HID 觸控裝置

NuMicro® 32 位系列微控制器範例代碼介紹

文件資訊

代碼簡述	HID 觸控感應裝置
BSP 版本	NUC123 Series BSP CMSIS V3.01.001
開發平台	NuTiny-EVB-NUC123-LQFP64 v1.0

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1 功能介紹

1.1 簡介

本範例實作一個HID(Human Interface Device)觸控裝置。模擬兩個輸入軌跡。

1.2 原理

本裝置內含控制管線(端點0)，用於控制傳輸。此控制管線由裝置端硬體的端點0和端點1構成。從USB主機的角度看來，只會看到端點0；HID觸控資料傳輸則是由唯一的介面完成，此介面有個中斷的輸入端點，此端點用於輸入方向的中斷傳輸(Interrupt Transfer)。介面和端點的關係列於表 1。

Endpoints in NUC123	Composite Device	Function
Endpoint 0 Control IN **Endpoint 1 Control OUT**	Control Pipe (Endpoint 0)	Control Transfer
Endpoint 2	Interface 0: Endpoint 1: Interrupt IN	HID Touch

表 1: HID 觸控裝置的介面和端點組態

介面0的觸控資料，使用表 2的格式回傳。此格式即是HID的報告描述元所定義的資料格式，定義了兩組相同的資料結構，讓此裝置可同時回傳兩個不同的軌跡。關於觸控裝置報告描述元更詳細的欄位解說，可參考微軟公司網站。

Byte	Bits	Description
0	0	Tip Switch
0	1	In Range
0	2	Touch Valid
0	3 ~ 7	Padding
1	0 ~ 7	Contact Identifier
2 ~ 3	0 ~ 7	X-axis
4 ~ 5	0 ~ 7	Y-axis
6	0	Tip Switch
6	1	In Range
6	2	Touch Valid
6	3 ~ 7	Padding
7	0 ~ 7	Contact Identifier
8 ~ 9	0 ~ 7	X-axis
10 ~ 11	0 ~ 7	Y-axis

表 2: HID 觸控裝置的 報告格式

1.3 執行結果

此範例需與連接個人電腦才能運行。此範例程式執行時，使用windows的裝置管理員，可以獲得圖 1的裝置列表，HID-compliant touch screen就是此次展示的裝置。

圖 1:裝置管理員的裝置列表

圖 2是使用USB封包分析儀紀錄的傳輸封包，可看見每次交易(transaction)，有14 位元組的資料以輸入的方向傳送。

Transaction	F	IN	ADDR	ENDP	T	Data	ACK	Time	Time Stamp
196	S	0x96	60	1	1	01 00 00 00 00 00 00 00 01 00 00 00 00 00	0x4B	1.000 ms	1 . 722 543 132
197	S	0x96	60	1	0	01 00 00 00 00 00 00 00 01 00 00 00 00 00	0x4B	999.982 us	1 . 723 543 150
198	S	0x96	60	1	1	01 00 00 00 00 00 00 00 01 00 00 00 00 00	0x4B	1.000 ms	1 . 724 543 132
199	S	0x96	60	1	0	01 00 00 00 00 00 00 00 01 00 00 00 00 00	0x4B	1.000 ms	1 . 725 543 132
200	S	0x96	60	1	1	01 00 00 00 00 00 00 00 01 00 00 00 00 00	0x4B	999.982 us	1 . 726 543 150
201	S	0x96	60	1	0	01 07 00 02 02 00 01 07 01 02 02 20 01 02	0x4B	1.000 ms	1 . 727 543 132
202	S	0x96	60	1	1	01 07 00 02 02 00 01 07 01 02 02 20 01 02	0x4B	1.000 ms	1 . 728 543 132
203	S	0x96	60	1	0	01 07 00 02 02 00 01 07 01 02 02 20 01 02	0x4B	1.000 ms	1 . 729 543 132
204	S	0x96	60	1	1	01 07 00 02 02 00 01 07 01 02 02 20 01 02	0x4B	1.000 ms	1 . 730 543 132
205	S	0x96	60	1	0	01 07 00 02 02 00 01 07 01 02 02 20 01 02	0x4B	1.000 ms	1 . 731 543 132

圖 2:HID 觸控裝置的傳輸資料

在裝置連加上電腦後，打開”小畫家”軟體，此裝置會畫出兩條平行的軌跡，如圖 3。

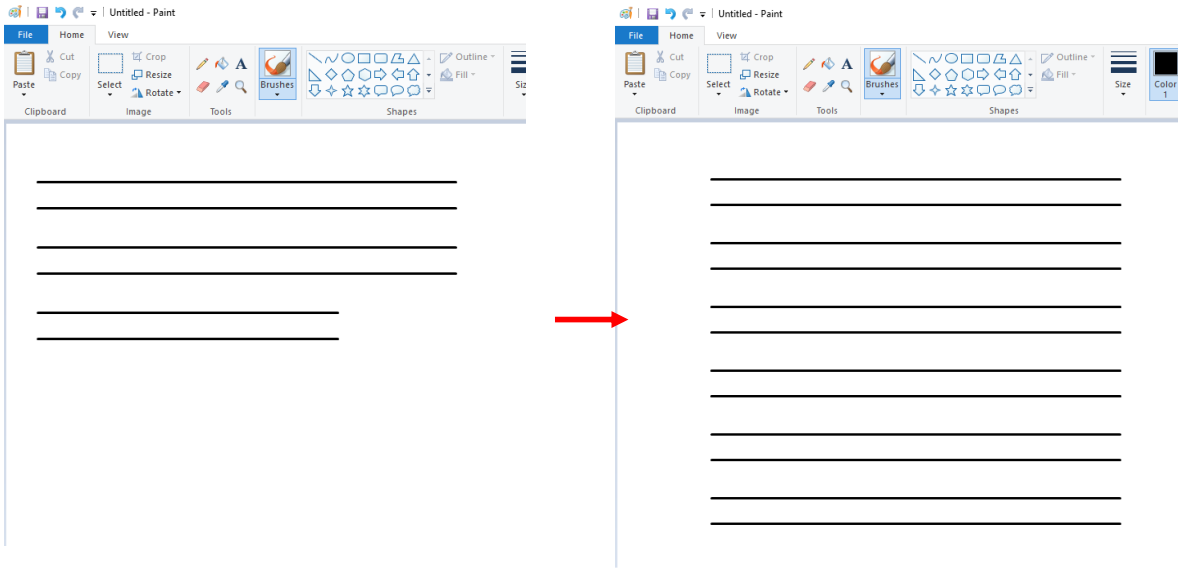


圖 3: HID 觸碰裝置在小畫家畫平行線

2 代碼介紹

此範例程式使用 HID 標準實現觸控裝置的模擬。當主機發出 IN TOKEN 時，IN 的中斷傳輸端點使用定義於 HID 報告描述元的資料格式回傳資料，如圖 2。2.1~2.2 節將介紹程式處理的流程。

2.1 Main.c

While回圈內的HID_UpdateTouchData()用於資料的傳輸。裡面實作的IN token中斷產生時的處理邏輯。

```
    while(1)
    {
       HID_UpdateTouchData();
    }
```

2.2 hid_touch.c

USB主機會發出IN Token向端點2請求資料。當IN Token收到時，端點2的USBD中斷處理程序會把g_u8EP2Ready設為真。當HID_UpdateTouchData ()檢查到g_u8EP2Ready為真時，就會設定封包回傳資料。 由於有兩條軌跡同時上傳，每條軌跡需要6位元組的空間，每組資料前會再加上一個位元組，存放Report ID。所以一次回傳的資料長度總共14位元組。

```
/* two lines demo in Paint */
uint32_t u32ReportCount = 0;
uint8_t u8IsX1Send04 = 0, u8IsX2Send04 = 0;
void HID_UpdateTouchData(void)
{
    uint8_t *pu8buf;
    static uint16_t u16X1 = 0x01f0, u16Y1 = 0x0100;

    if(g_u8EP2Ready)
    {

        pu8buf = (uint8_t *)(USBD_BUF_BASE + USBD_GET_EP_BUF_ADDR(EP2));

        /* Report ID 1 */
        pu8buf[0] = 1;
        pu8buf[2] = 0;
        pu8buf[8] = 1;
```

以下是畫線的實作，把欲執行的觸控資料填入對應的欄位，使用者可以根據自己的需求更改程式，來模擬不同的軌跡效果。

```
        u32ReportCount++;

        if ((u16X1 >= 0x0200) && (u16X1 <= 0x0400)) /* touchDown */
```

```
        {
            u8IsX1Send04 = 1;

            pu8buf[1] = 0x07;
            pu8buf[3] = u16X1 & 0xff;
            pu8buf[4] = (u16X1 >> 8) & 0xff;
            pu8buf[5] = u16Y1 & 0xff;
            pu8buf[6] = (u16Y1 >> 8) & 0xff;
            pu8buf[7] = 0x07;
            pu8buf[9] = u16X1 & 0xff;
            pu8buf[10] = (u16X1 >> 8) & 0xff;
            pu8buf[11] = (u16Y1+0x20) & 0xff;
            pu8buf[12] = ((u16Y1+0x20) >> 8) & 0xff;
            pu8buf[13] = 2;
        }
        else if (u8IsX1Send04)     /* touchUp */
        {
            u8IsX1Send04 = 0;
            pu8buf[1] = 0x04;
            pu8buf[3] = 0x00;
            pu8buf[4] = 0x04;
            pu8buf[5] = u16Y1 & 0xff;
            pu8buf[6] = (u16Y1 >> 8) & 0xff;
            pu8buf[7] = 0x04;
            pu8buf[9] = 0x00;
            pu8buf[10] = 0x04;
            pu8buf[11] = (u16Y1+0x20) & 0xff;
            pu8buf[12] = ((u16Y1+0x20) >> 8) & 0xff;
            pu8buf[13] = 2;

            if (u16Y1 == 0x0100)
            {
                pu8buf[5] = 0xE0;
                pu8buf[6] = 0x02;
                pu8buf[11] = 0x00;
                pu8buf[12] = 0x03;
            }
            else
            {
                pu8buf[5] = (u16Y1-0x50) & 0xff;
                pu8buf[6] = ((u16Y1-0x50) >> 8) & 0xff;
                pu8buf[11] = ((u16Y1+0x20)-0x50) & 0xff;
                pu8buf[12] = (((u16Y1+0x20)-0x50) >> 8) & 0xff;
            }
        }
        else
        {
            pu8buf[1] = 0;
            pu8buf[3] = 0;
            pu8buf[4] = 0;
            pu8buf[5] = 0;
            pu8buf[6] = 0;
            pu8buf[7] = 0;
            pu8buf[9] = 0;
            pu8buf[10] = 0;
            pu8buf[11] = 0;
            pu8buf[12] = 0;
            pu8buf[13] = 0;
        }

        if ((u32ReportCount % 6) == 0)
            u16X1 += 0x3;

        if (u16X1 > 0x0400)
        {
```

```
            u16X1 = 0x01f0;
            u16Y1 += 0x50;
            if (u16Y1 > 0x0300)
                u16Y1 = 0x0100;
        }
```

最後設定端點2的資料長度來回傳資料。

```
        g_u8EP2Ready = 0;
        USBD_SET_PAYLOAD_LEN(EP2, 14);
    }
}
```

2.3 Descriptor.c

2.3.1 HID Report Descriptor

HID_DigitizerReportDescriptor是此觸控裝置的HID報告描述元。此描述元定義了表 2中的資料格式。

欄位的相關資料可以參考微軟公司官方網站和USB開發者論壇(USB-IF)的HID Usage Table。

```
/*!<USB HID Report Descriptor */
const uint8_t HID_DigitizerReportDescriptor[] =
{
    0x05, 0x0D,         // USAGE_PAGE (Digitizers)
    0x09, 0x04,         // USAGE (Touch Screen)
    0xA1, 0x01,         // COLLECTION (Application)
    0x85, 0x01,         // REPORT_ID (1)
    0x09, 0x22,         // USAGE (Finger)

    0xA1, 0x02,         // COLLECTION (Logical)
    0x09, 0x42,         // USAGE (Tip Switch)
    0x15, 0x00,         // LOGICAL_MINIMUM (0)
    0x25, 0x01,         // LOGICAL_MAXIMUM (1)
    0x75, 0x01,         // REPORT_SIZE (1)
    0x95, 0x01,         // REPORT_COUNT (1)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x09, 0x32,         // USAGE (In Range)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x09, 0x47,         // USAGE (Touch Valid)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x95, 0x05,         // REPORT_COUNT (5)
    0x81, 0x03,         // INPUT (Cnst,Ary,Abs)
    0x75, 0x08,         // REPORT_SIZE (8)
    0x09, 0x51,         // USAGE (Contact Identifier)
    0x95, 0x01,         // REPORT_COUNT (1)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x05, 0x01,         // USAGE_PAGE (Generic Desktop)
    0x75, 0x10,         // REPORT_SIZE (16)
    0x55, 0x0E,         // UNIT_EXPONENT (-2)
    0x65, 0x11,         // UNIT (Centimeter)
    0x09, 0x30,         // USAGE (X)
    0x35, 0x00,         // PHYSICAL_MINIMUM (0)
    0x46, 0xE3, 0x13,   // PHYSICAL_MAXIMUM (0x13E3)
    0x26, 0x7F, 0x07,   // LOGICAL_MAXIMUM (0x77F)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x09, 0x31,         // USAGE (Y)
    0x46, 0x2F, 0x0B,   // PHYSICAL_MAXIMUM (0xB2F)
    0x26, 0x37, 0x04,   // LOGICAL_MAXIMUM (0x437)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
```

```
    0xC0,               // END_COLLECTION

    0xA1, 0x02,         // COLLECTION (Logical)
    0x05, 0x0D,         // USAGE_PAGE (Digitizers)
    0x09, 0x42,         // USAGE (Tip Switch)
    0x15, 0x00,         // LOGICAL_MINIMUM (0)
    0x25, 0x01,         // LOGICAL_MAXIMUM (1)
    0x75, 0x01,         // REPORT_SIZE (1)
    0x95, 0x01,         // REPORT_COUNT (1)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x09, 0x32,         // USAGE (In Range)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x09, 0x47,         // USAGE (Touch Valid)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x95, 0x05,         // REPORT_COUNT (5)
    0x81, 0x03,         // INPUT (Cnst,Ary,Abs)
    0x75, 0x08,         // REPORT_SIZE (8)
    0x09, 0x51,         // USAGE (Contact Identifier)
    0x95, 0x01,         // REPORT_COUNT (1)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x05, 0x01,         // USAGE_PAGE (Generic Desktop)
    0x75, 0x10,         // REPORT_SIZE (16)
    0x55, 0x0E,         // UNIT_EXPONENT (-2)
    0x65, 0x11,         // UNIT (Centimeter)
    0x09, 0x30,         // USAGE (X)
    0x35, 0x00,         // PHYSICAL_MINIMUM (0)
    0x46, 0xE3, 0x13,   // PHYSICAL_MAXIMUM (0x13E3)
    0x26, 0x7F, 0x07,   // LOGICAL_MAXIMUM (0x77F)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x46, 0x2F, 0x0B,   // PHYSICAL_MAXIMUM (0xB2F)
    0x26, 0x37, 0x04,   // LOGICAL_MAXIMUM (0x437)
    0x09, 0x31,         // USAGE (Y)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0xC0,               // END_COLLECTION

    0x05, 0x0D,         // USAGE_PAGE (Digitizers)
    0x09, 0x54,         // USAGE (Contact Count)
    0x15, 0x00,         // LOGICAL_MINIMUM (0)
    0x26, 0xFF, 0x00,       // LOGICAL_MAXIMUM (0x00FF)
    0x95, 0x01,         // REPORT_COUNT (1)
    0x75, 0x08,         // REPORT_SIZE (8)
    0x81, 0x02,         // INPUT (Data,Var,Abs)
    0x09, 0x55,         // USAGE (Contact Count Maximum)
    0x25, 0x02,         // LOGICAL_MAXIMUM (2)
    0x95, 0x01,         // REPORT_COUNT (1)
    0x85, 0x02,         // REPORT_ID (2)
    0xB1, 0x02,         // FEATURE (Data,Var,Abs)
    0xC0                // END_COLLECTION
};
```

2.3.2 Configuration Descriptor

USB主機需要組態描述元(Configuration Descriptor)來辨識裝置。gu8ConfigDescriptor是此範例使用的組態描述元，裡面含有1組介面的描述。“bNumInterfaces”欄位設定為1，讓USB主機知道此裝置有1組介面。介面描述元(Interface Descriptor)，HID描述元(HID descriptor)和端點描述元(Endpoint Descriptor)，依序列於組態描述元之後。

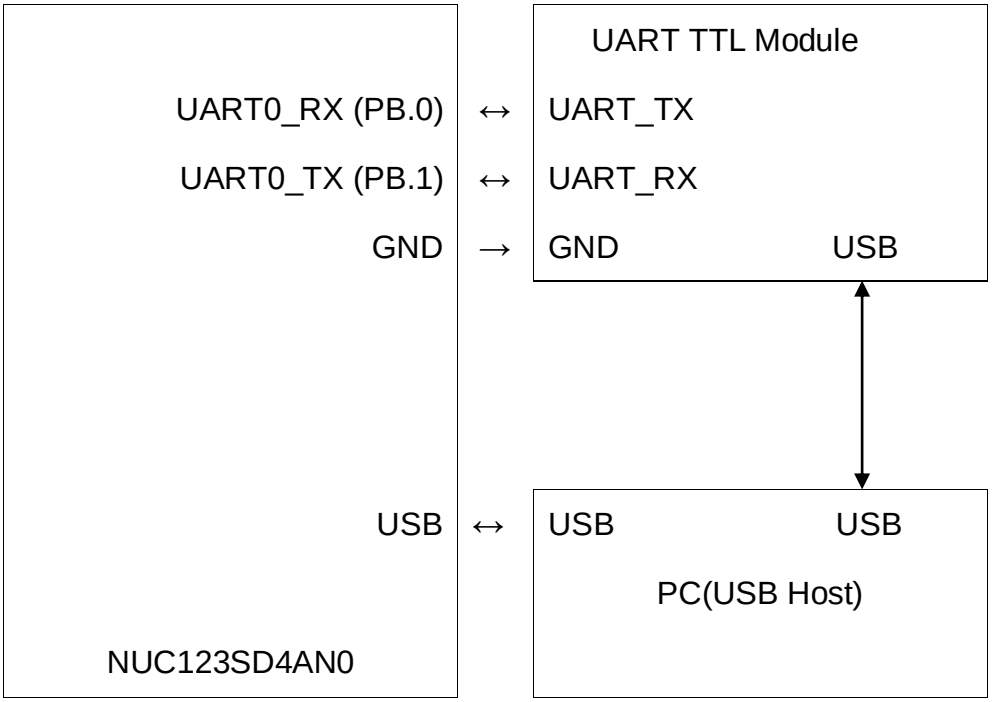
```
/*!<USB Configure Descriptor */
const uint8_t gu8ConfigDescriptor[] =
{
    LEN_CONFIG,     /* bLength */
```

```
    DESC_CONFIG,    /* bDescriptorType */
    /* wTotalLength */
    LEN_CONFIG_AND_SUBORDINATE & 0x00FF,
    ((LEN_CONFIG_AND_SUBORDINATE & 0xFF00) >> 8),
    0x01,           /* bNumInterfaces */
    0x01,           /* bConfigurationValue */
    0x00,           /* iConfiguration */
    0x80 | (USBD_SELF_POWERED << 6) | (USBD_REMOTE_WAKEUP << 5),/* bmAttributes */
    USBD_MAX_POWER, /* MaxPower */

    /* I/F descr: HID */
    LEN_INTERFACE,  /* bLength */
    DESC_INTERFACE, /* bDescriptorType */
    0x00,           /* bInterfaceNumber */
    0x00,           /* bAlternateSetting */
    0x01,           /* bNumEndpoints */
    0x03,           /* bInterfaceClass */
    0x00,           /* bInterfaceSubClass */
    HID_NONE,       /* bInterfaceProtocol */
    0x00,           /* iInterface */

    /* HID Descriptor */
    LEN_HID,        /* Size of this descriptor in UINT8s. */
    DESC_HID,       /* HID descriptor type. */
    0x10, 0x01,     /* HID Class Spec. release number. */
    0x00,           /* H/W target country. */
    0x01,           /* Number of HID class descriptors to follow. */
    DESC_HID_RPT,   /* Descriptor type. */
    /* Total length of report descriptor. */
    sizeof(HID_DigitizerReportDescriptor) & 0x00FF,
    ((sizeof(HID_DigitizerReportDescriptor) & 0xFF00) >> 8),

    /* EP Descriptor: interrupt in. */
    LEN_ENDPOINT,   /* bLength */
    DESC_ENDPOINT,  /* bDescriptorType */
    (INT_IN_EP_NUM | EP_INPUT), /* bEndpointAddress */
    EP_INT,         /* bmAttributes */
    /* wMaxPacketSize */
    EP2_MAX_PKT_SIZE & 0x00FF,
    ((EP2_MAX_PKT_SIZE & 0xFF00) >> 8),
    HID_DEFAULT_INT_IN_INTERVAL     /* bInterval */
};
```

3 軟體與硬體環境

- **軟體環境**
  - BSP 版本
    - NUC123 Series BSP CMSIS V3.01.001
  - IDE 版本
    - Keil uVersion 5.26
  - USB 封包擷取工具
    - USBLyzer (http://www.usblyzer.com/)
- **硬體環境**
  - 電路元件
    - NuTiny-EVB-NUC123-LQFP64 v1.0
    - USB mini USB cable
    - USB-UART TTL(Optional)
    - USB packet analyzer(Optional)

■ 示意圖


UART TTL Module
UART0_RX (PB.0)
↔
UART_TX
UART0_TX (PB.1)
↔
UART_RX
GND
→
GND
USB
USB
↔
USB
USB
PC(USB Host)
NUC123SD4AN0

4 目錄資訊

- EC_NUC123_USBD_HID_Touch_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 如何執行範例程式

1. 根據目錄資訊章節進入 ExampleCode 路徑中的 KEIL 資料夾，雙擊 NUC123_USBD_HID_Touch.uvproj。
2. 進入編譯模式介面
   a. 編譯
   b. 下載代碼至記憶體
   c. 進入 / 離開除錯模式
3. 進入除錯模式介面
   a. 執行代碼

6 修訂紀錄

Date	Revision	Description
Nov. 01, 2019	1.00	1. 初始發佈.

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