应用指南

32位 Cortex™-M0单片机
NuMicro® 系列

*怎样使用**SPI 2-Bit**模式*

目录

1 简介

本文档描述了怎样使用NUC1xx系列芯片SPI控制器的2-bit模式

1.1 概览

本文中，SPI控制器配置为2-bit主机，使用2个SPI flash（W25Q16BV,华邦spiFlash）作为从机。SPI主机使用串行时钟（SPICLKx），一个从机选择（SPISSx0）以及2通道数据输入/输出（MISOx0/1, MOSIx0/1）控制这两个SPI flash。

1.2 性能

- 支持主/从模式
- 支持1位和2位数据传输
- 可配置最大传输字1~32位,一次可传输1~2字
- MSB 或 LSB 在前传送
- 主模式下2个从机选择信号
- 支持字及字节睡眠
- 支持传送和接收DMA

1.3 结构

1.3.1 SPI模块图

下图描述了SPI控制器模块图。SPICLKx是SPI主机的串行时钟，在主机模式下SPISSx0 和 SPISSx1两脚是从机选择脚，在从机模式下只有SPISSx0是从机选择脚。MOSIx0 和 MISOx0引脚组合成第一通道数据收/发脚，MOSIx1 和 MISOx1引脚组合成第二通道数据收/发脚

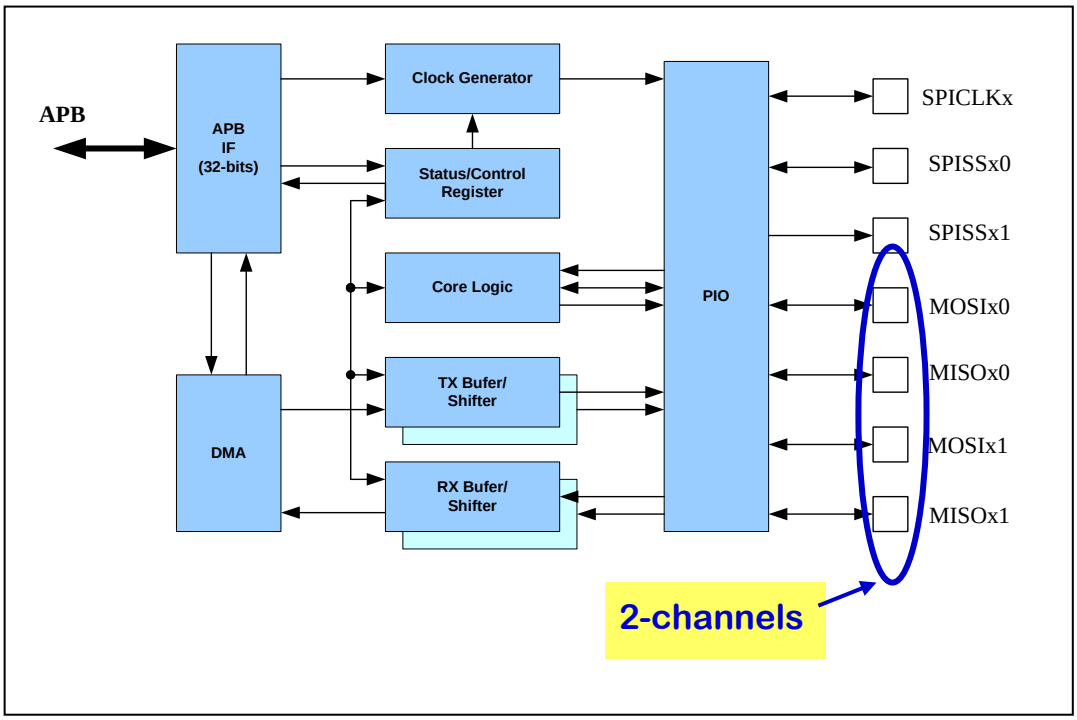


图 1 SPI 模块图

1.3.2 SPI应用框图

下图是应用框图，我们设定NUC100的SPI控制器2(SPI2)作为SPI 2-bit模式主机，SPICLK2是主机用来与两个SPI flash收发数据的时钟信号，SPISS20是SPI主机的从机选择输出，MISO20 和 MOSI20组成第一通道接到SPI flash0，MISO21 和 MOSI21组成第二通道接到SPI flash1。

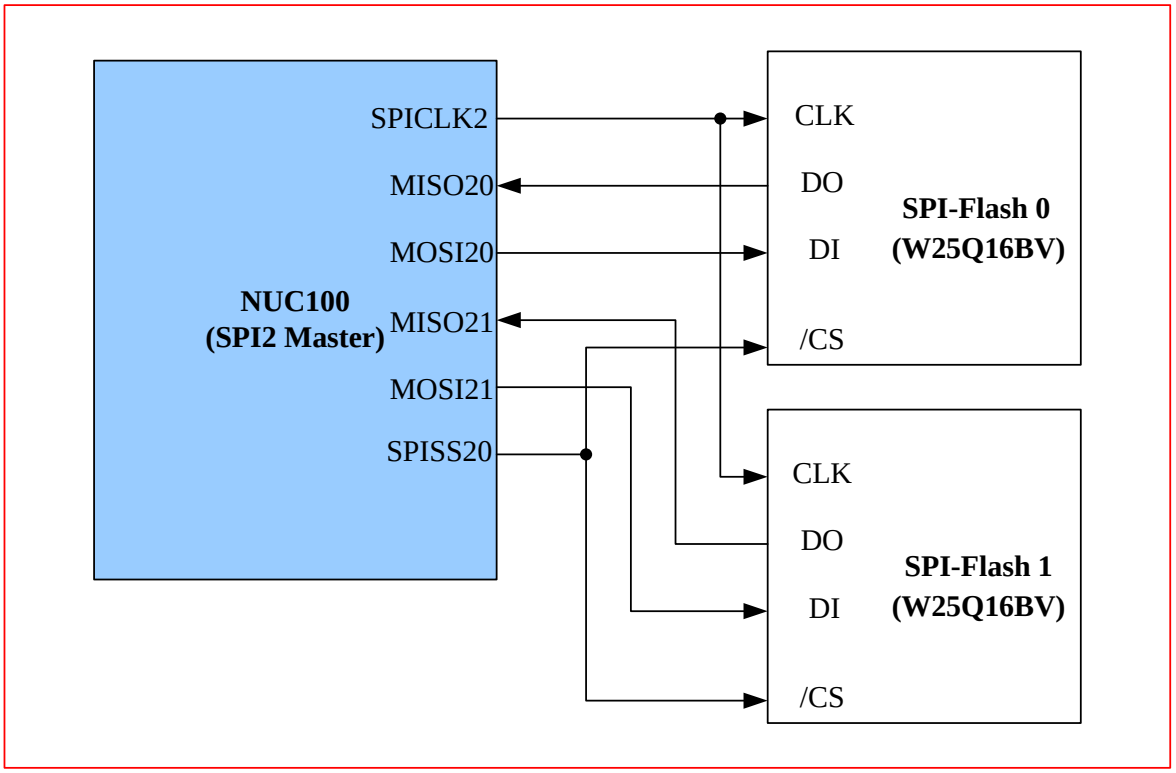


图 2 SPI 2-Bit 传送模式应用框图

1.3.3 2-Bit模式下的Tx/Rx寄存器和I/O口

在2-Bit模式中一次传送只能收发32位长度数据，MOSIx0 和 MISOx0引脚组成通道0，从SPI_Tx0寄存器发送数据，用SPI_Rx0接收数据。MOSIx1 和 MISOx1引脚组成通道1，从SPI_Tx1寄存器发送数据，用SPI_Rx1接收数据。下图描述了了寄存器和IO之间的关系：

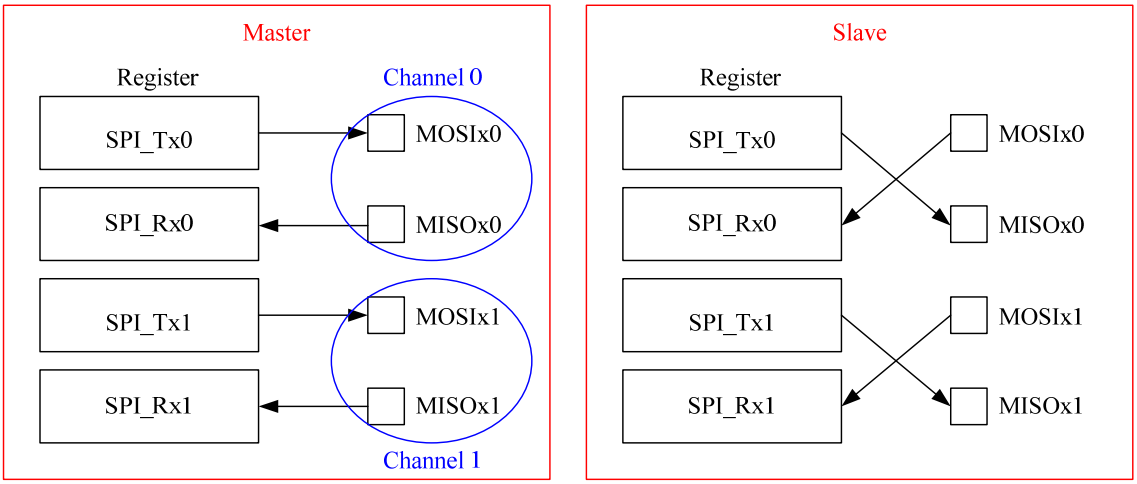


图 3 2-Bit 传送模式下 Tx/Rx 寄存器和 I/O 图

1.3.4 2-Bit传送模式时序图

下图描述SPI 2-Bit传送模式时序图：

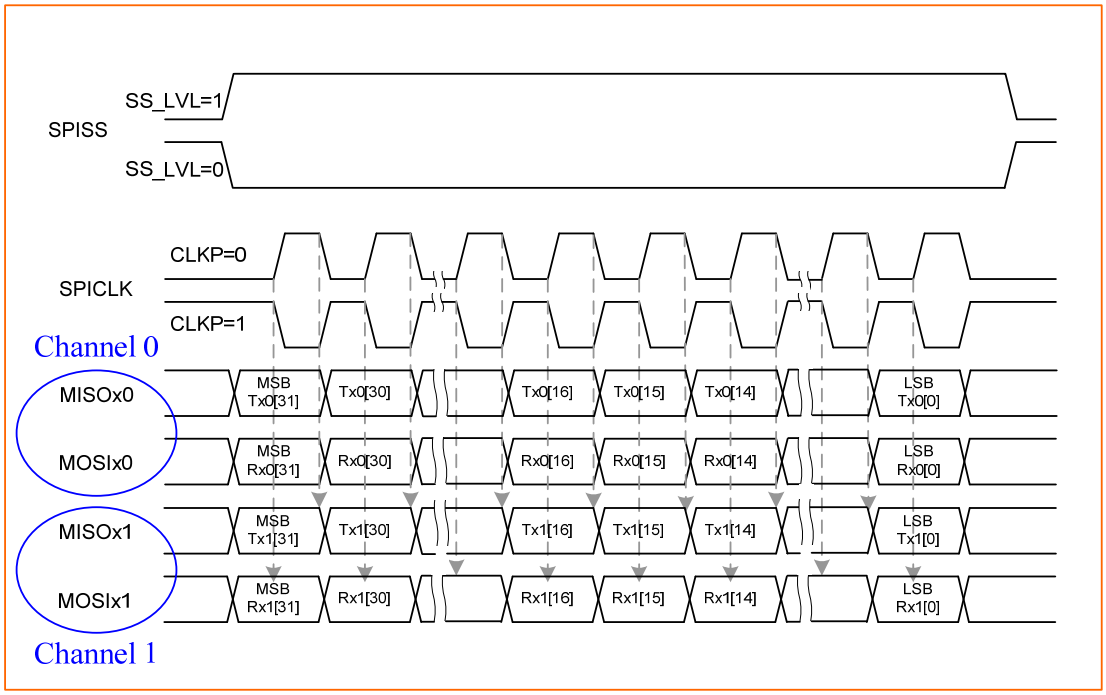


图 4 2-Bit 传送模式时序图

2 代码部分

2.1 主函数

主函数中首先检查了这2个SPI flash的MID和DID，然后擦除这2个flash，接着写数据0x00~0xff到flash0的第一页，写数据0xff~0x00到flash1的第一页，最后验证2个flash的数据

```
#define TEST_NUMBER 1
int main(void)
{
        uint32_t u32ByteCount, u32FlashAddress, u32PageNumber;
        uint8_t DataBuffer0[256];
        uint8_t DataBuffer1[256];

        /* Unlock the protected registers */
        UNLOCKREG();

        /* Enable the 12MHz oscillator oscillation */
        DrvSYS_SetOscCtrl(E_SYS_XTL12M, 1);

        /* HCLK clock source. 0: external 12MHz; 4:internal 22MHz RC oscillator */
        DrvSYS_SetHCLKSource(0);

        LOCKREG();

        /* HCLK clock frequency = HCLK clock source / (HCLK_N + 1) */
        DrvSYS_SetClockDivider(E_SYS_HCLK_DIV, 0);

        /* Configure SPI2 as a master, Type1 waveform, 32-bit transaction */
        DrvSPI_Open(eDRVSPI_PORT2, eDRVSPI_MASTER, eDRVSPI_TYPE1, 32);

        /* MSB first */
        DrvSPI_SetEndian(eDRVSPI_PORT2, eDRVSPI_MSB_FIRST);

        /* Disable the automatic slave select function of SS0. */
        DrvSPI_DisableAutoCS(eDRVSPI_PORT2);
```

```
/* Set the active level of slave select. */
DrvSPI_SetSlaveSelectActiveLevel(eDRVSPI_PORT2, eDRVSPI_ACTIVE_LOW_FALLING);

/* Configure SPI2 as 2-bit transfer mode */
DrvSPI_Set2BitSerialDataIOMode(eDRVSPI_PORT2, TRUE);

/* SPI clock rate 1MHz */
DrvSPI_SetClock(eDRVSPI_PORT2, 1000000, 0);

/* Check MID & DID */
SpiFlashx2_ReadMidDid();

/* Erase SPI flash */
SpiFlashx2_ChipErase();

/* Wait ready */
SpiFlashx2_WaitReady();

/* initial source data */
for(u32ByteCount=0; u32ByteCount<256; u32ByteCount++)
{
        DataBuffer0[u32ByteCount] = u32ByteCount;
}

/* Program SPI flash */
u32FlashAddress = 0;
for(u32PageNumber=0; u32PageNumber<TEST_NUMBER; u32PageNumber++)
{
        /* page program */
        SpiFlashx2_PageProgram(DataBuffer0, u32FlashAddress, 256);
        SpiFlashx2_WaitReady();
        u32FlashAddress += 0x100;
}
```

```
/* clear data buffer */
for(u32ByteCount=0; u32ByteCount<256; u32ByteCount++)
{
        DataBuffer0[u32ByteCount] = 0;
        DataBuffer1[u32ByteCount] = 0;
}

/* Verify SPI flash */
u32FlashAddress = 0;
for(u32PageNumber=0; u32PageNumber<TEST_NUMBER; u32PageNumber++)
{
        SpiFlashx2_ReadData(DataBuffer0, DataBuffer1, u32FlashAddress, 256);
        u32FlashAddress += 0x100;

        for(u32ByteCount=0; u32ByteCount<256; u32ByteCount++)
        {
                if(DataBuffer0[u32ByteCount]!=u32ByteCount)
                        while(1); /* Verify Error! */

                if((uint8_t)DataBuffer1[u32ByteCount]!=(uint8_t)~DataBuffer0[u32ByteCount])
                        while(1); /* Verify Error! */
        }

        /* clear data buffer */
        for(u32ByteCount=0; u32ByteCount<256; u32ByteCount++)
        {
                DataBuffer0[u32ByteCount] = 0;
                DataBuffer1[u32ByteCount] = 0;
        }
}

DrvSPI_Close(eDRVSPI_PORT2);

return 1;
```

```
}
```

2.2 检查SPI Flash的MID和DID

SPI主机发送0x90命令到这两个SPI flash,读回各自的制造ID(MID)和设备ID(DID)，检查读到的数据是否等于0xEF14，如果数据正确则NUC1xx SPI主机和两个flash从机连接成功。

```
// ***************************************
// For W25Q16BV, Manufacturer ID: 0xEF; Device ID: 0x14
void SpiFlashx2_ReadMidDid(void)
{
    uint32_t au32SourceData[2];
    uint32_t au32DestinationData[2];

    /* configure transaction length as 8 bits */
    DrvSPI_SetBitLength(eDRVSPI_PORT2, 8);

    /* /CS: active */
    DrvSPI_SetCS(eDRVSPI_PORT2, eDRVSPI_SS0);

    /* send Command: 0x90, Read Manufacturer/Device ID */
    au32SourceData[0] = 0x90;
    au32SourceData[1] = 0x90;
    DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

    /* wait */
    while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

    /* configure transaction length as 24 bits */
    DrvSPI_SetBitLength(eDRVSPI_PORT2, 24);

    /* send 24-bit '0', dummy */
    au32SourceData[0] = 0x0;
    au32SourceData[1] = 0x0;
   DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

    /* wait */
```

```
        while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

        /* configure transaction length as 16 bits */
        DrvSPI_SetBitLength(eDRVSPI_PORT2, 16);

        /* receive */
        au32SourceData[0] = 0x0;
        au32SourceData[1] = 0x0;
        DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

        /* wait */
        while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

        /* /CS: de-active */
        DrvSPI_ClrCS(eDRVSPI_PORT2, eDRVSPI_SS0);

        /* dump Rx register */
        DrvSPI_DumpRxRegister(eDRVSPI_PORT2, &au32DestinationData[0], 2);

        /* check the MID and DID */
        if ((au32DestinationData[0] & au32DestinationData[1] & 0xffff) != 0xEF14)
                while (1);  /* MID & DID Error */

}
```

2.3 擦除SPI Flash

SPI主机可以发送0xC7命令到这两个SPI flash将其擦除

```
void SpiFlashx2_ChipErase(void)
{
    uint32_t au32SourceData[2];

    /* configure transaction length as 8 bits */
    DrvSPI_SetBitLength(eDRVSPI_PORT2, 8);

    /* /CS: active */
    DrvSPI_SetCS(eDRVSPI_PORT2, eDRVSPI_SS0);

    /* send Command: 0x06, Write enable */
    au32SourceData[0] = 0x06;
    au32SourceData[1] = 0x06;
    DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

    /* wait */
    while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

    /* /CS: de-active */
    DrvSPI_ClrCS(eDRVSPI_PORT2, eDRVSPI_SS0);

    /* /CS: active */
    DrvSPI_SetCS(eDRVSPI_PORT2, eDRVSPI_SS0);

    /* send Command: 0xC7, Chip Erase */
    au32SourceData[0] = 0xc7;
    au32SourceData[1] = 0xc7;
    DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

    /* wait */
    while (DrvSPI_Busy(eDRVSPI_PORT2)) {}
```

```
        /* /CS: de-active */
        DrvSPI_ClrCS(eDRVSPI_PORT2, eDRVSPI_SS0);
}
```

2.4 读SPI Flash的状态寄存器 1

SPI主机发送0x05命令到这两个SPI Flash可以读回各自的状态寄存器1

```
uint32_t SpiFlash2_ReadStatusReg1(void)
{
        uint32_t au32SourceData[2];
        uint32_t au32DestinationData[2];

        /* configure transaction length as 16 bits */
        DrvSPI_SetBitLength(eDRVSPI_PORT2, 16);

        /* /CS: active */
        DrvSPI_SetCS(eDRVSPI_PORT2, eDRVSPI_SS0);

        /* send Command: 0x05, Read status register 1 */
        au32SourceData[0] = 0x0500;
        au32SourceData[1] = 0x0500;
        DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

        /* wait */
        while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

        /* /CS: de-active */
        DrvSPI_ClrCS(eDRVSPI_PORT2, eDRVSPI_SS0);

        /* dump Rx register */
        DrvSPI_DumpRxRegister(eDRVSPI_PORT2, &au32DestinationData[0], 2);

        return ((au32DestinationData[0] | au32DestinationData[1]) & 0xFF);

}
```

2.5 检查SPI flash的BUSY位

SPI主机读回SPI flash状态寄存器1的值并检查SPI flash是否正忙

```
void SpiFlashx2_WaitReady(void)
{
        uint32_t ReturnValue;

        do{
                ReturnValue = SpiFlash2_ReadStatusReg1();
                ReturnValue = ReturnValue & 1;
        }while(ReturnValue!=0); // check the BUSY bit

}
```

2.6 SPI Flash编程

SPI主机发送0x02命令到SPI flash，可以对其编程

```
void SpiFlashx2_PageProgram(uint8_t *DataBuffer, uint32_t StartAddress, uint32_t ByteCount)
{
    uint32_t au32SourceData[2];
    uint32_t Counter;

    /* configure transaction length as 8 bits */
    DrvSPI_SetBitLength(eDRVSPI_PORT2, 8);

    /* /CS: active */
    DrvSPI_SetCS(eDRVSPI_PORT2, eDRVSPI_SS0);

    /* send Command: 0x06, Write enable */
    au32SourceData[0] = 0x06;
    au32SourceData[1] = 0x06;
    DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

    /* wait */
    while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

    /* /CS: de-active */
    DrvSPI_ClrCS(eDRVSPI_PORT2, eDRVSPI_SS0);

    /* /CS: active */
    DrvSPI_SetCS(eDRVSPI_PORT2, eDRVSPI_SS0);

    /* send Command: 0x02, Page program */
    au32SourceData[0] = 0x02;
    au32SourceData[1] = 0x02;
    DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

    /* wait */
    while (DrvSPI_Busy(eDRVSPI_PORT2)) {}
```

```
        /* configure transaction length as 24 bits */
        DrvSPI_SetBitLength(eDRVSPI_PORT2, 24);

        /* send 24-bit start address */
        au32SourceData[0] = StartAddress;
        au32SourceData[1] = StartAddress;
        DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

        /* wait */
        while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

        /* configure transaction length as 8 bits */
        DrvSPI_SetBitLength(eDRVSPI_PORT2, 8);

        for(Counter=0; Counter<ByteCount; Counter++)
        {
                /* send data to program */
                 au32SourceData[0] = DataBuffer[Counter];
                 au32SourceData[1] = ~au32SourceData[0];
                DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

                 /* wait */
                 while (DrvSPI_Busy(eDRVSPI_PORT2)) {}
        }

        /* /CS: de-active */
        DrvSPI_ClrCS(eDRVSPI_PORT2, eDRVSPI_SS0);

}
```

2.7 从SPI Flash读数据

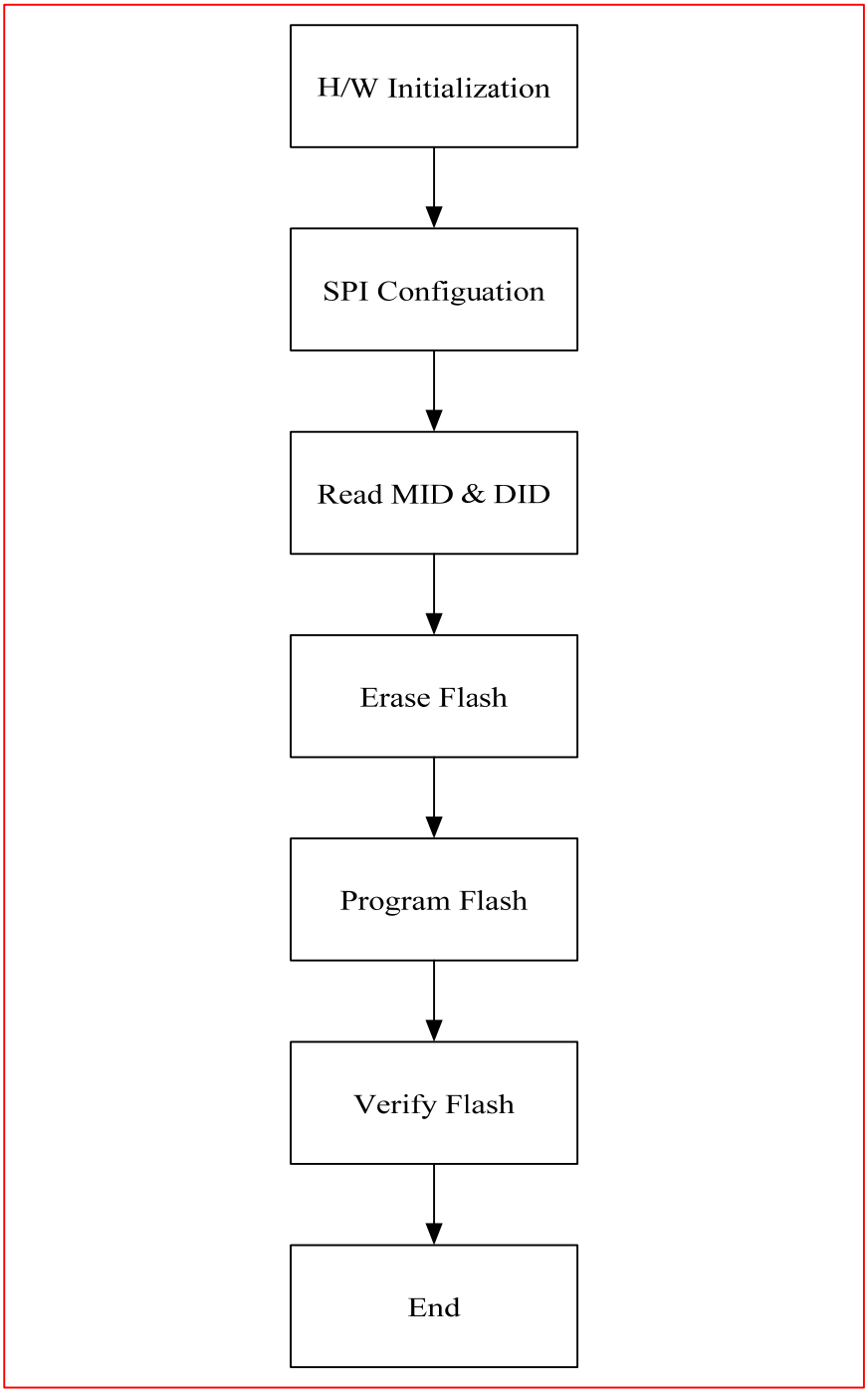
SPI主机发送0x03命令到SPI Flash可以读其数据

```
void SpiFlashx2_ReadData(uint8_t *DataBuffer0, uint8_t *DataBuffer1, uint32_t StartAddress, uint32_t ByteCount)
{
    uint32_t au32SourceData[2];
    uint32_t au32DestinationData[2];
    uint32_t Counter;

    /* configure transaction length as 8 bits */
    DrvSPI_SetBitLength(eDRVSPI_PORT2, 8);

    /* /CS: active */
    DrvSPI_SetCS(eDRVSPI_PORT2, eDRVSPI_SS0);

    /* send Command: 0x03, Read data */
    au32SourceData[0] = 0x03;
    au32SourceData[1] = 0x03;
    DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

    /* wait */
    while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

    /* configure transaction length as 24 bits */
    DrvSPI_SetBitLength(eDRVSPI_PORT2, 24);

    /* send 24-bit start address */
    au32SourceData[0] = StartAddress;
    au32SourceData[1] = StartAddress;
    DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

    /* wait */
    while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

    /* configure transaction length as 8 bits */
```

```
        DrvSPI_SetBitLength(eDRVSPI_PORT2, 8);

        for(Counter=0; Counter<ByteCount; Counter++)
        {
                /* receive */
                au32SourceData[0] = 0x0;
                au32SourceData[1] = 0x0;
                DrvSPI_BurstWrite(eDRVSPI_PORT2, &au32SourceData[0]);

                /* wait */
                while (DrvSPI_Busy(eDRVSPI_PORT2)) {}

                /* dump Rx register */
                DrvSPI_DumpRxRegister(eDRVSPI_PORT2, &au32DestinationData[0], 2);
                DataBuffer0[Counter] = (uint8_t) au32DestinationData[0];
                DataBuffer1[Counter] = (uint8_t) au32DestinationData[1];
        }

        /* /CS: de-active */
        DrvSPI_ClrCS(eDRVSPI_PORT2, eDRVSPI_SS0);

}
```

3 调用顺序

3.1 综合SPI控制器和SPI Flash



3.2 NUC100 设定

1. 硬件初始化：使能12MHz晶振，设置HCLK时钟源及其分频
2. 配置SPI控制器2为主机，2-bit传送模式，数据在下降沿发送，上升沿接收，禁止自动从机选择输出，从机选择有效电平为低，比特率1MHz
3. 读回MID和DID检查连接是否成功
4. 整片擦除这两个SPI flash
5. 对这两个SPI Flash的第一页写入互补的数据
6. 从两个SPI Flash中读出数据并检查
7. 关闭SPI控制器2

3.3 有关的API参考：

1. SPI Driver Reference Guide.doc

4 运行环境设置及结果

4.1 测试 Smpl_SPI_Flashx2

这个SPI示例程序使用2-bit传送模式控制两个SPI flash，Smpl_SPI_Flashx2可以用Keil MDK编译并通过ICE下载到NUC1xx系列学习板，然后用户可以在ICE环境下执行代码，或者复位学习板运行片内Flash程序

4.2 结果

擦除这两个Flash，写数据0x00~0xff到flash0的第一页，写数据0xff~0x00到flash1的第一页

5 修订历史

版本.	日期	描述
1.00	2010-5-12	1. 初次发布

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