包含**HID** 鼠标功能并使用**SPI Mode**读取**SD**卡的**USB**储存装置

NuMicro® 32 位系列微控制器范例代码介绍

文件信息

代码简述	此范例透过 SPI 接口读取 SD 卡作为 USB 储存装置并支持 HID 鼠标功能
BSP 版本	NUC200 Series BSP CMSIS V3.00.003
开发平台	NuTiny-EVB-NUC240-LQFP100 V1.00

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1 功能介绍

1.1 简介

此范例示范包含HID鼠标功能的USB储存装置，透过SPI接口读取SD Card，并使用GPIO仿真鼠标输入。

1.2 原理

1.2.1 SPI Mode SD Card

SD Card支持两种运作模式：SD Card模式与SPI模式，相关讯号定义于表格 1。

Pin	SD Mode			SPI Mode		
	Name	Type	Description	Name	Type	Description
1	CD/DAT3	I/O/PP	Card Detect/ Data Line [Bit 3]	CS	I	Chip Select (neg true)
2	CMD	PP	Command/Response	DI	PP	Data In
3	VSS	S	Supply voltage ground	VSS	S	Supply voltage ground
4	VDD	S	Supply voltage	VDD	S	Supply voltage
5	CLK	I	Clock	SCLK	I	Clock
6	VSS	S	Supply voltage ground	VSS	S	Supply voltage ground
7	DAT0	I/O/PP	Data Line [Bit 0]	DO	O/PP	DataOut
8	DAT1	I/O/PP	Data Line [Bit 1]	RSV		
9	DAT2	I/O/PP	Data Line [Bit 2]	RSV		

表格 1 SD 卡运作模式讯号定义

此范例提供SPI Mode SD Card命令与初始化流程的原始码。

1.2.2 USB 装置

此范例程序复合装置有2组接口，使用MSC(Mass Storage Device)与HID(Human Interface Devices)标准实作。一个USB装置一定会有一个控制管线(端点0)，用于控制传输。其他端点可以根据应用而有不同的设定。此范例中的控制管线由装置端硬件的端点0和端点1构成，从USB主机的角度看来，只会看到端点0；接口0包含一个批量的输入端点与一个批量的输出端点，用于批量传输(Bulk Transfer)；接口1包含一个中断的输入端点，此端点用于输入方向的中断传输(Interrupt Transfer)。这些接口和端点的关系列于表格 2。

Function	USB Composite Device	NUC200 Hardware setting

Control Transfer	Control Pipe
	endpoint 0: Control IN/OUT
		endpoint 0: Control IN
		endpoint 1: Control OUT

Mass Storage	Interface 0
	endpoint 2: Bulk IN
		endpoint 2: Bulk IN
		endpoint 3: Bulk OUT

	endpoint 3: Bulk OUT	
HID Mouse	Interface 1 endpoint 4: Interrupt IN	endpoint 4: Interrupt IN

表格 2 复合装置的接口和端点组态

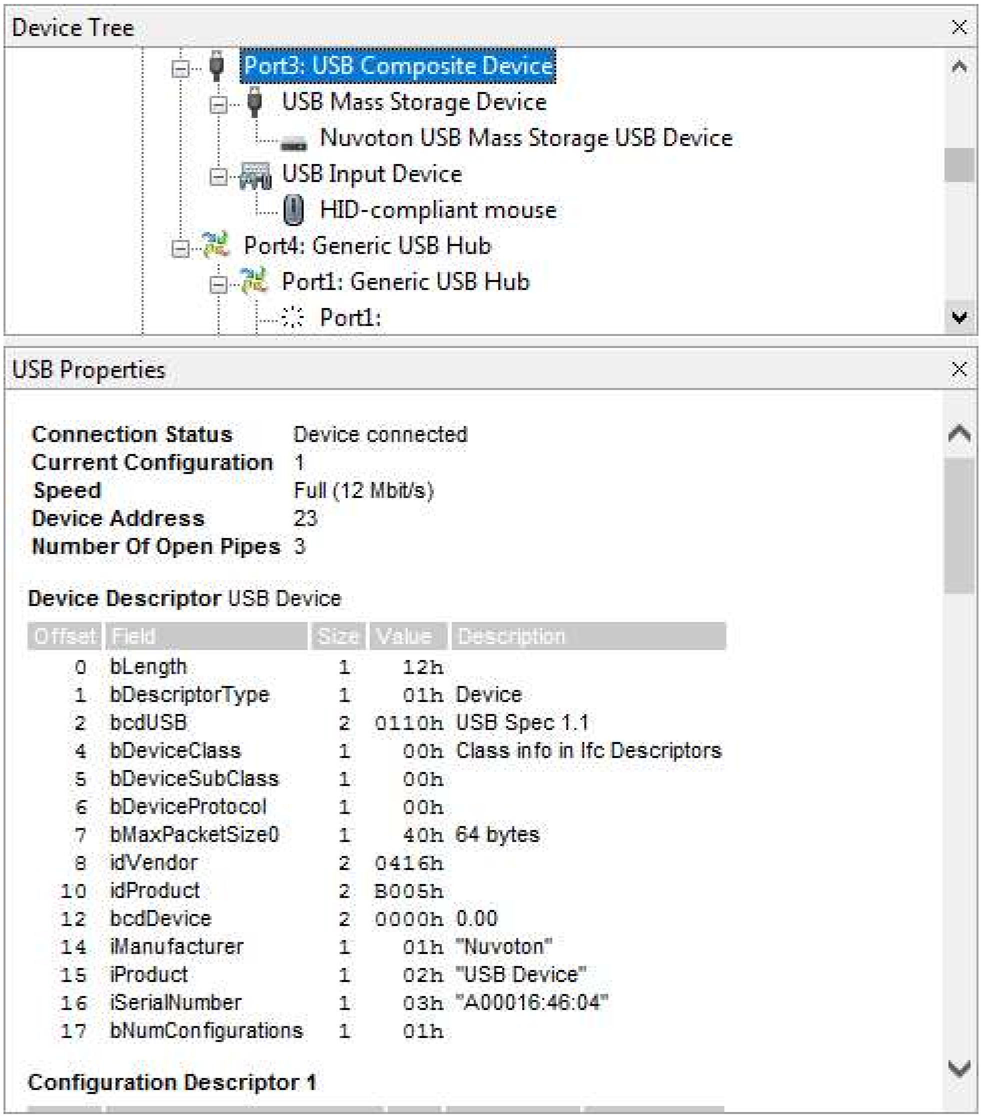
接口1是一个HID鼠标装置，使用表格 3的数据格式回传数据。

Byte	Bits	Description
0	0~2	Button 1~3
0	3~7	Padding
1	0~7	X-axis
2	0~7	Y-axis

表格 3 HID 鼠标报告格式

1.3 执行结果

此范例需与连接个人计算机才能运行。此范例程序执行时，使用USBLyzer我们可以获得图表 1 的装置列表。可以看到此复合装置有2组接口。



- Port3: USB Composite Device
  - USB Mass Storage Device
    - Nuvoton USB Mass Storage USB Device
  - USB Input Device
    - HID-compliant mouse
- Port4: Generic USB Hub
  - Port1: Generic USB Hub
    - Port1:

Connection Status	Device connected
Current Configuration	1
Speed	Full (12 Mbit/s)
Device Address	23
Number Of Open Pipes	3

Device Descriptor USB Device

Offset	Field	Size	Value	Description
0	bLength	1	12h	
1	bDescriptorType	1	01h	Device
2	bcdUSB	2	0110h	USB Spec 1.1
4	bDeviceClass	1	00h	Class info in Ifc Descriptors
5	bDeviceSubClass	1	00h	
6	bDeviceProtocol	1	00h	
7	bMaxPacketSize0	1	40h	64 bytes
8	idVendor	2	0416h	
10	idProduct	2	B005h	
12	bcdDevice	2	0000h	0.00
14	iManufacturer	1	01h	"Nuvoton"
15	iProduct	1	02h	"USB Device"
16	iSerialNumber	1	03h	"A00016:46:04"
17	bNumConfigurations	1	01h	

Configuration Descriptor 1

图表 1 装置列表

2 代码介绍

2.1 SPI Mode SD Card

设定 SPI 接口与 SD Card 初始化。

```
    uint8_t udcFlashInit(void)
    {
        RoughDelay(100000);

        if(DrvSDCARD_Open() == E_SUCCESS)
            printf("SDCard Open success\n");
        else
            printf("SDCard Open failed\n");

        if (!Flash_Identify())
            return 0;

        return 1;
    }
```

读取 SC Card。

```
void SpiRead(uint32_t addr, uint32_t size, uint8_t* buffer)
{
/* This is low level read function of USB Mass Storage */
    uint32_t response;
    if(addr>=LogicSector)
    {
        DBG_PRINTF("Read illegal Sector:0x%x\n",addr);
        return;
    }
    if(SDtype&SDBlock)
    {
        while(size >= PHYSICAL_BLOCK_SIZE)
        {
            while(MMC_Command_Exec(READ_SINGLE_BLOCK,addr,buffer,&response)==FALSE);
            addr   ++;
            buffer += PHYSICAL_BLOCK_SIZE;
            size   -= PHYSICAL_BLOCK_SIZE;
        }
    }
    else
    {
        addr*=PHYSICAL_BLOCK_SIZE;
        while(size >= PHYSICAL_BLOCK_SIZE)
        {
            while(MMC_Command_Exec(READ_SINGLE_BLOCK,addr,buffer,&response)==FALSE);
            addr   += PHYSICAL_BLOCK_SIZE;
            buffer += PHYSICAL_BLOCK_SIZE;
            size   -= PHYSICAL_BLOCK_SIZE;
        }
    }
}
```

写入 SD Card。

```
void SpiWrite(uint32_t addr, uint32_t size, uint8_t* buffer)
{
    uint32_t response;
    if(addr>=LogicSector)
    {
        DBG_PRINTF("Write illegal Sector:0x%x\n",addr);
        return;
    }
    if(SDtype&SDBlock)
    {
        while(size >= PHYSICAL_BLOCK_SIZE)
        {
            while(MMC_Command_Exec(WRITE_BLOCK,addr,buffer,&response)==FALSE);
            addr   ++;
            buffer += PHYSICAL_BLOCK_SIZE;
            size   -= PHYSICAL_BLOCK_SIZE;
        }
    }
    else
    {
        addr*=PHYSICAL_BLOCK_SIZE;
        while(size >= PHYSICAL_BLOCK_SIZE)
        {
            while(MMC_Command_Exec(WRITE_BLOCK,addr,buffer,&response)==FALSE);
            addr   += (PHYSICAL_BLOCK_SIZE);
            buffer += PHYSICAL_BLOCK_SIZE;
            size   -= PHYSICAL_BLOCK_SIZE;
        }
    }
}
```

2.2 鼠标

USB 主机会发出 IN Token 向端点 4 请求数据，当 IN Token 收到时，会执行端点 4 的中断处理程序设定并回传数据。以此范例为例，当 GPB15 电位为 0 时，设定 buf[2] (表格 3 的 X 轴字段) 为 0x1。

```
void EP4_Handler(void)
{
    uint8_t *buf;
    buf = (uint8_t *)(USBD_BUF_BASE + USBD_GET_EP_BUF_ADDR(EP4));

    buf[0] = 0x00;
    if(PB15 == 0)
        buf[1] = 0x01;
    else
        buf[1] = 0x00;
    buf[2] = 0x00;
    USBD_SET_PAYLOAD_LEN(EP4, 3);
}
```

2.3 MSC & HID 类别请求

MSC_ClassRequest()包含了 MSC 与 HID 类别请求。

```
void MSC_ClassRequest(void)
{
    uint8_t buf[8];
    USBD_GetSetupPacket(buf);

    if(buf[0] & EP_INPUT)    /* request data transfer direction */
    {
 /* Device to host */
        switch(buf[1])
        {
        case GET_MAX_LUN:
```

```
        {
            if((buf[4] == gsInfo.gu8ConfigDesc[LEN_CONFIG + 2]) &&
                 (buf[2] + buf[3] + buf[6] + buf[7] == 1))
            {
                M8(USBD_BUF_BASE + USBD_GET_EP_BUF_ADDR(EP0)) = 0;
/* Data stage */
                USBD_SET_DATA1(EP0);
                USBD_SET_PAYLOAD_LEN(EP0, 1);
                /* Status stage */
                USBD_PrepareCtrlOut(0, 0);
            }
            else
                USBD_SET_EP_STALL(EP1); /* Stall when wrong parameter */
            break;
        }
        case GET_REPORT:
        case GET_IDLE:
        case GET_PROTOCOL:
        default:
        {
 /* Setup error, stall the device */
            USBD_SetStall(0);
            DBG_PRINTF("Unknow MSC req(0x%x). stall ctrl pipe\n", buf[1]);
            break;
        }
        }
    }
    else
    {
       /* Host to device */
        switch(buf[1])
        {
        case BULK_ONLY_MASS_STORAGE_RESET:
        {
 /* Check interface number with cfg descriptor and check wValue = 0,
               wLength = 0 */
            if((buf[4] == gsInfo.gu8ConfigDesc[LEN_CONFIG + 2]) &&
                (buf[2] + buf[3] + buf[6] + buf[7] == 0))
            {
                g_u32Length = 0; /* Reset all read/write data transfer */
                USBD_LockEpStall(0);
               /* Clear ready */
                USBD->EP[EP2].CFGP |= USBD_CFGP_CLRRDY_Msk;
                USBD->EP[EP3].CFGP |= USBD_CFGP_CLRRDY_Msk;

                /* Prepare to receive the CBW */
                g_u8EP3Ready = 0;
                g_u8BulkState = BULK_CBW;
                USBD_SET_DATA1(EP3);
                USBD_SET_EP_BUF_ADDR(EP3, g_u32BulkBuf0);
                USBD_SET_PAYLOAD_LEN(EP3, 31);
            }
            else
            {
                /* Stall when wrong parameter */
                USBD_SET_EP_STALL(EP1);
            }
            /* Status stage */
            USBD_SET_DATA1(EP0);
            USBD_SET_PAYLOAD_LEN(EP0, 0);
            break;
        }
        case SET_REPORT:
        {
            if(buf[3] == 3)
            {
                /* Request Type = Feature */
                USBD_SET_DATA1(EP1);
                USBD_SET_PAYLOAD_LEN(EP1, 0);
            }
            break;
        }
        case SET_IDLE:
        {
            /* Status stage */
            USBD_SET_DATA1(EP0);
            USBD_SET_PAYLOAD_LEN(EP0, 0);
            EP4_Handler();
            break;
        }
        case SET_PROTOCOL:
```

```
        default:
        {
            /* Setup error, stall the device */
            USBD_SetStall(0);
            DBG_PRINTF("Unknow MSC req (0x%x). stall ctrl pipe\n", buf[1]);
            break;
        }
        }
    }
}
```

2.4 装置描述符

2.4.1 HID 报告描述符

HID_MouseReportDescriptor 是鼠标的 HID 报告描述符元。此描述元定义了表格 3 中的数据格式。此数据格式内有，3 个按钮、X 轴、Y 轴和滚轮。

```
const uint8_t HID_MouseReportDescriptor[] =
{
    0x05, 0x01,     /* Usage Page(Generic Desktop Controls) */
    0x09, 0x02,     /* Usage(Mouse) */
    0xA1, 0x01,     /* Collection(Application) */
    0x09, 0x01,     /* Usage(Pointer) */
    0xA1, 0x00,     /* Collection(Physical) */
    0x05, 0x09,     /* Usage Page(Button) */
    0x19, 0x01,     /* Usage Minimum(0x1) */
    0x29, 0x03,     /* Usage Maximum(0x3) */
    0x15, 0x00,     /* Logical Minimum(0x0) */
    0x25, 0x01,     /* Logical Maximum(0x1) */
    0x95, 0x03,     /* Report Count(0x3) */
    0x75, 0x01,     /* Report Size(0x1) */
    0x81, 0x02,     /* Input(3 button bit) */
    0x95, 0x01,     /* Report Count(0x1) */
    0x75, 0x05,     /* Report Size(0x5) */
    0x81, 0x01,     /* Input(5 bit padding) */
    0x05, 0x01,     /* Usage Page(Generic Desktop Controls) */
    0x09, 0x30,     /* Usage(X) */
    0x09, 0x31,     /* Usage(Y) */
    0x15, 0x81,     /* Logical Minimum(0x81)(-127) */
    0x25, 0x7F,     /* Logical Maximum(0x7F)(127) */
    0x75, 0x08,     /* Report Size(0x8) */
    0x95, 0x02,     /* Report Count(0x2) */
    0x81, 0x06,     /* Input(1 byte) */
    0xC0,           /* End Collection */
    0xC0,           /* End Collection */
};
```

2.4.2 组态描述元

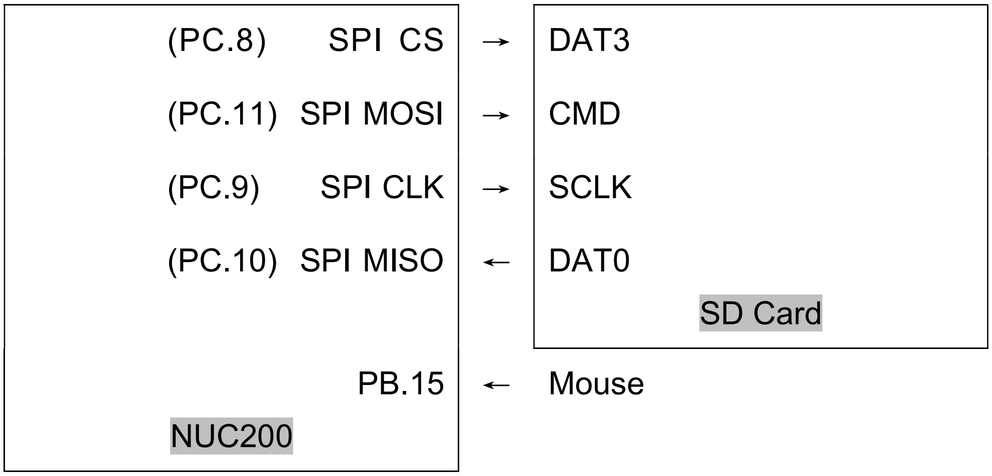
USB 主机需要组态描述元(Configuration Descriptor)来辨识装置。gu8ConfigDescriptor 是此范例使用的组态描述元，里面含有 2 组界面的描述。“bNumInterfaces”字段设定为 2，用来让 USB 主机知道此复合装置有 2 组接口。2 组界面描述元(Interface Descriptor)，HID 描述元(HID descriptor)和端点描述元(Endpoint Descriptor)，依序列于组态描述元之后。

```
/*!<USB Configure Descriptor */
const uint8_t gu8ConfigDescriptor[] =
{
   /* Configuration Descriptor */
    LEN_CONFIG,                     /* bLength             */
    DESC_CONFIG,                    /* bDescriptorType     */
    LEN_TOTAL & 0x00FF,             /* wTotalLength        */
    (LEN_TOTAL & 0xFF00) >> 8,
    0x02,                           /* bNumInterfaces      */
    0x01,                           /* bConfigurationValue */
    0x00,                           /* iConfiguration      */
    0xC0,                           /* bmAttributes        */
    0x32,                           /* MaxPower            */

    /* Interface Descriptor */
    LEN_INTERFACE,                  /* bLength             */
    DESC_INTERFACE,                 /* bDescriptorType     */
    0x00,                           /* bInterfaceNumber    */
    0x00,                           /* bAlternateSetting   */
    0x02,                           /* bNumEndpoints       */
    0x08,                           /* bInterfaceClass     */
    0x05,                           /* bInterfaceSubClass  */
    0x50,                           /* bInterfaceProtocol  */
    0x00,                           /* iInterface          */

    /* Endpoint Descriptor */
    LEN_ENDPOINT,                   /* bLength             */
    DESC_ENDPOINT,                  /* bDescriptorType     */
    (BULK_IN_EP_NUM | EP_INPUT),    /* bEndpointAddress    */
    EP_BULK,                        /* bmAttributes        */
    EP2_MAX_PKT_SIZE, 0x00,          /* wMaxPacketSize      */
    0x00,                            /* bInterval           */

    /* Endpoint Descriptor */
    LEN_ENDPOINT,                    /* bLength             */
    DESC_ENDPOINT,                   /* bDescriptorType     */
    BULK_OUT_EP_NUM,                 /* bEndpointAddress    */
    EP_BULK,                         /* bmAttributes        */
    EP3_MAX_PKT_SIZE, 0x00,          /* wMaxPacketSize      */
    0x00,                            /* bInterval           */

    /* Interface Descriptor */
    LEN_INTERFACE,                   /* bLength             */
    DESC_INTERFACE,                  /* bDescriptorType     */
    0x01,                            /* bInterfaceNumber    */
    0x00,                            /* bAlternateSetting   */
    0x01,                            /* bNumEndpoints       */
    0x03,                            /* bInterfaceClass     */
    0x01,                            /* bInterfaceSubClass  */
    HID_MOUSE,                       /* bInterfaceProtocol  */
    0x00,                            /* iInterface          */

    /* HID Descriptor */
    LEN_HID,                         /* bLength             */
    DESC_HID,                        /* bDescriptorType     */
    0x10, 0x01,                      /* bcdHID              */
    0x00,                            /* bCountryCode        */
    0x01,                            /* bNumDescriptors     */
    DESC_HID_RPT,                    /* DbDescriptorType    */
    LEN_REPORT_DESC & 0x00FF,        /* wDescriptorLength   */
    (LEN_REPORT_DESC & 0xFF00) >> 8,

  /* Endpoint Descriptor */
    LEN_ENDPOINT,                    /* bLength             */
    DESC_ENDPOINT,                   /* bDescriptorType     */
    (INT_IN_EP_NUM | EP_INPUT),      /* bEndpointAddress    */
    EP_INT,                          /* bmAttributes        */
    EP4_MAX_PKT_SIZE & 0x00FF,       /* wMaxPacketSize      */
    (EP4_MAX_PKT_SIZE & 0xFF00) >> 8,
    HID_DEFAULT_INT_IN_INTERVAL      /* bInterval           */
};
```

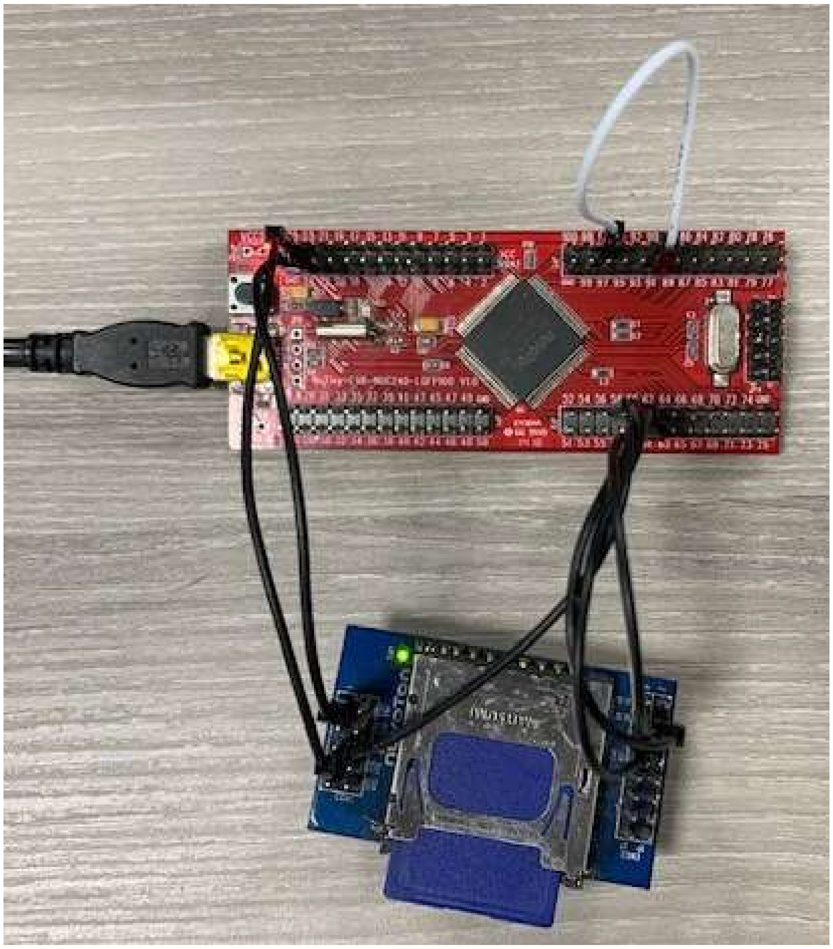
3 软件与硬件环境

- 软件环境
  - BSP 版本
    - NUC200 Series BSP CMSIS V3.00.003
  - IDE 版本
    - Keil uVersion5.26
- 硬件环境
  - 电路组件
    - NuTiny-EVB-NUC240-LQFP100 V1.00
    - SD card socket board
    - USB mini USB cable
  - 示意图

NUC200 使用 SPI1 接口读取 SD Card，并使用 GPB.15 仿真鼠标输入。以下是 NUC200 与 SD Card 的连接方式。



- SPI CS 是 Chip Select 连接 SD card 的 DAT3 pin
- SPI MOSI 是 NUC200 的数据输出，连接 SD card 的 DAT0 pin (必须连接上拉电阻)。
- NUC200 SPI SCK 连接 SD card Clock。
- SPI MISO 是 NUC200 的数据输入，连接 SD card 的 CMD pin (必须连接上拉电阻)。



4 目录信息

🗁 EC_NUC200_USBD_MSD_SPI_Mode_SDCard_HID_Mouse_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

5 如何执行范例程序

1. 根据目录信息章节进入 ExampleCode 路径中的 KEIL 文件夹，双击 USBD_MSD_SPI_Mode_SDCard_HID_Mouse.uvproj。
2. 进入编译模式接口
    a. 编译
    b. 下载代码至内存
    c. 进入 / 离开除错模式
3. 进入除错模式接口
    a. 执行代码

6 修订纪录

Date	Revision	Description
Nov.22, 2019	1.00	1. 初始发布.

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