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Low Pin Count USB Development Kit User's Guide

Low Pin Count USB Development Kit User's Guide

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Object of Declaration: Low Pin Count USB Development Kit

EU Declaration of Conformity

This declaration of conformity is issued by the manufacturer.
The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).
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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

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VP Development Tools

16-July-2013
Date

NOTES:

Table of Contents

Preface **7**
Introduction 7
Document Layout 7
Conventions Used in this Guide 8
Recommended Reading 9
The Microchip Web Site 9
Customer Support 10
Document Revision History 10

Chapter 1: Overview **11**
Introduction 11
Highlights 11
Low Pin Count USB Development Kit Contents 11
Low Pin Count USB Development Board Construction and Layout 13
PIC18F14K50 ICD Debug Header 14
Getting Started and Using the Out-of-Box Demo Firmware 16
Using the Out-of-Box Demo Firmware/PC Software 16

Chapter 2: Getting Started With USB Development **16**
Re-Programming the Microcontroller 18
Special considerations for programming the PIC18F14K50 19
Using the PIC16F1454 and PIC16F1455 Devices with the Low pin Count USB Development Kit Board 20

Chapter 3: Developing a USB Application **21**
Tips when Developing a USB Application 23
Introduction 25
Schematics 27

Worldwide Sales and Service **29**

NOTES:

Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the Low Pin Count USB Development Kit. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the Low Pin Count USB Development Kit as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Overview"**
- **Chapter 2. "Getting Started With USB Development"**
- **Chapter 3. "Developing a USB Application"**
- **Appendix A. "Schematics"**

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	<u>*File>Save*</u>
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void)` `{ ...` `}`

RECOMMENDED READING

This user's guide describes how to use the Low Pin Count USB Development Kit. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Read me Files

For the latest information on using other tools, read the tool-specific Readme files in the Readmes subdirectory of the MPLAB® IDE installation directory. The Readme files contain update information and known issues that may not be included in this user's guide.

Design Center

Microchip has a USB design center which can be found on **www.microchip.com/usb**.

The following Microchip Application Notes are available and recommended as supplemental reference resources.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://support.microchip.com

DOCUMENT REVISION HISTORY

Revision A (September 2008)

- Initial Release of this Document.

Revision B (February 2009)

- Corrected document errors

Revision C (March 2014)

- Significant updates for PIC16F145X related support, and to reflect changes in the new revision of the PCB design.

Chapter 1. Overview

1.1 INTRODUCTION

The Low Pin Count USB Development Kit provides an easy, low-cost way to evaluate the functionality of Microchip's PIC18F1XK50 and PIC16F145X USB microcontrollers. The kit provides a hardware development platform which can help speed your next USB design from concept to first prototype. The hardware works directly in conjunction with the extensive USB firmware/software/drivers/utilities in the Microchip Libraries for Applications (MLA), which provides all of the source code necessary for the development of a complete USB application.

1.2 HIGHLIGHTS

This chapter discusses:

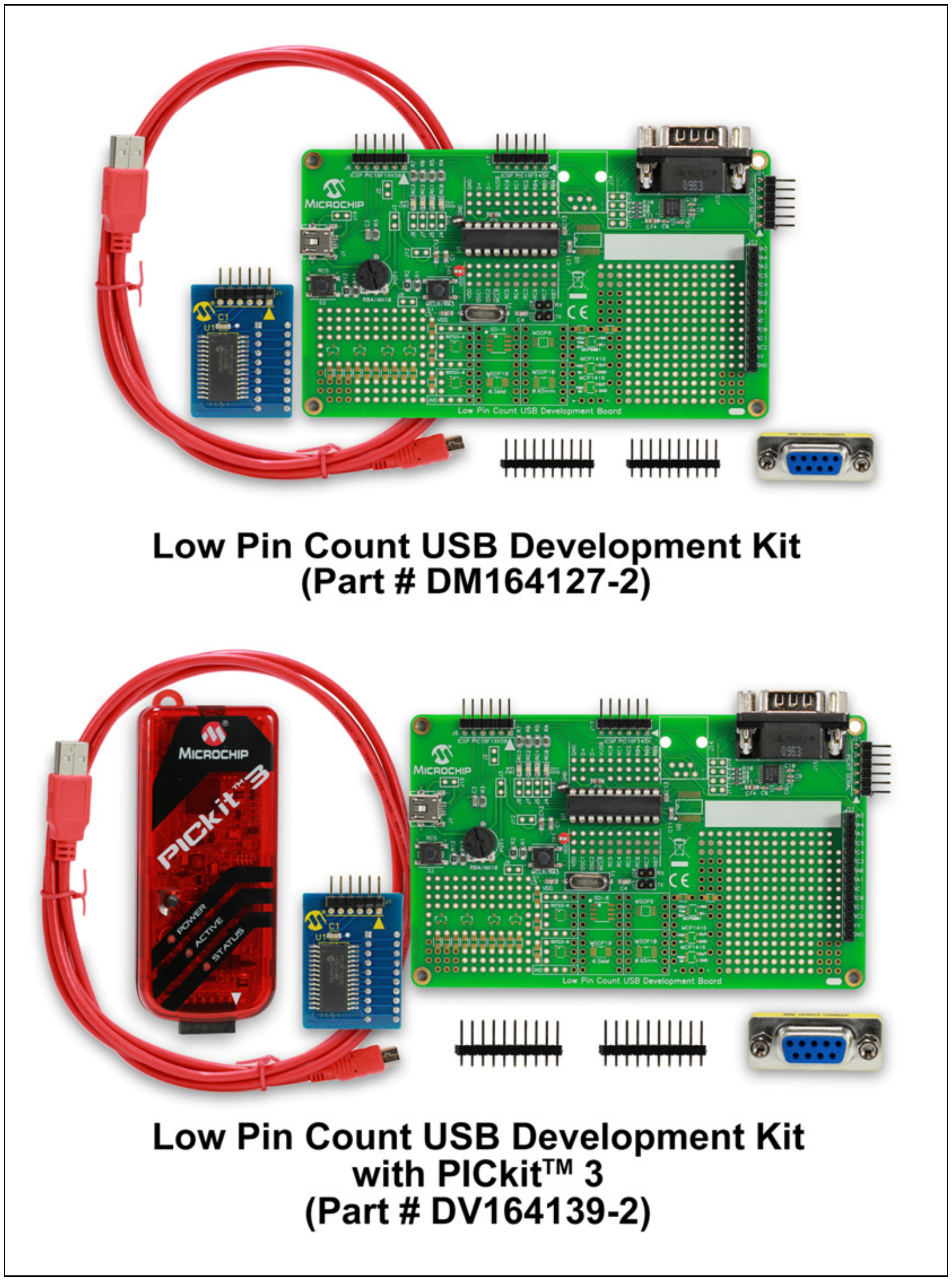
- Low Pin Count USB Development kit contents
- Low Pin Count USB Development Board construction and layout

1.3 LOW PIN COUNT USB DEVELOPMENT KIT CONTENTS

The Low Pin Count USB Development Kit contains the following:

- (1) fully populated Low Pin Count USB Development Board
- (1) PIC18F14K50 ICD populated expansion header
- (1) PIC16F1459 sample silicon
- (1) PICkit™ 3 Debugger/Programmer (included with DV164139-2, not included in DM164127-2).
- DB9 null modem mini adapter
- 10-pin male-male headers
- USB cable (A to mini-B)
- Quick Start Guide

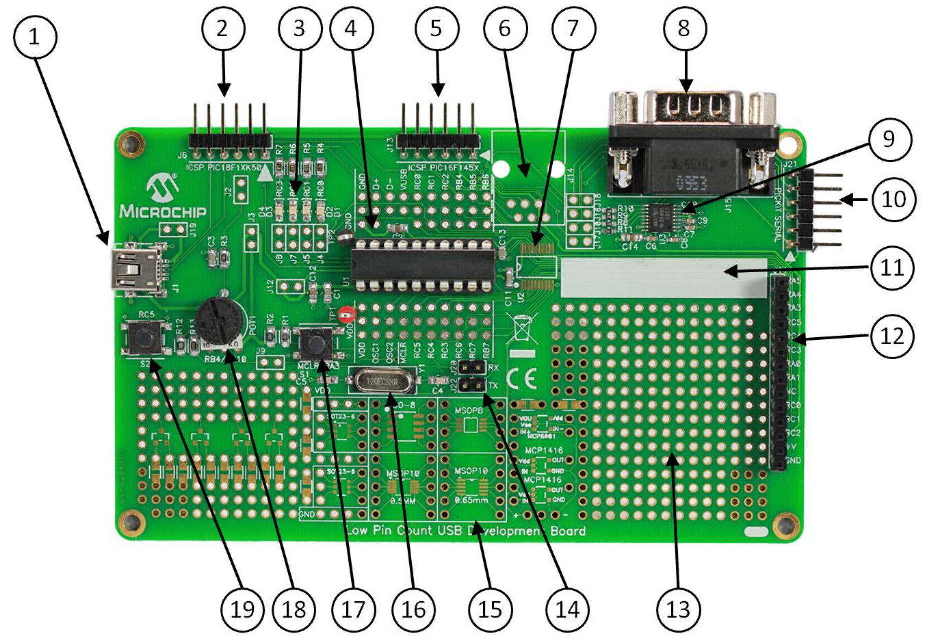
FIGURE 1-1: LOW PIN COUNT USB DEVELOPMENT KITS WITH AND WITHOUT PICkit™ 3



1.4 LOW PIN COUNT USB DEVELOPMENT BOARD CONSTRUCTION AND LAYOUT

The Low Pin Count USB Development Board and populated components are shown in Figure 1-2.

FIGURE 1-2: LOW PIN COUNT USB DEVELOPMENT BOARD



1. USB mini-B connector
2. PICkit 2/3 Style ICSP™ programming header (for programming PIC18F1XK50 devices)
3. LEDs connected to PORTC (RC0, RC1, RC2, RC3)
4. PIC18F1XK50 or PIC16F1459 microcontroller
5. PIC kit 2/3 Style ICSP programming header (for programming/debugging-PIC16F145X devices)
6. Footprint for RJ-11 connector
7. SSOP Expansion
8. RS-232 Connector
9. MAX3232 RS-232 line driver/receiver
10. PICkit Serial Analyzer header (Note: Not populated on some boards)
11. User-writable silk screen area
12. PICtail™ daughter board expansion header
13. Prototyping area
14. EUSART Transmit and Receive
15. External device expansion footprints

16. 12 MHz crystal (not required for USB operation with the PIC16F145X devices, but still included for use with the PIC18F1XK50 devices)
17. $\overline{\text{MCLR}}$/RA3 push button (pressed = logic low)
18. Potentiometer (connects to RB4/AN10)
19. RC5 push button (pressed = logic low)

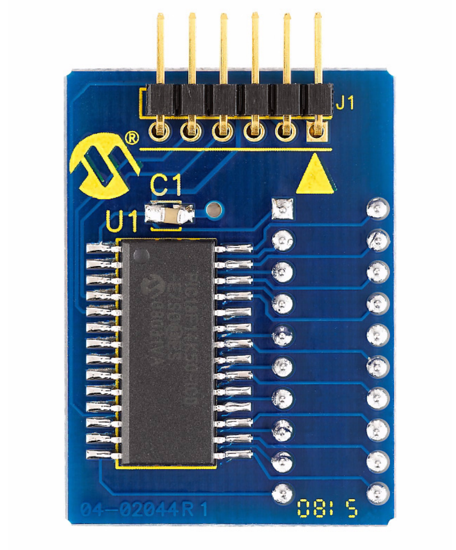
Note: J2-J5, J7, J8, J10 and J16-J19 are shunted on the bottom side of the board and thus the functions default connected even though no jumper is installed. The PCB traces can be cut to optionally disable the circuitry attached to each pin.

1.5 PIC18F14K50 ICD DEBUG HEADER

The PIC18F1XK50 microcontrollers are feature-rich, but low pin count, therefore necessitating some level of pin functionality multiplexing. On the PIC18F1XK50 devices, the PGC/PGD pins are multiplexed with the USB D+/D- pins. Therefore, in circuit firmware, debugging is not supported with the normal/production PIC18F14K50 silicon. However, in order to enable in-circuit debugging of PIC18F1XK50-based USB designs, a dedicated In-Circuit Debugging (ICD) board is provided in the Low Pin Count USB Development Kit, which contains special PIC18F14K50 silicon (with more pins than normal) that demultiplexes the USB D+/D- pins from the ICSP™ program/debug PGC/PGD pins. The dedicated/non-multiplexed PGC/PGD pins on this special device allow for the active debugging of USB firmware projects, without interfering with the D+/D- signaling necessary for normal USB communication.

No special debug header is necessary for debugging USB projects based on the PIC16F145X microcontrollers. On these microcontrollers, there are two PGC/PGD pin pairs, and in-circuit debugging operations can be performed using the RC0/PGD and RC1/PGC pin pair, which are not multiplexed with any USB functionality.

FIGURE 1-3: PIC18F14K50 POPULATED MPLAB® ICD DEBUG HEADER



To use the debug header, simply remove the PIC18F14K50 or PIC16F1459 microcontroller mounted in the DIP-20 socket (U1) on the Low Pin Count USB Development Board. Using the pin headers provided, connect the debug header into the MCU socket and connect a Microchip programmer/debug device, such as the PICkit™ 2 or 3, to the provided connection header (J1 on the debug header board).

When connecting the debug header, the "square pin" shown in the upper right quadrant of Figure 1-3 is the microcontroller pin 1 (V_{DD}), which should be electrically connected to the pin 1 (V_{DD}) of the U1 DIP-20 socket on the Low Pin Count USB Development Kit board.

Chapter 2. Getting Started With USB Development

2.1 GETTING STARTED AND USING THE OUT-OF-BOX DEMO FIRMWARE

The PIC16F1459 DIP-20 microcontroller that comes with the Low Pin Count USB Development Kit board comes pre-programmed with some example USB demo firmware. The example firmware demonstrates basic USB communication between the USB microcontroller and a custom PC host software program (HID PnP Demo.exe).

In order to run the demo program, you will first need to download and install the Microchip Libraries for Applications (MLA), which is a free-software package that contains source code for a wide variety of example application related projects and resources, both USB and non-USB related (ex: cap touch, ethernet, wireless, etc.). Included among the USB resources in the MLA are firmware projects, example USB PC software programs, drivers, documentation and other resources useful for developing complete USB applications. The MLA package can be obtained from:

http://www.microchip.com/mla

The USB device firmware projects in the MLA provide pre-configured MPLAB X-based build configurations for the standard Microchip USB demo boards/platforms, which include the Low Pin Count USB Development Kit (LPC USB Development Kit, or LPCUSBDK). Therefore, USB example projects in the MLA can be directly built and targeted for the LPC USB Development Kit board, with no modifications required, simply by opening the appropriate project and selecting the correct MPLAB X build configuration.

The MLA is regularly updated with new/additional contents, documentation improvements, bug fixes, and to add new microcontroller/demo board support. Therefore, when starting design work on a new application project, it is recommended to obtain the latest version of the MLA. However, this user's guide document is written based on Microchip Libraries for Application v2013-06-15. In future versions of the MLA (which could be renamed to something other than "MLA"), the exact directory structure of the relevant contents may differ somewhat from this document.

2.2 USING THE OUT-OF-BOX DEMO FIRMWARE/PC SOFTWARE

The programmed USB demo firmware (on the PIC16F1459 included with the Low Pin Count USB Development Kit) can be used by:

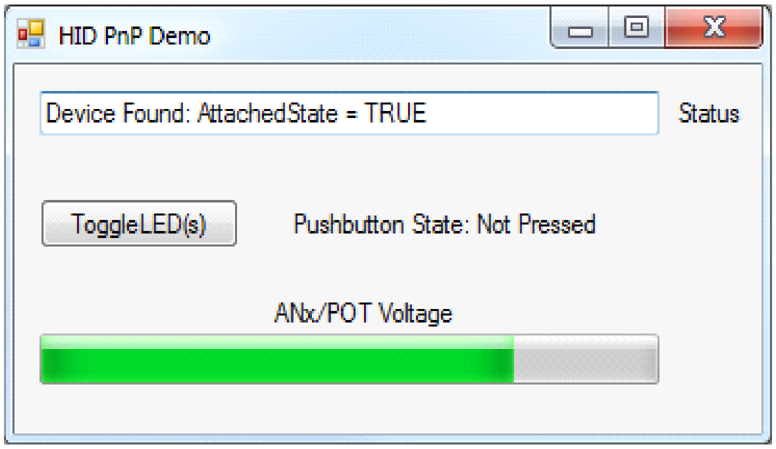
1. Plug the demo board into an x86 or x64 Microsoft Windows®-based computer, using the provided USB mini-B to full size A cable. The mini-B connector on the demo board is "J1".
2. The Low Pin Count USB Development Kit demo board is designed to be USB-bus powered, and should automatically power-up and begin the USB "enumeration" sequence (where the host begins sending the microcontroller various standard device requests that all USB devices are required to respond to, such as "get device descriptor").

3. The PC should automatically detect the USB device and begin installing standard Human Interface Device (HID) class drivers for the USB device. No manual/user installation of drivers should be necessary, as all standard x86/x64 Windows OSes (as well as Mac OS X and Linux based OSes) provide out-of-box HID USB drivers.
4. Once step #3 completes, the device should be ready to use, and custom PC application software programs that were written to communicate with the USB device should be able to find it and "connect" up to the device. The "HID PnP Demo.exe" is one such program, which is provided in the MLA.

- The "HID PnP Demo.exe" program can be found in the MLA v2013-06-15 under the folder: C:\[MLA install location]\USB\Device - HID - Custom Demos\
- Future versions of the MLA (subsequent to the v2013-06-15 release) are anticipated to have a somewhat different directory structure/organization, and the "HID PnP Demo.exe" file can likely be found under some other folder, which might be: `C:\[base install location]\apps\usb\device\hid_custom`

5. Launch the "HID PnP Demo.exe" program executable. This is a custom PC program that was originally written in Microsoft Visual C++ 2005 Express Edition. Therefore, this program requires the NET framework v2.0 or later redistributable package to run. Newer OSes (ex: Windows Vista® and later) already come with this package pre-installed, but on older OSes it may be necessary to download and install the redistributable from Microsoft, if it has not been previously installed. Upon the successful opening of the program, a window like shown in Figure 2-1should appear.

FIGURE 2-1: HID PNP Demo.exe APPEARANCE WITH USB DEVICE ATTACHED

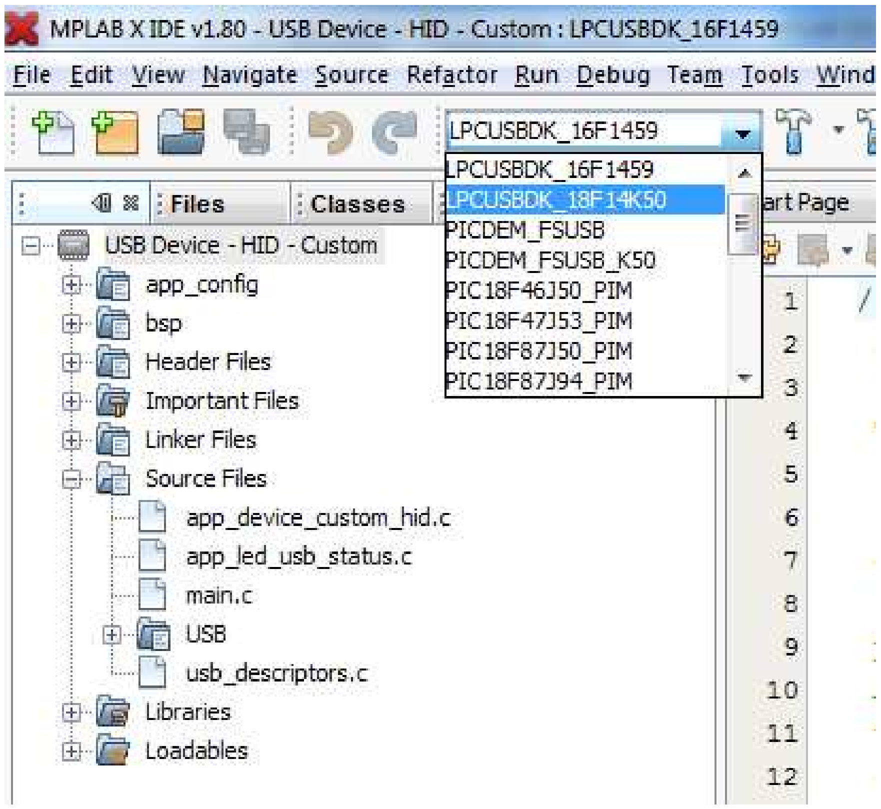

HID PnP Demo
Device Found: AttachedState = TRUE
Status
ToggleLED(s)
Pushbutton State: Not Pressed
ANx/POT Voltage

Upon successful connection, the PC software opens endpoints on the USB device, and periodically sends commands, requesting the demo board push button status (try pressing the S1 push button on the Low Pin Count USB Development Kit demo board) and the ADC reading for the pin with the potentiometer. Additionally, when the user clicks the "Toggle LED(s)" button, a USB packet is sent to the firmware instructing it to change the I/O pin states controlling the LEDs, to achieve the LED toggling effect. This application therefore demonstrates two-way USB communications and "plug and play" operation (try detaching and reattaching the demo board to/from the computer; the PC application should automatically detect this and disconnect/reconnect to/from the device).

2.3 RE-PROGRAMMING THE MICROCONTROLLER

Once you have finished experimenting with the out-of-box demo firmware and PC application software, the next step will be to re-program the microcontroller with new firmware. To do this, it is recommended to start with one of the existing USB firmware projects in the MLA. In order to build the project you will need to have MPLAB X and the latest MPLAB X C8 compiler (available at www.microchip.com/xc8). After opening the desired USB project, you will also need to make sure you select the correct MPLAB X build configuration for the microcontroller you are using (ex: PIC18F14K50 or PIC16F1459). The build configuration menu is shown in Figure 2-2, although the exact appearance may vary depending on the version of the MLA that you are using. In the drop down menu, the correct selection for the Low Pin Count USB Development Kit Demo board is either the LPCUSBDK_18F14K50 (when U1 is populated with PIC18F14K50) or LPCUSBDK_16F1459 (when U1 is populated with the PIC16F1459) configurations. Please note, that the exact name/appearance in this menu may be somewhat different (ex: different abbreviations) in other versions of the MLA.

FIGURE 2-2: MPLAB X BUILD CONFIGURATION DROP DOWN MENU



Assuming the proper compiler is installed for the target device, the project should build, normally without requiring any user modifications, when used with a native Microchip USB demo board/platform, such as the Low Pin Count USB Dev Kit board.

The out of box demo firmware is based on the "hid_custom" demo firmware in the MLA v2013-06-15. The MLA contains several other demos that can also be built and used directly with the Low Pin Count USB Development Kit board. It is recommended to refer to the USB Library Help documentation that comes with the MLA, to learn more about these other USB demos/device class examples.

2.4 SPECIAL CONSIDERATIONS FOR PROGRAMMING THE PIC18F14K50

When working with the PIC18F1XK50 device, it is important to be aware that the microcontroller PGC/PGD pins are multiplexed with the USB D+/D- pins, which have some implications when attempting to re-program the microcontroller.

In particular, when attempting to re-program the microcontroller, it is necessary to first unplug the USB cable from the USB host, prior to performing the ICSP programming operation. This is necessary to ensure that the ICSP programmer does not have I/O pin contention with the USB host, which may detect the activity on the D+/D- (which are the ICSP PGC/PGD pins), and incorrectly believe that a microcontroller is attempting to communicate with it. If both the ICSP programmer and USB cable are simultaneously attached, I/O pin contention can occur during the programming operation, which may result in a failed program/verify operation, and/or the USB host may think that the device is malfunctioning.

The official USB specifications contain a special provision whereby USB hubs are supposed to disable USB hub downstream ports, which have “malfunctioning” USB devices attached to them, that continuously generate erroneous and incorrect USB traffic (which is known as “babble”). Although the USB microcontroller should never generate this babble condition when correctly configured with the appropriate clock settings and compliant USB firmware, during an ISCP programming operation (when multiplexed with D+/D-), the host/hub may potentially interpret the ICSP signals (which are not in any way related to USB) as erroneous USB traffic, causing the hub to disable the USB port that the microcontroller is attached to. If this occurs, the situation can be recovered by power-cycling the USB hub that the device is attached to, and/or rebooting the computer. However, it is best to avoid this situation entirely, by ensuring that the ICSP programmer and USB cable are never simultaneously plugged-in, unless you are using the dedicated in-circuit debugger header board, which has de-multiplexed D+/D- and PGC/PGD pin functions.

Therefore, to re-program the standard PIC18F14K50 silicon (rather than the dedicated ICD device), it is recommended to:

1. Unplug the USB cable from the demo board (at the USB mini-B connector, not by unplugging the USB A connector from the host/hub, since the USB cable still represents a major parasitic capacitance, which depending upon size could still interfere with ICSP operations).
2. Connect the ICSP programmer such as the PICkit™ 3 to the Low Pin Count USB Development Kit board.
3. Within the MPLAB X IDE settings for the programmer, configure the programmer to enable the option that allows the programmer to supply power to the target board. Enable the power and configure the programmer to supply 3.3V nominal to the V_{DD} of the Low Pin Count USB Development Kit board.
4. Program the microcontroller with the ICSP programmer.
5. Once the program/verify sequence is successfully completed, unplug the ICSP programmer, and then re-attach the USB cable to the mini-B connector to test your newly programmed firmware project.

When developing with the PIC16F145X devices, or when developing with the dedicated PIC18F14K50 with the ICD board, the above procedures are not necessary, and it is fully acceptable to keep both the USB connector and ICSP programmer/debugger simultaneously attached. For these devices, the D+/D- USB pins and the PGC/PGD pins are not shared, and therefore, no contention is possible between the programmer/debugger and USB host.

When programming or debugging with the PIC16F145X devices, the ICSP programmer/debugger should be attached to the PICkit style header J13, or ICD3 style RJ11 jack J14 (J6 should not be used). However, if programming with the dedicated ICD board for the PIC18F14K50, the ICSP programmer/debugger should be attached to the J6 header on the dedicated ICD board.

2.5 USING THE PIC16F1454 AND PIC16F1455 DEVICES WITH THE LOW PIN COUNT USB DEVELOPMENT KIT BOARD

The PIC16F1454 and PIC16F1455 devices are available in the 14-PDIP package, which can potentially be used with the Low Pin Count USB Development Kit board. The DIP socket U1 on the Low Pin Count USB Development is designed for 20-pin microcontrollers (like the PIC18F14K50 and PIC16F1459). However, the 14-pin PIC16F1454/PIC16F1455 devices are pinout similar to the higher pin count devices (ex. PIC16F1459 and PIC18F14K50), and therefore can be plugged into the 20-DIP socket U1 on the Low Pin Count Development Kit board.

To use the PIC16F1454 or PIC16F1455 14-PDIP devices with the Low Pin Count USB Development Kit board, the microcontroller should be plugged in such that the microcontroller is "left justified" in the 20-DIP socket U1. In other words, the microcontroller pins 1-7 and 8-14 should be connected to the 20-DIP U1 socket pins 1-7 and 14-20, respectively.

When installed in the above described manner, most functionality of the demo board will remain intact; however, special changes are required in order to use the RS-232 based UART interface with a PIC16F1454 or PIC16F1455 device. On these 14-pin devices, the UART RX/TX pins are located on different port pins compared to the higher pin count devices. Therefore, in order to connect the 14-pin device RX/TX pins to the appropriate pins on the MAX3232 level translator device, the J20 and J22 pads need to be populated with 2-pin, 100 ml spacing, standard jumper headers. Additionally, both the J20 and J22 jumper headers should be shorted using standard jumper caps.

When using the 20-pin microcontrollers (ex: PIC18F1XK50 and PIC16F1459), the J20/J22 headers do not need to be populated, but if they are, the jumpers should be left open.

Chapter 3. Developing a USB Application

When developing a new USB application, it is suggested to evaluate all of the available USB device classes and USB example firmware/software projects that are already implemented in the MLA. A listing of the official USB Implementor's Forum (USB-IF) approved device class specifications can be found at:

http://www.usb.org/developers/devclass_docs#approved

The MLA contains example implementations of many of the different USB device classes. A USB device class can be thought of as a higher-level specification/standard, that "bolts on" to the existing USB 2.0 specifications (ex: usb_20.pdf, which includes various specifications that all USB devices, regardless of class, must adhere to). These additional specifications usually are associated with additional commands that the firmware must implement/support, but makes the device somewhat standardized with other similar devices of the same class, allowing for the sharing of the same/existing USB drivers on the host, etc.

When creating a new USB application, in many cases, you may have a choice as to what USB device class specifications you decide to base your design around. Each class tends to have various pros and cons, which may be useful to know when choosing the device class for your application. A brief summary of some of the more popular, better known classes and what they are best suited for is provided below.

Human Interface Device (HID) class: This class is especially versatile. It is primarily intended for implementing USB human interface type products (such as mice, keyboards, game pads, touch screens and pen input digitizer tablets, etc.), but can also be used for sending generic application-specific data not related to human interfacing at all. For example, the PICkit 3 programmer implements the USB HID class, even though it only sends "custom" data unrelated to interfacing with a human. All standard Windows, Linux, and Mac OS X operating systems provide standard HID class USB drivers and, therefore, the installation of such a device is normally fully "plug and play" without the user having to download or install additional kernel mode components. However, the primarily limitation of the HID class is that it only supports up to one "interrupt" IN endpoint and one interrupt OUT endpoint, which are only allowed to transmit/receive up to 64 bytes every 1 ms for a full-speed USB device. This restricts the maximum data transfer rate to 64 kB/sec maximum, and is, therefore, best suited for devices with relatively low bandwidth requirements.

Communication Device Class (CDC): This class is particularly useful for implementing USB devices that appear on the host as legacy COMx serial port devices. This can be convenient when migrating legacy hardware designs, which used to be based on real RS232 based serial ports to USB. When using the CDC class, the USB device appears and acts essentially the same as a real COMx serial port, and therefore, no PC software changes are normally needed when migrating the hardware to USB. The same PC software APIs for opening/reading/writing/closing COMx ports can still be used with a CDC class USB device implementing a virtual COMx port. However, the primary disadvantages of this class are:

1. Requires an end user installed driver package on Windows-based OSes. This can be especially problematic on Windows 8 64-bit, since this OS requires that the driver package must contain a valid Microsoft Authenticode™ or Microsoft WHQL signature to install. Although the driver packages in the MLA are WHQL signed, any modifications to the driver package will "break" the signature, requiring resigning.
2. As a legacy COMx port, it implements the input/output data flow as raw byte streams instead of using packets/transfers. In general, it is easier and more robust to implement higher level command/response style protocols using packets and transfers, which have clear beginning and end delimiters, rather than raw byte streams with no out-of-band communication beyond the byte stream.
3. Typically inferior error case handling/reporting/auto-retry options in the driver, as compared to other newer USB drivers, which are not restricted by the same error case reporting mechanisms of legacy COMx ports.
4. Imperfect "plug and play" implementation. Legacy COMx ports were not plug and play, and could not dynamically be attached/removed at runtime. However, all USB devices are always required to support dynamic runtime attachment/detachment. Although it is possible to unplug/reattach a CDC device, the PC software interfacing with the CDC device must be modified to be aware of plug and play events (and to automatically close the COMx port upon device removal), in order to ensure that the device can work again upon re-attachment. Other USB drivers/device classes are not hindered by these legacy restrictions.

Mass Storage Device (MSD) class: This device class is particularly useful for implementing USB Flash media devices and readers. Once enumerated, USB MSD devices appear as a new "drive" on the host. This device class is relatively dedicated in purpose, and does not expose any user level APIs that can be used for sending generic/unrelated USB data to/from the device. However, this class is often still useful, especially when combined with other device classes in a "composite" USB device configuration (where a USB device uses multiple interfaces to implement more than one USB device class or function simultaneously).

Custom/Vendor Defined class: The custom/vendor defined class is not a "standard" class, like the other USB device classes. This class does not have any additional class specification documents associated with it (beyond the basic USB specs), as the vendor is allowed to make up and implement their own higher level communication protocol and command set as they see fit. This class is especially useful when sending custom/arbitrary data, and the USB host drivers and APIs for this device class generally tend to be "excellent". This class is especially flexible and allows the designer to implement any combination of control, interrupt, bulk, and isochronous endpoints (subject to potential limitations of the host USB driver being used).

Under Windows, the Microsoft provided WinUSB driver implements the custom/vendor class and exposes easy to use API functions for sending/receiving USB packets/transfers to/from the device firmware. Additionally, the open source community has created the libusb driver which allows for the development of cross platform PC software applications that can work equally well on Windows, Mac OS X, and Linux-based OSes, with a single PC software code base. Moreover, the good quality of API documentation and flexibility of this device class make it quite easy to use.

Nonetheless, the custom nature of the device class requires a custom driver package to be installed (even if using the Microsoft Windows provided WinUSB driver, except on Windows 8, which allows USB devices to implement special USB "descriptors" to install the WinUSB driver package automatically without user intervention), which is the primary disadvantage of this device class.

3.1 TIPS WHEN DEVELOPING A USB APPLICATION

When developing your first USB application, there are a few common problems that you may at some point encounter, such as:

USB enumeration problems, with "Unknown Device" showing up in the Windows Device manager (under the Universal Serial Bus controllers category)

These symptoms normally occur anytime that the USB device/firmware is working well enough to successfully turn on the USB module (and the D+ or D- pull up resistor in the microcontroller, which signals attachment to the USB host), but not well enough to properly process and respond to required USB commands, which the host will send to the device early in the USB enumeration sequence. Failure to respond to the necessary host requests can be caused by a variety of factors, but the most common ones to double check include:

1. *Hardware problems on your circuit board*. This should not be a problem when using the Microchip Low Pin Count USB Development Kit board, but may be encountered when migrating your design from the demo board to your own custom hardware platform. The most common potential issues that deserve double checking include:
   - D+/D- connection problems. These microcontroller pins must be connected directly to the same named pins on the USB cable or USB connector. D+ should be tied to D+, and D- should be tied to D-. The pin pairs should not be swapped (like done in UART-based systems). No additional resistance should be placed in series with the pins between the microcontroller and USB connector (small values $\leq 10\Omega$ are normally harmless). Furthermore, any additional parasitic capacitance added to the D+/D- nets (ex: due to possible external ESD protection circuitry) should be kept to minimum (when operating at USB 12 Mbps full-speed data rate). For full-speed operation, values up to approximately 50 pF of additional capacitance are allowed (per pin, which needs to be symmetrically implemented for both D+ and D-), but values larger than this may begin to introduce USB signal quality distortions.
   - VUSB/VUSB3V3 pin connection problems. This microcontroller pin feeds the USB transceiver, and is therefore critical for providing good USB transmit signal quality, and providing good USB signal reception capability. Refer to the device data sheet for the correct connections/proper capacitance for this pin.
2. Software configuration problems, which may include:
   - Oscillator settings and Configuration bits settings – make certain that the new settings being used are genuinely compatible with USB operation. Although the microcontroller may support operation at many frequencies and many clock sources, only certain options are valid/compatible with active USB module operation and will result in the correct USB transmit/receive bit rates matching the USB specifications. Make sure they are correctly configured, and if using a device without a crystal but with active clock tuning (ex: a PIC16F145X device), make sure that the feature is enabled in the ACTCON register, sometime prior to enabling the USB module.
   - Problems with the hardware profile/default pins used in the project. If using the MLA v2013-06-15, make sure the usb_config.h and Hardware Profile – [platform name].h files are correctly configured for your platform. When using the MLA v2013-12-20 and likely later versions of the MLA, make sure the usb_config.h and system.h/system.c files are correctly configured for the intended application hardware design.

3. Other software problems introduced during the code editing/development process. For these types of issues, it is suggested to develop the application code under an SVN repository (so as to be able to revert back to “last known good/working” code), and to consider investing in a hardware-based USB protocol analyzer. USB protocol analyzers allow the user to capture raw USB traffic moving across a USB bus segment, and formats the data for easy viewing/interpretation to the user. Although relatively expensive, these hardware tools can save significant amount of debugging time and frustration, as they allow the developer a true glimpse into the actual operation of the USB link.

Appendix A. Schematics

A.1 INTRODUCTION

This appendix contains the Low Pin Count USB Development Kit hardware diagrams.The schematics provided in this user's guide are for the DM164127-2/DV164139-2 version of the hardware/PCB. Earlier versions of this board exist (which do not have the "-2" suffix in the part number. For schematics for the older versions of this board, refer to 41356B.pdf. A newer "-2" version of the board can be identified by the silk screen text for header J13 (upper middle portion of the board). On the original (non "-2" suffix) version of the board, the silk screen text for J13 reads "PICkit Serial". On the newer "-2" suffix boards, the J13 silk screen text reads "ICSP PIC16F145X".

The new version of the board primarily differs from prior versions of the board, in that it re-purposes the J13 header (from being a PICkit Serial connection) to a dedicated PIC16F145X programming/debug port), while adding the header J21 (a new PICkit Serial connection). Additionally, the new boards have more smoothing capacitance on V_{DD}. The board revisions are software/firmware compatible with each other, although it is recommended to add additional V_{DD} capacitance (1-8 uF) if using an old revision board.