PIC32 DEVELOPMENT

A Design Project Report

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Submitted by

Qinrong Yu

MEng Field Advisor: Prof. Bruce R Land

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Abstract

Master of Engineering Program

School of Electrical and Computer Engineering

Cornell University

Design Project Report

Project Title: PIC32 Development

Author: Qinrong Yu

Abstract:

PIC32 is Microchip's 32-bit microcontroller. It offers high performance and all tools to develop embedded projects. It is widely used as learning materials in microcontroller courses. ECE4760 is upgrading its learning material now. They are going to adopt PIC32 microcontroller as study object. The aim of this project is to provide a complete USB module that can be used in the course directly. This project mainly focuses on the development of USB module of PIC32, enabling the USB port to transfer data between end devices (mouse and keyboard) and the microcontroller PIC32MX250F128B. Both software code and hardware verification are necessary for the project. Certain data transfer functions were realized. When a devices such as a keyboard or a mouse plug in to the USB interface of PIC32, PIC32 is able to get every letter we type on a keyboard or get every input command we click on a mouse.

Keywords:

PIC32, USB

Executive Summary

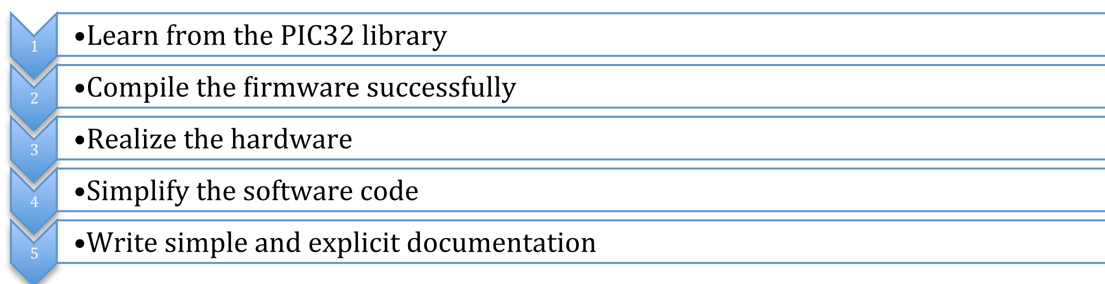
PIC32 microcontroller is a powerful, 32-bit CPU with many peripherals and available libraries. It is a good tool for students to understand and practice microcontroller. This project mainly focuses on the development of USB module of PIC32, enabling the USB port to transfer data between end devices (mouse and keyboard) and the microcontroller PIC32MX250F128B.

Both software code and hardware verification are necessary for the project. Certain data transfer functions were realized. When a devices such as a keyboard or a mouse plug in to the USB interface of PIC32, PIC32 is able to get every letter we type on a keyboard or get every input command we click on a mouse.

The final outcome is a finished working USB module and can be used by students in Course ECE4760 to incorporate into their course work directly.

Approach

The approach of the project is shown in the following chart.



The project adopts a development board on which a microcontroller PIC32MX250F128B is integrated. We used the Microstick II from Microchip Technology Inc. as the development board. Besides, as this project is to enable data transfer of USB port, a USB board is necessary. There are a variety of USB boards on market. For this designing project, USB Type A Female Breakout board is used. The USB picture is shown in Figure.1. It has a USB interface requiring 2 power wires (VCC, GND) and 2 data wires (D+ and D-). For the purpose of showing results in real time, a serial port board is also necessary. The serial port is used to enable communication between the microcontroller and a computer, thus enabling displaying results on the screen of a computer. Putty application is used to show the results [1].

For developing tools, C is used as the programming language and MPLAB IDE is used as the development environment [2]. XC32 is used as compiler [3].

The microcontroller acts as the "host" in the USB protocol while end devices such as a keyboard or a mouse takes the "device" role. The software code part refers to the microchip library. To start with, I learnt from the PIC32 library and got familiar with USB protocol. Microchip provides a library containing a variety of application for different series of Microchip microcontrollers. The library gives clear examples of how to use USB modules and explains how USB protocol works well. The USB applications provided by the library, however, can't work properly on our board. The possible explanation is that the library is for all series of microcontrollers. Some adjustments were made to make the applications work on our specific board. The adjustments will be stated in the section of key issues addressed.

After the completion of software code, the hardware verification was carried out. Firstly, the microcontroller should be able to work normally. A power supply of 3.3V should be given to the Vusb3.3v pin to enable USB function of PIC32. The pin diagram of PIC32MX250F128B is shown in Figure.2. Then the external USB board should be connected to the microcontroller correctly. The data wires (D+, D-) should be connected to PIN 21, PIN 22 of PIC32MX250F128B and the power supply wires (VCC, GND) should be connected to the board to share the same ground power with the microcontroller. (Shown in Figure.1) After that, serial port board should be connected to the microcontroller. The data wires (Rx, Tx) were connected to PIN 17, PIN 25 of PIC32.

Then, debug the program to ensure the USB interface works properly to transfer data between end devices and the microcontrollers. The debugging process was actually carried out step by step. I first debug microcontroller and did some simple tests to prove that PIC32 was working. Then after USB board was connected, I tested to see if the board was working appropriately. As the data transmitted from the end devices was stored in data buffers and parsed according to the USB protocol, I checked the related buffers in the variable window to see whether the transmitted data was correct. For instance, when a mouse was clicked on a right button and moved to the right, certain bit indicating the right button in the data buffer should be set to 1 and the coordinate of the mouse should be set the current location. Then, after serial port board

was connected, I tested to see if the results could be displayed on the screen of the computer correctly. This step-by-step debugging approach enabled me to find errors or mistakes one by one, and helped me a lot. For example, there was a time when no results were shown on the screen. Since I knew that PIC32 and USB board were both working fine, I focused on serial port board only, which was much more efficient than checking everything.

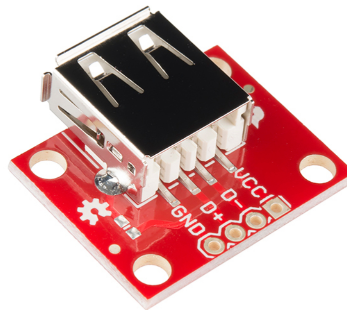


Figure 1. USB Type A Female Breakout Board [4]

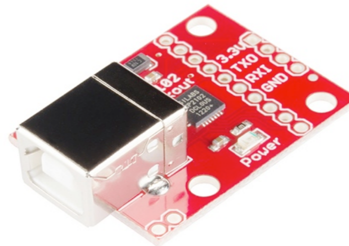
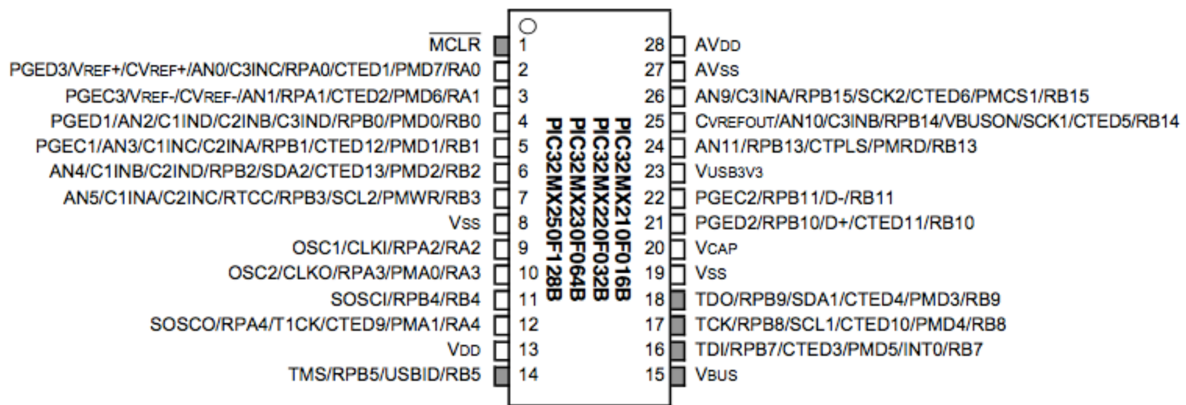


Figure 2. USB to Serial Breakout - CP2102 [5]



Microstick II PIC32 PDIP

Figure.2 PIC32 Pin Diagram [6]

Key issues addressed

Hardware Connection

I encountered a problem when carrying out hardware connection. I did the connection according to the pin diagram on the datasheet, but the circuits didn't work anyway. The voltage detected on the pins was not what it should have been. It turned out that the pin diagram of PIC32MX250F128B in the data sheet didn't correspond to the real pin design on the development board. The real layout pin diagram should have been the one that I referred to. After I re-did the connection, the voltage on each pin was correct.

External Power

Another issue is that the USB board requires a power supply of 5V. As the microcontroller can merely provide a power supply of 3.3V, which is not enough for the USB board, an external power supply is necessary. And also, the USB port and the development board should share the same ground.

Oscillator Configuration

After all the hardware connection was done, I started to debug the program. However, the message "The target device is not ready for debugging. Please check your configuration bit

settings and program the device before proceeding" was shown on the output window every time I tried to initiated a debug. I referred to the documents and found that there might be 3 possible causes for this problem. Firstly, the oscillator might have not been operating correctly, so that the microcontroller was not able to run the code. Then, I needed to ensure that the debug pins set in the configuration bits is the same one that the debugger (starter kit PKOB) on the development board was physically connected to. Last but not least, the inappropriate load on the debug pins might have contributed to the problem. To solve the problem, I started with checking the oscillator first. I found that the firmware set the system clock to be 60Mhz. However, the configuration bits for system clock were set as follows:

```
    #pragma config FNOSC       = FRCPLL        // Oscillator Selection, select internal oscillator
    #pragma config FPLLMUL    = MUL_20       // PLL Multiplier
    #pragma config FPLLIDIV = DIV_2              // PLL Input Divider
    #pragma config FPLLODIV = DIV_1              // PLL Output Divider
```

From the oscillator diagram, a part of which is shown in Figure.3, we can easily find that the system clock is get from the equation:

$$SYSCLK = \frac{OscFreq \times FPLLMUL}{FPLLIDIV \times FPLLODIV}$$

However, with the default configuration bits, the system clock would be $SYSCLK = \frac{8MHz \times 20}{2 \times 1} = 80MHz$, which was not corresponding with 60MHz. Therefore, I modified the configuration bits to the following and the system clock was 60MHz.

```
#pragma config FPLLMUL    = MUL_15       // PLL Multiplier
#pragma config FPLLIDIV = DIV_2              // PLL Input Divider
#pragma config FPLLODIV = DIV_1              // PLL Output Divider
```

Then for the debug pins, I found that there was a switch SW2 on the development board controlling which pair of pins to use. SW2 was switched to PEGCA and PEGDA side, so I modified the configuration bit from

```
#pragma config ICESEL     = ICS_PGx2        // ICE/ICD Comm Channel Select
```

to

```
#pragma config ICESEL     = ICS_PGx1        // ICE/ICD Comm Channel Select.
```

After all the modification was done, the debug process was able to start without any error message.

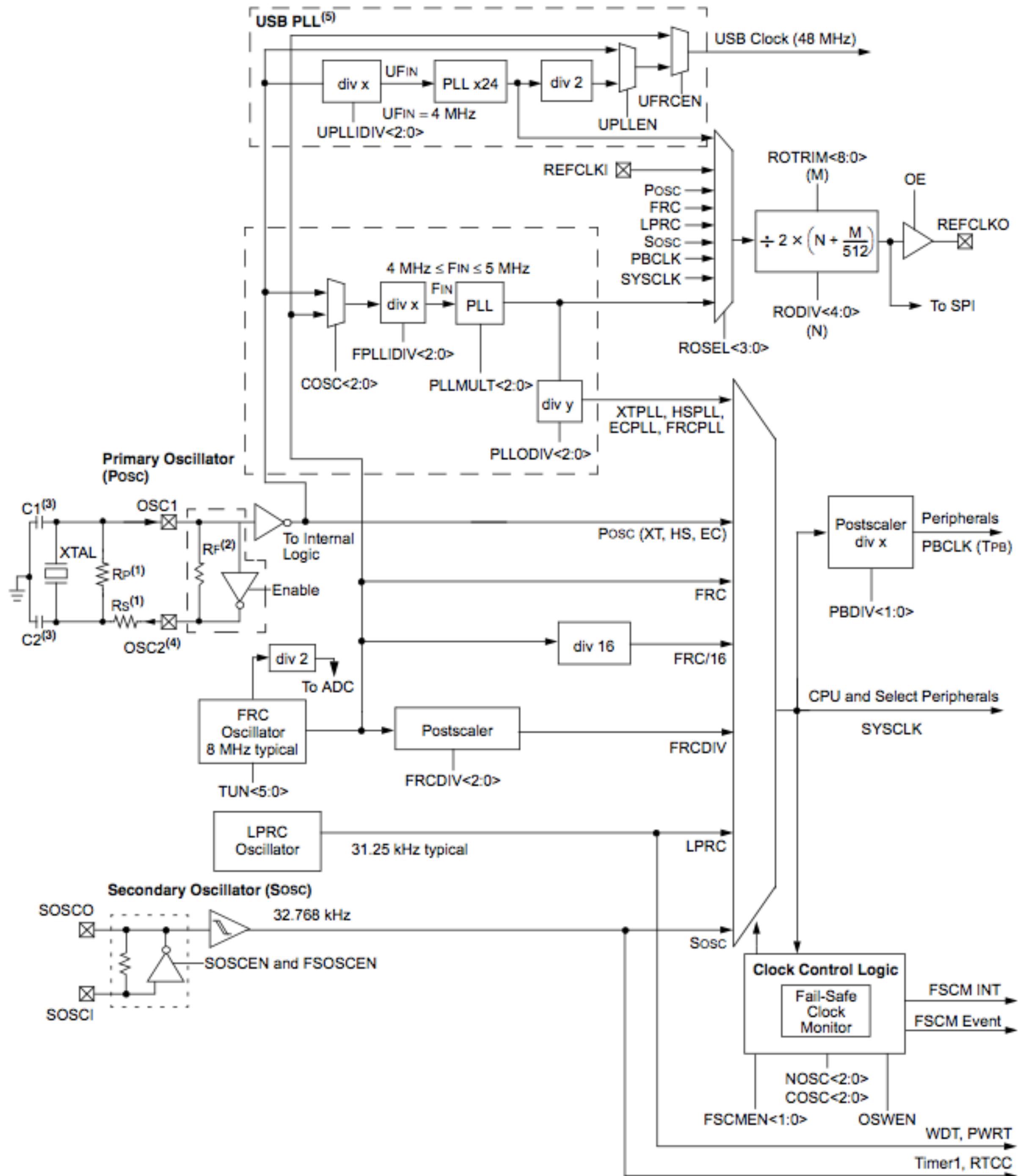


Figure.3 Oscillator diagram [6]

During debugging, I found that whenever I plugged a mouse into the USB port, the USB module of the microcontroller was not able to detect the device. The state machine was always stuck in state DEVICE_NOT_CONNECTED. I checked the diagram of USB module and found that the

possible cause might be the use of internal oscillator FRC. USB module could not use FRC. The reason is that the internal oscillator is fed into USB module directly without passing through a PLL as we can see in Figure 4. The oscillator part of PIC32 USB interface diagram is shown in Figure 4. Therefore, 8MHz of FRC is far from enough to provide the USB module with the required 48MHz clock. The possible solution is to put an external oscillator to the OSC1 and OSC2 pins with some configuration circuits. As the USB module needs a 48 MHz clock, the external oscillator of 8 MHz will be adequate. To ensure the external oscillator work properly, the ground should be placed as close as possible to the oscillator. Then the configuration bits were modified to be:

```
#pragma config UPLLEN      = ON              // USB PLL Enable
#pragma config UPLLIDIV = DIV_2              // USB PLL Input Divider
#pragma config FNOSC       = PRIPLL          // Oscillator Selection: select primary oscillator
```

// As the USB PLL is by default set to be 24 and then divided by 2 (shown in Figure 3), there is no need to specifically set USBPLL.

As for the configuration circuits for the external oscillator, the OSC1 and OSC2 pins should both be connected to a capacitor and then connected to the ground. The configuration circuit is shown in Figure 3. The capacitors would be 20~30 pF for an oscillator of 8MHz. Since the capacitors are so small that the breadboard can provide enough capacitance, so I just put an 8MHz crystal oscillator on OSC1 and OSC2 pins without any additional connections. Resistor Rs may be required cut crystals or to eliminate clipping. RP is used to increase oscillator circuit gain, add a parallel resistor, with a value of 1 MΩ. [6]

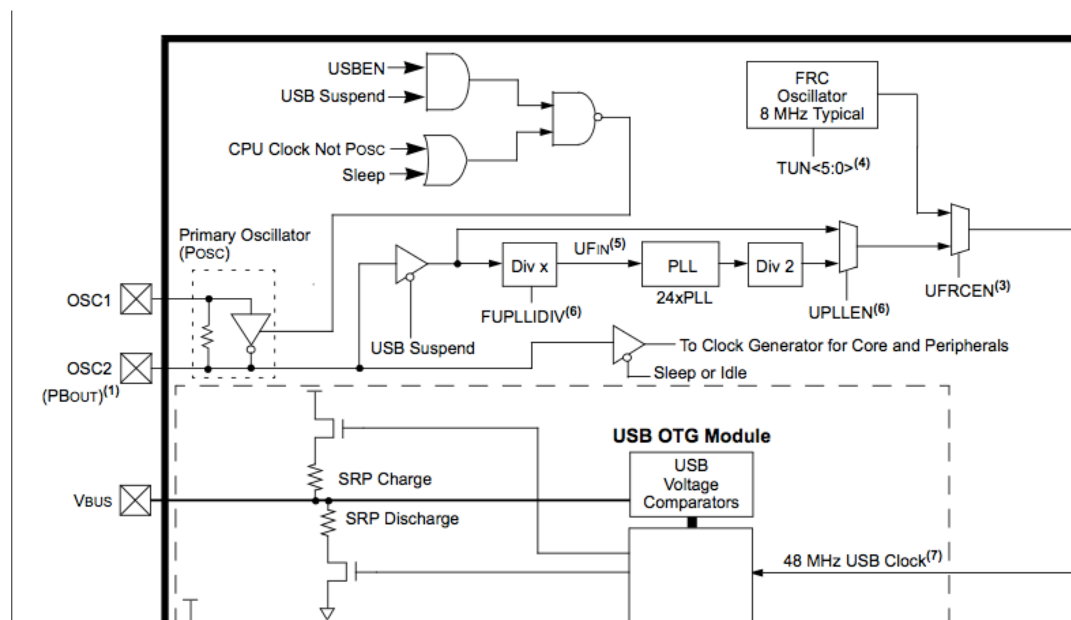


Figure 4. PIC32 USB OTG Interface Diagram (Clock Part)

Serial Port Configuration

Serial port board has two data wires Rx and Tx. Two pins on PIC32 should be mapped to be TX and RX[8]. The configuration part is as following.

```
//specify PPS group, signal, logical pin name
PPSInput (2, U2RX, RPB8); //Assign U2RX to pin RPB8 -- Physical pin 17 on 28 PDIP
PPSOutput(4, RPB14, U2TX); //Assign U2TX to pin RPB14 -- Physical pin 25 on 28 PDIP
```

Then configure UART communication in a higher lever[8]. The code part is as following.

```
UARTConfigure(UART2, UART_ENABLE_PINS_TX_RX_ONLY);
UARTSetLineControl(UART2, UART_DATA_SIZE_8_BITS | UART_PARITY_NONE | UART_STOP_BITS_1);
UARTSetDataRate(UART2, PB_FREQ, BAUDRATE);
UARTEnable(UART2, UART_ENABLE_FLAGS(UART_PERIPHERAL | UART_RX | UART_TX));
```

Data Processing

For mouse data processing, the input report parsing process didn't get out all the data I needed. It only produced data of the button clicked and the movement of scroll wheel. But the movement of mouse is also a key parameter. Therefore, I looked into the data parsing process

and got the data of relative coordinate of X-Y axis in the input report. In addition, the output format is not easy to read. So I reorganize the output data in a way that data for each button or movement is clear.

The Button data is stored in Appl_Button_report_buffer, where data of left button stores in the 0th bit and data of right button stores in the 1th bit. The scroll weel data is stored in Appl_raw_report_buffer.ReportData[3]. The movement of mouse representing in X-Y axis is stored in Appl_XY_report_buffer, where data of X-axis is stored in bit 0 and that of Y-axis is stored in bit 1. The modified code segment is shown in the following. The data is much easy to read.

```
UART2PrintString( "\n\r    Left Bt :    " ); UART2PutHex( Appl_Button_report_buffer[0]);
UART2PrintString( "\n\r    Right Bt :    " ); UART2PutHex( Appl_Button_report_buffer[1]);
UART2PrintString( "\n\r    X-Axis :    " ); UART2PutHex( Appl_XY_report_buffer[0]);
UART2PrintString( "\n\r    Y-Axis :    " ); UART2PutHex( Appl_XY_report_buffer[1]);
UART2PrintString( "\n\r    Scroll :    " ); UART2PutHex( Appl_raw_report_buffer.ReportData[3]);
```

Besides, the results are shown on the screen every certain interval, which could make our output data very huge and useless. What I really need is the updated data when there is any operation on the mouse. So I added a Boolean type flag to distinguish between useful data and useless data, and only showed the data when there was any change. The code is shown in the following.

```
unsigned int i;
BOOL flag = 0;
for(i=0;i<(Appl_raw_report_buffer.ReportSize);i++){
     if(Appl_raw_report_buffer.ReportData[i]){
            flag = 1;
       }
  }
if(flag){
   UART2PrintString( "\n\rHID: Raw Report    " );
              for(i=0;i<(Appl_raw_report_buffer.ReportSize);i++)
```

```
        {
            UART2PutHex( Appl_raw_report_buffer.ReportData[i]);
            if(Appl_raw_report_buffer.ReportData[i]){
                flag = 1;
            }
            UART2PrintString( "-" );
        }
UART2PrintString( "\n\r    Left Bt :    " ); UART2PutHex( Appl_Button_report_buffer[0]);
UART2PrintString( "\n\r    Right Bt :    " ); UART2PutHex( Appl_Button_report_buffer[1]);
UART2PrintString( "\n\r    X-Axis :    " ); UART2PutHex( Appl_XY_report_buffer[0]);
UART2PrintString( "\n\r    Y-Axis :    " ); UART2PutHex( Appl_XY_report_buffer[1]);
UART2PrintString( "\n\r    Scroll :    " ); UART2PutHex( Appl_raw_report_buffer.ReportData[3]);
}
```

The final output data for mouse is shown in Figure 9.

For the keyboard part, the input report parsing function didn't handle some important special characters including backspace, space. I added some functions to handle these corner cases. In addition, I'm not confortable with the output format either. So I reorganized the format to display whatever I typed on the screen and got rid of useless displayed information. The following codes were added to handle some important characters.

```
if(a == 0x2c){         // handle space command
return(0x20);
}
if(a == 0x2a){             // handle backspace command
return(0x08) ;
}
```

The final output data for keyboard is shown in Figure 10.

Results

The final outcome is a finished working USB module. The picture of the development board is shown in the Figure 6.

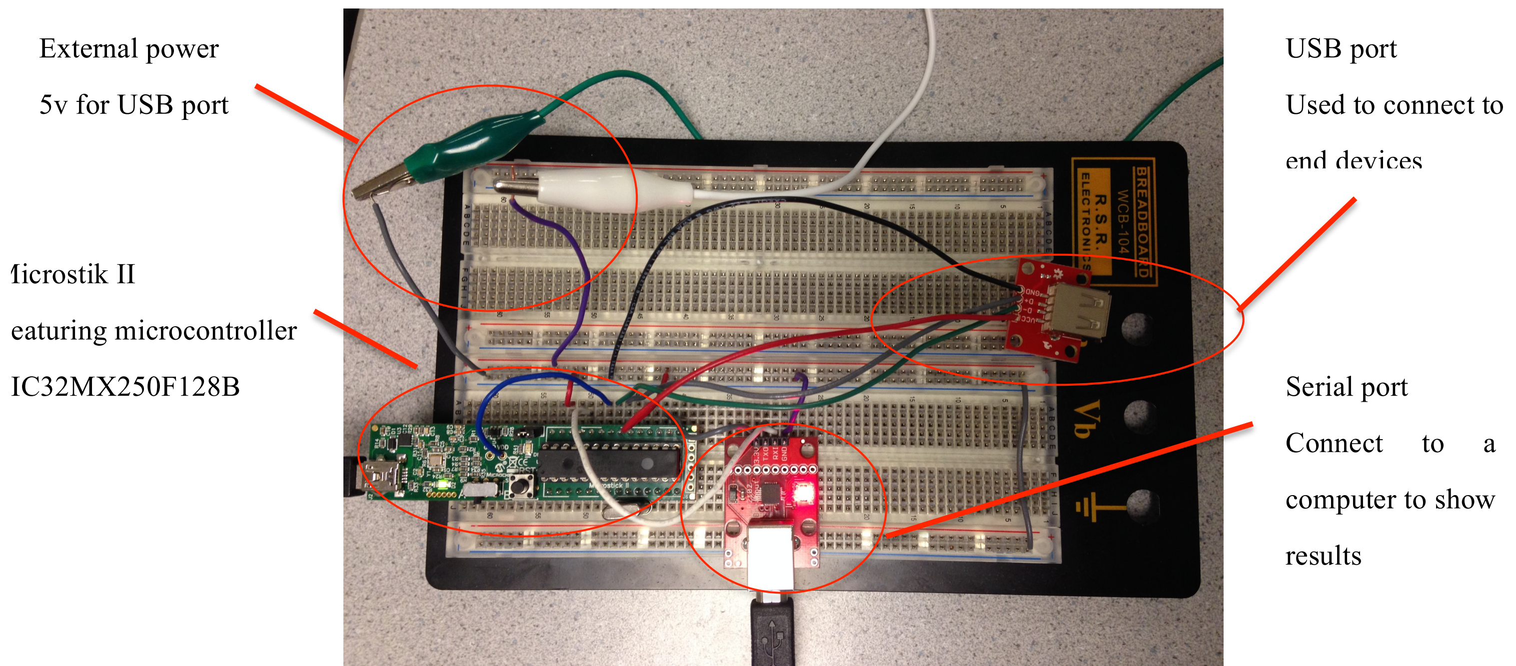


Figure 6. The picture of the development board

PuTTY is used to display the results. The serial line should be set properly. And the baud rate should be set the same as that of PIC32. In my case, it's 9600. The putty window is shown in Figure 7.

The displayed information shows that the microcontroller is able to handle typing on keyboard correctly, including characters (both upper and lower cases), digits, symbols and some special characters such as Caps lock, Num lock, Space and Backspace and so on. The displayed information is shown in Figure 8. If Caps lock is typed, the following characters will all shown in upper cases. If Num lock is typed, the microcontroller won't handle input from the digits area, which is on the right of the keyboard. The microcontroller can respond immediately on every input.

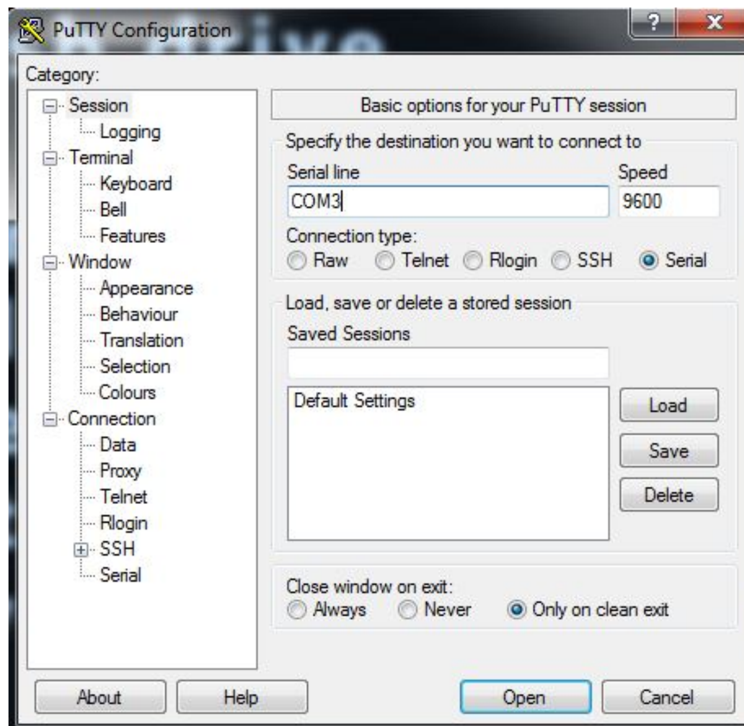


Figure 7. The configuration of PuTTY

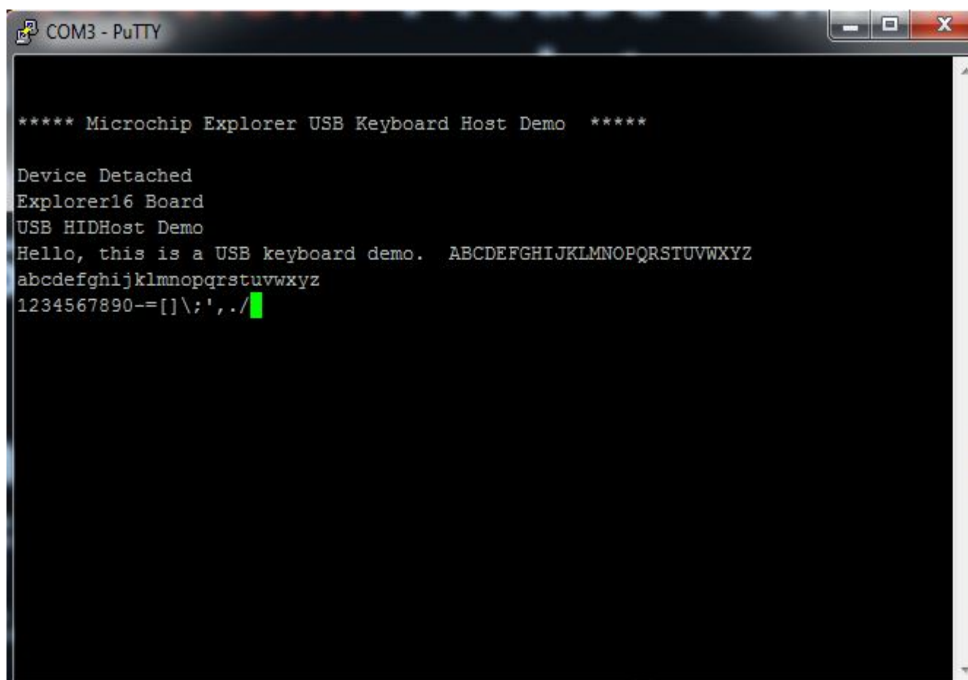


Figure 8. The screen shot of demo of keyboard

The tests for the mouse part were designed to check button clicks first, then scroll wheel, and finally X-Y axis movements. The results for button clicks were shown in Figure 9. I clicked left button and right button in order. The results show that the microcontroller can process button click correctly and in the correct order.

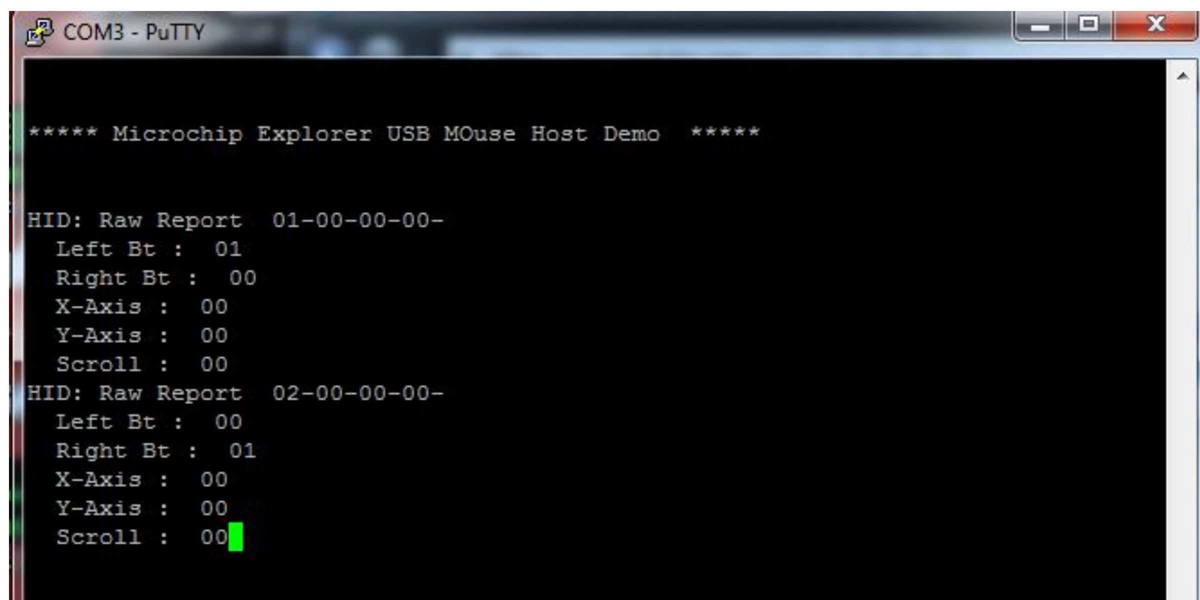


Figure 9. The screen shot of button clicks on mouse

For scroll wheel tests, I scrolled up and down. The results were shown in Figure 10. When I scrolled up, the data in Scroll line showed a positive integer. In this test, I scrolled up a little bit, so the integer is only 0x01. When I scrolled down, the results showed a negative integer. The negative indicates the scrolling direction, and the absolute value indicates how much I scrolled. As I scrolled down a little bit, the result is 0xFF (absolute value: 0x01). After that, I tested how microcontroller reacted if I scrolled the scroll wheel with larger movement. The result is shown in Figure 11. The results display larger values as integer 0x02 when I scrolled up, and integer 0xFA When I scroll down (absolute value 0x06).

The tests and results shows that the microcontroller can process scroll wheel commands correctly. PIC32 is able to distinguish different scrolling directions (up and down), and different scrolling length.

For mouse movement tests, I moved the mouse to different directions and checked the results to see if it matched. The results were signed integers. Directions were distinguished between

positive and negative integers. Right and down movements were in positive integers while left and up in negative. And the absolute values gave the relative movement position. Since the movement detection is very sensible, there would be a series of results shown on the screen with a little move. So I write the results into log for the purpose of checking. The results are shown in Figure 12. The results shows that the microcontroller can process mouse movements correctly.

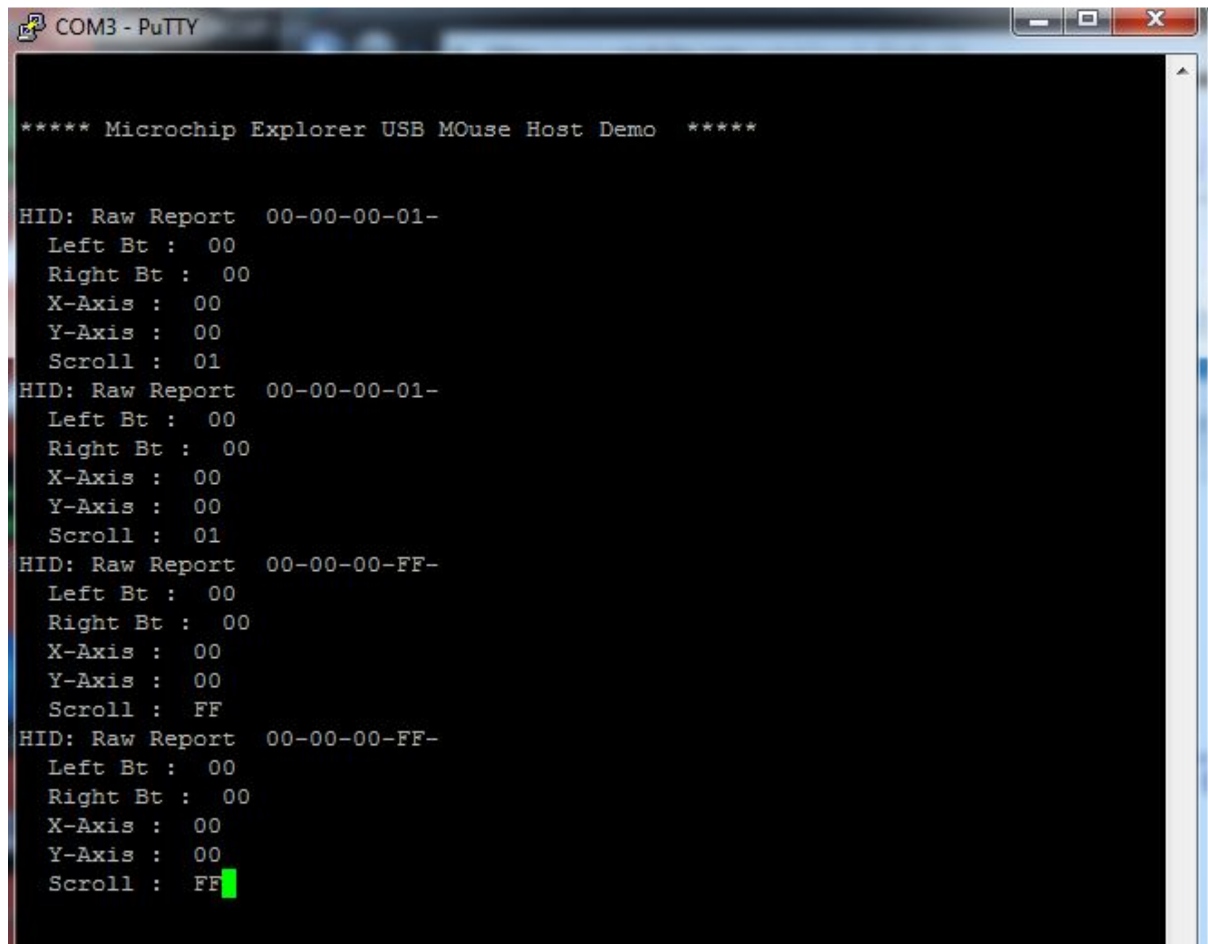


Figure 10. The screen shot of scroll wheel on mouse (a)

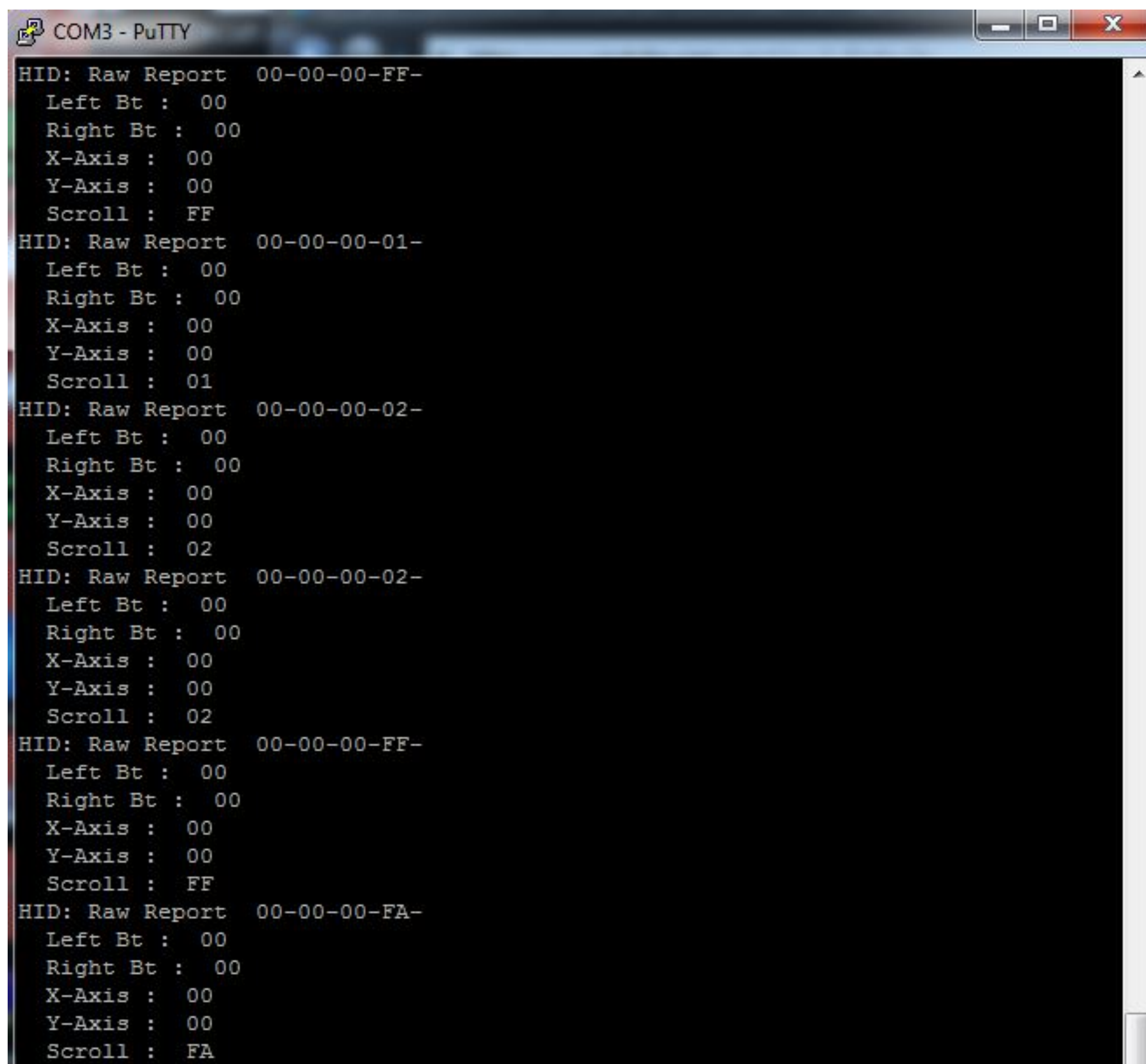


Figure 11. The screen shot of scroll wheel on mouse (b)

```
=~=~=~=~=~=~=~=~=~=~=~= PuTTY log 2015.05.17 15:26:05 =~=~=~=~=~=~=~=~=~=~=~=

***** Microchip Explorer USB MOuse Host Demo  *****

HID: Raw Report  00-02-00-00-
  Left Bt :  00
  Right Bt :  00
  X-Axis :  02
  Y-Axis :  00
  Scroll :  00
HID: Raw Report  00-74-F2-00-
  Left Bt :  00
  Right Bt :  00
  X-Axis :  74
  Y-Axis :  F2
  Scroll :  00
HID: Raw Report  00-7F-FF-00-
  Left Bt :  00
  Right Bt :  00
  X-Axis :  7F
  Y-Axis :  FF
  Scroll :  00
```

Figure 12. The screen shot of log of mouse movements

Conclusions

PIC32 is able to process end devices (mouse and keyboard) request immediately and correctly. The results can be displayed on the screen in real time.

The keyboard demo takes about 48% of the program space of PIC32. The mouse demo takes about 51% of the program space of PIC32. Although there is still space left for other programs, it would be better to simplify the firmware to give more space for other programs.

Acknowledgements

I would like to thank my advisor Bruce Land for his advice, encouragement, and continued support of this project.

I would like to thank Alex Whiteway for his help and kindness of this project.

I would also like to thank my family and friends for their support.

References

[1] http://www.putty.org

[2] http://www.microchip.com/pagehandler/en-us/family/mplabx/

[3] http://www.microchip.com/forums/f251.aspx

[4] https://www.sparkfun.com/products/12700?gclid=COGrybOTxMUCFVGRHwodraQAdg

[5] Microchip PIC32MX1XX/2XX family datasheet

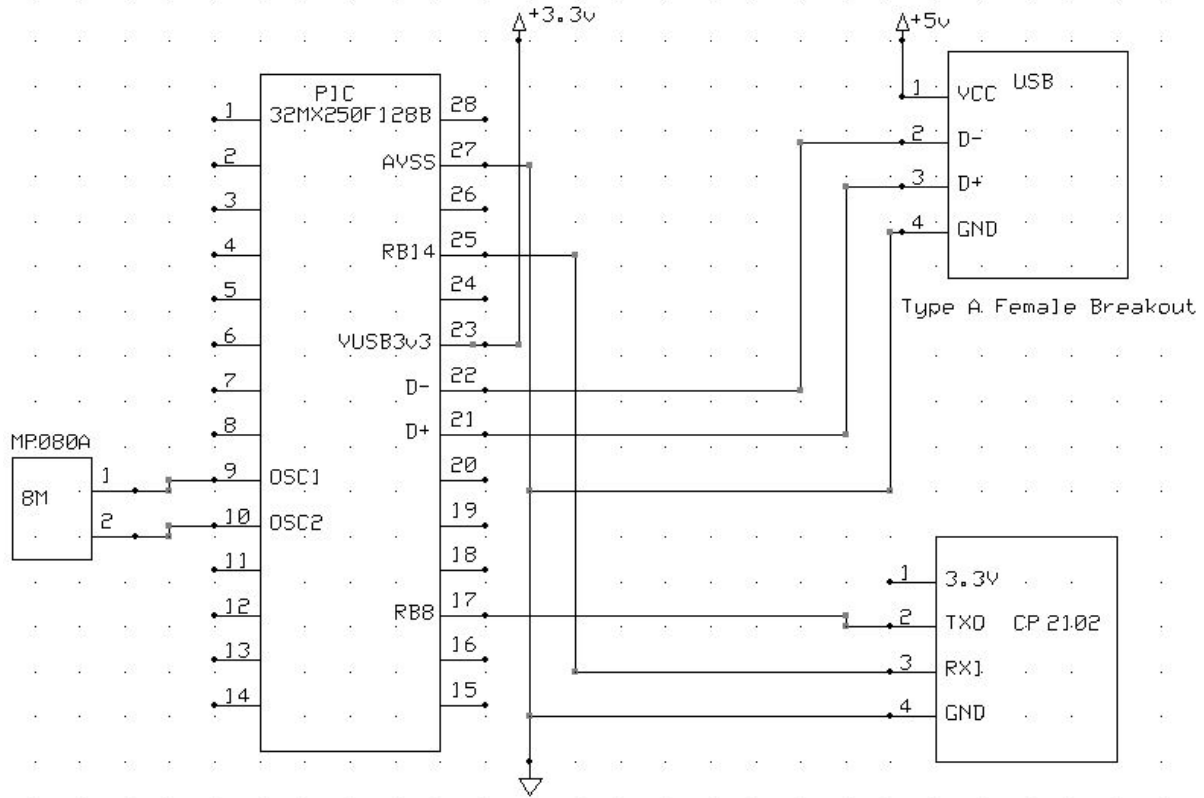
[6] PIC32 Family Reference Manual 6 Oscillators

[7] PIC32 Family Reference Manual 27 USB OTG

[8] http://people.ece.cornell.edu/land/courses/ece4760/PIC32/index.html

Appendix

1. schematic diagram for circuits



2. demo file for mouse and keyboard

/**

USB Mouse Host Application Demo

Description:

This file contains the basic USB Mouse application demo. Purpose of the demo

is to demonstrate the capability of HID host . Any Low speed/Full Speed

USB Mouse can be connected to the PICtail USB adapter along with

Explorer 16 demo board. This file schedules the HID ransfers, and interprets

the report received from the mouse. X & Y axis coordinates, Left & Right Click

received from the mouse are diaplayed on the the LCD display mounted on the

Explorer 16 board. Demo gives a fair idea of the HID host and user should be

```
      able to incorporate necessary changes for the required application.

      Below is the format in which the information received from mouse is displayed

      on the LCD didsplay.

        ----------------

      |X: 0x--    Y: 0x--|

      |LFT: -      RHT: - |

        ----------------


Summary:

  This file contains the basic USB mouse application.


Remarks:

      This demo requires Explorer 16 board and the USB PICtail plus connector.


*******************************************************************************/

//DOM-IGNORE-BEGIN

/*******************************************************************************

* File Name:           Mouse_demo.c

* Dependencies:        None

* Processor:           PIC24FJ256GB110

* Compiler:            C30 v2.01

* Company:             Microchip Technology, Inc.


Software License Agreement

The software supplied herewith by Microchip Technology Incorporated


*******************************************************************************/

//DOM-IGNORE-END


//#define _SUPRESS_PLIB_WARNING

#define _SUPPRESS_PLIB_WARNING
```

```
#include <stdlib.h>

#include <string.h>

#include <stdio.h>

#include "GenericTypeDefs.h"

#include "HardwareProfile.h"

#include "usb_config.h"

#include "lcd_demo.h"

#include "USB/usb.h"

#include "USB/usb_host_hid_parser.h"

#include "USB/usb_host_hid.h"



#if defined(__dsPIC33EP512MU810__)||defined(__PIC24EP512GU810__)


/* While using the dsPIC33EPxx USB PIM

 * the LCD on the Explorer 16 board may

 * not function as expected. The demo

 * uses the Explorer 16 UART connector

 * to display data. Connect the UART port

 * to a PC COM port and run hyperterminal

 * at 57600 baud. */

#define DEBUG_MODE


#endif


//#define DEBUG_MODE

// *****************************************************************************

// *****************************************************************************

// Constants

// *****************************************************************************

// *****************************************************************************


// We are taking Timer 3   to schedule input report transfers
```

```
// NOTE - The datasheet doesn't state this, but the timer does get reset to 0
// after a period register match.    So we don't have to worry about resetting
// the timer manually.

#define STOP_TIMER_IN_IDLE_MODE          0x2000
#define TIMER_SOURCE_INTERNAL            0x0000
#define TIMER_ON                         0x8000
#define GATED_TIME_DISABLED              0x0000
#define TIMER_16BIT_MODE                 0x0000

#define TIMER_PRESCALER_1                0x0000
#define TIMER_PRESCALER_8                0x0010
#define TIMER_PRESCALER_64               0x0020
#define TIMER_PRESCALER_256              0x0030
#define TIMER_INTERRUPT_PRIORITY         0x0001
// useful ASCII/VT100 macros for PuTTY
#define clrscr() printf( "\x1b[2J")
#define home()      printf( "\x1b[H")

// ******************************************************************************
// ******************************************************************************
// Configuration Bits
// ******************************************************************************
// ******************************************************************************

#if defined __C30__ || defined __XC16__
    #if defined(__PIC24FJ256GB110__)
        _CONFIG2(FNOSC_PRIPLL & POSCMOD_HS & PLL_96MHZ_ON & PLLDIV_DIV2 & IESO_OFF) // Primary HS
OSC with PLL, USBPLL /2
        _CONFIG1(JTAGEN_OFF & FWDTEN_OFF & ICS_PGx2)      // JTAG off, watchdog timer off
    #elif defined(__PIC24FJ64GB004__)
```

```
        _CONFIG1(WDTPS_PS1 & FWPSA_PR32 & WINDIS_OFF & FWDTEN_OFF & ICS_PGx1 & GWRP_OFF &
GCP_OFF & JTAGEN_OFF)
        _CONFIG2(POSCMOD_HS & I2C1SEL_PRI & IOL1WAY_OFF & OSCIOFNC_ON & FCKSM_CSDCMD &
FNOSC_PRIPLL & PLL96MHZ_ON & PLLDIV_DIV2 & IESO_OFF)
        _CONFIG3(WPFP_WPFP0 & SOSCSEL_SOSC & WUTSEL_LEG & WPDIS_WPDIS & WPCFG_WPCFGDIS &
WPEND_WPENDMEM)
        _CONFIG4(DSWDTPS_DSWDTPS3 & DSWDTOSC_LPRC & RTCOSC_SOSC & DSBOREN_OFF & DSWDTEN_OFF)
    #elif defined(__PIC24FJ256GB106__)
        _CONFIG1( JTAGEN_OFF & GCP_OFF & GWRP_OFF & FWDTEN_OFF & ICS_PGx2)
        _CONFIG2( PLL_96MHZ_ON & IESO_OFF & FCKSM_CSDCMD & OSCIOFNC_OFF & POSCMOD_HS &
FNOSC_PRIPLL & PLLDIV_DIV3 & IOL1WAY_ON)
    #elif defined(__PIC24FJ256DA210__) || defined(__PIC24FJ256GB210__)
        _CONFIG1(FWDTEN_OFF & ICS_PGx2 & GWRP_OFF & GCP_OFF & JTAGEN_OFF)
        _CONFIG2(POSCMOD_HS & IOL1WAY_ON & OSCIOFNC_ON & FCKSM_CSDCMD & FNOSC_PRIPLL &
PLL96MHZ_ON & PLLDIV_DIV2 & IESO_OFF)
     #elif defined(__dsPIC33EP512MU810__)||defined(__PIC24EP512GU810__)
        _FOSCSEL(FNOSC_FRC);
        _FOSC(FCKSM_CSECMD & OSCIOFNC_OFF & POSCMD_XT);
        _FWDT(FWDTEN_OFF);
    #else
    #endif
#elif defined( __PIC32MX__ )
    #pragma config UPLLEN    = ON            // USB PLL Enabled
    //#pragma config FPLLMUL  = MUL_20       // PLL Multiplier
    #pragma config FPLLMUL   = MUL_15        // PLL Multiplier
    #pragma config UPLLIDIV = DIV_2          // USB PLL Input Divider
    #pragma config FPLLIDIV = DIV_2          // PLL Input Divider
    #pragma config FPLLODIV = DIV_1          // PLL Output Divider
    #pragma config FPBDIV    = DIV_1         // Peripheral Clock divisor
    #pragma config FWDTEN    = OFF           // Watchdog Timer
    #pragma config WDTPS     = PS1           // Watchdog Timer Postscale
    #pragma config FCKSM     = CSDCMD        // Clock Switching & Fail Safe Clock Monitor
    #pragma config OSCIOFNC = OFF            // CLKO Enable
```

```
    //#pragma config POSCMOD    = HS             // Primary Oscillator
    #pragma config POSCMOD    = XT              // Primary Oscillator
    #pragma config IESO       = OFF             // Internal/External Switch-over
    #pragma config FSOSCEN    = OFF             // Secondary Oscillator Enable (KLO was off)
    #pragma config FNOSC      = PRIPLL          // Oscillator Selection
    //#pragma config FNOSC      = FRCPLL          // Oscillator Selection
    #pragma config CP         = OFF             // Code Protect
    #pragma config BWP        = OFF             // Boot Flash Write Protect
    #pragma config PWP        = OFF             // Program Flash Write Protect
    #pragma config ICESEL     = ICS_PGx1        // ICE/ICD Comm Channel Select
   //USB USID Selection:
  //#pragma FUSBIDIO = ON             //Controlled by the USB Module
 //USB VBUS ON Selection:
  //#pragma FVBUSONIO = ON             //Controlled by USB Module
#define DEBUG_MODE
#else

    #error Cannot define configuration bits.

#endif

// *****************************************************************************
// *****************************************************************************
// Data Structures
// *****************************************************************************
// *****************************************************************************

typedef enum _APP_STATE
{
    DEVICE_NOT_CONNECTED,
    DEVICE_CONNECTED, /* Device Enumerated    - Report Descriptor Parsed */
    READY_TO_TX_RX_REPORT,
    GET_INPUT_REPORT, /* perform operation on received report */
```

```
    INPUT_REPORT_PENDING,
    ERROR_REPORTED
} APP_STATE;

typedef struct _HID_REPORT_BUFFER
{
    WORD    Report_ID;
    WORD    ReportSize;
//      BYTE* ReportData;
    BYTE    ReportData[4];
    WORD    ReportPollRate;
}    HID_REPORT_BUFFER;

// *****************************************************************************
// *****************************************************************************
// Internal Function Prototypes
// *****************************************************************************
// *****************************************************************************
BYTE App_DATA2ASCII(BYTE a);
void AppInitialize(void);
BOOL AppGetParsedReportDetails(void);
void App_Detect_Device(void);
void App_ProcessInputReport(void);
BOOL USB_HID_DataCollectionHandler(void);

void LCDDisplayString(BYTE* data, BYTE lineNum);
void LCD_Display_Routine(BYTE data, BYTE HIDData);

// *****************************************************************************
// *****************************************************************************
// Macros
// *****************************************************************************
// *****************************************************************************
```

```
#define MAX_ALLOWED_CURRENT            (500)         // Maximum power we can supply in mA
#define MINIMUM_POLL_INTERVAL          (0x0A)        // Minimum Polling rate for HID reports is 10ms

#define USAGE_PAGE_BUTTONS             (0x09)

#define USAGE_PAGE_GEN_DESKTOP         (0x01)

#define MAX_ERROR_COUNTER              (10)

#define LCD_LINE_ONE                   (1)
#define LCD_LINE_TWO                   (2)

// ****************************************************************************
// ****************************************************************************
// Global Variables
// ****************************************************************************
// ****************************************************************************

APP_STATE App_State_Mouse = DEVICE_NOT_CONNECTED;

HID_DATA_DETAILS Appl_Mouse_Buttons_Details;
HID_DATA_DETAILS Appl_XY_Axis_Details;

HID_REPORT_BUFFER    Appl_raw_report_buffer;

HID_USER_DATA_SIZE Appl_Button_report_buffer[3];
HID_USER_DATA_SIZE Appl_XY_report_buffer[3];

BYTE LCD_DATA_LINE_ONE[16] = "X: 0x00 Y: 0x00 ";
BYTE LCD_DATA_LINE_TWO[16] = "LFT: 0    RHT: 0    ";
```

```
BYTE ErrorDriver;
BYTE ErrorCounter;
BYTE NumOfBytesRcvd;

BOOL ReportBufferUpdated;
BOOL LED_Key_Pressed = FALSE;
BOOL DisplayConnectOnce = FALSE;
BOOL DisplayDeatachOnce = FALSE;

BYTE currCharPos;
BYTE FirstKeyPressed ;
//******************************************************************************
//******************************************************************************
// USB Support Functions
//******************************************************************************
//******************************************************************************

BOOL USB_ApplicationEventHandler( BYTE address, USB_EVENT event, void *data, DWORD size )
{
    switch( (INT)event )
    {
        case EVENT_VBUS_REQUEST_POWER:
            // The data pointer points to a byte that represents the amount of power
            // requested in mA, divided by two.    If the device wants too much power,
            // we reject it.
            if (((USB_VBUS_POWER_EVENT_DATA*)data)->current <= (MAX_ALLOWED_CURRENT / 2))
            {
                return TRUE;
            }
            else
            {
                UART2PrintString( "\r\n***** USB Error - device requires too much current *****\r\n" );
            }
```

```
        break;

    case EVENT_VBUS_RELEASE_POWER:
        // Turn off Vbus power.
        // The PIC24F with the Explorer 16 cannot turn off Vbus through software.
        return TRUE;
        break;

    case EVENT_HUB_ATTACH:
        UART2PrintString( "\r\n***** USB Error - hubs are not supported *****\r\n" );
        return TRUE;
        break;

    case EVENT_UNSUPPORTED_DEVICE:
        UART2PrintString( "\r\n***** USB Error - device is not supported *****\r\n" );
        return TRUE;
        break;

    case EVENT_CANNOT_ENUMERATE:
        UART2PrintString( "\r\n***** USB Error - cannot enumerate device *****\r\n" );
        return TRUE;
        break;

    case EVENT_CLIENT_INIT_ERROR:
        UART2PrintString( "\r\n***** USB Error - client driver initialization error *****\r\n" );
        return TRUE;
        break;

    case EVENT_OUT_OF_MEMORY:
        UART2PrintString( "\r\n***** USB Error - out of heap memory *****\r\n" );
        return TRUE;
        break;
```

```
        case EVENT_UNSPECIFIED_ERROR:    // This should never be generated.
            UART2PrintString( "\r\n***** USB Error - unspecified *****\r\n" );
            return TRUE;
            break;

          case EVENT_HID_RPT_DESC_PARSED:
                #ifdef APPL_COLLECT_PARSED_DATA
                    return(APPL_COLLECT_PARSED_DATA());
               #else
                     return TRUE;
                #endif
               break;

        default:
            break;
    }
    return FALSE;
}

//******************************************************************************
//******************************************************************************
// Main
//******************************************************************************
//******************************************************************************



int main (void)
{
    BYTE i;

    #if defined (__C30__) || defined __XC16__
        #if defined(__dsPIC33EP512MU810__)||(__PIC24EP512GU810__)
```

```
    // Configure the device PLL to obtain 60 MIPS operation. The crystal
    // frequency is 8MHz. Divide 8MHz by 2, multiply by 60 and divide by
    // 2. This results in Fosc of 120MHz. The CPU clock frequency is
    // Fcy = Fosc/2 = 60MHz. Wait for the Primary PLL to lock and then
    // configure the auxilliary PLL to provide 48MHz needed for USB
    // Operation.

PLLFBD = 38;                    /* M    = 60      */
CLKDIVbits.PLLPOST = 0;         /* N1 = 2   */
CLKDIVbits.PLLPRE = 0;          /* N2 = 2   */
OSCTUN = 0;

    /*      Initiate Clock Switch to Primary
     *      Oscillator with PLL (NOSC= 0x3)*/

    __builtin_write_OSCCONH(0x03);
__builtin_write_OSCCONL(0x01);

while (OSCCONbits.COSC != 0x3);

    // Configuring the auxiliary PLL, since the primary
    // oscillator provides the source clock to the auxiliary
    // PLL, the auxiliary oscillator is disabled. Note that
    // the AUX PLL is enabled. The input 8MHz clock is divided
    // by 2, multiplied by 24 and then divided by 2. Wait till
    // the AUX PLL locks.

    ACLKCON3 = 0x24C1;
    ACLKDIV3 = 0x7;

    ACLKCON3bits.ENAPLL = 1;
    while(ACLKCON3bits.APLLCK != 1);
```

```
ANSELA = 0x0000;
        ANSELB = 0x0000;
        ANSELC = 0x0000;
        ANSELD = 0x0000;
        ANSELE = 0x0000;
        ANSELG = 0x0000;

    // The dsPIC33EP512MU810 features Peripheral Pin
    // select. The following statements map UART2 to
    // device pins which would connect to the the
    // RX232 transciever on the Explorer 16 board.

      RPINR19 = 0;
      RPINR19 = 0x64;
      RPOR9bits.RP101R = 0x3;

    #endif

    #if defined( __PIC24FJ256GB110__ )
        // PPS - Configure U2RX - put on pin 49 (RP10)
        RPINR19bits.U2RXR = 10;

        // PPS - Configure U2TX - put on pin 50 (RP17)
        RPOR8bits.RP17R = 5;

        OSCCON = 0x3302;      // Enable secondary oscillator
        CLKDIV = 0x0000;      // Set PLL prescaler (1:1)
        TRISD = 0x00C0;
    #endif
    #if defined(__PIC24FJ64GB004__)
//On the PIC24FJ64GB004 Family of USB microcontrollers, the PLL will not power up and be enabled
//by default, even if a PLL enabled oscillator configuration is selected (such as HS+PLL).
//This allows the device to power up at a lower initial operating frequency, which can be
```

```
    //advantageous when powered from a source which is not gauranteed to be adequate for 32MHz
    //operation.    On these devices, user firmware needs to manually set the CLKDIV<PLLEN> bit to
    //power up the PLL.
        {
            unsigned int pll_startup_counter = 600;
            CLKDIVbits.PLLEN = 1;
            while(pll_startup_counter--);
        }

        //Device switches over automatically to PLL output after PLL is locked and ready.
        #endif
    #elif defined(__PIC32MX__)
        {
                //int i = 0;
                //OSCCON = 0;

            int    value ;

            value = SYSTEMConfigWaitStatesAndPB( GetSystemClock() );

            // Enable the cache for the best performance
            CheKseg0CacheOn();

            INTEnableSystemMultiVectoredInt();
//




            //SYSKEY=0;
  //SYSKEY=0xaa996655;
  //SYSKEY=0x556699aa;    // unlock OSCCON
  //OSCCONSET=4;    // enable usb use of frc
            //OSCCON = 0x3302;
```

```
        //OSCCONbits.UFRCEN = 0;
        //OSCCONbits.PLLMULT = 0x07;
       //SYSKEY=0x33333333;
        value = OSCCON;

       while (!(value & 0x00000020))
        {
            value = OSCCON;     // Wait for PLL lock to stabilize
        }
    }
    //AD1PCFG = 0xFFFF;//added
    ANSELA = 0;    // Set analog pins to digital.
    ANSELB = 0;

    //ANSELC = 0xFFFF;
    //TRISF    = 0x00;
//TRISD = 0x00C0;
#else
    #error Cannot initialize.
#endif

// specify PPS group, signal, logical pin name
PPSInput (2, U2RX, RPB8); //Assign U2RX to pin RPB8 -- Physical pin 17 on 28 PDIP
PPSOutput(4, RPB14, U2TX); //Assign U2TX to pin RPB14 -- Physical pin 25 on 28 PDIP
UART2Init();
clrscr();//clear PuTTY screen
home();

   PMMODE = 0x03ff;
 // Enable PMP Module, No Address & Data Muxing,
 // Enable RdWr Port, Enable Enb Port, No Chip Select,
 // Select RdWr and Enb signals Active High
  PMCON = 0x8383;// debug can't go over this commmand
```

```
// Enable A0

    PMAEN = 0x0001;// can't run to this line. commented to see whether it can go over

    LCDInit();// DEBUG STUCK
    mInitAllLEDs(); //DEBUG STUCK
#ifdef DEBUG_MODE
    UART2PrintString( "\r\n\r\n***** Microchip Explorer " );
    UART2PrintString( "USB MOuse Host Demo " );
    UART2PrintString( " *****\r\n\r\n" );
#endif

    // Initialize USB layers
    USBInitialize( 0 );
    while(1)
    {
        USBTasks();
        App_Detect_Device();
        switch(App_State_Mouse)
        {
            case DEVICE_NOT_CONNECTED:
                        USBTasks();
                                    if(DisplayDeatachOnce == FALSE)
                        {
                            LCDClear();
                            LCDL1Home();
                            LCDDisplayString((BYTE*)"Device Detached ", LCD_LINE_ONE);
                            DisplayDeatachOnce = TRUE;
                        }
                        if(USBHostHID_ApiDeviceDetect()) /* True if report descriptor is parsed with no
error */
                        {
```

```
                App_State_Mouse = DEVICE_CONNECTED;
                DisplayConnectOnce = FALSE;
            }
    break;
case DEVICE_CONNECTED:
            App_State_Mouse = READY_TO_TX_RX_REPORT;
            if(DisplayConnectOnce == FALSE)
            {
                LCDClear();
                LCDL1Home();
                LCDDisplayString((BYTE*)"Explorer16 Board", LCD_LINE_ONE);
                LCDDisplayString((BYTE*)"USB HIDHost Demo", LCD_LINE_TWO);
                DisplayConnectOnce = TRUE;
                DisplayDeatachOnce = FALSE;
            }

    break;
case READY_TO_TX_RX_REPORT:
            if(!USBHostHID_ApiDeviceDetect())
            {
                App_State_Mouse = DEVICE_NOT_CONNECTED;
            }
            else
            {
                App_State_Mouse = GET_INPUT_REPORT;
            }

    break;
case GET_INPUT_REPORT:
            if(USBHostHID_ApiGetReport(Appl_raw_report_buffer.Report_ID,0,
                                    Appl_raw_report_buffer.ReportSize,
Appl_raw_report_buffer.ReportData))
            {
```

```
                    /* Host may be busy/error -- keep trying */
                }
                else
                {
                    App_State_Mouse = INPUT_REPORT_PENDING;
                }
                USBTasks();
        break;
    case INPUT_REPORT_PENDING:
                if(USBHostHID_ApiTransferIsComplete(&ErrorDriver,&NumOfBytesRcvd))
                {
                    if(ErrorDriver ||(NumOfBytesRcvd != Appl_raw_report_buffer.ReportSize ))
                    {
                      ErrorCounter++ ;
                      if(MAX_ERROR_COUNTER <= ErrorDriver)
                          App_State_Mouse = ERROR_REPORTED;
                      else
                          App_State_Mouse = READY_TO_TX_RX_REPORT;
                    }
                    else
                    {
                      ErrorCounter = 0;
                      ReportBufferUpdated = TRUE;
                      App_State_Mouse = READY_TO_TX_RX_REPORT;

                      if(DisplayConnectOnce == TRUE)
                        {
                            for(i=0;i<Appl_raw_report_buffer.ReportSize;i++)
                            {
                                if(Appl_raw_report_buffer.ReportData[i] != 0)
                                {
                                    LCDClear();
                                    LCDL1Home();
```

```
                                                DisplayConnectOnce = FALSE;
                                            }
                                        }
                                    }

                                    App_ProcessInputReport();
                                }
                            }
                    break;

                case ERROR_REPORTED:
                    break;
                default:
                    break;

            }
        }
}

/*************************************************************************
  Function:
    void App_ProcessInputReport(void)

  Description:
    This function processes input report received from HID device.

  Precondition:
    None

  Parameters:
    None

  Return Values:
```

```
    None


  Remarks:
    None
***************************************************************************/
void App_ProcessInputReport(void)
{
    BYTE    data;
   /* process input report received from device */
    USBHostHID_ApiImportData(Appl_raw_report_buffer.ReportData, Appl_raw_report_buffer.ReportSize
                            ,Appl_Button_report_buffer, &Appl_Mouse_Buttons_Details);
    USBHostHID_ApiImportData(Appl_raw_report_buffer.ReportData, Appl_raw_report_buffer.ReportSize
                            ,Appl_XY_report_buffer, &Appl_XY_Axis_Details);

 // X-axis
    data = (Appl_XY_report_buffer[0] & 0xF0) >> 4;
    LCD_DATA_LINE_ONE[5] = App_DATA2ASCII(data);
    data = (Appl_XY_report_buffer[0] & 0x0F);
    LCD_DATA_LINE_ONE[6] = App_DATA2ASCII(data);

 // Y-axis
    data = (Appl_XY_report_buffer[1] & 0xF0) >> 4;
    LCD_DATA_LINE_ONE[13] = App_DATA2ASCII(data);
    data = (Appl_XY_report_buffer[1] & 0x0F);
    LCD_DATA_LINE_ONE[14] = App_DATA2ASCII(data);

    if(Appl_Button_report_buffer[0] == 1)
    {
        if(LCD_DATA_LINE_TWO[5] == '0')
            LCD_DATA_LINE_TWO[5] =    '1';
        else
            LCD_DATA_LINE_TWO[5] =    '0';
    }
```

```
if(Appl_Button_report_buffer[1] == 1)
{
    if(LCD_DATA_LINE_TWO[13] == '0')
        LCD_DATA_LINE_TWO[13] =   '1';
    else
        LCD_DATA_LINE_TWO[13] =   '0';
}

LCDDisplayString((BYTE*)LCD_DATA_LINE_ONE, LCD_LINE_ONE);
LCDDisplayString((BYTE*)LCD_DATA_LINE_TWO, LCD_LINE_TWO);

//#ifdef DEBUG_MODE
//{
    unsigned int i;
    BOOL flag = 0;



     for(i=0;i<(Appl_raw_report_buffer.ReportSize);i++){
        if(Appl_raw_report_buffer.ReportData[i]){
             flag = 1;
         }
     }
    if(flag){
        UART2PrintString( "\n\rHID: Raw Report    " );
    //printf("\n\rHID: Raw Report");
    for(i=0;i<(Appl_raw_report_buffer.ReportSize);i++)
    {
        UART2PutHex( Appl_raw_report_buffer.ReportData[i]);
        if(Appl_raw_report_buffer.ReportData[i]){
            flag = 1;
        }

        UART2PrintString( "-" );
```

```
        }
        UART2PrintString( "\n\r    Left Bt :    " ); UART2PutHex( Appl_Button_report_buffer[0]);
        UART2PrintString( "\n\r    Right Bt :    " ); UART2PutHex( Appl_Button_report_buffer[1]);

        UART2PrintString( "\n\r    X-Axis :    " ); UART2PutHex( Appl_XY_report_buffer[0]);
        UART2PrintString( "\n\r    Y-Axis :    " ); UART2PutHex( Appl_XY_report_buffer[1]);
        UART2PrintString( "\n\r    Scroll :    " ); UART2PutHex( Appl_raw_report_buffer.ReportData[3]);
        }

    //}
    //#endif

}

/*************************************************************************
  Function:
    BYTE App_HID2ASCII(BYTE a)
  Description:
    This function converts the HID code of the key pressed to coressponding
    ASCII value. For Key strokes like Esc, Enter, Tab etc it returns 0.

  Precondition:
    None

  Parameters:
    BYTE a                -    HID code for the key pressed

  Return Values:
    BYTE                  -    ASCII code for the key pressed

  Remarks:
    None
```

```
************************************************************************/
BYTE App_DATA2ASCII(BYTE a) //convert USB HID code (buffer[2 to 7]) to ASCII code
{
    if(a<=0x9)
     {
         return(a+0x30);
     }

    if(a>=0xA && a<=0xF)
     {
         return(a+0x37);
     }

    return(0);
}



/************************************************************************
  Function:
    void App_Detect_Device(void)

  Description:
    This function monitors the status of device connected/disconnected

  Precondition:
    None

  Parameters:
    None

  Return Values:
    None
```

```
   Remarks:
     None
**************************************************************************/
void App_Detect_Device(void)
{
   if(!USBHostHID_ApiDeviceDetect())
   {
        App_State_Mouse = DEVICE_NOT_CONNECTED;
   }
}



/**************************************************************************
   Function:
     void LCD_Display_Routine(BYTE data , BYTE HIDData)
   Description:
     This function displays the key strokes on the LCD    mounted on Explorer16
     demo board.

   Precondition:
     None

   Parameters:
     BYTE data          -    ASCII code for the key pressed
     BYTE HIDData       -    HID code for the key pressed, this is needed to take
                             action for keys like Esc, Enter, Tab etc.

   Return Values:
     None

   Remarks:
**************************************************************************/
```

```
void LCD_Display_Routine(BYTE data , BYTE HIDData)
{
    BYTE LineNum;
    BYTE CharPos;

    LineNum = ((currCharPos & 0x30) >> 4);

    if((LineNum == 1) && (CharPos == 0x0))
    {
        LCDL2Home();
        currCharPos = 0x10;
    }else if((LineNum == 2) && (CharPos == 0x0))
    {
        LCDClear();
        LCDL1Home();
        currCharPos = 0;
    }

   if(currCharPos > 0x20)
    {
        LCDClear();
        LCDL1Home();
        currCharPos = 0;
    }

}

/**************************************************************************
  Function:
    void LCDDisplayString(BYTE* data, BYTE lineNum)
  Description:
    This function displays the string on the LCD
```

```
  Precondition:
    None

  Parameters:
    BYTE* data        -    Array of characters to be displayed on the LCD
    BYTE lineNum      -    LCD_LINE_ONE : To display on Line one to the LCD
                           LCD_LINE_TWO : To display on Line two to the LCD

  Return Values:
    None

  Remarks:
***********************************************************************/
void LCDDisplayString(BYTE* data, BYTE lineNum)
{
    BYTE index = 0;
    if(lineNum == 1)
     {
        LCDL1Home();
        while((*data != '\0') && (index < 16))
        {
            LCDPut(*data );
            index++;
            data++;
        }
     }
     if(lineNum == 2)
     {
        LCDL2Home();
        while((*data != '\0') && (index < 16))
        {
            LCDPut(*data );
```

```
            index++;
            data++;
        }
    }
}


/*************************************************************************
  Function:
    BOOL USB_HID_DataCollectionHandler(void)
  Description:
    This function is invoked by HID client , purpose is to collect the
    details extracted from the report descriptor. HID client will store
    information extracted from the report descriptor in data structures.
    Application needs to create object for each report type it needs to
    extract.
    For ex: HID_DATA_DETAILS Appl_ModifierKeysDetails;
    HID_DATA_DETAILS is defined in file usb_host_hid_appl_interface.h
    Each member of the structure must be initialized inside this function.
    Application interface layer provides functions :
    USBHostHID_ApiFindBit()
    USBHostHID_ApiFindValue()
    These functions can be used to fill in the details as shown in the demo
    code.

  Precondition:
    None

  Parameters:
    None

  Return Values:
    TRUE      - If the report details are collected successfully.
```

```
    FALSE     - If the application does not find the the supported format.


  Remarks:
    This Function name should be entered in the USB configuration tool
    in the field "Parsed Data Collection handler".
    If the application does not define this function , then HID cient
    assumes that Application is aware of report format of the attached
    device.
***************************************************************************/
BOOL USB_HID_DataCollectionHandler(void)
{
  BYTE NumOfReportItem = 0;
  BYTE i;
  USB_HID_ITEM_LIST* pitemListPtrs;
  USB_HID_DEVICE_RPT_INFO* pDeviceRptinfo;
  HID_REPORTITEM *reportItem;
  HID_USAGEITEM *hidUsageItem;
  BYTE usageIndex;
  BYTE reportIndex;

  pDeviceRptinfo = USBHostHID_GetCurrentReportInfo(); // Get current Report Info pointer
  pitemListPtrs = USBHostHID_GetItemListPointers();    // Get pointer to list of item pointers

  BOOL status = FALSE;
   /* Find Report Item Index for Modifier Keys */
   /* Once report Item is located , extract information from data structures provided by the parser */
   NumOfReportItem = pDeviceRptinfo->reportItems;
   for(i=0;i<NumOfReportItem;i++)
    {
       reportItem = &pitemListPtrs->reportItemList[i];
       if((reportItem->reportType==hidReportInput) && (reportItem->dataModes ==
(HIDData_Variable|HIDData_Relative))&&
           (reportItem->globals.usagePage==USAGE_PAGE_GEN_DESKTOP))
```

```
        {
            /* We now know report item points to modifier keys */
            /* Now make sure usage Min & Max are as per application */
             usageIndex = reportItem->firstUsageItem;
             hidUsageItem = &pitemListPtrs->usageItemList[usageIndex];

             reportIndex = reportItem->globals.reportIndex;
             Appl_XY_Axis_Details.reportLength = (pitemListPtrs->reportList[reportIndex].inputBits + 7)/8;
             Appl_XY_Axis_Details.reportID = (BYTE)reportItem->globals.reportID;
             Appl_XY_Axis_Details.bitOffset = (BYTE)reportItem->startBit;
             Appl_XY_Axis_Details.bitLength = (BYTE)reportItem->globals.reportsize;
             Appl_XY_Axis_Details.count=(BYTE)reportItem->globals.reportCount;
             Appl_XY_Axis_Details.interfaceNum= USBHostHID_ApiGetCurrentInterfaceNum();
        }
        else if((reportItem->reportType==hidReportInput) && (reportItem->dataModes == HIDData_Variable)&&
            (reportItem->globals.usagePage==USAGE_PAGE_BUTTONS))
        {
            /* We now know report item points to modifier keys */
            /* Now make sure usage Min & Max are as per application */
             usageIndex = reportItem->firstUsageItem;
             hidUsageItem = &pitemListPtrs->usageItemList[usageIndex];

             reportIndex = reportItem->globals.reportIndex;
             Appl_Mouse_Buttons_Details.reportLength = (pitemListPtrs->reportList[reportIndex].inputBits + 7)/8;
             Appl_Mouse_Buttons_Details.reportID = (BYTE)reportItem->globals.reportID;
             Appl_Mouse_Buttons_Details.bitOffset = (BYTE)reportItem->startBit;
             Appl_Mouse_Buttons_Details.bitLength = (BYTE)reportItem->globals.reportsize;
             Appl_Mouse_Buttons_Details.count=(BYTE)reportItem->globals.reportCount;
             Appl_Mouse_Buttons_Details.interfaceNum= USBHostHID_ApiGetCurrentInterfaceNum();
        }
    }

if(pDeviceRptinfo->reports == 1)
```

```
    {
        Appl_raw_report_buffer.Report_ID = 0;
        Appl_raw_report_buffer.ReportSize = (pitemListPtrs->reportList[reportIndex].inputBits + 7)/8;
//      Appl_raw_report_buffer.ReportData = (BYTE*)malloc(Appl_raw_report_buffer.ReportSize);
        Appl_raw_report_buffer.ReportPollRate = pDeviceRptinfo->reportPollingRate;
        status = TRUE;
    }
    return(status);
}
```

```
/******************************************************************************

    USB Keyboard Host Application Demo

Description:
    This file contains the basic USB keyboard application. Purpose of the demo
    is to demonstrate the capability of HID host . Any Low speed/Full Speed
    USB keyboard can be connected to the PICtail USB adapter along with
    Explorer 16 demo board. This file schedules the HID ransfers, and interprets
    the report received from the keyboard. Key strokes are decoded to ascii
    values and the same can be displayed either on hyperterminal or on the LCD
    display mounted on the Explorer 16 board. Since the purpose is to
```

demonstrate HID host all the keys have not been decoded. However demo gives
a fair idea and user should be able to incorporate necessary changes for
the required application. All the alphabets, numeric characters, special
characters, ESC , Shift, CapsLK and space bar keys have been implemented.

Summary:
This file contains the basic USB keyboard application.

Remarks:
This demo requires Explorer 16 board and the USB PICtail plus connector.

***/
//DOM-IGNORE-BEGIN
/***

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```
CONSEQUENTIAL DAMAGES, FOR ANY REASON WHATSOEVER.
******************************************************************************/
//DOM-IGNORE-END
#include <stdlib.h>
#include <string.h>
#include <stdio.h>
#include "GenericTypeDefs.h"
#include "HardwareProfile.h"
#include "usb_config.h"
#include "lcd_demo.h"
#include "USB/usb.h"
#include "USB/usb_host_hid_parser.h"
#include "USB/usb_host_hid.h"

#if defined( __PIC32MX__ )
#endif

#if defined(__dsPIC33EP512MU810__)||defined(__PIC24EP512GU810__)
/* While using the dsPIC33EPxx USB PIM
 * the LCD on the Explorer 16 board may
 * not function as expected. The demo
 * uses the Explorer 16 UART connector
 * to display data. Connect the UART port
 * to a PC COM port and run hyperterminal
 * at 57600 baud. */
#define DEBUG_MODE

#endif
//#define DEBUG_MODE
// *****************************************************************************
// *****************************************************************************
// Constants
// *****************************************************************************
```

```
// ********************************************************************************

// We are taking Timer 3    to schedule input report transfers

// NOTE - The datasheet doesn't state this, but the timer does get reset to 0
// after a period register match.    So we don't have to worry about resetting
// the timer manually.

#define STOP_TIMER_IN_IDLE_MODE         0x2000
#define TIMER_SOURCE_INTERNAL           0x0000
#define TIMER_ON                        0x8000
#define GATED_TIME_DISABLED             0x0000
#define TIMER_16BIT_MODE                0x0000

#define TIMER_PRESCALER_1               0x0000
#define TIMER_PRESCALER_8               0x0010
#define TIMER_PRESCALER_64              0x0020
#define TIMER_PRESCALER_256             0x0030
#define TIMER_INTERRUPT_PRIORITY        0x0001


// ********************************************************************************
// ********************************************************************************
// Configuration Bits
// ********************************************************************************
// ********************************************************************************

#if defined __C30__ || defined __XC16__
    #if defined(__PIC24FJ256GB110__)
        _CONFIG2(FNOSC_PRIPLL & POSCMOD_HS & PLL_96MHZ_ON & PLLDIV_DIV2 & IESO_OFF) // Primary HS
OSC with PLL, USBPLL /2
        _CONFIG1(JTAGEN_OFF & FWDTEN_OFF & ICS_PGx2)    // JTAG off, watchdog timer off
    #elif defined(__PIC24FJ64GB004__)
```

```
        _CONFIG1(WDTPS_PS1 & FWPSA_PR32 & WINDIS_OFF & FWDTEN_OFF & ICS_PGx1 & GWRP_OFF &
GCP_OFF & JTAGEN_OFF)
        _CONFIG2(POSCMOD_HS & I2C1SEL_PRI & IOL1WAY_OFF & OSCIOFNC_ON & FCKSM_CSDCMD &
FNOSC_PRIPLL & PLL96MHZ_ON & PLLDIV_DIV2 & IESO_OFF)
        _CONFIG3(WPFP_WPFP0 & SOSCSEL_SOSC & WUTSEL_LEG & WPDIS_WPDIS & WPCFG_WPCFGDIS &
WPEND_WPENDMEM)
        _CONFIG4(DSWDTPS_DSWDTPS3 & DSWDTOSC_LPRC & RTCOSC_SOSC & DSBOREN_OFF & DSWDTEN_OFF)
    #elif defined(__PIC24FJ256GB106__)
        _CONFIG1( JTAGEN_OFF & GCP_OFF & GWRP_OFF & FWDTEN_OFF & ICS_PGx2)
        _CONFIG2( PLL_96MHZ_ON & IESO_OFF & FCKSM_CSDCMD & OSCIOFNC_OFF & POSCMOD_HS &
FNOSC_PRIPLL & PLLDIV_DIV3 & IOL1WAY_ON)
    #elif defined(__PIC24FJ256DA210__) || defined(__PIC24FJ256GB210__)
        _CONFIG1(FWDTEN_OFF & ICS_PGx2 & GWRP_OFF & GCP_OFF & JTAGEN_OFF)
        _CONFIG2(POSCMOD_HS & IOL1WAY_ON & OSCIOFNC_ON & FCKSM_CSDCMD & FNOSC_PRIPLL &
PLL96MHZ_ON & PLLDIV_DIV2 & IESO_OFF)
    #elif defined(__dsPIC33EP512MU810__)||defined(__PIC24EP512GU810__)
        _FOSCSEL(FNOSC_FRC);
        _FOSC(FCKSM_CSECMD & OSCIOFNC_OFF & POSCMD_XT);
        _FWDT(FWDTEN_OFF);
    #else
    #endif

#elif defined( __PIC32MX__ )

    #pragma config UPLLEN   = ON            // USB PLL Enabled
    #pragma config FPLLMUL  = MUL_15        // PLL Multiplier
    #pragma config UPLLIDIV = DIV_2         // USB PLL Input Divider
    #pragma config FPLLIDIV = DIV_2         // PLL Input Divider
    #pragma config FPLLODIV = DIV_1         // PLL Output Divider
    #pragma config FPBDIV   = DIV_1         // Peripheral Clock divisor
    #pragma config FWDTEN   = OFF           // Watchdog Timer
    #pragma config WDTPS    = PS1           // Watchdog Timer Postscale
    #pragma config FCKSM    = CSDCMD        // Clock Switching & Fail Safe Clock Monitor
```

```
    #pragma config OSCIOFNC = OFF           // CLKO Enable
    //#pragma config POSCMOD   = HS              // Primary Oscillator
    #pragma config POSCMOD   = XT              // Primary Oscillator
    #pragma config IESO      = OFF            // Internal/External Switch-over
    #pragma config FSOSCEN   = OFF            // Secondary Oscillator Enable (KLO was off)
    #pragma config FNOSC     = PRIPLL         // Oscillator Selection
    #pragma config CP        = OFF            // Code Protect
    #pragma config BWP       = OFF            // Boot Flash Write Protect
    #pragma config PWP       = OFF            // Program Flash Write Protect
    #pragma config ICESEL    = ICS_PGx1       // ICE/ICD Comm Channel Select
  #define DEBUG_MODE
#else

    #error Cannot define configuration bits.

#endif

// *****************************************************************************
// *****************************************************************************
// Data Structures
// *****************************************************************************
// *****************************************************************************

typedef enum _APP_STATE
{
    DEVICE_NOT_CONNECTED,
    DEVICE_CONNECTED, /* Device Enumerated  - Report Descriptor Parsed */
    READY_TO_TX_RX_REPORT,
    GET_INPUT_REPORT, /* perform operation on received report */
    INPUT_REPORT_PENDING,
    SEND_OUTPUT_REPORT, /* Not needed in case of mouse */
    OUTPUT_REPORT_PENDING,
    ERROR_REPORTED
```

```
} APP_STATE;

typedef struct _HID_REPORT_BUFFER
{
    WORD    Report_ID;
    WORD    ReportSize;
    BYTE* ReportData;
    WORD    ReportPollRate;
}    HID_REPORT_BUFFER;

typedef struct _HID_LED_REPORT_BUFFER
{
    BYTE    NUM_LOCK          : 1;
    BYTE    CAPS_LOCK         : 1;
    BYTE    SCROLL_LOCK       : 1;
    BYTE    UNUSED            : 5;
}    HID_LED_REPORT_BUFFER;



// *****************************************************************************
// *****************************************************************************
// Internal Function Prototypes
// *****************************************************************************
// *****************************************************************************
BYTE App_HID2ASCII(BYTE a); //convert USB HID code (buffer[2 to 7]) to ASCII code
void AppInitialize(void);
BOOL AppGetParsedReportDetails(void);
void App_Detect_Device(void);
void App_ProcessInputReport(void);
void App_PrepareOutputReport(void);
void InitializeTimer(void);
void App_Clear_Data_Buffer(void);
```

```
BOOL App_CompareKeyPressedPrevBuf(BYTE data);
void App_CopyToShadowBuffer(void);
BOOL USB_HID_DataCollectionHandler(void);

void LCDDisplayString(BYTE* data, BYTE lineNum);
void LCD_Display_Routine(BYTE data, BYTE HIDData);

// *****************************************************************************
// *****************************************************************************
// Macros
// *****************************************************************************
// *****************************************************************************
#define MAX_ALLOWED_CURRENT             (500)         // Maximum power we can supply in mA
#define MINIMUM_POLL_INTERVAL           (0x0A)        // Minimum Polling rate for HID reports is 10ms

#define USAGE_PAGE_LEDS                 (0x08)

#define USAGE_PAGE_KEY_CODES            (0x07)
#define USAGE_MIN_MODIFIER_KEY          (0xE0)
#define USAGE_MAX_MODIFIER_KEY          (0xE7)

#define USAGE_MIN_NORMAL_KEY            (0x00)
#define USAGE_MAX_NORMAL_KEY            (0xFF)

/* Array index for modifier keys */
#define MODIFIER_LEFT_CONTROL           (0)
#define MODIFIER_LEFT_SHIFT             (1)
#define MODIFIER_LEFT_ALT               (2)
#define MODIFIER_LEFT_GUI               (3)
#define MODIFIER_RIGHT_CONTROL          (4)
#define MODIFIER_RIGHT_SHIFT            (5)
#define MODIFIER_RIGHT_ALT              (6)
#define MODIFIER_RIGHT_GUI              (7)
```

```
#define HID_CAPS_LOCK_VAL                (0x39)

#define HID_NUM_LOCK_VAL                 (0x53)


#define MAX_ERROR_COUNTER                (10)




#define LCD_LINE_ONE                     (1)

#define LCD_LINE_TWO                     (2)


//******************************************************************************

//    macros to identify special charaters(other than Digits and Alphabets)

//******************************************************************************

#define Symbol_Exclamation               (0x1E)

#define Symbol_AT                        (0x1F)

#define Symbol_Pound                     (0x20)

#define Symbol_Dollar                    (0x21)

#define Symbol_Percentage                (0x22)

#define Symbol_Cap                       (0x23)

#define Symbol_AND                       (0x24)

#define Symbol_Star                      (0x25)

#define Symbol_NormalBracketOpen         (0x26)

#define Symbol_NormalBracketClose        (0x27)


#define Symbol_Return                    (0x28)

#define Symbol_Escape                    (0x29)

#define Symbol_Backspace                 (0x2A)

#define Symbol_Tab                       (0x2B)

#define Symbol_Space                     (0x2C)

#define Symbol_HyphenUnderscore          (0x2D)

#define Symbol_EqualAdd                  (0x2E)

#define Symbol_BracketOpen               (0x2F)

#define Symbol_BracketClose              (0x30)
```

```
#define Symbol_BackslashOR              (0x31)

#define Symbol_SemiColon                (0x33)

#define Symbol_InvertedComma            (0x34)

#define Symbol_Tilde                    (0x35)

#define Symbol_CommaLessThan            (0x36)

#define Symbol_PeriodGreaterThan        (0x37)

#define Symbol_FrontSlashQuestion       (0x38)


// *****************************************************************************

// *****************************************************************************

// Global Variables

// *****************************************************************************

// *****************************************************************************


APP_STATE App_State_Keyboard = DEVICE_NOT_CONNECTED;


HID_DATA_DETAILS Appl_LED_Indicator;




HID_DATA_DETAILS Appl_ModifierKeysDetails;

HID_DATA_DETAILS Appl_NormalKeysDetails;


HID_USER_DATA_SIZE Appl_BufferModifierKeys[8];

HID_USER_DATA_SIZE Appl_BufferNormalKeys[6];

HID_USER_DATA_SIZE Appl_ShadowBuffer1[6];


HID_REPORT_BUFFER       Appl_raw_report_buffer;

HID_LED_REPORT_BUFFER Appl_led_report_buffer;


BYTE ErrorDriver;

BYTE ErrorCounter;

BYTE NumOfBytesRcvd;
```

```
BOOL ReportBufferUpdated;
BOOL LED_Key_Pressed = FALSE;
BOOL DisplayConnectOnce = FALSE;
BOOL DisplayDeatachOnce = FALSE;
BYTE CAPS_Lock_Pressed = 0;
BYTE NUM_Lock_Pressed = 0;
BYTE HeldKeyCount = 0;
BYTE HeldKey;

BYTE currCharPos;
BYTE FirstKeyPressed ;

//******************************************************************************
//******************************************************************************
// USB Support Functions
//******************************************************************************
//******************************************************************************

BOOL USB_ApplicationEventHandler( BYTE address, USB_EVENT event, void *data, DWORD size )
{
    switch( (INT)event )
    {
        case EVENT_VBUS_REQUEST_POWER:
            // The data pointer points to a byte that represents the amount of power
            // requested in mA, divided by two.    If the device wants too much power,
            // we reject it.
            if (((USB_VBUS_POWER_EVENT_DATA*)data)->current <= (MAX_ALLOWED_CURRENT / 2))
            {
                return TRUE;
            }
            else
            {
                UART2PrintString( "\r\n***** USB Error - device requires too much current *****\r\n" );
```

```
        }
        break;

    case EVENT_VBUS_RELEASE_POWER:
        // Turn off Vbus power.
        // The PIC24F with the Explorer 16 cannot turn off Vbus through software.
        return TRUE;
        break;

    case EVENT_HUB_ATTACH:
        UART2PrintString( "\r\n***** USB Error - hubs are not supported *****\r\n" );
        return TRUE;
        break;

    case EVENT_UNSUPPORTED_DEVICE:
        UART2PrintString( "\r\n***** USB Error - device is not supported *****\r\n" );
        return TRUE;
        break;

    case EVENT_CANNOT_ENUMERATE:
        UART2PrintString( "\r\n***** USB Error - cannot enumerate device *****\r\n" );
        return TRUE;
        break;

    case EVENT_CLIENT_INIT_ERROR:
        UART2PrintString( "\r\n***** USB Error - client driver initialization error *****\r\n" );
        return TRUE;
        break;

    case EVENT_OUT_OF_MEMORY:
        UART2PrintString( "\r\n***** USB Error - out of heap memory *****\r\n" );
        return TRUE;
        break;
```

```
            case EVENT_UNSPECIFIED_ERROR:      // This should never be generated.
                UART2PrintString( "\r\n***** USB Error - unspecified *****\r\n" );
                return TRUE;
                break;

              case EVENT_HID_RPT_DESC_PARSED:
                     #ifdef APPL_COLLECT_PARSED_DATA
                         return(APPL_COLLECT_PARSED_DATA());
                    #else
                          return TRUE;
                     #endif
                    break;

            default:
                break;
        }
        return FALSE;
}

//*****************************************************************************
//*****************************************************************************
// Main
//*****************************************************************************
//*****************************************************************************


int main (void)
{
        BYTE i;
#if defined(__PIC32MX__)
        {
            int    value;
```

```
        value = SYSTEMConfigWaitStatesAndPB( GetSystemClock() );

        // Enable the cache for the best performance
        CheKseg0CacheOn();

        INTEnableSystemMultiVectoredInt();

        value = OSCCON;
        while (!(value & 0x00000020))
        {
            value = OSCCON;     // Wait for PLL lock to stabilize
        }
    }

    //ANSELA = 0xFFFF;
    //ANSELB = 0xFFFF;
    ANSELA = 0;    // Set analog pins to digital.
        ANSELB = 0;
    //ANSELC = 0xFFFF;

    //AD1PCFG = 0xFFFF;    // Set analog pins to digital.
    //TRISF    = 0x00;
#endif

#if defined(__PIC24FJ64GB004__)
    //On the PIC24FJ64GB004 Family of USB microcontrollers, the PLL will not power up and be enabled
    //by default, even if a PLL enabled oscillator configuration is selected (such as HS+PLL).
    //This allows the device to power up at a lower initial operating frequency, which can be
    //advantageous when powered from a source which is not gauranteed to be adequate for 32MHz
    //operation.   On these devices, user firmware needs to manually set the CLKDIV<PLLEN> bit to
    //power up the PLL.
    {
```

```
        unsigned int pll_startup_counter = 600;
        CLKDIVbits.PLLEN = 1;
        while(pll_startup_counter--);
    }
#endif

#if defined(__dsPIC33EP512MU810__)||defined(__PIC24EP512GU810__)

    // Configure the device PLL to obtain 60 MIPS operation. The crystal
    // frequency is 8MHz. Divide 8MHz by 2, multiply by 60 and divide by
    // 2. This results in Fosc of 120MHz. The CPU clock frequency is
    // Fcy = Fosc/2 = 60MHz. Wait for the Primary PLL to lock and then
    // configure the auxilliary PLL to provide 48MHz needed for USB
    // Operation.

    PLLFBD = 38;                    /* M  = 60     */
    CLKDIVbits.PLLPOST = 0;         /* N1 = 2  */
    CLKDIVbits.PLLPRE = 0;          /* N2 = 2  */
    OSCTUN = 0;

    /*    Initiate Clock Switch to Primary
     *    Oscillator with PLL (NOSC= 0x3)*/

    __builtin_write_OSCCONH(0x03);
    __builtin_write_OSCCONL(0x01);

    while (OSCCONbits.COSC != 0x3);

        // Configuring the auxiliary PLL, since the primary
        // oscillator provides the source clock to the auxiliary
        // PLL, the auxiliary oscillator is disabled. Note that
        // the AUX PLL is enabled. The input 8MHz clock is divided
        // by 2, multiplied by 24 and then divided by 2. Wait till
```

```
        // the AUX PLL locks.

        ACLKCON3 = 0x24C1;
        ACLKDIV3 = 0x7;

        ACLKCON3bits.ENAPLL = 1;
        while(ACLKCON3bits.APLLCK != 1);

        ANSELA = 0x0000;
        ANSELB = 0x0000;
        ANSELC = 0x0000;
        ANSELD = 0x0000;
        ANSELE = 0x0000;
        ANSELG = 0x0000;

        // The dsPIC33EP512MU810 features Peripheral Pin
        // select. The following statements map UART2 to
        // device pins which would connect to the the
        // RX232 transciever on the Explorer 16 board.

        RPINR19 = 0;
        RPINR19 = 0x64;
        RPOR9bits.RP101R = 0x3;

#endif

#if defined( __PIC24FJ256GB110__ ) || defined(__PIC24FJ256GB210__)
        // PPS - Configure U2RX - put on pin 49 (RP10)
        RPINR19bits.U2RXR = 10;

        // PPS - Configure U2TX - put on pin 50 (RP17)
        RPOR8bits.RP17R = 5;
```

```
        OSCCON = 0x3302;        // Enable secondary oscillator
        CLKDIV = 0x0000;        // Set PLL prescaler (1:1)

        TRISD = 0x00C0;

#endif
        // specify PPS group, signal, logical pin name
    PPSInput (2, U2RX, RPB8); //Assign U2RX to pin RPB8 -- Physical pin 17 on 28 PDIP
    PPSOutput(4, RPB14, U2TX); //Assign U2TX to pin RPB14 -- Physical pin 25 on 28 PDIP
        UART2Init();

        PMMODE = 0x03ff;
        // Enable PMP Module, No Address & Data Muxing,
        // Enable RdWr Port, Enable Enb Port, No Chip Select,
        // Select RdWr and Enb signals Active High
        PMCON = 0x8383;
        // Enable A0
        PMAEN = 0x0001;
        LCDInit();

#ifdef DEBUG_MODE
        UART2PrintString( "\r\n\r\n***** Microchip Explorer " );
        UART2PrintString( "USB Keyboard Host Demo " );
        UART2PrintString( " *****\r\n\r\n" );
#endif



        // Initialize USB layers
        USBInitialize(0);

        while(1)
        {
            USBTasks();
```

```
App_Detect_Device();
switch(App_State_Keyboard)
{
    case DEVICE_NOT_CONNECTED:
        USBTasks();
        if(DisplayDeatachOnce == FALSE)
        {
            LCDClear();
            LCDL1Home();
            LCDDisplayString((BYTE*)"Device Detached ", LCD_LINE_ONE);
            #ifdef DEBUG_MODE
            UART2PrintString( "Device Detached \r\n" );
            #endif
            DisplayDeatachOnce = TRUE;
        }
        if(USBHostHID_ApiDeviceDetect()) /* True if report descriptor is parsed with no error */
        {
            App_State_Keyboard = DEVICE_CONNECTED;
            DisplayConnectOnce = FALSE;
        }
        break;
    case DEVICE_CONNECTED:
        App_State_Keyboard = READY_TO_TX_RX_REPORT;
        if(DisplayConnectOnce == FALSE)
        {
            LCDClear();
            LCDL1Home();
            LCDDisplayString((BYTE*)"Explorer16 Board", LCD_LINE_ONE);
            LCDDisplayString((BYTE*)"USB HIDHost Demo", LCD_LINE_TWO);
            #ifdef DEBUG_MODE
            UART2PrintString( "Explorer16 Board \r\n" );
            UART2PrintString( "USB HIDHost Demo \r\n" );
```

```
                #endif
                DisplayConnectOnce = TRUE;
                DisplayDeatachOnce = FALSE;
            }
            InitializeTimer(); // start 10ms timer to schedule input reports

            break;
        case READY_TO_TX_RX_REPORT:
            if(!USBHostHID_ApiDeviceDetect())
            {
                App_State_Keyboard = DEVICE_NOT_CONNECTED;
                //                          DisplayOnce = FALSE;
            }
            break;
        case GET_INPUT_REPORT:

if(USBHostHID_ApiGetReport(Appl_raw_report_buffer.Report_ID,Appl_ModifierKeysDetails.interfaceNum,
                    Appl_raw_report_buffer.ReportSize, Appl_raw_report_buffer.ReportData))
            {
                /* Host may be busy/error -- keep trying */
            }
            else
            {
                App_State_Keyboard = INPUT_REPORT_PENDING;
            }
            USBTasks();
            break;
        case INPUT_REPORT_PENDING:
            if(USBHostHID_ApiTransferIsComplete(&ErrorDriver,&NumOfBytesRcvd))
            {
                if(ErrorDriver ||(NumOfBytesRcvd !=     Appl_raw_report_buffer.ReportSize ))
                {
                    ErrorCounter++ ;
```

```
            if(MAX_ERROR_COUNTER <= ErrorDriver)
                App_State_Keyboard = ERROR_REPORTED;
            else
                App_State_Keyboard = READY_TO_TX_RX_REPORT;
        }
        else
        {
            ErrorCounter = 0;
            ReportBufferUpdated = TRUE;
            App_State_Keyboard = READY_TO_TX_RX_REPORT;

            if(DisplayConnectOnce == TRUE)
            {
                for(i=0;i<Appl_raw_report_buffer.ReportSize;i++)
                {
                    if(Appl_raw_report_buffer.ReportData[i] != 0)
                    {
                        LCDClear();
                        LCDL1Home();
                        DisplayConnectOnce = FALSE;
                    }
                }
            }

            App_ProcessInputReport();
            App_PrepareOutputReport();
        }
    }
    break;

case SEND_OUTPUT_REPORT: /* Will be done while implementing Keyboard */
```

```
if(USBHostHID_ApiSendReport(Appl_LED_Indicator.reportID,Appl_LED_Indicator.interfaceNum,
Appl_LED_Indicator.reportLength,
                (BYTE*)&Appl_led_report_buffer))
          {
              /* Host may be busy/error -- keep trying */
          }
          else
          {
              App_State_Keyboard = OUTPUT_REPORT_PENDING;
          }
          USBTasks();

          break;
        case OUTPUT_REPORT_PENDING:
          if(USBHostHID_ApiTransferIsComplete(&ErrorDriver,&NumOfBytesRcvd))
          {
              if(ErrorDriver)
              {
                  ErrorCounter++ ;
                  if(MAX_ERROR_COUNTER <= ErrorDriver)
                      App_State_Keyboard = ERROR_REPORTED;

                  //                    App_State_Keyboard =
READY_TO_TX_RX_REPORT;
              }
              else
              {
                  ErrorCounter = 0;
                  App_State_Keyboard = READY_TO_TX_RX_REPORT;
              }
          }
          break;
```

```
                case ERROR_REPORTED:
                    break;
                default:
                    break;

            }
        }
}

/***************************************************************************
  Function:
    void App_PrepareOutputReport(void)

  Description:
    This function schedules output report if any LED indicator key is pressed.

  Precondition:
    None

  Parameters:
    None

  Return Values:
    None

  Remarks:
    None
***************************************************************************/
void App_PrepareOutputReport(void)
{
//      if((READY_TO_TX_RX_REPORT == App_State_Keyboard) && (ReportBufferUpdated == TRUE))
    if(ReportBufferUpdated == TRUE)
```

```
    {
        ReportBufferUpdated = FALSE;
        if(LED_Key_Pressed)
        {
            App_State_Keyboard = SEND_OUTPUT_REPORT;
            LED_Key_Pressed = FALSE;
        }
     }
}

/*************************************************************************
  Function:
    void App_ProcessInputReport(void)

  Description:
    This function processes input report received from HID device.

  Precondition:
    None

  Parameters:
    None

  Return Values:
    None

  Remarks:
    None
*************************************************************************/
void App_ProcessInputReport(void)
{
    BYTE    i;
    BYTE    data;
```

```
    BOOL valid = 0;
   /* process input report received from device */
    USBHostHID_ApiImportData(Appl_raw_report_buffer.ReportData, Appl_raw_report_buffer.ReportSize
                                   ,Appl_BufferModifierKeys, &Appl_ModifierKeysDetails);
    USBHostHID_ApiImportData(Appl_raw_report_buffer.ReportData, Appl_raw_report_buffer.ReportSize
                                   ,Appl_BufferNormalKeys, &Appl_NormalKeysDetails);

    #ifdef DEBUG_MODE
//      for(i=0;i<(Appl_raw_report_buffer.ReportSize);i++)
//      {
//          if(Appl_raw_report_buffer.ReportData[i] != 0){
//              valid = 1;
//              break;
//            }
//      }
//      if(valid){
//          UART2PrintString( "\n\rHID: Raw Report    " );
//          for(i=0;i<(Appl_raw_report_buffer.ReportSize);i++){
//          UART2PutHex( Appl_raw_report_buffer.ReportData[i]);
//          UART2PrintString( "-" );
//          }
//      }


    #endif

    for(i=0;i<(sizeof(Appl_BufferNormalKeys)/sizeof(Appl_BufferNormalKeys[0]));i++)
    {
        if(Appl_BufferNormalKeys[i] != 0)
        {
            if(Appl_BufferNormalKeys[i] == HID_CAPS_LOCK_VAL)
            {
                CAPS_Lock_Pressed = !CAPS_Lock_Pressed;
```

```
            LED_Key_Pressed = TRUE;
            Appl_led_report_buffer.CAPS_LOCK = CAPS_Lock_Pressed;
        }else if(Appl_BufferNormalKeys[i] == HID_NUM_LOCK_VAL)
        {
            NUM_Lock_Pressed = !NUM_Lock_Pressed;
            LED_Key_Pressed = TRUE;
            Appl_led_report_buffer.NUM_LOCK = NUM_Lock_Pressed;
        }else
        {
        /* check if key press was present in previous report */
        // if key press was pressed in previous report neglect it ????
            if(!App_CompareKeyPressedPrevBuf(Appl_BufferNormalKeys[i]))
            {
                data = App_HID2ASCII(Appl_BufferNormalKeys[i]);    // convert data to ascii
                #ifdef DEBUG_MODE
                    UART2PutChar(data);
                #endif
                LCD_Display_Routine(data,Appl_BufferNormalKeys[i] );
            }
        }
    }
    else
    {
        if(i==0)
        {
            HeldKeyCount = 0;
        }
        else
        {
            if(Appl_BufferNormalKeys[i-1] == HeldKey)
            {
                if(HeldKeyCount < 3)
                {
```

```
                        HeldKeyCount++;
                    }
                    else
                    {
                        data = App_HID2ASCII(HeldKey);    // convert data to ascii
                        #ifdef DEBUG_MODE
                            UART2PutChar(data);
                        #endif
                        LCD_Display_Routine(data,HeldKey );
                    }
                }
                else
                {
                    HeldKeyCount = 0;
                    HeldKey = Appl_BufferNormalKeys[i-1];
                }
            }
            break;
        }
    }
    App_CopyToShadowBuffer();
    App_Clear_Data_Buffer();
}

/**************************************************************************
  Function:
    void App_CopyToShadowBuffer(void)

  Description:
    This function updates the shadow buffers with previous reports.

  Precondition:
    None
```

```
   Parameters:
     None

   Return Values:
     None

   Remarks:
     None
************************************************************************/
void App_CopyToShadowBuffer(void)
{
     BYTE i;

     for(i=0;i<(sizeof(Appl_BufferNormalKeys)/sizeof(Appl_BufferNormalKeys[0]));i++)
     {
          Appl_ShadowBuffer1[i] = Appl_BufferNormalKeys[i];
     }
}

/************************************************************************
   Function:
     BOOL App_CompareKeyPressedPrevBuf(BYTE data)

   Description:
     This function compares if the data byte received in report was sent in
     previous report. This is to avoid duplication incase user key in strokes
     at fast rate.

   Precondition:
     None

   Parameters:
```

```
    BYTE data           -   data byte that needs to be compared with previous
                            report

  Return Values:
    None

  Remarks:
    None
***************************************************************************/
BOOL App_CompareKeyPressedPrevBuf(BYTE data)
{
    BYTE i;

    for(i=0;i<(sizeof(Appl_BufferNormalKeys)/sizeof(Appl_BufferNormalKeys[0]));i++)
    {
        if(data == Appl_ShadowBuffer1[i])
        {
            return TRUE;
        }
    }
    return FALSE;
}


/***************************************************************************
  Function:
    void App_Detect_Device(void)

  Description:
    This function monitors the status of device connected/disconnected

  Precondition:
    None
```

```
  Parameters:
    None

  Return Values:
    None

  Remarks:
    None
************************************************************************/
void App_Detect_Device(void)
{
  if(!USBHostHID_ApiDeviceDetect())
  {
      App_State_Keyboard = DEVICE_NOT_CONNECTED;
  }
}

/*************************************************************************
  Function:
    void App_Clear_Data_Buffer(void)

  Description:
    This function clears the content of report buffer after reading

  Precondition:
    None

  Parameters:
    None

  Return Values:
    None
```

```
  Remarks:
    None
***************************************************************************/
void App_Clear_Data_Buffer(void)
{
    BYTE i;

    for(i=0;i<(sizeof(Appl_BufferNormalKeys)/sizeof(Appl_BufferNormalKeys[0]));i++)
    {
        Appl_BufferNormalKeys[i] = 0;
    }

    for(i=0;i<Appl_raw_report_buffer.ReportSize;i++)
    {
        Appl_raw_report_buffer.ReportData[i] = 0;
    }
}

/****************************************************************************
  Function:
    BYTE App_HID2ASCII(BYTE a)
  Description:
    This function converts the HID code of the key pressed to coressponding
    ASCII value. For Key strokes like Esc, Enter, Tab etc it returns 0.

  Precondition:
    None

  Parameters:
    BYTE a          -    HID code for the key pressed

  Return Values:
```

```
    BYTE            -    ASCII code for the key pressed


  Remarks:
    None
*************************************************************************/
BYTE App_HID2ASCII(BYTE a) //convert USB HID code (buffer[2 to 7]) to ASCII code
{
   BYTE AsciiVal;
   BYTE ShiftkeyStatus = 0;
   if((Appl_BufferModifierKeys[MODIFIER_LEFT_SHIFT] == 1)||(Appl_BufferModifierKeys[MODIFIER_RIGHT_SHIFT]
== 1))
    {
        ShiftkeyStatus = 1;
    }

       if(a>=0x1E && a<=0x27)
    {
       if(ShiftkeyStatus)
        {
            switch(a)
            {
                case Symbol_Exclamation: AsciiVal = 0x21;
                    break;
                case Symbol_AT: AsciiVal = 0x40;
                    break;
                case Symbol_Pound: AsciiVal = 0x23;
                    break;
                case Symbol_Dollar: AsciiVal = 0x24;
                    break;
                case Symbol_Percentage: AsciiVal = 0x25;
                    break;
                case Symbol_Cap: AsciiVal = 0x5E;
                    break;
```

```
                case Symbol_AND: AsciiVal = 0x26;
                    break;
                case Symbol_Star: AsciiVal = 0x2A;
                    break;
                case Symbol_NormalBracketOpen: AsciiVal = 0x28;
                    break;
                case Symbol_NormalBracketClose: AsciiVal = 0x29;
                    break;
                default:
                    break;
            }

            return(AsciiVal);
        }
        else
        {
            if(a==0x27)
            {
                return(0x30);
            }
            else
            {
                return(a+0x13);
            }
        }
    }
if(a == 0x2c){// added for space
    return(0x20);
}

if(a == 0x2a){// added for backspace
   return(0x08) ;
}
```

```
if((a>=0x59 && a<=0x61)&&(NUM_Lock_Pressed == 1))
 {
     return(a-0x28);
 }

if((a==0x62) &&(NUM_Lock_Pressed == 1)) return(0x30);



if(a>=0x04 && a<=0x1D)
 {
    if(((CAPS_Lock_Pressed == 1)&&((Appl_BufferModifierKeys[MODIFIER_LEFT_SHIFT] == 0)&&
                                    (Appl_BufferModifierKeys[MODIFIER_RIGHT_SHIFT] == 0)))
        ||((CAPS_Lock_Pressed == 0)&&((Appl_BufferModifierKeys[MODIFIER_LEFT_SHIFT] == 1) ||
                                          (Appl_BufferModifierKeys[MODIFIER_RIGHT_SHIFT] == 1))))
         return(a+0x3d); /* return capital */
    else
         return(a+0x5d); /* return small case */
 }



if(a>=0x2D && a<=0x38)
 {
     switch(a)
     {
         case Symbol_HyphenUnderscore:
             if(!ShiftkeyStatus)
                 AsciiVal = 0x2D;
             else
                 AsciiVal = 0x5F;
             break;
         case Symbol_EqualAdd:
             if(!ShiftkeyStatus)
```

```
            AsciiVal = 0x3D;
        else
            AsciiVal = 0x2B;
        break;
    case Symbol_BracketOpen:
        if(!ShiftkeyStatus)
            AsciiVal = 0x5B;
        else
            AsciiVal = 0x7B;
        break;
    case Symbol_BracketClose:
        if(!ShiftkeyStatus)
            AsciiVal = 0x5D;
        else
            AsciiVal = 0x7D;
        break;
    case Symbol_BackslashOR:
        if(!ShiftkeyStatus)
            AsciiVal = 0x5C;
        else
            AsciiVal = 0x7C;
        break;
    case Symbol_SemiColon:
        if(!ShiftkeyStatus)
            AsciiVal = 0x3B;
        else
            AsciiVal = 0x3A;
        break;
    case Symbol_InvertedComma:
        if(!ShiftkeyStatus)
            AsciiVal = 0x27;
        else
            AsciiVal = 0x22;
```

```
                break;
            case Symbol_Tilde:
                if(!ShiftkeyStatus)
                    AsciiVal = 0x60;
                else
                    AsciiVal = 0x7E;
                break;
            case Symbol_CommaLessThan:
                if(!ShiftkeyStatus)
                    AsciiVal = 0x2C;
                else
                    AsciiVal = 0x3C;
                break;
            case Symbol_PeriodGreaterThan:
                if(!ShiftkeyStatus)
                    AsciiVal = 0x2E;
                else
                    AsciiVal = 0x3E;
                break;
            case Symbol_FrontSlashQuestion:
                if(!ShiftkeyStatus)
                    AsciiVal = 0x2F;
                else
                    AsciiVal = 0x3F;
                break;
            default:
                break;
        }
        return(AsciiVal);
    }

  return(0);
}
```

```
/**************************************************************************
  Function:
    void LCD_Display_Routine(BYTE data , BYTE HIDData)
  Description:
    This function displays the key strokes on the LCD    mounted on Explorer16
    demo board.

  Precondition:
    None

  Parameters:
    BYTE data         -    ASCII code for the key pressed
    BYTE HIDData      -    HID code for the key pressed, this is needed to take
                           action for keys like Esc, Enter, Tab etc.

  Return Values:
    None

  Remarks:
**************************************************************************/

void LCD_Display_Routine(BYTE data , BYTE HIDData)
{
    BYTE LineNum;
    BYTE CharPos;

    LineNum = ((currCharPos & 0x30) >> 4);
    CharPos = currCharPos & 0x0F;

   if((HIDData>=0x1E && HIDData<=0x27) || (HIDData>=0x04 && HIDData<=0x1D) ||
```

```
            (HIDData>=0x2D && HIDData<=0x38) || ((HIDData>=0x59 &&
HIDData<=0x62)&&(NUM_Lock_Pressed == 1)))
    {
        LCDPut(data);
        currCharPos++;
    }
    else if(HIDData == 0x29)        // escape key pressed
    {
        LCDClear();
        LCDL1Home();
        currCharPos = 0;
    }
    else if (HIDData == 0x2C) // space pressed
    {
        LCDPut(0x20);        // space ascii value 0x20
        currCharPos++;
    }
    else if (HIDData == Symbol_Backspace) // back space pressed
    {
        if(currCharPos != 0)
        {
            LCDShiftCursorLeft();
            LCDPut(0x20);        // space ascii value 0x20
            LCDShiftCursorLeft();
            currCharPos--;
        }
    }
    else if((HIDData>=0x4F && HIDData<=0x52) ||
            (( HIDData==0x5C || HIDData==0x5E || HIDData==0x5A || HIDData==0x60    )
                && (NUM_Lock_Pressed == 0)))
    {
        switch(HIDData)
        {
```

```
        case 0x4F :     // Right Arrow
        case 0x5E :
            LCDShiftCursorRight();
            currCharPos++;
            break;
        case 0x50 :     // Left Arrow
        case 0x5C :
            LCDShiftCursorLeft();
            currCharPos--;
            break;
        case 0x52 :     // Up Arrow
        case 0x60 :
            if(LineNum == 1)
            {
                LCDShiftCursorUp();
                currCharPos = currCharPos - 16;
                LineNum = 0;
            }
            break;
        case 0x51 :     // Down Arrow
        case 0x5A :
            if(LineNum == 0)
            {
                LCDShiftCursorDown();
                currCharPos = currCharPos + 16;
                LineNum = 1;
            }
            break;
        default :
            break;
    }

}
```

```
    LineNum = ((currCharPos & 0x30) >> 4);
    CharPos = currCharPos & 0x0F;

    if((LineNum == 1) && (CharPos == 0x0))
    {
        LCDL2Home();
        currCharPos = 0x10;
    }else if((LineNum == 2) && (CharPos == 0x0))
    {
        LCDClear();
        LCDL1Home();
        currCharPos = 0;
    }

   if(currCharPos > 0x20)
    {
        LCDClear();
        LCDL1Home();
        currCharPos = 0;
    }

}

/*****************************************************************************
  Function:
    void LCDDisplayString(BYTE* data, BYTE lineNum)
  Description:
    This function displays the string on the LCD

  Precondition:
    None
```

```
  Parameters:
    BYTE* data          -    Array of characters to be displayed on the LCD
    BYTE lineNum        -    LCD_LINE_ONE : To display on Line one to the LCD
                             LCD_LINE_TWO : To display on Line two to the LCD

  Return Values:
    None

  Remarks:
**********************************************************************/
void LCDDisplayString(BYTE* data, BYTE lineNum)
{
    BYTE index = 0;
    if(lineNum == 1)
     {
        LCDL1Home();
        while((*data != '\0') && (index < 16))
        {
            LCDPut(*data );
            index++;
            data++;
        }
     }
     if(lineNum == 2)
     {
        LCDL2Home();
        while((*data != '\0') && (index < 16))
        {
            LCDPut(*data );
            index++;
            data++;
        }
     }
```

```
}



/***************************************************************************
  Function:
    BOOL USB_HID_DataCollectionHandler(void)
  Description:
    This function is invoked by HID client , purpose is to collect the
    details extracted from the report descriptor. HID client will store
    information extracted from the report descriptor in data structures.
    Application needs to create object for each report type it needs to
    extract.
    For ex: HID_DATA_DETAILS Appl_ModifierKeysDetails;
    HID_DATA_DETAILS is defined in file usb_host_hid_appl_interface.h
    Each member of the structure must be initialized inside this function.
    Application interface layer provides functions :
    USBHostHID_ApiFindBit()
    USBHostHID_ApiFindValue()
    These functions can be used to fill in the details as shown in the demo
    code.

  Precondition:
    None

  Parameters:
    None

  Return Values:
    TRUE    - If the report details are collected successfully.
    FALSE   - If the application does not find the the supported format.

  Remarks:
    This Function name should be entered in the USB configuration tool
```

```
    in the field "Parsed Data Collection handler".
    If the application does not define this function , then HID cient
    assumes that Application is aware of report format of the attached
    device.
***************************************************************************/
BOOL USB_HID_DataCollectionHandler(void)
{
   BYTE NumOfReportItem = 0;
   BYTE i;
   USB_HID_ITEM_LIST* pitemListPtrs;
   USB_HID_DEVICE_RPT_INFO* pDeviceRptinfo;
   HID_REPORTITEM *reportItem;
   HID_USAGEITEM *hidUsageItem;
   BYTE usageIndex;
   BYTE reportIndex;
   BOOL foundLEDIndicator = FALSE;
   BOOL foundModifierKey = FALSE;
   BOOL foundNormalKey = FALSE;




   pDeviceRptinfo = USBHostHID_GetCurrentReportInfo(); // Get current Report Info pointer
   pitemListPtrs = USBHostHID_GetItemListPointers();     // Get pointer to list of item pointers

   BOOL status = FALSE;
    /* Find Report Item Index for Modifier Keys */
    /* Once report Item is located , extract information from data structures provided by the parser */
    NumOfReportItem = pDeviceRptinfo->reportItems;
    for(i=0;i<NumOfReportItem;i++)
     {
        reportItem = &pitemListPtrs->reportItemList[i];
        if((reportItem->reportType==hidReportInput) && (reportItem->dataModes == HIDData_Variable)&&
            (reportItem->globals.usagePage==USAGE_PAGE_KEY_CODES))
```

```
{
    /* We now know report item points to modifier keys */
    /* Now make sure usage Min & Max are as per application */
     usageIndex = reportItem->firstUsageItem;
     hidUsageItem = &pitemListPtrs->usageItemList[usageIndex];
     if((hidUsageItem->usageMinimum == USAGE_MIN_MODIFIER_KEY)
            &&(hidUsageItem->usageMaximum == USAGE_MAX_MODIFIER_KEY)) //else application cannot
suuport
     {
          reportIndex = reportItem->globals.reportIndex;
          Appl_ModifierKeysDetails.reportLength = (pitemListPtrs->reportList[reportIndex].inputBits + 7)/8;
          Appl_ModifierKeysDetails.reportID = (BYTE)reportItem->globals.reportID;
          Appl_ModifierKeysDetails.bitOffset = (BYTE)reportItem->startBit;
          Appl_ModifierKeysDetails.bitLength = (BYTE)reportItem->globals.reportsize;
          Appl_ModifierKeysDetails.count=(BYTE)reportItem->globals.reportCount;
          Appl_ModifierKeysDetails.interfaceNum= USBHostHID_ApiGetCurrentInterfaceNum();
          foundModifierKey = TRUE;
     }

}
else if((reportItem->reportType==hidReportInput) && (reportItem->dataModes == HIDData_Array)&&
    (reportItem->globals.usagePage==USAGE_PAGE_KEY_CODES))
{
    /* We now know report item points to modifier keys */
    /* Now make sure usage Min & Max are as per application */
     usageIndex = reportItem->firstUsageItem;
     hidUsageItem = &pitemListPtrs->usageItemList[usageIndex];
     if((hidUsageItem->usageMinimum == USAGE_MIN_NORMAL_KEY)
            &&(hidUsageItem->usageMaximum <= USAGE_MAX_NORMAL_KEY)) //else application cannot
suuport
     {
          reportIndex = reportItem->globals.reportIndex;
          Appl_NormalKeysDetails.reportLength = (pitemListPtrs->reportList[reportIndex].inputBits + 7)/8;
```

```
                Appl_NormalKeysDetails.reportID = (BYTE)reportItem->globals.reportID;

                Appl_NormalKeysDetails.bitOffset = (BYTE)reportItem->startBit;

                Appl_NormalKeysDetails.bitLength = (BYTE)reportItem->globals.reportsize;

                Appl_NormalKeysDetails.count=(BYTE)reportItem->globals.reportCount;

                Appl_NormalKeysDetails.interfaceNum= USBHostHID_ApiGetCurrentInterfaceNum();

                foundNormalKey = TRUE;

            }


        }

        else if((reportItem->reportType==hidReportOutput) &&

                (reportItem->globals.usagePage==USAGE_PAGE_LEDS))

        {

            usageIndex = reportItem->firstUsageItem;

            hidUsageItem = &pitemListPtrs->usageItemList[usageIndex];


            reportIndex = reportItem->globals.reportIndex;

            Appl_LED_Indicator.reportLength = (pitemListPtrs->reportList[reportIndex].outputBits + 7)/8;

            Appl_LED_Indicator.reportID = (BYTE)reportItem->globals.reportID;

            Appl_LED_Indicator.bitOffset = (BYTE)reportItem->startBit;

            Appl_LED_Indicator.bitLength = (BYTE)reportItem->globals.reportsize;

            Appl_LED_Indicator.count=(BYTE)reportItem->globals.reportCount;

            Appl_LED_Indicator.interfaceNum= USBHostHID_ApiGetCurrentInterfaceNum();

            foundLEDIndicator = TRUE;

        }


    }



  if(pDeviceRptinfo->reports == 1)

    {

        Appl_raw_report_buffer.Report_ID = 0;

        Appl_raw_report_buffer.ReportSize = (pitemListPtrs->reportList[reportIndex].inputBits + 7)/8;

        Appl_raw_report_buffer.ReportData = (BYTE*)malloc(Appl_raw_report_buffer.ReportSize);
```

```
            Appl_raw_report_buffer.ReportPollRate = pDeviceRptinfo->reportPollingRate;
            if((foundNormalKey == TRUE)&&(foundModifierKey == TRUE))
            status = TRUE;
      }

      return(status);
}

/****************************************************************************
   Function:
        void InitializeTimer( void )

   Description:
      This function initializes the tick timer.    It configures and starts the
      timer, and enables the timer interrupt.

   Precondition:
      None

   Parameters:
      None

   Returns:
      None

   Remarks:
      None
   ***************************************************************************/
void InitializeTimer( void )
{
      #if defined(__C30__) || defined __XC16__
      WORD timerPeriod;
```

```
    IPC2bits.T3IP = TIMER_INTERRUPT_PRIORITY;
    IFS0bits.T3IF = 0;


    TMR3 = 0;
    timerPeriod = TIMER_PERIOD*(Appl_raw_report_buffer.ReportPollRate/MINIMUM_POLL_INTERVAL);
        // adjust the timer presaclar if poll rate is too high
        // 20000 counts correspond to 10ms , so current pre sacaler setting will
        // allow maximum 30ms poll interval
    PR3 = TIMER_PERIOD;
    T3CON = TIMER_ON | STOP_TIMER_IN_IDLE_MODE | TIMER_SOURCE_INTERNAL |
            GATED_TIME_DISABLED | TIMER_16BIT_MODE | TIMER_PRESCALER;


    IEC0bits.T3IE = 1;


    #elif defined(__PIC32MX__)
    //TODO - PIC32 support


    T4CON = 0x0; //Stop and Init Timer
    T4CON = 0x0060;
    //prescaler=1:64,
    //internal clock
    TMR4 = 0; //Clear timer register
    PR4 = 0x7FFF; //Load period register


    IPC4SET = 0x00000004; // Set priority level=1 and
    IPC4SET = 0x00000001; // Set subpriority level=1
    // Could have also done this in single
    // operation by assigning IPC5SET = 0x00000005


//      IFS0CLR = 0x00010000; // Clear the Timer5 interrupt status flag
//      IEC0SET = 0x00010000; // Enable Timer5 interrupts
    IFS0bits.T4IF = 0;
    IEC0bits.T4IE = 1;
```

```
    T4CONSET = 0x8000;//Start Timer

    #else
        #error No timer configuration.
    #endif

    return;
}

/*************************************************************************
  Function:
    void __attribute__((__interrupt__, auto_psv)) _T3Interrupt(void)

  Description:
    Timer ISR, used to update application state. If no transfers are pending
    new input request is scheduled.
  Precondition:
    None

  Parameters:
    None

  Return Values:
    None

  Remarks:
    None
  ***********************************************************************/

#if defined(__C30__) || defined __XC16__
void __attribute__((__interrupt__, auto_psv)) _T3Interrupt( void )
{
```

```
    if (IFS0bits.T3IF)
    {
        IFS0bits.T3IF    = 0;
        if(READY_TO_TX_RX_REPORT == App_State_Keyboard)
        {
            App_State_Keyboard = GET_INPUT_REPORT; // If no report is pending schedule new request
        }
    }
}
#elif defined(__PIC32MX__)
#pragma interrupt _T4Interrupt ipl4 vector 16
void _T4Interrupt( void )
{
    if (IFS0bits.T4IF)
    {
        IFS0bits.T4IF    = 0;
        if(READY_TO_TX_RX_REPORT == App_State_Keyboard)
        {
            App_State_Keyboard = GET_INPUT_REPORT; // If no report is pending schedule new request
        }
    }
}
#else
    #error No timer interrupt
#endif
```