AN13079
UART to HID Mouse based on FRDM-KE15Z Board

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Contents

1 Introduction

This application note describes how to implement the function of UART to HID mouse on K20. NXP's Kinetis series FRDM boards provide an onboard debugger with JTAG interface, using K20DX128VFM5 as the onboard debugger. K20DX128VFM5 is a Cortex$^{®}$-M4 core processor, it contains the following features:

- The main frequency is up to 50 MHz.
- The flash size is 160 KB.
- The SRAM size is 16 KB.
- It is euqipped with an FS USB device controller.

Kinetis E series MCUs have a Touch Sensing Input (TSI) module. Users may need to use the UART to HID mouse module to display the TSI demo more intuitively and convert touch events into corresponding HID mouse behaviors. This application note takes FRDM-KE15Z board as an example to implement the function of UART to HID mouse on K20. This example implements the function of setting the relative position and absolute position of the mouse through UART commands.

Figure 1 shows the system block diagram.

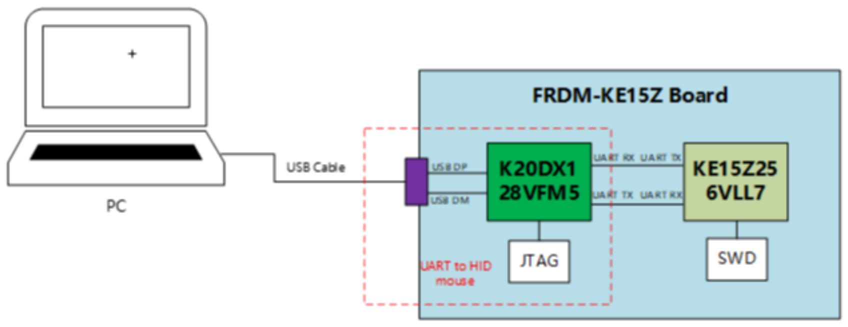


Figure 1. Block diagram of UART to HID mouse on FRDM-KE15Z board

2 Required environment

2.1 Hardware

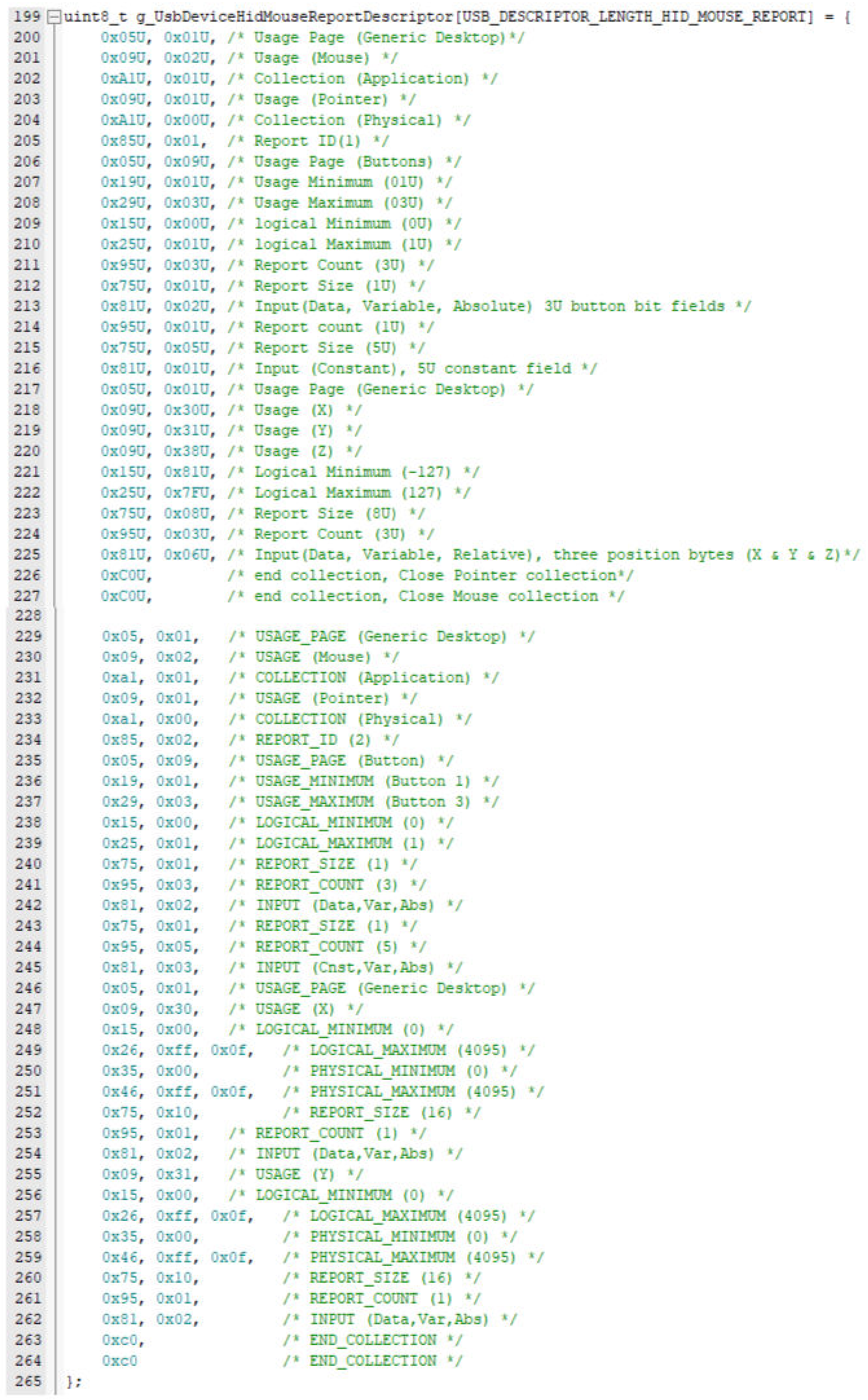
- FRDM-KE15Z board
- A USB cable
- PC

2.2 Software

Since NXP does not provide SDK examples for K20DX128VFM5, this application note implements the function of K20 UART to USB HID mouse based on the *usb_device_hid_mouse* project in TWK-K60 SDK. For details, see AN13079SW.

3 USB HID mouse descriptor

The K60 *SDK usb_device_hid_mouse* example only implements the function of setting the relative position of the mouse. In order to implement the function of setting the absolute position of the mouse, a new HID report descriptor, report ID 2, needs to be added to the original HID report descriptor. The complete HID report descriptor is as shown in Figure 2.



```
uint8_t g_UsbDeviceHidMouseReportDescriptor[USB_DESCRIPTOR_LENGTH_HID_MOUSE_REPORT] = {
    0x05U, 0x01U, /* Usage Page (Generic Desktop)*/
    0x09U, 0x02U, /* Usage (Mouse) */
    0xA1U, 0x01U, /* Collection (Application) */
    0x09U, 0x01U, /* Usage (Pointer) */
    0xA1U, 0x00U, /* Collection (Physical) */
    0x85U, 0x01,  /* Report ID(1) */
    0x05U, 0x09U, /* Usage Page (Buttons) */
    0x19U, 0x01U, /* Usage Minimum (01U) */
    0x29U, 0x03U, /* Usage Maximum (03U) */
    0x15U, 0x00U, /* logical Minimum (0U) */
    0x25U, 0x01U, /* logical Maximum (1U) */
    0x95U, 0x03U, /* Report Count (3U) */
    0x75U, 0x01U, /* Report Size (1U) */
    0x81U, 0x02U, /* Input(Data, Variable, Absolute) 3U button bit fields */
    0x95U, 0x01U, /* Report count (1U) */
    0x75U, 0x05U, /* Report Size (5U) */
    0x81U, 0x01U, /* Input (Constant), 5U constant field */
    0x05U, 0x01U, /* Usage Page (Generic Desktop) */
    0x09U, 0x30U, /* Usage (X) */
    0x09U, 0x31U, /* Usage (Y) */
    0x09U, 0x38U, /* Usage (Z) */
    0x15U, 0x81U, /* Logical Minimum (-127) */
    0x25U, 0x7FU, /* Logical Maximum (127) */
    0x75U, 0x08U, /* Report Size (8U) */
    0x95U, 0x03U, /* Report Count (3U) */
    0x81U, 0x06U, /* Input(Data, Variable, Relative), three position bytes (X & Y & Z)*/
    0xC0U,        /* end collection, Close Pointer collection*/
    0xC0U,        /* end collection, Close Mouse collection */

    0x05, 0x01,   /* USAGE_PAGE (Generic Desktop) */
    0x09, 0x02,   /* USAGE (Mouse) */
    0xa1, 0x01,   /* COLLECTION (Application) */
    0x09, 0x01,   /* USAGE (Pointer) */
    0xa1, 0x00,   /* COLLECTION (Physical) */
    0x85, 0x02,   /* REPORT_ID (2) */
    0x05, 0x09,   /* USAGE_PAGE (Button) */
    0x19, 0x01,   /* USAGE_MINIMUM (Button 1) */
    0x29, 0x03,   /* USAGE_MAXIMUM (Button 3) */
    0x15, 0x00,   /* LOGICAL_MINIMUM (0) */
    0x25, 0x01,   /* LOGICAL_MAXIMUM (1) */
    0x75, 0x01,   /* REPORT_SIZE (1) */
    0x95, 0x03,   /* REPORT_COUNT (3) */
    0x81, 0x02,   /* INPUT (Data,Var,Abs) */
    0x75, 0x01,   /* REPORT_SIZE (1) */
    0x95, 0x05,   /* REPORT_COUNT (5) */
    0x81, 0x03,   /* INPUT (Cnst,Var,Abs) */
    0x05, 0x01,   /* USAGE_PAGE (Generic Desktop) */
    0x09, 0x30,   /* USAGE (X) */
    0x15, 0x00,   /* LOGICAL_MINIMUM (0) */
    0x26, 0xff, 0x0f,   /* LOGICAL_MAXIMUM (4095) */
    0x35, 0x00,         /* PHYSICAL_MINIMUM (0) */
    0x46, 0xff, 0x0f,   /* PHYSICAL_MAXIMUM (4095) */
    0x75, 0x10,         /* REPORT_SIZE (16) */
    0x95, 0x01,   /* REPORT_COUNT (1) */
    0x81, 0x02,   /* INPUT (Data,Var,Abs) */
    0x09, 0x31,   /* USAGE (Y) */
    0x15, 0x00,   /* LOGICAL_MINIMUM (0) */
    0x26, 0xff, 0x0f,   /* LOGICAL_MAXIMUM (4095) */
    0x35, 0x00,         /* PHYSICAL_MINIMUM (0) */
    0x46, 0xff, 0x0f,   /* PHYSICAL_MAXIMUM (4095) */
    0x75, 0x10,         /* REPORT_SIZE (16) */
    0x95, 0x01,         /* REPORT_COUNT (1) */
    0x81, 0x02,         /* INPUT (Data,Var,Abs) */
    0xc0,               /* END_COLLECTION */
    0xc0                /* END_COLLECTION */
};
```

Figure 2. HID mouse report descriptor

Report descriptor 1, report id 1, is used to set the relative position of the mouse. Report descriptor 2, report id 2, is used to set the absolute position of the mouse. Table 1 and Table 2 describe the data structure of the USB HID mouse corresponding to the report descriptor.

Table 1. Data format of report descriptor 1

Report 1	Descriptor
Byte 0	Report ID – Must be 0x01
Byte 1	• bit7: — 1: The change of Y coordinate exceeds the range of -256-255. — 0: No overflow • bit6: — 1: The change of X coordinate exceeds the range of -256-255. — 0: No overflow • bit5: Sign bit of Y coordinate — 1: The mouse moves to the right. • bit4: Sign bit of X coordinate. — 1: The mouse moves to the left. • bit3: Always 1 • bit2: — 1: Middle button press • bit1 — 1: Right click • bit0: — 1: Left click
Byte 2	Change value in X coordinate
Byte 3	Change value in Y coordinate
Byte 4	Wheel change

Table 2. Data format of report descriptor 1

Report 2	Descriptor
Byte 0	Report ID – Must be 0x02
Byte 1	• bit7: — 1: The change of Y coordinate exceeds the range of -256-255. — 0: No overflow • bit6:

Table continues on the next page...

Table 2. Data format of report descriptor 1 (continued)

Report 2	Descriptor
	— 1: The change of X coordinate exceeds the range of -256-255. — 0: No overflow • **bit5**: Sign bit of Y coordinate — 1: The mouse moves to the right. • **bit4**: Sign bit of X coordinate. — 1: The mouse moves to the left. • **bit3**: Always 1 • **bit2**: — 1: Middle button press • **bit1** — 1: Right click • **bit0**: — 1: Left click
Byte 2	Low 8 bits of X coordinate
Byte 3	High 8 bits of X coordinate
Byte 4	Low 8 bits of Y coordinate
Byte 5	High 8 bits of Y coordinate

4 UART to HID mouse protocol

This section introduces the implementation of the UART to HID mouse commands, including two commands to set the absolute position and relative position of the mouse.

Table 3. UART to HID mouse commands

Command	Description
CMD_SEND_MS_ABS_DATA	Set absolute position of the mouse
CMD_SEND_MS_REL_DATA	Set relative position of the mouse

4.1 Set absolute position of the mouse

Use the `CMD_SEND_MS_ABS_DATA` command to set the absolute position of the mouse. Table 4 describes the corresponding UART data format.

Table 4. Data format of CMD_SEN_MS_ABS_DATA command

HEAD	ADDR	CMD	LEN	DATA field	SUM[1]
0x57, 0xAB	0x00	0x04	7	7-byte data	0x?

1. SUM = HEAD + ADDR + CMD + LEN + DATA

This command has a 7-byte data field. Table 5 describes the specific content of data field.

Table 5. Data field of CMD_SEND_MS_ABS_DATA command

Data field	Description
Byte 0	Must be 0x02
Byte 1	• Bit 0: Left button • Bit 1: Right button • Bit 2: Middle button • Bit 3 - Bit 7: 0 • Bit 0 - Bit2: — 1: The button is pressed. — 0: The button is released or not pressed.
Byte 2, 3	Two bytes of X-axis coordinate value. The high byte follows the low byte.
Byte 4, 5	Two bytes of Y-axis coordinate value. The high byte follows the low byte.
Byte 6	Wheel variation • 0: The wheel does not move. • 0x01-0x7F: The wheel scrolls up. • 0x81-0xFF: The wheel scrolls down.

After receiving the complete UART command from KE15Z, K20 sends a response to KE15Z. Table 6 describes the data format of response.

Table 6. The response of CMD_SEND_MS_ABS_DATA command

HEAD	ADDR	CMD	LEN	DATA	SUM
0x57, 0xAB	0x00	0x84	1	1-byte data	0x?

The returned 1-byte data field indicates the current command execution status, which can be defined by the user.

The default absolute mouse resolution in the USB HID descriptor is 4096 × 4096. When KE15Z sends the absolute position in the X and Y coordinates, it needs to be calculated according to the actual screen resolution, and then sends the calculated value.

For example, the current screen resolution is: X_MAX(1920) × Y_MAX(1080). To move the mouse to the point (100,100), you need to perform the following calculation:

```
X1 = (4096 × 100) / X_MAX;
Y1 = (4096 × 100) / Y_MAX;
```

The calculation results are as follows:

```
X1 = ( 100 × 4096 ) / 1920 = 213 = 0xD5
Y1 = ( 100 × 4096 ) / 1080 = 379 = 0x17B
```

The KE15Z sends the UART data packet, `0x57 0xAB 0x00 0x04 0x07 0x02 0x00 0xD5 0x00 0x7B 0x01 0x00 0x60`, to K20. After receiving the UART command, K20 parses the UART data and sends it to the PC according to the HID mouse data format to implement the function of setting the absolute position of the mouse. At the same time, K20 responds to KE15Z with data of `0x57 0xAB 0x00 0x84 0x01 0x00 0x87` through UART interface to tell the KE15Z that the UART command is successfully received.

4.2 Set relative position of the mouse

Use the `CMD_SEND_MS_REL_DATA` command to set the relative position of the mouse. Table 7 describes the corresponding UART data format.

Table 7. Data format of CMD_SEN_MS_REL_DATA command

HEAD	ADDR	CMD	LEN	DATA	SUM
0x57, 0xAB	0x00	0x05	5	5-byted data	0x?

This command has a 5-byte data field. Table 8 describes the specific content of data field.

Table 8. Data field of CMD_SEND_MS_REL _DATA command

Data field	Description
Byte 0	Must be 0x01
Byte 1	• Bit 0: Left button • Bit 1: Right button • Bit 2: Middle button • Bit 3 - Bit 7: 0 • Bit 0 - Bit 2: — 1: The button is pressed. — 0: The button is released or not pressed.
Byte 2	1 byte of pixels moved in X direction
Byte 3	1 byte of pixels moved in Y direction
Byte 4	Wheel variation • 0: The wheel does not move. • 0x01-0x7F: Wheel scrolls up. • 0x81-0xFF: Wheel scrolls down.

After receiving the complete UART command from KE15Z, K20 sends a response to KE15Z. Table 9 describes the data format of response.

Table 9. The response of CMD_SEND_MS_REL _DATA command

HEAD	ADDR	CMD	LEN	DATA	SUM
0x57, 0xAB	0x00	0x85	1	1-byte data	0x?

Here is an example of how to set the mouse to move three pixels to the left.

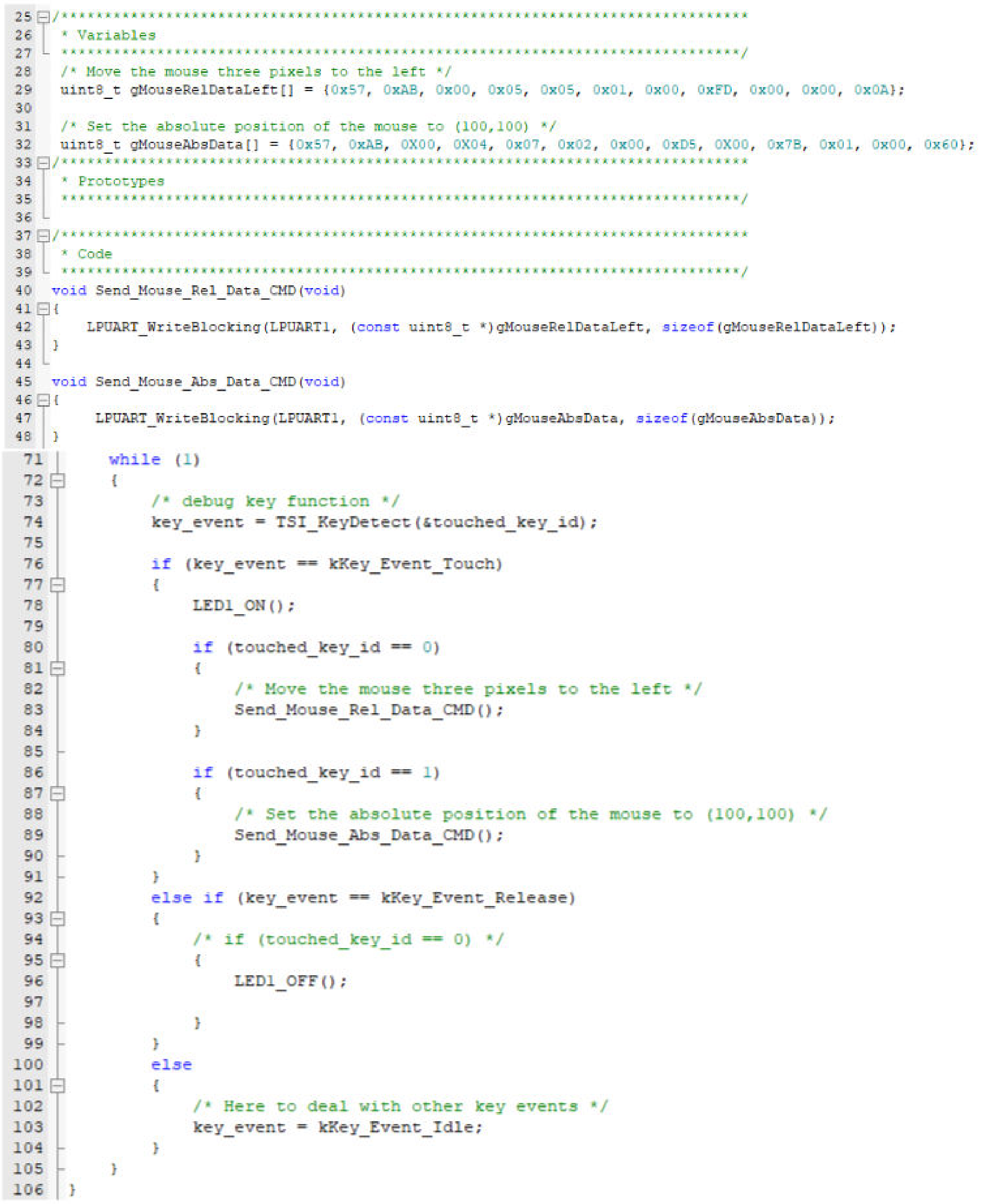
1. KE15Z sends UART data, `0x57 0xAB 0x00 0x05 0x05 0x01 0x00 0xFD 0x00 0x00 0x0A`, to K20.
2. After receiving the UART command, K20 parses the UART data and sends it to the PC according to the HID mouse data format to implement the function of setting the relative position of the mouse.
3. At the same time, K20 responds to KE15Z with the data of `0x57 0XAB 0x00 0x85 0x01 0x00 0x88` through UART interface to tell the KE15Z that the UART command has been successfully received.

5 Function test

This section describes how to control the relative position and absolute position of the mouse through the two touch buttons on the FRDM-KE15Z board.

The steps are as follows:

1. Download the *K20_UART_to_HID_Mouse* project through K20's JTAG interface, **J11**.
2. Open the `tsi_v5_selfmode` example in the KE15Z SDK and add the function of sending `CMD_SEND_MS_ABS_DATA` and `CMD_SEND_MS_REL_DATA` commands via UART (add the code in Figure 3 to the *main.c* file of the *tsi_v5_selfmode* project).



```
/*******************************************************************************
 * Variables
 ******************************************************************************/
/* Move the mouse three pixels to the left */
uint8_t gMouseRelDataLeft[] = {0x57, 0xAB, 0x00, 0x05, 0x05, 0x01, 0x00, 0xFD, 0x00, 0x00, 0x0A};

/* Set the absolute position of the mouse to (100,100) */
uint8_t gMouseAbsData[] = {0x57, 0xAB, 0X00, 0X04, 0x07, 0x02, 0x00, 0xD5, 0X00, 0x7B, 0x01, 0x00, 0x60};
/*******************************************************************************
 * Prototypes
 ******************************************************************************/

/*******************************************************************************
 * Code
 ******************************************************************************/
void Send_Mouse_Rel_Data_CMD(void)
{
    LPUART_WriteBlocking(LPUART1, (const uint8_t *)gMouseRelDataLeft, sizeof(gMouseRelDataLeft));
}

void Send_Mouse_Abs_Data_CMD(void)
{
     LPUART_WriteBlocking(LPUART1, (const uint8_t *)gMouseAbsData, sizeof(gMouseAbsData));
}
    while (1)
    {
        /* debug key function */
        key_event = TSI_KeyDetect(&touched_key_id);

        if (key_event == kKey_Event_Touch)
        {
            LED1_ON();

            if (touched_key_id == 0)
            {
                /* Move the mouse three pixels to the left */
                Send_Mouse_Rel_Data_CMD();
            }

            if (touched_key_id == 1)
            {
                /* Set the absolute position of the mouse to (100,100) */
                Send_Mouse_Abs_Data_CMD();
            }
        }
        else if (key_event == kKey_Event_Release)
        {
            /* if (touched_key_id == 0) */
            {
                LED1_OFF();

            }
        }
        else
        {
            /* Here to deal with other key events */
            key_event = kKey_Event_Idle;
        }
    }
}
```

Figure 3. Add the function of sending UART HID command in tsi_v5_selfmode example

Then compile the project and download the program to KE15Z through the SWD interface, **J17**.

3. Reset the board.
   - Press the E1 touch button, and the mouse pointer on the PC will move three pixels to the left.
   - Press the E2 touch button, and the mouse pointer on the PC will move to (100,100).

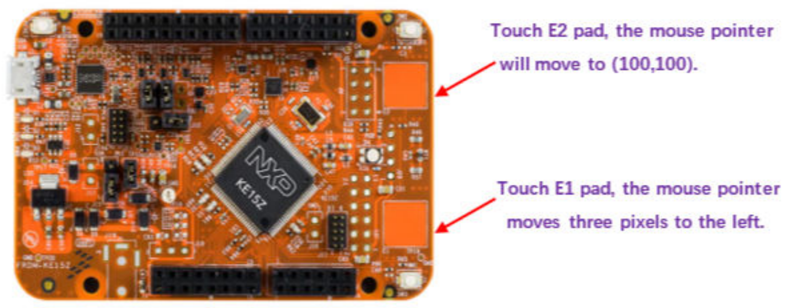

Touch E2 pad, the mouse pointer will move to (100,100).
Touch E1 pad, the mouse pointer moves three pixels to the left.

Figure 4. FRDM-KE15Z board

Users can also connect their own touchpads to the FRDM-KE15Z board and use the function of UART to HID Mouse to display their demos more intuitively. For more details on the function implement, see AN13079SW.

6 Reference

- CH9329 Data sheet
- *Kinetis KE1xZ with up to 256 KB Flash* (document KE1xZP100M72SF0)
- *K20 Sub-Family Reference Manual* (document K20P32M50SF0RM)

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