PICDEM™ PIC18 Explorer Demonstration Board User's Guide

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.

- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.

- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.

- Microchip is willing to work with the customer who is concerned about the integrity of their code.

- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

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PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD USER'S GUIDE

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PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD USER'S GUIDE

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 PICDEM™ PIC18 Explorer Demonstration Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in This Guide
- Warranty Registration
- Recommended Reading
- The Microchip Web Site
- Development Systems Product Change Notification Service
- Customer Support
- Revision History

DOCUMENT LAYOUT

This document describes how to use the PICDEM PIC18 Explorer Demonstration Board as a development tool to emulate and debug firmware on a target board. The document is organized as follows:

- **Chapter 1. "Introduction"** – Overview of the development board and kit
- **Chapter 2. "Getting Started"** – Description of the different ways to use the board
- **Chapter 3. "Tutorial Program"** – Explanation of the tutorial preprogrammed on the sample devices
- **Appendix A. "Hardware Details"** – Description of the board's hardware elements, including layout and schematic drawings

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	*File>Save*
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)`
		`{ ...`
		`}`

WARRANTY REGISTRATION

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in the Warranty Registration Card entitles users to receive new product updates. Interim software releases are available at the Microchip web site.

RECOMMENDED READING

This user's guide describes how to use the PICDEM PIC18 Explorer Demonstration Board. The following documents are available and recommended as supplemental reference resources.

Readme file

This file contains brief details regarding the contents of the folders included in the CD-ROM which comes with the PIC18 Explorer development kit.

MPLAB® ICD 3 In-Circuit Debugger User's Guide (DS51766)

This document provides all the necessary information on the MPLAB® ICD 3 In-Circuit Debugger's operation, installation, general setup and tutorial details. The MPLAB ICD 3 is a cost-effective high-speed hardware debugger/programmer developed by Microchip for PIC® microcontrollers and Digital Signal Controllers (DSCs).

MPLAB® REAL ICE™ In-Circuit Emulator User's Guide (DS50002085)

This user's guide describes how to use the MPLAB® REAL ICE In-Circuit Emulator as a development tool to emulate and debug firmware on a target board, as well as how to program devices. It provides details on the emulator's operation, features, troubleshooting, software and hardware reference and emulator accessories.

PICkit™ 2 Programmer/Debugger User's Guide (DS51553)

This user's guide describes how to use the PICkit™ 2 as a development tool to program and debug firmware on a target board. It covers the features, operation, troubleshooting, using the ICSP™ and other essential information about the PICkit 2 Programmer/Debugger.

PICkit™ 3 In-Circuit Debugger/Programmer User's Guide for MPLAB® X IDE (DS52116)

This user's guide describes the PICkit™ 3 In-Circuit Debugger/Programmer's operation, usage, troubleshooting methods and hardware specifications. The PICkit 3 can be implemented as a debugger or development programmer for Microchip PIC MCUs and DSCs that are based on In-Circuit Serial Programming™ (ICSP™) and Enhanced ICSP™ 2-wire serial interfaces.

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

DEVELOPMENT SYSTEMS PRODUCT CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com, click on Product Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers, assemblers, linkers and other language tools. These include the MPLAB® XC Compilers that support all 8-, 16- and 32-bit PIC MCUs and dsPIC® DSCs.
- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB® REAL ICE™ In-Circuit Emulator.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debuggers. This includes the MPLAB® ICD 3 In-Circuit Debugger and the PICkit™ 3 In-Circuit Debugger.
- **MPLAB® X IDE** – The latest information on Microchip MPLAB X IDE, the Integrated Development Environment for development systems tools which can be run on Windows®, Mac OS® and LINUX®operating systems.
- **Programmers** – The latest information on Microchip programmers. These include the device (production) programmers MPLAB REAL ICE in-circuit emulator, MPLAB ICD 3 in-circuit debugger, MPLAB PM3 and the development (nonproduction) programmer PICkit 3.

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://www.microchip.com/support.

REVISION HISTORY

Revision A (March 2008)

Initial release of this document.

Revision B (May 2008)

Name and title change.

Revision C (June 2015)

IDE, compiler, programmer, debugger and board tutorial program updates.

NOTES:

Chapter 1. Introduction

1.1 INTRODUCTION

The PICDEM™ PIC18 Explorer Demonstration Board is a demonstration board for evaluating Microchip Technology's PIC18FXXXX and PIC18FXXJXX families of devices.

The board can be used as a stand-alone device or with an in-circuit debugger, such as the MPLAB ICD 3, and host PC.

Sample programs are provided to demonstrate the unique features of the supported devices. Free software development tools are available for application development and debugging.

1.2 DEVELOPMENT KIT CONTENTS

The PICDEM PIC18 Explorer Demonstration Board Kit comes with the following:

- PICDEM PIC18 Explorer Demonstration Board (Figure 1-1)
- Board-mounted PIC18F8722 and an alternate PIC18F87J11 mounted on a Plug-In Module (PIM)
- CD-ROM that contains:
    - Sample programs, source code and hex files
    - *PICDEM™ PIC18 Explorer Demonstration Board User's Guide* (DS50001721)
    - Other referenced documents

If the kit is missing any of these parts, please contact the nearest Microchip sales office listed in the back of this publication.

The MPLAB® Integrated Development Environment (IDE) is a free, integrated software tool set for application development and debugging. Compilers and other board-compatible software and hardware tools can be purchased.

To download the MPLAB IDE software and documentation, or get information on the other tools, visit www.microchip.com.

1.3   PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD

The PICDEM PIC18 Explorer Demonstration Board has the following hardware features with each feature's number corresponding to the number in Figure 1-1 that shows the feature's location on the board:

1. PIC18F8722 microcontroller – The sample, primary microcontroller mounted on the board.
2. Male header pins for connecting Plug-In Modules (PIMs). A PIM enables an alternate PIC18 device to be connected to the board, as the primary microcontroller.
3. In-Circuit Debugger (ICD) connector.
4. 6-pin, PICkit™ 2 connector.
5. 10 kΩ potentiometer for analog inputs.
6. Push button switch – For external Reset.
7. USB connector – For RS-232 communication.
8. PIC18LF2450 microcontroller – For converting RS-232 communication to USB protocol for attachment of a host PC.
9. 12 MHz crystal – For the PIC18LF2450 microcontroller.
10. RS-232 DB9 socket and associated hardware – For direct connection to an RS-232 interface.
11. Jumper J13 for routing RS-232 communication through either the USB port or the RS-232 socket.
12. Jumper J4 – For selecting between programming the main PIC® device or the PIC18LF2450, used for USB to RS-232 communication.
13. Switch S4 – For designating the main microcontroller as either the board-mounted PIC18F8722 or a PIM-mounted microcontroller.
14. LED – For power-on indication.
15. JP1 – For disconnecting the eight display LEDs.
16. Eight LEDs.
17. 32.768 kHz crystal – For Timer1 clock operation.
18. Two push button switches – For external stimulus.
19. Analog temperature sensor, MPC9701A.
20. 25LC256 SPI EEPROM.
21. JP2 – To enable/disable EEPROM.
22. JP3 – To enable/disable LCD.
23. 10 MHz crystal – For the main microcontroller.
24. PICtail™ daughter board connector socket.
25. SPI I/O expander – For LCD display, MCP23S17.
26. Prototype area – For user hardware.
27. LCD display.
28. J2 three-pin, male header – For selecting between a voltage of 3.3V or 5V.
29. J14 four-pin, male header – For use with a PIM, if required, to connect 3.3V or 5V, V_{IN} and ICE $\overline{MCLR}$.

FIGURE 1-1: **PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD**
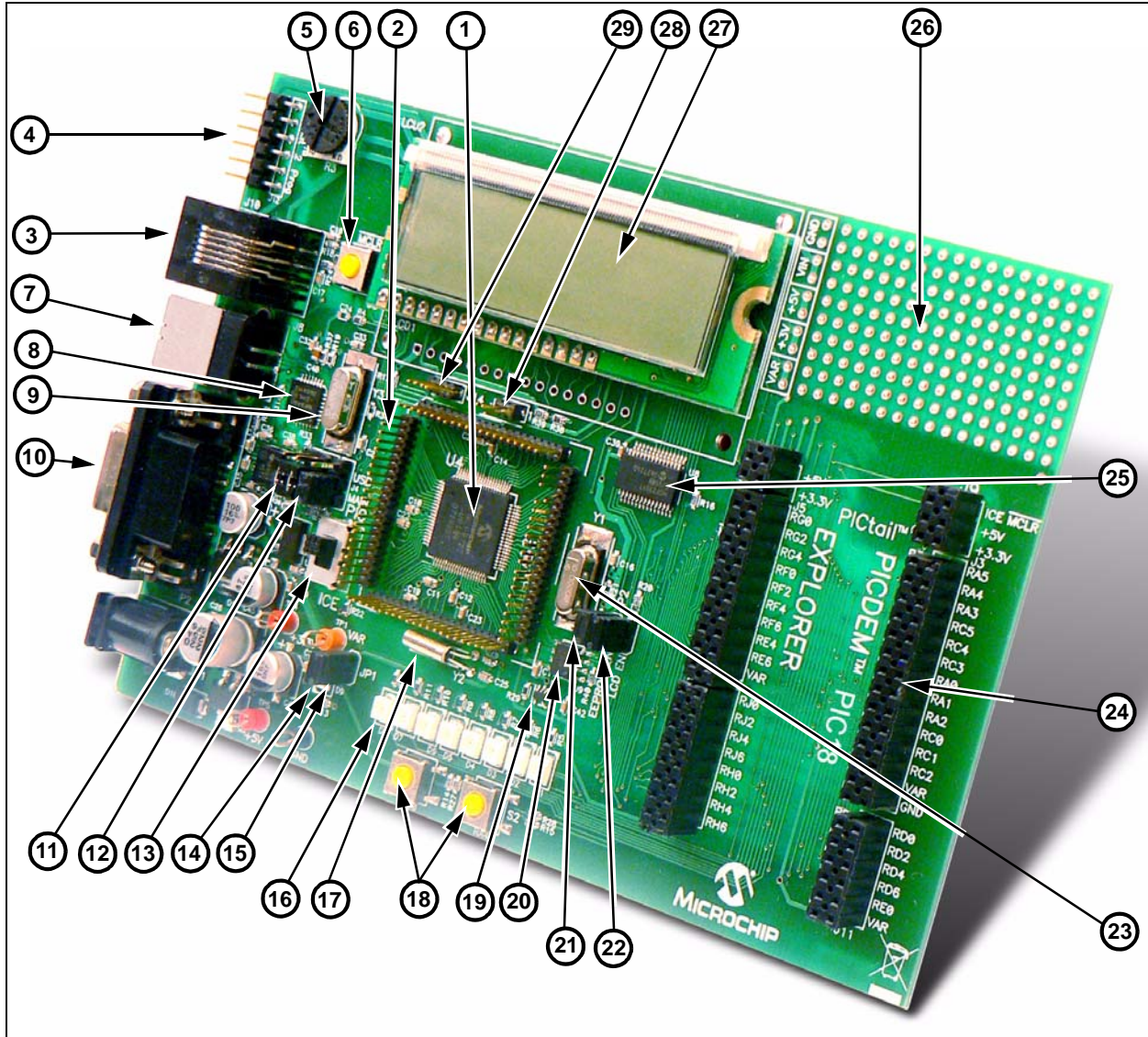
1.4 SAMPLE DEVICES

The PICDEM PIC18 Explorer Demonstration Board comes with two sample devices that alternately can be used as the main microcontroller:

- An 80-pin, 5V PIC microcontroller (the PIC18F8722) mounted on the board
- A 3.3V PIC18 device (PIC18F87J11) mounted on an 80-pin PIM that connects to the demo board via an 80-pin male

1.5 SAMPLE PROGRAMS

The PICDEM PIC18 Explorer Demonstration Board Kit includes a CD-ROM with sample demonstration programs. These programs may be used with the included sample devices and with an in-circuit debugger (ICD).

Also provided on the disc is demonstration source code that includes several assembly source code (ASM) files and one hex compiled code file.

Demo source codes in C are also available on the Microchip web site.

NOTES:

Chapter 2. Getting Started

The PICDEM PIC18 Explorer Demonstration Board may be used in a variety of ways. Table 2-1 lists the three primary configurations and the required equipment and capabilities of each.

TABLE 2-1: PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD CONFIGURATIONS

Configuration	Board Connections	Board Capabilities
Stand-alone board	Power supply	• Access board's full functionality • Demonstrate sample code • Display functionality with LCD or LEDs • Connect ICD/programmer for debugging or programming • Connect PICtail™ daughter cards
Board with In-Circuit Debugger/Programmer	• Power supply • In-Circuit Debugger (ICD) that also can be used as a programmer	• Access board's full functionality • Demonstrate sample code • Develop and debug code • Reprogram microcontrollers • Connect PICtail daughter cards
Board with alternate microcontroller, attached through a Plug-In Module (PIM)	• Power supply • ICD that can also be used as a programmer • PIM with mounted microcontroller	• Substitute PIM-mounted device as main microcontroller[†] • Use 3.3V or 5V devices as main microcontroller • Demonstrate sample code • Develop and debug code • Reprogram microcontrollers • Connect PICtail daughter cards

† PIM enables 80, 64, 44 and 28-pin devices to be used as the main microcontroller. For information on the available PIMs, go to www.microchip.com.

This chapter describes:

• How to implement each of the uses described in Table 2-1
• How to reprogram the main and RS-232 to USB microcontrollers
• How to connect the demonstration board to a host PC for RS-232 communication

2.1 BOARD AS STAND-ALONE DEVICE

In using the PICDEM PIC18 Explorer Demonstration Board as a stand-alone device, an implementation can:

• Use the board as is, utilizing the firmware loaded on the main, PIC18F8722 microcontroller and RS-232 to USB PIC18LF2450 microcontroller
• Reprogram the main, PIC18F8722 microcontroller or the RS-232 to USB, PIC18LF2450 microcontroller and demonstrate user programs

2.1.1 Using the Board As Is

To immediately implement the PICDEM PIC18 Explorer Demonstration Board to demonstrate the PIC18F8722 microcontroller:

1. Designate the mounted, PIC18F8722 device as the board's main microcontroller by moving switch S4 to **PIC** MCU, as shown in Figure 2-1.

FIGURE 2-1: S4 SWITCH – SETTING FOR DEFAULT MAIN MICROCONTROLLER
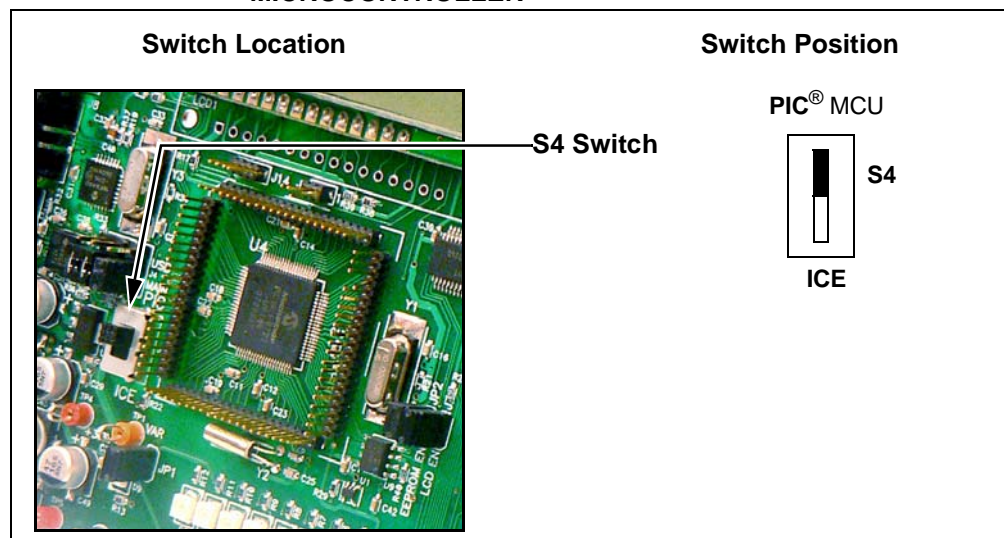
2. Enable the LEDs by placing a jumper on JP1, as shown in Figure 2-2.

FIGURE 2-2: JP1, JP2 AND JP3 JUMPERS
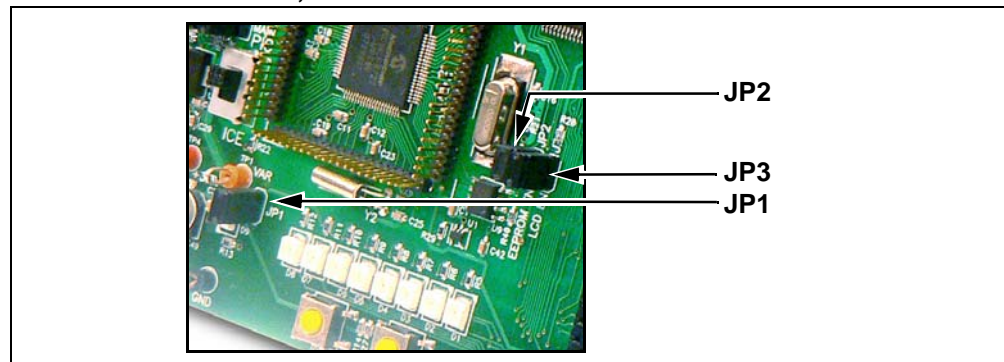
3. Enable the EEPROM and the LCD by placing a jumper on JP2 and JP3, as shown in Figure 2-2.

4. Apply power to the board.

   For information on acceptable power sources, see **Appendix A. "Hardware Details".**

The device now can be demonstrated using the tutorial program. (See **Section 3.1 "Tutorial Program Operation"**.)

2.1.2 Reprogramming the Microcontroller

Either or both the main PIC18F8722 microcontroller and RS-232-USB, or the PIC18LF2450 microcontroller, can be reprogrammed for running the board as a stand-alone device.

To implement this usage:

1. Reprogram either or both devices, as described in **Section 2.4 "Programming the Microcontrollers"**.
2. Disconnect the programming devices.
3. Follow the procedure given in **Section 2.1.1 "Using the Board As Is"**.

2.2 BOARD WITH IN-CIRCUIT DEBUGGER

The PICDEM PIC18 Explorer Demonstration Board can also be connected to an In-Circuit Debugger (ICD) that is connected to a host PC. This can be done with the board's main microcontroller configured as either the mounted PIC18F8722 device or an alternate device mounted to a PIM that is plugged into the board. (For information on PIM attached devices, see **Section 2.3 "Board with PIM Attached Devices"**.)

The MPLAB ICD 3 In-Circuit Debugger is an inexpensive ICD that could be used. (For more information, see **Section 2.4.1 "Programming Requirements"**.) The ICD is connected, as shown in Figure 2-3, to the ICD connector. For operational information, see *MPLAB® ICD 3 In-Circuit Debugger User's Guide* (DS51766).

The PICDEM PIC18 Explorer Demonstration Board can alternately use the PICkit™ 3 In-Circuit Debugger/Programmer or the MPLAB REAL ICE™ emulator as debugger.

FIGURE 2-3: **BOARD WITH MPLAB® ICD 3 IN-CIRCUIT DEBUGGER ATTACHED**
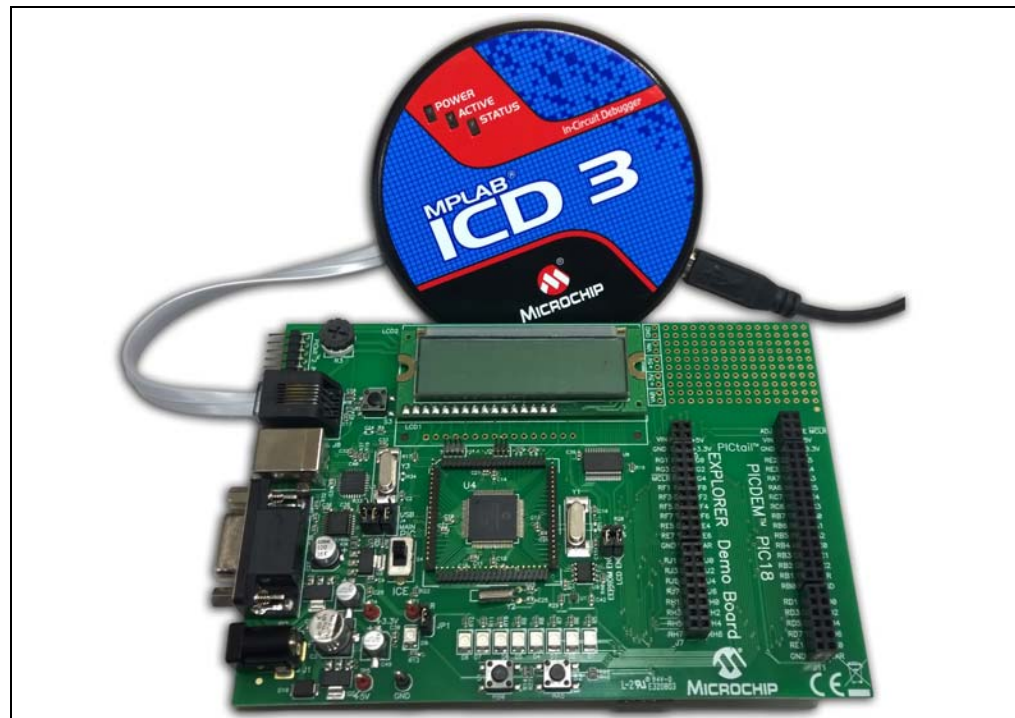
For information on other microcontroller compatible ICD or ICE devices, see the Microchip web site at www.microchip.com.

2.3   BOARD WITH PIM ATTACHED DEVICES

The PICDEM PIC18 Explorer Demonstration Board also can be used to demonstrate other PIC18 devices – having them replace the PIC18F8722 mounted on the board as the board's main microcontroller. This is done by attaching a Plug-In Module (PIM) that has the other microcontroller mounted to it.

The PICDEM PIC18 Explorer Demonstration Board comes with the PIC18F87J11 PIM representing the super set device for the PIC18 J-series of products.

FIGURE 2-4:   **PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD WITH PIM**

The PIM enables the attachment of 80, 64, 44 or 28-pin devices. Some PIMs also enable the board's 5V output to be automatically reset to 3.3V.

For a list of microcontroller-compatible PIMs go to www.microchip.com.

2.3.1 Attaching the PIM

To attach the PIM:

1. Seat the PIM in the 80-pin, elevated, male connectors that encircle the PIC18F8722 (see Figure 2-5).

FIGURE 2-5: PIM CONNECTORS AND S4 SWITCH
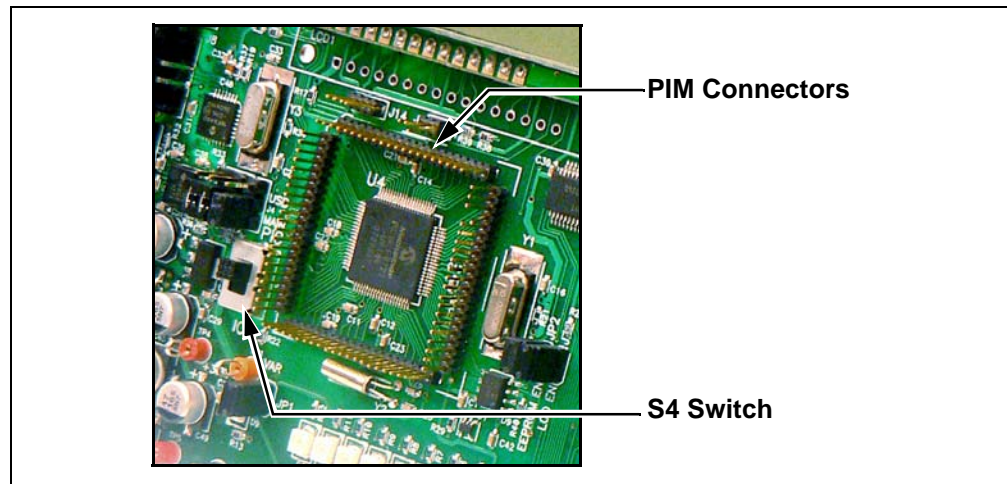
2. Alternately, an In-Circuit Emulator (ICE) can be attached to the male connectors. This enables in-circuit emulation and user development and debugging of code. For information on this use, see the Microchip web site (www.microchip.com).

2. To designate the PIM-mounted device as the main microcontroller, set switch S4 (shown in Figure 2-5) to **ICE** (see Figure 2-6).

FIGURE 2-6: S4 SWITCH – SETTING FOR PIM-MOUNTED DEVICES
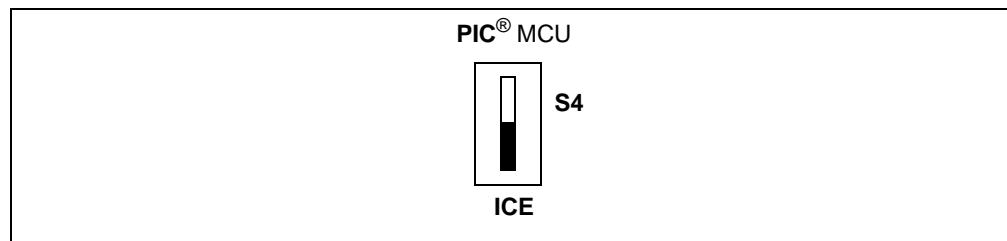
3. If you are converting from the board's default V_{DD} of 5V, see **Section 2.3.2 "Varying the Device Voltage (5V/3.3V)"**.

2.3.2 Varying the Device Voltage (5V/3.3V)

By default, the PICDEM PIC18 Explorer Demonstration Board's V$_{DD}$ supply is 5V. The V$_{DD}$ can be varied, for PIM-mounted microcontrollers, from 5 to 3.3V to accommodate devices running at 5 or 3.3V. This V$_{DD}$ is named VAR.

The PICDEM PIC18 Explorer Demonstration Board enables the voltage change with PIM connection headers and a variable voltage regulator. PIMs mounted with 3.3V devices implement the voltage change through two resistors with values that produce the desired voltage (see **Section 2.3.3 "Calculating Other V$_{DD}$ Values"**.)

The voltage varying hardware includes:

- An adjustable voltage regulator, the LM317 – Located on the board, left of the PIM connectors and marked as **U2** (recognizable by the TO-220 package commonly used for transistors)
- Header J2 – Located above the PIM connectors
- Resistors R25 and R26 – Located below jumper J13
- Resistors R101 and R102 – Located on the PIM board

In setting the board's voltage:

- For the default, 5V voltage –
  - For board-mounted PIC18F8722 device:
    - Board resistor R25 = 1 kΩ
    - Board resistor R26 = 330Ω
  - For a PIM-mounted, 5V microcontroller:
    - Board resistors R25 and R26 – Same values of 1 kΩ and 330Ω, respectively
    - PIM-mounted resistors R101 and R102 – Unpopulated

- For 3.3V V$_{DD}$ (achieved only with a PIM with a mounted 3.3V device, such as the PIC18F87J11) –
  - Header J2 goes into the PIM board where resistors R101 and R102 are inserted in parallel to the board resistors R25 and R26
  - PIM board resistor R101 can be unpopulated
  - PIM board resistor R102 can be 1.18 kΩ

> **Note:** For precise adjustment of V$_{DD}$, 1% resistors are recommended.

2.3.3 Calculating Other V_{DD} Values

Other V_{DD} values can be produced by the LM317 adjustable voltage regulator by populating the PIM board's R101 and R102 with different value resistors.

A brief overview follows, on how to calculate alternate values for these resistors. For detailed information, see the LM317 data sheet.

EQUATION 2-1: REGULATOR VOLTAGE OUTPUT

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right) + I_{ADJ} \cdot R2$$

I_{ADJ} is minimized by the LM317, so it can be assumed to be zero, or very small. V_{REF} is the reference voltage developed by the LM317 between the output and adjustment terminal and equals 1.25V.

That produces the equations shown in Equation 2-2.

EQUATION 2-2: CALCULATING OUTPUT VOLTAGE

$$V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right)$$

$$R2 = R25 \parallel R102 = \frac{(R25 \cdot R102)}{(R25 + R102)}$$

$$R1 = R26 \parallel R101 = \frac{(R26 \cdot R101)}{(R26 + R101)}$$

As stated previously, R25 = 1 kΩ, and R26 = 330Ω. Without R102 and R101 being inserted in parallel on the PIM board, V_{OUT} =1.25V(1+ 1 kΩ/330Ω) = 5.04V.

To calculate a desired V_{OUT}:

1. Solve for R2, given R1 = R26 = 330Ω.
2. Now knowing R2 and R25, solve for R102.
3. Determine the nearest available resistor value for R102 and recalculate the resulting V_{DD} to make sure it does not exceed the maximum V_{DD} for the part you will be using.

Table 2-2 shows the R101 and R102 resistor values to use for different V_{DD} values. The table assumes that the PICDEM PIC18 Explorer Demonstration Board's R25 and R26 resistors are left at their default values of 1KΩ and 330Ω, respectively.

TABLE 2-2: CALCULATING R101, R102 VALUES FOR V_{DD} OUTPUTS[†]

V_{DD}	R101 Value	R102 Value
5V	Open	Open
3.6V	Open	1.62 kΩ
3.3V	Open	1.18 kΩ
3.0V	Open	866 RΩ

† This table assumes that the PICDEM PIC18 Explorer Demonstration Board's R25 and R26 resistors are left at their default values of 1 kΩ and 330Ω, respectively.

2.4   PROGRAMMING THE MICROCONTROLLERS

Either or both the main microcontroller (PIC18F8722) and the RS-232 to USB, or the PIC18LF2450 microcontroller, can be reprogrammed. The main microcontroller that is reprogrammed can either be the board-mounted PIC18F8722 device or an alternate main microcontroller, mounted on a PIM attached to the board.

This section discusses:

• Programming Requirements
• Loading the Program Using MPLAB® IDE
• Loading the Program Using MPLAB X® IDE

2.4.1   Programming Requirements

To reprogram a sample device, the following is required:

• Program source code – Sample code is preloaded on the device, but user source code can be substituted.

  If this is done, the sample program can be restored using the file on the board kit's CD-ROM or by downloading the project files available at the Microchip web site.
• An assembler or compiler – Source code must be assembled or compiled into a hex file before it can be programmed into the device.
• A programmer – Once the code is in the hex file format, this device programs the microcontroller's Flash memory.

  If the code protection bit(s) have not been programmed, the on-chip program memory can be read out for verification purposes.

In meeting these requirements, the following items are to be taken into consideration:

• Code development and debugging –

  The free MPLAB X IDE and MPLAB IDE software development tools include a debugger and several other software tools as well as a unified graphical user interface for working with other Microchip and third-party software and hardware tools.
• Assembler –

  The free MPLAB IDE tool includes the MPASM™ assembler.
• Compiler –

  Microchip's MPLAB® XC8 Compiler and the MPLAB® C18 Compiler are fully integrated for the MPLAB IDE environment.
• Programmer –

  Microchip's MPLAB® In-Circuit Debugger (ICD) 3, PICkit 3 In-Circuit Debugger/Programmer, or MPLAB REAL ICE In-Circuit Emulator can be used to program the device and all are fully integrated for the MPLAB IDE environment.

The free MPLAB IDE tool set and its documentation can be downloaded at www.microchip.com.

For a list of the other mentioned devices' documentation, see **"Recommended Reading**.

Other assemblers/compilers can be used. For a list of tools compatible with PIC microcontrollers, see the Microchip web site (www.microchip.com).

2.4.2 Loading the Program Using MPLAB® IDE

This section describes how to program the PICDEM PIC18 Explorer Demonstration Board using the MPLAB® Integrated Development Environment (IDE) and the sample hex code on the compact disc in the PICDEM PIC18 Explorer Demonstration Board's Kit.

2.4.2.1 REPROGRAMMING WITH THE COMPACT DISC SAMPLE CODE

To program the PIC18F8722:

1. Launch the MPLAB IDE application and select *Configure>Select Device>18F8722*.
2. To start the programmer, select *Programmer>Select Programmer> ICD2*.
3. To open the hex code file, select *File>Import>Open* and select `CD/Hex/18F8722/Demo8722.hex`.
4. Connect the J4 jumper to **Main** (main controller), as shown in Figure 2-7.

FIGURE 2-7:   J4 JUMPER AND 'MAIN' SETTING
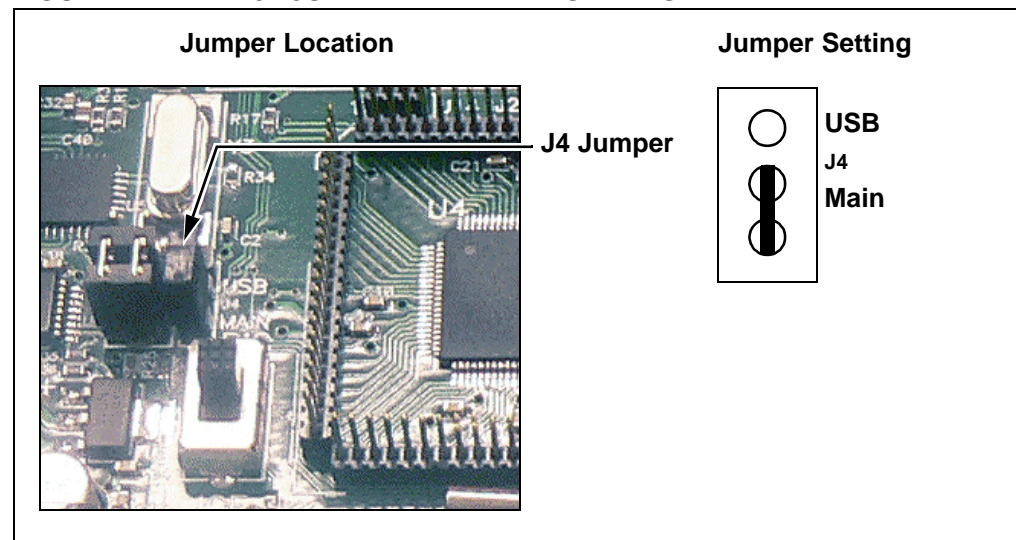
5. Move the S4 switch to **PIC** MCU, as described in **Section 2.1.1 "Using the Board As Is"**.

To program the PIC18F87J11 on the PIM:

1. Attach the PIM to the demonstration board.
2. Move the S4 switch to **ICE**.

> **Note:**   Steps 1 and 2 are described in **Section 2.3.1 "Attaching the PIM"**.

3. Launch the MPLAB IDE application and select *Configure>Select Device>18F87J11*.
4. To start the programmer, select *Programmer>Select Programmer>ICD2*.
5. To open the hex code file, select *File>Import>Open* and select `CD/Hex/18F87J11/Demo87J11.hex`.
6. Connect the J4 jumper to **Main** (main controller), as shown in Figure 2-7.

To program the PIC18LF2450 for RS-232 UART communication:

1. Launch the MPLAB IDE application and select _Configure>Select Device>18F2450_.
2. To start the programmer, select _Programmer>Select Programmer>ICD2_.
3. To open the hex code file, select _File>Import>Open_ and select `CD/Hex/RS232_USB_18F2450/Demo2450.hex`.
4. Connect the J4 jumper to **USB**, as shown in Figure 2-8.

FIGURE 2-8:   J4 JUMPER AND 'USB' SETTING
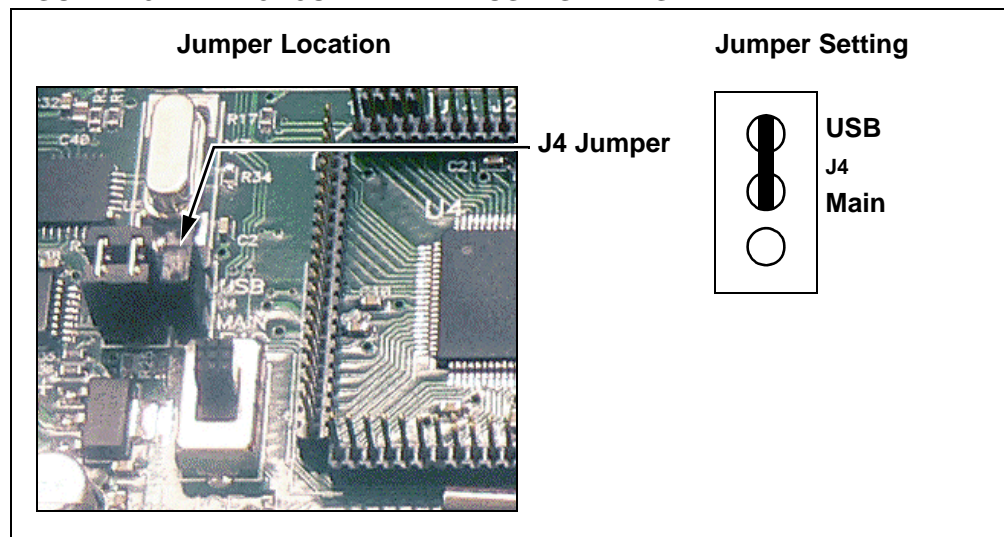
2.4.3 Loading the Program Using MPLAB® X IDE

This section describes how to program the PICDEM PIC18 Explorer Demonstration Board using the MPLAB® X Integrated Development Environment (IDE) and the sample hex code on the compact disc in the PICDEM PIC18 Explorer Demonstration Board's Kit.

2.4.3.1 REPROGRAMMING WITH THE COMPACT DISC SAMPLE CODE

> **Note:** The MPLAB® X IDE will generate a Prebuilt Project file folder. Since the CD drive does not have enough free space, the hex files should be copied to another drive location (i.e., **C:** drive). Once the hex files are already transferred to another location, the following steps can now be executed.

To program PIC18F8722:

1. Launch the MPLAB X IDE application and select _File>Import>Hex/ELF… (Prebuilt) File_ and a pop-up window will appear as shown in Figure 2-9.

FIGURE 2-9: CREATING A PRE-BUILT PROJECT ON MPLAB® X
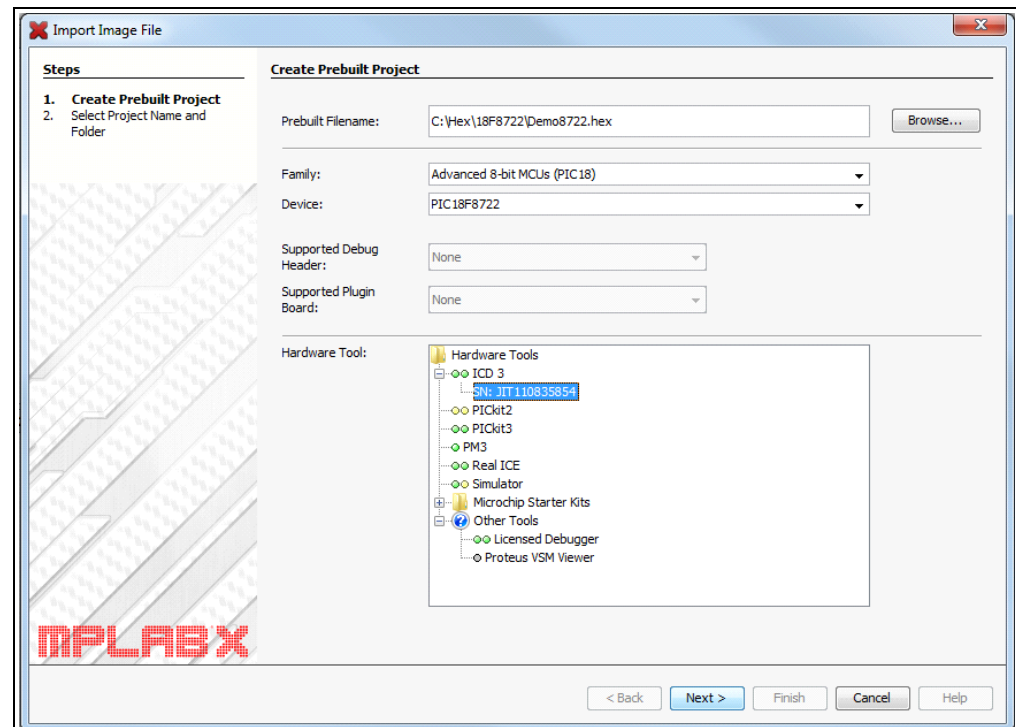
2. Browse the `Demo8722.hex` file on the **C:** drive. Select "Advanced 8-bit MCUs (PIC18)" under the Family menu. Select "PIC18F8722" as the Device. Under the Hardware Tool, select the programmer to be used. For this example, the MPLAB ICD 3 is used to program the device.
3. Click **Next>**. Select "Set as main project".
4. Click **Finish**. The Prebuilt Project file is now created.
5. Connect the J4 jumper to **Main** (main controller), as shown in Figure 2-7.
6. Move the S4 switch to **PIC MCU**, as described in **Section 2.1.1 "Using the Board As Is"**.
7. Click the **Make and Program Device** icon ([icon]).

To program PIC18F87J11 on the PIM:

1. Attach the PIM to the demonstration board.
2. Move the S4 switch to **ICE**.

> **Note:** Steps 1 and 2 are described in **Section 2.3.1 "Attaching the PIM"**.

3. Launch the MPLAB X IDE application and select *File>Import>Hex/ELF… (Prebuilt) File* and a pop-up window will appear.
4. Browse the `Demo87J11.hex` file on the **C:** drive. Select "Advanced 8-bit MCUs (PIC18)" under the Family menu. Select "PIC18F87J11" as the Device. Under the Hardware Tool, select the programmer to be used.
5. Click **Next>**. Select "Set as main project".
6. Click **Finish**. The Prebuilt Project file is now created.
7. Connect the J4 jumper to **Main** (main controller), as shown in Figure 2-7.
8. Click the **Make and Program Device** icon.

To program the PIC18LF2450 for RS-232 UART communication:

1. Launch the MPLAB X IDE application and select *File>Import>Hex/ELF… (Prebuilt) File* and a pop-up window will appear.
2. Browse the `Demo2450.hex` file on the **C:** drive. Select "Advanced 8-bit MCUs (PIC18)" under the Family menu. Select PIC18LF2450 as the Device. Under the Hardware Tool, select the programmer to be used.
3. Click **Next>**. Select "Set as main project".
4. Click **Finish**. The Prebuilt Project file is now created.
5. Connect the J4 jumper to USB, as shown in Figure 2-8.
6. Click the **Make and Program Device** icon.

2.4.4   Converting the MPLAB IDE Project to an MPLAB X IDE Project

This section describes how to convert the `HPC.mcp` MPLAB 8 project to an `HPC.X` MPLAB X project. The `HPC.mcp` project file is included on the compact disc in the PICDEM PIC18 Explorer Demonstration Board's Kit. Make sure that the C18 compiler is also installed.

> **Note:**   The MPLAB® X IDE will generate an `HPC.X` project file folder. Since the CD drive does not have enough free space, the `SourceCode` folder should be copied to another drive location (i.e., **C:** drive). Once the folder is transferred to another location, the steps listed below can be executed.

1. Launch the MPLAB X IDE application and select *File > Import > MPLAB IDE v8 Project*. A pop-up window will appear. Browse for the `HPC.mcp` file on the **C:** drive. Click **Next>**.
2. Select "Advanced 8-bit MCUs (PIC18)" under Family. Select "PIC18F8722" under the Device menu.
3. Select the programmer to be used under Hardware Tools. Click **Next>**.
4. Select C18 under Compiler Toolchain. Click **Next>**.
5. Select "Set as main project". Click **Next>**, then **Finish**. An `HPC.X` project file is now created.

> **Note:**   Before loading the program, make sure that the J4 jumper and S4 switch are on their proper positions (see Figure 2-7 and Figure 2-1).

6. To load the program to the PIC18F8722 device, simply click the **Make and Program Device** icon.

For PIM attached devices, see **Section 2.4.6 "How to Select Device on MPLAB X IDE"**.

2.4.5 Opening the MPLAB X Project File on MPLAB X IDE

This section describes how to open the `PIC18_Explorer_Demo.X` MPLAB X project on MPLAB X IDE. The `PIC18_Explorer_Demo.X` project file can be found on the Microchip web site. Make sure that the MPLAB XC8 Compiler is also installed.

Download the `PIC18_Explorer_Demo.X` project file from the Microchip web site. Save the project anywhere in the **C:** drive.

1. Launch the MPLAB X IDE application and select *File>Open Project> PIC18_Explorer_Demo.X>Open Project*. The project file will appear on the Projects area.

2. Right click the *PIC18_Explorer_Demo project>Set as main project*.

3. Right click the *PIC18_Explorer_Demo project >Properties*. A pop-up window will appear as shown in Figure 2-10.

FIGURE 2-10: CONFIGURING PROJECT PROPERTIES ON MPLAB® X
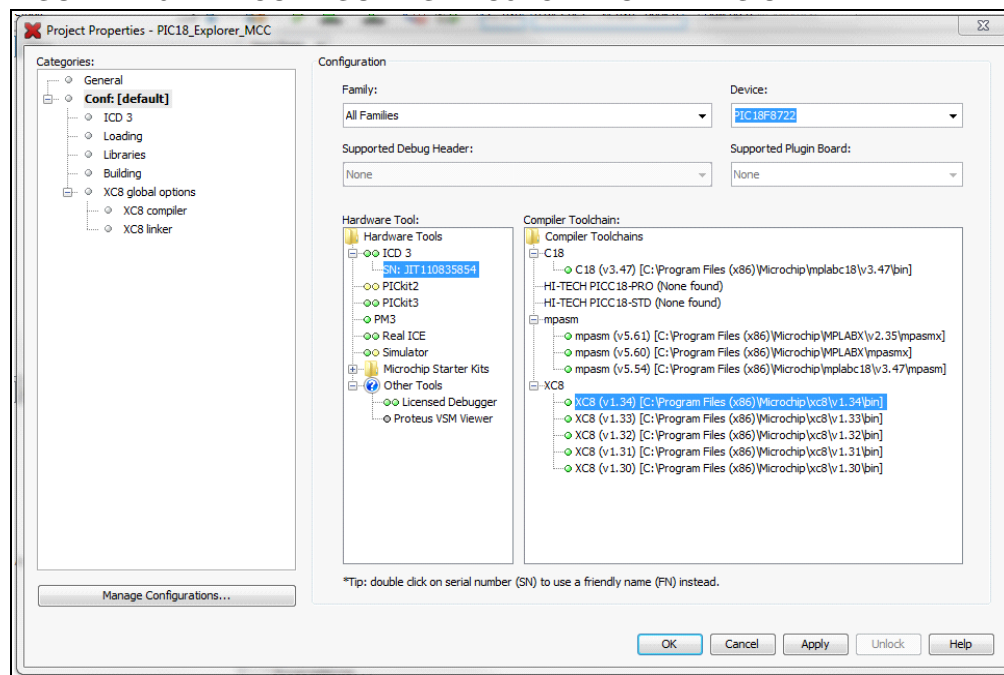
4. Select "PIC18F8722" under the Device menu. Select the programmer to be used under the Hardware Tools area. Select XC8 under the Compiler Toolchain. Click **Apply**, then **OK**.

5. Make sure to connect the J4 jumper to **Main**, as shown in Figure 2-7, and the S4 switch is set for default main microcontroller, as shown in Figure 2-1.

6. To load the program to the PIC18F8722 device, click the **Make and Program Device** icon.

For PIM attached devices, see **Section 2.4.6 "How to Select Device on MPLAB X IDE"**.

2.4.6   How to Select Device on MPLAB X IDE

Both **Section 2.4.4** and **Section 2.4.5** used the board attached PIC18F8722 as the main PIC device. However, if a PIM-mounted microcontroller attached to the board is to be used, the project properties should be modified. The `HPC.X` project and the PIC18F87J11 are used in the following example.

> **Note:**   The MPLAB® X project is assumed to be already present on the Projects area. If not, see **Section 2.4.4 "Converting the MPLAB IDE Project to an MPLAB X IDE Project"** or **Section 2.4.5 "Opening the MPLAB X Project File on MPLAB X IDE"**.

1. Attach the PIM to the demonstration board.
2. Move the S4 switch to **ICE**.

> **Note:**   Steps 1 and 2 are described in **Section 2.3.1 "Attaching the PIM"**.

3. Right click the *HPC project>Set as main project*.
4. Right click the *HPC project >Properties*.
5. Select "PIC18F87J11" under the Device menu. Click **Apply**, then **OK**.
6. The device is now changed from PIC18F8722 to PIC18F87J11.

2.4.7   Using the MPLAB Device Driver Switcher

The user might encounter problems on driver incompatibility if both the MPLAB® IDE 8 and MPLAB X IDE are installed on the same Windows®-based system, especially when both programs are used simultaneously.

The MPLAB device driver switcher enables different USB drivers for communication with Microchip tools to be used when both MPLAB versions are running. USB drivers should be switched when moving from one MPLAB version to another.

After installing MPLAB X IDE, the switcher utility can typically be found on the desktop or in the Start menu under *Programs>Microchip>MPLAB X IDE>MPLAB Driver Switcher*.

Figure 2-11 shows a sample driver selection in which the Real ICE is setup for MPLAB 8 and ICD 3 is setup for MPLAB X. `No Change` means that there is no change on the driver currently being used.

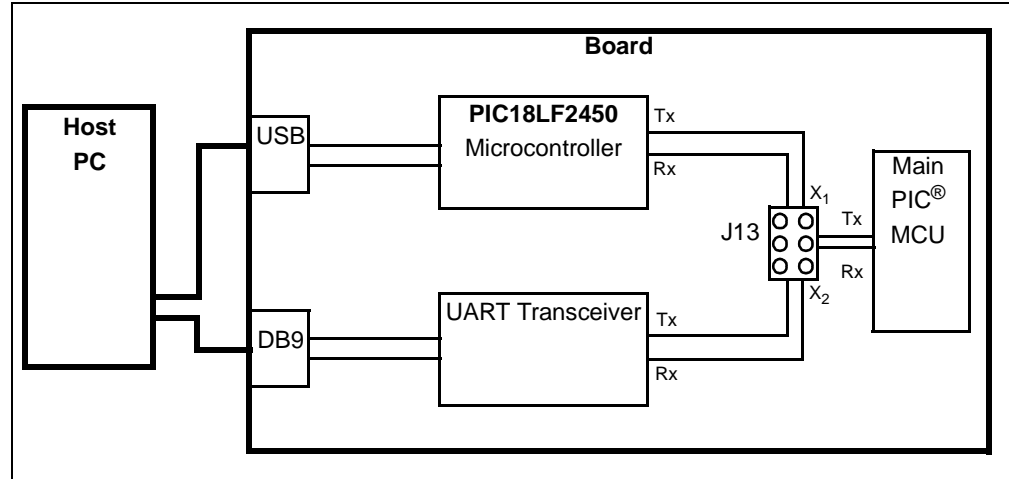**FIGURE 2-11:**   **MPLAB® DEVICE DRIVER SWITCHER WINDOW**
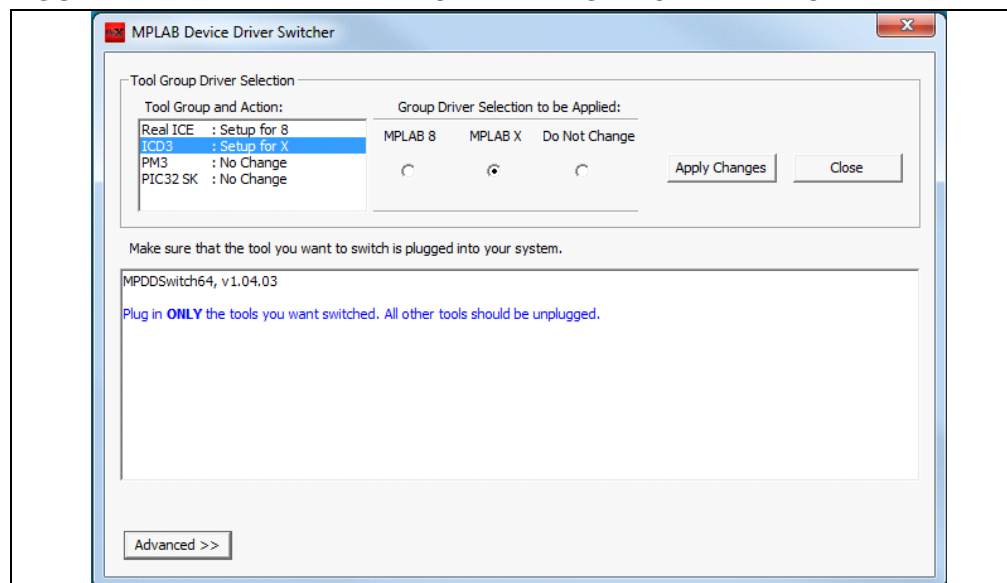
2.5   CONNECTING TO HOST PC FOR RS-232 COMMUNICATION

As shown in Figure 2-12, there are two ways to connect a PC to the PICDEM PIC18 Explorer Demonstration Board.
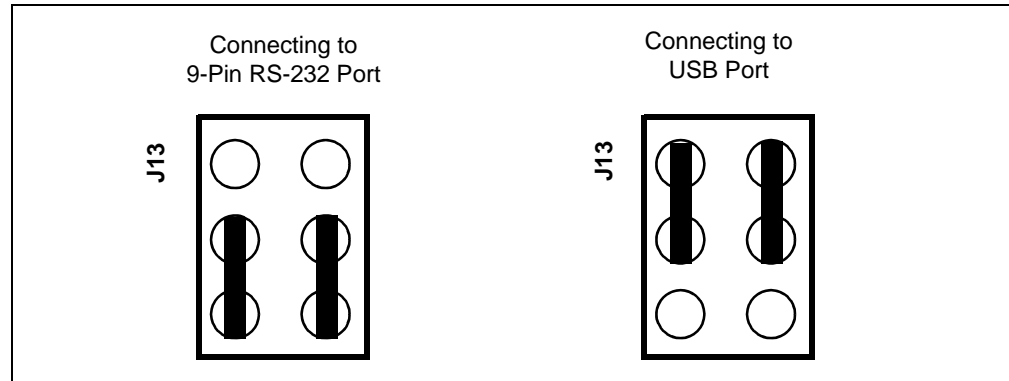
• Via the USB Port
• Via the DB9 Pin (RS-232 Port)

FIGURE 2-12:   BOARD TO PC CONNECTION

2.5.1   PC Connection Via DB9 Pin

To connect the PICDEM PIC18 Explorer Demonstration Board to a host PC via the 9-pin DB9 connector, set jumper J13, as shown in the first illustration in Figure 2-13.

This routes the main microcontroller's communications through a transceiver.

FIGURE 2-13:   JUMPER J13 – SETTINGS FOR RS-232 OR USB

2.5.2   PC Connection Via USB Port

If the board PC communication is via the USB port, the data will be routed through the PIC18LF2450 mounted on the board, to convert the RS-232 communication to the USB protocol.

To connect the PICDEM PIC18 Explorer Demonstration Board to a host PC via the USB port:

1.   Set jumper J13, as shown in the second illustration in Figure 2-13.
2.   Install the required file on the host PC. (See the following procedure.)

If the USB port is used, an `*.inf` file must be installed on the host PC. To do this:

1.   Create a folder named, `HPCINF`, anywhere on the host PC's hard drive.
2.   Using the development kit's CD, copy the file, `mchpcdc.inf`, into that folder.
3.   Connect the board to the PC and power up the board. The pop-up window, shown in Figure 2-14, appears.

> **Note:**   This procedure displays the dialog boxes that appear for the Windows® XP operating system. In newer Windows® operating systems, the device driver software is automatically installed once the powered-up board is connected to the PC.

FIGURE 2-14:   INSTALLING USB `*.inf` FILE ON PC – SCREEN 1

4.   Select the **Install from a list or specific location** option and click **Next**. The screen shown in Figure 2-15 appears.

FIGURE 2-15:   INSTALLING USB `*.inf` FILE ON PC – SCREEN 2
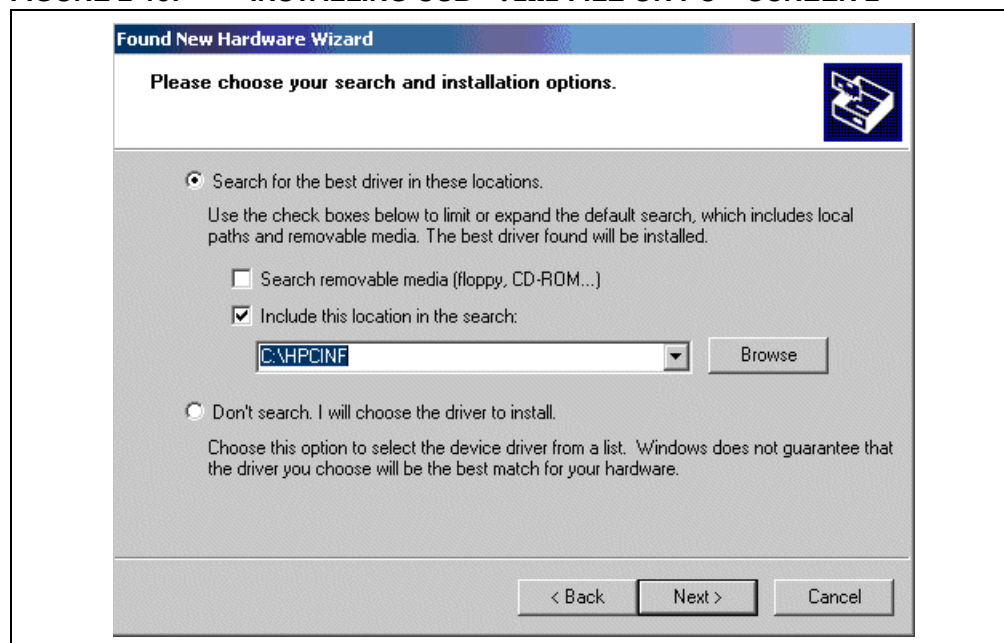
5. Select the check box, **Include this location in the search**, enter the name of the path (created in step 1) in the text box below and click **Next**. The screen shown in Figure 2-16 appears.

FIGURE 2-16:   INSTALLING USB `*.inf` FILE ON PC – SCREEN 4
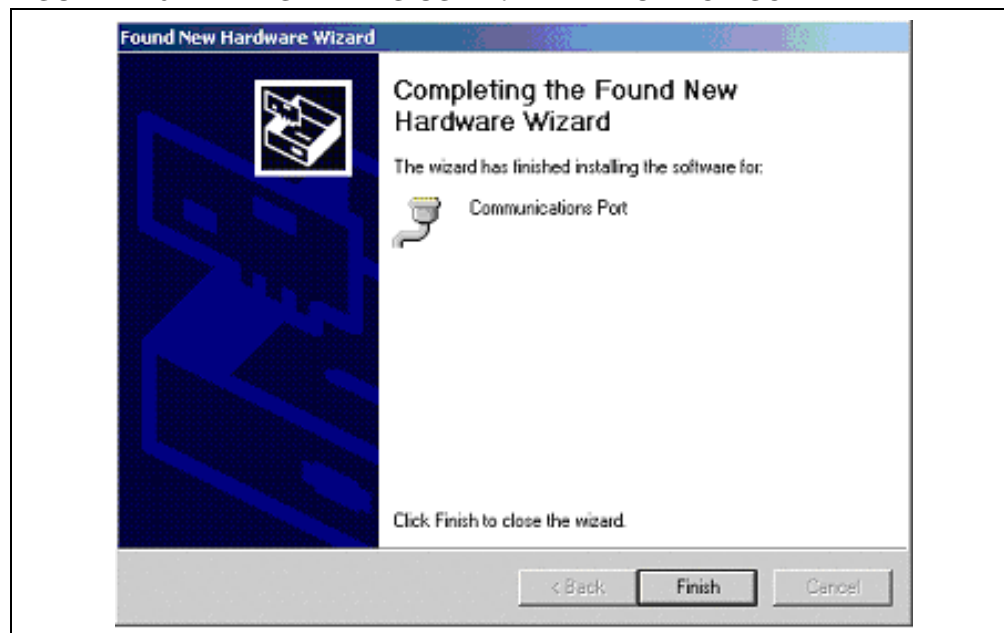
6. Press **Finish**. The RS-232 to USB functionality is ready to be used.

Chapter 3. Tutorial Program

The tutorial program is preprogrammed into the PIC18F8722 on the PICDEM PIC18 Explorer Demonstration Board. This tutorial program is available both in Assembly and in C. The Assembly code, which is on the PICDEM PIC18 Explorer Demonstration Board kit's CD ROM, can be run using the MPLAB IDE or the MPLAB X IDE (see **Section 2.4.4 "Converting the MPLAB IDE Project to an MPLAB X IDE Project"**). On the other hand, the C code can be run on the MPLAB X IDE. Both demo codes are available on the Microchip web site.

For detailed information on the PICDEM PIC18 Explorer Demonstration Board hardware, see **Appendix A. "Hardware Details"**.

3.1 TUTORIAL PROGRAM OPERATION

The tutorial program consists of three components that appear sequentially on the board's LCD. A flowchart, showing the button navigation through the entire program, is given in Figure 3-2.

When the board boots up, the device name appears on the LCD and the program proceeds to the first component.

To select menu options, use the RB0 and RA5 buttons on the bottom of the board (see Figure 3-1).

FIGURE 3-1:   RB0 AND RA5 BUTTONS

RB0 Button
RA5 Button
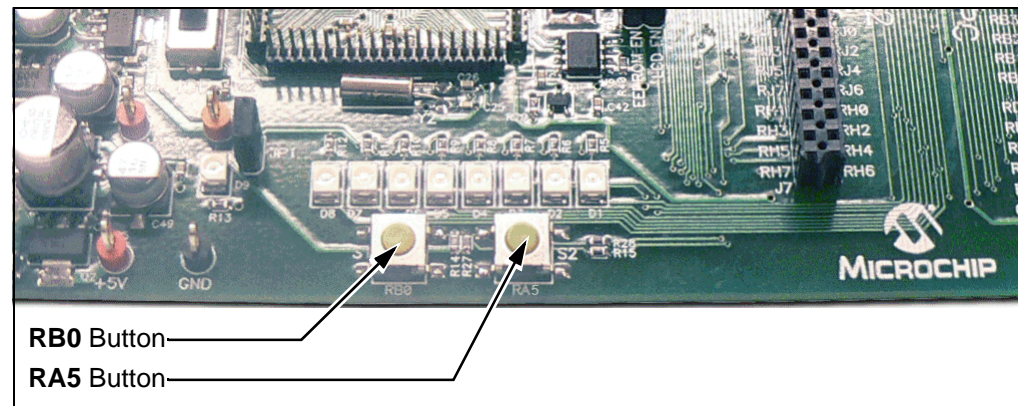
1. Voltmeter

This mode uses the Analog-to-Digital Converter (A/D) module to measure the voltage of the R3 potentiometer and display a value between 0.00V and 5.00V on the LCD. (In the case of 3.3V devices, the displayed value will be 0.00V to 3.3V.)

The voltage reading is updated continually until the mode is exited by pressing **RB0**.

2. Temperature

This mode uses an MCP9701A thermal sensor to measure ambient temperature in Celsius and displays it on the LCD. The program also stores the current temperature, when exited, by writing to a defined address on the external, on-board EEPROM.

Communication between the microcontroller and sensor is done by the A/D module.

To exit this mode, press **RB0**.

3. Clock

Once this mode is entered from the main menu, a Real-Time Clock (RTC) will start counting from 00:00:00. The Timer1 module uses a 32 kHz clock crystal to establish the clock.

The program also sends the time data to the RS-232 serial port using the Universal Asynchronous Receiver Transmitter (UART) on the microcontroller. This enables the host PC to display the LCD's data using the Hyper Terminal application on the PC.

> **Note:** For information on connecting the board's RS-232 serial port to the PC, see **Section 2.5 "Connecting to Host PC for RS-232 Communication"**.

If using the Hyper Terminal application, use the settings given in Table 3-1.

TABLE 3-1: HYPER TERMINAL SETTINGS

Field	Setting
Bits per second	9600
Data bits	8
Parity	None
Stop bits	1
Flow control	None

To set the clock time:

1. Enter the clock-setting program by pressing **RB0**. The clock begins running.
2. To set the hours value, press **RA5**.
3. Increment the hours to the desired value by pressing **RB0**.
4. To set the minutes value, press **RA5**.
5. Increment the minutes to the desired value by pressing **RB0**.
6. To start the clock with the set time, press **RA5**. The LCD returns to an active clock display.
7. To return to the main menu, press **RB0**.

FIGURE 3-2: **TUTORIAL PROGRAM FLOWCHART**
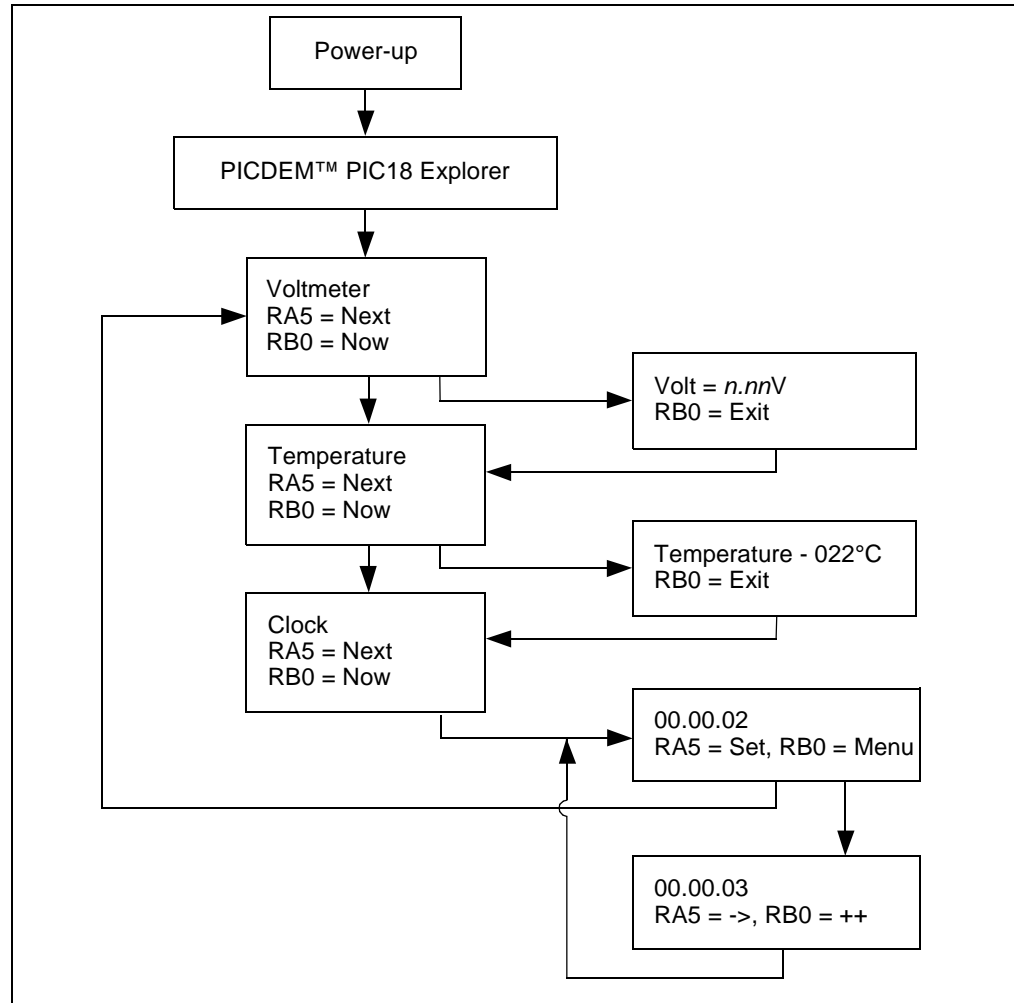
3.2   SOURCE CODE AND DATA SHEETS

The PICDEM PIC18 Explorer Demonstration Board Kit's CD-ROM contains the assembled tutorial program (the hex files) as well as the source code used to create those hex files. The CD has device-specific directories for each set of source code and hex files. This program can be run both on MPLAB IDE (see **Section 2.4.2 "Loading the Program Using MPLAB® IDE"**) and MPLAB X IDE (see **Section 2.4.3 "Loading the Program Using MPLAB® X IDE"**).

The tutorial program for MPLAB X IDE is available on the Microchip web site. The source codes in C and hex files are contained in one `.x` project file. This program utilizes the MPLAB® Code Configurator plugin to generate initialization codes for the various peripherals used in the sample applications.

For information on reprogramming the device with new or modified code, see **Section 2.1 "Board as Stand-Alone Device"**.

NOTES:

Appendix A. Hardware Details

A.1   HARDWARE ELEMENTS

A.1.1   Processor Sockets

The PICDEM PIC18 Explorer Demonstration Board can be populated with 64 and 80-pin devices. Using a Plug-In Module (PIM), the board also can support 28, 44, 64 and 80-pin devices.

For a list of available PIMs, go to the Microchip web site at www.microchip.com.

A.1.2   Display

Eight LEDs are connected to PORTD of the PICDEM PIC18 Explorer Demonstration Board. The PORTD pins are set high to light the LEDs.

These LEDs may be disconnected by removing jumper JP1.

One LED (D9) lights to indicate when the board has power.

A.1.3   Power Supply

The PIC18 Explorer Board does not come with a power supply. It can be powered, via J1, with an unregulated DC supply of 9V to 15V. The preferred supply is 9V.

For default functionality, a power supply with a current capability of 250 mA is sufficient.

Since the board can serve as a modular development platform connecting to multiple expansion boards, voltage regulators (Q1 and Q2) are used. Their maximum current capability is 800 mA. This current capacity may require a power supply of up to 1.6A. Because the regulators do not have heat sinks, long-term operation at such loads is not recommended.

When the board is powered, LED D9 is on, indicating the presence of V_VAR.

If an external supply is needed, Microchip's 9V, 750 mA power supply (part number AC162039) can be used.

> **Note:** Do not attempt to power the PICDEM PIC18 Explorer Demonstration Board using the MPLAB ICD 3 module. That module is not designed to be a USB bus power source.

A.1.4   RS-232 Serial Port

An RS-232, level-shifting integrated circuit has been provided with all the necessary hardware to support the connection of an RS-232 host through the DB9 connector. The port can be connected to a PC using a straight-through cable.

The PIC18 receive and transmit pins are tied to the receive and transmit lines of the MAX3232 transceiver through jumper J13. That jumper can direct where the receive and transmit pins of the PIC18 are connected, either to:

• The PIC18LF2450 which does the RS-232 to USB communication
• The MAX3232 transceiver

> **Note:** For details on this connection, see **Section 2.5 "Connecting to Host PC for RS-232 Communication"**.

A.1.5   Switches

The following switches are available:

- S1 – Active-low switch connected to RB0
- S2 – Active-low switch connected to RA5
- S3 – $\overline{\text{MCLR}}$ to hard reset the processor
- S4 – $\overline{\text{MCLR}}$ select switch

    If the on board, PIC18F8722 microcontroller is being used, set this to **PIC** MCU.

    If an alternate, PIM-mounted microcontroller is being used, set this to **ICE**.

A.1.6   Oscillator Options

The main oscillator uses a 10 MHz crystal (Y1) which serves as the controller's primary oscillator. A second circuit, using a 32.768 kHz (watch type) crystal (Y2), functions as the Timer1 oscillator, the source for the Real-Time Clock/Calendar (RTCC) and secondary oscillator.

The PIC18LF2450, the heart of the RS-232 to USB conversion, is independently clocked with its own 12 MHz crystal (Y3).

A.1.7   Analog Input (Potentiometer)

A 10 kΩ potentiometer is connected through a series resistor to AN0. To provide an analog input to one of the controller's Analog-to-Digital (A/D) channels, the potentiometer can be adjusted from VDD to GND.

A.1.8   ICD Connector

Microchip's low-cost, In-Circuit Debugger, MPLAB ICD 3, can be connected to the modular connector (J10). The ICD connector utilizes RB6 and RB7 for in-circuit debugging. The MPLAB ICD 2 or the MPLAB REAL ICE can also be connected to this interface.

> **Note:**   For details, see **Section 2.4.1 "Programming Requirements"**.

A.1.9   PICkit™ 2 Connector

Microchip's low-cost programmer, PICkit 2, can be connected to the 6-pin interface provided by J12. A PICkit 3 In-Circuit Debugger/Programmer can also be connected to this interface.

> **Note:**   For details, see **Section 2.4.1 "Programming Requirements"**.

A.1.10   Temperature Sensor

The analog thermal sensor, MCP9701A (U1), is used for monitoring temperature. The device is connected to the Analog-to-Digital Converter (A/D) module through RA1.

A.1.11   Serial EEPROM

A 25LC256, 256 Kbit (32K x 8) serial EEPROM (U9) is included for nonvolatile storage of firmware.

The EEPROM also can demonstrate the operation of the Serial Peripheral Interface (SPI) bus. The EEPROM is enabled or disabled from the SPI bus by jumper JP2.

A.1.12 PICtail™ Daughter Board Connector

The PICtail™ interface enables the PICDEM PIC18 Explorer Demonstration Board to be connected directly to available PICtail daughter board cards. This provides a one-to-one connection between the microcontrollers and the cards through SPI/I^{2}C™ interfaces.

A.1.13 LCD

An LCD display with two lines, 16 characters each, is connected to the SPI I/O expander, MCP23S17. The two control lines and eight data lines are connected to the I/O expander.

The I/O expander has an SPI interface that connects it to the microcontroller.The I/O expander is disabled or enabled from the SPI by jumper JP3.

A.1.14 Sample Devices

A sample part programmed with a simple program is included in the PICDEM PIC18 Explorer Demonstration Board Kit. The devices' I/O features and port connections are listed in Table A-1.

TABLE A-1:   SAMPLE DEVICE I/O FEATURES AND CONNECTIONS

Device	LEDs	RS-232/ USB	S1	S2	S3	LCD	Pot R3	EEPROM	Temp Sensor	ICD/ PICkit™	Y1, Y2
PIC18F8722	RD7:RD0	RC6/RC7	RB0	RA5	MCLR	RC3:RC5	RA0	RC3:RC5	RA1	RB6/RB7	Yes
PIC18F87J11	RD7:RD0	RC6/RC7	RB0	RA5	MCLR	RC3:RC5	RA0	RC3:RC5	RA1	RB6/RB7	Yes

A.2   BOARD LAYOUT AND SCHEMATICS

FIGURE A-1:   **PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD LAYOUT**

FIGURE A-2: **PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD SCHEMATIC – 1 OF 2**
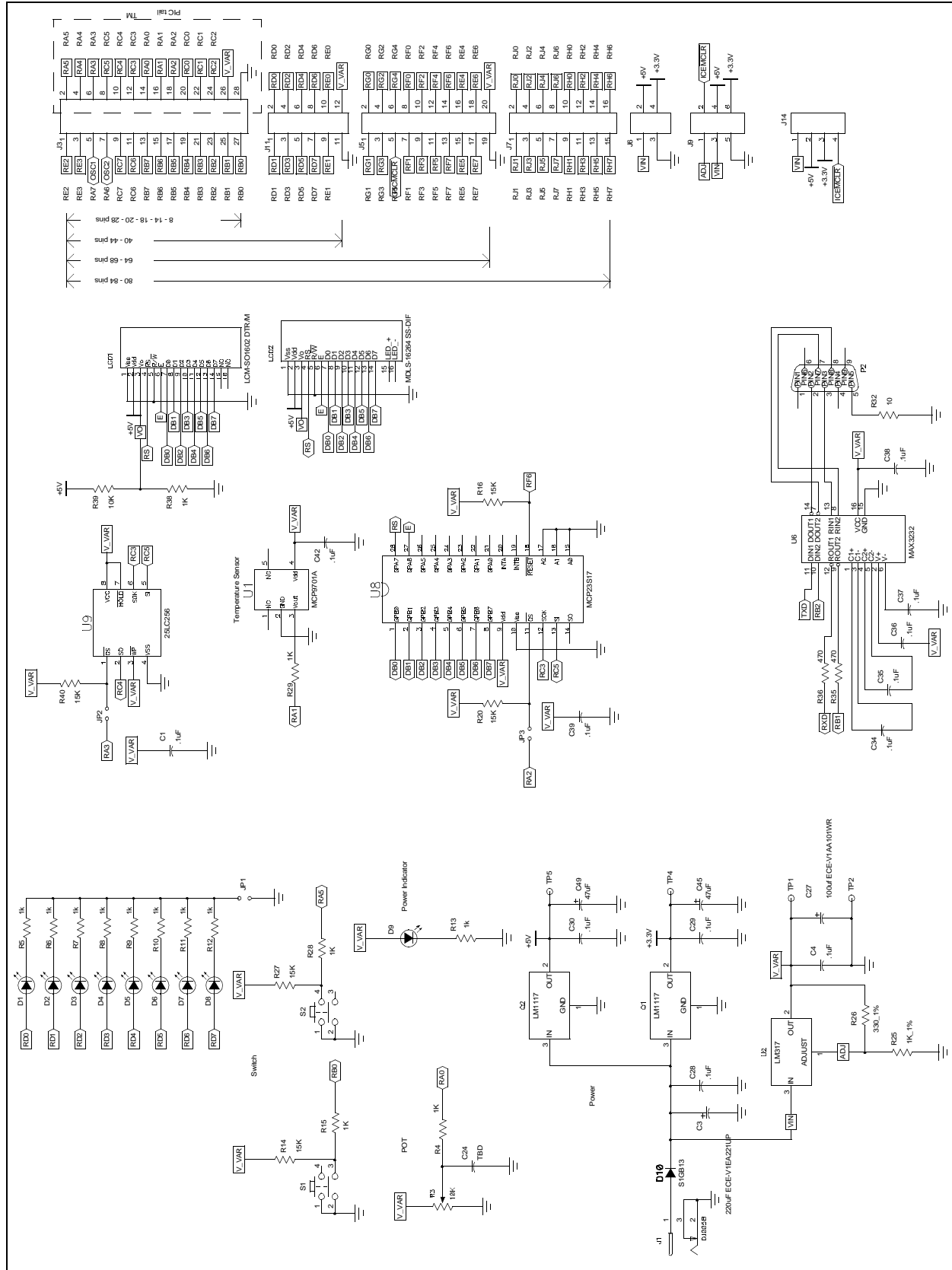
FIGURE A-3: **PICDEM™ PIC18 EXPLORER DEMONSTRATION BOARD SCHEMATIC – 2 OF 2**

NOTES: