time: ertc_time_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

ertc_time_type* time

The ertc_time_type is defined in the "at32f423_ertc.h":

typedef struct

{

```

    uint8_t      year;
    uint8_t      month;
    uint8_t      day;
    uint8_t      hour;
  
```

```

    uint8_t          min;
    uint8_t          sec;
    uint8_t          week;
    ertc_am_pm_type ampm;
} ertc_time_type;

year
Range 0~99

month
Range 1~12

day
Range 1~31

week
Range 1~7

hour
Range 0~23

min
Range 0~59

sec
Range 0~59

ampm
AM/PM in 12-hour format (only for 12-hour format, doesn't care in 24-hour format), including:  

ERTC_AM: AM in 12-hour format  

ERTC_PM: PM in 12-hour format

```

Example:

```
ertc_timestamp_get(&time);
```

5.9.42 ertc_timestamp_sub_second_get function

The table below describes the function ertc_timestamp_sub_second_get.

Table 248. ertc_timestamp_sub_second_get function

Name	Description
Function name	ertc_timestamp_sub_second_get
Function prototype	uint32_t ertc_timestamp_sub_second_get(void);
Function description	Get timestamp subsecond
Input parameter 1	NA
Output parameter	NA
Return value	Return timestamp subsecond
Required preconditions	NA
Called functions	NA

Example:

```
ertc_timestamp_sub_second_get();
```

5.9.43 ertc_tamper_1_pin_select function

The table below describes the function ertc_tamper_1_pin_select.

Table 249. ertc_tamper_1_pin_select function

Name	Description
Function name	ertc_tamper_1_pin_select
Function prototype	void ertc_tamper_1_pin_select(ertc_pin_select_type pin);
Function description	Tamper detection 1 pin selection
Input parameter 1	pin: Tamper detection pin Refer to the following "pin" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

pin

Tamper detection pin

ERTC_PIN_PC13: PC13 is selected as a tamper detection pin

ERTC_PIN_PA0: PA0 is selected as a tamper detection pin

Example:

```
ertc_tamper_1_pin_select(ERTC_PIN_PC13);
```

5.9.44 ertc_tamper_pull_up_enable function

The table below describes the function ertc_tamper_pull_up_enable.

Table 250. ertc_tamper_pull_up_enable function

Name	Description
Function name	ertc_tamper_pull_up_enable
Function prototype	void ertc_tamper_pull_up_enable(confirm_state new_state);
Function description	Enable tamper pin pull-up resistor
Input parameter 1	new_state: tamper pin pull-up resistor enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_tamper_pull_up_enable(TRUE);
```

5.9.45 ertc_tamper_purge_set function

The table below describes the function ertc_tamper_purge_set.

Table 251. ertc_tamper_purge_set function

Name	Description
Function name	ertc_tamper_purge_set
Function prototype	void ertc_tamper_purge_set(ertc_tamper_purge_type purge);
Function description	Set tamper pin purge time. This setting is needed only when the tamper pull-up resistor is enabled through the function ertc_tamper_pull_up_enable.
Input parameter 1	purge: tamper pin purge time Refer to the following “purge” descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

purge

Tamper pin purge time

- ERTC_TAMPER_PR_1_ERTCCLK: One ERTC_CLK cycle
- ERTC_TAMPER_PR_2_ERTCCLK: Two ERTC_CLK cycles
- ERTC_TAMPER_PR_4_ERTCCLK: Four ERTC_CLK cycles
- ERTC_TAMPER_PR_8_ERTCCLK: Eight ERTC_CLK cycles

Example:

```
ertc_tamper_purge_set(ERTC_TAMPER_PR_2_ERTCCLK);
```

5.9.46 ertc_tamper_filter_set function

The table below describes the function ertc_tamper_filter_set.

Table 252. ertc_tamper_filter_set function

Name	Description
Function name	ertc_tamper_filter_set
Function prototype	void ertc_tamper_filter_set(ertc_tamper_filter_type filter);
Function description	Set tamper filtering time
Input parameter 1	filter: tamper filtering time Refer to the following “filter” descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

filter

Set tamper filtering time

ERTC_TAMPER_FILTER_DISABLE:

No filtering

ERTC_TAMPER_FILTER_2:

Tamper event is considered to have occur after two valid consecutive sampling

ERTC_TAMPER_FILTER_4:

Tamper event is considered to have occur after four valid consecutive sampling

ERTC_TAMPER_FILTER_8:

Tamper event is considered to have occur after eight valid consecutive sampling

Example:

```
ertc_tamper_filter_set(ERTC_TAMPER_FILTER_2);
```

5.9.47 ertc_tamper_detect_freq_set function

The table below describes the function ertc_tamper_detect_freq_set.

Table 253. ertc_tamper_detect_freq_set function

Name	Description
Function name	ertc_tamper_detect_freq_set
Function prototype	void ertc_tamper_detect_freq_set(ertc_tamper_detect_freq_type freq);
Function description	Set tamper detection frequency
Input parameter 1	freq: tamper detection frequency Refer to the following "freq" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

freq

Select tamper detection frequency

ERTC_TAMPER_FREQ_DIV_32768: ERTC_CLK / 32768
ERTC_TAMPER_FREQ_DIV_16384: ERTC_CLK / 16384
ERTC_TAMPER_FREQ_DIV_8192: ERTC_CLK / 8192
ERTC_TAMPER_FREQ_DIV_4096: ERTC_CLK / 4096
ERTC_TAMPER_FREQ_DIV_2048: ERTC_CLK / 2048
ERTC_TAMPER_FREQ_DIV_1024: ERTC_CLK / 1024
ERTC_TAMPER_FREQ_DIV_512: ERTC_CLK / 512
ERTC_TAMPER_FREQ_DIV_256: ERTC_CLK / 256

Example:

```
ertc_tamper_detect_freq_set(ERTC_TAMPER_FREQ_DIV_512);
```

5.9.48 ertc_tamper_valid_edge_set function

The table below describes the function ertc_tamper_valid_edge_set.

Table 254. ertc_tamper_valid_edge_set function

Name	Description
Function name	ertc_tamper_valid_edge_set
Function prototype	void ertc_tamper_valid_edge_set(ertc_tamper_select_type tamper_x, ertc_tamper_valid_edge_type trigger);
Function description	Set tamper detection valid edge
Input parameter 1	tamper_x: tamper selection Refer to the following “tamper_x” descriptions for details.
Input parameter 2	trigger: tamper detection valid edge Refer to the following “trigger” descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tamper_x

Tamper selection

ERTC_TAMPER_1: Tamper detection 1

ERTC_TAMPER_2: Tamper detection 2

trigger

Tamper detection valid edge selection

ERTC_TAMPER_EDGE_RISING: Rising edge

ERTC_TAMPER_EDGE_FALLING: Falling edge

ERTC_TAMPER_EDGE_LOW: Low level

ERTC_TAMPER_EDGE_HIGH: High level

Example:

```
ertc_tamper_valid_edge_set(ERTC_TAMPER_1, ERTC_TAMPER_EDGE_RISING);
```

5.9.49 ertc_tamper_timestamp_enable function

The table below describes the function ertc_tamper_timestamp_enable.

Table 255. ertc_tamper_timestamp_enable function

Name	Description
Function name	ertc_tamper_timestamp_enable
Function prototype	void ertc_tamper_timestamp_enable(confirm_state new_state);
Function description	Enable timestamp when a tamper event occurred
Input parameter 1	new_state: timestamp feature enable state when a tamper event occurred This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
ertc_tamper_timestamp_enable(TRUE);
```

5.9.50 ertc_tamper_enable function

The table below describes the function ertc_tamper_enable.

Table 256. ertc_tamper_enable function

Name	Description
Function name	ertc_tamper_enable
Function prototype	void ertc_tamper_enable(ertc_tamper_select_type tamper_x, confirm_state new_state);
Function description	Enable tamper detection
Input parameter 1	tamper_x: tamper selection Refer to the following “tamper_x” descriptions for details.
Input parameter 2	new_state: tamper detection enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tamper_x

Tamper selection

ERTC_TAMPER_1: Tamper detection 1

ERTC_TAMPER_2: Tamper detection 2

Example:

```
ertc_tamper_enable(ERTC_TAMPER_1, TRUE);
```

5.9.51 ertc_interrupt_enable function

The table below describes the function ertc_interrupt_enable.

Table 257. ertc_interrupt_enable function

Name	Description
Function name	ertc_interrupt_enable
Function prototype	void ertc_interrupt_enable(uint32_t source, confirm_state new_state);
Function description	Interrupt enable
	source: interrupt source to be enabled Refer to the following “source” descriptions for details.
Input parameter 1	new_state: interrupt enable state This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

source

Interrupt source to be enabled

ERTC_TP_INT: Tamper detection interrupt

ERTC_ALA_INT: Alarm A interrupt

ERTC_ALB_INT: Alarm B interrupt

ERTC_WAT_INT: Wakeup timer interrupt

ERTC_TS_INT: Time stamp interrupt

Example:

<code>ertc_interrupt_enable(ERTC_TP_INT, TRUE);</code>
--

5.9.52 ertc_interrupt_get function

The table below describes the function ertc_interrupt_get.

Table 258. ertc_interrupt_get function

Name	Description
Function name	ertc_interrupt_get
Function prototype	<code>flag_status ertc_interrupt_get(uint32_t source);</code>
Function description	Get interrupt enable state
Input parameter 1	source: interrupt source Refer to the following "source" descriptions for details.
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

source

Interrupt source

ERTC_TP_INT: Tamper detection interrupt

ERTC_ALA_INT: Alarm A interrupt

ERTC_ALB_INT: Alarm B interrupt

ERTC_WAT_INT: Wakeup timer interrupt

ERTC_TS_INT: Time stamp interrupt

Example:

<code>ertc_interrupt_get(ERTC_TP_INT);</code>

5.9.53 ertc_flag_get function

The table below describes the function ertc_flag_get.

Table 259. ertc_flag_get function

Name	Description
Function name	ertc_flag_get
Function prototype	<code>flag_status ertc_flag_get(uint32_t flag);</code>
Function description	Get flag status
Input parameter 1	flag: flag selection Refer to the following "flag" descriptions for details.
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

flag

This bit is used to select a flag. Optional parameters are as follows:

ERTC_ALAWF_FLAG:	Alarm A write enable flag
ERTC_ALBWF_FLAG:	Alarm B write enable flag
ERTC_WATWF_FLAG:	Wakeup timer register write enable flag
ERTC_TADJF_FLAG:	Time adjust flag
ERTC_INITF_FLAG:	Calendar initialization flag
ERTC_UPDF_FLAG:	Calendar update flag
ERTC_IMF_FLAG:	Initialization mode entry flag
ERTC_ALAF_FLAG:	Alarm A flag
ERTC_ALBF_FLAG:	Alarm B flag
ERTC_WATF_FLAG:	Wakeup timer flag
ERTC_TSF_FLAG:	Time stamp flag
ERTC_TSOF_FLAG:	Time stamp overflow flag
ERTC_TP1F_FLAG:	Tamper detection 1 flag
ERTC_TP2F_FLAG:	Tamper detection 2 flag
ERTC_CALUPDF_FLAG:	Calibration value update complete flag

Example:

```
ertc_flag_get(ERTC_TP1F_FLAG);
```

5.9.54 ertc_interrupt_flag_get function

The table below describes the function ertc_interrupt_flag_get.

Table 260. ertc_interrupt_flag_get function

Name	Description
Function name	ertc_interrupt_flag_get
Function prototype	flag_status ertc_interrupt_flag_get(uint32_t flag);
Function description	Get ERTC interrupt flag bit status, and check the corresponding interrupt enable bit
Input parameter 1	flag: flag selection Refer to the "flag" below for details.
Output parameter	NA
Return value	flag_status: SET or RESET
Required preconditions	NA
Called functions	NA

flag

This bit is used to select a flag. Optional parameters are as follows:

ERTC_ALAF_FLAG:	Alarm A flag
ERTC_ALBF_FLAG:	Alarm B flag
ERTC_WATF_FLAG:	Wakeup timer flag
ERTC_TSF_FLAG:	Time stamp flag
ERTC_TSOF_FLAG:	Time stamp overflow flag
ERTC_TP1F_FLAG:	Tamper detection 1 flag
ERTC_TP2F_FLAG:	Tamper detection 2 flag

Example:

```
ertc_interrupt_flag_get(ERTC_TP1F_FLAG);
```

5.9.55 ertc_flag_clear function

The table below describes the function ertc_flag_clear.

Table 261. ertc_flag_clear function

Name	Description
Function name	ertc_flag_clear
Function prototype	void ertc_flag_clear(uint32_t flag);
Function description	Clear flag
Input parameter 1	flag: flag selection Refer to the following "flag" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

flag

This bit is used to select a flag. Optional parameters are as follows:

ERTC_ALAWF_FLAG:	Alarm A write enable flag
ERTC_ALBWF_FLAG:	Alarm B write enable flag
ERTC_WATWF_FLAG:	Wakeup timer register write enable flag
ERTC_TADJF_FLAG:	Time adjust flag
ERTC_INITF_FLAG:	Calendar initialization flag
ERTC_UPDF_FLAG:	Calendar update flag
ERTC_IMF_FLAG:	Initialization mode entry flag
ERTC_ALAF_FLAG:	Alarm A flag
ERTC_ALBF_FLAG:	Alarm B flag
ERTC_WATF_FLAG:	Wakeup timer flag
ERTC_TSOF_FLAG:	Time stamp flag
ERTC_TSOF_FLAG:	Time stamp overflow flag
ERTC_TP1F_FLAG:	Tamper detection 1 flag
ERTC_TP2F_FLAG:	Tamper detection 2 flag
ERTC_CALUPDF_FLAG:	Calibration value update complete flag

Example:

```
ertc_flag_clear(ERTC_TP1F_FLAG);
```

5.9.56 ertc_bpr_data_write function

The table below describes the function ertc_bpr_data_write.

Table 262. ertc_bpr_data_write function

Name	Description
Function name	ertc_bpr_data_write
Function prototype	void ertc_bpr_data_write(ertc_dt_type dt, uint32_t data);
Function description	Write data to BPR register (battery powered data register)
Input parameter 1	dt: data register Refer to the following "dt" descriptions for details.
Input parameter 1	data: 32-bit data

Name	Description
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dt

Data register

ERTC_DT1: Data register 1

ERTC_DT2: Data register 2

ERTC_DT19: Data register 19

ERTC_DT20: Data register 20

Example:

```
ertc_bpr_data_write(ERTC_DT1, 0x12345678);
```

5.9.57 ertc_bpr_data_read function

The table below describes the function ertc_bpr_data_read.

Table 263. ertc_bpr_data_read function

Name	Description
Function name	ertc_bpr_data_read
Function prototype	uint32_t ertc_bpr_data_read(ertc_dt_type dt);
Function description	Read data from BPR register (battery powered data register)
Input parameter 1	dt: data register Refer to the following "dt" descriptions for details.
Output parameter	NA
Return value	Data from BPR register
Required preconditions	NA
Called functions	NA

dt

Data register

ERTC_DT1: Data register 1

ERTC_DT2: Data register 2

...

ERTC_DT19: Data register19

ERTC_DT20: Data register 20

Example:

```
ertc_bpr_data_read(ERTC_DT1);
```

5.10 External interrupt/event controller (EXINT)

The EXINT register structure exint_type is defined in the “at32f423_exint.h”:

```
/*
 * @brief type define exint register all
 */
typedef struct
{
    ...
} exint_type;
```

The table below gives a list of the EXINT registers:

Table 264. Summary of EXINT registers

Register	Description
inten	Interrupt enable register
evten	Event enable register
polcfg1	Polarity configuration register 1
polcfg2	Polarity configuration register 2
swtrg	Software trigger register
intsts	Interrupt status register

The table below gives a list of EXINT library functions.

Table 265. Summary of EXINT library functions

Function name	Description
exint_reset	Reset all EXINT registers to their reset values
exint_default_para_init	Configure the EXINT initial structure with the initial value
exint_init	Initialize EXINT
exint_flag_clear	Clear the selected EXINT interrupt flag
exint_flag_get	Read the selected EXINT flag
exint_interrupt_flag_get	Get the selected EXINT interrupt flag status
exint_software_interrupt_event_generate	Software interrupt event generation
exint_interrupt_enable	Enable the selected EXINT interrupt
exint_event_enable	Enable the selected EXINT event

5.10.1 exint_reset function

The table below describes the function exint_reset.

Table 266. exint_reset function

Name	Description
Function name	exint_reset
Function prototype	void exint_reset(void);
Function description	Reset all EXINT registers to their reset values.
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	crm_periph_reset();

Example:

```
exint_reset();
```

5.10.2 exint_default_para_init function

The table below describes the function exint_default_para_init.

Table 267. exint_default_para_init function

Name	Description
Function name	exint_default_para_init
Function prototype	void exint_default_para_init(exint_init_type *exint_struct);
Function description	Configure the EXINT initial structure with the initiali value
Input parameter 1	exint_struct: exint_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of exint_init_type before starting.
Called functions	NA

Example:

```
exint_init_type exint_init_struct;  
exint_default_para_init(&exint_init_struct);
```

5.10.3 exint_init function

The table below describes the function exint_init.

Table 268. exint_init function

Name	Description
Function name	exint_init
Function prototype	void exint_init(exint_init_type *exint_struct);
Function description	Initialize EXINT
Input parameter 1	exint_init_type : exint_init_struct pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of exint_init_type before starting.
Called functions	NA

The exint_init_type is defined in the “at32f423_exint.h”:

```
typedef struct
{
    exint_line_mode_type          line_mode;
    uint32_t                      line_select;
    exint_polarity_config_type   line_polarity;
    confirm_state                 line_enable;
} exint_init_type;
```

line_mode

Select event mode or interrupt mode

EXINT_LINE_INTERRUPT: Interrupt mode

EXINT_LINE_EVENT: Event mode

line_select

Line selection

EXINT_LINE_NONE: No e

EXINT_LINE_0: line0

EXINT_LINE_1: line1

...

EXINT_LINE_18: line18

EXINT_LINE_21: line21

EXINT_LINE_22: line22

EXINT_LINE_23: line23

EXINT_LINE_25: line25

EXINT_LINE_26: line26

EXINT_LINE_28: line28

line_polarity

Trigger edge selection

EXINT_TRIGGER_RISING_EDGE: Rising edge

EXINT_TRIGGER_FALLING_EDGE: Falling edge

EXINT_TRIGGER_BOTH_EDGE: Rising/Falling edge

line_enable

Enable/disable line

FALSE: Disable line

TRUE: Enable line

Example:

```
exint_init_type exint_init_struct;
exint_default_para_init(&exint_init_struct);
exint_init_struct.line_enable = TRUE;
exint_init_struct.line_mode = EXINT_LINE_INTERRUPT;
exint_init_struct.line_select = EXINT_LINE_0;
exint_init_struct.line_polarity = EXINT_TRIGGER_RISING_EDGE;
exint_init(&exint_init_struct);
```

5.10.4 exint_flag_clear function

The table below describes the function exint_flag_clear.

Table 269. exint_flag_clear function

Name	Description
Function name	exint_flag_clear
Function prototype	void exint_flag_clear(uint32_t exint_line);
Function description	Clear the selected EXINT interrupt flag
Input parameter	exint_line: line selection Refer to the line_select for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
exint_flag_clear(EXINT_LINE_0);
```

5.10.5 exint_flag_get function

The table below describes the function exint_flag_get.

Table 270. exint_flag_get function

Name	Description
Function name	exint_flag_get
Function prototype	flag_status exint_flag_get(uint32_t exint_line);
Function description	Get the selected EXINT interrupt flag
Input parameter	exint_line: line selection Refer to line_select for details.
Output parameter	NA
Return value	flag_status: indicates the status of the selected flag This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
flag_status status = RESET;
status = exint_flag_get(EXINT_LINE_0);
```

5.10.6 exint_interrupt_flag_get function

The table below describes the function exint_interrupt_flag_get.

Table 271. exint_interrupt_flag_get function

Name	Description
Function name	exint_interrupt_flag_get
Function prototype	flag_status exint_interrupt_flag_get(uint32_t exint_line)
Function description	Get EXINT interrupt flag status
Input parameter	exint_line: line selection Refer to line_select for details.
Output parameter	NA
Return value	flag_status: SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
flag_status status = RESET;
status = exint_interrupt_flag_get (EXINT_LINE_0);
```

5.10.7 exint_software_interrupt_event_generate function

The table below describes the function exint_software_interrupt_event_generate.

Table 272. exint_software_interrupt_event_generate function

Name	Description
Function name	exint_software_interrupt_event_generate
Function prototype	void exint_software_interrupt_event_generate(uint32_t exint_line);
Function description	Generate software interrupt event
Input parameter	exint_line: line selection Refer to line_select for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
exint_software_interrupt_event_generate (EXINT_LINE_0);
```

5.10.8 exint_interrupt_enable function

The table below describes the function exint_interrupt_enable.

Table 273. exint_interrupt_enable function

Name	Description
Function name	exint_interrupt_enable
Function prototype	void exint_interrupt_enable(uint32_t exint_line, confirm_state new_state);
Function description	Enable the selected EXINT interrupt
Input parameter 1	exint_line: line selection Refer to line_select for details.
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
exint_interrupt_enable (EXINT_LINE_0);
```

5.10.9 exint_event_enable function

The table below describes the function exint_event_enable.

Table 274. exint_event_enable function

Name	Description
Function name	exint_event_enable
Function prototype	void exint_event_enable(uint32_t exint_line, confirm_state new_state);
Function description	Enable the selected EXINT event
Input parameter 1	exint_line: line selection Refer to line_select for details.
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
exint_event_enable (EXINT_LINE_0);
```

5.11 Flash memory controller (FLASH)

The FLASH register structure flash_type is defined in the “at32f423_flash.h”:

```
/**  
 * @brief type define flash register all  
 */  
  
typedef struct  
{  
    ...  
} flash_type;
```

The table below gives a list of the FLASH registers

Table 275. Summary of FLASH registers

Register	Description
flash_psr	Flash performance select register
flash_unlock	Flash unlock register
flash_usd_unlock	Flash user system data unlock register
flash_sts	Flash status register
flash_ctrl	Flash control register
flash_addr	Flash address register
flash_usd	User system data register
flash_epps	Erase/program protection status register
slib_sts0	Flash security library status register 0
slib_sts1	Flash security library status register 1
slib_pwd_clr	Flash security library password clear register
slib_misc_sts	Flash security library extra status register
Flash_crc_addr	Flash CRC address register
flash_crc_ctrl	Flash CRC check control register
flash_crc_chkr	Flash CRC check result register
slib_set_pwd	Flash security library password setting register
slib_set_range	Flash security library address setting register
em_slib_set	Extended memory security library setting register
btm_mode_set	Boot memory mode setting register
slib_unlock	Flash security library unlock register

The table below gives a list of FLASH library functions.

Table 276. Summary of FLASH library functions

Function name	Description
flash_flag_get	Get flag status
flash_flag_clear	Clear flag
flash_operation_wait_for	Wait for operation complete (Flash memory bank 1)
flash_operation_status_get	Get Flash operation status
flash_operation_wait_for	Wait for Flash operation complete
flash_unlock	Unlock Flash (Flash memory bank 1 and 2)
flash_lock	Lock Flash (Flash memory bank 1 and 2)
flash_sector_erase	Erase Flash sector
flash_internal_all_erase	Erase internal Flash
flash_user_system_data_erase	Erase user system data
flash_word_program	Flash word programming
flash_halfword_program	Flash half-word programming
flash_byte_program	Flash byte programming
flash_user_system_data_program	User system data programming
flash_epp_set	Erase/programming protection configuration
flash_epp_status_get	Get erase/programming protection status
flash_fap_enable	Flash low level access protection enable
flash_fap_status_get	Get Flash low level access protection status
flash_fap_high_level_enable	Flash high level access protection enable
flash_fap_high_level_status_get	Get Flash high level access protection status
flash(ssb)_set	System configuration byte configuration
flash(ssb)_status_get	Get system configuration byte configuration status
flash_interrupt_enable	Flash interrupt configuration
flash_slib_enable	sLib enable
flash_slib_disable	sLib disable
flash_slib_state_get	Get sLib states
flash_slib_start_sector_get	Get sLib start sector
flash_slib_datastart_sector_get	Get sLib data area start sector
flash_slib_end_sector_get	Get sLib end sector
flash_crc_calibrate	Flash CRC verify
flash_boot_memory_extension_mode_enable	Boot memory is used as an extended Flash memory
flash_extension_memory_slib_enable	Extended Flash memory is used as a security library
flash_extension_memory_slib_state_get	Get the status of extended Flash memory which is used as a security library
flash_em_slib_inststart_sector_get	Get the start page of instruction area of security library in the extended memory

5.11.1 flash_flag_get function

The table below describes the function flash_flag_get.

Table 277. flash_flag_get function

Name	Description
Function name	flash_flag_get
Function prototype	flag_status flash_flag_get(uint32_t flash_flag);
Function description	Get flag status
Input parameter	flash_flag: Flag selection
Output parameter	NA
Return value	flag_status: indicates the flag status Return RESET or SET
Required preconditions	NA
Called functions	NA

flash_flag

Flag selection.

FLASH_OBF_FLAG:	Flash operation busy (bank 1)
FLASH_ODF_FLAG:	Flash operation complete (bank 1)
FLASH_PGMERR_FLAG:	Flash programming error (bank 1)
FLASH_EPPERR_FLAG:	Flash erase error (bank 1)
FLASH_USDERR_FLAG:	User system data area error

Example:

```
flag_status status;  
status = flash_flag_get (FLASH_ODF_FLAG);
```

5.11.2 flash_flag_clear function

The table below describes the function flash_flag_clear.

Table 278. flash_flag_clear function

Name	Description
Function name	flash_flag_clear
Function prototype	void flash_flag_clear(uint32_t flash_flag);
Function description	Clear flag
Input parameter	flash_flag: flag selection
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

flash_flag

Flag selection

FLASH_ODF_FLAG: Flash operation complete

FLASH_PRGMERR_FLAG: Flash programming error

FLASH_EPPERR_FLAG: Flash erase error

Example:

```
flash_flag_clear(FLASH_ODF_FLAG);
```

5.11.3 flash_operation_status_get function

The table below describes the function flash_operation_status_get.

Table 279. flash_operation_status_get function

Name	Description
Function name	flash_operation_status_get
Function prototype	flash_status_type flash_operation_status_get(void);
Function description	Get operation status
Input parameter	NA
Output parameter	NA
Return value	Refer to the flash_status_type for details.
Required preconditions	NA
Called functions	NA

flash_status_type

FLASH_OPERATE_BUSY Operate busy

FLASH_PROGRAM_ERROR Programming error

FLASH_EPP_ERROR Erase/program protection error

FLASH_OPERATE_DONE Operation complete

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
/* check for the flash status */
status = flash_operation_status_get();
```

5.11.4 flash_operation_wait_for function

The table below describes the function `flash_operation_wait_for`.

Table 280. `flash_operation_wait_for` function

Name	Description
Function name	<code>flash_operation_wait_for</code>
Function prototype	<code>flash_status_type flash_operation_wait_for(uint32_t time_out);</code>
Function description	Wait for Flash operation
Input parameter	<code>time_out</code> : wait timeout The timeout value is defined in the <code>flash.h</code> file, refer to <code>flash_time_out</code> for details.
Output parameter	NA
Return value	Refer to <code>flash_status_type</code> for details.
Required preconditions	NA
Called functions	NA

`flash_time_out`

`OPERATION_TIMEOUT` General operation timeout

Example:

```
/* wait for operation to be completed */
status = flash_operation_wait_for(PROGRAMMING_TIMEOUT);
```

5.11.5 flash_unlock function

The table below describes the function `flash_unlock`.

Table 281. `flash_unlock` function

Name	Description
Function name	<code>flash_unlock</code>
Function prototype	<code>void flash_unlock(void);</code>
Function description	Unlock Flash memory controller
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
flash_unlock();
```

5.11.6 flash_lock function

The table below describes the function flash_lock.

Table 282. flash_lock function

Name	Description
Function name	flash_lock
Function prototype	void flash_lock(void);
Function description	Lock Flash memory controller
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
flash_lock();
```

5.11.7 flash_sector_erase function

The table below describes the function flash_sector_erase.

Table 283. flash_sector_erase function

Name	Description
Function name	flash_sector_erase
Function prototype	flash_status_type flash_sector_erase(uint32_t sector_address);
Function description	Erase data in the selected Flash sector address
Input parameter	sector_address: select the Flash sector address to be erased, usually Flash sector start address
Output parameter	NA
Return value	Refer to flash_status_type for details.
Required preconditions	NA
Called functions	NA

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
flash_unlock();
status = flash_sector_erase(0x08001000);
```

5.11.8 flash_internal_all_erase function

The table below describes the function flash_internal_all_erase.

Table 284. flash_internal_all_erase function

Name	Description
Function name	flash_internal_all_erase
Function prototype	flash_status_type flash_internal_all_erase(void);
Function description	Erase internal Flash data
Input parameter	NA
Output parameter	NA
Return value	Refer to flash_status_type for details.

Name	Description
Required preconditions	NA
Called functions	NA

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
flash_unlock();
status = flash_internal_all_erase();
```

5.11.9 flash_user_system_data_erase function

The table below describes the function `flash_user_system_data_erase`.

Table 285. `flash_user_system_data_erase` function

Name	Description
Function name	<code>flash_user_system_data_erase</code>
Function prototype	<code>flash_status_type flash_user_system_data_erase(void);</code>
Function description	Erase user system data
Input parameter	NA
Output parameter	NA
Return value	Refer to flash_status_type for details.
Required preconditions	NA
Called functions	NA

Note: As this function remains in FAP state, it only erases data except FAP in the user system data area.

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
flash_unlock();
status = flash_user_system_data_erase();
```

5.11.10 flash_word_program function

The table below describes the function `flash_word_program`.

Table 286. `flash_word_program` function

Name	Description
Function name	<code>flash_word_program</code>
Function prototype	<code>flash_status_type flash_word_program(uint32_t address, uint32_t data);</code>
Function description	Write one word data to a given address
Input parameter 1	Address: programmed address, word-aligned
Input parameter 2	Data: programmed data
Output parameter	NA
Return value	Refer to flash_status_type for details.
Required preconditions	The programming operation can be allowed only when data in the address are all 0xFF
Called functions	NA

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
uint32_t i;
flash_unlock();
```

```

status = flash_sector_erase(0x08001000);
if(status == FLASH_OPERATE_DONE)
{
    /* program 256 words */
    for(i = 0; i < 256; i++)
    {
        status = flash_word_program(0x08001000 + i*4, i);
    }
}

```

5.11.11 flash_halfword_program function

The table below describes the function flash_halfword_program.

Table 287. flash_halfword_program function

Name	Description
Function name	flash_halfword_program
Function prototype	flash_status_type flash_halfword_program(uint32_t address, uint16_t data);
Function description	Write a half-word data to a given address
Input parameter 1	Address: programmed address, half-word-aligned
Input parameter 2	Data: programmed data
Output parameter	NA
Return value	Refer to flash_status_type for details.
Required preconditions	The programming operation can be allowed only when data in the address are all 0xFF
Called functions	NA

Example:

```

flash_status_type status = FLASH_OPERATE_DONE;
uint32_t i;
flash_unlock();
status = flash_sector_erase(0x08001000);
if(status == FLASH_OPERATE_DONE)
{
    /* program 256 halfwords */
    for(i = 0; i < 256; i++)
    {
        status = flash_halfword_program(0x08001000 + i*2, (uint16_t)i);
    }
}

```

5.11.12 flash_byte_program function

The table below describes the function flash_byte_program.

Table 288. flash_byte_program function

Name	Description
Function name	flash_byte_program
Function prototype	flash_status_type flash_byte_program(uint32_t address, uint8_t data);
Function description	Program a byte data to a given address
Input parameter 1	Address: programmed address
Input parameter 2	Data: programmed data
Output parameter	NA
Return value	Refer to flash_status_type for details.
Required preconditions	The programming operation can be allowed only when data in the address are all 0xFF
Called functions	NA

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
uint32_t i;
flash_unlock();
status = flash_sector_erase(0x08001000);
if(status = FLASH_OPERATE_DONE)
{
    /* program 256 bytes */
    for(i = 0; i < 256; i++)
    {
        status = flash_byte_program(0x08001000 + i*2, (uint8_t)i);
    }
}
```

5.11.13 flash_user_system_data_program function

The table below describes the function flash_user_system_data_program.

Table 289. flash_user_system_data_program function

Name	Description
Function name	flash_user_system_data_program
Function prototype	flash_status_type flash_user_system_data_program (uint32_t address, uint8_t data);
Function description	Program a byte data to a given address in the user system data area
Input parameter 1	Address: programmed address
Input parameter 2	Data: programmed data
Output parameter	NA
Return value	Refer to flash_status_type for details.
Required preconditions	The programming operation can be allowed only when data and its inverse data in the user system data area are all 0xFF
Called functions	NA

Example:

```

flash_status_type status = FLASH_OPERATE_DONE;
flash_unlock();
status = flash_user_system_data_erase();
if(status = FLASH_OPERATE_DONE)
{
    /* program user system data */
    status = flash_user_system_data_program(0x1FFF804, 0x55);
}

```

5.11.14 flash_epp_set function

The table below describes the function `flash_epp_set`.

Table 290. `flash_epp_set` function

Name	Description
Function name	<code>flash_epp_set</code>
Function prototype	<code>flash_status_type flash_epp_set(uint32_t *sector_bits);</code>
Function description	Enable erase programming protection
Input parameter	*sector_bits: Erase programming protection sector address pointer. Each bit in bits 30~0 protects 4KB sectors, bit 31 protects 256KB of Flash memory from sector 62 to sector 63, as well; as 128KB of Flash memory from sector 124 to sector 127, the extended Flash memory. Setting this bit to 1 enables sector protection.
Output parameter	NA
Return value	Return operation status. Refer to flash_status_type for details.
Required preconditions	NA
Called functions	NA

Example:

```

flash_status_type status = FLASH_OPERATE_DONE;
uint32_t epp_val[1];
flash_unlock();
status = flash_user_system_data_erase();
if(status = FLASH_OPERATE_DONE)
{
    epp_val[0] = 0x00000001;
    /* program epp */
    status = flash_epp_set(epp_val);
}

```

5.11.15 flash_epp_status_get function

The table below describes the function flash_epp_status_get.

Table 291. flash_epp_status_get function

Name	Description
Function name	flash_epp_status_get
Function prototype	void flash_epp_status_get(uint32_t *sector_bits);
Function description	Get the status of erase programming protection
Input parameter	NA
Output parameter	*sector_bits: Erase programming protection sector address pointer. Each bit in bits 30~0 protects 4KB sectors, bit 31 protects 256KB of Flash memory from sector 62 to sector 63, as well as 128KB of Flash memory from sector 124 to sector 127, the extended Flash memory. Setting this bit to 1 enables sector protection.
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
uint32_t epp_val[1];
/* get epp status */
flash_epp_status_get(epp_val);
```

5.11.16 flash_fap_enable function

The table below describes the function flash_fap_enable.

Table 292. flash_fap_enable function

Name	Description
Function name	flash_fap_enable
Function prototype	flash_status_type flash_fap_enable(confirm_state new_state);
Function description	Enable Flash low level access protection
Input parameter	new_state: Flash access protection status This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	Refer to flash_status_type for details.
Required preconditions	NA
Called functions	NA

Note: This function will erase the whole user system data area. If there were data programmed in the user system data area before calling this function, they have to be re-programmed after calling this function.

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
flash_unlock();
status = flash_fap_enable(TRUE);
```

5.11.17 flash_fap_status_get function

The table below describes the function flash_fap_status_get.

Table 293. flash_fap_status_get function

Name	Description
Function name	flash_fap_status_get
Function prototype	flag_status flash_fap_status_get(void);
Function description	Get the status of Flash low level access protection
Input parameter	NA
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
flag_status status;
status = flash_fap_status_get();
```

5.11.18 flash_fap_high_level_enable

The table below describes the function flash_fap_high_level_enable.

Table 294. flash_fap_high_level_enable function

Name	Description
Function name	flash_fap_high_level_enable
Function prototype	flash_status_type flash_fap_high_level_enable (void);
Function description	Enable Flash high level access protection
Input parameter	NA
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
flash_unlock();
status = flash_fap_high_level_enable (void);
```

5.11.19 flash_fap_high_level_status_get

The table below describes the function flash_fap_high_level_status_get.

Table 295. flash_fap_high_level_status_get function

Name	Description
Function name	flash_fap_high_level_status_get
Function prototype	flash_status_flash_fap_high_level_status_get (void);
Function description	Get Flash high level access protection status
Input parameter	NA
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
flag_status status;
status = flash_fap_high_level_status_get();
```

5.11.20 flash(ssb)_set function

The table below describes the function flash(ssb)_set.

Table 296. flash(ssb)_set function

Name	Description
Function name	flash_ssbb_set
Function prototype	flash_status_type flash_ssbb_set(uint8_t usd_ssbb);
Function description	Configure system setting bytes
Input parameter	usd_ssbb: system setting byte value is a combination of the selected data from all data group, refer to ssb_data_define for details.
Output parameter	NA
Return value	Return operation status, refer to the flash_status_type for details.
Required preconditions	NA
Called functions	NA

ssb_data_define

type 1:

USD_WDT_ATO_DISABLE:	Watchdog auto-start disabled
USD_WDT_ATO_ENABLE:	Watchdog auto-start enabled

type 2:

USD_DEPSLP_NO_RST:	No reset occurred when entering Deepsleep mode
USD_DEPSLP_RST:	Reset occurred when entering Deepsleep mode

type 3:

USD_STDBY_NO_RST:	No reset occurred when entering Standby mode
USD_STDBY_RST:	Reset occurred when entering Standby mode

type 4:

USD_BOOT1_LOW	BOOT1 LOW
USD_BOOT1_HIGH	BOOT1 HIGH

type 5:

USD_DEPSLP_WDT_CONTINUE WDT continues counting in Deepsleep mode

USD_DEPSLP_WDT_STOP WDT stops counting in Deepsleep mode

type 6:

USD_STDBY_WDT_CONTINUE WDT continues counting in Standby mode

USD_STDBY_WDT_STOP WDT stops counting in Standby mode

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
flash_unlock();
status = flash_user_system_data_erase();
if(status == FLASH_OPERATE_DONE)
{
    status = flash_ssb_set(USD_WDT_ATO_DISABLE | USD_DEPSLP_NO_RST | USD_STDBY_RST |
USD_BOOT1_LOW);
}
```

5.11.21 flash_ssb_status_get function

The table below describes the function flash_ssb_status_get.

Table 297. flash_ssb_status_get function

Name	Description
Function name	flash_ssb_status_get
Function prototype	uint8_t flash_ssb_status_get(void);
Function description	Get the status of system setting bytes
Input parameter	NA
Output parameter	NA
Return value	Return system setting byte value, refer to ssb_data_define for details.
Required preconditions	NA
Called functions	NA

Example:

```
uint8_t ssb_val;
ssb_val = flash_ssb_status_get();
```

5.11.22 flash_interrupt_enable function

The table below describes the function flash_interrupt_enable.

Table 298. flash_interrupt_enable function

Name	Description
Function name	flash_interrupt_enable
Function prototype	void flash_interrupt_enable(uint32_t flash_int, confirm_state new_state);
Function description	Enable Flash interrupts
Input parameter 1	flash_int: Flash interrupt type. Refer to flash_interrupt_type for details.
Input parameter 2	new_state: interrupt status This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA

Name	Description
Called functions	NA

flash_interrupt_type

- FLASH_ERR_INT: Flash error interrupt
 FLASH_ODF_INT: Flash operation complete interrupt

Example:

```
flash_interrupt_enable(FLASH_ERR_INT | FLASH_ODF_INT, TRUE);
```

5.11.23 flash_slib_enable function

The table below describes the function `flash_slib_enable`.

Table 299. `flash_slib_enable` function

Name	Description
Function name	<code>flash_slib_enable</code>
Function prototype	<code>flash_status_type flash_slib_enable(uint32_t pwd, uint16_t start_sector, uint16_t inst_start_sector, uint16_t end_sector);</code>
Function description	Enable security library (sLib) and its address range
Input parameter 1	Pwd: sLib password. The sLib data are saved as ciphertext, associated with encrypted computing. A correct password is entered in order to unlock encryption.
Input parameter 2	start_sector: sLib start sector number
Input parameter 3	inst_start_sector: sLib data area instruction start sector number
Input parameter 4	end_sector: sLib end sector number
Output parameter	NA
Return value	Refer to flash_status_type for details.
Required preconditions	NA
Called functions	NA

Example:

```
flash_status_type status = FLASH_OPERATE_DONE;
status = flash_slib_enable(0x12345678, 0x04, 0x05, 0x06);
```

5.11.24 flash_slib_disable function

The table below describes the function `flash_slib_disable`.

Table 300. `flash_slib_disable` function

Name	Description
Function name	<code>flash_slib_disable</code>
Function prototype	<code>error_status flash_slib_disable(uint32_t pwd);</code>
Function description	Disable security library (sLib)
Input parameter	Pwd: sLib password. it must be entered correctly, otherwise it is not allowed to enter until reset.
Output parameter	NA
Return value	Return error status This parameter can be ERROE or SUCCESS.
Required preconditions	NA
Called functions	NA

Note: Successful calling of this function will erase the whole internal Flash memory.

Example:

```
error_status status;
status = flash_slib_disable(0x12345678);
```

5.11.25 flash_slib_state_get function

The table below describes the function flash_slib_state_get.

Table 301. flash_slib_state_get function

Name	Description
Function name	flash_slib_state_get
Function prototype	flag_status flash_slib_state_get(void);
Function description	Get the status of sLib
Input parameter	NA
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
flag_status status;
status = flash_slib_state_get();
```

5.11.26 flash_slib_start_sector_get function

The table below describes the function flash_slib_start_sector_get.

Table 302. flash_slib_start_sector_get function

Name	Description
Function name	flash_slib_start_sector_get
Function prototype	uint16_t flash_slib_start_sector_get(void);
Function description	Get the start sector number of sLib
Input parameter	NA
Output parameter	NA
Return value	Return the start sector number of sLib
Required preconditions	NA
Called functions	NA

Example:

```
uint16_t num;
num = flash_slib_start_sector_get();
```

5.11.27 flash_slib_inststart_sector_get function

The table below describes the function flash_slib_inststart_sector_get.

Table 303. flash_slib_inststart_sector_get function

Name	Description
Function name	flash_slib_inststart_sector_get
Function prototype	uint16_t flash_slib_inststart_sector_get(void);
Function description	Get the start sector number of sLib instruction area
Input parameter	NA
Output parameter	NA
Return value	Return the start sector number of sLib instruction area
Required preconditions	NA
Called functions	NA

Example:

```
uint16_t num;
num = flash_slib_inststart_sector_get();
```

5.11.28 flash_slib_end_sector_get function

The table below describes the function flash_slib_end_sector_get.

Table 304. flash_slib_end_sector_get function

Name	Description
Function name	flash_slib_end_sector_get
Function prototype	uint16_t flash_slib_end_sector_get(void);
Function description	Get the end sector number of sLib
Input parameter	NA
Output parameter	NA
Return value	Return the end sector number of sLib
Required preconditions	NA
Called functions	NA

Example:

```
uint16_t num;
num = flash_slib_end_sector_get();
```

5.11.29 flash_crc_calibrate function

The table below describes the function flash_crc_calibrate.

Table 305. flash_crc_calibrate function

Name	Description
Function name	flash_crc_calibrate
Function prototype	uint32_t flash_crc_calibrate(uint32_t start_sector, uint32_t sector_cnt);
Function description	Enable Flash CRC check
Input parameter 1	start_addr: CRC check start address
Input parameter 2	sector_cnt: CRC check sector count
Output parameter	NA

Name	Description
Return value	Return CRC calculation result
Required preconditions	NA
Called functions	NA

Note: The sector set to go through CRC check is only allowed to be on a single area, rather than on both security library and common area.

Example:

```
uint32_t crc_val;
crc_val = flash_crc_calibrate(0, 10);
```

5.11.30 flash_boot_memory_extension_mode_enable

The table describes the flash_boot_memory_extension_mode_enable

Table 306. flash_boot_memory_extension_mode_enable

Name	Description
Function name	flash_boot_memory_extension_mode_enable
Function prototype	void flash_boot_memory_extension_mode_enable (void);
Function description	Boot memory is used as extended Flash memory
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
flash_boot_memory_extension_mode_enable();
```

5.11.31 flash_extension_memory_slib_enable

The table describes the flash_extension_memory_slib_enable

Table 307. flash_extension_memory_slib_enable

Name	Description
Function name	flash_extension_memory_slib_enable
Function prototype	void flash_extension_memory_slib_enable (uint32_t pwd, uint16_t inst_start_sector);
Function description	Extended Flash memory is used as security library
Input parameter	Pwd: sLib password inst_start_sector: the start sector of security library instruction area when extended Flash memory is used as security library
Output parameter	NA
Return value	Operature status, see flash_status_type
Required preconditions	NA
Called functions	NA

Example:

```
flash_extension_memory_slib_enable(0x12345678, 0x04);
```

5.11.32 flash_extension_memory_slib_state_get

The table describes the flash_extension_memory_slib_state_get

Table 308. flash_extension_memory_slib_state_get

Name	Description
Function name	flash_extension_memory_slib_state_get
Function prototype	flag_status flash_extension_memory_slib_state_get (void);
Function description	Get the status of extended Flash memory which is used to store security library code
Input parameter	NA
Output parameter	NA
Return value	flag_status: flag status This value can be SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
flag_status status;
status = flash_extension_memory_slib_state_get();
```

5.11.33 flash_em_slib_inststart_sector_get

The table describes the flash_em_slib_inststart_sector_get

Table 309. flash_em_slib_inststart_sector_get

Name	Description
Function name	flash_em_slib_inststart_sector_get
Function prototype	uint16_t flash_em_slib_inststart_sector_get (void);
Function description	Get the start sector of security library instruction area when an extended Flash memory is used as security library
Input parameter	NA
Output parameter	NA
Return value	Return the start sector of security library instruction area when the extended Flash memory is used as a security library
Required preconditions	NA
Called functions	NA

Example:

```
uint16_t num;
num = flash_em_slib_inststart_sector_get();
```

5.12 General-purpose I/Os and multiplexed I/Os (GPIO/IOMUX)

The GPIO register structure `gpio_type` is defined in the “`at32f423_gpio.h`”:

```
/*
 * @brief type define gpio register all
 */
typedef struct
{
} gpio_type;
```

Table 299 gives a list of the GPIO registers

Table 310. Summary of GPIO registers

Register	Description
cfg	GPIO configuration register
omode	GPIO output mode register
odrvr	GPIO drive capability switch control register
pull	GPIO pull-up/pull-down register
idt	GPIO input register
odt	GPIO output register
scr	GPIO set/clear register
wpr	GPIO write protection register
muxl	GPIO multiplexed function low register
muxh	GPIO multiplexed function high register
clr	GPIO port bit clear register
hdrv	GPIO huge current control register

Table 300 gives a list of GPIO and IOMUX library functions.

Table 311. GPIO and IOMUX library functions

Function name	Description
gpio_reset	GPIO is reset by CRM reset register
gpio_init	Initialize GPIO peripherals
gpio_default_para_init	Initialize GPIO default parameters
gpio_input_data_bit_read	Read GPIO input data bit
gpio_input_data_read	Read GPIO input data
gpio_output_data_bit_read	Read GPIO output data bit
gpio_output_data_read	Read GPIO output data
gpio_bits_set	Set GPIO bits
gpio_bits_reset	Reset GPIO bits
gpio_bits_toggle	Toggle GPIO bits
gpio_bits_write	Write GPIO bits
gpio_port_write	Write GPIO ports
gpio_pin_wp_config	Configure GPIO pin write protection
gpio_pins_huge_driven_config	Configure GPIO huge drive capability

gpio_pin_mux_config	Configure GPIO pin multiplexed function
---------------------	---

5.12.1 gpio_reset function

The table below describes the function gpio_reset.

Table 312. gpio_reset function

Name	Description
Function name	gpio_reset
Function prototype	void gpio_reset(gpio_type *gpio_x);
Function description	GPIO is reset by CRM reset register
Input parameter	gpio_x: Select a GPIO peripheral. GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	crm_periph_reset();

Example:

```
gpio_reset(GPIOA);
```

5.12.2 gpio_init function

The table below describes the function gpio_init.

Table 313. gpio_init function

Name	Description
Function name	gpio_init
Function prototype	void gpio_init(gpio_type *gpio_x, gpio_init_type *gpio_init_struct);
Function description	Initialize GPIO peripherals
Input parameter 1	gpio_x: the selected GPIO peripheral GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Input parameter 2	gpio_init_struct: gpio_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

gpio_init_type structure

The gpio_init_type is defined in the at32f423_gpio.h:

typedef struct

```
{
    uint32_t          gpio_pins;
    gpio_output_type  gpio_out_type;
    gpio_pull_type    gpio_pull;
    gpio_mode_type    gpio_mode;
    gpio_drive_type   gpio_drive_strength;
} gpio_init_type;
```

gpio_pins

Select a GPIO pin.

GPIO_PINS_0:	GPIO pin 0
GPIO_PINS_1:	GPIO pin 1
GPIO_PINS_2:	GPIO pin 2
GPIO_PINS_3:	GPIO pin 3
GPIO_PINS_4:	GPIO pin 4
GPIO_PINS_5:	GPIO pin 5
GPIO_PINS_6:	GPIO pin 6
GPIO_PINS_7:	GPIO pin 7
GPIO_PINS_8:	GPIO pin 8
GPIO_PINS_9:	GPIO pin 9
GPIO_PINS_10:	GPIO pin 10
GPIO_PINS_11:	GPIO pin 11
GPIO_PINS_12:	GPIO pin 12
GPIO_PINS_13:	GPIO pin 13
GPIO_PINS_14:	GPIO pin 14
GPIO_PINS_15:	GPIO pin 15

gpio_out_type

Set GPIO output type.

GPIO_OUTPUT_PUSH_PULL:	GPIO push-pull
------------------------	----------------

GPIO_OUTPUT_OPEN_DRAIN: GPIO open drain

gpio_pull

Set GPIO pull-up or pull-down.

GPIO_PULL_NONE: No GPIO pull-up/pull-down

GPIO_PULL_UP: GPIO pull-up

GPIO_PULL_DOWN: GPIO pull-down

gpio_mode

Set GPIO mode

GPIO_MODE_INPUT: GPIO input mode

GPIO_MODE_OUTPUT: GPIO output mode

GPIO_MODE_MUX: GPIO multiplexed mode

GPIO_MODE_ANALOG: GPIO analog mode

gpio_drive_strength

Set GPIO driver capability.

GPIO_DRIVE_STRENGTH_STRONGER: Strong drive strength

GPIO_DRIVE_STRENGTH_MODERATE: Moderate drive strength

Example:

```
gpio_init_type gpio_init_struct;
gpio_init_struct.gpio_pins = GPIO_PINS_0;
gpio_init_struct.gpio_mode = GPIO_MODE_MUX;
gpio_init_struct.gpio_out_type = GPIO_OUTPUT_PUSH_PULL;
gpio_init_struct.gpio_pull = GPIO_PULL_NONE;
gpio_init_struct.gpio_drive_strength = GPIO_DRIVE_STRENGTH_STRONGER;
gpio_init(GPIOA, &gpio_init_struct);
```

5.12.3 gpio_default_para_init function

The table below describes the function gpio_default_para_init.

Table 314. gpio_default_para_init function

Name	Description
Function name	gpio_default_para_init
Function prototype	void gpio_default_para_init(gpio_init_type *gpio_init_struct);
Function description	Initialize GPIO default parameters
Input parameter	gpio_init_struct: gpio_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

The table below describes the default values of members of the gpio_init_struct.

Table 315. gpio_init_struct default values

Member	Default value
gpio_pins	GPIO_PINS_ALL
gpio_mode	GPIO_MODE_INPUT
gpio_out_type	GPIO_OUTPUT_PUSH_PULL
gpio_pull	GPIO_PULL_NONE
gpio_drive_strength	GPIO_DRIVE_STRENGTH_STRONGER

Example:

```
gpio_init_type gpio_init_struct;
gpio_default_para_init(&gpio_init_struct);
```

5.12.4 gpio_input_data_bit_read function

The table below describes the function gpio_input_data_bit_read.

Table 316. gpio_input_data_bit_read function

Name	Description
Function name	gpio_input_data_bit_read
Function prototype	flag_status gpio_input_data_bit_read(gpio_type *gpio_x, uint16_t pins);
Function description	Read GPIO input port pins
Input parameter 1	gpio_x: the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Input parameter 2	Pins: indicates the GPIO pins, refer to typedef struct { uint32_t gpio_pins; gpio_output_type gpio_out_type; gpio_pull_type gpio_pull; gpio_mode_type gpio_mode; gpio_drive_type gpio_drive_strength; } gpio_init_type; gpio_pins for details.
Output parameter	NA
Return value	Return GPIO input pin status
Required preconditions	NA
Called functions	NA

Example:

```
gpio_input_data_bit_read(GPIOA, GPIO_PINS_0);
```

5.12.5 gpio_input_data_read function

The table below describes the function gpio_input_data_read.

Table 317. gpio_input_data_read function

Name	Description
Function name	gpio_input_data_read
Function prototype	uint16_t gpio_input_data_read(gpio_type *gpio_x);
Function description	Read GPIO input ports
Input parameter	gpio_x: indicates the selected GPIO peripheral. This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF

Name	Description
Output parameter	NA
Return value	Return GPIO input port status
Required preconditions	NA
Called functions	NA

Example:

```
gpio_input_data_read(GPIOA);
```

5.12.6 gpio_output_data_bit_read function

The table below describes the function gpio_output_data_bit_read.

Table 318. gpio_output_data_bit_read function

Name	Description
Function name	gpio_output_data_bit_read
Function prototype	uint16_t gpio_output_data_bit_read(gpio_type *gpio_x);
Function description	Read GPIO output port pin
Input parameter 1	gpio_x: indicates the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Input parameter 2	Pins: indicates the GPIO pins, refer to, refer to typedef struct gpio_pins <pre>{ uint32_t gpio_pins; gpio_output_type gpio_out_type; gpio_pull_type gpio_pull; gpio_mode_type gpio_mode; gpio_drive_type gpio_drive_strength; } gpio_init_type;</pre> gpio_pins for details.
Output parameter	NA
Return value	Return GPIO output pin status
Required preconditions	NA
Called functions	NA

Example:

```
gpio_output_data_bit_read(GPIOA, GPIO_PINS_0);
```

5.12.7 gpio_output_data_read function

The table below describes the function gpio_output_data_read.

Table 319. gpio_output_data_read function

Name	Description
Function name	gpio_output_data_read
Function prototype	uint16_t gpio_output_data_read(gpio_type *gpio_x);
Function description	Read GPIO output port
Input parameter	gpio_x: the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Output parameter	NA
Return value	Read GPIO output port status
Required preconditions	NA
Called functions	NA

Example:

```
gpio_output_data_read(GPIOA);
```

5.12.8 gpio_bits_set function

The table below describes the function gpio_bits_set.

Table 320. gpio_bits_set function

Name	Description
Function name	gpio_bits_set
Function prototype	void gpio_bits_set(gpio_type *gpio_x, uint16_t pins);
Function description	Set GPIO pins
Input parameter 1	gpio_x: indicates the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Input parameter 2	Pins: indicates the GPIO pins, refer to typedef struct <pre>{ uint32_t gpio_pins; gpio_output_type gpio_out_type; gpio_pull_type gpio_pull; gpio_mode_type gpio_mode; gpio_drive_type gpio_drive_strength; } gpio_init_type;</pre> gpio_pins for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
gpio_bits_set(GPIOA, GPIO_PINS_0);
```

5.12.9 gpio_bits_reset function

The table below describes the function gpio_bits_reset.

Table 321. gpio_bits_reset function

Name	Description
Function name	gpio_bits_reset
Function prototype	void gpio_bits_reset(gpio_type *gpio_x, uint16_t pins);
Function description	Reset GPIO pins
Input parameter 1	gpio_x: indicates the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Input parameter 2	Pins: indicates the GPIO pins, refer to typedef struct <pre>{ uint32_t gpio_pins; gpio_output_type gpio_out_type; gpio_pull_type gpio_pull; gpio_mode_type gpio_mode; gpio_drive_type gpio_drive_strength; } gpio_init_type;</pre> gpio_pins for details.
Output parameter	NA

Name	Description
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
gpio_bits_reset(GPIOA, GPIO_PINS_0);
```

5.12.10 gpio_bits_write function

The table below describes the function gpio_bits_write.

Table 322. gpio_bits_write function

Name	Description
Function name	gpio_bits_toggle
Function prototype	void gpio_bits_toggle(gpio_type *gpio_x, uint16_t pins);
Function description	Write GPIO pins
Input parameter 1	gpio_x: indicates the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Input parameter 2	Pins: indicates the GPIO pins, refer to typedef struct <pre>{ uint32_t gpio_pins; gpio_output_type gpio_out_type; gpio_pull_type gpio_pull; gpio_mode_type gpio_mode; gpio_drive_type gpio_drive_strength; } gpio_init_type;</pre> gpio_pins for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
gpio_bits_toggle(GPIOA, GPIO_PINS_0);
```

5.12.11 gpio_bits_write function

The table below describes the function gpio_bits_write.

Table 323. gpio_bits_write function

Name	Description
Function name	gpio_bits_write
Function prototype	void gpio_bits_write(gpio_type *gpio_x, uint16_t pins, confirm_state bit_state);
Function description	Write GPIO pins
Input parameter 1	gpio_x: indicates the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF
Input parameter 2	Pins: indicates the GPIO pins, refer to typedef struct <pre>{ uint32_t gpio_pins; gpio_output_type gpio_out_type; gpio_pull_type gpio_pull; gpio_mode_type gpio_mode; gpio_drive_type gpio_drive_strength; } gpio_init_type;</pre> gpio_pins for details.
Input parameter 3	bit_state: GPIO pin value to be written, it can be 1 (TRUE) or 0 (FALSE)

Name	Description
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
gpio_bits_write(GPIOA, GPIO_PINS_0, TRUE);
```

5.12.12 gpio_port_write function

The table below describes the function gpio_port_write.

Table 324. gpio_port_write function

Name	Description
Function name	gpio_port_write
Function prototype	void gpio_port_write(gpio_type *gpio_x, uint16_t port_value);
Function description	Write GPIO ports
Input parameter 1	gpio_x: indicates the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF, GPIOG, GPIOH
Input parameter 2	port_value: indicates the port value to write This parameter can be 0x0000~0xFFFF.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
gpio_port_write(GPIOA, 0xFFFF);
```

5.12.13 gpio_pin_wp_config function

The table below describes the function gpio_pin_wp_config.

Table 325. gpio_pin_wp_config function

Name	Description
Function name	gpio_pin_wp_config
Function prototype	void gpio_pin_wp_config(gpio_type *gpio_x, uint16_t pins);
Function description	Configure GPIO pin write protection
Input parameter 1	gpio_x: indicates the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF, GPIOG, GPIOH
Input parameter 2	Pins: indicates the GPIO pins, refer to typedef struct { uint32_t gpio_pins; gpio_output_type gpio_out_type; gpio_pull_type gpio_pull; gpio_mode_type gpio_mode; gpio_drive_type gpio_drive_strength; } gpio_init_type; gpio_pins for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
gpio_pin_wp_config(GPIOA, GPIO_PINS_0);
```

5.12.14 gpio_pins_huge_driven_config function

The table below describes the function gpio_pins_huge_driven_config.

Table 326. gpio_pins_huge_driven_config function

Name	Description
Function name	gpio_pins_huge_driven_config
Function prototype	void gpio_pins_huge_driven_config(gpio_type *gpio_x, uint16_t pins, confirm_state new_state);
Function description	Configure huge drive capability of GPIO pins
Input parameter 1	gpio_x: indicates the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF, GPIOG, GPIOH
Input parameter 2	Pins: refer to the <i>typedef struct</i> <pre>{ uint32_t gpio_pins; gpio_output_type gpio_out_type; gpio_pull_type gpio_pull; gpio_mode_type gpio_mode; gpio_drive_type gpio_drive_strength; } gpio_init_type;</pre> gpio_pins for details
Input parameter 3	new_state: Enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
gpio_pins_huge_driven_config(GPIOA, GPIO_PINS_0, TRUE);
```

5.12.15 gpio_pin_mux_config function

The table below describes the function gpio_pin_mux_config.

Table 327. gpio_pin_mux_config function

Name	Description
Function name	gpio_pin_mux_config
Function prototype	void gpio_pin_mux_config(gpio_type *gpio_x, gpio_pins_source_type gpio_pin_source, gpio_mux_sel_type gpio_mux);
Function description	Configure GPIO pin multiplexed function
Input parameter 1	gpio_x: the selected GPIO peripheral This parameter can be GPIOA, GPIOB, GPIOC, GPIOD, GPIOE, GPIOF, GPIOG, GPIOH
Input parameter 2	gpio_pin_source: GPIO pin to be configured
Input parameter 3	gpio_mux: IOMUX index to be configured
Output parameter	NA
Return value	NA
Required preconditions	NA

Name	Description
Called functions	NA

gpio_pin_source

Set GPIO pins

GPIO_PINS_SOURCE0:	GPIO pin 0
GPIO_PINS_SOURCE1:	GPIO pin 1
GPIO_PINS_SOURCE2:	GPIO pin 2
GPIO_PINS_SOURCE3:	GPIO pin 3
GPIO_PINS_SOURCE4:	GPIO pin 4
GPIO_PINS_SOURCE5:	GPIO pin 5
GPIO_PINS_SOURCE6:	GPIO pin 6
GPIO_PINS_SOURCE7:	GPIO pin 7
GPIO_PINS_SOURCE8:	GPIO pin 8
GPIO_PINS_SOURCE9:	GPIO pin 9
GPIO_PINS_SOURCE10:	GPIO pin 10
GPIO_PINS_SOURCE11:	GPIO pin 11
GPIO_PINS_SOURCE12:	GPIO pin 12
GPIO_PINS_SOURCE13:	GPIO pin 13
GPIO_PINS_SOURCE14:	GPIO pin 14
GPIO_PINS_SOURCE15:	GPIO pin 15

gpio_mux

Select IOMUX index

GPIO_MUX_0
GPIO_MUX_1
GPIO_MUX_2
GPIO_MUX_3
GPIO_MUX_4
GPIO_MUX_5
GPIO_MUX_6
GPIO_MUX_7
GPIO_MUX_8
GPIO_MUX_9
GPIO_MUX_10
GPIO_MUX_11
GPIO_MUX_12
GPIO_MUX_13
GPIO_MUX_14
GPIO_MUX_15

Example:

```
gpio_pin_mux_config(GPIOA, GPIO_PINS_SOURCE0, GPIO_MUX_0);
```

5.13 I2C interfaces

The I2C register structure i2c_type is defined in the “at32f423_i2c.h”:

```
/*
 * @brief type define i2c register all
 */
typedef struct
{
} i2c_type;
```

The table below gives a list of the I2C registers

Table 328. Summary of I2C register

Register	Description
ctrl1	I2C Control register 1
ctrl2	I2C Control register 2
oaddr1	I2C Own address register 1
oaddr2	I2C Own address register 2
clkctrl	Timing register
timeout	Timeout register
sts	Status register
clr	Status clear register
pec	PEC register
rxdt	Receive data register
txdt	Transmit data register

The table below gives a list of I2C library functions.

Table 329. Summary of I2C library functions

Function name	Description
i2c_reset	I2C peripheral reset
i2c_init	Set I2C bus speed
i2c_own_address1_set	Set I2C own address 1
i2c_own_address2_set	Set I2C own address 2
i2c_own_address2_enable	Enable I2C own address 2
i2c_smbus_enable	Enable Smbus mode
i2c_enable	Enable I2C
i2c_clock_stretch_enable	Enable clock stretching capability
i2c_ack_enable	Enable ACK response
i2c_addr10_mode_enable	Enable master transmit 10-bit address mode
i2c_transfer_addr_set	Set master transfer address (slave address)
i2c_transfer_addr_get	Get slave address from master
i2c_transfer_dir_set	Set master data transfer direction
i2c_transfer_dir_get	Slave gets data transfer direction
i2c_matched_addr_get	Slave gets address match value

i2c_auto_stop_enable	Enable auto transmission stop conditions
i2c_reload_enable	Enable transmitted data reload mode
i2c_cnt_set	Set number of data to send/receive
i2c_addr10_header_enable	Enable 10-bit address header read timing
i2c_general_call_enable	Enable general call (broadcast address enable)
i2c_smbus_alert_set	Set SMBus alert pin level
i2c_slave_data_ctrl_enable	Enable slave single-byte receive control
i2c_pec_calculate_enable	Enable PEC calculation
i2c_pec_transmit_enable	Enable PEC transmit
i2c_pec_value_get	Get current PEC value
i2c_timeout_set	Set clock level timeout detection
i2c_timeout_detct_set	Set clock level timeout detect mode
i2c_timeout_enable	Enable clock level timeout detect
i2c_ext_timeout_set	Set accumulated clock stretching timeout
i2c_ext_timeout_enable	Enable accumulated clock stretching timeout
i2c_interrupt_enable	I2C interrupt enable
i2c_interrupt_get	Get interrupt status
i2c_dma_enable	DMA transfer enable
i2c_transmit_set	Set master-initiated transfer
i2c_start_generate	Generate start conditions
i2c_stop_generate	Generate stop conditions
i2c_data_send	Send data
i2c_data_receive	Receive data
i2c_flag_get	Get flag
i2c_flag_clear	Clear flag

Table 330. I2C application-layer library functions

Function name	Description
i2c_config	I2C application initialization
i2c_lowlevel_init	I2C low-layer initialization
i2c_wait_end	I2C wait data transmit complete
i2c_wait_flag	I2C wait flag
i2c_master_transmit	I2C master transmits data (polling mode)
i2c_master_receive	I2C master receives data (polling mode)
i2c_slave_transmit	I2C slave transmits data (polling mode)
i2c_slave_receive	I2C slave receives data (polling mode)
i2c_master_transmit_int	I2C master transmits data (interrupt mode)
i2c_master_receive_int	I2C master receives data (interrupt mode)
i2c_slave_transmit_int	I2C slave transmits data (interrupt mode)
i2c_slave_receive_int	I2C slave receives data (interrupt mode)
i2c_master_transmit_dma	I2C master transmits data (DMA mode)
i2c_master_receive_dma	I2C master receives data (DMA mode)
i2c_slave_transmit_dma	I2C slave transmits data (DMA mode)
i2c_slave_receive_dma	I2C slave receives data (DMA mode)
i2c_smbus_master_transmit	SMBus master sends data (polling mode)

Function name	Description
i2c_smbus_master_receive	SMBus master receives data (polling mode)
i2c_smbus_slave_transmit	SMBus slave sends data (polling mode)
i2c_smbus_slave_receive	SMBus slave receives data (polling mode)
i2c_memory_write	I2C writes data to EEPROM (polling mode)
i2c_memory_write_int	I2C writes data to EEPROM (interrupt mode)
i2c_memory_write_dma	I2C writes data to EEPROM (DMA mode)
i2c_memory_read	I2C reads from EEPROM (polling mode)
i2c_memory_read_int	I2C reads from EEPROM (interrupt mode)
i2c_memory_read_dma	I2C reads from EEPROM (DMA mode)
i2c_evt_irq_handler	I2C event interrupt function
i2c_err_irq_handler	I2C error interrupt function
i2c_dma_tx_irq_handler	I2C DMA Tx interrupt function
i2c_dma_rx_irq_handler	I2C DMA Rx interrupt function

5.13.1 i2c_reset function

The table below describes the function i2c_reset.

Table 331. i2c_reset function

Name	Description
Function name	i2c_reset
Function prototype	void i2c_reset(i2c_type *i2c_x);
Function description	Reset all I2C registers to their initial values through CRM (Clock and reset management)
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	void crm_periph_reset(crm_periph_reset_type value, confirm_state new_state)

Example:

```
i2c_reset(I2C1);
```

5.13.2 i2c_init function

The table below describes the function i2c_init.

Table 332. i2c_init function

Name	Description
Function name	i2c_init
Function prototype	void i2c_init(i2c_type *i2c_x, uint8_t dfilters, uint32_t clk);
Function description	Set I2C bus speed and digital filter
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3
Input parameter 2	Dfilters: digital filter, ranging from 0x00 to 0x0F When in use, it is recommended to program the digital filter with a maximum value to effectively filter disturbance
Input parameter 3	Clk: timing register (I2C_CLKCTRL) value used to control I2C communication speed. This value can be calculated through “Artery_I2C_Timing_Configuration” defined in the 《AN0091_AT32F423_I2C_Application_Note》
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_init(I2C1, 0x0F, 0x80504C4E);
```

5.13.3 i2c_own_address1_set function

The table below describes the function i2c_own_address1_set.

Table 333. i2c_own_address1_set function

Name	Description
Function name	i2c_own_address1_set
Function prototype	void i2c_own_address1_set(i2c_type *i2c_x, i2c_address_mode_type mode, uint16_t address);
Function description	Set own address 1
Input parameter 1	Mode: Own address 1 address mode Refer to the “mode” description below for details.
Input parameter 2	Address: own address 1
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

mode

Own address 1 address mode

I2C_ADDRESS_MODE_7BIT: 7-bit address

I2C_ADDRESS_MODE_10BIT: 10-bit address

Example:

```
i2c_own_address1_set(I2C1, I2C_ADDRESS_MODE_7BIT, 0xA0);
```

5.13.4 i2c_own_address2_set function

The table below describes the function i2c_own_address2_set.

Table 334. i2c_own_address2_set function

Name	Description
Function name	i2c_own_address2_set
Function prototype	void i2c_own_address2_set(i2c_type *i2c_x, uint8_t address, i2c_addr2_mask_type mask);
Function description	Set own address 2. The address 2 becomes active only after it is enabled. Note: only 7-bit address is supported, not 10-bit address mode
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Address: own address 2
Input parameter 3	Mask: own address 2 bit mask Refer to the following "mask" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

mask

Own address 2 bit mask.

I2C_ADDR2_NOMASK:	match address bit [7:1]
I2C_ADDR2_MASK01:	match address bit [7:2] only
I2C_ADDR2_MASK02:	match address bit [7:3] only
I2C_ADDR2_MASK03:	match address bit [7:4] only
I2C_ADDR2_MASK04:	match address bit [7:5] only
I2C_ADDR2_MASK05:	match address bit [7:6] only
I2C_ADDR2_MASK06:	match address bit [7] only
I2C_ADDR2_MASK07:	All non-I2C reserved addresses would respond

Example:

```
i2c_own_address2_set(I2C1, 0xB0, I2C_ADDR2_NOMASK);
```

5.13.5 i2c_own_address2_enable function

The table below describes the function i2c_own_address2_enable.

Table 335. i2c_own_address2_enable function

Name	Description
Function name	i2c_own_address2_enable
Function prototype	void i2c_own_address2_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable own address 2. The address becomes active only after it is enabled. Note that this function should be used in conjunction with the i2c_own_address2_set.
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: indicates address 2 status This parameter can be TRUE or FALSE.

Name	Description
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

i2c_own_address2_enable(I2C1, TRUE);

5.13.6 i2c_smbus_enable function

The table below describes the function i2c_smbus_enable.

Table 336. i2c_smbus_enable function

Name	Description
Function name	i2c_smbus_enable
Function prototype	void i2c_smbus_enable(i2c_type *i2c_x, i2c_smbus_mode_type mode, confirm_state new_state);
Function description	Enable SMBus mode. After power-on reset, the default mode is I2C mode.
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Mode: SMBus mode selection Refer to the following “mode” descriptions for details.
Input parameter 3	new_state: indicates SMBus mode status This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

mode

SMBus mode

I2C_SMBUS_MODE_DEVICE: SMBus device

I2C_SMBUS_MODE_HOST: SMBus host

Example:

i2c_smbus_enable(I2C1, I2C_SMBUS_MODE_DEVICE, TRUE);
--

5.13.7 i2c_enable function

The table below describes the function i2c_enable.

Table 337. i2c_enable function

Name	Description
Function name	i2c_enable
Function prototype	void i2c_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable I2C peripheral
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: indicates I2C status This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

i2c_enable(I2C1, TRUE);

5.13.8 i2c_clock_stretch_enable function

The table below describes the function i2c_clock_stretch_enable.

Table 338. i2c_clock_stretch_enable function

Name	Description
Function name	i2c_clock_stretch_enable
Function prototype	void i2c_clock_stretch_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable clock stretching capability. This function is applicable to slave mode only. In most cases, enabling the clock stretching mode is recommended in order to prevent slave from having no sufficient time to receive or send data due to slow process speed, which causes a loss of data. It should be noted that the host must be able to support clock stretching function before using this mode by slave. For example, some hosts based on IO analog are not equipped with the clock stretching capability.
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: indicates clock stretching status This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

i2c_clock_stretch_enable(I2C1, TRUE);

5.13.9 i2c_ack_enable function

The table below describes the function i2c_ack_enable.

Table 339. i2c_ack_enable function

Name	Description
Function name	i2c_ack_enable
Function prototype	void i2c_ack_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	<p>Enable ACK and NACK.</p> <p>This function is used to enable ACK or NACK of each byte in master and slave mode. For ACK information on I2C communication protocol, refer to I2C protocol or AT32 reference manual.</p>
Input parameter 1	<p>i2c_x: indicates the selected I2C peripheral</p> <p>This parameter can be I2C1, I2C2, I2C3.</p>
Input parameter 2	<p>new_state: indicates ACK response status</p> <p>This parameter can be TRUE or FALSE.</p>
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_ack_enable(I2C1, TRUE);
```

5.13.10 i2c_addr10_mode_enable function

The table below describes the function i2c_addr10_mode_enable.

Table 340. i2c_addr10_mode_enable function

Name	Description
Function name	i2c_addr10_mode_enable
Function prototype	void i2c_addr10_mode_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable master transmit 10-bit address mode
Input parameter 1	<p>i2c_x: indicates the selected I2C peripheral</p> <p>This parameter can be I2C1, I2C2, I2C3.</p>
Input parameter 2	<p>new_state: 10-bit address mode enable state</p> <p>This parameter can be TRUE or FALSE.</p>
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_addr10_mode_enable(I2C1, TRUE);
```

5.13.11 i2c_transfer_addr_set function

The table below describes the function i2c_transfer_addr_set.

Table 341. i2c_transfer_addr_set function

Name	Description
Function name	i2c_transfer_addr_set
Function prototype	void i2c_transfer_addr_set(i2c_type *i2c_x, uint16_t address);
Function description	Set master transfer address (slave address)
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Address: slave address
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_transfer_addr_set(I2C1, 0xA0);
```

5.13.12 i2c_transfer_addr_get function

The table below describes the function i2c_transfer_addr_get.

Table 342. i2c_transfer_addr_get function

Name	Description
Function name	i2c_transfer_addr_get
Function prototype	uint16_t i2c_transfer_addr_get(i2c_type *i2c_x);
Function description	Get slave address sent from master
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Output parameter	NA
Return value	uint16_t: slave address sent from master
Required preconditions	NA
Called functions	NA

Example:

```
i2c_transfer_addr_get(I2C1);
```

5.13.13 i2c_transfer_dir_set function

The table below describes the function i2c_transfer_dir_set.

Table 343. i2c_transfer_dir_set function

Name	Description
Function name	i2c_transfer_dir_set
Function prototype	void i2c_transfer_dir_set(i2c_type *i2c_x, i2c_transfer_dir_type i2c_direction);
Function description	Set master data transfer direction
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Direction: data transfer direction Refer to the following "direction" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

direction

Data transfer direction

I2C_DIR_TRANSMIT: Master sends data

I2C_DIR_RECEIVE: Master receives data

Example:

```
i2c_transfer_dir_set(I2C1, I2C_DIR_TRANSMIT);
```

5.13.14 i2c_transfer_dir_get function

The table below describes the function i2c_transfer_dir_get.

Table 344. i2c_transfer_dir_get function

Name	Description
Function name	i2c_transfer_dir_get
Function prototype	i2c_transfer_dir_type i2c_transfer_dir_get(i2c_type *i2c_x);
Function description	Get slave data transfer direction
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Output parameter	NA
Return value	i2c_transfer_dir_type: slave data transfer direction Refer to the following "i2c_transfer_dir_type" descriptions for details.
Required preconditions	NA
Called functions	NA

i2c_transfer_dir_type

Data transfer direction.

I2C_DIR_TRANSMIT: master sends data, and slave receives data

I2C_DIR_RECEIVE: master receives data and slave sends data

Example:

```
i2c_transfer_dir_get(I2C1);
```

5.13.15 i2c_matched_addr_get function

The table below describes the function i2c_matched_addr_get.

Table 345. i2c_matched_addr_get function

Name	Description
Function name	i2c_matched_addr_get
Function prototype	uint8_t i2c_matched_addr_get(i2c_type *i2c_x);
Function description	Get slave address match value
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Output parameter	NA
Return value	uint8_t: slave matched address
Required preconditions	NA
Called functions	NA

Example:

```
i2c_matched_addr_get(I2C1);
```

5.13.16 i2c_auto_stop_enable function

The table below describes the function i2c_auto_stop_enable.

Table 346. i2c_auto_stop_enable function

Name	Description
Function name	i2c_auto_stop_enable
Function prototype	void i2c_auto_stop_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable auto transmit stop conditions
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: auto transmit stop condition enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_auto_stop_enable(I2C1, TRUE);
```

5.13.17 i2c_reload_enable function

The table below describes the function i2c_reload_enable.

Table 347. i2c_reload_enable function

Name	Description
Function name	i2c_reload_enable
Function prototype	void i2c_reload_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable transmitted data reload mode
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: reload mode enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_reload_enable(I2C1, TRUE);
```

5.13.18 i2c_cnt_set function

The table below describes the function i2c_cnt_set.

Table 348. i2c_cnt_set function

Name	Description
Function name	i2c_cnt_set
Function prototype	void i2c_cnt_set(i2c_type *i2c_x, uint8_t cnt);
Function description	Set the number of data to send or receive, ranging from 1 to 255
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Cnt: number of data to send/receive
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_cnt_set(I2C1, 200);
```

5.13.19 i2c_addr10_header_enable function

The table below describes the function i2c_addr10_header_enable.

Table 349. i2c_addr10_header_enable function

Name	Description
Function name	i2c_addr10_header_enable
Function prototype	void i2c_addr10_header_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable 10-bit address header read timing
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: enable state of auto transmit stop conditions This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_addr10_header_enable(I2C1, TRUE);
```

5.13.20 i2c_general_call_enable function

The table below describes the function i2c_dma_enable.

Table 350. i2c_general_call_enable function

Name	Description
Function name	i2c_general_call_enable
Function prototype	void i2c_general_call_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable broadcast address. After enabled, broadcast address 0x00 is responded
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: Broadcast address enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_general_call_enable(I2C1, TRUE);
```

5.13.21 i2c_smbus_alert_set function

The table below describes the function i2c_smbus_alert_set.

Table 351. i2c_smbus_alert_set function

Name	Description
Function name	i2c_smbus_alert_set
Function prototype	void i2c_smbus_alert_set(i2c_type *i2c_x, i2c_smbus_alert_set_type level);
Function description	Set SMBus alert pin level (high or low)
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	level: SMBus alert pin level Refer to the following "level" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

source

SMBus alert pin level

I2C_SMBUS_ALERT_LOW: SMBus alert pin output low

I2C_SMBUS_ALERT_HIGH: SMBus alert pin output high

Example:

```
i2c_smbus_alert_set(I2C1, I2C_SMBUS_ALERT_LOW);
```

5.13.22 i2c_slave_data_ctrl_enable function

The table below describes the function i2c_start_generate.

Table 352. i2c_start_generate function

Name	Description
Function name	i2c_slave_data_ctrl_enable
Function prototype	void i2c_slave_data_ctrl_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable slave data receive control. This function is used to control ACK or NACK response to each received byte when in slave receive mode. It is usually used for SMBus.
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_slave_data_ctrl_enable(I2C1, FALSE);
```

5.13.23 i2c_pec_calculate_enable function

The table below describes the function i2c_pec_calculate_enable

Table 353. i2c_pec_calculate_enable

Name	Description
Function name	i2c_pec_calculate_enable
Function prototype	void i2c_pec_calculate_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable PEC calculation
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: PEC calculation state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_pec_calculate_enable(I2C1, TRUE);
```

5.13.24 i2c_pec_transmit_enable function

The table below describes the function i2c_pec_transmit_enable.

Table 354. i2c_pec_transmit_enable function

Name	Description
Function name	i2c_pec_transmit_enable
Function prototype	void i2c_pec_transmit_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	PEC transmit enable (send/receive PEC)
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: PEC transmit enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_pec_transmit_enable(I2C1, TRUE);
```

5.13.25 i2c_pec_value_get function

The table below describes the function i2c_pec_value_get

Table 355. i2c_pec_value_get function

Name	Description
Function name	i2c_pec_value_get
Function prototype	uint8_t i2c_pec_value_get(i2c_type *i2c_x);
Function description	Get current PEC value
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Output parameter	uint8_t: current PEC value
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
pec_value = i2c_pec_value_get(I2C1);
```

5.13.26 i2c_timeout_set function

The table below describes the function i2c_timeout_set.

Table 356. i2c_timeout_set function

Name	Description
Function name	i2c_timeout_set
Function prototype	void i2c_timeout_set(i2c_type *i2c_x, uint16_t timeout);
Function description	Set SCL line level timeout detect time
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Timeout: timeout value, ranging from 0x0000 to 0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_timeout_set(I2C1, 0xFFFF);
```

5.13.27 i2c_timeout_detcet_set function

The table below describes the function i2c_timeout_detcet_set.

Table 357. i2c_timeout_detcet_set function

Name	Description
Function name	i2c_timeout_detcet_set
Function prototype	void i2c_timeout_detcet_set(i2c_type *i2c_x, i2c_timeout_detcet_type mode);
Function description	Set SCL line level timeout detect mode
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Mode: level detect mode Refer to the following "mode" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

mode

Level detection mode.

I2C_TIMEOUT_DETCET_HIGH: High level timeout detect

I2C_TIMEOUT_DETCET_LOW: Low level timeout detect

Example:

```
i2c_timeout_detcet_set(I2C1, I2C_TIMEOUT_DETCET_HIGH);
```

5.13.28 i2c_timeout_enable function

The table below describes the function i2c_timeout_enable.

Table 358. i2c_timeout_enable function

Name	Description
Function name	i2c_timeout_enable
Function prototype	void i2c_timeout_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable SCL line level timeout detect
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: level timeout detect enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_timeout_enable(I2C1, TRUE);
```

5.13.29 i2c_ext_timeout_set function

The table below describes the function i2c_ext_timeout_set.

Table 359. i2c_ext_timeout_set function

Name	Description
Function name	i2c_ext_timeout_set
Function prototype	void i2c_ext_timeout_set(i2c_type *i2c_x, uint16_t timeout);
Function description	Set SCL line cumulative clock stretching timeout value, usually used in SMBus mode
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Timeout: range from 0x0000 to 0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_ext_timeout_set(I2C1, 0xFFFF);
```

5.13.30 i2c_ext_timeout_enable function

The table below describes the function i2c_ext_timeout_enable.

Table 360. i2c_ext_timeout_enable function

Name	Description
Function name	i2c_ext_timeout_enable
Function prototype	void i2c_ext_timeout_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable SCL line cumulative clock stretching timeout
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	new_state: cumulative clock stretching timeout enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_ext_timeout_enable(I2C1, TRUE);
```

5.13.31 i2c_interrupt_enable function

The table below describes the function i2c_interrupt_enable.

Table 361. i2c_interrupt_enable function

Name	Description
Function name	i2c_interrupt_enable
Function prototype	void i2c_interrupt_enable(i2c_type *i2c_x, uint32_t source, confirm_state new_state);
Function description	I2C interrupt enable
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Source: interrupt sources Refer to the following "source" descriptions for details.
Input parameter 3	new_state: interrupt enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

source

Interrupt source.

I2C_TD_INT:	Data transmit interrupt
I2C_RD_INT:	Data receive interrupt
I2C_ADDR_INT:	Address match interrupt
I2C_ACKFIAL_INT:	Acknowledge failure interrupt
I2C_STOP_INT:	Stop condition generation complete interrupt
I2C_TDC_INT:	Data transfer complete interrupt
I2C_ERR_INT:	Error interrupt

Example:

```
i2c_interrupt_enable(I2C1, I2C_TD_INT, TRUE);
```

5.13.32 i2c_interrupt_get function

The table below describes the function i2c_interrupt_get.

Table 362. i2c_interrupt_get function

Name	Description
Function name	i2c_interrupt_get
Function prototype	flag_status i2c_interrupt_get(i2c_type *i2c_x, uint16_t source);
Function description	Get interrupt enable state
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Source: interrupt source Refer to the following "source" descriptions for details.
Output parameter	flag_status: flag status This parameter can be SET or RESET
Return value	NA
Required preconditions	NA
Called functions	NA

source

Interrupt source.

I2C_TD_INT:	Data transmit interrupt
I2C_RD_INT:	Data receive interrupt
I2C_ADDR_INT:	Address match interrupt
I2C_ACKFAIL_INT:	Acknowledge failure interrupt
I2C_STOP_INT:	Stop condition generation complete interrupt
I2C_TDC_INT:	Data transfer complete interrupt
I2C_ERR_INT:	Error interrupt

Example:

```
i2c_interrupt_get(I2C1, I2C_TD_INT, TRUE);
```

5.13.33 i2c_dma_enable function

The table below describes the function i2c_dma_enable.

Table 363. i2c_dma_enable function

Name	Description
Function name	i2c_dma_enable
Function prototype	void i2c_dma_enable(i2c_type *i2c_x, i2c_dma_request_type dma_req, confirm_state new_state);
Function description	DMA transfer enable
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	dma_req: DMA request Refer to the following "dma_req" descriptions for details.
Input parameter 3	new_state: DMA enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA

Name	Description
Required preconditions	NA
Called functions	NA

dma_req

I2C_DMA_REQUEST_TX: DMA data transmit enable

I2C_DMA_REQUEST_RX: DMA data receive enable

Example:

```
i2c_dma_enable(I2C1, I2C_DMA_REQUEST_TX, TRUE);
```

5.13.34 i2c_transmit_set function

The table below describes the function i2c_transmit_set.

Table 364. i2c_transmit_set function

Name	Description
Function name	i2c_transmit_set
Function prototype	void i2c_transmit_set(i2c_type *i2c_x, uint16_t address, uint8_t cnt, i2c_reload_stop_mode_type rld_stop, i2c_start_mode_type start);
Function description	Set master transmit. This function is used to start data transfer on bus.
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Address: slave address
Input parameter 3	Cnt: count of data to send/receive
Input parameter 4	rld_stop: reload mode and STOP condition generation mode Refer to the following "rld_stop" descriptions for details.
Input parameter 5	Start: set START condition generation mode Refer to the following "start" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

rld_stop

Reload mode and STOP condition generation mode.

I2C_AUTO_STOP_MODE: Auto stop mode (automatically sends STOP condition)

I2C_SOFT_STOP_MODE: Software stop mode (software sends STOP condition, usually RESTART condition)

I2C_RELOAD_MODE: Reload mode (when a single transfer >255)

start

START condition generation mode.

I2C_WITHOUT_START: Start sending data, without START, used in reload mode

I2C_GEN_START_READ: Start sending data, with START condition (for master receive data)

I2C_GEN_START_WRITE: Start sending data with START condition (for master transmit data)

Example:

```
i2c_transmit_set(I2C1, I2C_AUTO_STOP_MODE, I2C_GEN_START_WRITE);
```

5.13.35 i2c_start_generate function

The table below describes the function i2c_start_generate.

Table 365. i2c_slave_transmit function

Name	Description
Function name	i2c_start_generate
Function prototype	void i2c_start_generate(i2c_type *i2c_x);
Function description	Generate a START condition (for master)
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_start_generate(I2C1);
```

5.13.36 i2c_stop_generate function

The table below describes the function i2c_stop_generate.

Table 366. i2c_stop_generate function

Name	Description
Function name	i2c_stop_generate
Function prototype	void i2c_stop_generate(i2c_type *i2c_x);
Function description	Generate a STOP condition
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_stop_generate(I2C1);
```

5.13.37 i2c_data_send function

The table below describes the function i2c_data_send.

Table 367. i2c_data_send function

Name	Description
Function name	i2c_data_send
Function prototype	void i2c_data_send(i2c_type *i2c_x, uint8_t data);
Function description	Send data
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Data: data to be sent
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_data_send(I2C1, 0x55);
```

5.13.38 i2c_data_receive function

The table below describes the function i2c_data_receive

Table 368. i2c_data_receive function

Name	Description
Function name	i2c_data_receive
Function prototype	uint8_t i2c_data_receive(i2c_type *i2c_x);
Function description	Receive data
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Output parameter	uint8_t: data to be received
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
data_value = i2c_data_receive(I2C1);
```

5.13.39 i2c_flag_get function

The table below describes the function i2c_flag_get

Table 369. i2c_flag_get function

Name	Description
Function name	i2c_flag_get
Function prototype	flag_status i2c_flag_get(i2c_type *i2c_x, uint32_t flag);
Function description	Get flag status
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Flag: the selected flag Refer to the following "flag" descriptions for details.
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET
Required preconditions	NA
Called functions	NA

flag

This bit is used to select a flag to get its status. Optional parameters are below:

I2C_TDBE_FLAG:	Transmit data register empty flag
I2C_TDIS_FLAG:	Transmit interrupt status flag
I2C_RDBF_FLAG:	Receive data buffer full flag
I2C_ADDRF_FLAG:	Address match flag
I2C_ACKFAIL_FLAG:	Acknowledge failure flag
I2C_STOPF_FLAG:	STOP condition generation complete flag
I2C_TDC_FLAG:	Data transfer complete flag
I2C_TCRLD_FLAG:	Transfer complete to wait for loading data
I2C_BUSERR_FLAG:	Bus error flag
I2C_ARLOST_FLAG:	Arbitration lost flag
I2C_OUF_FLAG:	Overflow or underflow flag
I2C_PECERR_FLAG:	PEC receive error flag
I2C_TMOUT_FLAG:	SMBus timeout flag
I2C_ALERTF_FLAG:	SMBus alert flag
I2C_BUSYF_FLAG:	Bus busy flag
I2C_SDIR_FLAG:	Slave data transfer direction

Example:

```
i2c_flag_get(I2C1, I2C_TDIS_FLAG);
```

5.13.40 i2c_interrupt_flag_get function

The table below describes the function i2c_interrupt_flag_get.

Table 370. i2c_interrupt_flag_get function

Name	Description
Function name	i2c_interrupt_flag_get
Function prototype	flag_status i2c_interrupt_flag_get(i2c_type *i2c_x, uint32_t flag);
Function description	Get I2C interrupt flag status, ancheck the corresponding interrupt enable bit
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Flag: the selected flag Refer to the "flag" below for details.
Output parameter	NA
Return value	flag_status: SET or RESET
Required preconditions	NA
Called functions	NA

flag

This bit is used to select a flag, including:

- I2C_TDBE_FLAG: Transmit data register empty flag
- I2C_TDIS_FLAG: Transmit interrupt status flag
- I2C_RDBF_FLAG: Receive data buffer full flag
- I2C_ADDRF_FLAG: Address match flag
- I2C_ACKFAIL_FLAG: Acknowledge failure flag
- I2C_STOPF_FLAG: STOP condition generation complete flag
- I2C_TDC_FLAG: Data transfer complete flag
- I2C_TCRLD_FLAG: Transfer complete to wait for loading data
- I2C_BUSERR_FLAG: Bus error flag
- I2C_ARLOST_FLAG: Arbitration lost flag
- I2C_OUF_FLAG: Overflow or underflow flag
- I2C_PECERR_FLAG: PEC receive error flag
- I2C_TMOUT_FLAG: SMBus timeout flag
- I2C_ALERTF_FLAG: SMBus alert flag

Example:

```
i2c_interrupt_flag_get(I2C1, I2C_TDIS_FLAG);
```

5.13.41 i2c_flag_clear function

The table below describes the function i2c_flag_clear.

Table 371. i2c_flag_clear function

Name	Description
Function name	i2c_flag_clear
Function prototype	void i2c_flag_clear(i2c_type *i2c_x, uint32_t flag);
Function description	Clear flag
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1, I2C2, I2C3.
Input parameter 2	Flag: the selected flag Refer to the following "flag" descriptions for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

flag

This bit is used to select a flag, including:

- I2C_ADDRF_FLAG: Address match flag
- I2C_ACKFAIL_FLAG: Acknowledge failure flag
- I2C_STOPF_FLAG: STOP condition generation complete flag
- I2C_BUSERR_FLAG: Bus error flag
- I2C_ARLOST_FLAG: Arbitration lost flag
- I2C_OUF_FLAG: Overflow or underflow flag
- I2C_PECERR_FLAG: PEC receive error flag
- I2C_TMOUT_FLAG: SMBus timeout flag
- I2C_ALERTF_FLAG: SMBus alert flag

Example:

```
i2c_flag_clear(I2C1, I2C_ACKFAIL_FLAG);
```

5.13.42 i2c_wakeup_enable function

The table below describes the function i2c_wakeup_enable.

Table 372. i2c_wakeup_enable function

Name	Description
Function name	i2c_wakeup_enable
Function prototype	void i2c_wakeup_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable Deepsleep mode wakeup
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1
Input parameter 2	new_state: Deepsleep mode wakeup enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_wakeup_enable(I2C1, TRUE);
```

5.13.43 i2c_analog_filter_enable function

The table below describes the function i2c_analog_filter_enable.

Table 373. i2c_analog_filter_enable function

Name	Description
Function name	i2c_analog_filter_enable
Function prototype	void i2c_analog_filter_enable(i2c_type *i2c_x, confirm_state new_state);
Function description	Enable analog filter
Input parameter 1	i2c_x: indicates the selected I2C peripheral This parameter can be I2C1
Input parameter 2	new_state: enable state This parameter can be TRUE or FALSE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
i2c_analog_filter_enable(I2C1, TRUE);
```

5.13.44 i2c_config function

The table below describes the function i2c_config.

Table 374. i2c_config function

Name	Description
Function name	i2c_config
Function prototype	void i2c_config(i2c_handle_type* hi2c);
Function description	I2C initialization function used to initialize I2C. Call the function i2c_lowlevel_init() to initialize I2C peripherals, GPIO, DMA, interrupts and others.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

i2c_handle_type* hi2c

i2c_handle_type is defined in the i2c_application.h.

typedef struct

```
{
    i2c_type          *i2cx;
    uint8_t            *pbuff;
    __IO uint16_t      psize;
    __IO uint16_t      pcount;
    __IO uint32_t      mode;
    __IO uint32_t      timeout;
    __IO uint32_t      status;
    __IO i2c_status_type error_code;
    dma_channel_type   *dma_tx_channel;
    dma_channel_type   *dma_rx_channel;
    dma_init_type      dma_init_struct;
}i2c_handle_type;
```

i2cx

Select an I2C peripheral from I2C1, I2C2 or I2C3

pbuff

An array of data to be sent or received.

psize

This bit is used to count the size of bytes in a single transfer when the transfer size is over 255. It is used in internal state machine. Users don't care.

pcount

The number of data to be sent or received.

mode

I2C communication mode. It is used in internal state machine. Users don't care.

timeout

Communications timeout

status

Transfer status. It is used in internal state machine. Users don't care.

error_code

This bit is used to enumerate error code in the i2c_status_type. When a communication error occurred, it logs the corresponding error code.

I2C_OK:	Communication OK
I2C_ERR_STEP_1:	Step 1 error
I2C_ERR_STEP_2:	Step 2 error
I2C_ERR_STEP_3:	Step 3 error
I2C_ERR_STEP_4:	Step 4 error
I2C_ERR_STEP_5:	Step 5 error
I2C_ERR_STEP_6:	Step 6 error
I2C_ERR_STEP_7:	Step 7 error
I2C_ERR_STEP_8:	Step 8 error
I2C_ERR_STEP_9:	Step 9 error
I2C_ERR_STEP_10:	Step 10 error
I2C_ERR_STEP_11:	Step 11 error
I2C_ERR_STEP_12:	Step 12 error
I2C_ERR_TCRLD:	Wait for TCRLD timeout
I2C_ERR_TDC:	Wait for TDC timeout
I2C_ERR_ADDR:	Address send error
I2C_ERR_STOP:	STOP condition send error
I2C_ERR_ACKFAIL:	Acknowledge error
I2C_ERR_TIMEOUT:	Timeout error
I2C_ERR_INTERRUPT:	Enter an interrupt when an error event occurred

dma_tx_channel

I2C transmit DMA channel

dma_rx_channel

I2C receive DMA channel

dma_init_struct

DMA initialization structure

Example:

```
i2c_handle_type hi2c;  
hi2c.i2cx = I2C1;  
i2c_config(&hi2c);
```

5.13.45 i2c_lowlevel_init function

The table below describes the function i2c_lowlevel_init.

Table 375. i2c_lowlevel_init function

Name	Description
Function name	i2c_lowlevel_init
Function prototype	void i2c_lowlevel_init(i2c_handle_type* hi2c);
Function description	I2C lower-level initialization callback function. It is called in the i2c_config to initialize I2C peripherals, GPIO, DMA, interrupts, etc. It requires users to implement I2C initialization inside the function.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
void i2c_lowlevel_init(i2c_handle_type* hi2c)
{
    if(hi2c->i2cx == I2C1)
    {
        Implement I2C1 initialization
    }
    else if(hi2c->i2cx == I2C2)
    {
        Implement I2C2 initialization
    }
}
```

5.13.46 i2c_wait_end function

The table below describes the function i2c_wait_end.

Table 376. i2c_wait_end function

Name	Description
Function name	i2c_wait_end
Function prototype	i2c_status_type i2c_wait_end(i2c_handle_type* hi2c, uint32_t timeout);
Function description	Wait for the end of communications. This function is used in DMA and interrupt transfer modes as they are non-blocking functions and can thus be used to wait for the end of transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA

Name	Description
Called functions	NA

Example:

```

if (i2c_master_transmit_dma(&hi2c, 0xB0, tx_buf, 8, 0xFFFFFFFF) != I2C_OK)
{
    error_handler(i2c_status);
}

/* wait for the end of transfer*/
if(i2c_wait_end(&hi2c, 0xFFFFFFFF) != I2C_OK)
{
    error_handler(i2c_status);
}

```

5.13.47 i2c_wait_flag function

The table below describes the function i2c_wait_flag.

Table 377. i2c_wait_flag function

Name	Description
Function name	i2c_wait_flag
Function prototype	i2c_status_type i2c_wait_flag(i2c_handle_type* hi2c, uint32_t flag, uint32_t event_check, uint32_t timeout)
Function description	Wait for a flag to be set or reset Only BUSFY flag is “wait for a flag to be reset”, and others are “wait for a flag to be set”
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Flag: the selected flag Refer to the following “flag” descriptions for details.
Input parameter 3	event_check: check if the event has occurred or not while waiting for a flag Refer to the “event_check” descriptions below for details.
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

flag

Select a flag to wait for.

- | | |
|-------------------|---|
| I2C_TDBE_FLAG: | Transmit data register empty flag |
| I2C_TDIS_FLAG: | Transmit interrupt status flag |
| I2C_RDBF_FLAG: | Receive data buffer full flag |
| I2C_ADDRF_FLAG: | Address match flag |
| I2C_ACKFAIL_FLAG: | Acknowledge failure flag |
| I2C_STOPF_FLAG: | STOP condition generation complete flag |
| I2C_TDC_FLAG: | Data transfer complete flag |

I2C_TCRLD_FLAG:	Transfer complete to wait for loading data
I2C_BUSERR_FLAG:	Bus error flag
I2C_ARLOST_FLAG:	Arbitration lost flag
I2C_OUF_FLAG:	Overflow or underflow flag
I2C_PECERR_FLAG:	PEC receive error flag
I2C_TMOUT_FLAG:	SMBus timeout flag
I2C_ALERTF_FLAG:	SMBus alert flag
I2C_BUSYF_FLAG:	Bus busy flag
I2C_SDIR_FLAG:	Slave data transfer direction

event_check

Check if the event has occurred or not while waiting for a flag.

I2C_EVENT_CHECK_NONE: None

I2C_EVENT_CHECK_ACKFAIL: Check ACKFAIL event

I2C_EVENT_CHECK_STOP: Check STOP event

Example:

```
i2c_wait_flag(&hi2c, I2C_BUSYF_FLAG, I2C_EVENT_CHECK_NONE, 0xFFFFFFFF);
```

5.13.48 i2c_master_transmit function

The table below describes the function i2c_master_transmit.

Table 378. i2c_master_transmit function

Name	Description
Function name	i2c_master_transmit
Function prototype	i2c_status_type i2c_master_transmit(i2c_handle_type* hi2c, uint16_t address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Master sends data (polling mode). This is a blocking function, and so I2C transfer ends after the function is executed
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Address: slave address
Input parameter 3	Pdata: array address of to-be-sent data
Input parameter 4	Size: the size of data to be sent
Input parameter 5	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_master_transmit(&hi2c, 0xB0, tx_buf, 8, 0xFFFFFFFF);
```

5.13.49 i2c_master_receive function

The table below describes the function i2c_master_receive.

Table 379. i2c_master_receivefunction

Name	Description
Function name	i2c_master_receive
Function prototype	i2c_status_type i2c_master_receive(i2c_handle_type* hi2c, uint16_t address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Master receives data (polling mode). This function is a blocking type. After the execution is done, so does I2C transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Address: slave address
Input parameter 3	Pdata: array address to receive data
Input parameter 4	Size: number of data to receive
Input parameter 5	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_master_receive(&hi2c, 0xB0, rx_buf, 8, 0xFFFFFFFF);
```

5.13.50 i2c_slave_transmit function

The table below describes the function i2c_slave_transmit.

Table 380. i2c_slave_transmit function

Name	Description
Function name	i2c_slave_transmit
Function prototype	i2c_status_type i2c_slave_transmit(i2c_handle_type* hi2c, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Slave sends data (polling mode). This function is a blocking type. In other words, after the function execution is done, so is I2C transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Pdata: array address of data to be sent
Input parameter 3	Size: number of data to be sent
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_slave_transmit(&hi2c, tx_buf, 8, 0xFFFFFFFF);
```

5.13.51 i2c_slave_receive function

The table below describes the function i2c_slave_receive.

Table 381. i2c_slave_receive function

Name	Description
Function name	i2c_slave_receive
Function prototype	i2c_status_type i2c_slave_receive(i2c_handle_type* hi2c, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Slave receives data (polling mode). This function is a blocking type. In other words, after the function execution is done, so is I2C transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Pdata: array address to receive data
Input parameter 3	Size: number of data to be received
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_slave_receive(&hi2c, rx_buf, 8, 0xFFFFFFFF);
```

5.13.52 i2c_master_transmit_int function

The table below describes the function i2c_master_transmit_int.

Table 382. i2c_master_transmit_int function

Name	Description
Function name	i2c_master_transmit_int
Function prototype	i2c_status_type i2c_master_transmit_int(i2c_handle_type* hi2c, uint16_t address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Master sends data (interrupt mode). This function is a non-blocking type. In other words, after the function execution is done, I2C transfer has not completed yet. In this case, it is possible to call the i2c_wait_end() to wait for the completion of communication.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Address: slave address
Input parameter 3	Pdata: array address of data to be sent
Input parameter 4	Size: number of data to be sent
Input parameter 5	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_master_transmit_int(&hi2c, 0xB0, tx_buf, 8, 0xFFFFFFFF);
```

5.13.53 i2c_master_receive_int function

The table below describes the function i2c_master_receive_int.

Table 383. i2c_master_receive_int function

Name	Description
Function name	i2c_master_receive_int
Function prototype	i2c_status_type i2c_master_receive_int(i2c_handle_type* hi2c, uint16_t address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Master receives data (through interrupt mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Address: slave address
Input parameter 3	Pdata: array address to receive data
Input parameter 4	Size: number of data to be received
Input parameter 5	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_master_receive_int(&hi2c, 0xB0, rx_buf, 8, 0xFFFFFFFF);
```

5.13.54 i2c_slave_transmit_int function

The table below describes the function i2c_master_receive_int.

Table 384. i2c_master_receive_int function

Name	Description
Function name	i2c_slave_transmit_int
Function prototype	i2c_status_type i2c_slave_transmit_int(i2c_handle_type* hi2c, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Slave sends data (through interrupt mode). This function operates in non-blocking mode. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Pdata: array address of data to be sent
Input parameter 3	Size: number of data to be sent
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.

Name	Description
Required preconditions	NA
Called functions	NA

Example:

```
i2c_slave_transmit_int(&hi2c, tx_buf, 8, 0xFFFFFFFF);
```

5.13.55 i2c_slave_receive_int function

The table below describes the function i2c_slave_receive_int

Table 385. i2c_master_receive_int function

Name	Description
Function name	i2c_slave_receive_int
Function prototype	i2c_status_type i2c_slave_receive_int(i2c_handle_type* hi2c, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Slave receives data (through interrupt mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Pdata: array address to receive data
Input parameter 3	Size: number of data to be received
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_slave_receive_int(&hi2c, rx_buf, 8, 0xFFFFFFFF);
```

5.13.56 i2c_master_transmit_dma function

The table below describes the function i2c_master_transmit_dma.

Table 386. i2c_master_transmit_dma function

Name	Description
Function name	i2c_master_transmit_dma
Function prototype	i2c_status_type i2c_master_transmit_dma(i2c_handle_type* hi2c, uint16_t address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Master sends data (through DMA mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Address: slave address
Input parameter 3	Pdata: array address of data to be sent
Input parameter 4	Size: number of data to send
Input parameter 5	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_master_transmit_dma(&hi2c, 0xB0, tx_buf, 8, 0xFFFFFFFF);
```

5.13.57 i2c_master_receive_dma function

The table below describes the function i2c_master_receive_dma.

Table 387. i2c_master_receive_dma function

Name	Description
Function name	i2c_master_receive_dma
Function prototype	i2c_status_type i2c_master_receive_dma(i2c_handle_type* hi2c, uint16_t address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Master receives data (through DMA mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Address: slave address
Input parameter 3	Pdata: array address to receive data
Input parameter 4	Size: number of data to be received
Input parameter 5	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_master_receive_dma(&hi2c, 0xB0, rx_buf, 8, 0xFFFFFFFF);
```

5.13.58 i2c_slave_transmit_dma function

The table below describes the function i2c_slave_transmit_dma.

Table 388. i2c_slave_transmit_dma function

Name	Description
Function name	i2c_slave_transmit_dma
Function prototype	i2c_status_type i2c_slave_transmit_dma(i2c_handle_type* hi2c, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Slave sends data (through DMA mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Pdata: array address of data to be sent
Input parameter 3	Size: number of data to be sent
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.

Name	Description
Required preconditions	NA
Called functions	NA

Example:

```
i2c_slave_transmit_dma(&hi2c, tx_buf, 8, 0xFFFFFFFF);
```

5.13.59 i2c_slave_receive_dma function

The table below describes the function i2c_slave_transmit_dma.

Table 389. i2c_slave_transmit_dma function

Name	Description
Function name	i2c_slave_receive_dma
Function prototype	i2c_status_type i2c_slave_receive_dma(i2c_handle_type* hi2c, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Slave receives data (through DMA mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Pdata: array address to receive data
Input parameter 3	Size: number of data to be received
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_slave_receive_dma(&hi2c, rx_buf, 8, 0xFFFFFFFF);
```

5.13.60 i2c_smbus_master_transmit function

The table below describes the function i2c_smbus_master_transmit

Table 390. i2c_smbus_master_transmit function

Name	Description
Function name	i2c_smbus_master_transmit
Function prototype	i2c_status_type i2c_smbus_master_transmit(i2c_handle_type* hi2c, uint16_t address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	SMBus master sends data (through polling mode). This function is a blocking type. In other words, after the function execution is done, so is data transfer. It is mainly used for PEC transmission and reception.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Address: slave address
Input parameter 3	Pdata: array address of data to be sent
Input parameter 4	Size: number of data to be sent

Name	Description
Input parameter 5	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_smbus_master_transmit(&hi2c, 0xB0, tx_buf, 8, 0xFFFFFFFF);
```

5.13.61 i2c_smbus_master_receive function

The table below describes the function i2c_smbus_master_receive

Table 391. i2c_smbus_master_receive function

Name	Description
Function name	i2c_smbus_master_receive
Function prototype	i2c_status_type i2c_smbus_master_receive(i2c_handle_type* hi2c, uint16_t address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	SMBus master receives data (through polling mode). This function is a blocking type. In other words, after the function execution is done, so is data transfer. It is mainly used for PEC transmission and reception.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Address: slave address
Input parameter 3	Pdata: array address to receive data
Input parameter 4	Size: number of data to be received
Input parameter 5	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_smbus_master_receive(&hi2c, 0xB0, rx_buf, 8, 0xFFFFFFFF);
```

5.13.62 i2c_smbus_slave_transmit function

The table below describes the function i2c_smbus_slave_transmit

Table 392. i2c_smbus_slave_transmit function

Name	Description
Function name	i2c_smbus_slave_transmit
Function prototype	i2c_status_type i2c_smbus_slave_transmit(i2c_handle_type* hi2c, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	SMBus slave sends data (through polling mode). This function is a blocking type. In other words, after the function execution is done, so is data transfer. It is mainly used for PEC transmission and reception.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Pdata: array address of data to be sent
Input parameter 3	Size: number of data to be sent
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_smbus_slave_transmit(&hi2c, tx_buf, 8, 0xFFFFFFFF);
```

5.13.63 i2c_smbus_slave_receive function

The table below describes the function i2c_smbus_slave_receive

Table 393. i2c_smbus_slave_receive function

Name	Description
Function name	i2c_smbus_slave_receive
Function prototype	i2c_status_type i2c_smbus_slave_receive(i2c_handle_type* hi2c, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	SMBus slave receives data (through polling mode). This function is a blocking type. In other words, after the function execution is done, so is data transfer. It is mainly used for PEC transmission and reception.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	Pdata: array address to receive data
Input parameter 3	Size: number of data to be received
Input parameter 4	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

Example:

```
i2c_smbus_slave_receive(&hi2c, rx_buf, 8, 0xFFFFFFFF);
```

5.13.64 i2c_memory_write function

The table below describes the function i2c_memory_write

Table 394. i2c_memory_write function

Name	Description
Function name	i2c_memory_write
Function prototype	i2c_status_type i2c_memory_write(i2c_handle_type* hi2c, i2c_mem_address_width_type mem_address_width, uint16_t address, uint16_t mem_address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Write data to EEPROM (through polling mode). This function is a blocking type. In other words, after the function execution is done, so is I2C transfer.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	mem_address_width: EEPROM memory address width Refer to the "mem_address_width" below for details.
Input parameter 3	address: EEPROM address
Input parameter 4	mem_address: EEPROM data memory address
Input parameter 5	Pdata: array address of data to be sent
Input parameter 6	Size: number of data to be sent
Input parameter 7	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code

Name	Description
	Refer to error_code for details.
Required preconditions	NA
Called functions	NA

mem_address_width

EEPROM memory address width

I2C_MEM_ADDR_WIDIH_8: 8-bit address width

I2C_MEM_ADDR_WIDIH_16: 16-bit address width

Example:`i2c_memory_write(&hi2c, 0xA0, 0x05, tx_buf, 8, 0xFFFFFFFF);`

5.13.65 i2c_memory_write_int function

The table below describes the function i2c_memory_write_int

Table 395. i2c_memory_write_int function

Name	Description
Function name	i2c_memory_write_int
Function prototype	i2c_status_type i2c_memory_write_int(i2c_handle_type* hi2c, i2c_mem_address_width_type mem_address_width, uint16_t address, uint16_t mem_address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Write EEPROM (through interrupt mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	mem_address_width: EEPROM memory address width Refer to the "mem_address_width" below for details.
Input parameter 3	address: EEPROM address
Input parameter 4	mem_address: EEPROM data memory address
Input parameter 5	pdata: array address of data to be sent
Input parameter 6	size: number of data to be sent
Input parameter 7	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

mem_address_width

EEPROM memory address width

I2C_MEM_ADDR_WIDIH_8: 8-bit address width

I2C_MEM_ADDR_WIDIH_16: 16-bit address width

Example:`i2c_memory_write_int(&hi2c, 0xA0, 0x05, tx_buf, 8, 0xFFFFFFFF);`

5.13.66 i2c_memory_write_dma function

The table below describes the function i2c_memory_write_dma

Table 396. i2c_memory_write_dma function

Name	Description
Function name	i2c_memory_write_dma
Function prototype	i2c_status_type i2c_memory_write_dma(i2c_handle_type* hi2c, i2c_mem_address_width_type mem_address_width, uint16_t address, uint16_t mem_address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Write EEPROM (through DMA mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	mem_address_width: EEPROM memory address width Refer to the “mem_address_width” below for details.
Input parameter 3	address: EEPROM address
Input parameter 4	mem_address: EEPROM data memory address
Input parameter 5	pdata: array address of data to be sent
Input parameter 6	size: number of data to be sent
Input parameter 7	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

mem_address_width

EEPROM memory address width

I2C_MEM_ADDR_WIDIH_8: 8-bit address width

I2C_MEM_ADDR_WIDIH_16: 16-bit address width

Example:

```
i2c_memory_write_dma(&hi2c, 0xA0, 0x05, tx_buf, 8, 0xFFFFFFFF);
```

5.13.67 i2c_memory_read function

The table below describes the function i2c_memory_write_dma

Table 397. i2c_memory_write_dma function

Name	Description
Function name	i2c_memory_read
Function prototype	i2c_status_type i2c_memory_read(i2c_handle_type* hi2c, i2c_mem_address_width_type mem_address_width, uint16_t address, uint16_t mem_address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Read EEPROM (through DMA mode). This function is a blocking type. In other words, after the function execution is done, so is data transfer. It is mainly used for PEC transmission and reception.
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	mem_address_width: EEPROM memory address width Refer to the “mem_address_width” below for details.
Input parameter 3	address: EEPROM address
Input parameter 4	mem_address: EEPROM data memory address
Input parameter 5	pdata: array address of data to be read
Input parameter 6	size: number of data to be read
Input parameter 7	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

mem_address_width

EEPROM memory address width

I2C_MEM_ADDR_WIDIH_8: 8-bit address width

I2C_MEM_ADDR_WIDIH_16: 16-bit address width

Example:

```
i2c_memory_read(&hi2c, 0xA0, 0x05, rx_buf, 8, 0xFFFFFFFF);
```

5.13.68 i2c_memory_read_int function

The table below describes the function i2c_memory_read_int

Table 398. i2c_memory_write_dma function

Name	Description
Function name	i2c_memory_read_int
Function prototype	i2c_status_type i2c_memory_read_int(i2c_handle_type* hi2c, i2c_mem_address_width_type mem_address_width, uint16_t address, uint16_t mem_address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Read EEPROM (through interrupt mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	mem_address_width: EEPROM memory address width Refer to the “mem_address_width” below for details.
Input parameter 3	address: EEPROM address
Input parameter 4	mem_address: EEPROM data memory address
Input parameter 5	pdata: array address of data to be read
Input parameter 6	size: number of data to be read
Input parameter 7	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

mem_address_width

EEPROM memory address width

I2C_MEM_ADDR_WIDIH_8: 8-bit address width

I2C_MEM_ADDR_WIDIH_16: 16-bit address width

Example:

```
i2c_memory_read_int(&hi2c, 0xA0, 0x05, rx_buf, 8, 0xFFFFFFFF);
```

5.13.69 i2c_memory_read_dma function

The table below describes the function i2c_memory_read_dma

Table 399. i2c_memory_write_dma function

Name	Description
Function name	i2c_memory_read_dma
Function prototype	i2c_status_type i2c_memory_read_dma(i2c_handle_type* hi2c, i2c_mem_address_width_type mem_address_width, uint16_t address, uint16_t mem_address, uint8_t* pdata, uint16_t size, uint32_t timeout);
Function description	Read EEPROM (through DMA mode). This function is a non-blocking type. In other words, after the function is executed, the I2C transfer has not completed yet. So in this case, it is possible to call the i2c_wait_end() to wait for the end of transfer
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Input parameter 2	mem_address_width: EEPROM memory address width Refer to the “mem_address_width” below for details.
Input parameter 3	address: EEPROM address
Input parameter 4	mem_address: EEPROM data memory address
Input parameter 5	pdata: array address of data to be read
Input parameter 6	size: number of data to be read
Input parameter 7	Timeout: wait timeout
Output parameter	NA
Return value	i2c_status_type: error code Refer to error_code for details.
Required preconditions	NA
Called functions	NA

mem_address_width

EEPROM memory address width

I2C_MEM_ADDR_WIDIH_8: 8-bit address width

I2C_MEM_ADDR_WIDIH_16: 16-bit address width

Example:

```
i2c_memory_read_dma(&hi2c, 0xA0, 0x05, rx_buf, 8, 0xFFFFFFFF);
```

5.13.70 i2c_evt_irq_handler function

The table below describes the function i2c_evt_irq_handler

Table 400. i2c_evt_irq_handler function

Name	Description
Function name	i2c_evt_irq_handler
Function prototype	void i2c_evt_irq_handler(i2c_handle_type* hi2c);
Function description	Event interrupt function. It is used to handle I2C event interrupt
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
void I2C1_EVT_IRQHandler(void)
{
    i2c_evt_irq_handler(&hi2c);
}
```

5.13.71 i2c_err_irq_handler function

The table below describes the function i2c_err_irq_handler

Table 401. i2c_err_irq_handler function

Name	Description
Function name	i2c_err_irq_handler
Function prototype	void i2c_err_irq_handler(i2c_handle_type* hi2c);
Function description	Error interrupt function. It is used to handle I2C error interrupt
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
void I2C1_ERR_IRQHandler(void)
{
    i2c_err_irq_handler(&hi2c);
}
```

5.13.72 i2c_dma_tx_irq_handler function

The table below describes the function i2c_dma_tx_irq_handler

Table 402. i2c_dma_tx_irq_handler function

Name	Description
Function name	i2c_dma_tx_irq_handler
Function prototype	void i2c_dma_tx_irq_handler(i2c_handle_type* hi2c);
Function description	DMA transmit interrupt function. It is used to handle DMA transmit interrupt
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
void DMA1_Channel6_IRQHandler(void)
{
    i2c_dma_rx_irq_handler(&hi2c);
}
```

5.13.73 i2c_dma_rx_irq_handler function

The table below describes the function i2c_dma_rx_irq_handler

Table 403. i2c_dma_rx_irq_handler function

Name	Description
Function name	i2c_dma_rx_irq_handler
Function prototype	void i2c_dma_rx_irq_handler(i2c_handle_type* hi2c);
Function description	DMA receive interrupt function. It is used to handle DMA receive interrupt
Input parameter 1	hi2c: i2c_handle_type pointer Refer to i2c_handle_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
void DMA1_Channel7_IRQHandler(void)
{
    i2c_dma_tx_irq_handler(&hi2c);
}
```

5.14 Nested vectored interrupt controller (NVIC)

The NVIC register structure NVIC_Type is defined in the “core_cm4.h”:

```
/*
 * @brief Structure type to access the Nested Vectored Interrupt Controller (NVIC).
 */
typedef struct
{
    .....
} NVIC_Type;
```

The table below gives a list of the NVIC registers

Table 404. Summary of NVIC registers

Register	Description
iser	Interrupt enable set register
icer	Interrupt enable clear register
ispr	Interrupt suspend set register
icpr	Interrupt suspend clear register
iabr	Interrupt activate bit register
ip	Interrupt priority register
stir	Software trigger interrupt register

The table below gives a list of NVIC library functions.

Table 405. Summary of NVIC library functions

Function name	Description
nvic_system_reset	System software reset
nvic_irq_enable	NVIC interrupt enable and priority enable
nvic_irq_disable	NVIC interrupt disable
nvic_priority_group_config	NVIC interrupt priority grouping configuration
nvic_vector_table_set	NVIC interrupt vector table base address and offset address configuration
nvic_lowpower_mode_config	NVIC low-power mode configuration

5.14.1 nvic_system_reset function

The table below describes the function nvic_system_reset.

Table 406. nvic_system_reset function

Name	Description
Function name	nvic_system_reset
Function prototype	void nvic_system_reset(void)
Function description	System software reset
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NVIC_SystemReset()

Example:

```
/* system reset */
nvic_system_reset();
```

5.14.2 nvic_irq_enable function

The table below describes the function nvic_irq_enable.

Table 407. nvic_irq_enable function

Name	Description
Function name	nvic_irq_enable
Function prototype	void nvic_irq_enable(IRQn_Type irqn, uint32_t preempt_priority, uint32_t sub_priority)
Function description	NVIC interrupt enable and priority configuration
Input parameter 1	Irqn: interrupt vector selection Refer to the "irqn" descriptions below for details.
Input parameter 2	preempt_priority: set preemption priority This parameter cannot be greater than the highest preemption priority defined in the NVIC_PRIORITY_GROUP_x
Input parameter 3	sub_priority: set response priority This parameter cannot be greater than the highest response priority defined in the NVIC_PRIORITY_GROUP_x
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NVIC_SetPriority() NVIC_EnableIRQ()

irqn

irqn is used to select interrupt vectors, including:

- | | |
|---------------------|---------------------------------|
| WWDT_IRQn: | Window timer interrupt |
| PVM_IRQn: | PVM interrupt linked to EXINT |
| | |
| DMA2_Channel6_IRQn: | DMA2 channel 6 global interrupt |
| DMA2_Channel7_IRQn: | DMA2 channel 7 global interrupt |

Example:

```
/* enable nvic irq */
nvic_irq_enable(ADC1_2_3 IRQn, 0, 0);
```

5.14.3 nvic_irq_disable function

The table below describes the function nvic_irq_disable.

Table 408. nvic_irq_disable function

Name	Description
Function name	nvic_irq_disable
Function prototype	void nvic_irq_disable(IRQn_Type irqn)
Function description	NVIC interrupt enable
Input parameter	Irqn: select interrupt vector. Refer to irqn for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NVIC_DisableIRQ()

Example:

```
/* disable nvic irq */
nvic_irq_disable(ADC1_2_3 IRQn);
```

5.14.4 nvic_priority_group_config function

The table below describes the function nvic_priority_group_config.

Table 409. nvic_priority_group_config function

Name	Description
Function name	nvic_priority_group_config
Function prototype	void nvic_priority_group_config(nvic_priority_group_type priority_group)
Function description	NVIC interrupt priority grouping configuration
Input parameter	priority_group: select interrupt priority group This parameter can be any enumerated value in the nvic_priority_group_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NVIC_SetPriorityGrouping()

priority_group

priority_group is used to select priority group from the parameters below

NVIC_PRIORITY_GROUP_0:

Priority group 0 (0 bit for preemption priority, and 4 bits for response priority)

NVIC_PRIORITY_GROUP_1:

Priority group 1 (1 bit for preemption priority, and 3 bits for response priority)

NVIC_PRIORITY_GROUP_2:

Priority group 2 (2 bits for preemption priority, and 2 bits for response priority)

NVIC_PRIORITY_GROUP_3:

Priority group 3 (3 bits for preemption priority, and 1 bit for response priority)

NVIC_PRIORITY_GROUP_4:

Priority group 4 (4 bits for preemption priority, and 0 bit for response priority)

Example:

```
/* config nvic priority group */  
nvic_priority_group_config(NVIC_PRIORITY_GROUP_4);
```

5.14.5 nvic_vector_table_set function

The table below describes the function nvic_vector_table_set.

Table 410. nvic_vector_table_set function

Name	Description
Function name	nvic_vector_table_set
Function prototype	void nvic_vector_table_set(uint32_t base, uint32_t offset)
Function description	Set NVIC interrupt vector table base address and offset address
Input parameter 1	Base: base address of interrupt vector table The base address can be set in RAM or FLASH
Input parameter 2	Offset: offset address of interrupt vector table This parameter defines the start address of interrupt vector table, so it must be set to a multiple of 0x200.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

base

base is used to select the base address of interrupt vector table, including:

NVIC_VECTTAB_RAM: Interrupt vector table base address is located in RAM
NVIC_VECTTAB_FLASH: Interrupt vector table base address is located in FLASH

Example:

```
/* config vector table offset */  
nvic_vector_table_set(NVIC_VECTTAB_FLASH, 0x4000);
```

5.14.6 nvic_lowpower_mode_config function

The table below describes the function nvic_lowpower_mode_config.

Table 411. nvic_lowpower_mode_config function

Name	Description
Function name	nvic_lowpower_mode_config
Function prototype	void nvic_lowpower_mode_config(nvic_lowpower_mode_type lp_mode, confirm_state new_state)
Function description	Configure NVIC low-power mode
Input parameter 1	lp_mode: select low-power modes This parameter can be any enumerated value in the nvic_lowpower_mode_type.
Input parameter 2	new_state: indicates the pre-configured status of battery powered domain This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

lp_mode

lp_mode is used to select low-power modes, including:

NVIC_LP_SEVONPEND:

Send wakeup event upon interrupt suspend (this option is usually used in conjunction with WFE)

NVIC_LP_SLEEPDEEP:

Deepsleep mode control bit (enable or disable core clock)

NVIC_LP_SLEEPONEXIT: Sleep mode entry when system leaves the lowest-priority interrupt

Example:

```
/* enable sleep-on-exit feature */  
nvic_lowpower_mode_config(NVIC_LP_SLEEPONEXIT, TRUE);
```

5.15 Power controller (PWC)

The PWC register structure pwc_type is defined in the “at32f423_pwc.h”:

```
/*
 * @brief type define pwc register all
 */
typedef struct
{
    .....
} pwc_type;
```

The table below gives a list of the PWC registers

Table 412. Summary of PWC registers

Register	Description
ctrl	Power control register
ctrlsts	Power control/status register
ldoov	LDO calibration register

The table below gives a list of PWC library functions.

Table 413. Summary of PWC library functions

Function name	Description
pwc_reset	Reset PWC registers to their reset values.
pwc_batteryPoweredDomainAccess	Enable battery powered domain access
pwc_pvm_level_select	Select PVM threshold
pwc_powerVoltageMonitorEnable	Enable Voltage monitor
pwc_wakeupPinEnable	Enable standby-mode wakeup pin
pwc_flag_clear	Clear flag
pwc_flag_get	Get flag status
pwc_sleepModeEnter	Enter Sleep mode
pwc_deepSleepModeEnter	Enter Deepsleep mode
pwc_voltageRegulateSet	Select voltage regulator status in Deepsleep mode
pwc_standbyModeEnter	Enter Standby mode
pwc_ldoOutputVoltageSet	LDO output voltage setting

5.15.1 pwc_reset function

The table below describes the function pwc_reset.

Table 414. pwc_reset function

Name	Description
Function name	pwc_reset
Function prototype	void pwc_reset(void)
Function description	Reset all PWC registers to their reset values.
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	crm_periph_reset()

Example:

```
/* deinitialize pwc */
pwc_reset();
```

5.15.2 pwc_battery_powered_domain_access function

The table below describes the function pwc_battery_powered_domain_access.

Table 415. pwc_battery_powered_domain_access function

Name	Description
Function name	pwc_battery_powered_domain_access
Function prototype	void pwc_battery_powered_domain_access(confirm_state new_state)
Function description	Battery powered domain access enable
Input parameter	new_state: indicates the pre-configured status of battery powered domain This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable the battery-powered domain write operations */
pwc_battery_powered_domain_access(TRUE);
```

Note: Access to battery powered domain (such as, RTC) is allowed only after enabling it through this function.

5.15.3 pwc_pvm_level_select function

The table below describes the function pwc_pvm_level_select.

Table 416. pwc_pvm_level_select function

Name	Description
Function name	pwc_pvm_level_select
Function prototype	void pwc_pvm_level_select(pwc_pvm_voltage_type pvm_voltage)
Function description	Select PVM threshold
Input parameter	pvm_voltage: indicates the selected PVM threshold This parameter can be any enumerated value in the pwc_pvm_voltage_type.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

pvm_voltage

pvm_voltage is used to select a PVM threshold from the optional parameters below:

PWC_PVM_VOLTAGE_2V3: PVM threshold is 2.3V
 PWC_PVM_VOLTAGE_2V4: PVM threshold is 2.4V
 PWC_PVM_VOLTAGE_2V5: PVM threshold is 2.5V
 PWC_PVM_VOLTAGE_2V6: PVM threshold is 2.6V
 PWC_PVM_VOLTAGE_2V7: PVM threshold is 2.7V
 PWC_PVM_VOLTAGE_2V8: PVM threshold is 2.8V
 PWC_PVM_VOLTAGE_2V9: PVM threshold is 2.9V

Example:

```
/* set the threshold voltage to 2.9v */
pwc_pvm_level_select(PWC_PVM_VOLTAGE_2V9);
```

5.15.4 pwc_power_voltage_monitor_enable function

The table below describes the function pwc_power_voltage_monitor_enable.

Table 417. pwc_power_voltage_monitor_enable function

Name	Description
Function name	pwc_power_voltage_monitor_enable
Function prototype	void pwc_power_voltage_monitor_enable(confirm_state new_state)
Function description	Enable power voltage monitor (PVM)
Input parameter	new_state: indicates the pre-configured status of PVM This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable power voltage monitor */
pwc_power_voltage_monitor_enable(TRUE);
```

5.15.5 pwc_wakeup_pin_enable function

The table below describes the function pwc_wakeup_pin_enable.

Table 418. pwc_wakeup_pin_enable function

Name	Description
Function name	pwc_wakeup_pin_enable
Function prototype	void pwc_wakeup_pin_enable(uint32_t pin_num, confirm_state new_state)
Function description	Enable Standby wakeup pin
Input parameter 1	pin_num: select a standby wakeup pin This parameter can be any pin that is capable of waking up from Standby mode.
Input parameter 2	new_state: indicates the pre-configured status of Standby wakeup pins This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

pin_num

pin_num is used to select Standby-mode wakeup pin, including:

PWC_WAKEUP_PIN_1: Standby wakeup pin 1 (corresponding GPIO is PA0)

PWC_WAKEUP_PIN_2: Standby wakeup pin 1 (corresponding GPIO is PC13)

Example:

```
/* enable wakeup pin - pa0 */
pwc_wakeup_pin_enable(PWC_WAKEUP_PIN_1, TRUE);
```

5.15.6 pwc_flag_clear function

The table below describes the function pwc_flag_clear.

Table 419. pwc_flag_clear function

Name	Description
Function name	pwc_flag_clear
Function prototype	void pwc_flag_clear(uint32_t pwc_flag)
Function description	Clear flag
Input parameter	pwc_flag: to-be-cleared flag Refer to the "pwc_flag" description below for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

pwc_flag

pwc_flag is used to select a flag from the optional parameters below:

PWC_WAKEUP_FLAG: Standby wakeup event

PWC_STANDBY_FLAG: Standby mode entry

PWC_PVM_OUTPUT_FLAG: PVM output (this parameter cannot be cleared by software)

Example:

```
/* wakeup event flag clear */
pwc_flag_clear(PWC_WAKEUP_FLAG);
```

5.15.7 pwc_flag_get function

The table below describes the function pwc_flag_get.

Table 420. pwc_flag_get function

Name	Description
Function name	pwc_flag_get
Function prototype	flag_status pwc_flag_get(uint32_t pwc_flag)
Function description	Get flag status
Input parameter	pwc_flag: select a flag. Refer to pwc_flag for details.
Output parameter	NA
Return value	flag_status: indicates flag status Return SET or RESET.
Required preconditions	NA
Called functions	NA

Example:

```
/* check if wakeup event flag is set */
if(pwc_flag_get(PWC_WAKEUP_FLAG) != RESET)
```

5.15.8 pwc_sleep_mode_enter function

The table below describes the function pwc_sleep_mode_enter.

Table 421. pwc_sleep_mode_enter function

Name	Description
Function name	pwc_sleep_mode_enter
Function prototype	void pwc_sleep_mode_enter(pwc_sleep_enter_type pwc_sleep_enter)
Function description	Enter Sleep mode
Input parameter	pwc_sleep_enter: select a command to enter Sleep mode This parameter can be any enumerated value in the pwc_sleep_enter_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

pwc_sleep_enter

pwc_sleep_enter is used to select a command to enter Sleep mode from the optional parameters below:

PWC_SLEEP_ENTER_WFI: Enter Sleep mode by WFI

PWC_SLEEP_ENTER_WFE: Enter Sleep mode by WFE

Example:

```
/* enter sleep mode */
pwc_sleep_mode_enter(PWC_SLEEP_ENTER_WFI);
```

5.15.9 pwc_deep_sleep_mode_enter function

The table below describes the function pwc_deep_sleep_mode_enter.

Table 422. pwc_deep_sleep_mode_enter function

Name	Description
Function name	pwc_deep_sleep_mode_enter
Function prototype	void pwc_deep_sleep_mode_enter(pwc_deep_sleep_enter_type pwc_deep_sleep_enter)
Function description	Enter Deepsleep mode
Input parameter	pwc_deep_sleep_enter: select a command to enter Deepsleep mode This parameter can be any enumerated value in the pwc_deep_sleep_enter_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

pwc_deep_sleep_enter

pwc_deep_sleep_enter is used to select a command to enter Deepsleep mode, including:

PWC_DEEP_SLEEP_ENTER_WFI: Enter Deepsleep mode by WFI

PWC_DEEP_SLEEP_ENTER_WFE: Enter Deepsleep mode by WFE

Example:

```
/* enter deep sleep mode */
pwc_deep_sleep_mode_enter(PWC_DEEP_SLEEP_ENTER_WFI);
```

5.15.10 pwc_voltage_regulate_set function

The table below describes the function pwc_voltage_regulate_set.

Table 423. pwc_voltage_regulate_set function

Name	Description
Function name	pwc_voltage_regulate_set
Function prototype	void pwc_voltage_regulate_set(pwc_regulator_type pwc_regulator)
Function description	Select the status of voltage regulator in Deepsleep mode
Input parameter	pwc_regulator: select voltage regulator status This parameter can be any enumerated value in the pwc_regulator_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

pwc_regulator

pwc_regulator is used to select the status of voltage regulator from the optional parameters below:

PWC_REGULATOR_ON: Voltage regulator ON in Deepsleep mode

PWC_REGULATOR_LOW_POWER: Voltage regulator low-power mode in Deepsleep mode

Example:

```
/* config the voltage regulator mode */
pwc_voltage_regulate_set(PWC_REGULATOR_LOW_POWER);
```

5.15.11 pwc_standby_mode_enter function

The table below describes the function pwc_standby_mode_enter

Table 424. pwc_standby_mode_enter function

Name	Description
Function name	pwc_standby_mode_enter
Function prototype	void pwc_standby_mode_enter(void)
Function description	Enter Standby mode
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enter standby mode */
pwc_standby_mode_enter();
```

5.15.12 pwc_ldo_output_voltage_set function

The table below describes the function pwc_ldo_output_voltage_set

Table 425. pwc_ldo_output_voltage_set function

Name	Description
Function name	pwc_ldo_output_voltage_set
Function prototype	pwc_ldo_output_voltage_set(val)
Function description	LDO output voltage setting
Input parameter	val: LDO output voltage value This parameter can be any value from the pwc_ldo_output_voltage_type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

val

val is used to select LDO output voltage value from the following options:

- | | |
|---------------------|------------------|
| PWC_LDO_OUTPUT_1V0: | LDO outputs 1.0V |
| PWC_LDO_OUTPUT_1V2: | LDO outputs 1.2V |
| PWC_LDO_OUTPUT_1V3: | LDO outputs 1.3V |

Example:

```
/* reduce ldo before enter deepsleep mode */
pwc_ldo_output_voltage_set(PWC_LDO_OUTPUT_1V0);
```

5.16 System configuration controller (SCFG)

The SCFG register structure scfg_type is defined in the “at32f423_scfg.h”

```
/*
 * @brief type define scfg register all
 */
typedef struct
{
    ...
} scfg_type;
```

The table below gives a list of the SCFG registers

Table 426. Summary of SCFG registers

Register	Description
scfg_cfg1	SCFG configuration register 1
scfg_cfg2	SCFG configuration register 2
scfg_exintc1	SCFG external interrupt configuration register 1
scfg_exintc2	SCFG external interrupt configuration register 2
scfg_exintc3	SCFG external interrupt configuration register 3
scfg_exintc4	SCFG external interrupt configuration register 4
scfg_uhdrv	SCFG ultra-high drive capability register

The table below gives a list of SCFG library functions.

Table 427. Summary of SCFG library functions

Function name	Description
scfg_reset	SCFG reset
scfg_infrared_config	infrared configuration
scfg_mem_map_get	Get memory address map
scfg_i2s_full_duplex_config	I2S full-duplex mode configuration
scfg_pvm_lock_enable	PVM Lock enable
scfg_lockup_enable	Lockup lock enable
scfg_exint_line_config	External interrupt line configuration
scfg_pins_ultra_driven_enable	Pin ultra-high current sinking capability enable

5.16.1 scfg_reset function

The table below describes the function scfg_reset.

Table 428. scfg_reset function

Name	Description
Function name	scfg_reset
Function prototype	void scfg_reset(void);
Function description	Reset SCFG
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
scfg_reset();
```

5.16.2 scfg_infrared_config function

The table below describes the function scfg_infrared_config.

Table 429. scfg_infrared_config function

Name	Description
Function name	scfg_infrared_config
Function prototype	void scfg_infrared_config(scfg_ir_source_type source, scfg_ir_polarity_type polarity);
Function description	Infrared configuration
Input parameter 1	Source: infrared modulation signal source
Input parameter 2	Polarity: output signal polarity
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

scfg_ir_source_type

Select infrared signal source.

SCFG_IR_SOURCE_TMR10: Infrared signal source is TMR10

scfg_ir_polarity_type

Select infrared signal polarity.

SCFG_IR_POLARITY_NO_AFFECTE: Infrared output signal not inverted

SCFG_IR_POLARITY_REVERSE: Infrared output signal inverted

Example:

```
scfg_infrared_config(SCFG_IR_SOURCE_TMR10, SCFG_IR_POLARITY_NO_AFFECTE);
```

5.16.3 scfg_mem_map_get function

The table below describes the function scfg_mem_map_get.

Table 430. scfg_mem_map_get function

Name	Description
Function name	scfg_mem_map_get
Function prototype	uint8_t scfg_mem_map_get(void);
Function description	Get the status on a memory being mapped on the address 0x00000000
Input parameter	NA
Output parameter	NA
Return value	uint8_t: memory address map type
Required preconditions	NA
Called functions	NA

scfg_mem_map_type

Select a memory to be mapped at address 0x00000000

SCFG_MEM_MAP_MAIN_MEMORY: Main memory is mapped to 0x00000000

SCFG_MEM_MAP_BOOT_MEMORY: Boot memory is mapped to 0x00000000

SCFG_MEM_MAP_INTERNAL_SRAM: Internal memory is mapped to 0x00000000

Example:

```
uint8_t value;
value = scfg_mem_map_get();
```

5.16.4 scfg_i2s_full_duplex_config function

The table below describes the function scfg_i2s_full_duplex_config.

Table 431. scfg_i2s_full_duplex_config function

Name	Description
Function name	scfg_i2s_full_duplex_config
Function prototype	void scfg_i2s_full_duplex_config(scfg_i2s_type i2s_full_duplex);
Function description	I2S full-duplex mode configuration
Input parameter	i2s_full_duplex: full-duplex mode selection
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

scfg_i2s_type

Set full-duplex mode.

SCFG_FULL_DUPLEX_I2S_NONE: None (SPI/I2S1~3 run independently)

SCFG_FULL_DUPLEX_I2S1_I2S3: Combine I2S1 and I2S3 as full-duplex mode

SCFG_FULL_DUPLEX_I2S2_I2S3: Combine I2S2 and I2S3 as full-duplex mode

SCFG_FULL_DUPLEX_I2S1_I2S2: Combine I2S1 and I2S2 as full-duplex mode

Example:

```
scfg_i2s_full_duplex_config(SCFG_FULL_DUPLEX_I2S1_I2S3);
```

5.16.5 scfg_pvm_lock_enable function

The table below describes the function scfg_adc_dma_channel_remap.

Table 432. scfg_adc_dma_channel_remap function

Name	Description
Function name	scfg_pvm_lock_enable
Function prototype	void scfg_pvm_lock_enable(confirm_state new_state);
Function description	PVM Lock enable
Input parameter	new_state: enabled or disables This parameter can be FALSE or TRUE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
scfg_pvm_lock_enable(TRUE);
```

5.16.6 scfg_lockup_enable function

The table below describes the function scfg_usart1_tx_dma_channel_remap.

Table 433. scfg_usart1_tx_dma_channel_remap function

Name	Description
Function name	scfg_lockup_enable
Function prototype	void scfg_lockup_enable(confirm_state new_state);
Function description	Lockup lock enable
Input parameter	new_state: enabled or disables This parameter can be FALSE or TRUE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
scfg_lockup_enable(TRUE);
```

5.16.7 scfg_exint_line_config function

The table below describes the function scfg_exint_line_config.

Table 434. scfg_exint_line_config function

Name	Description
Function name	scfg_exint_line_config
Function prototype	void scfg_exint_line_config(scfg_port_source_type port_source, scfg_pins_source_type pin_source);
Function description	External interrupt line configuration
Input parameter 1	port_source: port source
Input parameter 2	pin_source: pin source
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

scfg_port_source_type

SCFG_PORT_SOURCE_GPIOA: port A

SCFG_PORT_SOURCE_GPIOB: port B

SCFG_PORT_SOURCE_GPIOC: port C

SCFG_PORT_SOURCE_GPIOD: port D

SCFG_PORT_SOURCE_GPIOE: port E

SCFG_PORT_SOURCE_GPIOF: port F

scfg_pins_source_type

SCFG_PINS_SOURCE0: pin 0

SCFG_PINS_SOURCE1: pin 1

SCFG_PINS_SOURCE2: pin 2

.....

SCFG_PINS_SOURCE13: pin 13

SCFG_PINS_SOURCE14: pin 14

SCFG_PINS_SOURCE15: pin15

Example:

```
scfg_exint_line_config(SCFG_PORT_SOURCE_GPIOA, SCFG_PINS_SOURCE1);
```

5.16.8 scfg_pins_ultra_driven_enable function

The table below describes the function scfg_pins_ultra_driven_enable.

Table 435. scfg_pins_ultra_driven_enable function

Name	Description
Function name	scfg_pins_ultra_driven_enable
Function prototype	void scfg_pins_ultra_driven_enable(scfg_ultra_driven_pins_type value, confirm_state new_state);
Function description	Enable pin ultra-high current sinking capability
Input parameter 1	Value: pin
Input parameter 2	new_state: enabled or disabled This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

scfg_ultra_driven_pins_type

SCFG_ULTRA_DRIVEN_PB8: PB8
SCFG_ULTRA_DRIVEN_PB9: PB9
SCFG_ULTRA_DRIVEN_PD12: PD12
SCFG_ULTRA_DRIVEN_PD13: PD13

Example:

```
scfg_pins_ultra_driven_enable(SCFG_ULTRA_DRIVEN_PB8, TRUE);
```

5.17 Serial peripheral interface (SPI)/ I²S

The SPI register structure spi_type is defined in the “at32f423_spi.h”:

```
/*
 * @brief type define spi register all
 */
typedef struct
{
    ...
} spi_type;
```

The table below gives a list of the SPI registers

Table 436. Summary of SPI registers

Register	Description
ctrl1	SPI control register 1
ctrl2	SPI control register 2
sts	SPI status register
dt	SPI data register
cpoly	SPI CRC register
rcrc	SPI RxCRC register
tcrc	SPI TxCRC register
i2sctrl	SPI_I2S configuration register
i2sclkp	SPI_I2S prescaler register

The table below gives a list of SPI library functions.

Table 437. Summary of SPI library functions

Function name	Description
spi_i2s_reset	Reset SPI/I ² S registers to their reset values
spi_default_para_init	Configure the SPI initialization structure with an initial value
spi_init	Initialize SPI
spi_ti_mode_enable	SPI TI mode enable
spi_crc_next_transmit	Next data transfer is CRC command
spi_crc_polynomial_set	SPI CRC polynomial configuration
spi_crc_polynomial_get	Get SPI CRC polynomial
spi_crc_enable	Enable SPI CRC
spi_crc_value_get	Get CRC result of SPI receive/transmit
spi_hardware_cs_output_enable	Enable hardware CS output
spi_software_cs_internal_level_set	Set software CS internal level
spi_frame_bit_num_set	Set the number of frame bits
spi_half_duplex_direction_set	Set transfer direction of single-wire bidirectional half-duplex mode
spi_enable	Enable SPI
i2s_default_para_init	Set an initial value for the I ² S initialization structure
i2s_init	Initialize I ² S
i2s_enable	Enable I ² S
spi_i2s_interrupt_enable	Enable SPI/I ² S interrupts

spi_i2s_dma_transmitter_enable	Enable SPI/I ² S DMA transmit
spi_i2s_dma_receiver_enable	Enable SPI/I ² S DMA receive
spi_i2s_data_transmit	SPI/I ² S transmits data
spi_i2s_data_receive	SPI/I ² S receives data
spi_i2s_flag_get	Get SPI/I ² S flags
spi_i2s_flag_clear	Clear SPI/I ² S flags

5.17.1 spi_i2s_reset function

The table below describes the function spi_i2s_reset.

Table 438. spi_i2s_reset function

Name	Description
Function name	spi_i2s_reset
Function prototype	void spi_i2s_reset(spi_type *spi_x);
Function description	Reset SPI/I ² S registers to their reset values.
Input parameter 1	spi_x: select SPI peripherals This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	crm_periph_reset();

Example:

```
spi_i2s_reset (SPI1);
```

5.17.2 spi_default_para_init function

The table below describes the function spi_default_para_init.

Table 439. spi_default_para_init function

Name	Description
Function name	spi_default_para_init
Function prototype	void spi_default_para_init(spi_init_type* spi_init_struct);
Function description	Set an initial value for the SPI initialization structure
Input parameter 1	spi_init_struct: <i>spi_init_type</i> pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of <i>spi_init_type</i> before starting.
Called functions	NA

Example:

```
spi_init_type spi_init_struct;
spi_default_para_init (&spi_init_struct);
```

5.17.3 spi_init function

The table below describes the function spi_init.

Table 440. spi_init function

Name	Description
Function name	spi_init
Function prototype	void spi_init(spi_type* spi_x, spi_init_type* spi_init_struct);
Function description	Initialize SPI
Input parameter 1	spi_x: select SPI peripherals This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	spi_init_struct: <i>spi_init_type</i> pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of <i>spi_init_type</i> before starting.
Called functions	NA

spi_init_type is defined in the at32f423_spi.h:

typedef struct

```
{
    spi_transmission_mode_type      transmission_mode;
    spi_master_slave_mode_type     master_slave_mode;
    spi_mclk_freq_div_type        mclk_freq_division;
    spi_first_bit_type            first_bit_transmission;
    spi_frame_bit_num_type        frame_bit_num;
    spi_clock_polarity_type       clock_polarity;
    spi_clock_phase_type          clock_phase;
    spi_cs_mode_type              cs_mode_selection;
}
```

spi_init_type

spi_transmission_mode

SPI transmission mode.

SPI_TRANSMIT_FULL_DUPLEX:	Two-wire unidirectional full-duplex mode
SPI_TRANSMIT_SIMPLEX_RX:	Two-wire unidirectional receive-only mode
SPI_TRANSMIT_HALF_DUPLEX_RX:	Single-wire bidirectional receive-only mode
SPI_TRANSMIT_HALF_DUPLEX_TX:	Single-wire bidirectional transmit-only mode

master_slave_mode

Master/slave mode selection.

SPI_MODE_SLAVE:	Slave mode
SPI_MODE_MASTER:	Master mode

mclk_freq_division

Frequency division factor selection.

SPI_MCLK_DIV_2:	Divided by 2
SPI_MCLK_DIV_4:	Divided by 4
SPI_MCLK_DIV_8:	Divided by 8
SPI_MCLK_DIV_16:	Divided by 16
SPI_MCLK_DIV_32:	Divided by 32
SPI_MCLK_DIV_64:	Divided by 64
SPI_MCLK_DIV_128:	Divided by 128

SPI_MCLK_DIV_256: Divided by 256

SPI_MCLK_DIV_512: Divided by 512

SPI_MCLK_DIV_1024: Divided by 1024

first_bit_transmission

SPI MSB-first/LSB-first selection

SPI_FIRST_BIT_MSB: MSB-first

SPI_FIRST_BIT_LSB: LSB-first

frame_bit_num

Set the number of bits in a frame

SPI_FRAME_8BIT: 8-bit data in a frame

SPI_FRAME_16BIT: 16-bit data in a frame

clock_polarity

Select Clock polarity.

SPI_CLOCK_POLARITY_LOW: Clock output low in idle state

SPI_CLOCK_POLARITY_HIGH: Clock output high in idle state

clock_phase

Select clock phase.

SPI_CLOCK_PHASE_1EDGE: Sample on the first clock edge

SPI_CLOCK_PHASE_2EDGE: Sample on the second clock edge

cs_mode_selection

Select CS mode.

SPI_CS_HARDWARE_MODE: Hardware CS mode

SPI_CS_SOFTWARE_MODE: Software CS mode

Example:

```
spi_init_type spi_init_struct;
spi_default_para_init(&spi_init_struct);
spi_init_struct.transmission_mode = SPI_TRANSMIT_FULL_DUPLEX;
spi_init_struct.master_slave_mode = SPI_MODE_MASTER;
spi_init_struct.mclk_freq_division = SPI_MCLK_DIV_8;
spi_init_struct.first_bit_transmission = SPI_FIRST_BIT_MSB;
spi_init_struct.frame_bit_num = SPI_FRAME_16BIT;
spi_init_struct.clock_polarity = SPI_CLOCK_POLARITY_LOW;
spi_init_struct.clock_phase = SPI_CLOCK_PHASE_2EDGE;
spi_init_struct.cs_mode_selection = SPI_CS_SOFTWARE_MODE;
spi_init(SPI1, &spi_init_struct);
```

5.17.4 spi_ti_mode_enable function

The table below describes the function spi_crc_next_transmit.

Table 441. spi_ti_mode_enable function

Name	Description
Function name	spi_ti_mode_enable
Function prototype	void spi_ti_mode_enable(spi_type* spi_x, confirm_state new_state);
Function description	Enable SPI TI mode
Input parameter 1	spi_x: select SPI peripherals This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	new_state: enabled or disabled This parameter can be FALSE or TRUE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* spi ti mode enable */
spi_ti_mode_enable (SPI1, TRUE);
```

5.17.5 spi_crc_next_transmit function

The table below describes the function spi_crc_next_transmit.

Table 442. spi_crc_next_transmit function

Name	Description
Function name	spi_crc_next_transmit
Function prototype	void spi_crc_next_transmit(spi_type* spi_x);
Function description	The next data to be sent is CRC command
Input parameter 1	spi_x: select SPI peripherals This parameter can be SPI1, SPI2, SPI3, SPI4.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
spi_crc_next_transmit (SPI1);
```

5.17.6 spi_crc_polynomial_set function

The table below describes the function spi_crc_polynomial_set.

Table 443. spi_crc_polynomial_set function

Name	Description
Function name	spi_crc_polynomial_set
Function prototype	void spi_crc_polynomial_set(spi_type* spi_x, uint16_t crc_poly);
Function description	Set SPI CRC polynomial
Input parameter 1	spi_x: select SPI peripherals This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	crc_poly: CRC polynomial Value is 0x0000~0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/*set spi crc polynomial value */
spi_crc_polynomial_set (SPI1, 0x07);
```

5.17.7 spi_crc_polynomial_get function

The table below describes the function spi_crc_polynomial_get.

Table 444. spi_crc_polynomial_get function

Name	Description
Function name	spi_crc_polynomial_get
Function prototype	uint16_t spi_crc_polynomial_get(spi_type* spi_x);
Function description	Get SPI CRC polynomial
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Output parameter	NA
Return value	CRC polynomial Value is 0x0000~0xFFFF
Required preconditions	NA
Called functions	NA

Example:

```
/*get spi crc polynomial value */
uint16_t crc_poly;
crc_poly = spi_crc_polynomial_get (SPI1);
```

5.17.8 spi_crc_enable function

The table below describes the function spi_crc_enable.

Table 445. spi_crc_enable function

Name	Description
Function name	spi_crc_enable
Function prototype	void spi_crc_enable(spi_type* spi_x, confirm_state new_state);
Function description	Enable SPI CRC
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	new_state: enabled or disabled This parameter can be FALSE or TRUE
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* spi crc enable */
spi_crc_enable (SPI1, TRUE);
```

5.17.9 spi_crc_value_get function

The table below describes the function spi_crc_value_get.

Table 446. spi_crc_value_get function

Name	Description
Function name	spi_crc_value_get
Function prototype	uint16_t spi_crc_value_get(spi_type* spi_x, spi_crc_direction_type crc_direction);
Function description	Get SPI receive/transmit CRC result
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	<i>crc_direction</i> : Select receive/transmit CRC
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

crc_direction

Select receive/transmit CRC

SPI_CRC_RX: Receive CRC

SPI_CRC_TX: Transmit CRC

Example:

```
/* get spi rx & tx crc enable */
uint16_t spi_rx_crc, spi_tx_crc;
spi_rx_crc = spi_crc_value_get (SPI1, SPI_CRC_RX);
spi_tx_crc = spi_crc_value_get (SPI1, SPI_CRC_TX);
```

5.17.10 spi_hardware_cs_output_enable function

The table below describes the function spi_hardware_cs_output_enable.

Table 447. spi_hardware_cs_output_enable function

Name	Description
Function name	spi_hardware_cs_output_enable
Function prototype	void spi_hardware_cs_output_enable(spi_type* spi_x, confirm_state new_state);
Function description	Enable hardware CS output
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	new_state: enabled or disabled This parameter can FALSE or TRUE
Output parameter	NA
Return value	NA
Required preconditions	This setting is applicable to SPI master mode only.
Called functions	NA

Example:

```
/* enable the hardware cs output */
spi_hardware_cs_output_enable (SPI1, TRUE);
```

5.17.11 spi_software_cs_internal_level_set function

The table below describes the function spi_software_cs_internal_level_set.

Table 448. spi_software_cs_internal_level_set function

Name	Description
Function name	spi_software_cs_internal_level_set
Function prototype	void spi_software_cs_internal_level_set(spi_type* spi_x, spi_software_cs_level_type level);
Function description	Set software CS internal level
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	<i>level</i> : set software CS internal level
Output parameter	NA
Return value	NA
Required preconditions	1. This setting is applicable to software CS mode only; 2. In master mode, the "level" value must be "SPI_SWCS_INTERNAL_LEVEL_HIGHT".
Called functions	NA

level

Set software CS internal level

SPI_SWCS_INTERNAL_LEVEL_LOW: Software CS internal low level

SPI_SWCS_INTERNAL_LEVEL_HIGHT: Software CS internal high level

Example:

```
/* set the internal level high */
spi_software_cs_internal_level_set (SPI1, SPI_SWCS_INTERNAL_LEVEL_HIGHT);
```

5.17.12 spi_frame_bit_num_set function

The table below describes the function spi_frame_bit_num_set.

Table 449. spi_frame_bit_num_set function

Name	Description
Function name	spi_frame_bit_num_set
Function prototype	void spi_frame_bit_num_set(spi_type* spi_x, spi_frame_bit_num_type bit_num);
Function description	Set the number of bits in a frame
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	<i>bit_num</i> : Set the number of bits in a frame
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

bit_num

Set the number of bits in a frame

SPI_FRAME_8BIT: 8-bit data in a frame

SPI_FRAME_16BIT: 16-bit data in a frame

Example:

```
/* set the data frame bit num as 8 */
spi_frame_bit_num_set (SPI1, SPI_FRAME_8BIT);
```

5.17.13 spi_half_duplex_direction_set function

The table below describes the function spi_half_duplex_direction_set.

Table 450. spi_half_duplex_direction_set function

Name	Description
Function name	spi_half_duplex_direction_set
Function prototype	void spi_half_duplex_direction_set(spi_type* spi_x, spi_half_duplex_direction_type direction);
Function description	Set the transfer direction of single-wire bidirectional half-duplex mode
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	<i>direction</i> : transfer direction
Output parameter	NA
Return value	NA
Required preconditions	This setting is applicable to the single-wire bidirectional half-duplex mode only.
Called functions	NA

direction

Transfer direction

SPI_HALF_DUPLEX_DIRECTION_RX: Receive

SPI_HALF_DUPLEX_DIRECTION_TX: Transmit

Example:

```
/* set the data transmission direction as transmit */
spi_half_duplex_direction_set (SPI1, SPI_HALF_DUPLEX_DIRECTION_TX);
```

5.17.14 spi_enable function

The table below describes the function spi_enable.

Table 451. spi_enable function

Name	Description
Function name	spi_enable
Function prototype	void spi_enable(spi_type* spi_x, confirm_state new_state);
Function description	Enable SPI
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	new_state: enabled or disabled This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable spi */
spi_enable (SPI1, TRUE);
```

5.17.15 i2s_default_para_init function

The table below describes the function i2s_default_para_init.

Table 452. i2s_default_para_init function

Name	Description
Function name	i2s_default_para_init
Function prototype	void i2s_default_para_init(i2s_init_type* i2s_init_struct);
Function description	Set an initial value for the I ² S initialization structure
Input parameter 1	i2s_init_struct: <i>spi_i2s_flag</i> pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of i2s_init_type before starting.
Called functions	NA

Example:

```
i2s_init_type i2s_init_struct;
i2s_default_para_init (&i2s_init_struct);
```

5.17.16 i2s_init function

The table below describes the function i2s_init.

Table 453. i2s_init function

Name	Description
Function name	i2s_init
Function prototype	void i2s_init(spi_type* spi_x, i2s_init_type* i2s_init_struct);
Function description	Initialize I ² S
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Input parameter 2	i2s_init_struct: <i>spi_i2s_flag</i> pointer
Output parameter	NA
Return value	NA
Required preconditions	It is necessary to define a variable of i2s_init_type before starting.
Called functions	NA

i2s_init_type is defined in the at32f423_spi.h:

typedef struct

{

i2s_operation_mode_type	operation_mode;
i2s_audio_protocol_type	audio_protocol;
i2s_audio_sampling_freq_type	audio_sampling_freq;
i2s_data_channel_format_type	data_channel_format;
i2s_clock_polarity_type	clock_polarity;
confirm_state	mclk_output_enable;

} i2s_init_type;

operation_mode

I²S transfer mode

I2S_MODE_SLAVE_TX:	I2S slave transmit
I2S_MODE_SLAVE_RX:	I2S slave receive
I2S_MODE_MASTER_TX:	I2S master transmit
I2S_MODE_MASTER_RX:	I2S master receive

audio_protocol

I²S audio protocol standards

I2S_AUDIO_PROTOCOL_PHILLIPS:	Phillips
I2S_AUDIO_PROTOCOL_MSB:	MSB aligned (left-aligned)
I2S_AUDIO_PROTOCOL_LSB:	LSB aligned (right-aligned)
I2S_AUDIO_PROTOCOL_PCM_SHORT:	PCM short frame synchronization
I2S_AUDIO_PROTOCOL_PCM_LONG:	PCM long frame synchronization

audio_sampling_freq

I²S audio sampling frequency.

I2S_AUDIO_FREQUENCY_DEFAULT:

Kept at its reset value (sampling frequency changes with SCLK)

I2S_AUDIO_FREQUENCY_8K:	I2S sampling frequency 8K
I2S_AUDIO_FREQUENCY_11_025K:	I2S sampling frequency 11.025K
I2S_AUDIO_FREQUENCY_16K:	I2S sampling frequency 16K
I2S_AUDIO_FREQUENCY_22_05K:	I2S sampling frequency 22.05K
I2S_AUDIO_FREQUENCY_32K:	I2S sampling frequency 32K

I2S_AUDIO_FREQUENCY_44_1K:	I2S sampling frequency 44.1K
I2S_AUDIO_FREQUENCY_48K:	I2S sampling frequency 48K
I2S_AUDIO_FREQUENCY_96K:	I2S sampling frequency 96K
I2S_AUDIO_FREQUENCY_192K:	I2S sampling frequency 192K

data_channel_formatI²S data/channel bits format

I2S_DATA_16BIT_CHANNEL_16BIT:	16-bit data, 16-bit channel
I2S_DATA_16BIT_CHANNEL_32BIT:	16-bit data, 32-bit channel
I2S_DATA_24BIT_CHANNEL_32BIT:	24-bit data, 32-bit channel
I2S_DATA_32BIT_CHANNEL_32BIT:	32-bit data, 32-bit channel

clock_polarityI²S clock polarity

I2S_CLOCK_POLARITY_LOW:	Clock output low in idle state
I2S_CLOCK_POLARITY_HIGH:	Clock output high in idle state

mclk_output_enable

Enable mclk clock output

This parameter can be FALSE or TRUE.

Example:

```
i2s_init_type i2s_init_struct;
i2s_default_para_init(&i2s_init_struct);
i2s_init_struct.audio_protocol = I2S_AUDIO_PROTOCOL_PHILLIPS;
i2s_init_struct.data_channel_format = I2S_DATA_16BIT_CHANNEL_32BIT;
i2s_init_struct.mclk_output_enable = FALSE;
i2s_init_struct.audio_sampling_freq = I2S_AUDIO_FREQUENCY_48K;
i2s_init_struct.clock_polarity = I2S_CLOCK_POLARITY_LOW;
i2s_init_struct.operation_mode = I2S_MODE_MASTER_TX;
i2s_init(SPI2, &i2s_init_struct);
```

5.17.17 i2s_enable function

The table below describes the function i2s_enable.

Table 454. i2s_enable function

Name	Description
Function name	i2s_enable
Function prototype	void i2s_enable(spi_type* spi_x, confirm_state new_state);
Function description	Enable I ² S
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4.
Input parameter 2	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable i2s*/
i2s_enable (SPI1, TRUE);
```

5.17.18 spi_i2s_interrupt_enable function

The table below describes the function spi_i2s_interrupt_enable.

Table 455. spi_i2s_interrupt_enable function

Name	Description
Function name	spi_i2s_interrupt_enable
Function prototype	void spi_i2s_interrupt_enable(spi_type* spi_x, uint32_t spi_i2s_int, confirm_state new_state);
Function description	Enable SPI/I ² S interrupts
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Input parameter 2	<i>spi_i2s_int</i> : select SPI interrupts
Input parameter 3	new_state: Enable or disable This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

spi_i2s_int

Select SPI/I²S interrupt selection.

SPI_I2S_ERROR_INT: SPI/I²S error interrupts (including CRC error, overflow error, underflow error and mode error)

SPI_I2S_RDBF_INT: Receive data buffer full

SPI_I2S_TDBE_INT: Transmit data buffer empty

Example:

```
/* enable the specified spi/i2s interrupts */
spi_i2s_interrupt_enable(SPI1, SPI_I2S_ERROR_INT);
spi_i2s_interrupt_enable(SPI1, SPI_I2S_RDBF_INT);
spi_i2s_interrupt_enable(SPI1, SPI_I2S_TDBE_INT);
```

5.17.19 spi_i2s_dma_transmitter_enable function

The table below describes the function spi_i2s_dma_transmitter_enable.

Table 456. spi_i2s_dma_transmitter_enable function

Name	Description
Function name	spi_i2s_dma_transmitter_enable
Function prototype	void spi_i2s_dma_transmitter_enable(spi_type* spi_x, confirm_state new_state);
Function description	Enable SPI/I ² S DMA transmitter
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Input parameter 2	new_state: enabled or disabled This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA

Name	Description
Called functions	NA

Example:

```
/* enable spi transmitter dma */
spi_i2s_dma_transmitter_enable (SPI1, TRUE);
```

5.17.20 spi_i2s_dma_receiver_enable function

The table below describes the function spi_i2s_dma_receiver_enable.

Table 457. spi_i2s_dma_receiver_enable function

Name	Description
Function name	spi_i2s_dma_receiver_enable
Function prototype	void spi_i2s_dma_receiver_enable(spi_type* spi_x, confirm_state new_state);
Function description	Enable SPI/I ² S DMA receiver
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Input parameter 2	new_state: enabled or disabled This parameter can be FALSE or TRUE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable spi dma transmitter */
spi_i2s_dma_transmitter_enable (SPI1, TRUE);
```

5.17.21 spi_i2s_data_transmit function

The table below describes the function spi_i2s_data_transmit.

Table 458. spi_i2s_data_transmit function

Name	Description
Function name	spi_i2s_data_transmit
Function prototype	void spi_i2s_data_transmit(spi_type* spi_x, uint16_t tx_data);
Function description	SPI/I ² S sends data
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Input parameter 2	tx_data: data to send Value range (for 8-bit bit in a frame): 0x00~0xFF Value range (for 16-bit in a frame): 0x0000~0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* spi data transmit */
uint16_t tx_data = 0x6666;
spi_i2s_data_transmit (SPI1, tx_data);
```

5.17.22 spi_i2s_data_receive function

The table below describes the function spi_i2s_data_receive.

Table 459. spi_i2s_data_receive function

Name	Description
Function name	spi_i2s_data_receive
Function prototype	uint16_t spi_i2s_data_receive(spi_type* spi_x);
Function description	SPI/I ² S receives data
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Output parameter	rx_data: data to receive Value range (for 8-bit bit in a frame): 0x00~0xFF Value range (for 16-bit in a frame): 0x0000~0xFFFF
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* spi data receive */
uint16_t rx_data = 0;
rx_data = spi_i2s_data_receive (SPI1);
```

5.17.23 spi_i2s_flag_get function

The table below describes the function spi_i2s_flag_get.

Table 460. spi_i2s_flag_get function

Name	Description
Function name	spi_i2s_flag_get
Function prototype	flag_status spi_i2s_flag_get(spi_type* spi_x, uint32_t spi_i2s_flag);
Function description	Get SPI/I ² S flags
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Input parameter 2	spi_i2s_flag : flag selection Refer to the “spi_i2s_flag” description below for details.
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

spi_i2s_flag

SPI/I²S is used to select a flag from the optional parameters below:

- SPI_I2S_RDBF_FLAG: SPI/I²S receive data buffer full
- SPI_I2S_TDBE_FLAG: SPI/I²S transmit data buffer empty
- I2S_ACS_FLAG: I2S audio channel state (indicating left/right channel)
- I2S_TUERR_FLAG: I2S transmitter underload error
- SPI_CCERR_FLAG: SPI CRC error

SPI_MMERR_FLAG:	SPI master mode error
SPI_I2S_ROERR_FLAG:	SPI/I ² S receive overflow error
SPI_I2S_BF_FLAG:	SPI/I ² S busy
SPI_CSPAS_FLAG:	SPI CS pulse error

Example:

```
/* get receive data buffer full flag */
flag_status status;
status = spi_i2s_flag_get(SPI1, SPI_I2S_RDBF_FLAG);
```

5.17.24 **spi_i2s_interrupt_flag_get** function

The table below describes the function `spi_i2s_interrupt_flag_get`.

Table 461. `spi_i2s_interrupt_flag_get` function

Name	Description
Function name	<code>spi_i2s_interrupt_flag_get</code>
Function prototype	<code>flag_status spi_i2s_interrupt_flag_get(spi_type* spi_x, uint32_t spi_i2s_flag);</code>
Function description	Get SPI/I ² S interrupt flag status
Input parameter 1	<code>spi_x</code> : select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Input parameter 2	<code>spi_i2s_flag</code> : select a flag to clear Refer to the “ <code>spi_i2s_flag</code> ” description below for details.
Output parameter	NA
Return value	<code>flag_status</code> : SET or RESET.
Required preconditions	NA
Called functions	NA

spi_i2s_flag:

SPI/I²S is used for flag selection, including:

SPI_I2S_RDBF_FLAG:	SPI/I ² S receive data buffer full
SPI_I2S_TDBE_FLAG:	SPI/I ² S transmit data buffer empty
I2S_TUERR_FLAG:	I2S transmitter underload error
SPI_CCERR_FLAG:	SPI CRC error
SPI_MMERR_FLAG:	SPI master mode error
SPI_I2S_ROERR_FLAG:	SPI/I ² S receive overflow error
SPI_CSPAS_FLAG:	SPI CS pulse error

Example:

```
/* get receive data buffer full flag */
flag_status status;
status = spi_i2s_interrupt_flag_get(SPI1, SPI_I2S_RDBF_FLAG);
```

5.17.25 spi_i2s_flag_clear function

The table below describes the function spi_i2s_flag_clear.

Table 462. spi_i2s_flag_clear function

Name	Description
Function name	spi_i2s_flag_clear
Function prototype	void spi_i2s_flag_clear(spi_type* spi_x, uint32_t spi_i2s_flag)
Function description	Clear SPI/I ² S flags
Input parameter 1	spi_x: select SPI peripheral This parameter can be SPI1, SPI2, SPI3, SPI4, I2S2EXT, I2S3EXT.
Input parameter 2	<i>spi_i2s_flag</i> : select a flag to clear Refer to the “spi_i2s_flag” description below for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

spi_i2s_flag:

SPI/I²S is used for flag selection, including:

SPI_I2S_RDBF_FLAG:	SPI/I ² S receive data buffer full
I2S_TUERR_FLAG:	I2S transmitter underload error
SPI_CCERR_FLAG:	SPI CRC error
SPI_MMERR_FLAG:	SPI master mode error
SPI_I2S_ROERR_FLAG:	SPI/I ² S receive overflow error
SPI_CSPAS_FLAG:	SPI CS pulse error

Note: the SPI_I2S_TDBE_FLAG (SPI/I²S transmit data buffer empty), the I2S_ACS_FLAG (Audio channel state) and the SPI_I2S_BF_FLAG (SPI/I²S busy) are all set and cleared by hardware to indicate communication state, without the intervention of software.

Example:

```
/* clear receive data buffer full flag */  
spi_i2s_flag_clear (SPI1, SPI_I2S_RDBF_FLAG);
```

5.18 SysTick

The SysTick register structure SysTick_Type is defined in the “core_cm4.h”:

```
typedef struct
```

```
{
```

```
...
```

```
}
```

The table below gives a list of the SysTick registers

Table 463. Summary of SysTick registers

Register	Description
ctrl	Controls status register
load	Reload value register
val	Current counter value register
calib	Calibration register

The table below gives a list of SysTick library functions.

Table 464. Summary of SysTick library functions

Function name	Description
systick_clock_source_config	Configure SysTick clock sources
SysTick_Config	Configure SysTick counter reload value and interrupts

5.18.1 systick_clock_source_config function

The table below describes the function systick_clock_source_config.

Table 465. systick_clock_source_config function

Name	Description
Function name	systick_clock_source_config
Function prototype	void systick_clock_source_config(systick_clock_source_type source);
Function description	Configure SysTick clock source
Input parameter 1	Source: systick clock source
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

source

SYSTICK_CLOCK_SOURCE_AHBCLK_DIV8: AHB/8 as SysTick clock

SYSTICK_CLOCK_SOURCE_AHBCLK_NODIV: AHB as SysTick clock

Example:

```
/* config systick clock source */
systick_clock_source_config(SYSTICK_CLOCK_SOURCE_AHBCLK_NODIV);
```

5.18.2 SysTick_Config function

The table below describes the function SysTick_Config

Table 466. SysTick_Config function

Name	Description
Function name	SysTick_Config
Function prototype	uint32_t SysTick_Config(uint32_t ticks);
Function description	Configure SysTick counter reload value and enable interrupt
Input parameter 1	Ticks: SysTick counter interrupt reload value
Output parameter	NA
Return value	Return the setting status of this function, success (0) or failure (1)
Required preconditions	NA
Called functions	NA

Example:

```
/* config systick reload value and enable interrupt */  
SysTick_Config(1000);
```

5.19 TMR

The TMR register structure tmr_type is defined in the "at32f423_tmr.h":

```
/*
 * @brief type define tmr register all
 */
typedef struct
{
} tmr_type;
```

The table below gives a list of the TMR registers

Table 467. Summary of TMR registers

Register	Description
ctrl1	TMR control register 1
ctrl2	TMR control register 2
stctrl	TMR slave timer control register
iden	TMR DMA/ interrupt enable register
ists	TMR interrupt status register
swevt	TMR software event register
cm1	TMR channel mode register 1
cm2	TMR channel mode register 2
cctrl	TMR channel control register
cval	TMR counter value register
div	TMR division register
pr	TMR period register
rpr	TMR repetition period channel
c1dt	TMR channel 1 data register
c2dt	TMR channel 2 data register
c3dt	TMR channel 3 data register
c4dt	TMR channel 4 data register
brk	TMR break register
dmactrl	TMR DMA control register
dmadt	TMR DMA data register
rmp	TMR channel input remap register
cm3	TMR channel mode register 3
c5dt	TMR channel 5 data register

The table below gives a list of TMR library functions.

Table 468. Summary of TMR library functions

Function name	Description
tmr_reset	TMR is reset by CRM reset register
tmr_counter_enable	Enable or disable TMR
tmr_output_default_para_init	Initialize TMR output default parameters
tmr_input_default_para_init	Initialize TMR input default parameters
tmr_brkdt_default_para_init	Initialize TMR brkdt default parameters
tmr_base_init	Initialize TMR period and division
tmr_clock_source_div_set	Set TMR clock source frequency division factor
tmr_cnt_dir_set	Set TMR counter direction
tmr_repetition_counter_set	Set repetition period register
tmr_counter_value_set	Set TMR counter value
tmr_counter_value_get	Get TMR counter value
tmr_div_value_set	Set TMR division value
tmr_div_value_get	Get TMR division value
tmr_output_channel_config	Configure TMR output channels
tmr_output_channel_mode_select	Select TMR output channel mode
tmr_period_value_set	Set TMR period value
tmr_period_value_get	Get TMR period value
tmr_channel_value_set	Set TMR channel value
tmr_channel_value_get	Get TMR channel value
tmr_period_buffer_enable	Enable or disable TMR periodic buffer
tmr_output_channel_buffer_enable	Enable or disable TMR output channel buffer
tmr_output_channel_immediately_set	TMR output channel enable immediately
tmr_output_channel_switch_set	Set TMR output channel switch
tmr_one_cycle_mode_enable	Enable or disable TMR one-cycle mode
tmr_32_bit_function_enable	Enable or disable TMR 32-bit function (plus mode)
tmr_overflow_request_source_set	Select TMR overflow event source
tmr_overflow_event_disable	Enable or disable TMR overflow event generation
tmr_channel_enable	Enable or disable TMR channel
tmr_input_channel_filter_set	Set TMR input channel filter
tmr_pwm_input_config	Configure TMR pwm input
tmr_channel1_input_select	Select TMR channel 1 input
tmr_input_channel_divider_set	Set TMR input channel divider
tmr_primary_mode_select	Select TMR master mode
tmr_sub_mode_select	Select TMR slave timer mode
tmr_channel_dma_select	Select TMR channel DMA request source
tmr_hall_select	Select TMR hall mode
tmr_channel_buffer_enable	Enable or disable TMR channel buffer
tmr_trigger_input_select	Select TMR slave timer trigger input
tmr_sub_sync_mode_set	Set TMR slave timer synchronization mode
tmr_dma_request_enable	Enable or disable TMR DMA request
tmr_interrupt_enable	Enable or disable TMR interrupt
tmr_interrupt_flag_get	Get TMR interrupt flag bit
tmr_flag_get	Get TMR flag

tmr_flag_clear	Clear TMR flags
tmr_event_sw_trigger	Software trigger TMR event
tmr_output_enable	Enable or disable TMR output
tmr_internal_clock_set	Set TMR internal clock
tmr_output_channel_polarity_set	Set TMR output channel polarity
tmr_external_clock_config	Set TMR external clock
tmr_external_clock_mode1_config	Set TMR external clock mode 1
tmr_external_clock_mode2_config	Set TMR external clock mode 2
tmr_encoder_mode_config	Set TMR encode mode
tmr_force_output_set	Set TMR forced output
tmr_dma_control_config	Set TMR DMA control
tmr_brkdt_config	Set TMR break mode and dead-time
tmr_iremap_config	Set TMR internal remap

5.19.1 tmr_reset function

The table below describes the function tmr_reset.

Table 469. tmr_reset function

Name	Description
Function name	tmr_reset
Function prototype	void tmr_reset(tmr_type *tmr_x);
Function description	TMR is reset by CRM reset register.
Input parameter	tmr_x: select TMR peripheral, including: TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	crm_periph_reset();

Example:

tmr_reset(TMR1);

5.19.2 tmr_counter_enable function

The table below describes the function tmr_counter_enable.

Table 470. tmr_counter_enable function

Name	Description
Function name	tmr_counter_enable
Function prototype	void tmr_counter_enable(tmr_type *tmr_x, confirm_state new_state);
Function description	Enable or disable TMR
Input parameter 1	tmr_x: select TMR peripheral, including: TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	new_state: indicates counter status, ON (TRUE) or OFF (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_counter_enable(TMR1, TRUE);
```

5.19.3 tmr_output_default_para_init function

The table below describes the function tmr_output_default_para_init.

Table 471. tmr_output_default_para_init function

Name	Description
Function name	tmr_output_default_para_init
Function prototype	void tmr_output_default_para_init(tmr_output_config_type *tmr_output_struct);
Function description	Initialize tmr output default parameters
Input parameter	tmr_output_struct: tmr_output_config_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

The table below describes the default values of members of the function tmr_output_struct.

Table 472. tmr_output_struct default values

Member	Default values
oc_mode	TMR_OUTPUT_CONTROL_OFF
oc_idle_state	FALSE
occ_idle_state	FALSE
oc_polarity	TMR_OUTPUT_ACTIVE_HIGH
occ_polarity	TMR_OUTPUT_ACTIVE_HIGH
oc_output_state	FALSE
occ_output_state	FALSE

Example:

```
tmr_output_config_type tmr_output_struct;
tmr_output_default_para_init(&tmr_output_struct);
```

5.19.4 tmr_input_default_para_init function

The table below describes the function tmr_input_default_para_init.

Table 473. tmr_input_default_para_init function

Name	Description
Function name	tmr_input_default_para_init
Function prototype	void tmr_input_default_para_init(tmr_input_config_type *tmr_input_struct);
Function description	Initialize TMR input default parameters
Input parameter	tmr_input_struct: tmr_input_config_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Table 470 describes the default values of members of the function tmr_input_struct.

Table 474. tmr_input_struct default values

Member	Default values
input_channel_select	TMR_SELECT_CHANNEL_1
input_polarity_select	TMR_INPUT_RISING_EDGE
input_mapped_select	TMR_CC_CHANNEL_MAPPED_DIRECT
input_filter_value	0x0

Example:

```
tmr_input_config_type tmr_input_struct;
tmr_input_default_para_init(&tmr_input_struct);
```

5.19.5 tmr_brkdt_default_para_init function

The table below describes the function tmr_brkdt_default_para_init.

Table 475. tmr_brkdt_default_para_init function

Name	Description
Function name	tmr_brkdt_default_para_init
Function prototype	void tmr_brkdt_default_para_init(tmr_brkdt_config_type *tmr_brkdt_struct);
Function description	Initialize TMR brkdt default parameters
Input parameter	tmr_brkdt_struct: tmr_brkdt_config_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

The table below describes the default values of members of the function tmr_brkdt_struct.

Table 476. tmr_brkdt_struct default values

Member	Default values
brk_filter_value	0x0
deadtime	0x0
brk_polarity	TMR_BRK_INPUT_ACTIVE_LOW
wp_level	TMR_WP_OFF
auto_output_enable	FALSE
fcsoen_state	FALSE
fcsodis_state	FALSE
brk_enable	FALSE

Example:

```
tmr_brkdt_config_type tmr_brkdt_struct;
tmr_brkdt_default_para_init(&tmr_brkdt_struct);
```

5.19.6 tmr_base_init function

The table below describes the function tmr_base_init.

Table 477. tmr_base_init function

Name	Description
Function name	tmr_base_init
Function prototype	void tmr_base_init(tmr_type* tmr_x, uint32_t tmr_pr, uint32_t tmr_div);
Function description	Initialize TMR period and division
Input parameter 1	tmr_x: TMR peripheral including: TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_pr: timer period value, 0x0000~0xFFFF for 16-bit timer, and 0x0000_0000~0xFFFF_FFFF for 32-bit timer,
Input parameter 3	tmr_div: timer division value, 0x0000~0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_base_init(TMR1, 0xFFFF, 0xFFFF);
```

5.19.7 tmr_clock_source_div_set function

The table below describes the function tmr_clock_source_div_set.

Table 478. tmr_clock_source_div_set function

Name	Description
Function name	tmr_clock_source_div_set
Function prototype	void tmr_clock_source_div_set(tmr_type *tmr_x, tmr_clock_division_type tmr_clock_div);
Function description	Set TMR clock source division
Input parameter 1	tmr_x: TMR peripheral, including: TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_clock_div: timer clock source frequency division factor
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_clock_div

Select TMR clock source frequency division factor

TMR_CLOCK_DIV1: Divided by 1

TMR_CLOCK_DIV2: Divided by 2

TMR_CLOCK_DIV4: Divided by 4

Example:

```
tmr_clock_source_div_set(TMR1, TMR_CLOCK_DIV4);
```

5.19.8 tmr_cnt_dir_set function

The table below describes the function tmr_cnt_dir_set.

Table 479. tmr_cnt_dir_set function

Name	Description
Function name	tmr_cnt_dir_set
Function prototype	void tmr_cnt_dir_set(tmr_type *tmr_x, tmr_count_mode_type tmr_cnt_dir);
Function description	Set TMR counter direction
Input parameter 1	tmr_x: indicates the selected TMR peripheral, including: TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_cnt_dir: timer counting direction
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_cnt_dir

Select timer counting direction.

TMR_COUNT_UP:

Up counting

TMR_COUNT_DOWN:

Down counting

TMR_COUNT_TWO_WAY_1:

Center-aligned mode (up/down counting) 1

TMR_COUNT_TWO_WAY_2:

Center-aligned mode (up/down counting) 2

TMR_COUNT_TWO_WAY_3:

Center-aligned mode (up/down counting) 3

Example:

```
tmr_cnt_dir_set(TMR1, TMR_COUNT_UP);
```

5.19.9 tmr_repetition_counter_set function

The table below describes the function tmr_repetition_counter_set.

Table 480. tmr_repetition_counter_set function

Name	Description
Function name	tmr_repetition_counter_set
Function prototype	void tmr_repetition_counter_set(tmr_type *tmr_x, uint16_t tmr_rpr_value);
Function description	Set repetition period register (rpr)
Input parameter 1	tmr_x: TMR peripheral, it includes: TMR1, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_rpr_value: timer repetition period value, it can be 0x0000~0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_repetition_counter_set(TMR1, 0x1000);
```

5.19.10 tmr_counter_value_set function

The table below describes the function tmr_counter_value_set.

Table 481. tmr_counter_value_set function

Name	Description
Function name	tmr_counter_value_set
Function prototype	void tmr_counter_value_set(tmr_type *tmr_x, uint32_t tmr_cnt_value);
Function description	Set TMR counter value
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_cnt_value: timer counter value, 0x0000~0xFFFF for 16-bit timer; 0x0000_0000~0xFFFF_FFFF 32-bit timer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_counter_value_set(TMR1, 0xFFFF);
```

5.19.11 tmr_counter_value_get function

The table below describes the function tmr_counter_value_get.

Table 482. tmr_counter_value_get function

Name	Description
Function name	tmr_counter_value_get
Function prototype	uint32_t tmr_counter_value_get(tmr_type *tmr_x);
Function description	Get TMR counter value
Input parameter	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Output parameter	NA
Return value	Timer counter value
Required preconditions	NA
Called functions	NA

Example:

```
uint32_t counter_value;
counter_value = tmr_counter_value_get(TMR1);
```

5.19.12 tmr_div_value_set function

The table below describes the function tmr_div_value_set.

Table 483. tmr_div_value_set function

Name	Description
Function name	tmr_div_value_set
Function prototype	void tmr_div_value_set(tmr_type *tmr_x, uint32_t tmr_div_value);
Function description	Set TMR frequency division value
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_div_value: timer frequency division value. 0x0000~0xFFFF for 16-bit timer; 0x0000_0000~0xFFFF_FFFF for 32-bit timer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_div_value_set(TMR1, 0xFFFF);
```

5.19.13 tmr_div_value_get function

The table below describes the function tmr_div_value_get.

Table 484. tmr_div_value_get function

Name	Description
Function name	tmr_div_value_get
Function prototype	uint32_t tmr_div_value_get(tmr_type *tmr_x);
Function description	Get TMR frequency division value
Input parameter	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Output parameter	NA
Return value	Timer frequency division value
Required preconditions	NA
Called functions	NA

Example:

```
uint32_t div_value;
div_value = tmr_div_value_get(TMR1);
```

5.19.14 tmr_output_channel_config function

The table below describes the function tmr_output_channel_config.

Table 485. tmr_output_channel_config function

Name	Description
Function name	tmr_output_channel_config
Function prototype	void tmr_output_channel_config(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, tmr_output_config_type *tmr_output_struct);
Function description	Configure TMR output channels
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	tmr_output_struct: tmr_output_config_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: Channel 1

TMR_SELECT_CHANNEL_2: Channel 2

TMR_SELECT_CHANNEL_3: Channel 3

TMR_SELECT_CHANNEL_4: Channel 4

TMR_SELECT_CHANNEL_5: Channel 5

tmr_output_config_type structure

tmr_output_config_type is defined in the at32f423_tmr.h:

typedef struct

```
{
    tmr_output_control_mode_type      oc_mode;
    confirm_state                     oc_idle_state;
    confirm_state                     occ_idle_state;
    tmr_output_polarity_type         oc_polarity;
    tmr_output_polarity_type         occ_polarity;
    confirm_state                     oc_output_state;
    confirm_state                     occ_output_state;
} tmr_output_config_type;
```

oc_mode

Set output channel mode, that is, to configure channel original signals (CxORAW).

TMR_OUTPUT_CONTROL_OFF: Disconnect channel output (CxOUT) from CxORAW

TMR_OUTPUT_CONTROL_HIGH: CxORAW high

TMR_OUTPUT_CONTROL_LOW: CxORAW low

TMR_OUTPUT_CONTROL_SWITCH: Switch CxORAW level

TMR_OUTPUT_CONTROL_FORCE_LOW: CxORAW forced low

TMR_OUTPUT_CONTROL_FORCE_HIGH: CxORAW forced high

TMR_OUTPUT_CONTROL_PWM_MODE_A: PWM A mode

TMR_OUTPUT_CONTROL_PWM_MODE_B: PWM B mode

oc_idle_state

Set output channel idle state.

FALSE: Output channel idle state is 0

TRUE: Output channel idle state is 1

occ_idle_state

Set complementary output channel idle state.

FALSE: Complementary output channel idle state is 0

TRUE: Complementary output channel idle state is 1

oc_polarity

Set the polarity of output channels.

TMR_OUTPUT_ACTIVE_HIGH: Active high

TMR_OUTPUT_ACTIVE_LOW: Active low

occ_polarity

Set the polarity of complementary output channels.

TMR_OUTPUT_ACTIVE_HIGH: Active high

TMR_OUTPUT_ACTIVE_LOW: Active low

oc_output_state

Set the state of output channels.

FALSE: Output channel OFF

TRUE: Output channel ON

occ_output_state

Set the state of complementary output channels.

FALSE: Complementary output channel OFF

TRUE: Complementary output channel ON

Example:

```
tmr_output_config_type tmr_output_struct;
tmr_output_struct.oc_mode = TMR_OUTPUT_CONTROL_OFF;
tmr_output_struct.oc_output_state = TRUE;
tmr_output_struct.oc_polarity = TMR_OUTPUT_ACTIVE_HIGH;
tmr_output_struct.oc_idle_state = TRUE;
tmr_output_struct.occ_output_state = TRUE;
tmr_output_struct.occ_polarity = TMR_OUTPUT_ACTIVE_HIGH;
tmr_output_struct.occ_idle_state = TRUE;
tmr_output_channel_config(TMR1, TMR_SELECT_CHANNEL_1, &tmr_output_struct);
```

5.19.15 tmr_output_channel_mode_select function

The table below describes the function tmr_output_channel_mode_select.

Table 486. tmr_output_channel_mode_select function

Name	Description
Function name	tmr_output_channel_mode_select
Function prototype	void tmr_output_channel_mode_select(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, tmr_output_control_mode_type oc_mode);
Function description	Select TMR output channel mode
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: refer to the “ tmr_channel ” descriptions below for details
Input parameter 3	oc_mode: refer to the “ oc_mode ” descriptions below for details
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: Timer channel 1

TMR_SELECT_CHANNEL_2: Timer channel 2

TMR_SELECT_CHANNEL_3: Timer channel 3

TMR_SELECT_CHANNEL_4: Timer channel 4

TMR_SELECT_CHANNEL_5: Timer channel 5

oc_mode

Set output channel mode, that is, to configure channel original signals (CxORAW).

TMR_OUTPUT_CONTROL_OFF: Disconnect channel output (CxOUT) from CxORAW

TMR_OUTPUT_CONTROL_HIGH: CxORAW high

TMR_OUTPUT_CONTROL_LOW: CxORAW low

TMR_OUTPUT_CONTROL_SWITCH: Switch CxORAW level

TMR_OUTPUT_CONTROL_FORCE_LOW: CxORAW forced low

TMR_OUTPUT_CONTROL_FORCE_HIGH: CxORAW forced high

TMR_OUTPUT_CONTROL_PWM_MODE_A: PWM A mode

TMR_OUTPUT_CONTROL_PWM_MODE_B: PWM B mode

Example:

```
tmr_output_channel_mode_select(TMR1, TMR_SELECT_CHANNEL_1, TMR_OUTPUT_CONTROL_SWITCH);
```

5.19.16 tmr_period_value_set function

The table below describes the function tmr_period_value_set.

Table 487. tmr_period_value_set function

Name	Description
Function name	tmr_period_value_set
Function prototype	void tmr_period_value_set(tmr_type *tmr_x, uint32_t tmr_pr_value);
Function description	Set TMR period value
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_pr_value: timer period value., 0x0000~0xFFFF for 16-bit timer; 0x0000_0000~0xFFFF_FFFF for 32-bit timer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_period_value_set(TMR1, 0xFFFF);
```

5.19.17 tmr_period_value_get function

The table below describes the function tmr_period_value_get.

Table 488. tmr_period_value_get function

Name	Description
Function name	tmr_period_value_get
Function prototype	uint32_t tmr_period_value_get(tmr_type *tmr_x);
Function description	Get TMR period value
Input parameter	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Output parameter	NA
Return value	Timer period value
Required preconditions	NA
Called functions	NA

Example:

```
uint32_t pr_value;
pr_value = tmr_period_value_get(TMR1);
```

5.19.18 tmr_channel_value_set function

The table below describes the function tmr_channel_value_set.

Table 489. tmr_channel_value_set function

Name	Description
Function name	tmr_channel_value_set
Function prototype	void tmr_channel_value_set(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, uint32_t tmr_channel_value);
Function description	Set TMR channel value
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	tmr_channel_value: timer channel value. 0x0000~0xFFFF for 16-bit timer; 0x0000_0000~0xFFFF_FFFF for 32-bit timer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

- TMR_SELECT_CHANNEL_1: Channel 1
- TMR_SELECT_CHANNEL_2: Channel 2
- TMR_SELECT_CHANNEL_3: Channel 3
- TMR_SELECT_CHANNEL_4: Channel 4
- TMR_SELECT_CHANNEL_5: Channel 5

Example:

```
tmr_channel_value_set(TMR1, TMR_SELECT_CHANNEL_1, 0xFFFF);
```

5.19.19 tmr_channel_value_get function

The table below describes the function tmr_channel_value_get.

Table 490. tmr_channel_value_get function

Name	Description
Function name	tmr_channel_value_get
Function prototype	uint32_t tmr_channel_value_get(tmr_type *tmr_x, tmr_channel_select_type tmr_channel);
Function description	Get TMR channel value
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Output parameter	Timer channel value
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: TMR channel 1
 TMR_SELECT_CHANNEL_2: TMR channel 2
 TMR_SELECT_CHANNEL_3: TMR channel 3
 TMR_SELECT_CHANNEL_4: TMR channel 4
 TMR_SELECT_CHANNEL_5: TMR channel 5

Example:

```
uint32_t ch_value;
ch_value = tmr_channel_value_get(TMR1, TMR_SELECT_CHANNEL_1);
```

5.19.20 tmr_period_buffer_enable function

The table below describes the function tmr_period_buffer_enable.

Table 491. tmr_period_buffer_enable function

Name	Description
Function name	tmr_period_buffer_enable
Function prototype	void tmr_period_buffer_enable(tmr_type *tmr_x, confirm_state new_state);
Function description	Enable or disable TMR period buffer
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	new_state: indicates the status of period buffer. It can be Enable (TRUE) or Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_period_buffer_enable(TMR1, TRUE);
```

5.19.21 tmr_output_channel_buffer_enable function

The table below describes the function tmr_output_channel_buffer_enable.

Table 492. tmr_output_channel_buffer_enable function

Name	Description
Function name	tmr_output_channel_buffer_enable
Function prototype	void tmr_output_channel_buffer_enable(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, confirm_state new_state);
Function description	Enable or disable TMR output channel buffer
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	new_state: indicates the status of output channel buffer. It can be Enable (TRUE) or Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: Timer channel 1

TMR_SELECT_CHANNEL_2: Timer channel 2

TMR_SELECT_CHANNEL_3: Timer channel 3

TMR_SELECT_CHANNEL_4: Timer channel 4

TMR_SELECT_CHANNEL_5: Timer channel 5

Example:

```
tmr_output_channel_buffer_enable(TMR1, TMR_SELECT_CHANNEL_1, TRUE);
```

5.19.22 tmr_output_channel_immediately_set function

The table below describes the function tmr_output_channel_immediately_set.

Table 493. tmr_output_channel_immediately_set function

Name	Description
Function name	tmr_output_channel_immediately_set
Function prototype	void tmr_output_channel_immediately_set(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, confirm_state new_state);
Function description	Enable TMR output channel immediately
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	new_state: indicates the status of output channel enable. This parameter can be Enable (TRUE) or Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: Timer channel 1

TMR_SELECT_CHANNEL_2: Timer channel 2

TMR_SELECT_CHANNEL_3: Timer channel 3

TMR_SELECT_CHANNEL_4: Timer channel 4

TMR_SELECT_CHANNEL_5: Timer channel 5

Example:

```
tmr_output_channel_immediately_set(TMR1, TMR_SELECT_CHANNEL_1, TRUE);
```

5.19.23 tmr_output_channel_switch_set function

The table below describes the function tmr_output_channel_switch_set.

Table 494. tmr_output_channel_switch_set function

Name	Description
Function name	tmr_output_channel_switch_set
Function prototype	void tmr_output_channel_switch_set(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, confirm_state new_state);
Function description	Set TMR output channel switch
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	new_state: indicates the status of output channel switch. This parameter can be Enable (TRUE) or Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: Timer channel 1

TMR_SELECT_CHANNEL_2: Timer channel 2

TMR_SELECT_CHANNEL_3: Timer channel 3

TMR_SELECT_CHANNEL_4: Timer channel 4

TMR_SELECT_CHANNEL_5: Timer channel 5

Example:

```
tmr_output_channel_switch_set(TMR1, TMR_SELECT_CHANNEL_1, TRUE);
```

5.19.24 tmr_one_cycle_mode_enable function

The table below describes the function tmr_one_cycle_mode_enable.

Table 495. tmr_one_cycle_mode_enable function

Name	Description
Function name	tmr_one_cycle_mode_enable
Function prototype	void tmr_one_cycle_mode_enable(tmr_type *tmr_x, confirm_state new_state);
Function description	Enable or disable TMR one-cycle mode
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	new_state: indicates the status of one-cycle mode. This parameter can be Enable (TRUE) or Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

tmr_one_cycle_mode_enable(TMR1, TRUE);
--

5.19.25 tmr_32_bit_function_enable function

The table below describes the function tmr_32_bit_function_enable.

Table 496. tmr_32_bit_function_enable function

Name	Description
Function name	tmr_32_bit_function_enable
Function prototype	void tmr_32_bit_function_enable(tmr_type *tmr_x, confirm_state new_state);
Function description	Enable or disable TMR 32-bit feature (plus mode)
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR2
Input parameter 2	new_state: the status of 32-bit mode This parameter can be Enable (TRUE) or Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

tmr_32_bit_function_enable(TMR2, TRUE);

5.19.26 tmr_overflow_request_source_set function

The table below describes the function tmr_overflow_request_source_set.

Table 497. tmr_overflow_request_source_set function

Name	Description
Function name	tmr_overflow_request_source_set
Function prototype	void tmr_overflow_request_source_set(tmr_type *tmr_x, confirm_state new_state);
Function description	Select TMR overflow event sources
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	new_state: indicates the overflow event source.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

new_state

Select an overflow event source.

FALSE: Counter overflow, OVFSWTR being set, overflow event from slave mode timer controller

TRUE: Counter overflow only.

Example:

tmr_overflow_request_source_set(TMR1, TRUE);
--

5.19.27 tmr_overflow_event_disable function

The table below describes the function tmr_overflow_event_disable.

Table 498. tmr_overflow_event_disable function

Name	Description
Function name	tmr_overflow_event_disable
Function prototype	void tmr_overflow_event_disable(tmr_type *tmr_x, confirm_state new_state);
Function description	Enable or disable TMR overflow event generation
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	new_state: indicates the status of overflow event generation.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

new_state

Select the status of overflow event generation.

FALSE: Enable overflow event generation, which can be generated from the following:

- Counter overflow
- Set OVFSWTR=1
- Overflow event from slave mode timer controller

TRUE: Disable overflow event generation

Example:

```
tmr_overflow_event_disable(TMR1, TRUE);
```

5.19.28 tmr_input_channel_init function

The table below describes the function tmr_input_channel_init.

Table 499. tmr_input_channel_init function

Name	Description
Function name	tmr_input_channel_init
Function prototype	void tmr_input_channel_init(tmr_type *tmr_x, tmr_input_config_type *input_struct, tmr_channel_input_divider_type divider_factor);
Function description	Initialize TMR input channels
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	input_struct: tmr_input_config_type pointer
Input parameter 3	divider_factor: input channel frequency division factor
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_input_config_type structure

tmr_input_config_type is defined in the at32f423_tmr.h:

typedef struct

{

```
    tmr_channel_select_type      input_channel_select;
    tmr_input_polarity_type      input_polarity_select;
    tmr_input_direction_mapped_type input_mapped_select;
    uint8_t                      input_filter_value;
} tmr_input_config_type;
```

input_channel_select

Select a TMR input channel.

TMR_SELECT_CHANNEL_1: Timer channel 1

TMR_SELECT_CHANNEL_2: Timer channel 2

TMR_SELECT_CHANNEL_3: Timer channel 3

TMR_SELECT_CHANNEL_4: Timer channel 4

input_polarity_select

Select the polarity of input channels.

TMR_INPUT_RISING_EDGE: Rising edge

TMR_INPUT_FALLING_EDGE: Falling edge

TMR_INPUT_BOTH_EDGE: Both edges (Rising edge and Falling edge)

input_mapped_select

Select input channel mapping.

TMR_CC_CHANNEL_MAPPED_DIRECT:

TMR input channel 1,2,3 and 4 is linked to C1IRAW, C2IRAW, C3IRAW and C4IRAW respectively.

TMR_CC_CHANNEL_MAPPED_INDIRECT:

TMR input channel 1,2,3 and 4 is linked to C2IRAW, C1IRAW, C4IRAW and C3IRAW respectively.

TMR_CC_CHANNEL_MAPPED_STI:

TMR input channel is mapped on STI

input_filter_value

Select an input channel filter value, between 0x00~0x0F

divider_factor

Select input channel frequency division factor.

TMR_CHANNEL_INPUT_DIV_1: Divided by 1

TMR_CHANNEL_INPUT_DIV_2: Divided by 2

TMR_CHANNEL_INPUT_DIV_4: Divided by 4

TMR_CHANNEL_INPUT_DIV_8: Divided by 8

Example:

```
tmr_input_config_type tmr_input_config_struct;
tmr_input_config_struct.input_channel_select = TMR_SELECT_CHANNEL_2;
tmr_input_config_struct.input_mapped_select = TMR_CC_CHANNEL_MAPPED_DIRECT;
tmr_input_config_struct.input_polarity_select = TMR_INPUT_RISING_EDGE;
tmr_input_config_struct.input_filter_value = 0x00;
tmr_input_channel_init(TMR1, &tmr_input_config_struct, TMR_CHANNEL_INPUT_DIV_1);
```

5.19.29 tmr_channel_enable function

The table below describes the function tmr_channel_enable.

Table 500. tmr_channel_enable function

Name	Description
Function name	tmr_channel_enable
Function prototype	void tmr_channel_enable(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, confirm_state new_state);
Function description	Enable or disable TMR channels
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	new_state: indicates the status of timer channels. This parameter can be Enable (TRUE) or Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

- TMR_SELECT_CHANNEL_1: Timer channel 1
- TMR_SELECT_CHANNEL_1C: Complementary channel 1
- TMR_SELECT_CHANNEL_2: Timer channel 2
- TMR_SELECT_CHANNEL_2C: Complementary channel 2
- TMR_SELECT_CHANNEL_3: Timer channel 3
- TMR_SELECT_CHANNEL_3C: Complementary channel 3
- TMR_SELECT_CHANNEL_4: Timer channel 4

Example:

```
tmr_channel_enable(TMR1, TMR_SELECT_CHANNEL_1, TRUE);
```

5.19.30 tmr_input_channel_filter_set function

The table below describes the function tmr_input_channel_filter_set.

Table 501. tmr_input_channel_filter_set function

Name	Description
Function name	tmr_input_channel_filter_set
Function prototype	void tmr_input_channel_filter_set(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, uint16_t filter_value);
Function description	Set TMR input channel filter
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	filter_value: set channel filter value, 0x00~0x0F
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: Timer channel 1

TMR_SELECT_CHANNEL_2: Timer channel 2

TMR_SELECT_CHANNEL_3: Timer channel 3

TMR_SELECT_CHANNEL_4: Timer channel 4

Example:

```
tmr_input_channel_filter_set(TMR1, TMR_SELECT_CHANNEL_1, 0x0F);
```

5.19.31 tmr_pwm_input_config function

The table below describes the function tmr_pwm_input_config.

Table 502. tmr_pwm_input_config function

Name	Description
Function name	tmr_pwm_input_config
Function prototype	void tmr_pwm_input_config(tmr_type *tmr_x, tmr_input_config_type *input_struct, tmr_channel_input_divider_type divider_factor);
Function description	Configure TMR pwm input
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	input_struct: tmr_input_config_type pointer
Input parameter 3	divider_factor: input channel frequency division factor
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

input_struct

Point to the tmr_input_config_type, see [tmr_input_config_type](#) for details.

divider_factor

Select input channel frequency division factor

TMR_CHANNEL_INPUT_DIV_1: Divided by 1

TMR_CHANNEL_INPUT_DIV_2: Divided by 2

TMR_CHANNEL_INPUT_DIV_4: Divided by 4

TMR_CHANNEL_INPUT_DIV_8: Divided by 8

Example:

```
tmr_input_config_type tmr_ic_init_structure;
tmr_ic_init_structure.input_filter_value = 0;
tmr_ic_init_structure.input_channel_select = TMR_SELECT_CHANNEL_2;
tmr_ic_init_structure.input_mapped_select = TMR_CC_CHANNEL_MAPPED_DIRECT;
tmr_ic_init_structure.input_polarity_select = TMR_INPUT_RISING_EDGE;
tmr_pwm_input_config(TMR1, &tmr_ic_init_structure, TMR_CHANNEL_INPUT_DIV_1);
```

5.19.32 tmr_channel1_input_select function

The table below describes the function tmr_channel1_input_select.

Table 503. tmr_channel1_input_select function

Name	Description
Function name	tmr_channel1_input_select
Function prototype	void tmr_channel1_input_select(tmr_type *tmr_x, tmr_channel1_input_connected_type ch1_connect);
Function description	Select TMR channel 1 input
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4
Input parameter 2	ch1_connect: channel 1 input selection
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

ch1_connect

Select channel 1 input.

TMR_CHANNEL1_CONNECTED_C1IRAW: CH1 pin is connected to C1IRAW

TMR_CHANNEL1_2_3_CONNECTED_C1IRAW_XOR: Connect the XOR results of CH1, CH2 and CH3 pins to C1IRAW

Example:

```
tmr_channel1_input_select(TMR1, TMR_CHANNEL1_2_3_CONNECTED_C1IRAW_XOR);
```

5.19.33 tmr_input_channel_divider_set function

The table below describes the function tmr_input_channel_divider_set.

Table 504. tmr_input_channel_divider_set function

Name	Description
Function name	tmr_input_channel_divider_set
Function prototype	void tmr_input_channel_divider_set(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, tmr_channel_input_divider_type divider_factor);
Function description	Set TMR input channel divider
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	divider_factor: input channel frequency division factor
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: Timer channel 1

TMR_SELECT_CHANNEL_2: Timer channel 2

TMR_SELECT_CHANNEL_3: Timer channel 3

TMR_SELECT_CHANNEL_4: Timer channel 4

divider_factor

Select input channel frequency division factor

TMR_CHANNEL_INPUT_DIV_1: Divided by 1

TMR_CHANNEL_INPUT_DIV_2: Divided by 2

TMR_CHANNEL_INPUT_DIV_4: Divided by 4

TMR_CHANNEL_INPUT_DIV_8: Divided by 8

Example:

```
tmr_input_channel_divider_set(TMR1, TMR_SELECT_CHANNEL_1, TMR_CHANNEL_INPUT_DIV_2);
```

5.19.34 tmr_primary_mode_select function

The table below describes the function tmr_primary_mode_select.

Table 505. tmr_primary_mode_select function

Name	Description
Function name	tmr_primary_mode_select
Function prototype	void tmr_primary_mode_select(tmr_type *tmr_x, tmr_primary_select_type primary_mode);
Function description	Select TMR primary (master) mode
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR12
Input parameter 2	primary_mode: master mode
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

primary_mode

Select primary mode, that is, master timer output signal selection.

TMR_PRIMARY_SEL_RESET:	Reset
TMR_PRIMARY_SEL_ENABLE:	Enable
TMR_PRIMARY_SEL_OVERFLOW:	Overflow
TMR_PRIMARY_SEL_COMPARE:	Compare pulse
TMR_PRIMARY_SEL_C1ORAW:	C1ORAW
TMR_PRIMARY_SEL_C2ORAW:	C2ORAW
TMR_PRIMARY_SEL_C3ORAW:	C3ORAW
TMR_PRIMARY_SEL_C4ORAW:	C4ORAW

Example:

```
tmr_primary_mode_select(TMR1, TMR_PRIMARY_SEL_RESET);
```

5.19.35 tmr_sub_mode_select function

The table below describes the function tmr_sub_mode_select.

Table 506. tmr_sub_mode_select function

Name	Description
Function name	tmr_sub_mode_select
Function prototype	void tmr_sub_mode_select(tmr_type *tmr_x, tmr_sub_mode_select_type sub_mode);
Function description	Select TMR slave timer mode
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR5, TMR8, TMR9, TMR12
Input parameter 2	sub_mode: slave timer mode
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

primary_mode

Select slave timer modes.

TMR_SUB_MODE_DISABLE:	Disable
TMR_SUB_ENCODER_MODE_A:	Encoder mode A
TMR_SUB_ENCODER_MODE_B:	Encoder mode B
TMR_SUB_ENCODER_MODE_C:	Encoder mode C
TMR_SUB_RESET_MODE:	Reset
TMR_SUB_HANG_MODE:	Suspend
TMR_SUB_TRIGGER_MODE:	Trigger
TMR_SUB_EXTERNAL_CLOCK_MODE_A:	External clock A

Example:

```
tmr_sub_mode_select(TMR1, TMR_SUB_HANG_MODE);
```

5.19.36 tmr_channel_dma_select function

The table below describes the function tmr_channel_dma_select.

Table 507. tmr_channel_dma_select function

Name	Description
Function name	tmr_channel_dma_select
Function prototype	void tmr_channel_dma_select(tmr_type *tmr_x, tmr_dma_request_source_type cc_dma_select);
Function description	Select TMR channel DMA request source
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	cc_dma_select: TMR channel DMA request source
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

cc_dma_select

Select DMA request source for TMR channels.

TMR_DMA_REQUEST_BY_CHANNEL: DMA request upon a channel event (CxIF = 1)

TMR_DMA_REQUEST_BY_OVERFLOW: DMA request upon an overflow event (OVFIF = 1)

Example:

```
tmr_channel_dma_select(TMR1, TMR_DMA_REQUEST_BY_OVERFLOW);
```

5.19.37 tmr_hall_select function

The table below describes the function tmr_hall_select

Table 508. tmr_hall_select function

Name	Description
Function name	tmr_hall_select
Function prototype	void tmr_hall_select(tmr_type *tmr_x, confirm_state new_state);
Function description	Select TMR hall mode
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	new_state: indicates the status of TMR hall mode
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

new_state

Select the status of TMR hall mode in order to refresh channel control bit.

FALSE: Refresh channel control bit through HALL

TRUE: Refresh channel control bit through HALL or the rising edge of TRGIN

Example:

```
tmr_hall_select(TMR1, TRUE);
```

5.19.38 tmr_channel_buffer_enable function

The table below describes the function tmr_channel_buffer_enable.

Table 509. tmr_channel_buffer_enable function

Name	Description
Function name	tmr_channel_buffer_enable
Function prototype	void tmr_channel_buffer_enable(tmr_type *tmr_x, confirm_state new_state);
Function description	Enable or disable TMR channel buffer
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	new_state: indicates the status of TMR channel buffer. This parameter can be Enable (TRUE) or Disable (FALSE).
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_channel_buffer_enable(TMR1, TRUE);
```

5.19.39 tmr_trgout2_enable function

The table below describes the function tmr_trgout2_enable.

Table 510. tmr_trgout2_enable function

Name	Description
Function name	tmr_trgout2_enable
Function prototype	void tmr_trgout2_enable(tmr_type *tmr_x, confirm_state new_state);
Function description	Enable or disable TMR trigger output 2 signal
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1
Input parameter 2	new_state: indicates the status of TMR trigger output 2 signal. It can be enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_trgout2_enable(TMR1, TRUE);
```

5.19.40 tmr_trigger_input_select function

The table below describes the function tmr_trigger_input_select.

Table 511. tmr_trigger_input_select function

Name	Description
Function name	tmr_trigger_input_select
Function prototype	void tmr_trigger_input_select(tmr_type *tmr_x, sub_tmr_input_sel_type trigger_select);
Function description	Select TMR slave timer trigger input
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR12
Input parameter 2	trigger_select: select TMR slave timer trigger input
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

trigger_select

Select TMR slave timer trigger input.

- TMR_SUB_INPUT_SEL_IS0: Internal input 0
- TMR_SUB_INPUT_SEL_IS1: Internal input 1
- TMR_SUB_INPUT_SEL_IS2: Internal input 2
- TMR_SUB_INPUT_SEL_IS3: Internal input 3
- TMR_SUB_INPUT_SEL_C1INC: C1IRAW input detection
- TMR_SUB_INPUT_SEL_C1DF1: Filter input channel 1
- TMR_SUB_INPUT_SEL_C2DF2: Filter input channel 2
- TMR_SUB_INPUT_SEL_EXTIN: External input channel EXT

Example:

```
tmr_trigger_input_select(TMR1, TMR_SUB_INPUT_SEL_IS0);
```

5.19.41 tmr_sub_sync_mode_set function

The table below describes the function tmr_sub_sync_mode_set.

Table 512. tmr_sub_sync_mode_set function

Name	Description
Function name	tmr_sub_sync_mode_set
Function prototype	void tmr_sub_sync_mode_set(tmr_type *tmr_x, confirm_state new_state);
Function description	Set TMR slave timer synchronization mode
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR12
Input parameter 2	new_state: indicates the status of TMR slave timer synchronization mode This parameter can be Enable (TRUE) or Disable (FALSE).
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

tmr_sub_sync_mode_set(TMR1, TRUE);

5.19.42 tmr_dma_request_enable function

The table below describes the function tmr_dma_request_enable.

Table 513. tmr_dma_request_enable function

Name	Description
Function name	tmr_dma_request_enable
Function prototype	void tmr_dma_request_enable(tmr_type *tmr_x, tmr_dma_request_type dma_request, confirm_state new_state);
Function description	Enable or disable TMR DMA request
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	dma_request: DMA request
Input parameter 3	new_state: indicates the status of DMA request. This parameter can be Enable (TRUE) or Disable (FALSE).
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dma_request

Select a DMA request.

- TMR_OVERFLOW_DMA_REQUEST: Overflow event DMA request
- TMR_C1_DMA_REQUEST: Channel 1 DMA request
- TMR_C2_DMA_REQUEST: Channel 2 DMA request
- TMR_C3_DMA_REQUEST: Channel 3 DMA request
- TMR_C4_DMA_REQUEST: Channel 4 DMA request
- TMR_HALL_DMA_REQUEST: HALL event DMA request
- TMR_TRIGGER_DMA_REQUEST: Trigger event DMA request

Example:

tmr_dma_request_enable(TMR1, TMR_OVERFLOW_DMA_REQUEST, TRUE);

5.19.43 tmr_interrupt_enable function

The table below describes the function tmr_interrupt_enable.

Table 514. tmr_interrupt_enable function

Name	Description
Function name	tmr_interrupt_enable
Function prototype	void tmr_interrupt_enable(tmr_type *tmr_x, uint32_t tmr_interrupt, confirm_state new_state);
Function description	Enable or disable TMR interrupts
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_interrupt: TMR interrupts
Input parameter 3	new_state: indicates the status of TMR interrupts.

Name	Description
	This parameter can be Enable (TRUE) or Disable (FALSE).
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_interrupt

Select a TMR interrupt.

TMR_OVF_INT:	Overflow event interrupt
TMR_C1_INT:	Channel 1 event interrupt
TMR_C2_INT:	Channel 2 event interrupt
TMR_C3_INT:	Channel 3 event interrupt
TMR_C4_INT:	Channel 4 event interrupt
TMR_HALL_INT:	HALL event interrupt
TMR_TRIGGER_INT:	Trigger event interrupt
TMR_BRK_INT:	Break event interrupt

Example:

```
tmr_interrupt_enable(TMR1, TMR_OVF_INT, TRUE);
```

5.19.44 tmr_interrupt_flag_get function

The table below describes the function tmr_interrupt_flag_get.

Table 515. tmr_interrupt_flag_get function

Name	Description
Function name	tmr_interrupt_flag_get
Function prototype	flag_status tmr_interrupt_flag_get (tmr_type *tmr_x, uint32_t tmr_flag);
Function description	Get TMR interrupt flag status
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_flag: Flag selection Refer to the "tmr_flag" description below for details.
Output parameter	NA
Return value	flag_status: indicates the status of flags Return SET or RESET
Required preconditions	NA
Called functions	NA

tmr_flag

This is used for flag selection, including:

TMR_OVF_FLAG:	Overflow interrupt flag
TMR_C1_FLAG:	Channel 1 interrupt flag
TMR_C2_FLAG:	Channel 2 interrupt flag
TMR_C3_FLAG:	Channel 3 interrupt flag
TMR_C4_FLAG:	Channel 4 interrupt flag
TMR_HALL_FLAG:	HALL interrupt flag

TMR_TRIGGER_FLAG: Trigger interrupt flag
 TMR_BRK_FLAG: Break interrupt flag

Example:

```
if(tmr_interrupt_flag_get (TMR1, TMR_OVF_FLAG) != RESET)
```

5.19.45 tmr_flag_get function

The table below describes the function tmr_flag_get.

Table 516. tmr_flag_get function

Name	Description
Function name	tmr_flag_get
Function prototype	flag_status tmr_flag_get(tmr_type *tmr_x, uint32_t tmr_flag);
Function description	Get flag status
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_flag: Flag selection Refer to the "tmr_flag" description below for details.
Output parameter	NA
Return value	flag_status: indicates the status of flags Return SET or RESET
Required preconditions	NA
Called functions	NA

tmr_flag

This is used for flag selection, including:

TMR_OVF_FLAG: Overflow interrupt flag
 TMR_C1_FLAG: Channel 1 interrupt flag
 TMR_C2_FLAG: Channel 2 interrupt flag
 TMR_C3_FLAG: Channel 3 interrupt flag
 TMR_C4_FLAG: Channel 4 interrupt flag
 TMR_HALL_FLAG: HALL interrupt flag
 TMR_TRIGGER_FLAG: Trigger interrupt flag
 TMR_BRK_FLAG: Break interrupt flag
 TMR_C1_RECAPTURE_FLAG: Channel 1 recapture flag
 TMR_C2_RECAPTURE_FLAG: Channel 2 recapture flag
 TMR_C3_RECAPTURE_FLAG: Channel 3 recapture flag
 TMR_C4_RECAPTURE_FLAG: Channel 4 recapture flag

Example:

```
if(tmr_flag_get(TMR1, TMR_OVF_FLAG) != RESET)
```

5.19.46 tmr_flag_clear function

The table below describes the function tmr_flag_clear.

Table 517. tmr_flag_clear function

Name	Description
Function name	tmr_flag_clear
Function prototype	void tmr_flag_clear(tmr_type *tmr_x, uint32_t tmr_flag);
Function description	Clear flag
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_flag: flag selection Refer to tmr_flag for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_flag_clear(TMR1, TMR_OVF_FLAG);
```

5.19.47 tmr_event_sw_trigger function

The table below describes the function tmr_event_sw_trigger

Table 518. tmr_event_sw_trigger function

Name	Description
Function name	tmr_event_sw_trigger
Function prototype	void tmr_event_sw_trigger(tmr_type *tmr_x, tmr_event_trigger_type tmr_event);
Function description	Software triggers TMR events
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR6, TMR7, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_event: select a TMR event
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_event

Set TMR events triggered by software.

TMR_OVERFLOW_SWTRIG:	Overflow event
TMR_C1_SWTRIG:	Channel 1 event
TMR_C2_SWTRIG:	Channel 2 event
TMR_C3_SWTRIG:	Channel 3 event
TMR_C4_SWTRIG:	Channel 4 event
TMR_HALL_SWTRIG:	HALL event
TMR_TRIGGER_SWTRIG:	Trigger event
TMR_BRK_SWTRIG:	Break event

Example:

```
tmr_event_sw_trigger(TMR1, TMR_OVERFLOW_SWTRIG);
```

5.19.48 tmr_output_enable function

The table below describes the function tmr_output_enable

Table 519. tmr_output_enable function

Name	Description
Function name	tmr_output_enable
Function prototype	void tmr_output_enable(tmr_type *tmr_x, confirm_state new_state);
Function description	Enable or disable TMR output
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	new_state: TMR output status This parameter can be Enable (TRUE) or Disable (FALSE).
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_output_enable(TMR1, TRUE);
```

5.19.49 tmr_internal_clock_set function

The table below describes the function tmr_internal_clock_set.

Table 520. tmr_internal_clock_set function

Name	Description
Function name	tmr_internal_clock_set
Function prototype	void tmr_internal_clock_set(tmr_type *tmr_x);
Function description	Set TMR internal clock
Input parameter	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR12
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
tmr_internal_clock_set(TMR1);
```

5.19.50 tmr_output_channel_polarity_set function

The table below describes the function tmr_output_channel_polarity_set.

Table 521. tmr_output_channel_polarity_set function

Name	Description
Function name	tmr_output_channel_polarity_set
Function prototype	void tmr_output_channel_polarity_set(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, tmr_polarity_active_type oc_polarity);
Function description	Set TMR output channel polarity
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: Timer channel
Input parameter 3	oc_polarity: output channel polarity
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

- TMR_SELECT_CHANNEL_1: Timer channel 1
- TMR_SELECT_CHANNEL_1C: Complementary channel 1
- TMR_SELECT_CHANNEL_2: Timer channel 2
- TMR_SELECT_CHANNEL_2C: Complementary channel 2
- TMR_SELECT_CHANNEL_3: Timer channel 3
- TMR_SELECT_CHANNEL_3C: Complementary channel 3
- TMR_SELECT_CHANNEL_4: Timer channel 4

oc_polarity

Select TMR channel polarity.

TMR_POLARITY_ACTIVE_HIGH: Active high

TMR_POLARITY_ACTIVE_LOW: Active low

Example:

```
tmr_output_channel_polarity_set(TMR1, TMR_SELECT_CHANNEL_1, TMR_POLARITY_ACTIVE_HIGH);
```

5.19.51 tmr_external_clock_config function

The table below describes the function tmr_external_clock_config.

Table 522. tmr_external_clock_config function

Name	Description
Function name	tmr_external_clock_config
Function prototype	void tmr_external_clock_config(tmr_type *tmr_x, tmr_external_signal_divider_type es_divide, tmr_external_signal_polarity_type es_polarity, uint16_t es_filter);
Function description	Configure TMR external clock
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4
Input parameter 2	es_divide: external signal frequency division factor
Input parameter 3	es_polarity: external signal polarity
Input parameter 4	es_filter: external signal filter value, 0x00~0x0F
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

es_divide

Set TMR external signal frequency division factor.

TMR_ES_FREQUENCY_DIV_1: Divided by 1

TMR_ES_FREQUENCY_DIV_2: Divided by 2

TMR_ES_FREQUENCY_DIV_4: Divided by 4

TMR_ES_FREQUENCY_DIV_8: Divided by 8

es_polarity

Select TMR external signal polarity.

TMR_ES_POLARITY_NON_INVERTED: High or rising edge

TMR_ES_POLARITY_INVERTED: Low or falling edge

Example:

```
tmr_external_clock_config(TMR1, TMR_ES_FREQUENCY_DIV_1, TMR_ES_POLARITY_INVERTED, 0x0F);
```

5.19.52 tmr_external_clock_mode1_config function

The table below describes the function tmr_external_clock_mode1_config.

Table 523. tmr_external_clock_mode1_config function

Name	Description
Function name	tmr_external_clock_mode1_config
Function prototype	void tmr_external_clock_mode1_config(tmr_type *tmr_x, tmr_external_signal_divider_type es_divide, tmr_external_signal_polarity_type es_polarity, uint16_t es_filter);
Function description	Configure TMR external clock mode 1 (corresponding to external mode A in the reference manual)
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR12
Input parameter 2	es_divide: external signal frequency division factor
Input parameter 3	es_polarity: external signal polarity
Input parameter 4	es_filter: external signal filter value, 0x00~0x0F
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

es_divide

Set TMR external signal frequency division factor, refer to [es_divide](#) for details.

es_polarity

Set TMR external signal polarity, refer to [es_polarity](#) for details.

Example:

```
tmr_external_clock_mode1_config(TMR1, TMR_ES_FREQUENCY_DIV_1, TMR_ES_POLARITY_INVERTED,  
0x0F);
```

5.19.53 tmr_external_clock_mode2_config function

The table below describes the function tmr_external_clock_mode2_config.

Table 524. tmr_external_clock_mode2_config function

Name	Description
Function name	tmr_external_clock_mode2_config
Function prototype	void tmr_external_clock_mode2_config(tmr_type *tmr_x, tmr_external_signal_divider_type es_divide, tmr_external_signal_polarity_type es_polarity, uint16_t es_filter);
Function description	Configure TMR external clock mode 2 (corresponding to external mode B in the reference manual)
Input parameter 1	tmr_x : indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4
Input parameter 2	es_divide: external signal frequency division factor
Input parameter 3	es_polarity: external signal polarity
Input parameter 4	es_filter: external signal filter value,0x00~0x0F
Output parameter	NA
Return value	NA
Input parameter 2	es_divide: external signal frequency division factor
Input parameter 3	es_polarity: external signal polarity

es_divide

Set TMR external signal frequency division factor, refer to [es_divide](#) for details.

es_polarity

Set TMR external signal polarity, refer to [es_polarity](#)

for details.

Example:

```
tmr_external_clock_mode2_config(TMR1, TMR_ES_FREQUENCY_DIV_1, TMR_ES_POLARITY_INVERTED,  
0x0F);
```

5.19.54 tmr_encoder_mode_config function

The table below describes the function tmr_encoder_mode_config.

Table 525. tmr_encoder_mode_config function

Name	Description
Function name	tmr_encoder_mode_config
Function prototype	void tmr_encoder_mode_config(tmr_type *tmr_x, tmr_encoder_mode_type encoder_mode, tmr_input_polarity_type ic1_polarity, tmr_input_polarity_type ic2_polarity);
Function description	Configure TMR encoder mode
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4
Input parameter 2	encoder_mode: encoder mode
Input parameter 3	ic1_polarity: input channel 1 polarity
Input parameter 4	ic2_polarity: input channel 2 polarity
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

encoder_mode

Select a TMR encoder mode.

TMR_ENCODER_MODE_A: Encoder mode A

TMR_ENCODER_MODE_B: Encoder mode B

TMR_ENCODER_MODE_C: Encoder mode C

ic1_polarity

Select TMR input channel 1 polarity.

TMR_INPUT_RISING_EDGE: Rising edge

TMR_INPUT_FALLING_EDGE: Falling edge

TMR_INPUT_BOTH_EDGE: Both edges (Rising edge and Falling edge)

ic2_polarity

Select TMR input channel 2 polarity.

TMR_INPUT_RISING_EDGE: Rising edge

TMR_INPUT_FALLING_EDGE: Falling edge

TMR_INPUT_BOTH_EDGE: Both edges (Rising edge and Falling edge)

Example:

```
tmr_encoder_mode_config(TMR1, TMR_ENCODER_MODE_A, TMR_INPUT_RISING_EDGE,
TMR_INPUT_RISING_EDGE);
```

5.19.55 tmr_force_output_set function

The table below describes the function tmr_force_output_set.

Table 526. tmr_force_output_set function

Name	Description
Function name	tmr_force_output_set
Function prototype	void tmr_force_output_set(tmr_type *tmr_x, tmr_channel_select_type tmr_channel, tmr_force_output_type force_output);
Function description	Set TMR forced output
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	tmr_channel: timer channel
Input parameter 3	force_output: forced output level
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_channel

Select a TMR channel.

TMR_SELECT_CHANNEL_1: Timer channel 1

TMR_SELECT_CHANNEL_2: Timer channel 2

TMR_SELECT_CHANNEL_3: Timer channel 3

TMR_SELECT_CHANNEL_4: Timer channel 4

TMR_SELECT_CHANNEL_5: Timer channel 5

force_output

Forced output level of output channels.

TMR_FORCE_OUTPUT_HIGH: CxORAW forced high

TMR_FORCE_OUTPUT_LOW: CxORAW forced low

Example:

```
tmr_force_output_set(TMR1, TMR_SELECT_CHANNEL_1, TMR_FORCE_OUTPUT_HIGH);
```

5.19.56 tmr_dma_control_config function

The table below describes the function tmr_dma_control_config.

Table 527. tmr_dma_control_config function

Name	Description
Function name	tmr_dma_control_config
Function prototype	void tmr_dma_control_config(tmr_type *tmr_x, tmr_dma_transfer_length_type dma_length, tmr_dma_address_type dma_base_address);
Function description	Configure TMR DMA control
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR2, TMR3, TMR4, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	dma_length: DMA transfer length
Input parameter 3	dma_base_address: DMA transfer offset address
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

dma_length

Set DAM transfer bytes, including:

TMR_DMA_TRANSFER_1BYTE: 1 byte

TMR_DMA_TRANSFER_2BYTES: 2 bytes

TMR_DMA_TRANSFER_3BYTES: 3 bytes

...

TMR_DMA_TRANSFER_17BYTES: 17 bytes

TMR_DMA_TRANSFER_18BYTES: 18 bytes

dma_base_address

Set DMA transfer offset address, starting from TMR control register 1, including:

TMR_CTRL1_ADDRESS

TMR_CTRL2_ADDRESS

TMR_STCTRL_ADDRESS

TMR_IDEN_ADDRESS

TMRISTS_ADDRESS

TMR_SWEVT_ADDRESS

TMR_CM1_ADDRESS

TMR_CM2_ADDRESS

TMR_CCTRL_ADDRESS

TMR_CVAL_ADDRESS

TMR_DIV_ADDRESS

TMR_PR_ADDRESS

TMR_RPR_ADDRESS

TMR_C1DT_ADDRESS

TMR_C2DT_ADDRESS

TMR_C3DT_ADDRESS

TMR_C4DT_ADDRESS

TMR_BRK_ADDRESS

TMR_DMACTRL_ADDRESS

Example:

```
tmr_dma_control_config(TMR1, TMR_DMA_TRANSFER_8BYTES, TMR_CTRL1_ADDRESS);
```

5.19.57 tmr_brkdt_config function

The table below describes the function tmr_brkdt_config.

Table 528. tmr_brkdt_config function

Name	Description
Function name	tmr_brkdt_config
Function prototype	void tmr_brkdt_config(tmr_type *tmr_x, tmr_brkdt_config_type *brkdt_struct);
Function description	Configure TMR break mode and dead time
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	brkdt_struct: tmr_brkdt_config_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

tmr_brkdt_config_type structure

The tmr_brkdt_config_type is defined in the at32f423_tmr.h:

typedef struct

```
{
    uint8_t                deadline;
    tmr_brk_polarity_type brk_polarity;
    tmr_wp_level_type     wp_level;
    confirm_state          auto_output_enable;
    confirm_state          fcsoen_state;
    confirm_state          fcsodis_state;
    confirm_state          brk_enable;
}
```

} tmr_brkdt_config_type;

deadline

Set dead time, between 0x00~0xFF

brk_polarity

Select break input polarity

TMR_BRK_INPUT_ACTIVE_LOW: Active low

TMR_BRK_INPUT_ACTIVE_HIGH: Active high

wp_level

Set write protection level.

TMR_WP_OFF: Write protection OFF

TMR_WP_LEVEL_3:

Level 3 write protection, protecting the bits below:

- TMRx_BRK: DTC, BRKEN, BRKV and AOEN
- TMRx_CTRL2: CxIOS and CxCIOS

TMR_WP_LEVEL_2:

Level 2 write protection, protecting the bits below in addition to level-3 protected bits:

- TMRx_CCTRL: CxP and CxCP
- TMRx_BRK: FCSODIS and FCSOEN

TMR_WP_LEVEL_1:

Level 1 write protection, protecting the bits below in addition to level-2 protected bits:

- TMRx_CMx: CxOCTRL and CxOBEN

auto_output_enable

Enable auto output, Enable (TRUE) or disable (FALSE)

fcsoen_state

Indicates the frozen status when main output is ON. It is used to configure the status of complementary output channels when timer is OFF and output is enabled (OEN=1).

FALSE: Disable CxOUT/CxCOUT output

TRUE: Enable CxOUT/CxCOUT output, inactive level

fcsodis_state

Indicates the frozen status when main output is OFF. It is used to configure the status of complementary output channels when timer is OFF and output is disabled (OEN=0).

FALSE: Disable CxOUT/CxCOUT output

TRUE: Enable CxOUT/CxCOUT output, idle level

brk_enable

Enable break feature, Enable (TRUE) or disable (FALSE).

Example

```
tmr_brkdt_config_type tmr_brkdt_config_struct;
tmr_brkdt_config_struct.brk_enable = TRUE;
tmr_brkdt_config_struct.auto_output_enable = TRUE;
tmr_brkdt_config_struct.deadtime = 0;
tmr_brkdt_config_struct.fcsodis_state = TRUE;
tmr_brkdt_config_struct.fcsoen_state = TRUE;
tmr_brkdt_config_struct.brk_polarity = TMR_BRK_INPUT_ACTIVE_HIGH;
tmr_brkdt_config_struct.wp_level = TMR_WP_OFF;
tmr_brkdt_config(TMR1, &tmr_brkdt_config_struct);
```

5.19.58 tmr_brk_filter_value_set function

The table below describes the function tmr_brk_filter_value_set.

Table 529. tmr_brk_filter_value_set function

Name	Description
Function name	tmr_brk_filter_value_set
Function prototype	void tmr_brk_filter_value_set(tmr_type *tmr_x, uint8_t filter_value)
Function description	Set TMR break input filter value
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR1, TMR9, TMR10, TMR11, TMR12, TMR13, TMR14
Input parameter 2	filter_value: filter value (from 0x0 to 0xf)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example

```
tmr_brk_filter_value_set (TMR1, 0x4);
```

5.19.59 tmr_iremap_config function

The table below describes the function tmr_iremap_config.

Table 530. tmr_iremap_config function

Name	Description
Function name	tmr_iremap_config
Function prototype	void tmr_iremap_config(tmr_type *tmr_x, tmr_input_remap_type input_remap);
Function description	Set TMR internal remapping
Input parameter 1	tmr_x: indicates the selected TMR peripheral, it can be TMR14
Input parameter 2	input_remap: TMR input channel remap to be configured
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

input_remap

Set TMR2 internal trigger 1 remapping and TMR5 channel 4 input remapping

TMR14_GPIO: TMR14 is connected to GPIO

TMR14_ERTCCLK: TMR14 is connected to internal ERTC clock

TMR14_HEXT_DIV32: TMR14 is connected to HEXT/32

TMR14_CLKOUT: TMR14 is connected to CLKOUT

Example

```
tmr_iremap_config(TMR14, TMR14_GPIO);
```

5.20 Universal synchronous/asynchronous receiver/transmitter (USART)

The USART register structure usart_type is defined in the “at32f423_usart.h”:

```
/*
 * @brief type define usart register all
 */
typedef struct
{
    ...
} usart_type;
```

The table below gives a list of the USART registers

Table 531. Summary of USART registers

Register	Description
sts	Status register
dt	Data register
baudr	Baud rate register
ctrl1	Control register 1
ctrl2	Control register 2
ctrl3	Control register 3
gdiv	Guard time and divider Control register 1

The table below gives a list of USART library functions.

Table 532. Summary of USART library functions

Function name	Description
usart_reset	Reset USART peripheral registers
usart_init	Set baud rate, data bits and stop bits.
usart_parity_selection_config	Parity selection
usart_enable	Enable USART peripherals
usart_transmitter_enable	Enable USART transmitter
usart_receiver_enable	Enable USART receiver
usart_clock_config	Set clock polarity and phases for synchronization
usart_clock_enable	Set clock output for synchronization
usart_interrupt_enable	Enable interrupts
usart_dma_transmitter_enable	Enable DMA transmitter
usart_dma_receiver_enable	Enable DMA receiver
usart_wakeup_id_set	Set wakeup ID
usart_wakeup_mode_set	Set wakeup mode
usart_receiver_mute_enable	Enable receiver mute mode
usart_break_bit_num_set	Set break frame length
usart_lin_mode_enable	Enable LIN mode
usart_data_transmit	Data transmit
usart_data_receive	Data receive

uart_break_send	Send break frame
uart_smartcard_guard_time_set	Set smartcard guard time
uart_irda_smartcard_division_set	Set infrared and smartcard division
uart_smartcard_mode_enable	Enable smartcard mode
uart_smartcard_nack_set	Enable smartcard NACK
uart_single_line_halfduplex_select	Enable single-wire half-duplex mode
uart_irda_mode_enable	Enable infrared mode
uart_irda_low_power_enable	Enable infrared low-power mode
uart_hardware_flow_control_set	Enable hardware flow control
uart_flag_get	Get flag
uart_interrupt_flag_get	Get USART interrupt flag status
uart_flag_clear	Clear flag
uart_rs485_delay_time_config	Set latency for starting or ending consecutive data transmission in RS 485
uart_transmit_receive_pin_swap	Swap transmit/receive pins
uart_id_bit_num_set	Set ID bit count
uart_de_polarity_set	DE signal polarity selection
uart_rs485_mode_enable	RS485 mode enable
uart_low_power_wakeup_set	Set low-power wakeup
uart_deep_sleep_mode_enable	Deepsleep mode enable
uart_msb_transmit_first_enable	Enable MSB-first transmission
uart_dt_polarity_reverse	Enable data polarity reverse mode
uart_transmit_pin_polarity_reverse	Enable data transmit pin polarity reverse mode
uart_receive_pin_polarity_reverse	Enable data receive pin polarity reverse mode
uart_receiver_timeout_detection_enable	Enable data receive timeout detection
uart_receiver_timeout_value_set	Set data receive timeout value

5.20.1 usart_reset function

The table below describes the function usart_reset.

Table 533. usart_reset function

Name	Description
Function name	usart_reset
Function prototype	void usart_reset(usart_type* usart_x);
Function description	Reset USART peripheral registers
Input parameter 1	usart_x: indicates the selected peripherals, it can be USART1, USART2, and USART3...
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	crm_periph_reset

Example:

```
/* reset usart1 */
usart_reset(USART1);
```

5.20.2 usart_init function

The table below describes the function usart_init.

Table 534. usart_init function

Name	Description
Function name	usart_init
Function prototype	void usart_init(usart_type* usart_x, uint32_t baud_rate, usart_data_bit_num_type data_bit, usart_stop_bit_num_type stop_bit);
Function description	Set baud rate, data bits and stop bits.
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	baud_rate: baud rate for serial interfaces
Input parameter 3	data_bit: data bit width for serial interfaces
Input parameter 4	stop_bit: stop bit width for serial interfaces
Output parameter	NA
Return value	NA
Required preconditions	This operation can be allowed only when external low-speed clock is disabled.
Called functions	NA

data_bit

Select data bit size for serial interface communication.

USART_DATA_8BITS: 8-bit

USART_DATA_9BITS: 9-bit

stop_bit

Select stop bit size for serial interface communication.

USART_STOP_1_BIT: 1 bit

USART_STOP_0_5_BIT: 0.5 bit

USART_STOP_2_BIT: 2 bit

USART_STOP_1_5_BIT: 1.5 bit

Example:

```
/* configure uart param */  
usart_init(USART1, 115200, USART_DATA_8BITS, USART_STOP_1_BIT);
```

5.20.3 usart_parity_selection_config function

The table below describes the function usart_parity_selection_config.

Table 535. usart_parity_selection_config function

Name	Description
Function name	usart_parity_selection_config
Function prototype	void usart_parity_selection_config(usart_type* usart_x, usart_parity_selection_type parity);
Function description	Parity selection
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	Parity: parity mode for serial interface communication
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

parity

Select parity mode for serial interface communication.

USART_PARITY_NONE: No parity

USART_PARITY EVEN: Even

USART_PARITY ODD: Odd

Example:

```
/* config usart even parity */
usart_parity_selection_config(USART1, USART_PARITY_EVEN);
```

5.20.4 usart_enable function

The table below describes the function usart_enable.

Table 536. usart_enable function

Name	Description
Function name	usart_enable
Function prototype	void usart_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable USART
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	new_state: Enable (TRUE) and disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable usart1 */
usart_enable(USART1, TRUE);
```

5.20.5 usart_transmitter_enable function

The table below describes the function usart_transmitter_enable.

Table 537. usart_transmitter_enable function

Name	Description
Function name	usart_transmitter_enable
Function prototype	void usart_transmitter_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable USART transmitter
Input parameter 1	usart_x: indicates the selected peripheral it can be USART1, USART2, and USART3...
Input parameter 2	new_state: Enable (TRUE) and disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable usart1 transmitter */
usart_transmitter_enable(USART1, TRUE);
```

5.20.6 usart_receiver_enable function

The table below describes the function usart_receiver_enable.

Table 538. usart_receiver_enable function

Name	Description
Function name	usart_receiver_enable
Function prototype	void usart_receiver_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable USART receiver
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	new_state: Enable (TRUE) and disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable usart1 receiver */
usart_receiver_enable(USART1, TRUE);
```

5.20.7 usart_clock_config function

The table below describes the function usart_clock_config.

Table 539. usart_clock_config function

Name	Description
Function name	usart_clock_config
Function prototype	void usart_clock_config(usart_type* usart_x, usart_clock_polarity_type clk_pol, usart_clock_phase_type clk_ph, usart_lbc_type clk_lb);
Function description	Configure clock polarity and phase for synchronization feature
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	clk_pol: clock polarity for synchronization
Input parameter 3	clk_ph: clock phase for synchronization
Input parameter 4	clk_lb: selects whether to output clock on the last bit (upper bit) of data sent through synchronization feature
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

clk_pol

Clock polarity selection.

USART_CLOCK_POLARITY_LOW: Low

USART_CLOCK_POLARITY_HIGH: High

clk_ph

Clock phase selection.

USART_CLOCK_PHASE_1EDGE: 1st edge

USART_CLOCK_PHASE_2EDGE: 2nd edge

clk_lb

Select whether to output clock on the last bit of data.

USART_CLOCK_LAST_BIT_NONE: No clock output

USART_CLOCK_LAST_BIT_OUTPUT: Clock output

Example:

```
/* config synchronous mode */
usart_clock_config(USART1, USART_CLOCK_POLARITY_HIGH, USART_CLOCK_PHASE_2EDGE,
USART_CLOCK_LAST_BIT_OUTPUT);
```

5.20.8 usart_clock_enable function

The table below describes the function usart_clock_enable.

Table 540. usart_clock_enable function

Name	Description
Function name	usart_clock_enable
Function prototype	void usart_clock_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable clock output
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	new_state: Enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable clock */
usart_clock_enable(USART1, TRUE);
```

5.20.9 usart_interrupt_enable function

The table below describes the function usart_interrupt_enable.

Table 541. usart_interrupt_enable function

Name	Description
Function name	usart_interrupt_enable
Function prototype	void usart_interrupt_enable(usart_type* usart_x, uint32_t usart_int, confirm_state new_state);
Function description	Enable interrupts
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	usart_int: interrupt type
Input parameter 3	new_state: Enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

usart_int

Defines a peripheral interrupt.

- USART_IDLE_INT: Bus idle
- USART_RDBF_INT: Receive data buffer full
- USART_TDC_INT: Transmit data complete
- USART_TDBE_INT: Transmit data buffer empty
- USART_PERR_INT: Parity error
- USART_BF_INT: Break frame receive
- USART_ERR_INT: Error interrupt
- USART_CTSCF_INT: CTS (Clear To Send) change

Example:

```
/* enable usart1 transmit complete interrupt */
usart_interrupt_enable (USART1, USART_TDC_INT, TRUE);
```

5.20.10 usart_dma_transmitter_enable function

The table below describes the function usart_dma_transmitter_enable.

Table 542. usart_dma_transmitter_enable function

Name	Description
Function name	usart_dma_transmitter_enable
Function prototype	void usart_dma_transmitter_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable DMA transmitter
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	new_state: Enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable dma transmitter */
usart_dma_transmitter_enable (USART1, TRUE);
```

5.20.11 usart_dma_receiver_enable function

The table below describes the function usart_dma_receiver_enable.

Table 543. usart_dma_receiver_enable function

Name	Description
Function name	usart_dma_receiver_enable
Function prototype	void usart_dma_receiver_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable DMA receiver
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	new_state: Enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable dma receiver */
usart_dma_receiver_enable (USART1, TRUE);
```

5.20.12 usart_wakeup_id_set function

The table below describes the function usart_wakeup_id_set.

Table 544. usart_wakeup_id_set function

Name	Description
Function name	usart_wakeup_id_set
Function prototype	void usart_wakeup_id_set(usart_type* usart_x, uint8_t usart_id);
Function description	Set wakeup ID
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3...
Input parameter 2	usart_id: wakeup ID
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* config wakeup id */
usart_wakeup_id_set (USART1, 0x88);
```

5.20.13 usart_wakeup_mode_set function

The table below describes the function usart_wakeup_mode_set.

Table 545. usart_wakeup_mode_set function

Name	Description
Function name	usart_wakeup_mode_set
Function prototype	void usart_wakeup_mode_set(usart_type* usart_x, usart_wakeup_mode_type wakeup_mode);
Function description	Set wakeup mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3
Input parameter 2	wakeup_mode: wakeup mode
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

wakeup_mode

Set wakeup mode to wake up from silent state.

USART_WAKEUP_BY_IDLE_FRAME: Woke up by idle frame

USART_WAKEUP_BY_MATCHING_ID: Woke up by ID matching

Example:

```
/* config usart1 wakeup mode */
usart_wakeup_mode_set (USART1, USART_WAKEUP_BY_MATCHING_ID);
```

5.20.14 usart_receiver_mute_enable function

The table below describes the function usart_receiver_mute_enable.

Table 546. usart_receiver_mute_enable function

Name	Description
Function name	usart_receiver_mute_enable
Function prototype	void usart_receiver_mute_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable USART receiver mute mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3
Input parameter 2	new_state: Enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* config receiver mute */
usart_receiver_mute_enable (USART1, TRUE);
```

5.20.15 usart_break_bit_num_set function

The table below describes the function usart_break_bit_num_set.

Table 547. usart_break_bit_num_set function

Name	Description
Function name	usart_break_bit_num_set
Function prototype	void usart_break_bit_num_set(usart_type* usart_x, usart_break_bit_num_type break_bit);
Function description	Set USART break frame length
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3
Input parameter 2	break_bit: break frame length type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

break_bit

Set break frame length.

USART_BREAK_10BITS: 10 bits

USART_BREAK_11BITS: 11 bits

Example:

```
/* config break frame length 10bits */
usart_break_bit_num_set (USART1, USART_BREAK_10BITS);
```

5.20.16 usart_lin_mode_enable function

The table below describes the function usart_lin_mode_enable.

Table 548. usart_lin_mode_enable function

Name	Description
Function name	usart_lin_mode_enable
Function prototype	void usart_lin_mode_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable LIN mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3
Input parameter 2	new_state: Enable (TRUE) or disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable usart1 lin mode */
usart_lin_mode_enable (USART1, TRUE);
```

5.20.17 usart_data_transmit function

The table below describes the function usart_data_transmit.

Table 549. usart_data_transmit function

Name	Description
Function name	usart_data_transmit
Function prototype	void usart_data_transmit(usart_type* usart_x, uint16_t data);
Function description	Transmit data
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3
Input parameter 2	Data: data to send
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* transmit data */
uint16_t data = 0x88;
usart_data_transmit (USART1, data);
```

5.20.18 usart_data_receive function

The table below describes the function usart_data_receive.

Table 550. usart_data_receive function

Name	Description
Function name	usart_data_receive
Function prototype	uint16_t usart_data_receive(usart_type* usart_x);
Function description	Receives data
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3
Input parameter 2	NA
Output parameter	NA
Return value	uint16_t: return the received data
Required preconditions	NA
Called functions	NA

Example:

```
/* receive data */  
uint16_t data = 0;  
data = usart_data_receive (USART1);
```

5.20.19 usart_break_send function

The table below describes the function usart_break_send.

Table 551. usart_break_send function

Name	Description
Function name	usart_break_send
Function prototype	void usart_break_send(usart_type* usart_x);
Function description	Sends break frame
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3
Input parameter 2	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* send break frame */  
usart_break_send (USART1);
```

5.20.20 usart_smartcard_guard_time_set function

The table below describes the function usart_smartcard_guard_time_set.

Table 552. usart_smartcard_guard_time_set function

Name	Description
Function name	usart_smartcard_guard_time_set
Function prototype	void usart_smartcard_guard_time_set(usart_type* usart_x, uint8_t guard_time_val);
Function description	Set smartcard guard time
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2, and USART3
Input parameter 2	guard_time_val: guard time, 0x00~0xFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* usart guard time set to 2 bit */
usart_smartcard_guard_time_set(USART1, 0x2);
```

5.20.21 usart_irda_smartcard_division_set function

The table below describes the function usart_irda_smartcard_division_set.

Table 553. usart_irda_smartcard_division_set function

Name	Description
Function name	usart_irda_smartcard_division_set
Function prototype	void usart_irda_smartcard_division_set(usart_type* usart_x, uint8_t div_val);
Function description	Infrared and smartcard frequency division settings
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	div_val: division value
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* usart clock set to (apbclk / (2 * 20)) */
usart_irda_smartcard_division_set(USART1, 20);
```

5.20.22 usart_smartcard_mode_enable function

The table below describes the function usart_smartcard_mode_enable.

Table 554. usart_smartcard_mode_enable function

Name	Description
Function name	usart_smartcard_mode_enable
Function prototype	void usart_smartcard_mode_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable smartcode mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: Enable (TRUE), Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable the smartcard mode */
usart_smartcard_mode_enable(USART1, TRUE);
```

5.20.23 usart_smartcard_nack_set function

The table below describes the function usart_smartcard_nack_set.

Table 555. usart_smartcard_nack_set function

Name	Description
Function name	usart_smartcard_nack_set
Function prototype	void usart_smartcard_nack_set(usart_type* usart_x, confirm_state new_state);
Function description	Enable smartcard NACK
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: Enable (TRUE), Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable the nack transmission */
usart_smartcard_nack_set(USART1, TRUE);
```

5.20.24 usart_single_line_halfduplex_select function

The table below describes the function usart_single_line_halfduplex_select.

Table 556. usart_single_line_halfduplex_select function

Name	Description
Function name	usart_single_line_halfduplex_select
Function prototype	void usart_single_line_halfduplex_select(usart_type* usart_x, confirm_state new_state);
Function description	Enable single-wire half-duplex mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: Enable (TRUE), Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable halfduplex */
usart_single_line_halfduplex_select(USART1, TRUE);
```

5.20.25 usart_irda_mode_enable function

The table below describes the function usart_irda_mode_enable.

Table 557. usart_irda_mode_enable function

Name	Description
Function name	usart_irda_mode_enable
Function prototype	void usart_irda_mode_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable infrared mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: Enable (TRUE), Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable irda mode */
usart_irda_mode_enable(USART1, TRUE);
```

5.20.26 usart_irda_low_power_enable function

The table below describes the function usart_irda_low_power_enable.

Table 558. usart_irda_low_power_enable function

Name	Description
Function name	usart_irda_low_power_enable
Function prototype	void usart_irda_low_power_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable infrared low-power mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: Enable (TRUE), Disable (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable irda lowpower mode */
usart_irda_low_power_enable (USART1, TRUE);
```

5.20.27 usart_hardware_flow_control_set function

The table below describes the function usart_hardware_flow_control_set.

Table 559. usart_hardware_flow_control_set function

Name	Description
Function name	usart_hardware_flow_control_set
Function prototype	void usart_hardware_flow_control_set(usart_type* usart_x, usart_hardware_flow_control_type flow_state);
Function description	Set peripheral hardware flow control
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	flow_state: flow control type
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

flow_state

USART_HARDWARE_FLOW_NONE:	No hardware flow control
USART_HARDWARE_FLOW_RTS:	RTS
USART_HARDWARE_FLOW_CTS:	CTS
USART_HARDWARE_FLOW_RTS_CTS:	RTS and CTS

Example:

```
/* hardware flow set none */
usart_hardware_flow_control_set (USART1, USART_HARDWARE_FLOW_NONE);
```

5.20.28 usart_flag_get function

The table below describes the function usart_flag_get.

Table 560. usart_flag_get function

Name	Description
Function name	usart_flag_get
Function prototype	flag_status usart_flag_get(usart_type* usart_x, uint32_t flag);
Function description	Get flag status
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	Flag: flag
Output parameter	NA
Return value	flag_status: SET or RESET
Required preconditions	NA
Called functions	NA

flag

USART_CTSCF_FLAG:	CTS (Clear To Send) change flag
USART_BFF_FLAG:	Break frame receive flag
USART_TDBE_FLAG:	Transmit buffer empty flag
USART_TDC_FLAG:	Transmit complete flag
USART_RDBF_FLAG:	Receive data buffer full flag
USART_IDLEF_FLAG:	Idle frame flag
USART_ROERR_FLAG:	Receive overflow flag
USART_NERR_FLAG:	Noise error flag
USART_FERR_FLAG:	Frame error flag
USART_PERR_FLAG:	Parity error flag

Example:

```
/* wait data transmit complete flag */
while(usart_flag_get (USART1, USART_TDC_FLAG) == RESET);
```

5.20.29 usart_interrupt_flag_get function

The table below describes the function usart_interrupt_flag_get.

Table 561. usart_interrupt_flag_get function

Name	Description
Function name	usart_interrupt_flag_get
Function prototype	flag_status usart_interrupt_flag_get(usart_type* usart_x, uint32_t flag);
Function description	检查指定的 flag 状态是否置起
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2...
Input parameter 2	Flag: clear the selected flag
Output parameter	NA
Return value	flag_status: SET or RESET
Required preconditions	NA
Called functions	NA

flag

USART_RTODF_FLAG:	Receiver timeout detection flag
USART_CMDF_FLAG:	Byte match detection flag
USART_LPWUF_FLAG:	Low-power wakeup flag
USART_CTSCF_FLAG:	CTS (Clear To Send) change flag
USART_BFF_FLAG:	Break frame receive flag
USART_TDBE_FLAG:	Transmit buffer empty flag
USART_TDC_FLAG:	Transmit complete flag
USART_RDBF_FLAG:	Receive data buffer full flag
USART_IDLEF_FLAG:	Idle frame flag
USART_ROERR_FLAG:	Receive overflow flag
USART_NERR_FLAG:	Noise error flag
USART_FERR_FLAG:	Frame error flag
USART_PERR_FLAG:	Parity error flag

Example:

```
/* check received data flag */
if(usart_interrupt_flag_get(USART1, USART_RDBF_FLAG) != RESET)
{
}
```

5.20.30 usart_flag_clear function

The table below describes the function usart_flag_clear.

Table 562. usart_flag_clear function

Name	Description
Function name	usart_flag_clear
Function prototype	void usart_flag_clear(usart_type* usart_x, uint32_t flag);
Function description	Clear flag
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	Flag: clear the selected flag
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

flag

- USART_CTS_FLAG: CTS (Clear To Send) change flag
- USART_BFF_FLAG: Break frame receive flag
- USART_TDC_FLAG: Transmit complete flag
- USART_RDBF_FLAG: Receive data buffer full flag

Example:

```
/* clear data transmit complete flag */
usart_flag_clear (USART1, USART_TDC_FLAG );
```

5.20.31 usart_rs485_delay_time_config function

The table below describes the function usart_rs485_delay_time_config.

Table 563. usart_flag_clear function

Name	Description
Function name	usart_rs485_delay_time_config
Function prototype	void usart_rs485_delay_time_config(usart_type* usart_x, uint8_t start_delay_time, uint8_t complete_delay_time);
Function description	Delay time for setting and clearing data valid signal for continuous data transmission in RS485 mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	start_delay_time: After the first data is written in continuous transmit mode, data valid signal is set and “start_delay_time” is inserted before sending data. The time unit is 1/16 baud rate period.
Input parameter 3	complete_delay_time: After the last data is sent in continuous transmit mode, the “complete_delay_time” is inserted before clearing data valid signal. The time unit is 1/16 baud rate period.
Output parameter	NA
Return value	NA
Required preconditions	NA

Name	Description
Called functions	NA

Example:

```
/* config rs485 delay time */
usart_rs485_delay_time_config(USART1, 2, 2);
```

5.20.32 usart_transmit_receive_pin_swap function

The table below describes the function usart_transmit_receive_pin_swap.

Table 564. usart_transmit_receive_pin_swap function

Name	Description
Function name	usart_transmit_receive_pin_swap
Function prototype	void usart_transmit_receive_pin_swap(usart_type* usart_x, confirm_state new_state);
Function description	Swap transmit/receive pins
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: enabled (TRUE) or disabled (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable tx/rx swap */
usart_transmit_receive_pin_swap (USART1, TRUE);
```

5.20.33 usart_id_bit_num_set function

The table below describes the function usart_id_bit_num_set.

Table 565. usart_transmit_receive_pin_swap function

Name	Description
Function name	usart_id_bit_num_set
Function prototype	void usart_id_bit_num_set(usart_type* usart_x, usart_identification_bit_num_type id_bit_num);
Function description	Set ID bit number
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	id_bit_num: ID bit count
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

id_bit_num

USART_ID_FIXED_4_BIT: 4-bit ID

USART_ID RELATED DATA BIT: Current data bit -1

Example:

```
/* config ID bit width */
```

uart_id_bit_num_set (USART1, USART_ID_FIXED_4_BIT);

5.20.34 usart_de_polarity_set function

The table below describes the function usart_de_polarity_set.

Table 566. usart_de_polarity_set function

Name	Description
Function name	usart_de_polarity_set
Function prototype	void usart_de_polarity_set(usart_type* usart_x, usart_de_polarity_type de_polarity);
Function description	DE signal polarity selection
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	de_polarity: DE signal polarity
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

de_polarity

USART_DE_POLARITY_HIGH: DE signal active high

USART_DE_POLARITY_LOW: DE signal active low

Example:

/* config DE polarity */
usart_de_polarity_set(USART1, USART_DE_POLARITY_HIGH);

5.20.35 usart_rs485_mode_enable function

The table below describes the function usart_rs485_mode_enable.

Table 567. usart_rs485_mode_enable function

Name	Description
Function name	usart_rs485_mode_enable
Function prototype	void usart_rs485_mode_enable(usart_type* usart_x, confirm_state new_state);
Function description	RS485 mode enable
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: enabled (TRUE) or disabled (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

/* enable rs485 mode */
usart_rs485_mode_enable (USART1, TRUE);

5.20.36 usart_rs485_mode_enable function

The table below describes the function usart_low_power_wakeup_set.

Table 568. usart_low_power_wakeup_set function

Name	Description
Function name	usart_low_power_wakeup_set
Function prototype	void usart_low_power_wakeup_set(usart_type* usart_x, usart_wakeup_method_type wakeup_method);
Function description	Enable low-power wakeup
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	wakeup_method: wakeup mode
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

wakeup_method

USART_WAKEUP_METHOD_ID: woke up by ID

USART_WAKEUP_METHOD_START: woke by start bit

USART_WAKEUP_METHOD_RDBF: woke up by receive

Example:

```
/* config wakeup method */
usart_low_power_wakeup_set (USART1, USART_WAKEUP_METHOD_ID);
```

5.20.37 usart_deep_sleep_mode_enable function

The table below describes the function usart_deep_sleep_mode_enable

Table 569. usart_deep_sleep_mode_enable function

Name	Description
Function name	usart_deep_sleep_mode_enable
Function prototype	void usart_deep_sleep_mode_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable Deepsleep mode
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: enabled (TRUE) or disabled (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable deep sleep */
usart_deep_sleep_mode_enable (USART1, ENABLE);
```

5.20.38 usart_msbit_transmit_first_enable function

The table below describes the function usart_msbit_transmit_first_enable

Table 570. usart_msbit_transmit_first_enable function

Name	Description
Function name	usart_msbit_transmit_first_enable
Function prototype	void usart_msbit_transmit_first_enable(usart_type* usart_x, confirm_state new_state);
Function description	Enable MSB-first transmit
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: enabled (TRUE) or disabled (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable msb first transmission */
usart_msbit_transmit_first_enable (USART1, ENABLE);
```

5.20.39 usart_dt_polarity_reverse function

The table below describes the function usart_dt_polarity_reverse

Table 571. usart_dt_polarity_reverse function

Name	Description
Function name	usart_dt_polarity_reverse
Function prototype	void usart_dt_polarity_reverse(usart_type* usart_x, confirm_state new_state);
Function description	Reverse data polarity
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: enabled (TRUE) or disabled (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* reverse data polarity */
usart_dt_polarity_reverse (USART1, ENABLE);
```

5.20.40 usart_transmit_pin_polarity_reverse function

The table below describes the function usart_dt_polarity_reverse

Table 572. usart_dt_polarity_reverse function

Name	Description
Function name	usart_transmit_pin_polarity_reverse
Function prototype	void usart_transmit_pin_polarity_reverse(usart_type* usart_x, confirm_state new_state);
Function description	Reverse data transmit pin polarity
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: enabled (TRUE) or disabled (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* reverse transmit pin polarity */
usart_transmit_pin_polarity_reverse (USART1, ENABLE);
```

5.20.41 usart_receive_pin_polarity_reverse function

The table below describes the function usart_receive_pin_polarity_reverse

Table 573. usart_receive_pin_polarity_reverse function

Name	Description
Function name	usart_receive_pin_polarity_reverse
Function prototype	usart_receive_pin_polarity_reverse (usart_type* usart_x, confirm_state new_state);
Function description	Reverse data receive pin polarity
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: enabled (TRUE) or disabled (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* reverse receive pin polarity */
usart_receive_pin_polarity_reverse (USART1, ENABLE);
```

5.20.42 usart_receiver_timeout_detection_enable function

The table below describes the function usart_receiver_timeout_detection_enable

Table 574. usart_receiver_timeout_detection_enable function

Name	Description
Function name	usart_receiver_timeout_detection_enable
Function prototype	usart_receiver_timeout_detection_enable (usart_type* usart_x, confirm_state new_state);
Function description	Enable data receive timeout detection
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	new_state: enabled (TRUE) or disabled (FALSE)
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* enable receive timeout detection */
usart_receiver_timeout_detection_enable (USART1, ENABLE);
```

5.20.43 usart_receiver_timeout_value_set function

The table below describes the function usart_receiver_timeout_value_set

Table 575. usart_receiver_timeout_value_set function

Name	Description
Function name	usart_receiver_timeout_value_set
Function prototype	void usart_receiver_timeout_value_set(usart_type* usart_x, uint32_t time);
Function description	Set data receive timeout value
Input parameter 1	usart_x: indicates the selected peripheral, it can be USART1, USART2 and USART3
Input parameter 2	Time: Set data receive timeout threshold
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
/* configure receive timeout value */
usart_receiver_timeout_value_set (USART1, 32);
```

5.21 Watchdog timer (WDT)

The WDT register structure `wdt_type` is defined in the “`at32f423_wdt.h`”:

```
/**  
 * @brief type define wdt register all  
 */  
  
typedef struct  
{  
  
} wdt_type;
```

The table below gives a list of the WDT registers

Table 576. Summary of WDT registers

Register	Description
cmd	Command register
div	Divider register
rld	Reload register
sts	Status register
win	Window register

The table below gives a list of WDT library functions.

Table 577. Summary of WDT library functions

Function name	Description
<code>wdt_enable</code>	Enable watchdog
<code>wdt_counter_reload</code>	Reload counter
<code>wdt_reload_value_set</code>	Set reload value
<code>wdt_divider_set</code>	Set division value
<code>wdt_register_write_enable</code>	Unlock WDT_DIV and WDT_RLD register write protection
<code>wdt_flag_get</code>	Get flag
<code>wdt_window_counter_set</code>	Set window counter

5.21.1 wdt_enable function

The table below describes the function wdt_enable.

Table 578. wdt_enable function

Name	Description
Function name	wdt_enable
Function prototype	void wdt_enable(void);
Function description	Enable watchdog
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wdt_enable();
```

5.21.2 wdt_counter_reload function

The table below describes the function wdt_counter_reload.

Table 579. wdt_counter_reload function

Name	Description
Function name	wdt_counter_reload
Function prototype	void wdt_counter_reload(void);
Function description	Reload counter
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wdt_counter_reload();
```

5.21.3 wdt_reload_value_set function

The table below describes the function wdt_reload_value_set.

Table 580. wdt_reload_value_set function

Name	Description
Function name	wdt_reload_value_set
Function prototype	void wdt_reload_value_set(uint16_t reload_value);
Function description	Set reload value
Input parameter	reload_value: reload value, 0x000~0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wdt_reload_value_set(0xFFFF);
```

5.21.4 wdt_divider_set function

The table below describes the function wdt_divider_set.

Table 581. wdt_divider_set function

Name	Description
Function name	wdt_divider_set
Function prototype	void wdt_divider_set(wdt_division_type division);
Function description	Set division value
Input parameter	Division: watchdog division value Refer to the “division” description below for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

division

Select watchdog division value.

WDT_CLK_DIV_4: Divided by 4

WDT_CLK_DIV_8: Divided by 8

WDT_CLK_DIV_16: Divided by 16

WDT_CLK_DIV_32: Divided by 32

WDT_CLK_DIV_64: Divided by 64

WDT_CLK_DIV_128: Divided by 128

WDT_CLK_DIV_256: Divided by 256

Example:

```
wdt_divider_set(WDT_CLK_DIV_4);
```

5.21.5 `wdt_register_write_enable` function

The table below describes the function `wdt_register_write_enable`.

Table 582. `wdt_register_write_enable` function

Name	Description
Function name	<code>wdt_register_write_enable</code>
Function prototype	<code>void wdt_register_write_enable(confirm_state new_state);</code>
Function description	Unlock WDT_DIV and WDT_RLD write protection
Input parameter	new_state: unlock register write protection This parameter can be TRUE or FALSE.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wdt_register_write_enable(TRUE);
```

5.21.6 `wdt_flag_get` function

The table below describes the function `wdt_flag_get`.

Table 583. `wdt_flag_get` function

Name	Description
Function name	<code>wdt_flag_get</code>
Function prototype	<code>flag_status wdt_flag_get(uint16_t wdt_flag);</code>
Function description	Get flag
Input parameter	Flag: flag selection Refer to the "flag" description below for details.
Output parameter	NA
Return value	flag_status: flag status This parameter can be SET or RESET.
Required preconditions	NA
Called functions	NA

flag

This is used for flag selection, including:

- WDT_DIVF_UPDATE_FLAG: Division value update complete
- WDT_RLDF_UPDATE_FLAG: Reload value update complete
- WDT_WINF_UPDATE_FLAG: Window value update complete

Example:

```
wdt_flag_get(WDT_DIVF_UPDATE_FLAG);
```

5.21.7 `wdt_window_counter_set` function

The table below describes the function `wdt_window_counter_set`.

Table 584. `wdt_window_counter_set` function

Name	Description
Function name	<code>wdt_window_counter_set</code>
Function prototype	<code>void wdt_window_counter_set(uint16_t window_cnt);</code>
Function description	Set window counter
Input parameter	<code>window_cnt</code> : window value, from 0x000 to 0xFFFF
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wdt_window_counter_set(0x7FF);
```

5.22 Window watchdog timer (WWDT)

The WWDT register structure wwdt_type is defined in the “at32f423_wwdt.h”:

```
/**  
 * @brief type define wwdt register all  
 */  
  
typedef struct  
{  
  
} wwdt_type;
```

The table below gives a list of the WWDT registers

Table 585. Summary of WWDT registers

Register	Description
ctrl	Control register
cfg	Configuration register
sts	Status register

The table below gives a list of WWDT library functions.

Table 586. Summary of WWDT library functions

Function name	Description
wwdt_reset	Reset window watchdog registers
wwdt_divider_set	Set divider
wwdt_flag_clear	Clear reload counter interrupt flag
wwdt_enable	Enable WWDT
wwdt_interrupt_enable	Enable reload counter interrupt
wwdt_flag_get	Get flag
wwdt_counter_set	Set counter value
wwdt_window_counter_set	Set window value

5.22.1 wwdt_reset function

The table below describes the function wwdt_reset.

Table 587. wwdt_reset function

Name	Description
Function name	wwdt_reset
Function prototype	void wwdt_reset(void);
Function description	Reset window watchdog registers to their initial values.
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	void crm_periph_reset(crm_periph_reset_type value, confirm_state new_state);

Example:

```
wwdt_reset();
```

5.22.2 wwdt_divider_set function

The table below describes the function wwdt_divider_set.

Table 588. wwdt_divider_set function

Name	Description
Function name	wwdt_divider_set
Function prototype	void wwdt_divider_set(wwdt_division_type division);
Function description	Set divider
Input parameter	Division: WWDT division value Refer to the “division” description below for details.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

division

Select WWDT division value.

WWDT_PCLK1_DIV_4096: Divided by 4096

WWDT_PCLK1_DIV_8192: Divided by 8192

WWDT_PCLK1_DIV_16384: Divided by 16384

WWDT_PCLK1_DIV_32768: Divided by 32768

Example:

```
wwdt_divider_set(WWDT_PCLK1_DIV_4096);
```

5.22.3 wwdt_enable function

The table below describes the function wwdt_enable.

Table 589. wwdt_enable function

Name	Description
Function name	wwdt_enable
Function prototype	void wwdt_enable(uint8_t wwdt_cnt);
Function description	Enable WWDT
Input parameter	wwdt_cnt: WWDT counter initial value, 0x40~0x7F
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wwdt_enable(0x7F);
```

5.22.4 wwdt_interrupt_enable function

The table below 3 describes the function wwdt_interrupt_enable.

Table 590. wwdt_interrupt_enable function

Name	Description
Function name	wwdt_interrupt_enable
Function prototype	void wwdt_interrupt_enable(void);
Function description	Enable reload counter interrupt
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wwdt_interrupt_enable();
```

5.22.5 wwdt_counter_set function

The table below describes the function wwdt_counter_set.

Table 591. wwdt_counter_set function

Name	Description
Function name	wwdt_counter_set
Function prototype	void wwdt_counter_set(uint8_t wwdt_cnt);
Function description	Set counter value
Input parameter	wwdt_cnt: WWDT counter value, 0x40~0x7F
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wwdt_counter_set(0x7F);
```

5.22.6 wwdt_window_counter_set function

The table below describes the function wwdt_window_counter_set.

Table 592. wwdt_window_counter_set function

Name	Description
Function name	wwdt_window_counter_set
Function prototype	void wwdt_window_counter_set(uint8_t window_cnt);
Function description	Set window counter value
Input parameter	wwdt_cnt: WWDT window value, 0x40~0x7F
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wwdt_window_counter_set(0x6F);
```

5.22.7 wwdt_flag_get function

The table below describes the function wwdt_flag_get.

Table 593. wwdt_flag_get function

Name	Description
Function name	wwdt_flag_get
Function prototype	flag_status wwdt_flag_get(void);
Function description	Get reload counter interrupt flag
Input parameter	NA
Output parameter	NA
Return value	flag_status: flag status Return SET or RESET
Required preconditions	NA
Called functions	NA

Example:

```
wwdt_flag_get();
```

5.22.8 wwdt_interrupt_flag_get function

The table below describes the function wwdt_interrupt_flag_get.

Table 594. wwdt_interrupt_flag_get function

Name	Description
Function name	wwdt_interrupt_flag_get
Function prototype	flag_status wwdt_interrupt_flag_get(void);
Function description	Get reload counter interrupt flag status, and check the corresponding interrupt enable bit
Input parameter	NA
Output parameter	NA
Return value	flag_status: SET or RESET
Required preconditions	NA
Called functions	NA

Example:

```
wwdt_interrupt_flag_get();
```

5.22.9 wwdt_flag_clear function

The table below describes the function wwdt_flag_clear.

Table 595. wwdt_flag_clear function

Name	Description
Function name	wwdt_flag_clear
Function prototype	void wwdt_flag_clear(void);
Function description	Clear reload counter interrupt flag
Input parameter	NA
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Example:

```
wwdt_flag_clear();
```

5.23 External memory controller (XMC)

For XMC bank1 chip-select control register and timing register, their register structure xmc_bank1_ctrl_tmg_reg_type is defined in the “at32f423_xmc.h”:

```
/*
 * @brief type define xmc bank1 ctrl and tmg register
 */
typedef struct
{
    ...
}

} xmc_bank1_ctrl_tmg_reg_type;
```

XMC bank1 write timing register structure xmc_bank1_tmgwr_reg_type is defined in the “at32f423_xmc.h”:

```
/*
 * @brief type define xmc bank1 tmgwr register
 */
typedef struct
{
    ...
}

} xmc_bank1_tmgwr_reg_type;
```

XMC bank1 register structure xmc_bank1_type is defined in the “at32f423_xmc.h”:

```
/*
 * @brief xmc bank1 registers
 */
typedef struct
{
    ...
}

} xmc_bank1_type;
```

The table below gives a list of the XMC registers

Table 596. Summary of XMC registers

Register	Description
xmc_bk1ctrl1	SRAM/NOR Flash chip select control register 1
xmc_bk1tmg1	SRAM/NOR Flash chip select timing register 1
xmc_bk1ctrl2	SRAM/NOR Flash chip select control register 2
xmc_bk1tmg2	SRAM/NOR Flash chip select timing register 2
xmc_bk1ctrl4	SRAM/NOR Flash chip select control register 4
xmc_bk1tmg4	SRAM/NOR Flash chip select timing register 4
xmc_bk1tmgwr1	SRAM/NOR Flash write timing register1
xmc_bk1tmgwr2	SRAM/NOR Flash write timing register 2

Register	Description
xmc_bk1tmgwr4	SRAM/NOR Flash write timing register 4
xmc_ext1	SRAM/NOR Flash extra timing register 1
xmc_ext2	SRAM/NOR additional extend register 2
xmc_ext4	SRAM/NOR Flash additional timing register 4

The table below gives a list of XMC library functions.

Table 597. Summary of XMC library functions

Function name	Description
xmc_nor_sram_reset	Reset nor/sram controller
xmc_nor_sram_init	Initialize nor/sram controller
xmc_nor_sram_timing_config	Configure nor/sram controller timing
xmc_norsram_default_para_init	Initialize the parameters of the xmc_nor_sram_init_struct
xmc_norsram_timing_default_para_init	Initialize the parameters of the xmc_rw_timing_struct and xmc_w_timing_struct
xmc_nor_sram_enable	Enable nor/sram controller
xmc_ext_timing_config	Configure nor/sram extension controller

5.23.1 xmc_nor_sram_reset function

The table below describes the function xmc_nor_sram_reset.

Table 598. xmc_nor_sram_reset function

Name	Description
Function name	xmc_nor_sram_reset
Function prototype	void xmc_nor_sram_reset(xmc_nor_sram_subbank_type xmc_subbank);
Function description	Reset nor/sram controller
Input parameter	xmc_subbank: subbank selection
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

xmc_subbank

Select a subbank to reset.

XMC_BANK1_NOR_SRAM1: XMC subbank1

XMC_BANK1_NOR_SRAM3: XMC subbank3

XMC_BANK1_NOR_SRAM4: XMC subbank4

Example:

```
/* reset nor/sram subbank1 */
xmc_nor_sram_reset(XMC_BANK1_NOR_SRAM1);
```

5.23.2 xmc_nor_sram_init function

The table below describes the function xmc_nor_sram_init.

Table 599. xmc_nor_sram_init function

Name	Description
Function name	xmc_nor_sram_init
Function prototype	void xmc_nor_sram_init(xmc_norsram_init_type* xmc_norsram_init_struct);
Function description	Initialize nor/sram controller
Input parameter 1	xmc_norsram_init_struct: xmc_norsram_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

xmc_norsram_init_type struct

xmc_norsram_init_type is defined in the at32f423_xmc.h:

typedef struct

```
{
    xmc_nor_sram_subbank_type    subbank;
    xmc_data_addr_mux_type      data_addr_mux;
    xmc_memory_type              device;
    xmc_data_width_type          bus_type;
    xmc_burst_access_mode_type   burst_mode_enable;
    xmc_asyn_wait_type           asynwait_enable;
    xmc_wait_signal_polarity_type wait_signal_lv;
```

```
xmc_wrap_mode_type      wrapped_mode_enable;  
xmc_wait_timing_type    wait_signal_config;  
xmc_write_operation_type write_enable;  
xmc_wait_signal_type    wait_signal_enable;  
xmc_extended_mode_type  write_timing_enable;  
xmc_write_burst_type    write_burst_syn;  
} xmc_norsram_init_type;
```

subbank

Select a subbank to reset.

XMC_BANK1_NOR_SRAM1: XMC subbank1

XMC_BANK1_NOR_SRAM3: XMC subbank3

XMC_BANK1_NOR_SRAM4: XMC subbank4

data_addr_mux

Define whether the lower 16 bits of the xmc address line is multiplexed with data line or not.

XMC_DATA_ADDR_MUX_DISABLE: Not multiplexed

XMC_DATA_ADDR_MUX_ENABLE: Multiplexed

Device

Select an external memory device.

XMC_DEVICE_SRAM: sram

XMC_DEVICE_PSRAM: psram

XMC_DEVICE_NOR: nor

bus_type

xmc data bus bit width.

XMC_BUSTYPE_8_BITS: 8-bit data bus

XMC_BUSTYPE_16_BITS: 1-6bit data bus

burst_mode_enable

Enable or disable burst mode.

XMC_BURST_MODE_DISABLE: Burst mode disabled

XMC_BURST_MODE_ENABLE: Burst mode enabled

asynwait_enable

Enable or disable wait signals during asynchronous transmission.

XMC_ASYN_WAIT_DISABLE: Disabled

XMC_ASYN_WAIT_ENABLE: Enabled

wait_signal_lv

Select the polarity of wait signals. This bit is used to set the polarity of NWAIT signal in synchronous mode.

XMC_WAIT_SIGNAL_LEVEL_LOW: Active low

XMC_WAIT_SIGNAL_LEVEL_HIGH: Active high

wrapped_mode_enable

In synchronous mode, this bit is used to define whether the XMC controller will or not split a not-aligned AHB access into two accesses.

XMC_WWRAPPED_MODE_DISABLE: Direct wrapped burst mode is disabled

XMC_WWRAPPED_MODE_ENABLE: Direct wrapped burst mode is enabled

wait_signal_config

Wait timing configuration. Valid only in synchronous mode.

XMC_WAIT_SIGNAL_SYN_BEFORE: NWAIT signal is active one data cycle before wait state
XMC_WAIT_SIGNAL_SYN_DURING: NWAIT signal is active during wait state

write_enable

Write enable bit.

XMC_WRITE_OPERATION_DISABLE: Write operation is disabled

XMC_WRITE_OPERATION_ENABLE: Write operation is enabled

wait_signal_enable

Wait signal enable bit during synchronous transmission.

XMC_WAIT_SIGNAL_DISABLE: NWAIT signal disabled

XMC_WAIT_SIGNAL_ENABLE: NWAIT signal enabled

write_timing_enable

Wait timing enable bit. Read memory and write memory operate at different timings. In other words, SRAM/NOR write timing register (XMC_BKxTMGWR) is released.

XMC_WRITE_TIMING_DISABLE: Read and write timings are the same

XMC_WRITE_TIMING_ENABLE: Read and write timings are different

write_burst_syn

Write burst enable bit

XMC_WRITE_BURST_SYN_DISABLE: Write operation is performed in asynchronous mode

XMC_WRITE_BURST_SYN_ENABLE: Write operation is performed in synchronous mode

Example:

```
xmc_norsram_init_type xmc_norsram_init_struct;  
xmc_norsram_init_struct.subbank          = XMC_BANK1_NOR_SRAM1;  
xmc_norsram_init_struct.data_addr_mux    = XMC_DATA_ADDR_MUX_ENABLE;  
xmc_norsram_init_struct.device          = XMC_DEVICE_PSRAM;  
xmc_norsram_init_struct.bus_type        = XMC_BUSTYPE_16_BITS;  
xmc_norsram_init_struct.burst_mode_enable = XMC_BURST_MODE_DISABLE;  
xmc_norsram_init_struct.asynwait_enable = XMC_ASYN_WAIT_DISABLE;  
xmc_norsram_init_struct.wait_signal_lv   = XMC_WAIT_SIGNAL_LEVEL_LOW;  
xmc_norsram_init_struct.wrapped_mode_enable = XMC_WRAPPED_MODE_DISABLE;  
xmc_norsram_init_struct.wait_signal_config = XMC_WAIT_SIGNAL_SYN_BEFORE;  
xmc_norsram_init_struct.write_enable     = XMC_WRITE_OPERATION_ENABLE;  
xmc_norsram_init_struct.wait_signal_enable = XMC_WAIT_SIGNAL_DISABLE;  
xmc_norsram_init_struct.write_burst_syn = XMC_WRITE_BURST_SYN_DISABLE;  
xmc_norsram_init_struct.write_timing_enable = XMC_WRITE_TIMING_DISABLE;  
xmc_nor_sram_init(&xmc_norsram_init_struct);
```

5.23.3 scfg_mem_map_get function

The table below describes the function scfg_mem_map_get.

Table 600. scfg_mem_map_get function

Name	Description
Function name	xmc_nor_sram_timing_config
Function prototype	void xmc_nor_sram_timing_config(xmc_norsram_timing_init_type* xmc_rw_timing_struct, xmc_norsram_timing_init_type* xmc_w_timing_struct);
Function description	Configure nor/sram timings
Input parameter 1	xmc_rw_timing_struct: xmc_norsram_timing_init_type pointer. This structure is used to configure read and write timings when a separate write timing is not enabled.
Input parameter 2	xmc_w_timing_struct: xmc_norsram_timing_init_type pointer. This structure is used to configure write timings when a separate write timing is enabled.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

xmc_norsram_timing_init_type struct

xmc_norsram_timing_init_type is defined in the at32f423_xmc.h:

typedef struct

```
{
    xmc_nor_sram_subbank_type    subbank;
    xmc_extended_mode_type      write_timing_enable;
    uint32_t                      addr_setup_time;
    uint32_t                      addr_hold_time;
    uint32_t                      data_setup_time;
    uint32_t                      bus_latency_time;
    uint32_t                      clk_psc;
    uint32_t                      data_latency_time;
    xmc_access_mode_type         mode;
} xmc_norsram_timing_init_type;
```

subbank

Select a subbank to reset.

XMC_BANK1_NOR_SRAM1: XMC subbank1

XMC_BANK1_NOR_SRAM3: XMC subbank3

XMC_BANK1_NOR_SRAM4: XMC subbank4

write_timing_enable

Wait timing enable bit. Read memory and write memory operate at different timings. In other words, SRAM/NOR write timing register (XMC_BKxTMGWR) is released.

XMC_WRITE_TIMING_DISABLE: Read and write timings are the same

XMC_WRITE_TIMING_ENABLE: Read and write timings are different

addr_setup_time

Address setup time.

0000: 0 HCLK clock cycle added

0001: 1 HCLK clock cycles added

.....

1111: 15 HCLK clock cycles added

addr_hold_time

Address hold time.

0000: 0 HCLK clock cycle added

0001: 1 HCLK clock cycles added

.....

1111: 15 HCLK clock cycles added

data_setup_time

Data setup time

0000: 0 HCLK clock cycle added

0001: 1 HCLK clock cycles added

.....

1111: 15 HCLK clock cycles added

bus_latency_time

Bus latency time. In order to avoid conflicts on data bus, in multiplexed mode or synchronous mode, the XMC controller inserts latency time into data bus after a single read operation.

0000: 1 HCLK clock cycle added

0001: 2 HCLK clock cycles added

.....

1111: 16 HCLK clock cycles added

clk_psc

Clock frequency division factor. Valid only in synchronous mode. It is used to define the clock frequency of the XMC_CLK.

0000: Reserved

0001: XMC_CLK cycles= 2 x HCLK clock cycles

0010: XMC_CLK cycles= 3 x HCLK clock cycles

.....

1111: XMC_CLK cycles= 16 x HCLK clock cycles

data_latency_time

Data latency time. Valid only in synchronous mode.

0000: 0 HCLK clock cycle added

0001: 1 HCLK clock cycle added

.....

1111: 15 HCLK clock cycles added

Mode

Asynchronous access mode selection bit. Valid only when the RWTD bit is enabled.

00: Mode A

01: Mode B

10: Mode C

11: Mode D

Example:

```
xmc_norsram_timing_init_type rw_timing_struct, w_timing_struct;
```

```

rw_timing_struct.subbank          = XMC_BANK1_NOR_SRAM1;
rw_timing_struct.mode             = XMC_ACCESS_MODE_A;
rw_timing_struct.write_timing_enable = XMC_WRITE_TIMING_DISABLE;
rw_timing_struct.addr_hold_time   = 0x08;
rw_timing_struct.addr_setup_time  = 0x09;
rw_timing_struct.data_setup_time  = 0x0F;
rw_timing_struct.data_latency_time = 0x0;
rw_timing_struct.bus_latency_time = 0x0;
rw_timing_struct.clk_psc          = 0x0;

w_timing_struct.subbank          = XMC_BANK1_NOR_SRAM1;
w_timing_struct.mode             = XMC_ACCESS_MODE_A;
w_timing_struct.write_timing_enable = XMC_WRITE_TIMING_DISABLE;
w_timing_struct.addr_hold_time   = 0x08;
w_timing_struct.addr_setup_time  = 0x09;
w_timing_struct.data_setup_time  = 0x0F;
w_timing_struct.data_latency_time = 0x0;
w_timing_struct.bus_latency_time = 0x0;
w_timing_struct.clk_psc          = 0x0;

xmc_nor_sram_timing_config(&rw_timing_struct, &w_timing_struct);

```

5.23.4 xmc_norsram_default_para_init function

The table below describes the function xmc_norsram_default_para_init.

Table 601. xmc_norsram_default_para_init function

Name	Description
Function name	xmc_norsram_default_para_init
Function prototype	void xmc_norsram_default_para_init(xmc_norsram_init_type* xmc_nor_sram_init_struct);
Function description	Initialize the parameters of the xmc_nor_sram_init_struct
Input parameter	xmc_nor_sram_init_struct: xmc_norsram_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

Table 594 shows the values of members in the xmc_nor_sram_init_struct:

Table 602. xmc_nor_sram_init_struct default values

Member	Default values
subbank	XMC_BANK1_NOR_SRAM1
data_addr_mux	XMC_DATA_ADDR_MUX_ENABLE
device	XMC_DEVICE_SRAM
bus_type	XMC_BUSTYPE_8_BITS
burst_mode_enable	XMC_BURST_MODE_DISABLE
asynwait_enable	XMC_ASYN_WAIT_DISABLE
wait_signal_lv	XMC_WAIT_SIGNAL_LEVEL_LOW
wrapped_mode_enable	XMC_WWRAPPED_MODE_DISABLE
wait_signal_config	XMC_WAIT_SIGNAL_SYN_BEFORE
write_enable	XMC_WRITE_OPERATION_ENABLE
wait_signal_enable	XMC_WAIT_SIGNAL_ENABLE
write_timing_enable	XMC_WRITE_TIMING_DISABLE
write_burst_syn	XMC_WRITE_BURST_SYN_DISABLE

Example:

```
xmc_norsram_init_type xmc_norsram_init_struct;
/* fill each xmc_nor_sram_init_struct member with its default value */
xmc_norsram_default_para_init(&xmc_norsram_init_struct);
```

5.23.5 xmc_norsram_timing_default_para_init function

The table below describes the function xmc_norsram_timing_default_para_init.

Table 603. xmc_norsram_timing_default_para_init function

Name	Description
Function name	xmc_norsram_timing_default_para_init
Function prototype	void xmc_norsram_timing_default_para_init(xmc_norsram_timing_init_type* xmc_rw_timing_struct, xmc_norsram_timing_init_type* xmc_w_timing_struct);
Function description	Initialize the parameters of xmc_rw_timing_struct and xmc_w_timing_struct
Input parameter	xmc_rw_timing_struct: xmc_norsram_timing_init_type pointer xmc_w_timing_struct: xmc_norsram_timing_init_type pointer
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

The table below shows the values of members in the xmc_rw_timing_struct and xmc_w_timing_struct:

Table 604. xmc_rw_timing_struct and xmc_w_timing_struct

Member	Default values
subbank	XMC_BANK1_NOR_SRAM1
write_timing_enable	XMC_WRITE_TIMING_DISABLE
addr_setup_time	0xF
addr_hold_time	0xF
data_setup_time	0xFF
bus_latency_time	0xF
clk_psc	0xF
data_latency_time	0xF
mode	XMC_ACCESS_MODE_A

Example:

```
xmc_norsram_timing_init_type rw_timing_struct, w_timing_struct;
/* fill each xmc_rw_timing_struct and xmc_w_timing_struct member with its default value */
xmc_norsram_timing_default_para_init (&xmc_rw_timing_struct, &xmc_w_timing_struct);
```

5.23.6 xmc_nor_sram_enable function

The table below describes the function xmc_nor_sram_enable.

Table 605. xmc_nor_sram_enable function

Name	Description
Function name	xmc_nor_sram_enable
Function prototype	void xmc_nor_sram_enable(xmc_nor_sram_subbank_type xmc_subbank, confirm_state new_state);
Function description	Enable nor/sram controller
Input parameter 1	xmc_subbank: subbank selection
Input parameter 2	new_state: enable or disable
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

xmc_subbank

Select a subbank.

XMC_BANK1_NOR_SRAM1: xmc subbank1

XMC_BANK1_NOR_SRAM3: xmc subbank3

XMC_BANK1_NOR_SRAM4: xmc subbank4

new_state

FALSE: Disable controller

TRUE: Enable controller

Example:

```
/* enable xmc bank1_sram bank */
xmc_nor_sram_enable(XMC_BANK1_NOR_SRAM1, TRUE);
```

5.23.7 xmc_ext_timing_config function

The table below describes the function xmc_ext_timing_config.

Table 606. xmc_ext_timing_configfunction

Name	Description
Function name	xmc_ext_timing_config
Function prototype	void xmc_ext_timing_config(xmc_nor_sram_subbank_type xmc_sub_bank, uint16_t w2w_timing, uint16_t r2r_timing);
Function description	Configure nor/sram extension controller
Input parameter 1	xmc_subbank: subbank selection
Input parameter 2	w2w_timing: bus turnaround phase duration between two consecutive write operations.
Input parameter 3	r2r_timing: bus turnaround phase duration between two consecutive read operations.
Output parameter	NA
Return value	NA
Required preconditions	NA
Called functions	NA

xmc_subbank

Select a subbank to reset.

XMC_BANK1_NOR_SRAM1: xmc subbank1

XMC_BANK1_NOR_SRAM3: xmc subbank3

XMC_BANK1_NOR_SRAM4: xmc subbank4

w2w_timing

This is used to define the bus turnaround phase duration between two consecutive write operations.

00000000: 1 HCLK clock cycle inserted between two consecutive write operations

00000001: 2 HCLK clock cycles inserted between two consecutive write operations

.....

00001000: 9 HCLK clock cycles (default value) inserted between two consecutive read operations

.....

11111111: 256 HCLK clock cycles inserted between two consecutive read operations

r2r_timing

This is used to define the bus turnaround phase duration between two consecutive read operations.

00000000: 1 HCLK clock cycle inserted between two consecutive write operations

00000001: 2 HCLK clock cycles inserted between two consecutive write operations

.....

00001000: 9 HCLK clock cycles (default value) inserted between two consecutive read operations

.....

11111111: 256 HCLK clock cycles inserted between two consecutive write operations

Example:

```
/* bus turnaround phase for consecutive read duration and consecutive write duration */
xmc_ext_timing_config(XMC_BANK1_NOR_SRAM1, 0x08, 0x08);
```

6 Precautions

6.1 Device model replacement

While replacing the device part number in an existing project or demo with another one, if necessary, it is necessary to check the macro definitions corresponding to the device defined in [Table 1](#) before replacement. The subsequent sections give a detailed description of how to replace a device in KEIL and IAR environments (Just taking the at32f403avgt7 as an example as other devices share similar operations).

There are two steps to get this happen:

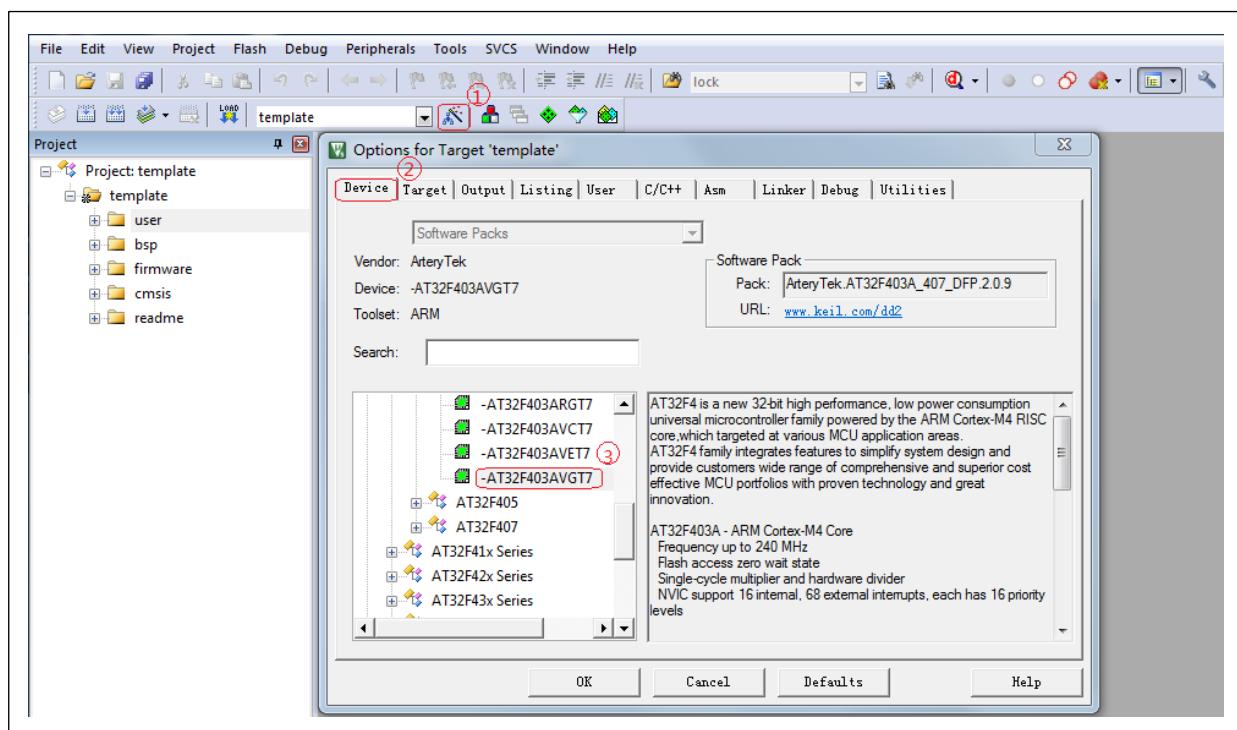
1. By changing device
2. By changing macro definition

6.1.1 KEIL environment

Follow the steps and illustration below for device replacement in Keil environment:

- ① Click on magic stick “Options for Target”
- ② Click on “Device”
- ③ Select the desired device part number

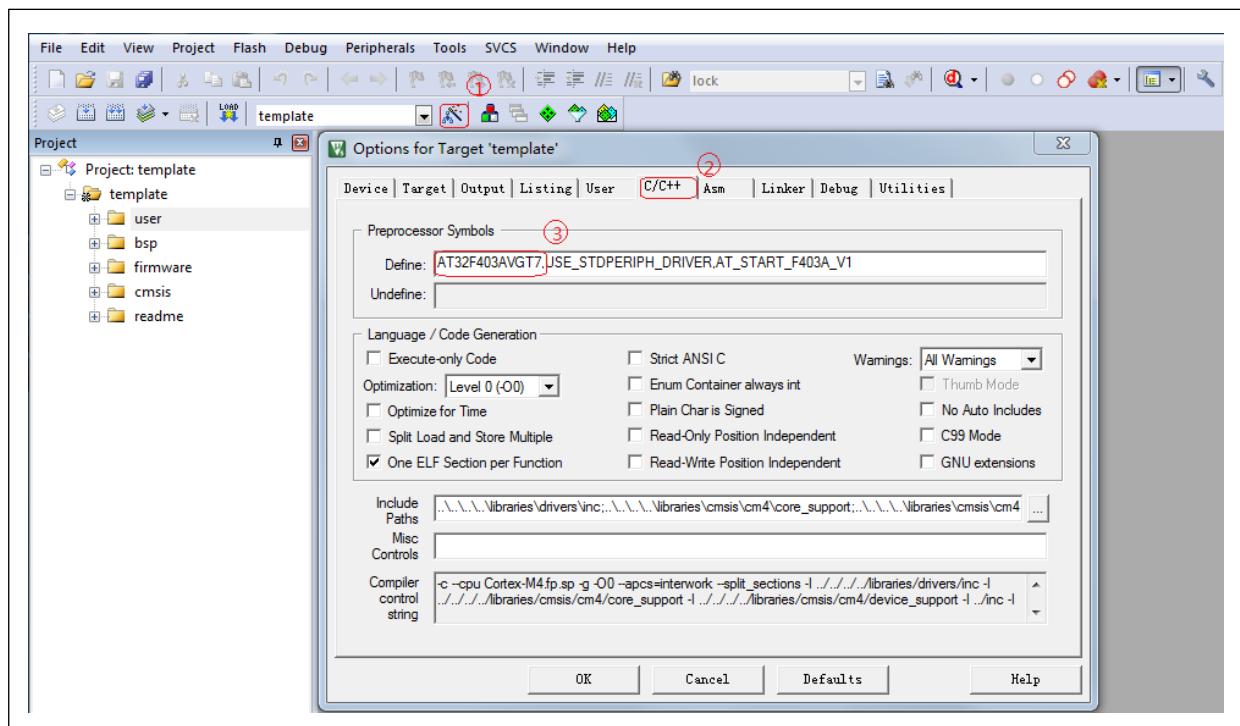
Figure 29. Change device part number in Keil



Follow the steps and illustration below to change macro definition.

- ① Click on magic stick “Options for Target”
- ② Click on “C/C++”
- ③ Delete the original macro definition in “Define” box, and write the desired one corresponding to the selected device part number based o [Table 1](#).

Figure 30. Change macro definition in Keil

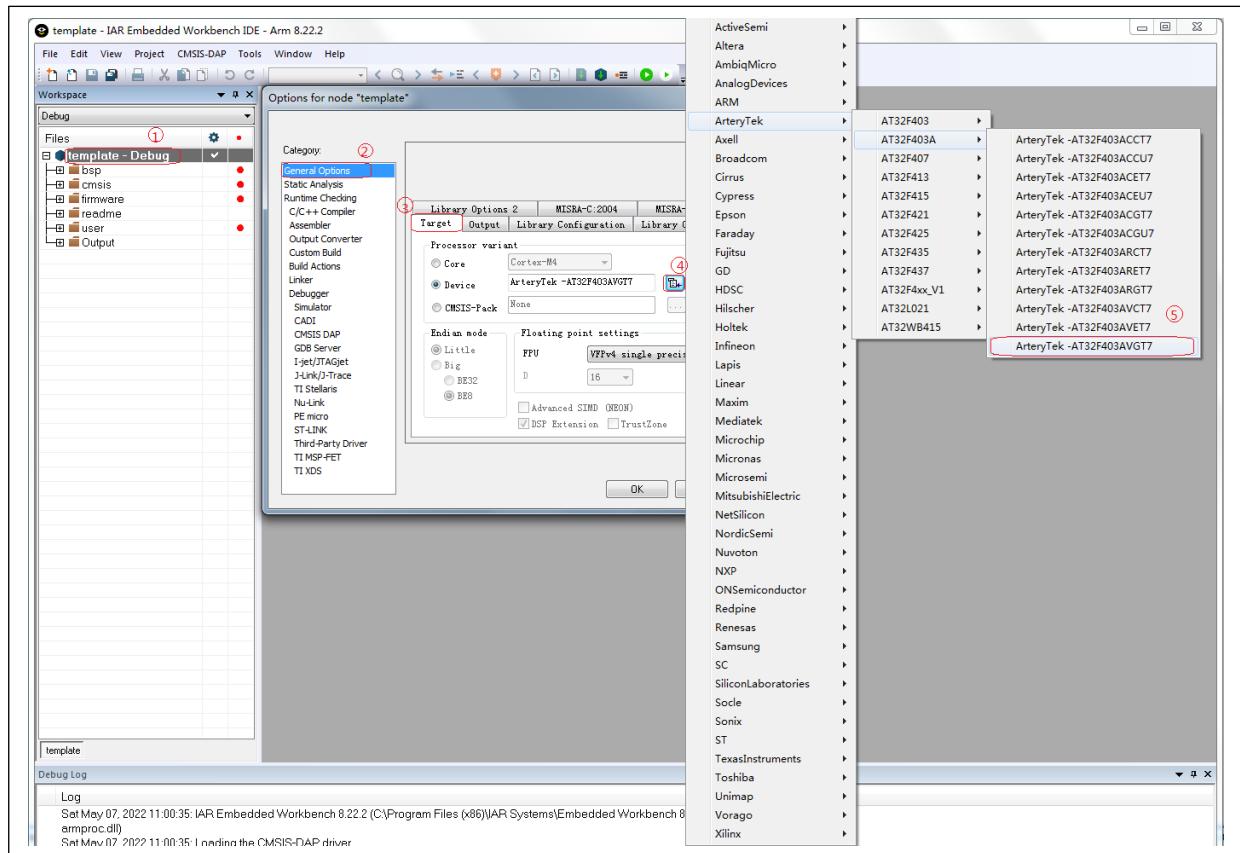


6.1.2 IAR environment

Follow the steps and illustration below for device replacement in IAR environment.

- ① Right click on the file name, and select “Options...”
- ② Select “General Options”
- ③ Select “Target”
- ④ Click on check box
- ⑤ Select the desired device part number.

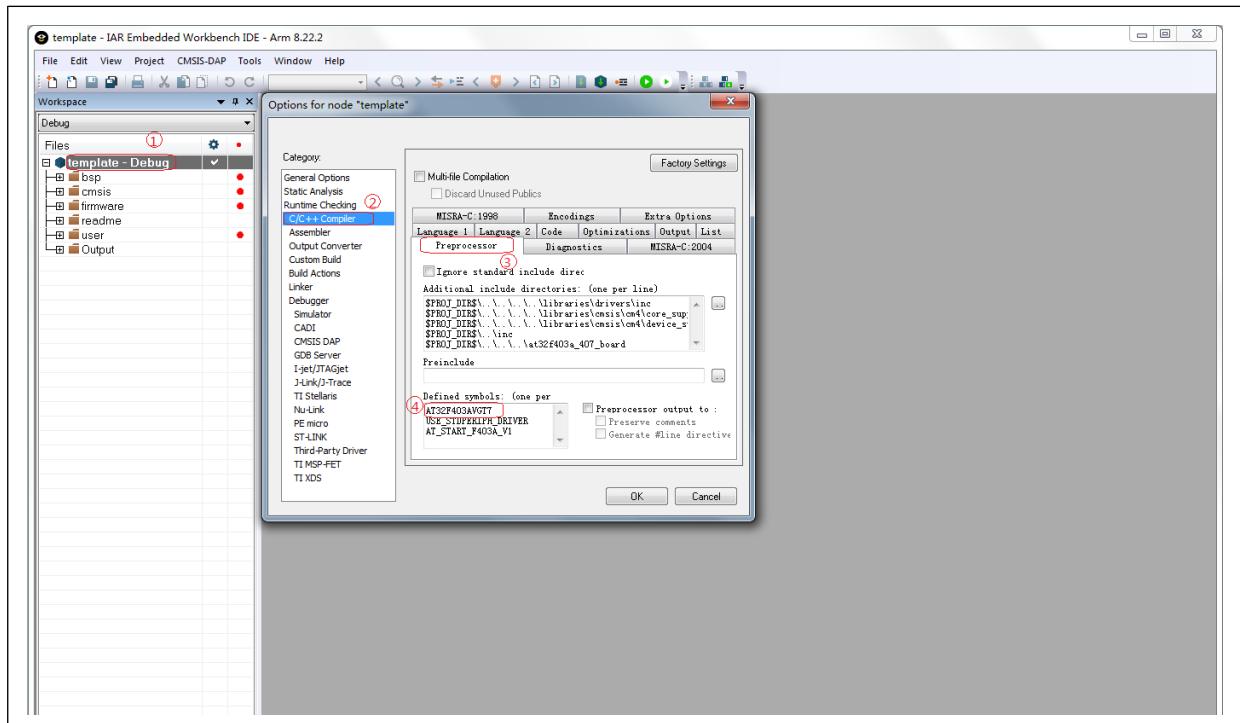
Figure 31. Change device part number in IAR



Follow the steps and illustration below to change macro definition in IAR environment.

- ① Right click on the file name, and select “Options...”
- ② Select “C/C++ Compiler”
- ③ Click on “Preprocessor”
- ④ Delete the original macro definition in “Defined symbols” column, and write the desired one corresponding to the selected device part number based on [Table 1](#).

Figure 32. Change macro definition in IAR



6.2 Unable to identify IC by JLink software in Keil

In special circumstances, the Keil project compiled by an engineer is unknown to the J-Link software even if it can be compiled by other engineers and identified by ICP software. For example, some warnings like below will be displayed.

Figure 33. Error warning 1

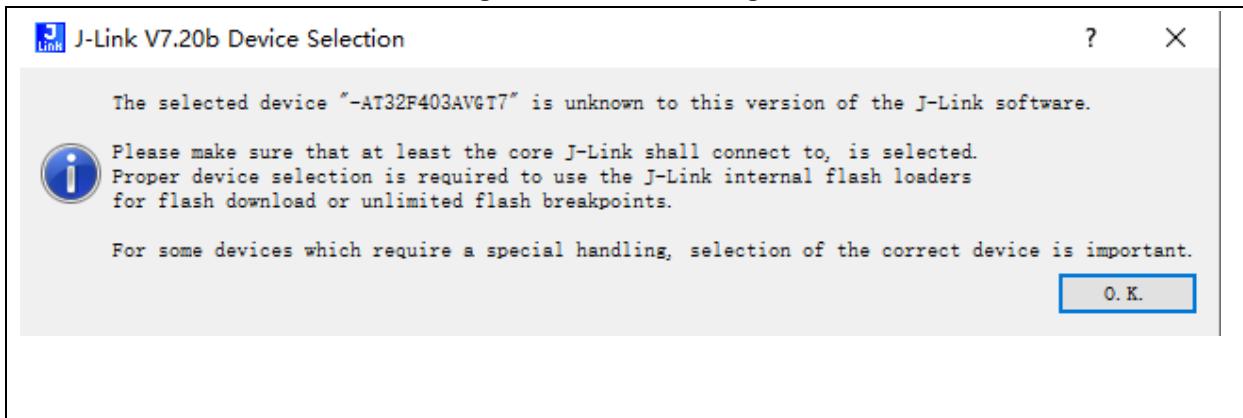


Figure 34. Error warning 2

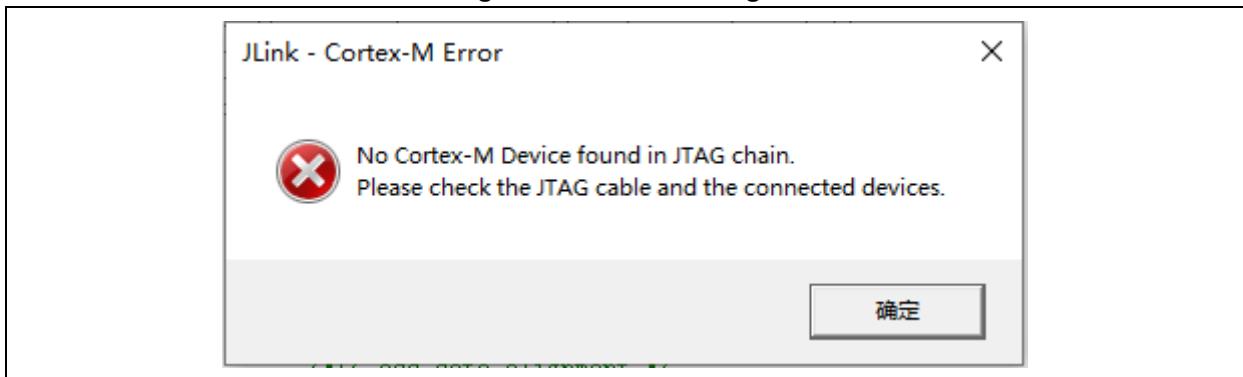
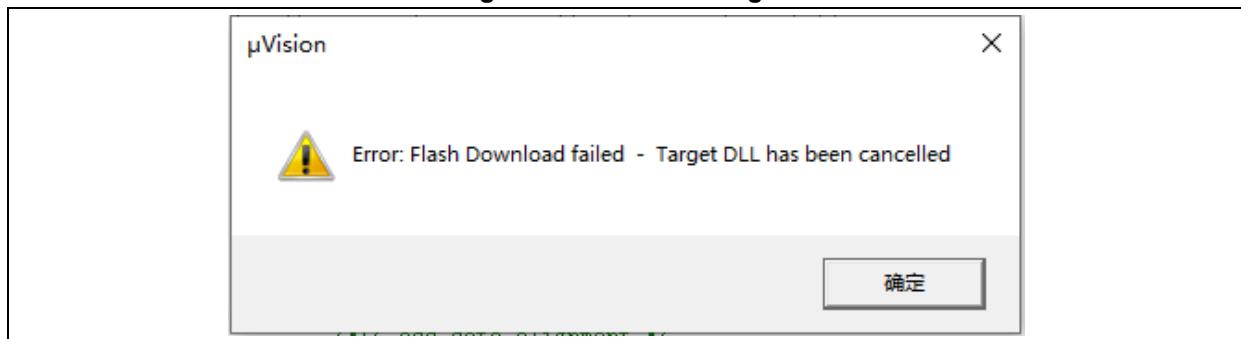


Figure 35. Error warning 3

**How to solve this problem?**

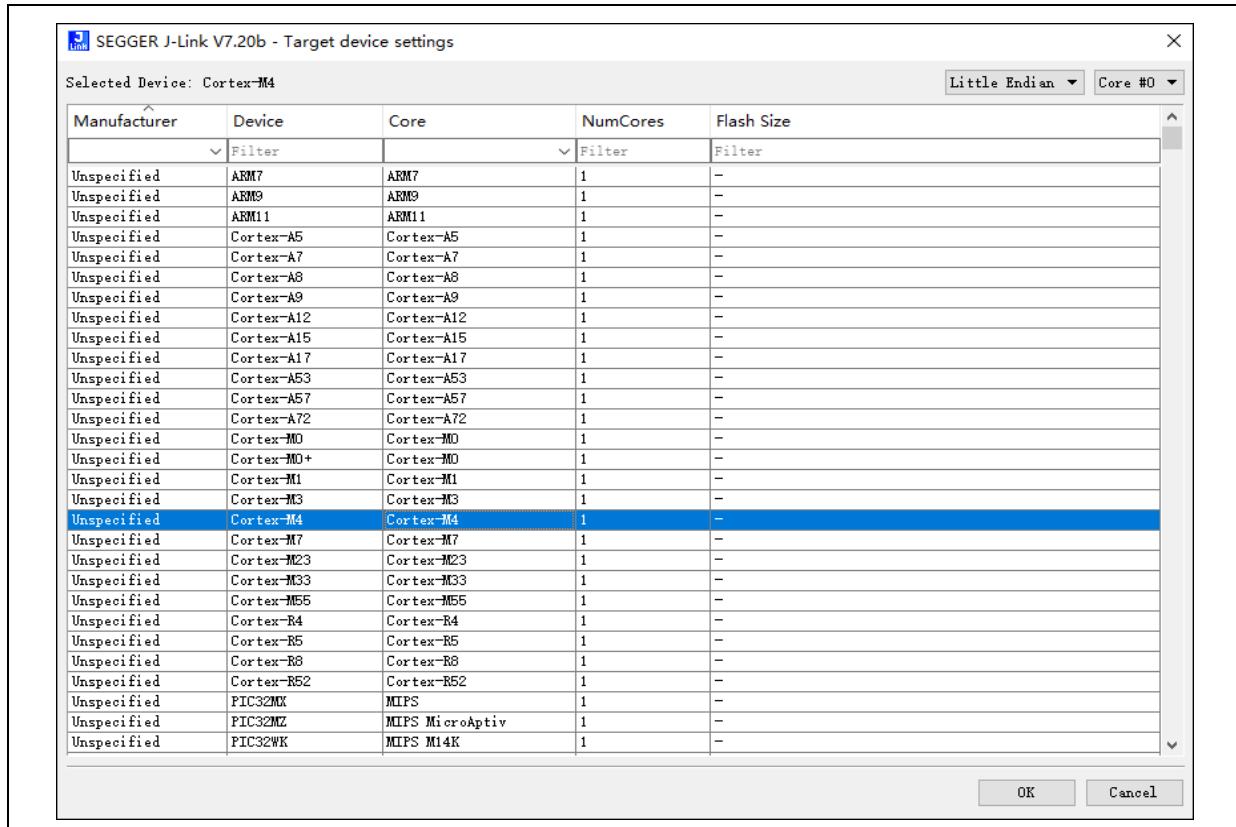
Step 1: Find “JLinkLog” and “JLinkSettings” files according to project path, and delete them.

Figure 36. JLinkLog and JLinkSettings

名称	修改日期	类型	大小
listings	2022/2/22 19:28	文件夹	
objects	2022/2/22 19:28	文件夹	
combine_mode_ordinary_simult.uvoptx	2022/2/22 19:28	UVOPTX 文件	12 KB
combine_mode_ordinary_simult	2022/2/22 19:28	Minision5 Project	17 KB
JLinkLog	2022/2/22 19:28	文本文档	7 KB
JLinkSettings	2022/2/22 19:27	配置设置	1 KB

Step 2: Click on magic wand, go to “Debug”, select “Unspecified Cortex-M4”

Figure 37. Unspecified Cortex-M4



6.3 How to change HEXT crystal

All examples used in BSP implements frequency multiplication based on 8 MHz external high-speed crystal oscillator on the evaluation board. If a non-8 MHz external crystal is used in actual scenarios, it is necessary to modify clock configuration in BSP to allow for accurate and stable clock frequency.

Therefore, the “AT32_New_Clock_Configuration” tool is specially developed by Artery to generate the desired BSP system clock code file, including external clock source, frequency division factor, frequency multiplication factor, clock source selection and other parameters, marked in red in Figure 38. After the completion of parameter configuration, it is ready to generate code file, avoiding complicated operations involved in code modification.

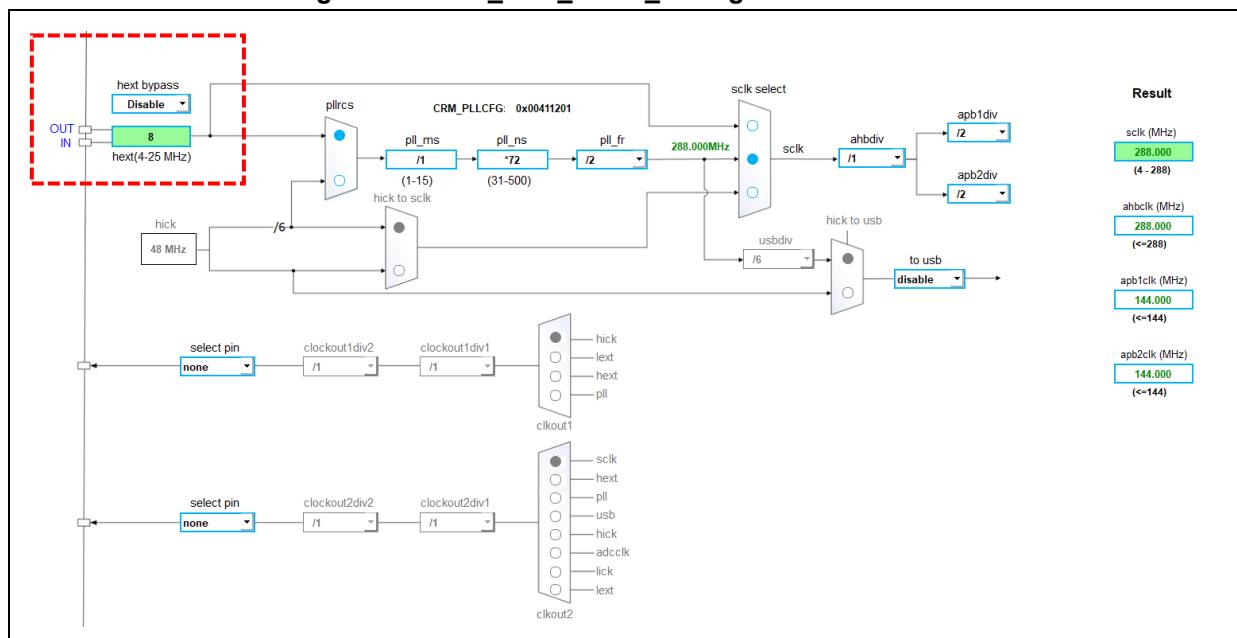
The users simply need to replace the original one in BSP demo with the newly generated clock code file (at32f4xx_clock.c/ at32f4xx_clock.h/ at32f4xx_conf.h), and call the function system_clock_config in main function.

Also, it is necessary to replace the macro definition HEXT_VALUE in the at32f4xx_conf.h. Taking the AT32F403A as an example, the HEXT_VALUE of the at32f403a_407_conf.h is defined as:

```
#define HEXT_VALUE ((uint32_t)8000000) /*!< value of the high speed external crystal in hz */
```

Figure 38 shows the window of AT32_New_Clock_Configuration tool.

Figure 38. AT32_New_Clock_Configuration window



For more information on the AT32_New_Clock_Configuration, please refer to the corresponding Application Note shown in Table 589, which are all available from the official website of Artery.

Table 607. Clock configuration guideline

Part number	Application note
AT32F403A/407 clock configuration	AN0082
AT32F435/437 clock configuration	AN0084
AT32F421 clock configuration	AN0116
AT32F415 clock configuration	AN0117
AT32F413 clock configuration	AN0118
AT32F425 clock configuration	AN0121

7 Revision history

Table 608. Document revision history

Date	Revision	Changes
2023.01.01	2.0.0	Initial release
2023.07.18	2.0.1	Added section 5.4.10 to 5.4.13
2023.10.26	2.0.2	Added the function “interrupt_flag_get” to each section of this file
2024.03.01	2.0.3	Added the function “pwc_ldo_output_voltage_set” and changed “PWC” to “NVIC” in the titles of Table 404 and Table 405.

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