USB 转 SPI 桥接器

NuMicro® 32 位系列微控制器范例代码介绍

文件信息

应用简述	本范例代码使用 USB HID 将数据传输到 SPI Flash。模拟 USB 转 SPI 桥接器。
BSP 版本	M480_Series_BSP_CMSIS_V3.05.001
开发平台	NuMaker-PFM-M487 V3.0

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1. 概述

本范例主要是仿真 USB 到 SPI 的桥接。 通过 USB 连接 PC 执行应用程序，并使用应用程序向 SPI 设备传输数据。 本范例使用 BSP 中的 USB HID Transfer 和 SPI Flash 范例来实现此仿真。 PC 端应用程序可以通过 USB 读写 SPI Flash。

本范例提供了一个简单的应用程序 HIDTransferTest.exe 来测试 USB 转 SPI 桥接器。 PC 通过 USB 向 M480 发出擦除/ 读取/ 写入命令，然后 SPI Flash 执行相应的擦除/ 读取/ 写入动作。 示意图如图 1-1 所示。

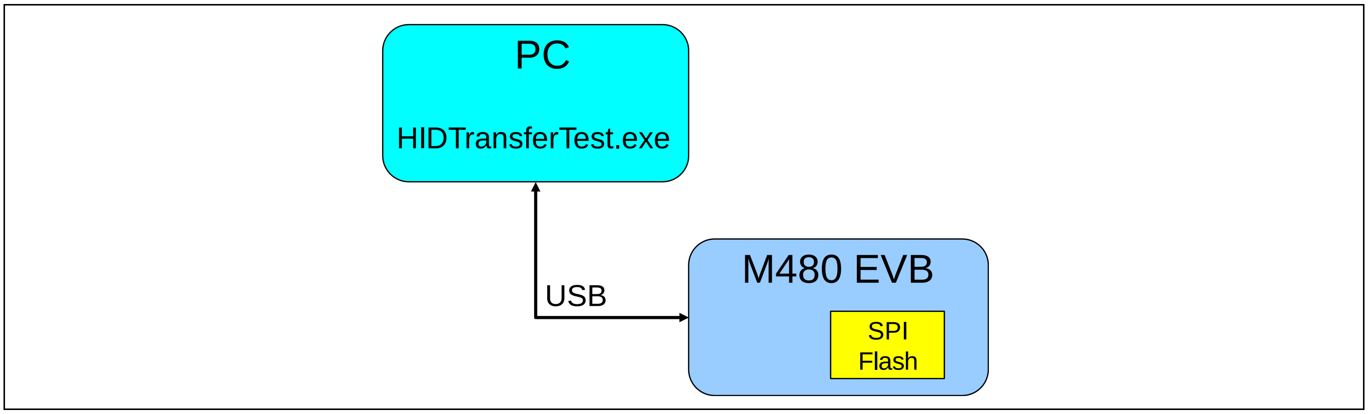
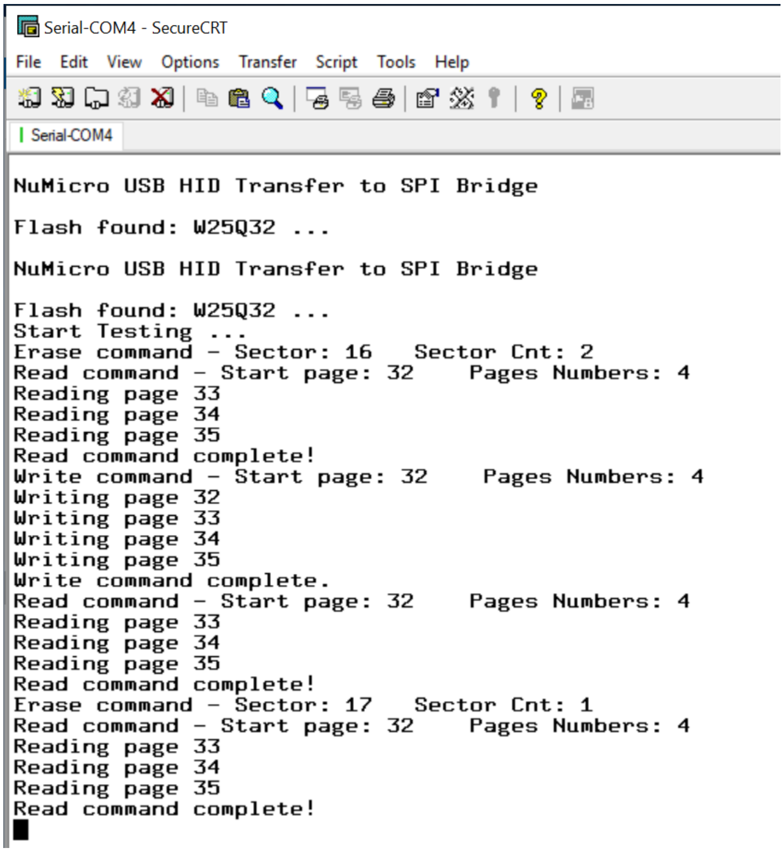


图 1-1 PC 与 M480 EVB 的关系

1.1 执行结果

这个 SPI Flash 的扇区大小为 4096 字节，而且页的大小为 2048 字节。 HIDTransferTest.exe 会擦除两个扇区，读回擦除的数据并检查是否为 0xFF；写入四页，读回写入数据并检查是否正确；擦除一个扇区，读回四页数据并检查是否正确。测试结果如下。



```
NuMicro USB HID Transfer to SPI Bridge

Flash found: W25Q32 ...

NuMicro USB HID Transfer to SPI Bridge

Flash found: W25Q32 ...
Start Testing ...
Erase command - Sector: 16   Sector Cnt: 2
Read command - Start page: 32    Pages Numbers: 4
Reading page 33
Reading page 34
Reading page 35
Read command complete!
Write command - Start page: 32    Pages Numbers: 4
Writing page 32
Writing page 33
Writing page 34
Writing page 35
Write command complete.
Read command - Start page: 32    Pages Numbers: 4
Reading page 33
Reading page 34
Reading page 35
Read command complete!
Erase command - Sector: 17   Sector Cnt: 1
Read command - Start page: 32    Pages Numbers: 4
Reading page 33
Reading page 34
Reading page 35
Read command complete!
█
```

图 1-2 执行结果

2. 代码介绍

SPI 相关函数。它包括读取、写入、擦除、读取状态和等待就绪功能。代码位于 *main.c* 中。

```
uint8_t SpiFlash_ReadStatusReg(void)
{
    // /CS: active
    QSPI_SET_SS_LOW(QSPI_FLASH_PORT);

    // send Command: 0x05, Read status register
    QSPI_WRITE_TX(QSPI_FLASH_PORT, 0x05);

    // read status
    QSPI_WRITE_TX(QSPI_FLASH_PORT, 0x00);

    // wait tx finish
    while(QSPI_IS_BUSY(QSPI_FLASH_PORT));

    // /CS: de-active
    QSPI_SET_SS_HIGH(QSPI_FLASH_PORT);

    // skip first rx data
    QSPI_READ_RX(QSPI_FLASH_PORT);

    return (QSPI_READ_RX(QSPI_FLASH_PORT) & 0xff);
}

void SpiFlash_WaitReady(void)
{
    uint8_t volatile ReturnValue;

    do
    {
        ReturnValue = SpiFlash_ReadStatusReg();
        ReturnValue = ReturnValue & 1;
    }
    while(ReturnValue!=0);    // check the BUSY bit
}

void SpiFlash_NormalRead(uint32_t StartAddress, uint8_t *u8DataBuffer)
{
    uint32_t i;

    // /CS: active
    QSPI_SET_SS_LOW(QSPI_FLASH_PORT);

    // send Command: 0x03, Read data
    QSPI_WRITE_TX(QSPI_FLASH_PORT, 0x03);

    // send 24-bit start address
    QSPI_WRITE_TX(QSPI_FLASH_PORT, (StartAddress>>16) & 0xFF);
    QSPI_WRITE_TX(QSPI_FLASH_PORT, (StartAddress>>8)  & 0xFF);
    QSPI_WRITE_TX(QSPI_FLASH_PORT, StartAddress       & 0xFF);
    while(QSPI_IS_BUSY(QSPI_FLASH_PORT));
    // clear RX buffer
    QSPI_ClearRxFIFO(QSPI_FLASH_PORT);

    // read data
    for(i=0; i<256; i++)
    {
        QSPI_WRITE_TX(QSPI_FLASH_PORT, 0x00);
        while(QSPI_IS_BUSY(QSPI_FLASH_PORT));
        u8DataBuffer[i] = QSPI_READ_RX(QSPI_FLASH_PORT);
    }

    // wait tx finish
    while(QSPI_IS_BUSY(QSPI_FLASH_PORT));

    // /CS: de-active
    QSPI_SET_SS_HIGH(QSPI_FLASH_PORT);
}

void SpiFlash_NormalPageProgram(uint32_t StartAddress, uint8_t *u8DataBuffer)
{
    uint32_t i = 0;

    // /CS: active
    QSPI_SET_SS_LOW(QSPI_FLASH_PORT);

    // send Command: 0x06, Write enable
    QSPI_WRITE_TX(QSPI_FLASH_PORT, 0x06);

    // wait tx finish
    while(QSPI_IS_BUSY(QSPI_FLASH_PORT));

    // /CS: de-active
    QSPI_SET_SS_HIGH(QSPI_FLASH_PORT);

    // /CS: active
    QSPI_SET_SS_LOW(QSPI_FLASH_PORT);

    // send Command: 0x02, Page program
    QSPI_WRITE_TX(QSPI_FLASH_PORT, 0x02);

    // send 24-bit start address
    QSPI_WRITE_TX(QSPI_FLASH_PORT, (StartAddress>>16) & 0xFF);
    QSPI_WRITE_TX(QSPI_FLASH_PORT, (StartAddress>>8)  & 0xFF);
    QSPI_WRITE_TX(QSPI_FLASH_PORT, StartAddress       & 0xFF);

    // write data
    while(1)
    {
        if(!QSPI_GET_TX_FIFO_FULL_FLAG(QSPI_FLASH_PORT))
        {
            QSPI_WRITE_TX(QSPI_FLASH_PORT, u8DataBuffer[i++]);
            if(i > 255) break;
        }
    }
    // wait tx finish
    while(QSPI_IS_BUSY(QSPI_FLASH_PORT));

    // /CS: de-active
    QSPI_SET_SS_HIGH(QSPI_FLASH_PORT);

    QSPI_ClearRxFIFO(QSPI_FLASH_PORT);
}

/* one sector is 4KB */
void SpiFlash_SecotrErase(uint32_t StartSector, uint32_t EraseCount)
{
    uint32_t volatile i, offset;

    for (i=0; i<EraseCount; i++)
    {
        offset = (StartSector + i) * 0x1000;
        // /CS: active
        QSPI_SET_SS_LOW(QSPI_FLASH_PORT);

        // send Command: 0x06, Write enable
        QSPI_WRITE_TX(QSPI_FLASH_PORT, 0x06);

        // wait tx finish
        while(QSPI_IS_BUSY(QSPI_FLASH_PORT));

        // /CS: de-active
        QSPI_SET_SS_HIGH(QSPI_FLASH_PORT);

        // /CS: active
        QSPI_SET_SS_LOW(QSPI_FLASH_PORT);

        // send Command: 0x20, sector erase
        QSPI_WRITE_TX(QSPI_FLASH_PORT, 0x20);

        // send 24-bit start address
        QSPI_WRITE_TX(QSPI_FLASH_PORT, (offset>>16) & 0xFF);
        QSPI_WRITE_TX(QSPI_FLASH_PORT, (offset>>8)  & 0xFF);
        QSPI_WRITE_TX(QSPI_FLASH_PORT, offset       & 0xFF);

        // wait tx finish
        while(QSPI_IS_BUSY(QSPI_FLASH_PORT));

        // /CS: de-active
        QSPI_SET_SS_HIGH(QSPI_FLASH_PORT);

        QSPI_ClearRxFIFO(QSPI_FLASH_PORT);
    }
}
```

初始化系统后，首先配置 QSPI，然后设置 USB 设备。 代码位于 *main.c* 中。

```
int32_t main(void)
{
    uint32_t u32TrimInit;
    uint16_t u16ID;

    /* Unlock protected registers */
    SYS_UnlockReg();

    SYS_Init();

    /* Configure UART0 and set UART0 Baudrate */
    UART_Open(UART0, 115200);

    /* Configure QSPI_FLASH_PORT as a master, MSB first, 8-bit transaction, QSPI Mode-0
timing, clock is 2MHz */
    QSPI_Open(QSPI_FLASH_PORT, QSPI_MASTER, QSPI_MODE_0, 8, 2000000);

    /* Enable the automatic hardware slave select function. Select the SS pin and
configure as low-active. */
    QSPI_EnableAutoSS(QSPI_FLASH_PORT, QSPI_SS, QSPI_SS_ACTIVE_LOW);

    printf("\nNuMicro USB HID Transfer to SPI Bridge\n\n");

    /* Read SPI Flash ID : W25Q32(0xEF15), W25Q16(0xEF14) */
    if((u16ID = SpiFlash_ReadMidDid()) != 0xEF15)
    {
        printf("Wrong ID, 0x%x\n", u16ID);
        while(1);
    }
    else
        printf("Flash found: W25Q32 ...\n");

    USBD_Open(&gsInfo, HID_ClassRequest, NULL);

    printf("Start Testing ...\n");
    /* Endpoint configuration */
    HID_Init();
    USBD_Start();

    ………

    NVIC_EnableIRQ(USBD_IRQn);

    while(1)
    {
    ………
    }
}
```

定义 USB HID 传输的命令和结构。代码位于 *hid_to_spi_bridge.c* 中。

```
/* HID Transfer Commands */
#define HID_CMD_NONE     0x00
#define HID_CMD_ERASE    0x71
#define HID_CMD_READ     0xD2
#define HID_CMD_WRITE    0xC3
#define HID_CMD_TEST     0xB4

#define PAGE_SIZE        2048
#define TEST_PAGES       4
#define SECTOR_SIZE      4096

typedef struct __attribute__((__packed__))
{
    uint8_t u8Cmd;
    uint8_t u8Size;
    uint32_t u32Arg1;
    uint32_t u32Arg2;
    uint32_t u32Signature;
    uint32_t u32Checksum;
}
CMD_T;
```

定义 USB HID Transfer 对应的函数。代码位于 *hid_to_spi_bridge.c* 中。

```
int32_t HID_CmdEraseSectors(CMD_T *pCmd)
{
    uint32_t u32StartSector;
    uint32_t u32Sectors;

    u32StartSector = pCmd->u32Arg1;
    u32Sectors = pCmd->u32Arg2;

    printf("Erase command - Sector: %d   Sector Cnt: %d\n", u32StartSector, u32Sectors);

    /* To erase the sector of storage */
    SpiFlash_SecotrErase(u32StartSector, u32Sectors);
    SpiFlash_WaitReady();

    /* To note the command has been done */
    pCmd->u8Cmd = HID_CMD_NONE;

    return 0;
}

int32_t HID_CmdReadPages(CMD_T *pCmd)
{
    uint32_t u32StartPage;
    uint32_t u32Pages;
    uint32_t volatile i, offset;

    u32StartPage = pCmd->u32Arg1;
    u32Pages     = pCmd->u32Arg2;
    printf("Read command - Start page: %d    Pages Numbers: %d\n", u32StartPage, 
u32Pages);

    if(u32Pages)
    {
        /* Update data to page buffer to upload */
        offset = u32StartPage * PAGE_SIZE;
        for (i=0; i<PAGE_SIZE/256; i++)
            SpiFlash_NormalRead(offset+i*256, g_u8PageBuff+i*256);
        g_u32BytesInPageBuf = PAGE_SIZE;

        /* The signature word is used as page counter */
        pCmd->u32Signature = 1;

        /* Trigger HID IN */
        USBD_MemCopy((uint8_t *)(USBD_BUF_BASE + USBD_GET_EP_BUF_ADDR(EP2)), (void 
*)g_u8PageBuff, EP2_MAX_PKT_SIZE);
        USBD_SET_PAYLOAD_LEN(EP2, EP2_MAX_PKT_SIZE);
        g_u32BytesInPageBuf -= EP2_MAX_PKT_SIZE;
    }

    return 0;
}

int32_t HID_CmdWritePages(CMD_T *pCmd)
{
    uint32_t u32StartPage;
    uint32_t u32Pages;

    u32StartPage = pCmd->u32Arg1;
    u32Pages     = pCmd->u32Arg2;

    printf("Write command - Start page: %d    Pages Numbers: %d\n", u32StartPage, 
u32Pages);
    g_u32BytesInPageBuf = 0;

    /* The signature is used to page counter */
    pCmd->u32Signature = 0;

    return 0;
}
```

3. 软件与硬件需求

3.1 软件需求

- BSP 版本
  - M480_Series_BSP_CMSIS_V3.05.001
- IDE 版本
  - Keil uVersion 5.28

3.2 硬件需求

- 电路组件
  - NuMaker-PFM-M487 V3.0
- 线路示意图
  - 将 UART0 TX (PB.13) pin 脚连接到 PC UART RX，以显示范例代码的执行结果。
  - 将 USB 连接到 PC。

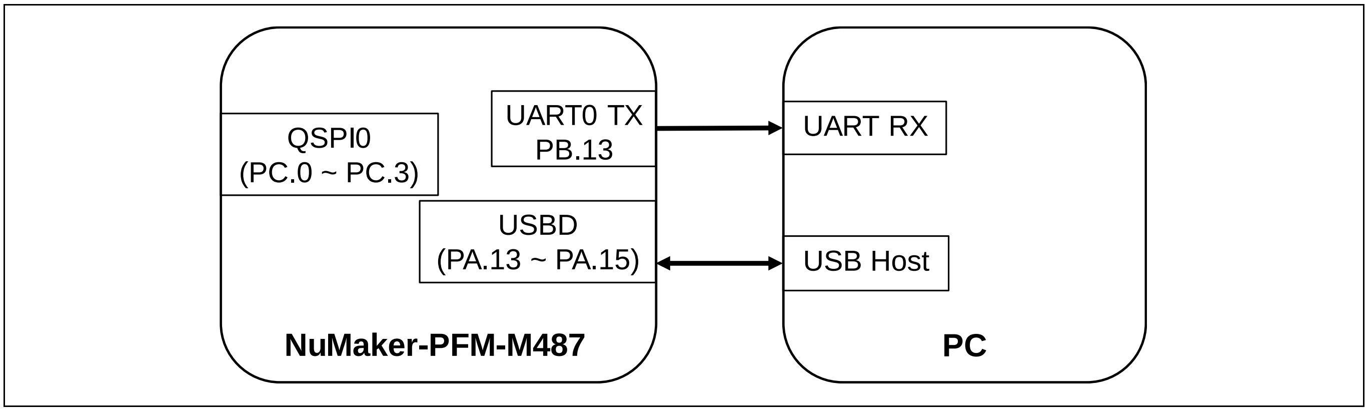


图 3-1 线路示意图

4. 目录信息

🗁 EC_M480_USBD_HID_to_SPI_Bridge_V1.00			
	🗁 Library		Sample code header and source files
		🗁 CMSIS	Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
		🗁 Device	CMSIS compliant device header file
		🗁 StdDriver	All peripheral driver header and source files
	🗁 SampleCode		
		🗁 ExampleCode	Source file of example code

图 4-1 目录信息

5. 范例程序执行

1. 根据目录信息章节进入 ExampleCode 路径中的 KEIL 文件夹，双击 *USBD_HID_to_SPI_bridge.uvproj*。
2. 进入编译模式界面
   - 编译
   - 下载代码至内存
   - 进入 / 离开仿真模式
3. 进入仿真模式界面
   - 执行代码

6. 修订纪录

Date	Revision	Description
2023.08.16	1.00	初始发布。

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