# GigaDevice Semiconductor Inc.

# Arm® Cortex®- M3/M4/M23/M33 32-bit MCU

# Application Note
# AN043

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# 1. Introduction

As a kind of non-volatile memory, flash plays an indispensable role in the microcontroller system, and its performance will affect the operating efficiency of the entire system. Its performance is mainly reflected in the flash operating time, including mass erasing time, page erasing time, and word programming time.

This application note provides two methods for measuring flash operating time.

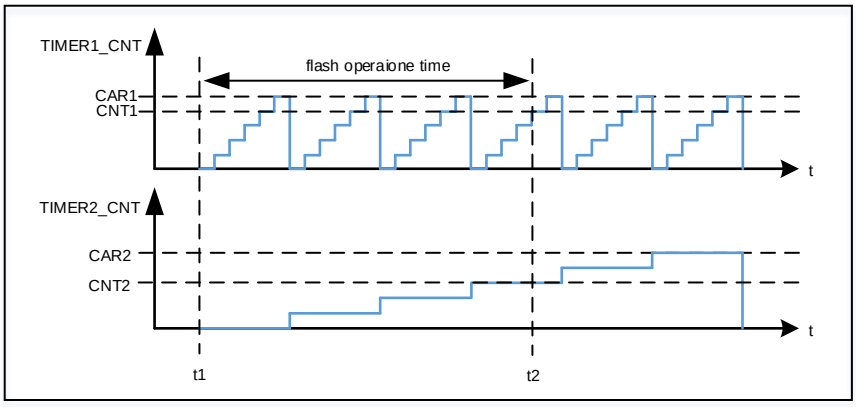
# 2. Flash operation time measurement method

## 2.1. Timer counting method

Timer counting method use the MCU internal timer to count and use the count value to calculate the operating time of the flash. This method clears the timer count value and starts counting before the flash operation is performed, and reads the counter value and turns off the count after the flash operation is completed. In order to improve the measurement accuracy, we run the system at the highest frequency of 64MHz, and divide the timer clock into 8MHz, that is, the timer count cycle is 0.125us. Since the L23x timer is a 16-bit timer, a single timer can only measure up to 65536*0.125us = 8.192ms. In order to increase the measurement time range, the timer cascade method can be used. By using one of the timer update event pulses as the clock source of the other timer, the measurement time can be expanded to 65536*8.192ms=536.870912s. This can ensure maximum accuracy. As shown in ***Figure 2-1. The method of timer to measure flash operation time***, flash operation time $t_f$:

$$tf = t2\text{-}t1 = (CNT1 + (CAR1 * CNT2)) * 0.125us \quad (2\text{-}1)$$

**Figure 2-1. The method of timer to measure flash operation time**

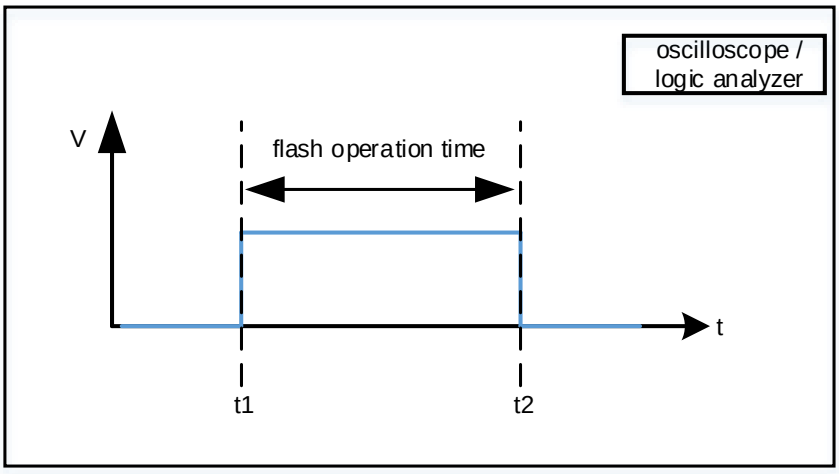



## 2.2. I/O level flip method

I/O level flip method use MCU external pins to output high and low levels, and use an oscilloscope / logic analyzer to measure the pulse time.

This method is to set the general IO port to high level before the flash operation, and set the general IO port to low level after the flash operation is completed. Finally, using an oscilloscope / logic analyzer to measure the positive pulse time. As shown in ***Figure 2-2. Method of IO port to measure flash operation time***, the flash operation time is tf=t2-t1.

**Figure 2-2. Method of IO port to measure flash operation time**

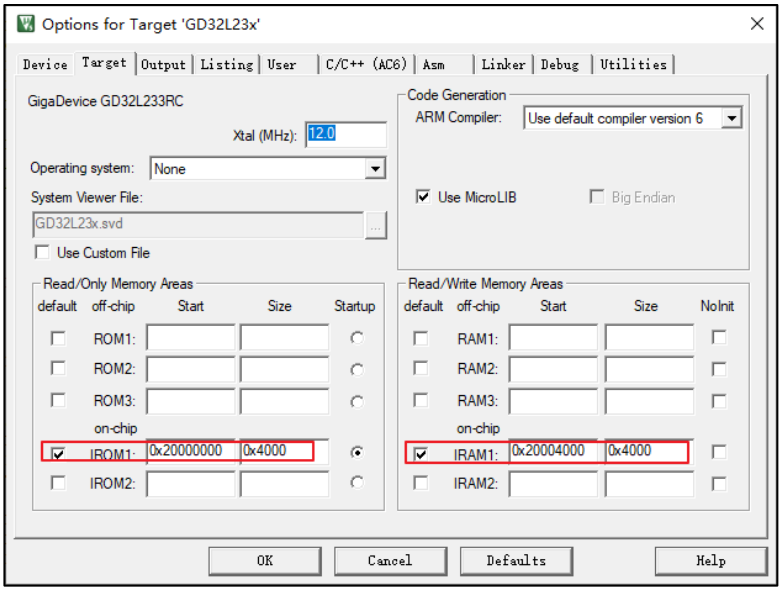

oscilloscope /
logic analyzer
V
flash operation time
t
t1
t2

# 3. Implementation of flash operation time measurement

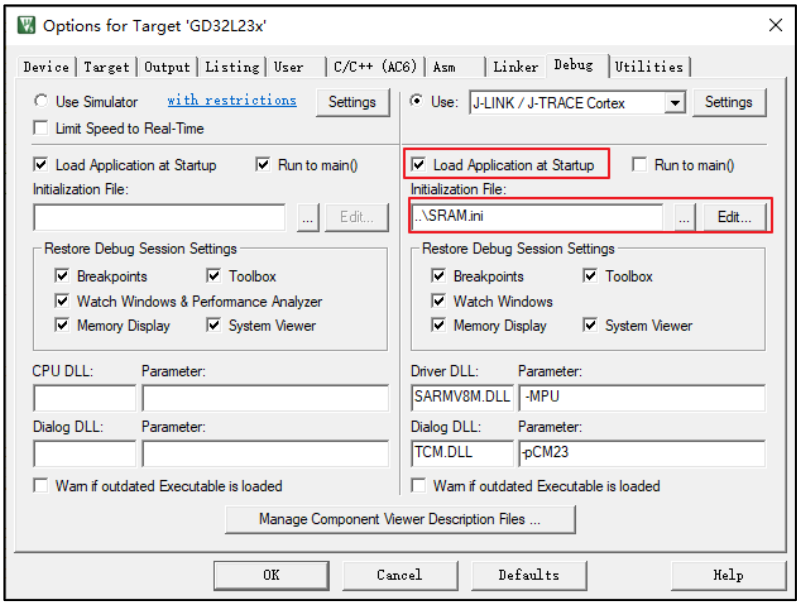
## 3.1. Startup configuration in SRAM

In order to measure flash characteristics, the measurement program needs to be run in sram. The steps to start debugging configuration in sram are as follows:

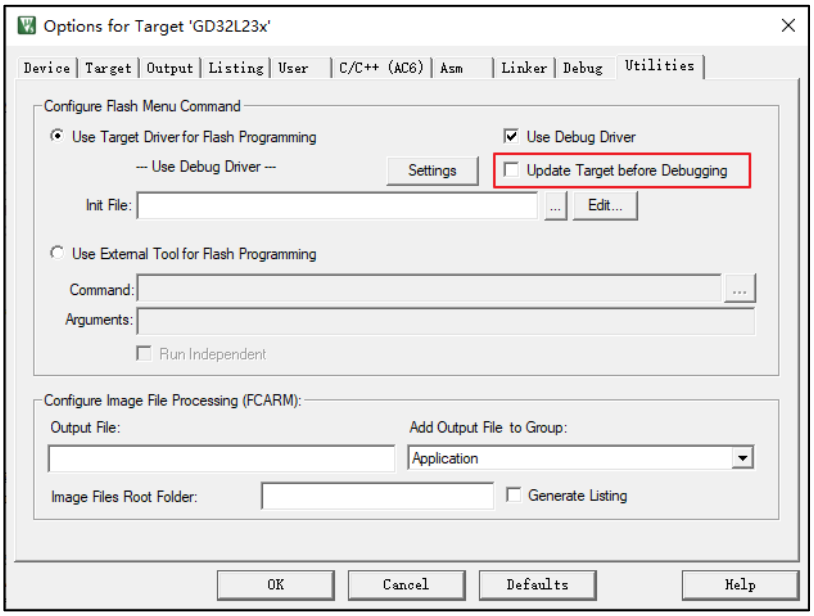
1. According to the actual sram space, configure the scatter-loading area




2. Add the initialization file to start from SRAM




3. Configure Utilities options




4. SRAM.ini initialization file

```
FUNC void Setup (void) {
/* Setup Stack Pointer */
SP = _RDWORD(0x20000000);
/* Setup Program Counter */
PC = _RDWORD(0x20000004);
/* Setup Vector Table Offset Register */
_WDWORD(0xE000ED08, 0x20000000);
}
/* Download, Project.axf, the same with your project name */
LOAD Project.axf INCREMENTAL
/* Setup for Running */
```

## 3.2. Software implementation

The timer method and the I/O level flip method can be used to measure the flash erasing, page erasing, and word programming time respectively by the conditional macro. The specific code implementation is as follows:

1. TIMER configuration

```
void timer_config(void)
{
    timer_parameter_struct timer_initpara;

    rcu_periph_clock_enable(RCU_TIMER);
    rcu_periph_clock_enable(RCU_TIMER2);

    timer_deinit(TIMER_USE);
```

```
    /* TIMER1 configuration */
    timer_initpara.prescaler          = TIMER_PRESCALER;
    timer_initpara.alignedmode        = TIMER_COUNTER_EDGE;
    timer_initpara.counterdirection   = TIMER_COUNTER_UP;
    timer_initpara.period             =65535;
    timer_initpara.clockdivision      = TIMER_CKDIV_DIV1;
    timer_init(TIMER_USE, &timer_initpara);

    /* auto-reload preload enable */
    timer_auto_reload_shadow_enable(TIMER_USE);
    /* configure TIMER1 master slave mode */
    timer_master_slave_mode_config(TIMER_USE, TIMER_MASTER_SLAVE_MODE_ENABLE);
    timer_master_output_trigger_source_select(TIMER_USE, TIMER_TRI_OUT_SRC_UPDATE);

    timer_deinit(TIMER2);
    /* TIMER2 configuration */
    timer_initpara.prescaler          = 0;
    timer_initpara.alignedmode        = TIMER_COUNTER_EDGE;
    timer_initpara.counterdirection   = TIMER_COUNTER_UP;
    timer_initpara.period             = 65535;
    timer_initpara.clockdivision      = TIMER_CKDIV_DIV1;
    timer_init(TIMER2, &timer_initpara);

    timer_auto_reload_shadow_enable(TIMER2);
    /* slave mode selection: TIMER2 */
    timer_slave_mode_select(TIMER2, TIMER_SLAVE_MODE_EXTERNAL0);
    timer_input_trigger_source_select(TIMER2, TIMER_SMCFG_TRGSEL_ITI0);
}
```

2. Main program code

```
/* macro definition */
#define GD32L233RC

#define TEST_MASS_ERASE                 1
#define TESE_PAGE_ERASE                 1
#define TEST_WORD_PROGRAMME             1
#define TIMER_CNT_MESURE_METHOD         1

#define TIMER_PRESCALER                 (8 - 1)
#define TIMER_USE                       TIMER1
#define RCU_TIMER                       RCU_TIMER1
#define PROGRAMME_DATA                  0xaa55aa55
#define ADDRESS_TO_PROGRAMME            0x08000000
#define PAGE_TO_ERASE1                  0x08000000
```

```
#define MEASURE_NUMS                    1
#define AVERAGE_VALUE_POSITION    (MEASURE_NUMS)

#if defined(GD32L233RC)
#define PAGE_SIZE1_WORD                 ((4*1024)/4)
#define FLASH_SIZE_WORD                 ((256*1024) /4)
#endif
#define   USART_COM          USART1
/* flash operation time struct definition */
typedef struct {
    uint32_t word_programme[MEASURE_NUMS+1];
    uint32_t page_erase[MEASURE_NUMS+1];
    uint32_t mass_erase[MEASURE_NUMS+1];
}flash_operation_time_struct;

flash_operation_time_struct    flash_operation_time;

int main(void)
{
    uint16_t measure_counts = 0;
    /* gpio, timer, usart configuration */
    rcu_periph_clock_enable(RCU_GPIOC);
    gpio_mode_set(GPIOC, GPIO_MODE_OUTPUT, GPIO_PUPD_NONE,GPIO_PIN_0);
    gpio_output_options_set(GPIOC, GPIO_OTYPE_PP, GPIO_OSPEED_50MHZ, GPIO_PIN_0);
    gpio_bit_reset(GPIOC, GPIO_PIN_0);
    gd_eval_com_init(USART_COM);
    timer_config();

    fmc_unlock();
    /* mass erase measure */
#if TEST_MASS_ERASE
    do{
      {
          uint32_t i =0;
          /* mass erase, then programme full flash with PROGRAMME_DATA */
          fmc_mass_erase();
          for(i = 0; i < FLASH_SIZE_WORD; i++){
              fmc_word_program((ADDRESS_TO_PROGRAME + (i * 4)),
PROGRAME_DATA);
      }
     }
#if TIMER_CNT_MESURE_METHOD
```

```
            /* clear timer count and enable timer */
            timer_disable(TIMER_USE);
            timer_disable(TIMER2);
            TIMER_CNT(TIMER_USE) = 0;
            TIMER_CNT(TIMER2) = 0;
            timer_enable(TIMER_USE);
            timer_enable(TIMER2);
#else
            /* set gpio pin to high level */
            gpio_bit_set(GPIOC, GPIO_PIN_0);
#endif
            /* start mass erase */
            fmc_mass_erase();
#if TIMER_CNT_MESURE_METHOD
            /* get the mass erase time */
            flash_operation_time.mass_erase[measure_counts] = TIMER_CNT(TIMER_USE) +
65536*TIMER_CNT(TIMER2);
#else
            /* set gpio pin to low level */
            gpio_bit_reset(GPIOC, GPIO_PIN_0);
#endif
      }while(++measure_counts < MEASURE_NUMS);
#if TIMER_CNT_MESURE_METHOD
      /* get the average mass erase time */
      {
            uint32_t temp =0;
            for(measure_counts =0; measure_counts < MEASURE_NUMS; measure_counts++)
            {
                  temp += flash_operation_time.mass_erase[measure_counts];
            }
            flash_operation_time.mass_erase[AVERAGE_VALUE_POSITION] = temp /
MEASURE_NUMS;
      }
#endif
#endif
      /* page erase measure */
#if TESE_PAGE_ERASE
measure_counts = 0;
do{
          {
                uint32_t i =0;
                /* page erase, then programme this page with PROGRAMME_DATA */
                fmc_page_erase(PAGE_TO_ERASE1);
```

```
                for(i = 0; i < 512; i++){
                    fmc_word_program((ADDRESS_TO_PROGRAME + (i * 4)),
PROGRAME_DATA);
                }
            }
#if TIMER_CNT_MESURE_METHOD
            /* clear timer count and enable timer */
            timer_disable(TIMER_USE);
            timer_disable(TIMER2);
            TIMER_CNT(TIMER_USE) = 0;
            TIMER_CNT(TIMER2) = 0;
            timer_enable(TIMER_USE);
            timer_enable(TIMER2);
#else
            /* set gpio pin to high level */
            gpio_bit_set(GPIOC, GPIO_PIN_0);
#endif
            /* start page erase */
            fmc_page_erase(PAGE_TO_ERASE1);
#if TIMER_CNT_MESURE_METHOD
            /* get the page erase time */
            flash_operation_time.page_erase[measure_counts] = TIMER_CNT(TIMER_USE) +
65536*TIMER_CNT(TIMER2);
#else
            /* set gpio pin to low level */
            gpio_bit_reset(GPIOC, GPIO_PIN_0);
#endif
    }while(++measure_counts < MEASURE_NUMS);
#if TIMER_CNT_MESURE_METHOD
    /* get the average page erase time */
    {
        uint32_t temp =0;
        for(measure_counts =0; measure_counts < MEASURE_NUMS; measure_counts++)
        {
            temp += flash_operation_time.page_erase[measure_counts];
        }
        flash_operation_time.page_erase[AVERAGE_VALUE_POSITION] = temp /
MEASURE_NUMS;
    }
#endif
#endif
    /* word programme measure */
#if TEST_WORD_PROGRAMME
```

```
measure_counts = 0;
do{
        fmc_page_erase(PAGE_TO_ERASE1);
#if TIMER_CNT_MESURE_METHOD
        /* clear timer count and enable timer */
        timer_disable(TIMER_USE);
        timer_disable(TIMER2);
        TIMER_CNT(TIMER_USE) = 0;
        TIMER_CNT(TIMER2) = 0;
        timer_enable(TIMER_USE);
        timer_enable(TIMER2);
#else
        /* set gpio pin to high level */
        gpio_bit_set(GPIOC, GPIO_PIN_0);
#endif
        /* start word programme */
        fmc_word_program(ADDRESS_TO_PROGRAMME +(4*measure_counts) ,
PROGRAMME_DATA);
#if TIMER_CNT_MESURE_METHOD
        /* get the word programme time */
        flash_operation_time.word_programme[measure_counts] = TIMER_CNT(TIMER_USE)+
65536*TIMER_CNT(TIMER2);
#else
        /* set gpio pin to low level */
        gpio_bit_reset(GPIOC, GPIO_PIN_0);
#endif
    }while(++measure_counts < MEASURE_NUMS);
#if TIMER_CNT_MESURE_METHOD
    /* get the average word programme time */
    {
        uint32_t temp =0;
        for(measure_counts =0; measure_counts < MEASURE_NUMS; measure_counts++)
        {
            temp += flash_operation_time.word_programme[measure_counts];
        }
        flash_operation_time.word_programme[AVERAGE_VALUE_POSITION] = temp /
MEASURE_NUMS;
    }
#endif
#endif

#if TIMER_CNT_MESURE_METHOD
    /* print flash operation time by usart */
```

```
    printf("word programme time:%.2f(us)\r\npage erase time:%.2f (us)\r\nmass erase time:%.2f (us)\r\n",
                flash_operation_time.word_programme[AVERAGE_VALUE_POSITION]*0.125, \
                flash_operation_time.page_erase[AVERAGE_VALUE_POSITION]*0.125, \
                flash_operation_time.mass_erase[AVERAGE_VALUE_POSITION]*0.125);
#endif
/* infinite loop */
    while(1){

    }
}
```

# 4. Test results

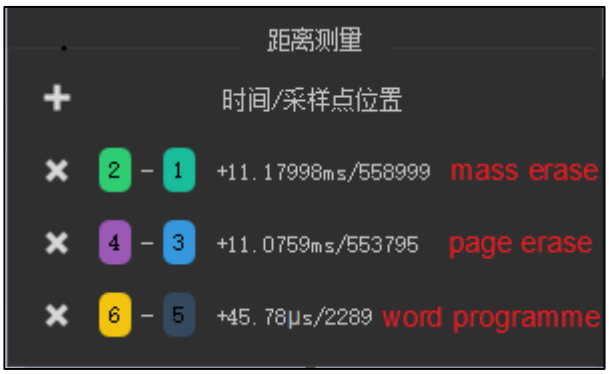
Open the macros TEST_MASS_ERASE, TESE_PAGE_ERASE, TEST_WORD_PROGRAMME and TIMER_CNT_MESURE_METHOD. Compile the project, click the debug button, and click run at full speed. ***Figure 4-1. Serial output of flash operation time*** result is as follows.

**Figure 4-1. Serial output of flash operation time**

```
word programe time:46.00(us)
page erase time:11072.63(us)
mass erase time:11176.75(us)
```

Open the macro TEST_MASS_ERASE, TESE_PAGE_ERASE, TEST_WORD_PROGRAMME, and close the macro TIMER_CNT_MESURE_METHOD. Compile the project, click the debug button, click run at full speed. ***Figure 4-2. Logic analyzer output of flash operation time*** results as follows.

**Figure 4-2. Logic analyzer output of flash operation time**



# 5. Revision history

**Table 5-1. Revision history**

| Revision No. | Description | Date |
|---|---|---|
| 1.0 | Initial Release | Nov.8,2021 |

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