GigaDevice Semiconductor Inc.

将代码下载到片外 FLASH 并在片外 SDRAM 调试程序的方法

应用笔记

AN096

1.0 版本

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目录

图索引

表索引

1. 简介

在 MCU 的实际应用场景中会出现片上 Flash 存储空间不足的情况，此时需要重新制作下载算法，将代码下载到片外 Flash，并编写 boot loder 程序复制代码到 SDRAM 中运行，本应用笔记将详细介绍该工程实现过程。

2. 编写 FLASH 下载算法

本应用笔记基于 IAR 开发环境和 GD32F470I-EVAL 板开发相关程序。

1） 制作 FlashGD32F470I_EX_NOR.out 文件，在下载算法的模板工程中，修改 Flash_gd32F4xx_ext.c 中的驱动函数接口(FLASH 初始化，读 FLASH 函数，擦除 FLASH 函数)与开发板板载 SPI NOR FLASH 相匹配，编译工程生成 FlashGD32F470I_EX_NOR.out 文件。

2） 修改 FlashGD32F470IK_NOR.board 文件，如*表 2-1 . FlashGD32F470IK_NOR*.board 文件所示。

表 2-1 . FlashGD32F470IK_NOR.board 文件

```
<?xml version="1.0" encoding="iso-8859-1"?>

<flash_board>
  <pass>
    <range>CODE 0x00000000 0x01000000</range>
    <loader>$TOOLKIT_DIR$\config\flashloader\GD\FlashGD32F470IK_NOR.flash</loader>
  </pass>
</flash_board>
```

3） 修改 FlashGD32F470IK_NOR.flash 文件，如*表 2-2 . FlashGD32F470IK_NOR*.flash 文件所示。

表 2-2 . FlashGD32F470IK_NOR.flash 文件

```
<?xml version="1.0" encoding="iso-8859-1"?>

<flash_device>
  <exe>$TOOLKIT_DIR$\config\flashloader\GD\FlashGD32F470I_EX_NOR.out</exe>
  <page>256</page>
  <block>32 0x10000</block>
  <flash_base>0x00000000</flash_base>
  <macro>$TOOLKIT_DIR$\config\flashloader\GD\FlashGD32F470IK_NOR.mac</macro>
  <aggregate>1</aggregate>
</flash_device>
```

4） 下载算法中的 FlashGD32F470IK_NOR.mac 无需修改，在 FlashGD32F470I_EX_NOR.out 文件中已经对 SPI 模块进行相应配置，因此.mac 文件可以不修改。

5） 完成上述步骤之后，将 FlashGD32F470I_EX_NOR.out、FlashGD32F470IK_NOR.board、FlashGD32F470IK_NOR.flash 和 FlashGD32F470IK_NOR.mac 文件复制到 IAR 安装路径下的下载算法文件夹中（如：..\IAR7.2\arm\config\flashloader\GD）。

3. 新建 boot loder 工程

将代码下载到外部 SPI NOR FLASH 之后，代码只能搬运到外部 SDRAM 才能运行，因此需要新建 boot loder 工程，在此工程中需要完成 SPI 读写 SPI NOR FLASH 和 EXMC 读写 SDRAMD 驱动的初始化 ，从片外 FLASH 中将代码搬运到片外 SDRAM 位置，并将 SDRAM 地址(0xC0000000)映射到 0x00000000 地址处以运行代码。Boot loder 程序主要代码如*表 3-1 . Boot* **loder 代码**所示。

表 3-1 . Boot loder 代码

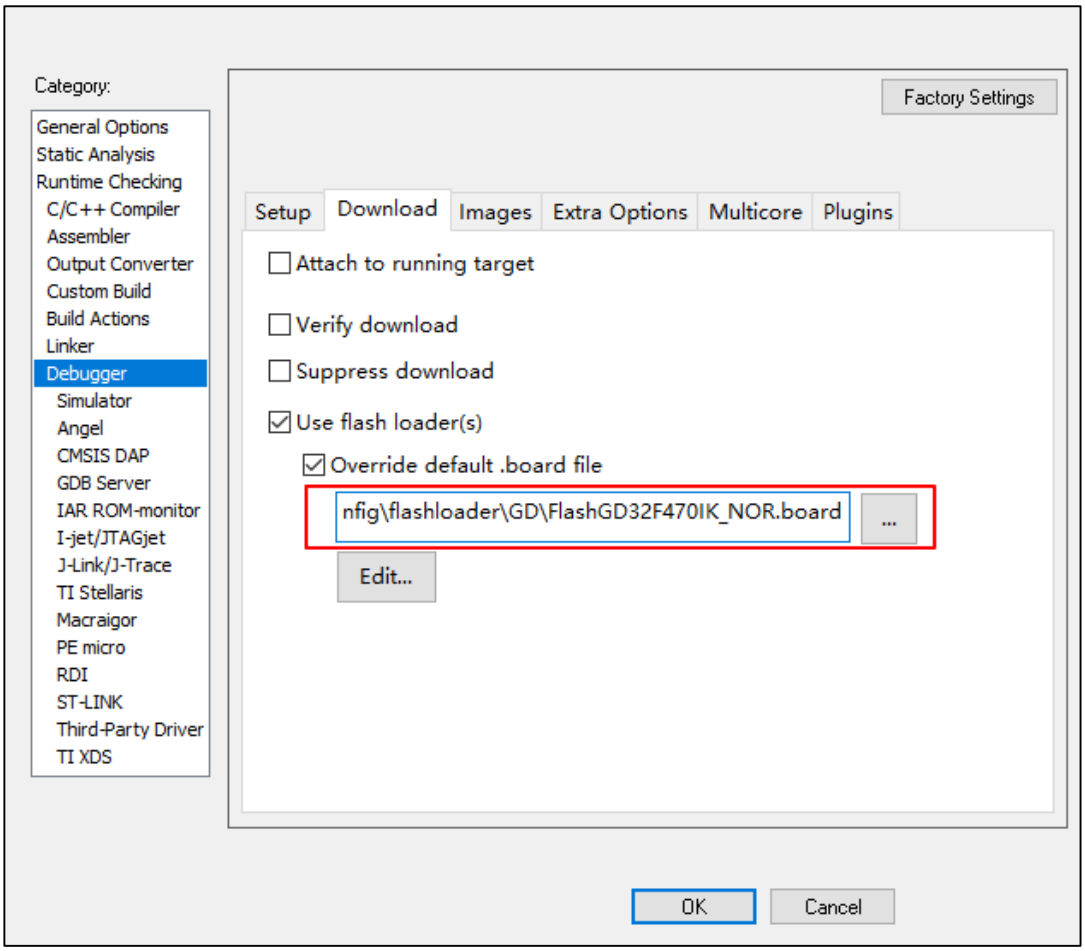
```
/* configure SPI5 GPIO and parameter */
spi_flash_init();

/* configure the EXMC access mode */
exmc_synchronous_dynamic_ram_init(EXMC_SDRAM_DEVICE0);

init_state = exmc_synchronous_dynamic_ram_init(EXMC_SDRAM_DEVICE0);

if(ERROR == init_state) {
    printf("\r\n\r\nSDRAM initialize fail!");
    while(1);
}

/* flash id is correct */
if(SFLASH_ID == spi_flash_read_id()) {

    while(addr < 0x200000){
        /* read a block of data from the flash to rx_buffer */
        qspi_quad_flash_buffer_read(rxbuffer, FLASH_READ_ADDRESS + addr,
BUFFER_SIZE);

        sdram_writebuffer_8(EXMC_SDRAM_DEVICE0, rxbuffer,
SDRAM_WRITE_READ_ADDR + addr, BUFFER_SIZE);
        addr += 256;
    }
} else {
    /* spi flash read id fail */
    printf("\n\rSPI Flash: Read ID Fail!\n\r");
    while(1);
}

rcu_periph_clock_enable(RCU_SYSCFG);
/* SDRAM bank0 of EXMC (0xC0000000~0xC7FFFFFF) is mapped at address 0x00000000 */
syscfg_bootmode_config(SYSCFG_BOOTMODE_EXMC_SDRAM);
```

```
/* Check whether the SP is correct */
 if(((*(__IO uint32_t*)ApplicationAddress) & 0x2FF00000) == 0x00000000){

    jump_address = *(__IO uint32_t*)(ApplicationAddress + 4);
    jump_to_application = (pFunction) jump_address;
    __set_MSP(*(__IO uint32_t*)ApplicationAddress);

    jump_to_application();
}
```

4. APP 工程配置

1） 配置下载算法，在工程下载配置选项中选择下载到外部 Flash 的下载算法，如*图 4-1* **.下载算法配置**所示。

图 4-1 .下载算法配置



2） 修改链接文件。首先修改向量表链接地址为 0x00000000，如*图 4-2* **.向量表链接地址配置**所示；其次，修改 ROM 和 RAM 地址，ROM 存放代码，RAM 存放堆栈内容，如*图 4-3* **. ROM 和 RAM 地址配置**所示。

图 4-2 .向量表链接地址配置

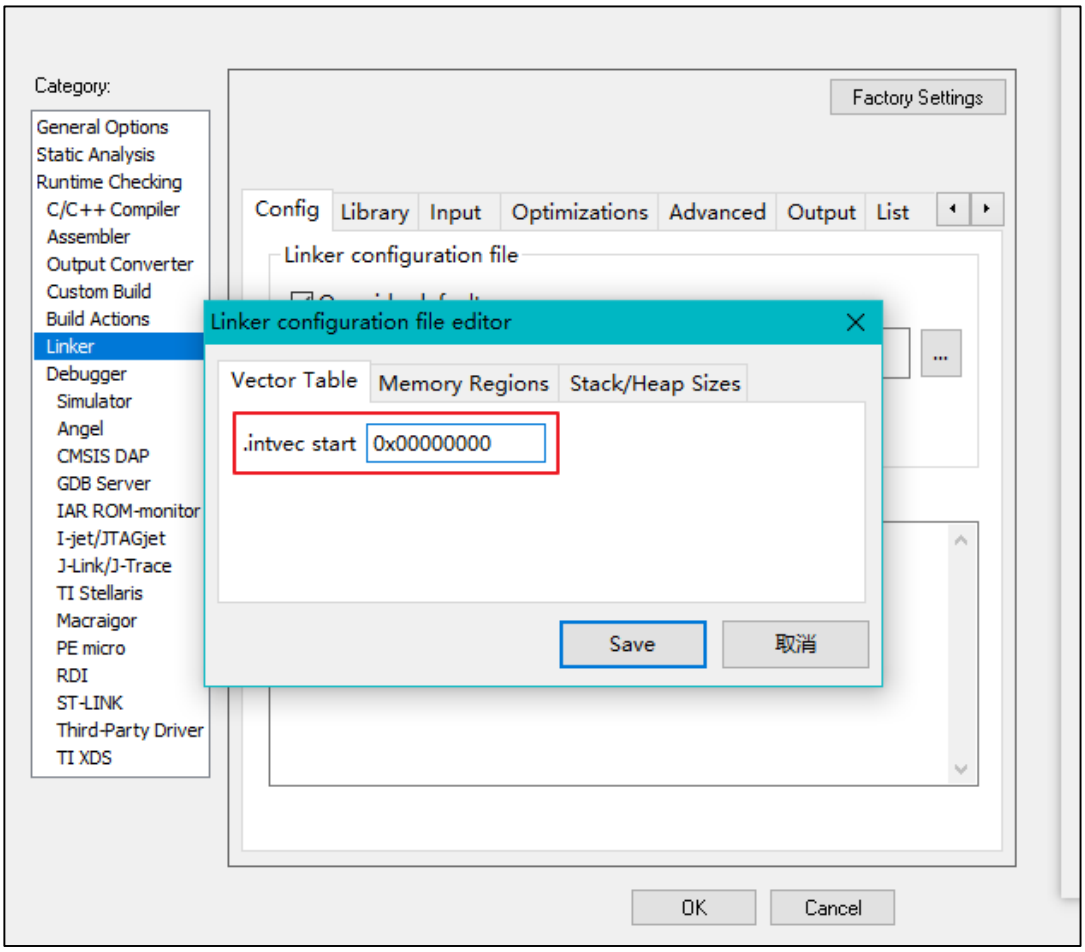
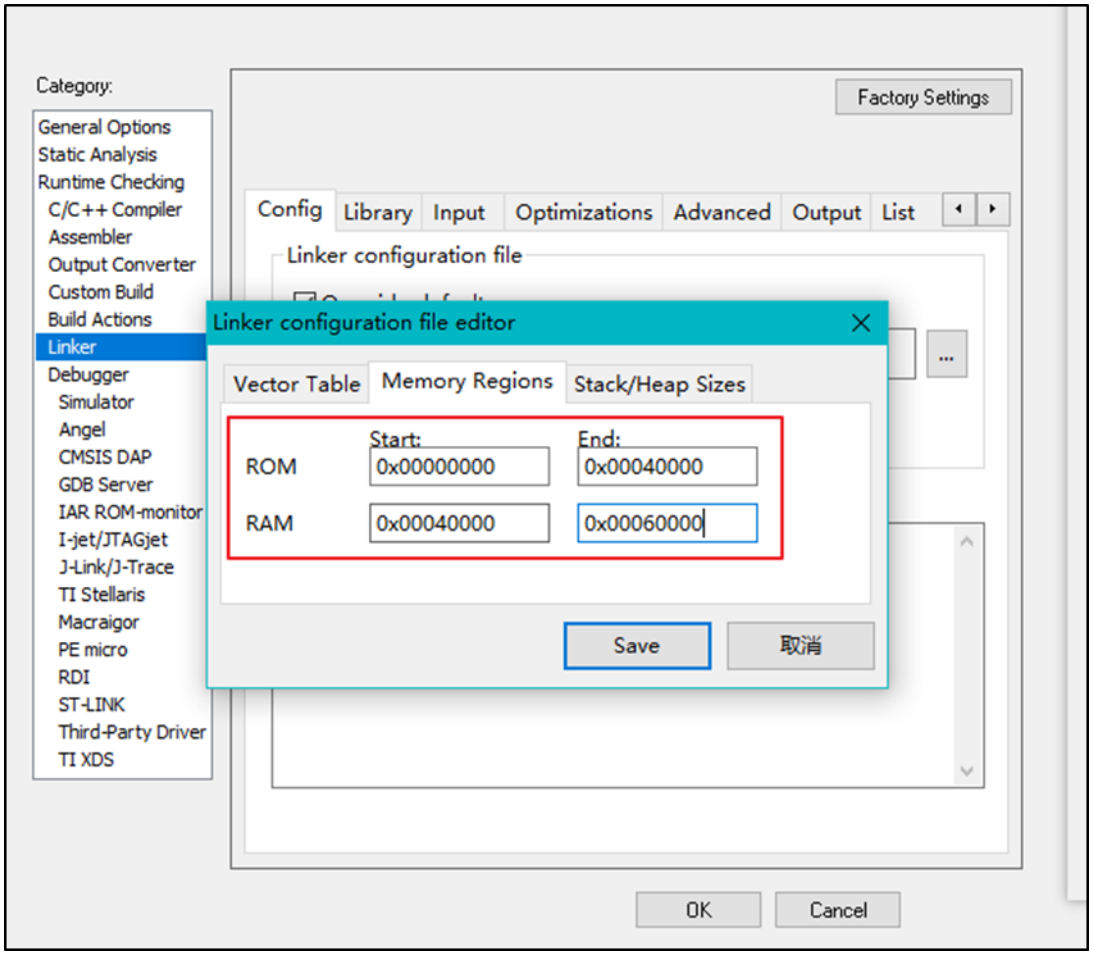


图 4-3 . ROM 和 RAM 地址配置



3） 在 main()函数中，添加向量表重定位语句，如*表 4-1* **.向量表重定位**所示。

表 4-1 .向量表重定位

```
int main(void)
{
    nvic_vector_table_set(0,0);
    /* configure systick */
    systick_config();

    /* enable the LEDs GPIO clock */
    rcu_periph_clock_enable(RCU_GPIOE);
    rcu_periph_clock_enable(RCU_GPIOF);
    ……
    ……
    ……
```

4） 注释启动文件中的系统初始化相关代码，如*表 4-2* **.启动文件代码修改**所示。

表 4-2 .启动文件代码修改

```
    ……
    ……
```

```
.......
Reset_Handler
        ;LDR     R0, =SystemInit
        ;BLX     R0
        LDR      R0, =__iar_program_start
        BX       R0
......
......
.......
```

5. 工程测试

1）在工程测试时，首先需要编译下载 APP 工程，将工程下载到板载 SPI NOR FLASH 中，然后，编译调试 boot loder 工程，可以对比 APP 工程的 bin 文件如**图 5-1 . APP 工程的 bin 文件**和调试 boot loder 工程时从 SPI NOR FLASH 读出的数据如**图 5-2 . SPI NOR FLASH 读出数据**，两者一致，说明 SPI NOR FLASH 下载算法正确。

图 5-1 . APP 工程的 bin 文件

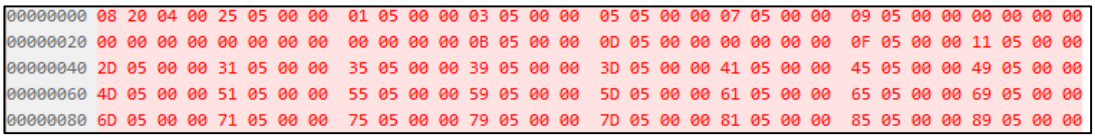
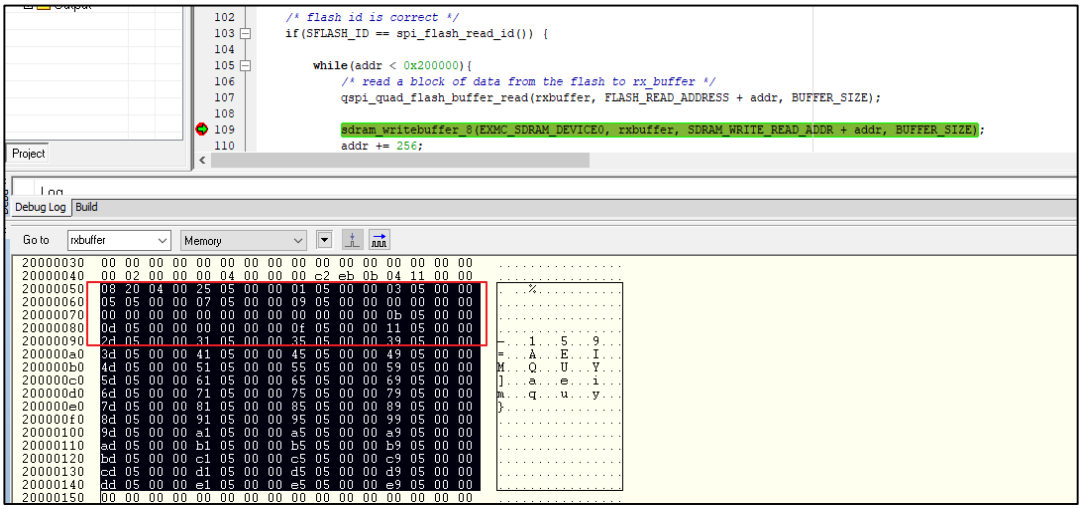
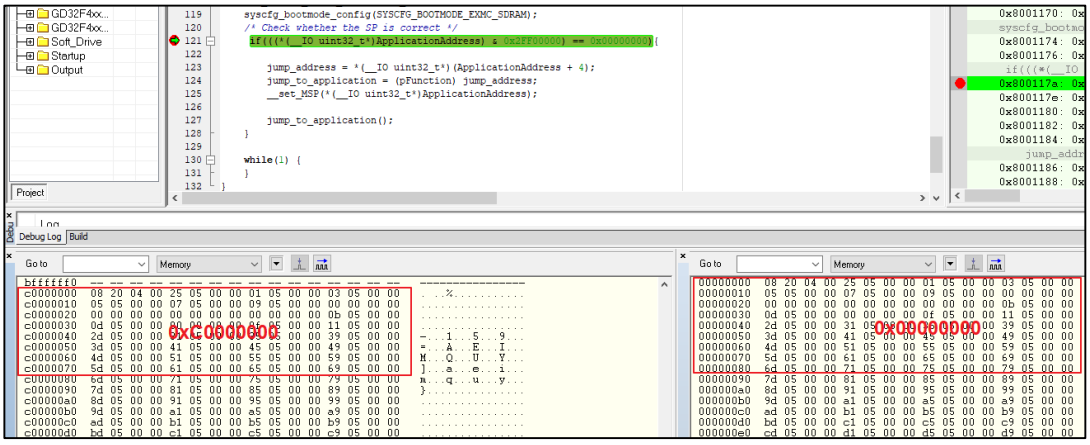


图 5-2 . SPI NOR FLASH 读出数据



2）重映射之后，0x00000000 地址内容和 0xC0000000 地址内容一致，如**图 5-3 . 0x00000000 地址内容和 0xC0000000 地址内容**。

图 5-3 . 0x00000000 地址内容和 0xC0000000 地址内容



3）若需要调试 APP 工程，只需再次点击 APP 工程中的调试不下载按钮，如**图 5-4 . 调试不下载按钮**所示，点击之后，运行程序呈现流水灯现象。

图 5-4 . 调试不下载按钮

6. 版本历史

表 6-1 .版本历史

版本号.	说明	日期
1.0	首次发布	2023 年 6 月 1 日

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