GigaDevice Semiconductor Inc.

基于 GD32 MCU 的 FATFS 文件系统移植

应用笔记

AN065

1.0 版本

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1. FATFS 简介

文件系统是用于在存储介质上存储和管理数据的组织结构，其包括系统引导区、目录和文件。在存储介质上建立文件系统前，需要先对存储介质进行格式化擦除原有的数据，然后新建文件分配表和目录，从而便于记录和管理数据存放的物理地址和剩余空间，如同图书管理分类系统一样。

文件系统庞大而复杂，需要根据应用的文件系统格式而编写，并且一般与驱动层分离开来，方便移植，因此工程应用中通常移植现成的文件系统源码。FATFS 是面向小型嵌入式系统的一种通用的 FAT 文件系统。FATFS 基于 ANSIC 语言编写，并且完全独立于底层的 I/O 介质。因此 FATFS 可以很方便地移植到多种处理器之中。

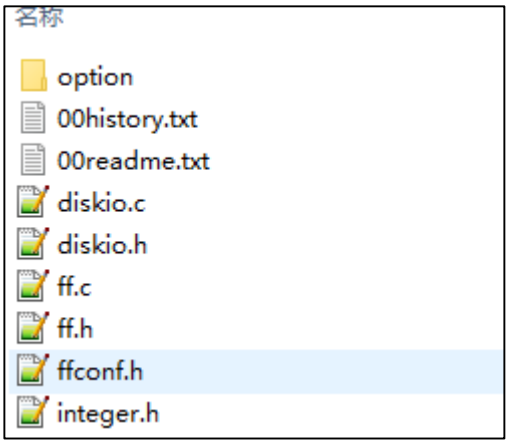
2. FATFS 移植

2.1. FATFS 移植平台

本文基于 GD32103C EVAL 开发板移植 FATFS，通过 FATFS 实现对 SPI-flash(GD25Q16)、片上 flash 以及 SD 卡进行存储数据的文件管理。FATFS 移植的 IDE 平台为 keil4.

FATFS 文件系统包可以从网址 ***http://elm-chan.org/fsw/ff/00index_e.html*** 获取，其包含的文件有：1、与底层接口硬件驱动移植相关的文件：diskio.c、diskio.h；2、与 FATFS 模块相关，用于实现 FAT 文件读/写协议的文件：ff.c、ff.h；3、与 FATFS 模块配置相关的文件：ffconf.h；4、与数据类型定相关的文件：interger.h；5、FATFS 提供支持不同语言的外部功能有关的文件夹：option 文件夹，如*图 2-1. FATFS 包文件结构*所示。本次移植 FATFS 文件系统的版本为 R0.11a.

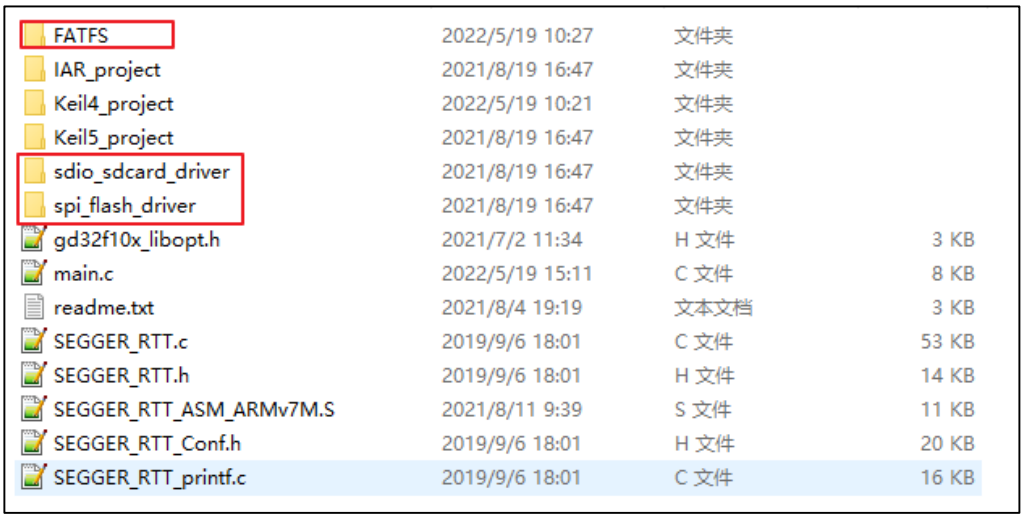
图 2-1. FATFS 包文件结构



2.2. 添加 FATFS 源代码

将工程文件夹命名为 SDIO_FATFS,并在该文件夹下添加已下载解压完成的 FATFS 包，并添加 SD 卡驱动文件和 SPI_flash 驱动文件，为了方便移植可以基于 Demo_Suites 中 16_SDIO_SDCardTest 例程进行修改。工项目添加上述文件之后，文件夹内容如*图 2-2. 项目文件*所示。

图 2-2. 项目文件



2.3. 修改 ffconf.h 文件

打开 FATFS 文件夹下的 ffconf.h 文件，在此需要修改以下部分：

1、 使能文件系统挂载函数 f_mkfs()，将编译宏_USE_MKFS 的值定义为 1；

2、 修改支持硬件驱动的数量 3，本次移植支持三种存储介质（SD 卡、SPI_Flash、片上 Flash），将编译宏_VOLUMES 的值定义为 3；

3、 定义存储介质块大小的范围，根据本次移植所用到的存储介质，将编译宏_MIN_SS 的值定义为 512，将编译宏_MAX_SS 的值定义为 4096；

2.4. 修改 diskio.c 文件

同样打开 diskio.c 文件，进行底层驱动编写，其中 disk_initialize 用于存储介质的初始化；disk_status 用于获取存储介质的工作状态；disk_read 用于存储介质的读操作；disk_write 用于存储介质的写操作；disk_ioctl 用于获取存储介质的块大小和块数量；get_fattime 用于获取文件系统时间戳，此次移植未用到此功能，不做修改。分别将 SD 卡、SPI_Flash 和片上 Flash 的驱动接口代码整合到 diskio.c 中，代码修改之后如*表 2-1. diskio.c 代码*所示

表 2-1. diskio.c 代码

```
#include "diskio.h"        /* FatFs lower layer API */
#include "spi_flash.h"
#include "sdcard.h"

#define   SD_CARD          0
#define   SPI_FLASH        1
#define   INTER_FLASH      2
#define   FLASH_SECTOR_COUNT   512        /*SPI_Flash SECTOR number*/
```

```
#define   FLASH_SECTOR_SIZE     4096        /*SPI_Flash SECTOR size*/
#define   FLASH_BLOCK_SIZE      1           /*smallest unit of erased sector*/
#define   SD_CARD_BLOCK_SIZE    1
#define   FMC_WRITE_START_ADDR      ((uint32_t)0x08000000U)
extern   sd_card_info_struct   sd_cardinfo;
/*-----------------------------------------------------------------------*/
/* Get Drive Status                                                      */
/*-----------------------------------------------------------------------*/

DSTATUS disk_status(
    BYTE pdrv           /* Physical drive nmuber to identify the drive */
)
{
    DSTATUS stat;

    switch(pdrv) {
    case SD_CARD :
        return 0;
    case SPI_FLASH :
        if(spi_flash_ID_read() == 0xC84015) {
            stat =   0; //initialization normal
        } else {
            stat = STA_NOINIT; //initialize not normal
        }
        return stat;
    case INTER_FLASH:
        stat =   0;
        return stat;
    }
    return STA_NOINIT;
}

/*-----------------------------------------------------------------------*/
/* Inidialize a Drive                                                    */
/*-----------------------------------------------------------------------*/

DSTATUS disk_initialize(
    BYTE pdrv/* Physical drive nmuber to identify the drive */
)
{
    DSTATUS stat;

    switch(pdrv) {
```

```
    case SD_CARD:
        stat &= ~STA_NOINIT;
        return 0;
    case SPI_FLASH :
        spi_flash_config();
        return   disk_status(SPI_FLASH);
    case INTER_FLASH:
        stat =   0;
        return stat;
    }
    return STA_NOINIT;
}

/*-----------------------------------------------------------------------*/
/* Read Sector(s)                                                        */
/*-----------------------------------------------------------------------*/

DRESULT disk_read(
    BYTE pdrv,          /* Physical drive nmuber to identify the drive */
    BYTE *buff,         /* Data buffer to store read data */
    DWORD sector,    /* Sector address in LBA */
    UINT count          /* Number of sectors to read */
)
{
    uint32_t *ptrd, *btrd;
    DRESULT res;
    sd_error_enum   SD_stat = SD_OK;
    switch(pdrv) {
    case SD_CARD :
        if(count > 1) {
            SD_stat = sd_multiblocks_read((uint32_t *)buff, sector * sd_cardinfo.card_blocksize,
sd_cardinfo.card_blocksize, count);
        } else {
            SD_stat = sd_block_read((uint32_t *)buff, sector * sd_cardinfo.card_blocksize,
sd_cardinfo.card_blocksize);
        }
        if(SD_stat == SD_OK) {
            res = RES_OK ;
        } else {
            res = RES_ERROR ;
        }
        return res;
```

```
    case SPI_FLASH :
        spi_flash_buffer_read((uint8_t *)buff, sector * FLASH_SECTOR_SIZE, count * FLASH_SECTOR_SIZE);
        res = RES_OK;

        return res;
    case INTER_FLASH:
        btrd = (uint32_t *)buff;
        for(ptrd = (uint32_t *)(FMC_WRITE_START_ADDR + (sector + 47) * 2048);ptrd < (uint32_t *)(FMC_WRITE_START_ADDR + ((sector + 47) * 2048) + (count * 2048)); ptrd++) {
            *btrd = *ptrd;
            btrd++;
        }
        res = RES_OK;
        return res;
    }
    return RES_PARERR;
}

/*-----------------------------------------------------------------------*/
/* Write Sector(s)                                                       */
/*-----------------------------------------------------------------------*/

#if _USE_WRITE
DRESULT disk_write(
    BYTE pdrv,              /* Physical drive nmuber to identify the drive */
    const BYTE *buff,       /* Data to be written */
    DWORD sector,           /* Sector address in LBA */
    UINT count              /* Number of sectors to write */
)
{
    DRESULT res;
    sd_error_enum    SD_stat = SD_OK;
    uint32_t address;
    uint32_t erase_counter;

    switch(pdrv) {
    case SD_CARD :
        if(count > 1) {
            SD_stat = sd_multiblocks_write((uint32_t *)buff, sector * sd_cardinfo.card_blocksize, sd_cardinfo.card_blocksize, count);
        } else {
            SD_stat = sd_block_write((uint32_t *)buff, sector * sd_cardinfo.card_blocksize,
```

```
sd_cardinfo.card_blocksize);
            }
            if(SD_stat == SD_OK) {
                res = RES_OK ;
            } else {
                res = RES_ERROR ;
            }
            return res;

        case SPI_FLASH:
            /*first erase then write*/
            spi_flash_sector_erase(sector * FLASH_SECTOR_SIZE);
            spi_flash_buffer_write((uint8_t *)buff, sector * FLASH_SECTOR_SIZE, count * FLASH_SECTOR_SIZE);
            res = RES_OK;
            return res;
        case INTER_FLASH:
            fmc_unlock();
            fmc_flag_clear(FMC_FLAG_BANK0_END);
            fmc_flag_clear(FMC_FLAG_BANK0_WPERR);
            fmc_flag_clear(FMC_FLAG_BANK0_PGERR);
            /* erase the flash pages */
            for(erase_counter = 0; erase_counter < count; erase_counter++) {
                fmc_page_erase(FMC_WRITE_START_ADDR + ((sector + 47) * 2048) + (2048 * erase_counter));
                fmc_flag_clear(FMC_FLAG_BANK0_END);
                fmc_flag_clear(FMC_FLAG_BANK0_WPERR);
                fmc_flag_clear(FMC_FLAG_BANK0_PGERR);
            }
            address = (sector + 47) * 2048 + FMC_WRITE_START_ADDR;
            while(address < (((sector + 47) * 2048 + FMC_WRITE_START_ADDR) + count * 2048)) {
                fmc_word_program(address, *(uint32_t *)buff);
                address += 4;
                buff += 4;
                fmc_flag_clear(FMC_FLAG_BANK0_END);
                fmc_flag_clear(FMC_FLAG_BANK0_WPERR);
                fmc_flag_clear(FMC_FLAG_BANK0_PGERR);
            }
            fmc_lock();
            res = RES_OK;
            return res;
        }
        return RES_PARERR;
```

```
}
#endif


/*-----------------------------------------------------------------------*/
/* Miscellaneous Functions                                               */
/*-----------------------------------------------------------------------*/

#if _USE_IOCTL
DRESULT disk_ioctl(
    BYTE pdrv,          /* Physical drive nmuber (0..) */
    BYTE cmd,           /* Control code */
    void *buff          /* Buffer to send/receive control data */
)
{
    DRESULT res;

    switch(pdrv) {
    case SD_CARD :
        switch(cmd) {
        /*return sector number*/
        case GET_SECTOR_COUNT:
            *(DWORD *)buff = sd_cardinfo.card_capacity / (sd_cardinfo.card_blocksize);
            break;
        /*return each sector size*/
        case GET_SECTOR_SIZE:
            *(WORD *)buff = sd_cardinfo.card_blocksize;
            break;
        /*Returns the smallest unit of erased sector (unit 1)*/
        case GET_BLOCK_SIZE:
            *(DWORD *)buff = SD_CARD_BLOCK_SIZE;
            break;
        }
        res = RES_OK;
        return res;

    case SPI_FLASH :
        switch(cmd) {
        /*return sector number*/
        case GET_SECTOR_COUNT:
            *(DWORD *)buff = FLASH_SECTOR_COUNT;
            break;
        /*return each sector size*/
```

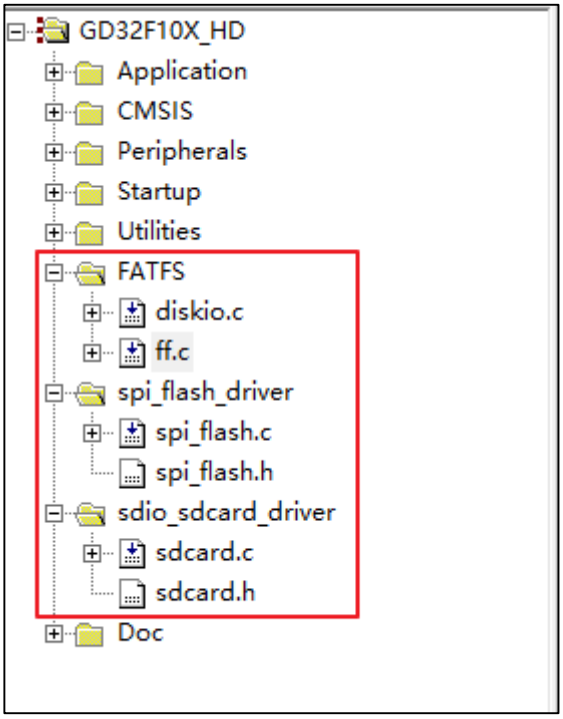
```
            case GET_SECTOR_SIZE:
                *(WORD *)buff = FLASH_SECTOR_SIZE;
                break;
            /*Returns the smallest unit of erased sector (unit 1)*/
            case GET_BLOCK_SIZE:
                *(DWORD *)buff = FLASH_BLOCK_SIZE;
                break;
            }
            res = RES_OK;
            return res;

        case INTER_FLASH:
            switch(cmd) {
            /*return sector number*/
            case GET_SECTOR_COUNT:
                *(DWORD *)buff = 128;
                break;
            /*return each sector size*/
            case GET_SECTOR_SIZE:
                *(WORD *)buff = 2048;
                break;
            /*Returns the smallest unit of erased sector (unit 1)*/
            case GET_BLOCK_SIZE:
                *(DWORD *)buff = 1;
                break;
            }
            res = RES_OK;
            return res;

        }

        return RES_PARERR;
}
#endif

DWORD get_fattime(void)
{
        return 0;
}
```

2.5. 添加工程代码

在 keil4 中添加各存储介质的驱动程序，并添加 FATFS 代码，添加完成后工程目录如*图 2-3.*

*工程目录*所示。

图 2-3. 工程目录



3. FATFS 文件系统测试

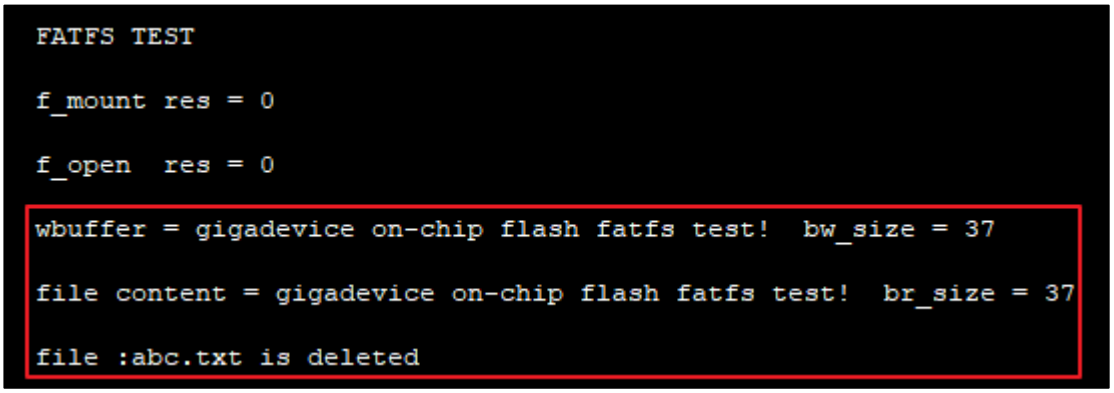
1、 利用 FATFS 文件系统对片上 Flash 进行文件的增删读写测试，并利用 J-Link RTT Viewer 打印结果，测试代码如下：

```
void on-chip_flash_fatfs_test(void)
{
    FRESULT res;
    SEGGER_RTT_printf(0, "\r\n FATFS TEST \r\n");
    res = f_mount(&fsObject, "2:", 1);
    SEGGER_RTT_printf(0, "\r\n f_mount res = %d \r\n", res);
    if(res == FR_NO_FILESYSTEM) {
        /*creates an FAT volume on on- chip FLASH(format)*/
        res = f_mkfs("2:", 0, 0);
        SEGGER_RTT_printf(0, "\r\n f_mkfs res = %d \r\n", res);
        /*unmount file system*/
        res = f_mount(NULL, "2:", 1);
        /*mount file system*/
        res = f_mount(&fsObject, "2:", 1);
        SEGGER_RTT_printf(0, "\r\n f_mkfs 2 res = %d \r\n", res);
    }
    /*create a file enabile write and read*/
    res = f_open(&fp, "2:abc.txt", FA_OPEN_ALWAYS | FA_WRITE | FA_READ);

    SEGGER_RTT_printf(0, "\r\n f_open   res = %d \r\n", res);
    if(res == FR_OK) {
        /*write data into a file*/
        res = f_write(&fp, wbuffer1, sizeof(wbuffer1), &bw_size);
        SEGGER_RTT_printf(0, "\r\n wbuffer = %s   bw_size = %d\r\n", wbuffer1, bw_size);
        if(res == FR_OK) {
            f_lseek(&fp, 0);
            /*read data from a file*/
            f_read(&fp, rbuffer, f_size(&fp), &br_size);
            if(res == FR_OK) {
                SEGGER_RTT_printf(0, "\r\n file content = %s   br_size = %d\r\n", rbuffer,
br_size);
            }
        }
        f_close(&fp);
        res = f_unlink("2:abc.txt");
        res = f_open(&fp, "2:abc.txt", FA_READ);
        if(res != FR_OK) {
            SEGGER_RTT_printf(0, "\r\n file :abc.txt is deleted \r\n");
```

```
        }
    }
}
```

测试结果如*图 3-1. FATFS 片上 Flash 文件增删读写结果*所示，说明 FATFS 文件系统成功实现在片上 Flash 增删读写 abc.txt 文件。

图 3-1. FATFS 片上 Flash 文件增删读写结果



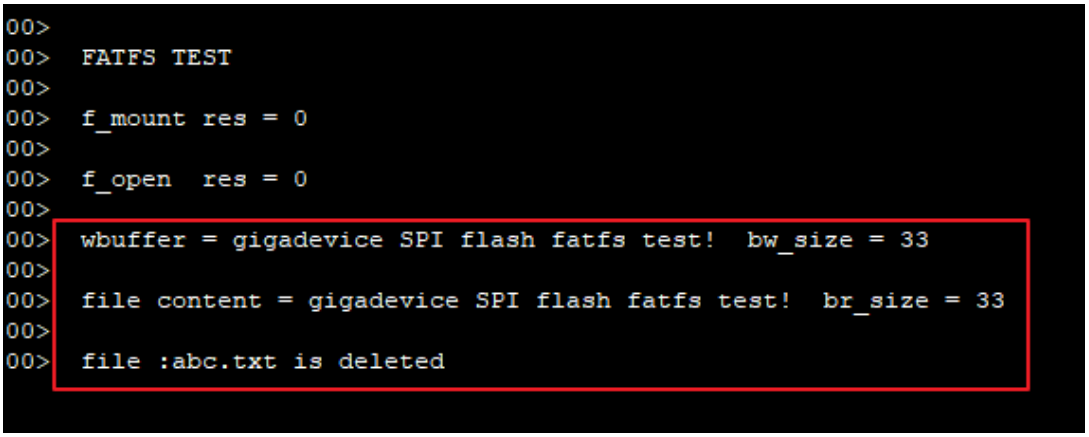
2、 利用 FATFS 文件系统对 SPI_Flash 进行文件的增删读写测试，并利用 J-Link RTT Viewer 打印结果，测试代码只需将片上 Flash 测试代码中的盘符修改为 SPI_Flash 即可测试，测试代码如下：

```
void SPI_Flash_fatfs_test(void)
{
    FRESULT res;
    SEGGER_RTT_printf(0, "\r\n FATFS TEST \r\n");
    res = f_mount(&fsObject, "1:", 1);
    SEGGER_RTT_printf(0, "\r\n f_mount res = %d \r\n", res);
    if(res == FR_NO_FILESYSTEM) {
        /*creates an FAT volume on SPI FLASH(format)*/
        res = f_mkfs("1:", 0, 0);
        SEGGER_RTT_printf(0, "\r\n f_mkfs res = %d \r\n", res);
        /*unmount file system*/
        res = f_mount(NULL, "1:", 1);
        /*mount file system*/
        res = f_mount(&fsObject, "1:", 1);
        SEGGER_RTT_printf(0, "\r\n f_mkfs 2 res = %d \r\n", res);
    }
    /*create a file enabile write and read*/
    res = f_open(&fp, "1:abc.txt", FA_OPEN_ALWAYS | FA_WRITE | FA_READ);
    SEGGER_RTT_printf(0, "\r\n f_open    res = %d \r\n", res);
    if(res == FR_OK) {
        /*write data into a file*/
        res = f_write(&fp, wbuffer1, sizeof(wbuffer1), &bw_size);
        SEGGER_RTT_printf(0, "\r\n wbuffer = %s    bw_size = %d\r\n", wbuffer1, bw_size);
```

```
        if(res == FR_OK) {
            f_lseek(&fp, 0);
            /*read data from a file*/
            f_read(&fp, rbuffer, f_size(&fp), &br_size);
            if(res == FR_OK) {
                SEGGER_RTT_printf(0, "\r\n file content = %s   br_size = %d\r\n", rbuffer,
br_size);
            }
        }
        f_close(&fp);
        res = f_unlink("1:abc.txt");
        res = f_open(&fp, "1:abc.txt", FA_READ);
        if(res != FR_OK) {
            SEGGER_RTT_printf(0, "\r\n file :abc.txt is deleted \r\n");
        }
    }
}
```

测试结果如**图 3-2.** ***FATFS SPI_Flash 文件增删读写结果***所示，文件增删读写成功。

图 3-2. FATFS SPI_Flash 文件增删读写结果



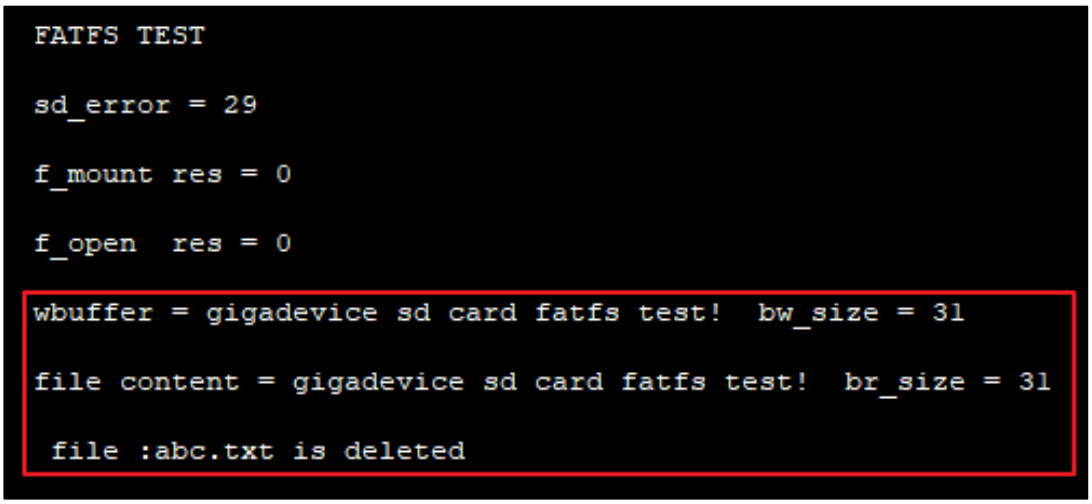
3、 利用 FATFS 文件系统对 SPI_Flash 进行文件的增删读写测试，并利用 J-Link RTT Viewer 打印结果,测试代码如下：

```
void sd_card_fatfs_test(void)
{
    sd_error_enum sd_error;
    uint16_t i = 5;
    FRESULT res;
    SEGGER_RTT_printf(0, "\r\n FATFS TEST \r\n");
    /* initialize SD card*/
    do {
        sd_error = sd_io_init();
    } while((SD_OK != sd_error) && (--i));
```

```
    if(sd_error == SD_OK) {
        SEGGER_RTT_printf(0, "\r\n sd_error = %d\r\n", sd_error);
    }
    /* registers/unregisters file system object to the FatFs module*/
    res = f_mount(&fsObject, "0:", 1);
    SEGGER_RTT_printf(0, "\r\n f_mount res = %d \r\n", res);
    if(res == FR_NO_FILESYSTEM) {
        /*creates an FAT volume on SD card(format)*/
        res = f_mkfs("0:", 0, 512);
        SEGGER_RTT_printf(0, "\r\n f_mkfs res = %d \r\n", res);
        /*unmount file system*/
        res = f_mount(NULL, "0:", 1);
        /*mount file system*/
        res = f_mount(&fsObject, "0:", 1);
        SEGGER_RTT_printf(0, "\r\n f_mkfs 2 res = %d \r\n", res);
    }
    /*create a file enabile write and read*/
    res = f_open(&fp, "0:abc.txt", FA_OPEN_ALWAYS | FA_WRITE | FA_READ);
    SEGGER_RTT_printf(0, "\r\n f_open    res = %d \r\n", res);
    if(res == FR_OK) {
        /*write data into a file*/
        res = f_write(&fp, wbuffer, sizeof(wbuffer), &bw_size);
        SEGGER_RTT_printf(0, "\r\n wbuffer = %s    bw_size = %d\r\n", wbuffer, bw_size);
        if(res == FR_OK) {
            f_lseek(&fp, 0);
            /*read data from a file*/
            f_read(&fp, rbuffer, f_size(&fp), &br_size);
            if(res == FR_OK) {
                SEGGER_RTT_printf(0, "\r\n file content = %s    br_size = %d\r\n", rbuffer,
br_size);
            }
        }
        f_close(&fp);
        res = f_unlink("0:abc.txt");
        if(res == FR_OK) {
            SEGGER_RTT_printf(0, "\r\n    file :abc.txt is deleted \r\n");
        }
    }
}
```

测试结果如*图 3-3. FATFS SD 卡文件增删读写结果*所示，文件增删读写成功。

图 3-3. FATFS SD 卡文件增删读写结果



4. 版本历史

表 4-1. 版本历史

版本号.	说明	日期
1.0	首次发布	2023 年 8 月 11 日

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