Explorer 16 Development 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."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Trademarks

The Microchip name and logo, the Microchip logo, Accuron, dsPIC, KEELOQ, microID, MPLAB, PIC, PICmicro, PICSTART, PRO MATE, PowerSmart, rfPIC, and SmartShunt are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AmpLab, FilterLab, Migratable Memory, MXDEV, MXLAB, PICMASTER, SEEVAL, SmartSensor and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, dsPICDEM, dsPICDEM.net, dsPICworks, ECAN, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, Linear Active Thermistor, MPASM, MPLIB, MPLINK, MPSIM, PICkit, PICDEM, PICDEM.net, PICLAB, PICtail, PowerCal, PowerInfo, PowerMate, PowerTool, rfLAB, rfPICDEM, Select Mode, Smart Serial, SmartTel, Total Endurance and WiperLock are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2005, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

♻ Printed on recycled paper.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
═══ ISO/TS 16949:2002 ═══

EXPLORER 16 DEVELOPMENT BOARD USER'S GUIDE

Table of Contents

NOTES:

EXPLORER 16 DEVELOPMENT 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 on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the Explorer 16 Development Board. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the Explorer 16 Development Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Introducing the Explorer 16 Development Board"** provides a brief overview of the Explorer 16 Development Board, its features and its uses.
- **Chapter 2. "Explorer 16 Programming Tutorial"** provides step-by-step instructions for using MBLAB® IDE to create a project and program the Explorer 16 board.
- **Chapter 3. "Explorer 16 Tutorial Programs"** describes the demonstration program created in **Chapter 2. "Explorer 16 Programming Tutorial"**.
- **Chapter 4. "Explorer 16 Development Hardware"** provides a more detailed description of the Explorer 16 board's hardware features.
- **Appendix A. "Explorer 16 Development Board Schematics"** provides a block diagram and detailed schematics of the Explorer 16 board.
- **Appendix B. "Updating the USB Connectivity Firmware"** describes how to upgrade the Explorer 16 board's USB connectivity subsystem.

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
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 (in source code)	`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.

Explorer 16 Development Board User's Guide

RECOMMENDED READING

This user's guide describes how to use the Explorer 16 Development Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Readme for the Explorer 16 Development Board

For the latest information on using the Explorer 16 Development Board, read the `Readme for Explorer 16 Development Board.txt` file (an ASCII text file) at the root level of the Explorer 16 CD-ROM. The Readme file contains update information and known issues that may not be included in this user's guide.

Readme 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.

PIC24FJ128GA010 PS Data Sheet (DS39756) and PIC24FJ128GA Family Data Sheet (DS39747)

Consult this document for detailed information on the PIC24F general purpose, 16-bit devices. Reference information found in this data sheet includes:

- Device memory map
- Device pinout and packaging details
- Device electrical specifications
- List of peripherals included on the device

Note that document, DS39756, is for use **only** with the initial prototype samples of the PIC24F family. These devices are all marked with a "PS" suffix at the end of the device number. For all other PIC24FJ128GA family devices, including those with an "ES" suffix, use DS39747.

dsPIC33F Family Data Sheet (DS70165)

Consult this document for detailed information on the dsPIC33F Digital Signal Controllers. Reference information found in this data sheet includes:

- Device memory map
- Device pinout and packaging details
- Device electrical specifications
- List of peripherals included on the device

dsPIC30F Programmer's Reference Manual (DS70030)

This manual is a software developer's reference for all of Microchip's 16-bit digital signal controllers. It describes the instruction set in detail and also provides general information to assist in developing software for PIC24 MCUs, dsPIC30F and dsPIC33F DSCs.

PIC24H Family Overview (DS70166)

This document provides an overview of the functionality of the new PIC24H product family. It helps determine how the PIC24H high-performance, 16-bit microcontrollers fit a specific product application.

MPLAB® C30 C Compiler User's Guide (DS51284)

This document details the use of Microchip's MPLAB C30 C Compiler for dsPIC® devices to develop an application. MPLAB C30 is a GNU-based language tool, based on source code from the Free Software Foundation (FSF). For more information about the FSF, see www.fsf.org.

Other GNU language tools available from Microchip are:

• MPLAB ASM30 Assembler
• MPLAB LINK30 Linker
• MPLAB LIB30 Librarian/Archiver

MPLAB® IDE Simulator, Editor User's Guide (DS51025)

Consult this document for more information pertaining to the installation and implementation of the MPLAB Integrated Development Environment (IDE) software.

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

Explorer 16 Development Board User's Guide

DEVELOPMENT SYSTEMS CUSTOMER 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 Customer Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools. These include the MPLAB C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ and MPLAB LIB30 object librarians.
- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB ICE 2000 and MPLAB ICE 4000.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 2.
- **MPLAB® IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB SIM simulator, MPLAB IDE Project Manager and general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 and PRO MATE® II device programmers and the PICSTART® Plus and PICkit™ 1 development programmers.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

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 (November 2005)

This is the initial release of this Document.

NOTES:

Chapter 1. Introducing the Explorer 16 Development Board

1.1   INTRODUCTION

Thank you for purchasing Microchip Technology's Explorer 16 Development Board Kit. The development board provides a low-cost, modular development system for Microchip's new line of 16-bit microcontroller families, including the PIC24, PIC24H and the 16-bit digital signal controller family, dsPIC33F.

As provided, the development board works as a demo board right from the box, and also has the ability to extend its functionality through modular expansion interfaces. The Explorer 16 board supports MPLAB ICD 2 for full emulation and debug capabilities, and also allows 3V controllers to interface with 5V peripheral devices.

1.2   HIGHLIGHTS

This chapter covers the following topics:

- What's in the Kit
- Explorer 16 Development Board Functionality and Features
- Using the Explorer 16 Out of the Box
- Explorer 16 Development Board Demonstration Programs
- Reference Documents

1.3   WHAT'S IN THE KIT

The Explorer 16 Development Board Kit contains the following:

- The Explorer 16 Development Board.
- A preprogrammed PIC24FJ128GA010 Processor Installation Module (PIM), already installed to the board
- A preprogrammed dsPIC33FJ256GP710 PIM
- An RS-232 cable
- The Explorer 16 Development CD ROM, containing:
  - This User's Guide
  - Data Sheets for the PIC24FJ128GA family and dsPIC33FJ256GP family
  - Schematics and PCB drawing files for the PIM modules
  - Example programs for use with the PIC24 and dsPIC33F devices
  - Files detailing general purpose expansion boards that can be used with the Explorer 16 board (provided in Gerber format)

If you are missing any part of the kit, please contact your nearest Microchip sales office, listed on the last page of this manual, for further assistance.

> **Note:**   The Explorer 16 Development Board has been designed to function primarily from a permanently mounted PIC24FJ128GA010 device at position U1. Initial units will be shipped with U1 unpopulated and a PIC24FJ PIM of equal functionality mounted on the U1A headers instead. When using the PIC24FJ PIM or any other PIM, it is critical to verify that switch S2 always remains in the "PIM" position. See **Section 4.2.1 "Processor Support"** for more information.

1.4 EXPLORER 16 DEVELOPMENT BOARD FUNCTIONALITY AND FEATURES

A layout of the Explorer 16 Development Board is shown in Figure 1-1. The board includes these key features, as indicated in the diagram:

1. 100-pin PIM riser, compatible with the PIM versions of all Microchip PIC24F/24H/dsPIC33F devices
2. Direct 9 VDC power input that provides +3.3V and +5V (regulated) to the entire board
3. Power indicator LED
4. RS-232 serial port and associated hardware
5. On-board analog thermal sensor
6. USB connectivity for communications and device programming/debugging
7. Standard 6-wire In-Circuit Debugger (ICD) connector for connections to an MPLAB ICD 2 programmer/debugger module
8. Hardware selection of PIM or soldered on-board microcontroller (in future versions)
9. 2-line by 16-character LCD
10. Provisioning on PCB for add on graphic LCD
11. Push button switches for device Reset and user-defined inputs
12. Potentiometer for analog input
13. Eight indicator LEDs
14. 74HCT4053 multiplexers for selectable crossover configuration on serial communication lines
15. Serial EEPROM
16. Independent crystals for precision microcontroller clocking (8 MHz) and RTCC operation (32.768 kHz)
17. Prototype area for developing custom applications
18. Socket and edge connector for PICtail™ Plus card compatibility
19. Six-pin interface for PICkit 2 Programmer
20. JTAG connector pad for optional boundary scan functionality

For additional details on these features, refer to **Chapter 4. "Explorer 16 Development Hardware"**.
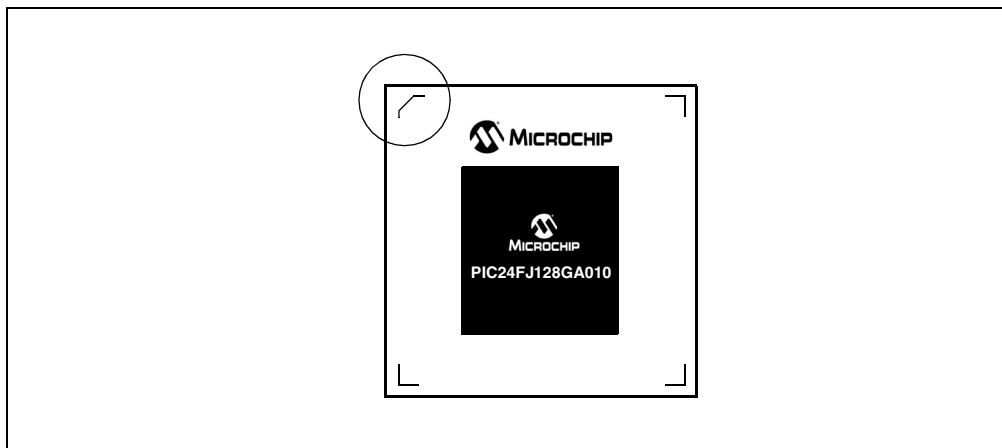
1.4.1 Sample Devices Included with the Development Kit

Each Explorer 16 Development Board Kit contains two preprogrammed 16-bit devices: a PIC24FJ128GA010 and a dsPIC33FJ256GP710. These are provided as 100-pin PIMs on riser sockets, which can be quickly installed on pin header U1A and exchanged as needed.

Note: As Microchip's 16-bit portfolio develops, alternate devices may be included with the Explorer 16 Development Board Kit. It is anticipated that one device each of the PIC24 and dsPIC33F families will always be included. Also in the future, the included PIC24 device will be soldered onto the board and only the dsPIC33F device will be provided as a PIM.

Explorer 16 Development Board User's Guide

FIGURE 1-1: **EXPLORER 16 DEVELOPMENT BOARD LAYOUT**

1.5   USING THE EXPLORER 16 OUT OF THE BOX

Although intended as a development platform, the Explorer 16 board may also be used directly from the box as a demonstration board for PIC24 and dsPIC33F devices. The programs discussed in **Chapter 3. "Explorer 16 Tutorial Programs"** are preprogrammed into the sample device PIMs (i.e., `PIC24ExplDemo.hex` for the PIC24 device and `dsPIC33ExplDemo.hex` for the dsPIC33F device) and are ready for immediate use.

To get started with the board:

1. For Explorer 16 boards without a permanently mounted PIC24FJ device: verify that the PIC24FJ128GA010 PIM is correctly installed onto the board. If you want to use the dsPIC® device PIM, carefully remove the PIC24 PIM and install the dsPIC33F PIM in its place. For all PIMs, be certain to align the PIM so the notched corner marking is oriented in the upper left corner.

2. For Explorer 16 boards without a permanently mounted PIC24FJ device: verify that switch S2 is set in the "PIM" position.
    For Explorer 16 boards with a permanently mounted PIC24FJ device: verify that switch S2 is set in the "PIC" position.

3. Verify that the jumper on JP2 is installed (to enable the LEDs).

4. Apply power to the board (9 VDC) at power input J2. For information on acceptable power sources, see **Appendix A. "Explorer 16 Development Board Schematics"**.

Refer to **Chapter 3. "Explorer 16 Tutorial Programs"** for details on the demonstration code operation.

FIGURE 1-2: **EXPLORER 16 PIM MODULE, SHOWING NOTCHED CORNER MARKING**

1.6 EXPLORER 16 DEVELOPMENT BOARD DEMONSTRATION PROGRAMS

The preprogrammed example code on the PIMs has been included on the Explorer 16 CD-ROM for future reference. All project files have been included, so that the code may be used directly to restore a PIM to its original state (i.e., if the sample device has been reprogrammed with another program), or so the user may use the tutorial code as a platform for further experimentation.

In addition, the CD-ROM contains sample demonstration programs for both PIC24 and dsPIC33F family devices. Separate demo source code (as files in C) and compiled code files (in Hex) are provided for each family. These may be used with the included PIC24 and dsPIC33F PIMs by reprogramming the devices using MPLAB ICD 2.

1.7 REFERENCE DOCUMENTS

In addition to the documents listed in the **"Recommended Reading"** section, these documents are also available from Microchip to support the use of the Explorer 16 Development Board:

- *PIC18F2455/2550/4455/4550 Data Sheet* (DS39632)
- *TC1047/TC1047A Data Sheet* (DS21498)
- *25AA256/25LC256 Data Sheet* (DS21822)
- *PICkit™ 2 Microcontroller Programmer User's Guide* (DS51553)
- *MPLAB® ICD 2 In-Circuit Debugger Quick Start Guide* (DS51268)
- *PRO MATE® II User's Guide* (DS30082)

You can obtain these reference documents from your nearest Microchip sales office (listed in the back of this document) or by downloading them from the Microchip web site (www.microchip.com).

Chapter 2. Explorer 16 Programming Tutorial

2.1   INTRODUCTION

This chapter is a self-paced tutorial to get you started using the Explorer 16 Development Board.

2.2   HIGHLIGHTS

Items discussed in this chapter include:

• Tutorial Overview
• Creating the Project
• Building the Code
• Programming the Device

2.3   TUTORIAL OVERVIEW

The tutorial in this chapter demonstrates the main features of the MPLAB IDE and MPLAB ICD 2 as they are used with the Explorer 16 Development Board. As presented, it is designed for use with the PIC24FJ128GA010 specifically. However, the same procedures and toolsuites can also be used with PIC24H or dsPIC33F devices.

The PIC24 tutorial project demonstrated here, `PIC24ExplDemo.mcp`, is written in C for MPLAB C30. The program displays PIC24 features on the alphanumeric LCD, and also displays voltage, temperature and date/time as the various buttons are pressed. Described with the PIC24 project is the dsPIC device tutorial, `Example1_RTC_LED_ADC.mcp`. It is also written in C for MPLAB C30. The program displays voltage and current time, updating the display on command. Both programs are described in more detail in **Chapter 3. "Explorer 16 Tutorial Programs"**.

For either project, the source file (`PIC24ExplDemo.c` or `main_rtc.c` for PIC24 or dsPIC33F, respectively) is used with a linker script file (`p24fj128ga010.gld` or `p33fj256gp710ps.gld`) and header file (`p24fj128ga010.h` or `p33fj256gp710ps.h`) to form a complete project. While these simple projects use a single source code file, more complex projects might use multiple assembler and compiler source files, as well as library files and precompiled object files.

Upon completing this tutorial, you should be able to:

• Create a project using the Project Wizard
• Assemble and link the code and set the Configuration bits
• Set up MPLAB IDE to use the MPLAB ICD 2
• Program the chip with the MPLAB ICD 2

There are three steps to this tutorial:

1.   Creating a project in MPLAB IDE.
2.   Assembling and linking the code.
3.   Programming the chip with the MPLAB ICD 2.

2.4 CREATING THE PROJECT

The first step is to create a project and a workspace in MPLAB IDE. Typically, there is one project in one workspace.

> **Note:** These instructions presume the use of MPLAB IDE 7.22 or newer.

A project contains the files needed to build an application (source code, linker script files, etc.) along with their associations to various build tools and build options.

A workspace contains one or more projects and information on the selected device, debug tool and/or programmer, open windows and their location and other MPLAB IDE configuration settings.

MPLAB IDE contains a Project Wizard to help create new projects. Before starting, create a folder named Tutorial for the project files for this tutorial (`C:\Tutorial` is assumed in the instructions that follow). From the `Example Code\Tutorial Code` directory on the Explorer 16 Development Kit Software CD-ROM, copy all of the source files into this folder.

> **Note:** The screen shots in the following sections show the PIC24 tutorial. Except for displayed file names, the screens for the dsPIC33F tutorial will be identical.

2.4.1 Select a Device

1. Start MPLAB IDE.
2. Close any workspace that might be open (*File > Close Workspace*).
3. From the *Project* menu, select *Project Wizard.*
4. From the Welcome screen, click **Next >** to display the Project Wizard Step One dialog (Figure 2-1).

FIGURE 2-1:   SELECTING THE DEVICE
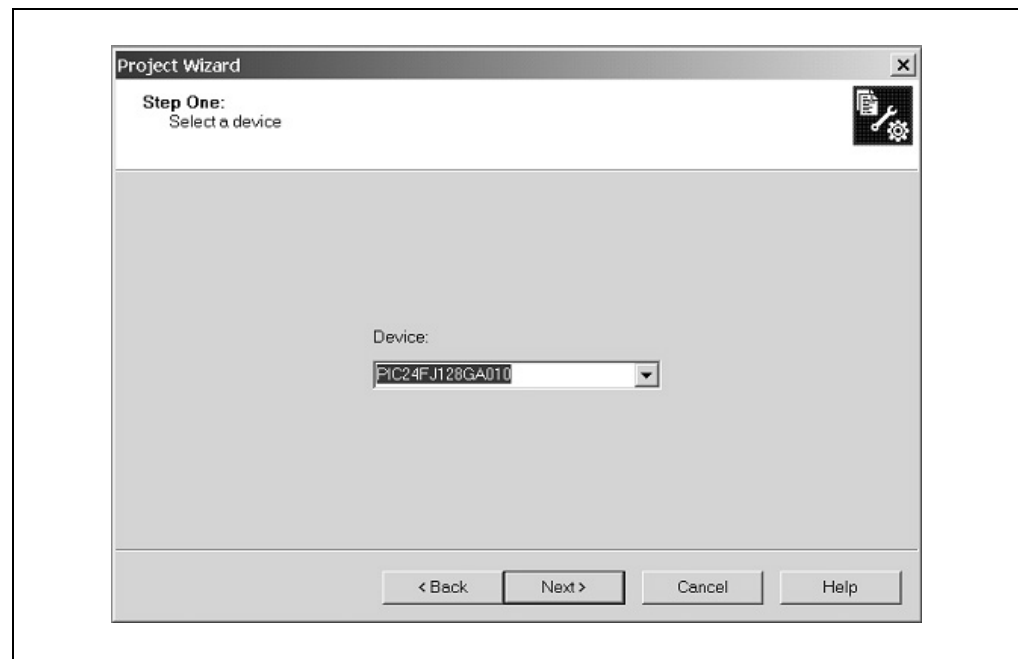
5. From the **Device** drop-down list, select "PIC24FJ128GA010" or "dsPIC33FJ256GP710PS", depending on the PIM being used. Click **Next >**. The Project Wizard Step Two dialog will be displayed (see Figure 2-2).

FIGURE 2-2: **SELECTING THE TOOLSUITE**
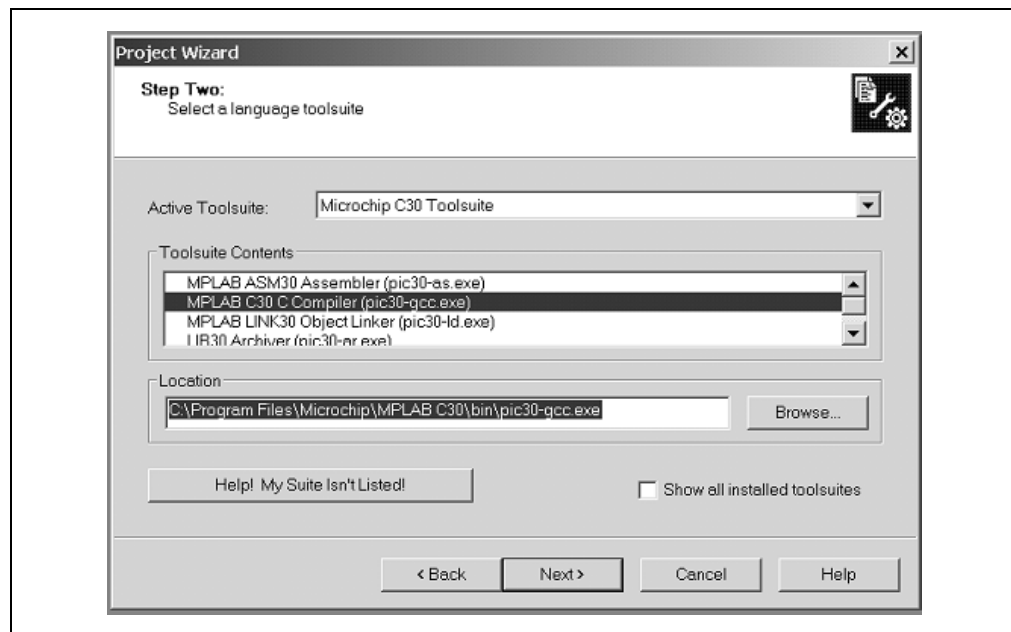
2.4.2 Select Language Toolsuite

1. From the **Active Toolsuite** drop-down list, select Microchip C30 Toolsuite. This toolsuite includes the assembler and linker that will be used.
2. In the **Toolsuite Contents** combo box, select MPLAB C30 Compiler (`pic30-gcc.exe`).
3. In the **Location** box, click **Browse...** and navigate to `C:\Program Files\Microchip\MPLAB C30\bin\pic30-as.exe`.
4. With MPLAB LINK 30 Object Linker (`pic30-ld.exe`) selected in **Toolsuite Contents**, click **Browse...** and navigate to `C:\Program Files\Microchip\MPLAB C30\bin\pic30-Id.exe`.
5. Click **Next >** to continue. The Project Wizard Step Three dialog displays (Figure 2-3).

FIGURE 2-3:   NAMING YOUR PROJECT
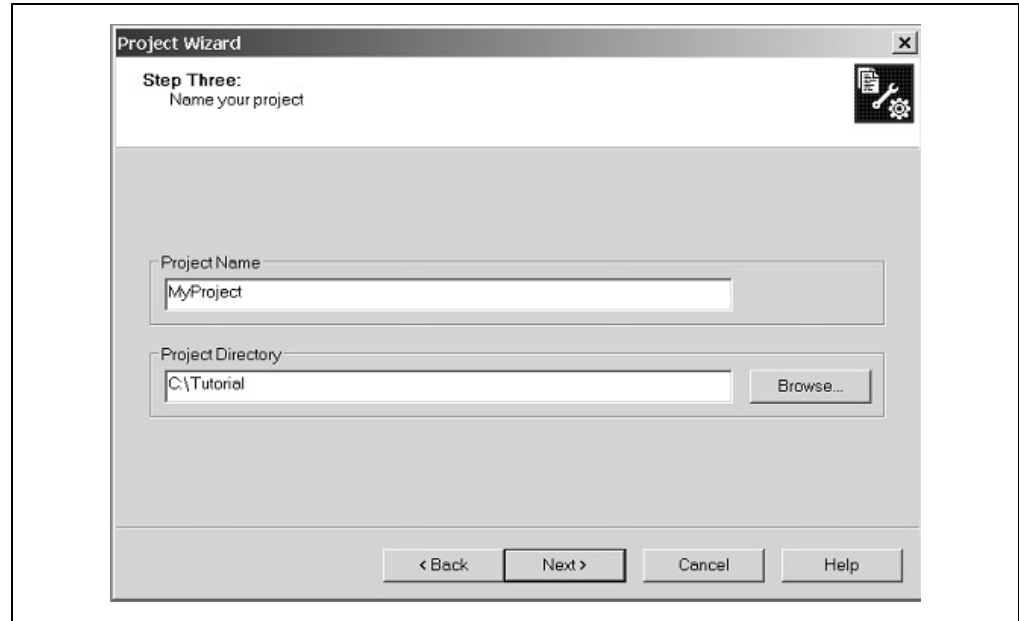
2.4.3   Name Your Project

1.   In the **Project Name** text box, type "MyProject".
2.   In the **Project Directory** box, click **Browse...** and navigate to `C:\Tutorial` to place your project in the Tutorial folder.
3.   Click **Next >** to continue. The Project Wizard Step Four dialog displays (Figure 2-4).

FIGURE 2-4:   ADDING FILES TO THE PROJECT
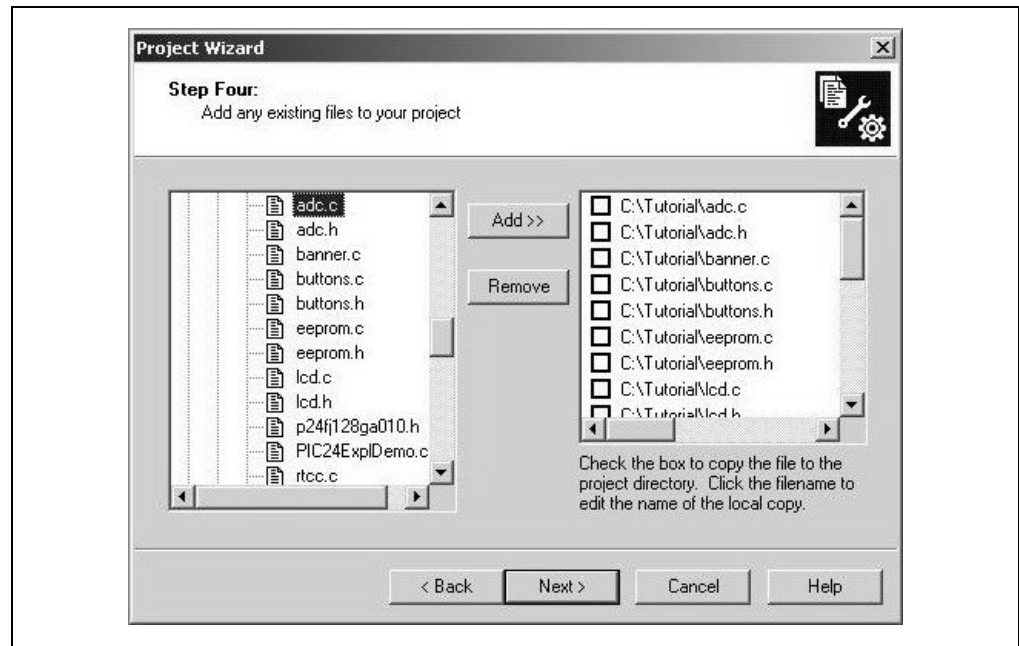
2.4.4   Add Files to Project

1. From the list of folders on the PC, locate the `C:\Tutorial` folder.
2. Select the source (`.c`) and header (`.h`) files. Click **Add >>** to include the file in the project.
3. Expand the `C:\Program Files\Microchip\MPLAB 30\support\gld` folder and select the `p24fj128ga010.gld` or `p33fj256gp710ps.gld` file, as appropriate.
4. Click **Add >>** to include this file in the project. There should now be two files in the project.
5. Click **Next >** to continue.
6. When the summary screen displays, click **Finish.**

After the Project Wizard completes, the MPLAB Project window shows the source files in the Source Files folder and the appropriate linker script in the Linker Scripts folder (Figure 2-5).

FIGURE 2-5:   PROJECT WINDOW
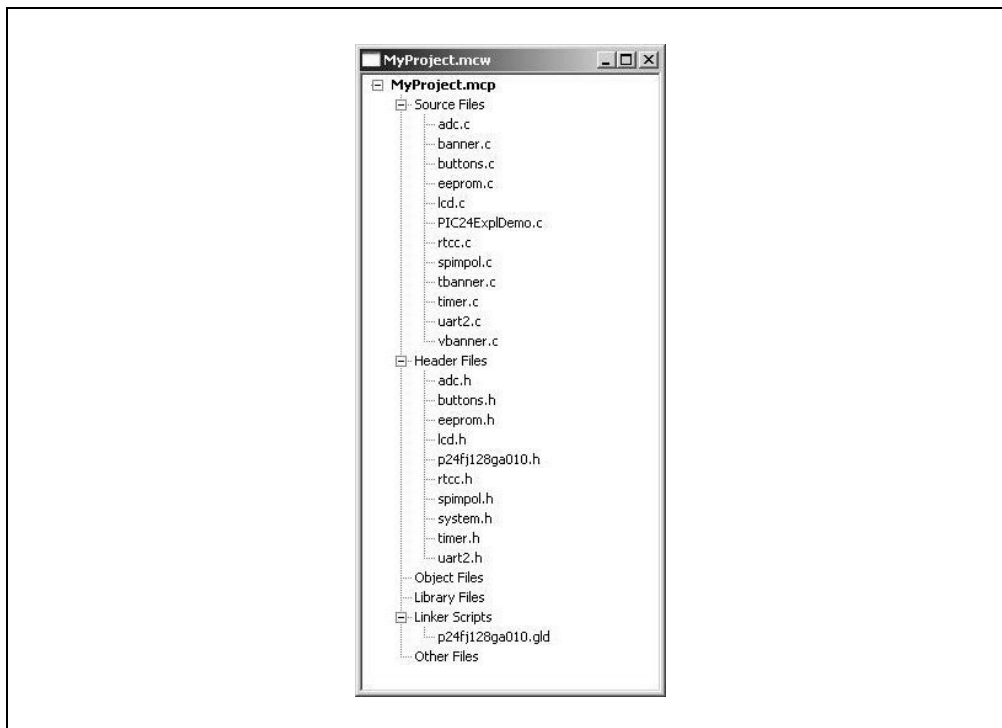
A project and workspace has now been created in MPLAB IDE. `MyProject.mcw` is the workspace file and `MyProject.mcp` is the project file. Double-click the `PIC24ExplDemo.c` file (for PIC24) or `main_rtc.c` file (for dsPIC33F) in the Project window to open the file. MPLAB IDE should now look similar to Figure 2-6.

FIGURE 2-6: **MPLAB® IDE WORKSPACE**
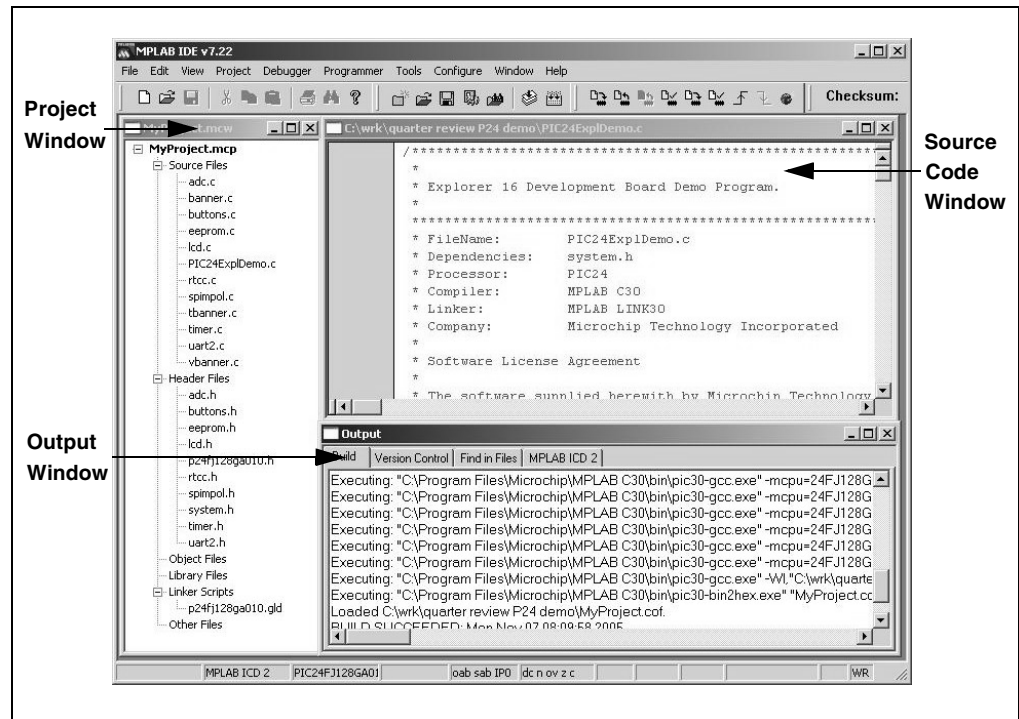
2.5   BUILDING THE CODE

In this project, building the code consists of compiling the source files to create an object file, `MyProject.o`, then linking the object file to create the `MyProject.hex` and `MyProject.cof` output files. (For dsPIC33F projects, the files would be `Example1_RTC_LED_ADC.o`, `Example1_RTC_LED_ADC.hex` and `Example1_RTC_LED_ADC.cof`.) The Hex file contains the data necessary to program the device, and the `.cof` file contains additional information that lets you debug the code at the source code level.

Before building, there are settings required to tell MPLAB IDE where to find the include files and to reserve space for the extra debug code when the MPLAB ICD 2 is used. For PIC24 projects, the following line in the `system.h` file is:

`#include "p24fj128ga010.h"`

For dsPIC33 projects, the line is:

`#include "p33fj256gp710ps.h"`

This line causes a standard include file to be used. Microchip provides these files with all the Special Function Register (SFR) labels already defined for convenience.

To build the code, select *Build Options > Project* from the *Project* menu. The Build Options dialog displays (Figure 2-7).

FIGURE 2-7:   BUILD OPTIONS
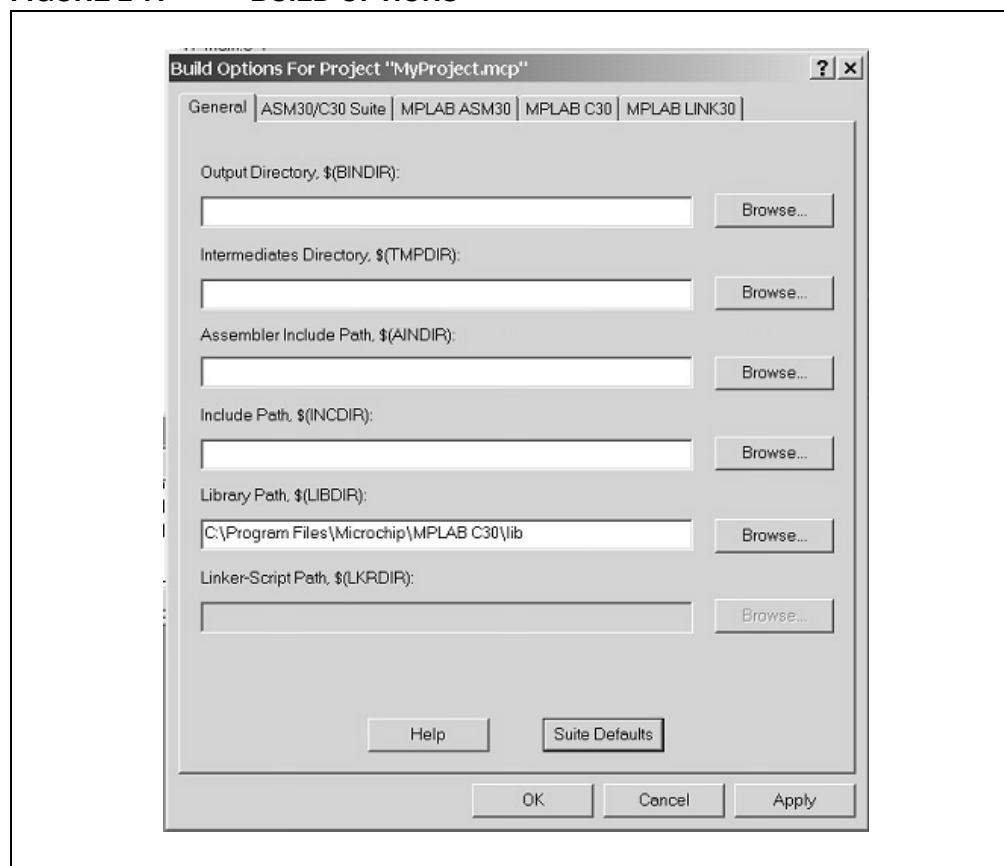
2.5.1   Identify Assembler Include Path

1.   Select the **General** tab.
2.   Click **Suite Default**. This tells the environment where to find the library files.
3.   Select the **MPLAB LINK30** tab to view the linker settings (Figure 2-8).
4.   Check **Link for ICD2**.
5.   Click **OK**. The text box closes while the linker reserves space for the debug code used by the MPLAB ICD 2.
6.   Click **OK** again to save these changes. The project is now ready to build.

FIGURE 2-8: **MPLAB® LINK30 BUILD OPTIONS**
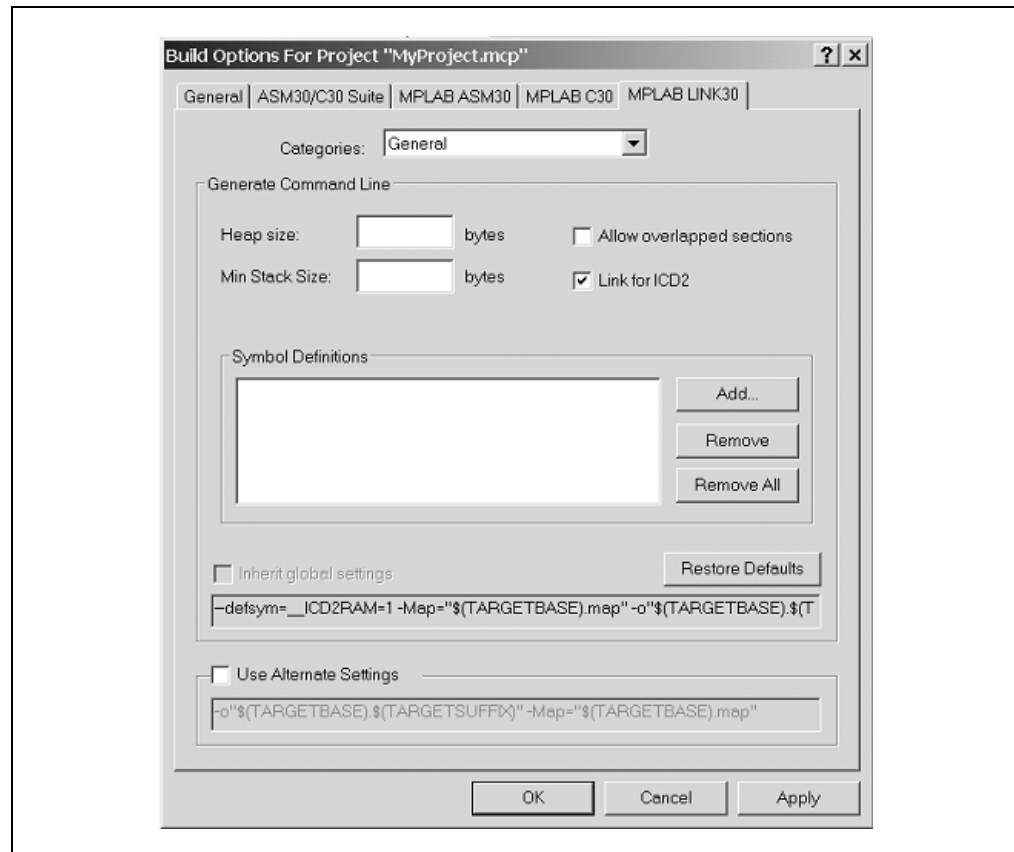
2.5.2 Build the Project

From the menu bar of the main MPLAB IDE window, select *Project > Make*. The Build Output window displays (Figure 2-9).

Observe the progress of the build. When the "BUILD SUCCEEDED" message displays, you are ready to program the device.

FIGURE 2-9: **BUILD OUTPUT**
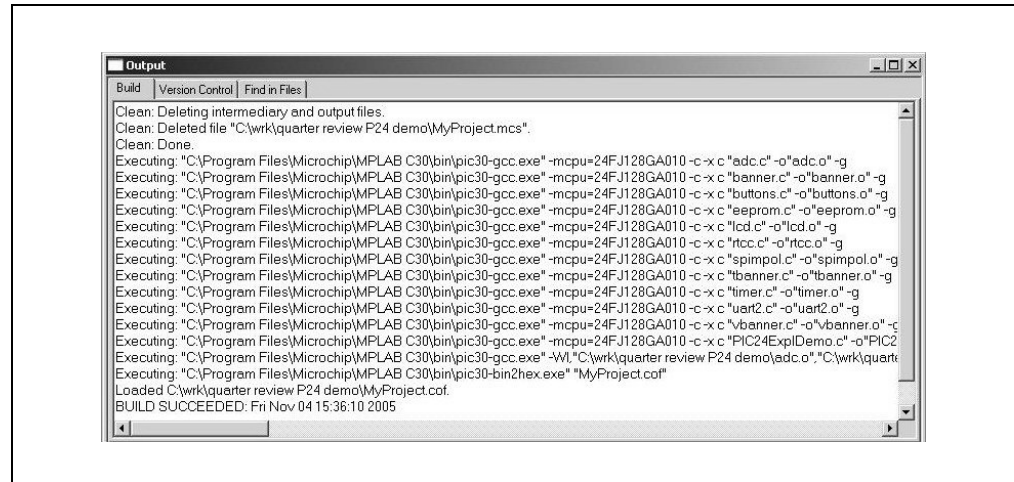
Explorer 16 Development Board User's Guide

2.6   PROGRAMMING THE DEVICE

The MPLAB ICD 2 In-Circuit Debugger is used to program and debug the microcontroller in-circuit on the Explorer 16 Development Board.

> **Note:**   Before proceeding, make sure that the USB driver for the MPLAB ICD 2 has been installed on the PC (see the *MPLAB® ICD 2 In-Circuit Debugger User's Guide* (DS51331) for more details regarding the installation of the MPLAB ICD 2).

2.6.1   Set Up the Device Configuration

The device configuration for the target microcontroller can be set by two methods: using configuration macros in the source code, or using the Configuration Bits window in MPLAB IDE.

The PIC24 Explorer 16 tutorial code already includes configuration macros in the source code itself. It is only necessary to confirm that the following macros are in place near the top of the `PIC24ExplDemo.c` file:

`_CONFIG1(JTAGEN_OFF & GSS0_OFF & GWRP_OFF & BKBUG_OFF & COE_OFF & FWDTEN_OFF & FNOSC_PRI)`

`_CONFIG2(FCKSM_CSDCMD & OSCIOFNC_ON & POSCMOD_HS)`

For the dsPIC33F tutorial code, confirm that the following macros are in place near the top of the `main_rtc.c` file:

`_FGS(CODE_WRITE_PROT_OFF);`

`_FOSCSEL(FRC_PLL);`

`_FOSC(CSW_FSCM_OFF & OSC2_IO & XT);`

`_FWDT(WDT_OFF);`

If configuration macros are not used in the source code, it is also possible to set device configuration with the Configuration Bits window. For the PIC24 code, the process is as follows:

1. From the main window's menu bar, select *Configure > Configuration Bits* to display the configuration settings (Figure 2-10).
2. Set the Configuration bits by clicking on a particular line item and selecting an option from the drop-down menu that appears. The Configuration bits should be set as shown in Figure 2-10.

    The settings that will most likely need to change are:

    a) Primary Oscillator Select: HS Oscillator Enabled
    b) Oscillator Select: Primary Oscillator (XT, HS, ES)
    c) Clock Switching and Monitor: SW Disabled, Mon Disabled
    d) Watchdog Timer Enable: Disable

**FIGURE 2-10:   CONFIGURATION SETTINGS (PIC24)**
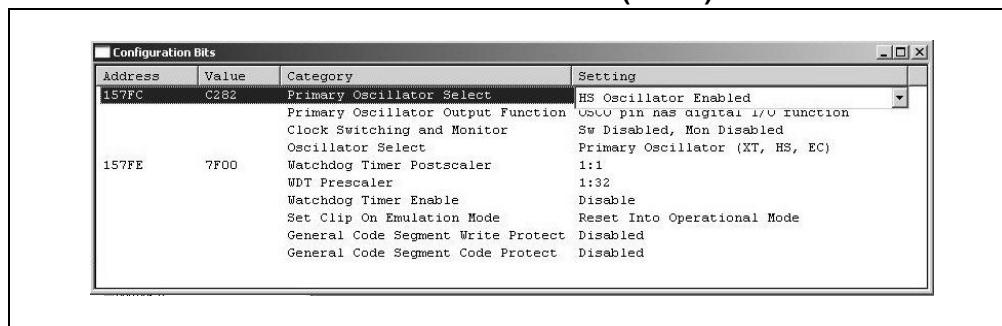
> **Note:** Do not use the Configuration Bits window to set device configuration if configuration macros are already used in the source code. In cases where both methods are used, configuration macros may override settings from the Configuration Bits window. Refer to the *MPLAB IDE Simulator, Editor User's Guide* (DS51025) for additional information.

2.6.2   Connect and Enable MPLAB ICD 2

1. Connect the MPLAB ICD 2 module to the PC with the USB cable.
2. Connect the MPLAB ICD 2 to the Explorer 16 Development Board with the short RJ-11 cable.
3. Apply power to the Explorer 16 board.
4. From the *Debugger* menu, click *Select Tool > MPLAB ICD 2* to set the MPLAB ICD 2 as the debug tool in MPLAB IDE.
5. From the *Debugger* menu, select *Connect* to connect the debugger to the device. MPLAB IDE should report that it found the PIC24FJ128GA010 device, as shown in Figure 2-11.

> **Note:** MPLAB IDE may need to download new firmware if this is the first time the MPLAB ICD 2 is being used with a PIC24FJ device. Allow it to do so. If any errors are shown, double-click the error message to get more information.

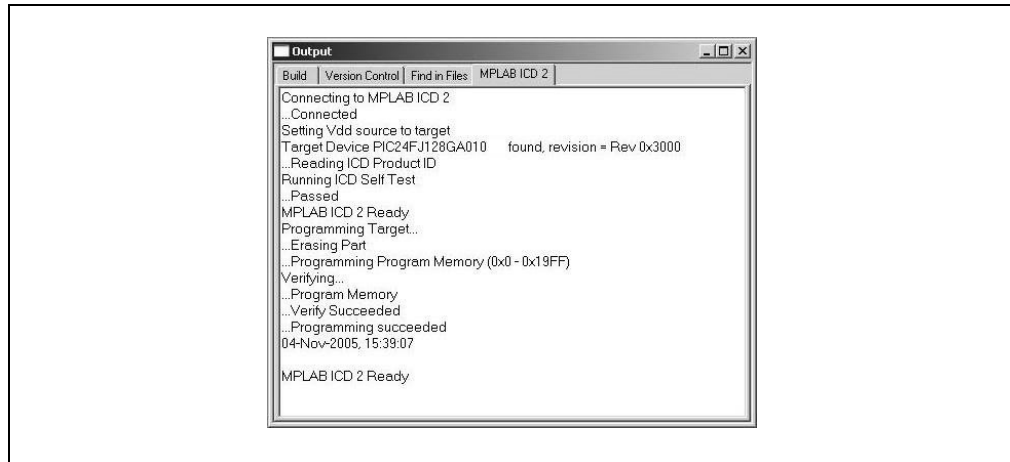**FIGURE 2-11:   ENABLING MPLAB® ICD 2**
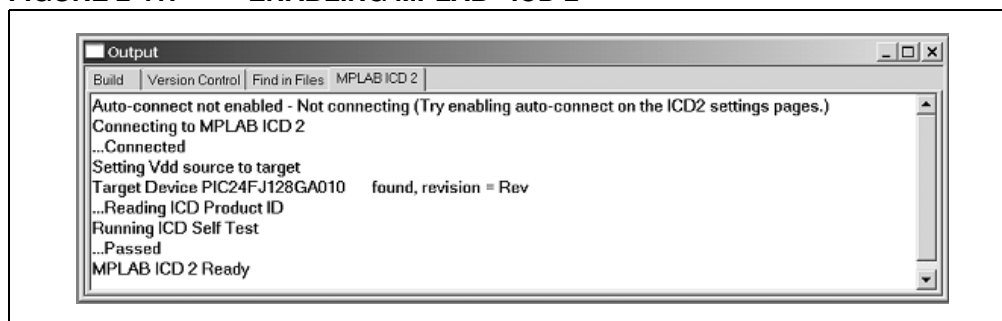
2.6.3 Program the Device

1. From the *Debugger* menu, select *Program* to program the part. The Output window (Figure 2-12) displays the program steps as they occur.

2. Observe the results of the programming. When "MPLAB ICD 2 Ready" displays, the device is programmed and ready to run.

FIGURE 2-12: **PROGRAMMING THE DEVICE**

NOTES:

Chapter 3. Explorer 16 Tutorial Programs

3.1 INTRODUCTION

This chapter provides a high-level overview of the PIC24 and dsPIC33F firmware programmed during the tutorial exercise in the previous chapter.

3.2 PIC24 TUTORIAL PROGRAM OPERATION

The PIC24 tutorial program is made up of three components which are individually displayed on the LCD. The program is used to demonstrate the new Parallel Master Port (PMP) module which is used to drive the LCD, as well as the new Real-Time Clock/Calendar module (RTCC). The program flow is shown in Figure 3-1.

3.2.1 PIC24 Features

Features mode displays a continuous description of the PIC24FJ128GA010 device feature set. To exit the display and continue to the next mode, press S4.

3.2.2 Voltmeter/Temperature

Voltmeter/Temperature mode uses the code modules, `vbanner.c` and `ADC.c`, and the A/D module to measure analog signals from the board and convert them for display on the LCD. The voltage is taken from the potentiometer (R6) and displays a voltage between 0.00V and 3.29V on line 1 of the LCD. Temperature is from a TC1074A analog thermal sensor (U5). The temperature is displayed on line 2 of the LCD and automatically alternates between Celsius and Fahrenheit values. The voltage and temperature are updated continuously.

This mode also lets users store the current temperature in the on-board serial EEPROM by pressing S5. Pressing S6 switches the display between current and stored temperature values. An 'M' on the right side of the LCD indicates that a stored temperature value is being displayed.

To exit and continue to the next mode, press S4.

3.2.3 Clock/Calendar

Clock/Calendar mode uses code in the modules, `rtcc.c` and `tbanner.c`. Once this mode is entered from the main menu, a Real-Time Clock will start counting from 10:00:00, and display the date and day for Oct. 10, 2005. The new RTCC module and a 32 kHz clock crystal are used to provide the Real-Time Clock with day/date calendar.

In Clock/Calendar mode, the user-defined push buttons do the following:

• S3 toggles the Clock Set mode, which allows the user to set the date and time. Setup mode starts with the tens digit of the hour in the time display.
• S4 accepts the value of the current item and moves cursor to the next item.
• S5 decrements the currently selected item.
• S6 increments the currently selected item.

Pressing S3 once superimposes a flashing cursor over the tens digit of the hour in the time display. Each press of S4 moves the cursor sequentially through the digits of the time display, then the month, day and year. Pressing S3 at any time in the process returns to the regular clock/calendar display.

Pressing S4 at this point exits Clock/Calendar mode and returns the device to the PIC24 Features mode.

The data that is sent to the LCD is also sent to the RS-232 serial port using the UART. A terminal emulator, such as HyperTerminal (installed by default on most Microsoft® Windows systems), will be able to display the same information. To do this, set the terminal emulator for 19200 baud, 8-bit data, 1 Stop bit and no parity check.

FIGURE 3-1:   PIC24 TUTORIAL PROGRAM FLOWCHART
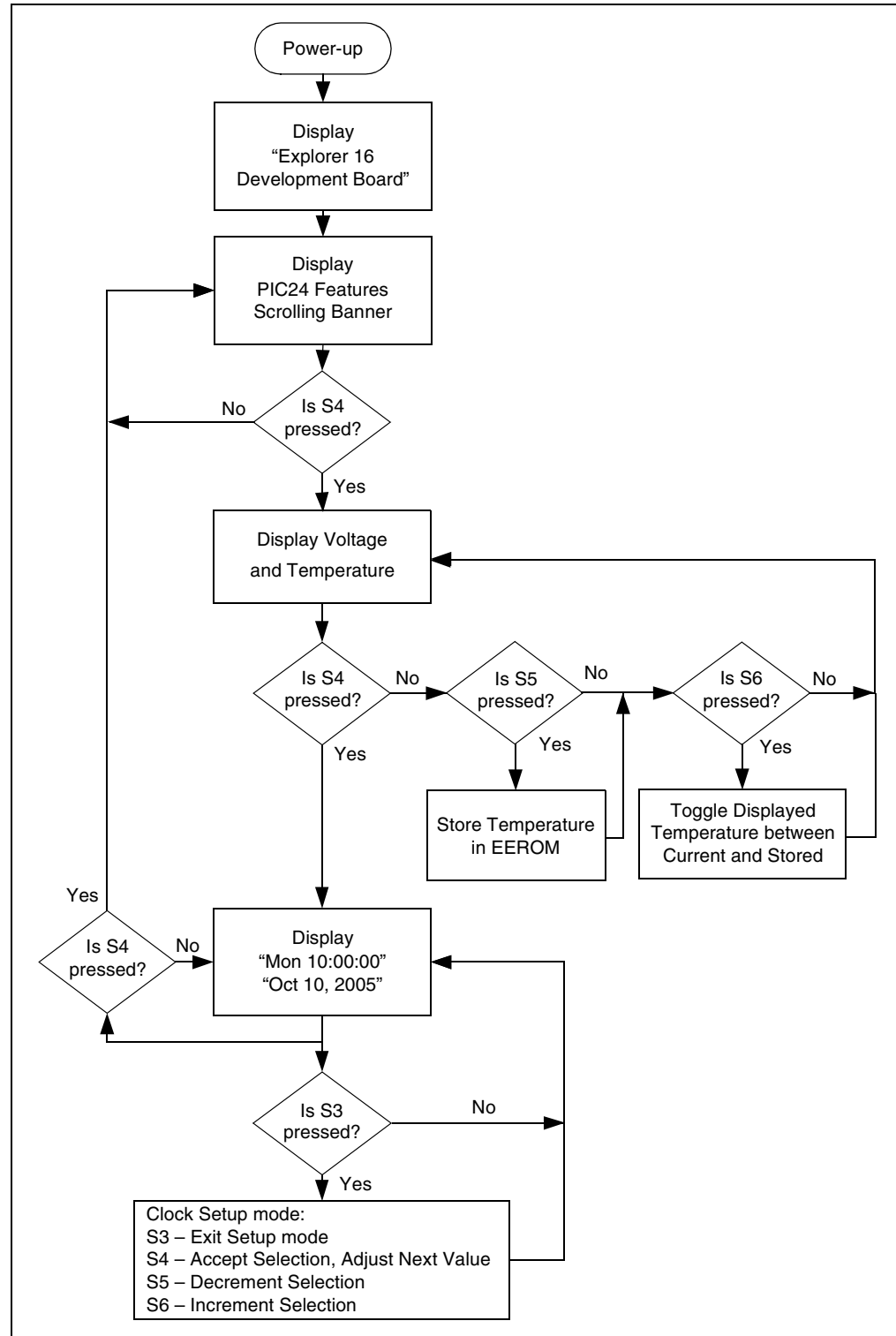
3.3 dsPIC33F TUTORIAL PROGRAM OPERATION

The dsPIC33F tutorial program is made up of five simple processes which continuously execute on the dsPIC33FJ256GP710 device:

- Real-Time Clock (RTC) using Timer1
- A/D conversion of Potentiometer (R6)
- A/D volts to Hex conversion
- Hex to Decimal conversion (for LCD display)
- LCD Update

The time of day and A/D conversion values are continually updated and displayed on the LCD. The program demonstrates the basic code to initialize Timer1, enable the Timer1 oscillator for RTC operation, and initialize the A/D for single channel conversion of potentiometer, RP5. The LCD is driven via the port pins. The program flow is shown in Figure 3-2.

In addition to the tutorial, the Explorer 16 CD also provides code examples to demonstrate higher level processing requirements, such as DMA, digital filters and Fast Fourier Transforms (FFT). See Code Example 2 on the CD for more information.

3.3.1 Voltmeter

The simple tutorial program initializes the A/D module for 12-bit mode with auto-sampling and conversion of the potentiometer connected to pin AN5 and initializes the respective interrupt. The A/D module continually samples and converts the potentiometer signal (0 to 3.3 VDC) on analog channel, AN5. When a conversion is complete, an interrupt is generated and the result in the ADCBUF0 register is copied into a temporary variable, `temp1`. The `adc_lcd_update` flag is then asserted and the A/D Interrupt Flag, AD1IF (IFS0<13>), is cleared.

The program exits the Interrupt Service Routine and re-enters the main program loop. The variable, `adc_lcd_update`, is evaluated in the main loop to determine if there is a new A/D conversion value which can be converted and displayed on the LCD.

The primary code modules associated with the operation of the ADC module and display are:

- `init_ADC.c`
- `isr_ADC.c`
- `advolts.c`
- `hexdec.c`

3.3.2 Real-Time Clock

The tutorial program also supports a Real-Time Clock demo. Timer1 is initialized with interrupts enabled and the external 32.768 kHz oscillator is enabled. Within the Timer1 Interrupt Service Routine (once every second), the variables, `hours`, `minutes` and `seconds`, are updated, the flag variable, `rtc_lcd_update`, is asserted and the Timer1 Interrupt Flag, T1IF (IFS0<3>), is cleared.

The program exits the Interrupt Service Routine and re-enters the main program loop. The variable, `rtc_lcd_update`, is evaluated in the main loop to determine if there is a new time of day value which can be converted and displayed on the LCD.

The primary code modules associated with the operation of the Timer1 module and display are:

- `init_timer1.c`
- `isr_timer1.c`
- `hexdec.c`

FIGURE 3-2:   dsPIC33F TUTORIAL PROGRAM FLOWCHART
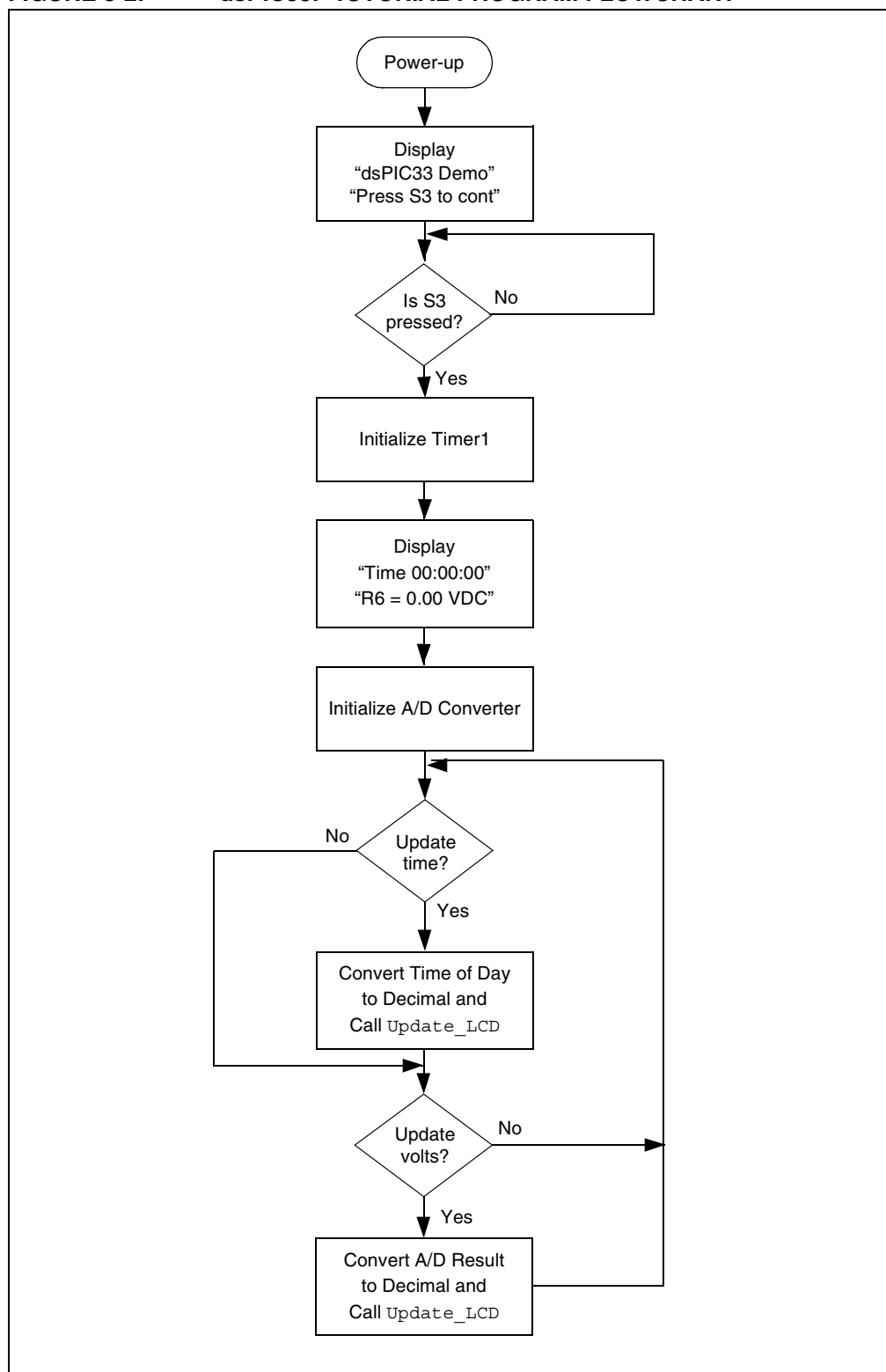
Chapter 4. Explorer 16 Development Hardware

4.1 INTRODUCTION

This chapter provides a more detailed description of the hardware features of the Explorer 16 Development Board.

4.2 HARDWARE FEATURES

The key features of the Explorer 16 board are listed below. They are presented in the order given in **Section 1.4 "Explorer 16 Development Board Functionality and Features"**, Figure 1-1.

4.2.1 Processor Support

The Explorer 16 board has been designed to accommodate both permanently mounted (i.e., soldered on) and detachable PIM processors. Slider switch, S2, allows the user to choose which processor to use. This makes it possible for the Explorer 16 board to support most 3V, 16-bit, pin compatible microcontrollers with appropriate PIMs.

PIMs are visually indexed for proper installation. The PIM is always installed with the notched corner mark on the corner of the PIM board oriented to the upper left corner.

Current revisions of the board do not have a permanently mounted microcontroller in U1. In order for the board to work, therefore, S2 must always be left in the "PIM" position. In future versions with a permanently mounted PIC24 device at U1, setting S2 in the "PIC" position will enable the on-board device and disable the PIM socket.

4.2.2 Power Supply

There are two ways to supply power to the Explorer 16 board:

• An unregulated DC supply of 9V to 15V (preferably 9V) supplied to J12.
  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 that can connect to multiple expansion boards, voltage regulators (Q1 and Q2) with a maximum current capability of 800 mA are used. This may require a larger power supply of up to 1.6A. Because the regulators do not have heat sinks, long-term operation at such loads is not recommended.

> **Note:** The Explorer 16 kit does not include a power supply. If an external supply is needed, use Microchip part number AC162039.

• An external, regulated DC power supply that provides both +5V and +3.3V can be connected to the terminals provided (at the bottom left side of the board, near S3).

> **Note:** Do not attempt to power the Explorer 16 board using the MPLAB ICD 2 module. It is not designed to be a USB bus power source.

One green LED (D1) is provided to show when the Explorer 16 board is powered up. The power-on LED indicates the presence of +3.3V.

4.2.3   RS-232 Serial Port

An RS-232 level shifter (U3) has been provided with all necessary hardware to support RS-232 connection with hardware flow control through the DB9 connector. The port is configured as a DCE device, and can be connected to a PC using a straight-through cable.

The PIC24/dsPIC33F RX and TX pins are tied to the RX and TX lines of U3. The PIC24/dsPIC33F RTS and CTS pins are tied to the RX2 (DIN2) and TX2 (DOUT2) lines of the MAX3232 for hardware flow control.

4.2.4   Temperature Sensor

An analog output thermal sensor (Microchip TC1074A, U4) is connected to one of the controller's A/D channels.

4.2.5   USB Connectivity

The Explorer 16 board includes a PIC18LF4550 USB microcontroller, which provides both USB connectivity and support for protocol translation. The PIC18LF4550 is hard-wired to the PIC24/dsPIC33F devices to provide three types of connectivity:

- SPI™ of PIC18LF4550 to SPI1 of PIC24/dsPIC33F
- I/O pins of PIC18LF4550 to ICSP™ pins of PIC24/dsPIC33F
- I/O pins of PIC18LF4550 to JTAG pins of PIC24/dsPIC33F

The type of connectivity depends on the firmware installed on the PIC18LF4550. At the time of initial release, the PIC18LF4550 is loaded with USB bootloader firmware, which permits easy upgrades of connectivity firmware over the USB. Installing this firmware is described in **Appendix B. "Updating the USB Connectivity Firmware"**.

PIC24 and dsPIC33F devices both have some 5V tolerant input pins. If a 5V tolerant input is connected to the PIC18LF4550, protection diodes on the PIC18LF4550 device's port pins will limit inputs to V$_{DD}$. For more information on which pins of the 16-bit devices are 5V tolerant, refer to the appropriate device data sheet.

4.2.6   ICD Connector

An MPLAB ICD 2 module can be connected by way of the modular connector (JP1) for low-cost debugging. The ICD connector utilizes port pins, RB6 and RB7 of the microcontroller, for in-circuit debugging.

Jumper J7 decides the terminus of the ICD 2 connector. If the jumper is set to the "PIC24" side, JP1 communicates directly with RB6/RB7 of the PIM or on-board device (determined by S2). If the jumper is set to the "F4450" side, JP1 communicates with the on-board PIC18LF4550 USB device.

4.2.7   LCD

The Explorer 16 board includes an alphanumeric LCD display with two lines of 16 characters each. The display is driven with three control lines (RD4, RD5 and RD15) and eight data lines (RE7:RE0). On PIC24 devices, the LCD is driven by the PMP module, not the I/O port.

The Explorer 16 board has multiple LCD footprints and support options, although only one footprint is ever populated at one time. The Lumex LCM-SO1062 (populated at LCD4) is a 5V LCD with TTL input, and is used in the initial version of the Explorer 16 board. The Tianma TM162JCAWG1 (populated at LCD1) is a 3V LCD; it is anticipated to be used in future versions of the board.

An alternate configuration option allows the use of RD3:RD0 as four of the data lines, instead of RE7:RE4. To do this, the user must cut the trace jumpers at R60/62/64/66 and create solder bridges from the pads for R61/63/65/67 (see Figure 4-1).

FIGURE 4-1: **MODIFICATIONS TO R60-R67 FOR LCD CONFIGURATION (SCALE ENHANCED FOR VISIBILITY)**
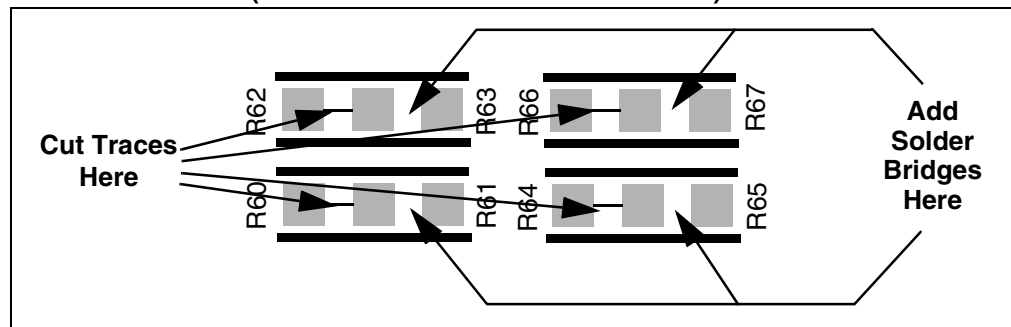
4.2.8   Graphic LCD

The Explorer 16 also has a footprint and layout support for the Optrex 128 x 64 dot-matrix graphic LCD (part number F-51320GNB-LW-AB) and associated circuitry. This is the same display used in Microchip's MPLAB PM3 programmer.

4.2.9   Switches

Five push button switches provide the following functions:

- S1: Active-low $\overline{MCLR}$ switch to hard reset the processor
- S3: Active-low switch connected to RD6 (user-defined)
- S4: Active-low switch connected to RD13 (user-defined)
- S5: Active-low switch connected to RA7 (user-defined)
- S6: Active-low switch connected to RD7 (user-defined)

Switch S1 has a debounce capacitor, whereas S3 through S6 do not; this allows the user to investigate debounce techniques. When Idle, the switches are pulled high (+3.3V). When pressed, they are grounded.

4.2.10   Analog Input (Potentiometer)

A 10 kΩ potentiometer is connected through a series resistor to AN5. It can be adjusted from VDD to GND to provide an analog input to one of the controller's A/D channels.

4.2.11   LEDs

Eight red LEDs (D2 through D9) are connected to PORTA of the PIM socket. The PORTA pins are set high to light the LEDs. These LEDs may be disabled by removing jumper JP2.

4.2.12   Oscillator Options

The installed microcontroller has two separate oscillator circuits connected.The main oscillator uses an 8 MHz crystal (Y3) and functions as the controller's primary oscillator. A second circuit, using a 32.768 kHz (watch type) crystal (Y2), functions as the Timer1 oscillator and serves as the source for the RTCC and secondary oscillator.

The PIC18LF4550, at the heart of the USB subsystem, is independently clocked and has its own 20 MHz crystal (Y1).

4.2.13   Serial EEPROM

A 25LC256 256K (32K x 8) serial EEPROM (U5) is included for nonvolatile firmware storage. It is also used to demonstrate SPI bus operation.

4.2.14 PICkit 2 Connector

Connector J14 provides the footprint for a 6-pin PICkit 2 programmer interface. This will provide a third low-cost programming option, besides MPLAB ICD 2 and the JTAG interface, when PICkit 2 support for larger devices become available in the future.

4.2.15 JTAG Connector

Connector J13 provides a standard JTAG interface, allowing users to connect to and program the controller via JTAG.

4.2.16 PICtail™ Plus Card Edge Modular Expansion Connectors

The Explorer 16 board has been designed with the PICtail™ Plus modular expansion interface, allowing the board to provide basic generic functionality and still be easily extendable to new technologies as they become available.

PICtail Plus is based on a 120-pin connection divided into three sections of 30 pins, 30 pins and 56 pins. The two 30-pin connections have parallel functionality; for example, pins 1, 3, 5 and 7 have SPI1 functionality on the top 30-pin segment, with similar SPI2 functionality on the corresponding pins in the middle 30-pin segment.

Each 30-pin section provides connections to all of the serial communications peripherals, as well as many I/O ports, external interrupts and A/D channels. This provides enough signals to develop many different expansion interfaces, such as Ethernet, Zigbee™, IrDA® and so on. The 30-pin PICtail Plus expansion boards can be used in either the top or middle 30-pin sections.

The Explorer 16 board provides footprints for two edge connectors for daughter cards, one populated (J5, Samtec # MEC1-160-02-S-D-A) and one unpopulated (J6). The board also has a matching male edge connection (J9), allowing it to be used as an expansion card itself.

4.2.16.1 CROSSOVER CONNECTIONS FOR SPI AND UART

The PICtail Plus interface allows two Explorer 16 boards to be connected directly to each other without any external connector. This provides 1-to-1 connection between the microcontrollers on the two boards, an interface that works well for many types of peripherals (I^2C, PMP, etc.). However, certain serial peripheral modules, such as SPIs and UARTs, require cross-wire connections; that is, the TX (or SDO) pin of one controller must be connected to the RX (or SDI) of the other and vice versa.

The Explorer 16 board uses two 74HCT4053 analog multiplexers to simplify the connections between itself and any daughter boards. U6 and U7 provide active control of the cross-wire capability on SPI1 and UART1, with a hardware flow control signal provided by three I/O pins.

The multiplexers are controlled by the state of pins RB12, RB13 and RB14. When a control pin is high (the default state), the corresponding SPI1 or UART1 pin pairs are connected to their default pins on the PICtail Plus interface. When a control pin is asserted low, the corresponding pin pair functions are swapped. Table 4-1 details the relationship between the control pins and SPI1/UART1 functions on the interface.

TABLE 4-1: LOCATION OF SPI1 AND UART1 PINS ON PICtail™ PLUS INTERFACE

Control Pin State	UART1 Control Pins				SPI1	
	Control Pin RB14		Control Pin RB13		Control Pin RB12	
	U1RX	U1TX	$\overline{\text{U1CTS}}$	$\overline{\text{U1RTS}}$	SDI1	SDO1
1	2	4	19	20	5	7
0	4	2	20	19	7	5

> **Note:** When connecting SPI and UART peripherals on two Explorer 16 boards, use crossover connection on only one of the boards.

NOTES:

Appendix A. Explorer 16 Development Board Schematics

A.1 INTRODUCTION

This section provides detailed technical information on the Explorer 16 board.

A.2 DEVELOPMENT BOARD BLOCK DIAGRAM

FIGURE A-1: **HIGH-LEVEL BLOCK DIAGRAM OF THE EXPLORER 16 DEVELOPMENT BOARD**

* Hardware support only; firmware support for SPI™, JTAG and ICSP™ via USB are not available at this time.
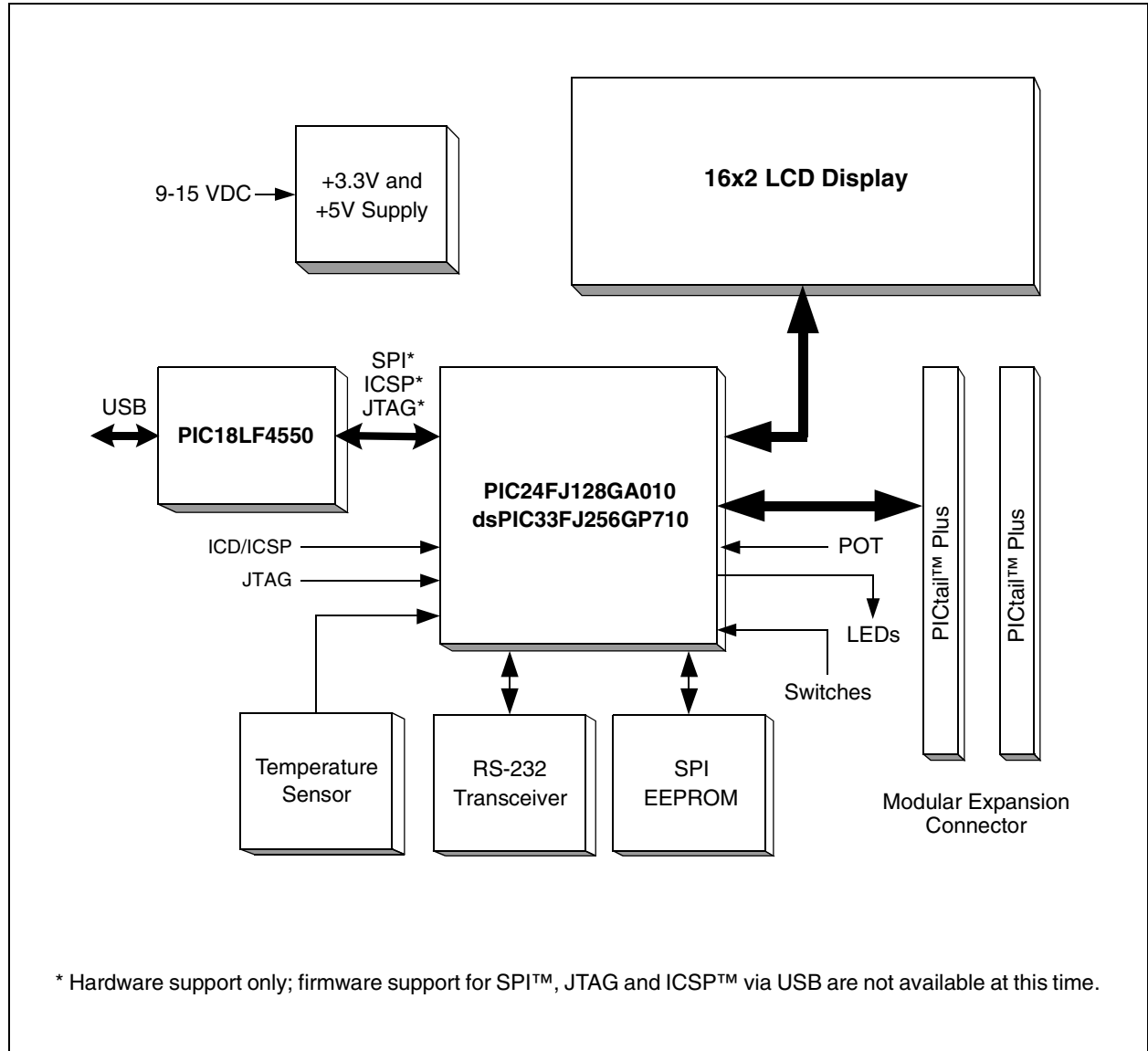
A.3   DEVELOPMENT BOARD SCHEMATICS

FIGURE A-2:   EXPLORER 16 BOARD SCHEMATIC, SHEET 1 OF 8 (PIM SOCKET)
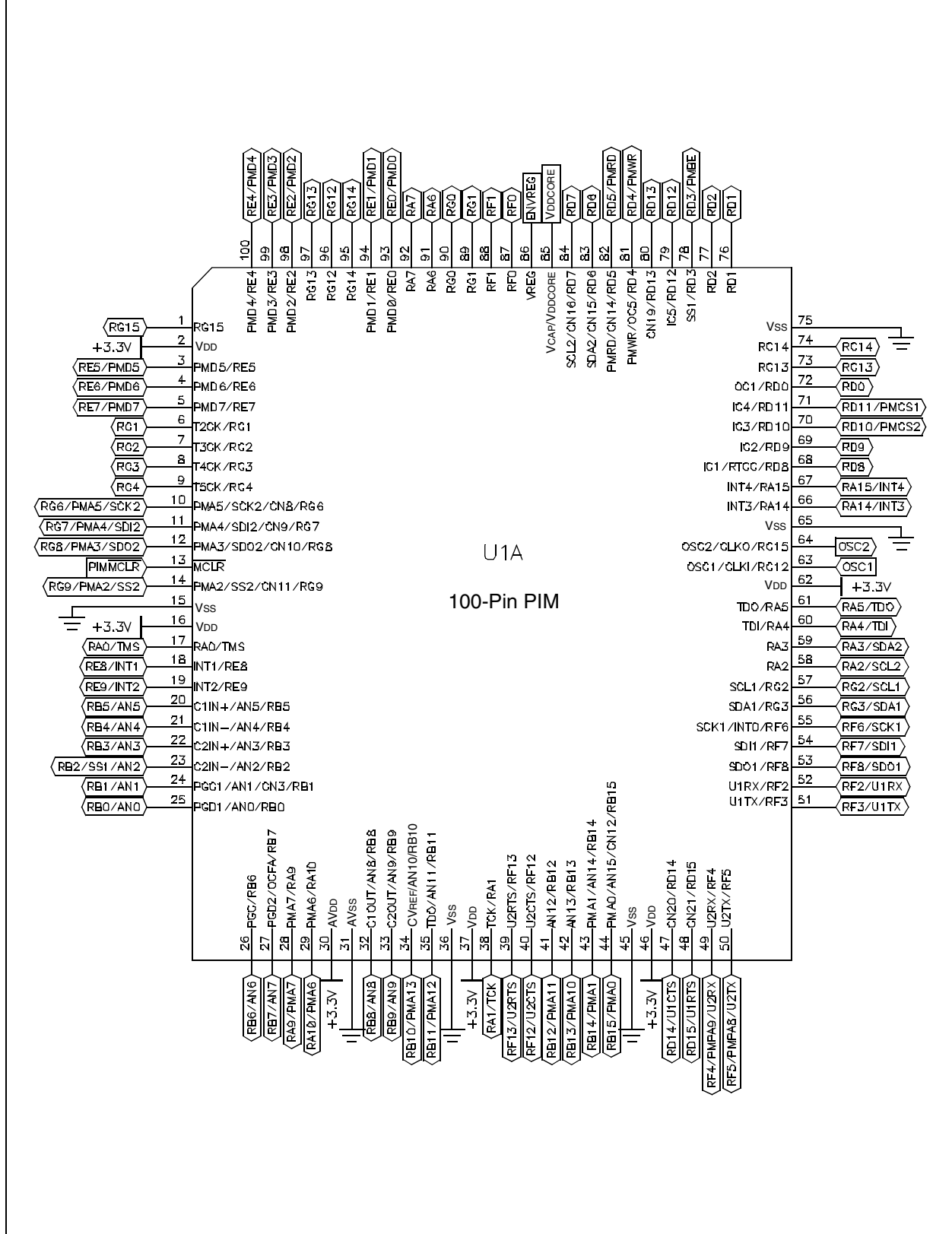
Explorer 16 Development Board User's Guide

FIGURE A-3: **EXPLORER 16 BOARD SCHEMATIC, SHEET 2 OF 8 (BOARD MOUNTED PIC24FJ128GA010 MCU, WHEN INSTALLED)**
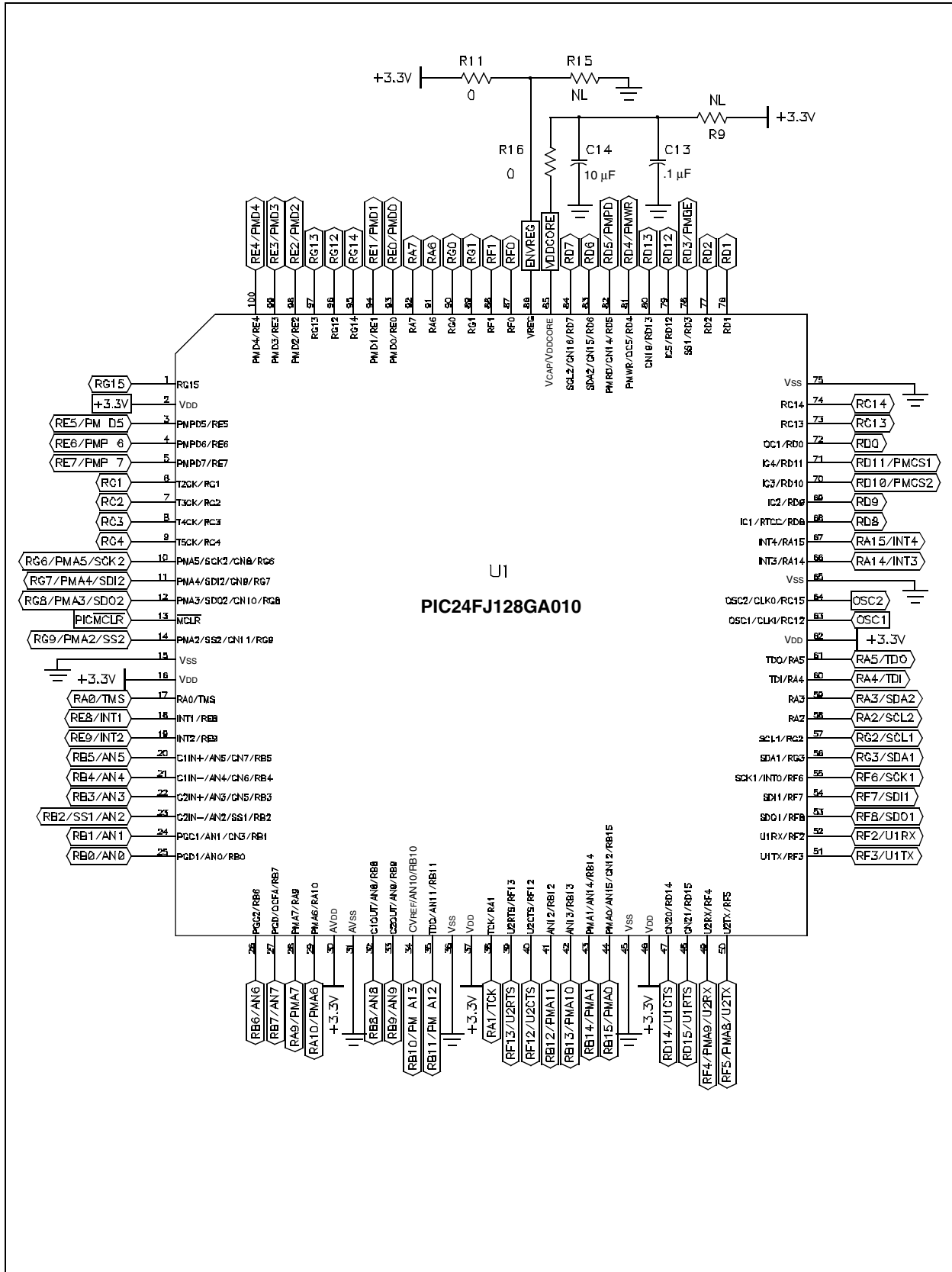
© 2005 Microchip Technology Inc.
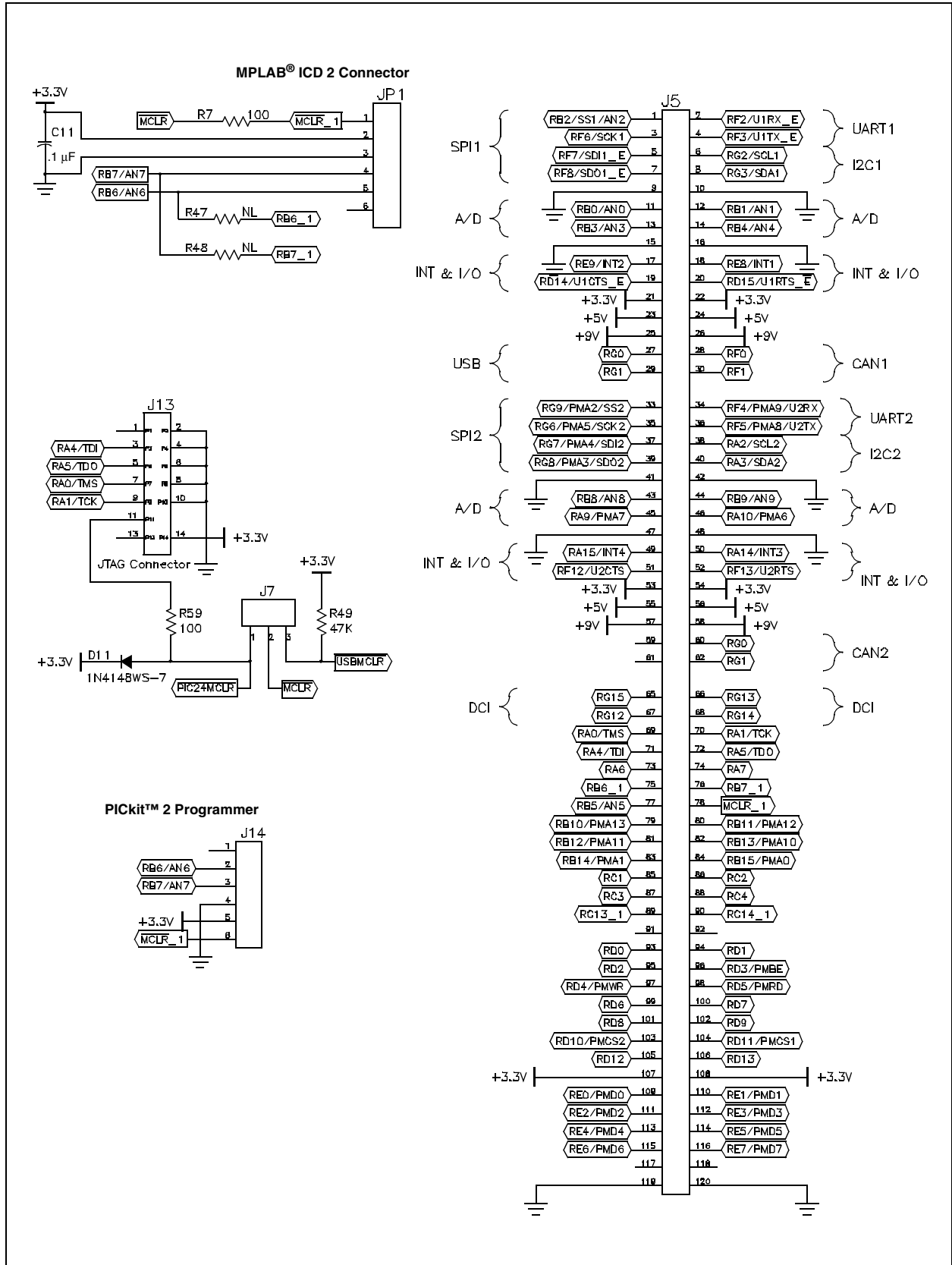
Explorer 16 Development Board Schematics

FIGURE A-5: EXPLORER 16 BOARD SCHEMATIC, SHEET 4 OF 8 (PICtail™ PLUS EDGE AND SOCKET CONNECTORS)
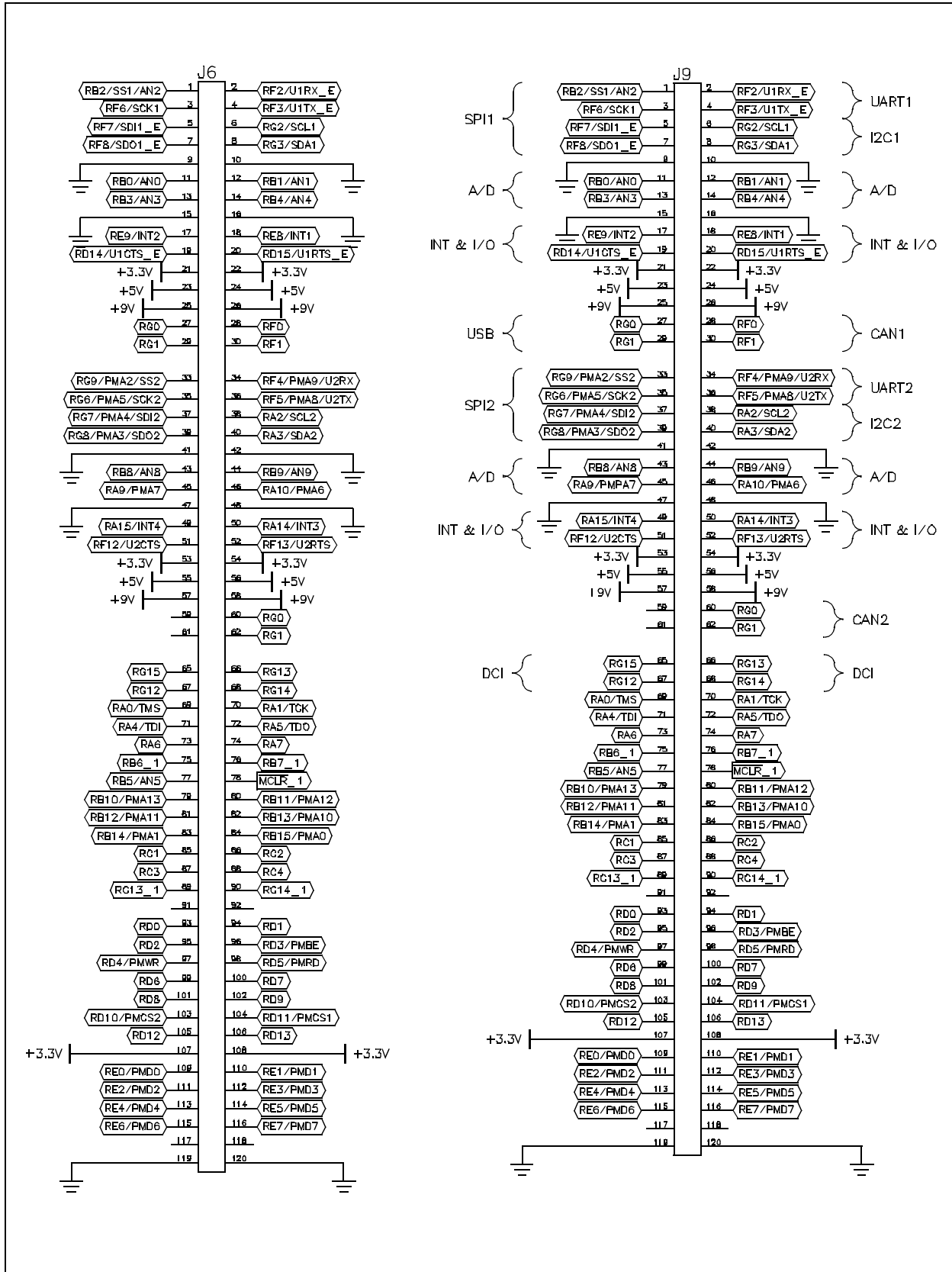
Explorer 16 Development Board Schematics

FIGURE A-6: **EXPLORER 16 BOARD SCHEMATIC, SHEET 5 OF 8 (SWITCHES, MULTIPLEXERS AND POTENTIOMETER)**
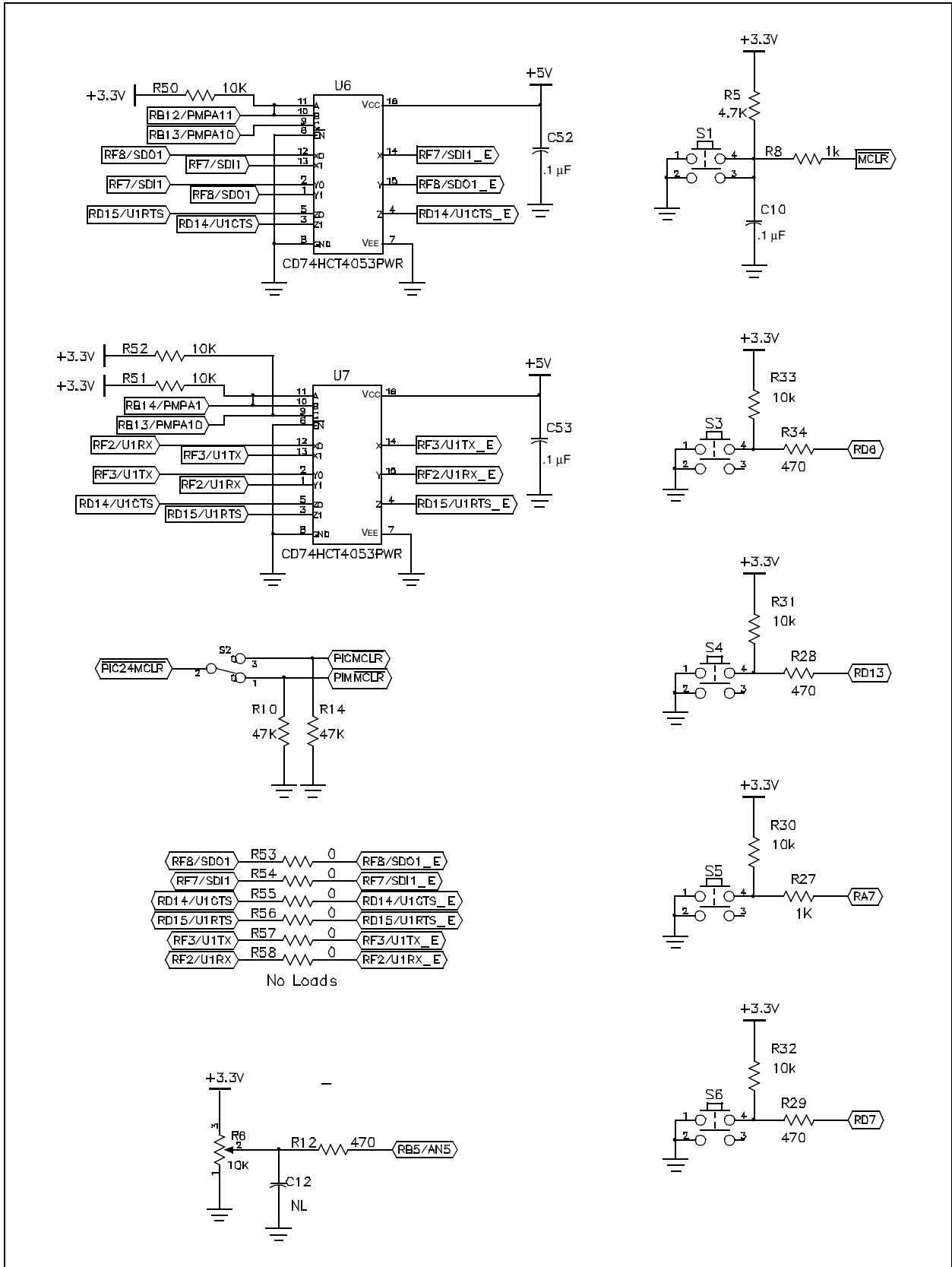
Explorer 16 Development Board User's Guide

Explorer 16 Development Board Schematics

FIGURE A-8: **EXPLORER 16 BOARD SCHEMATIC, SHEET 7 OF 8 (USB AND UART SUBSYSTEMS)**
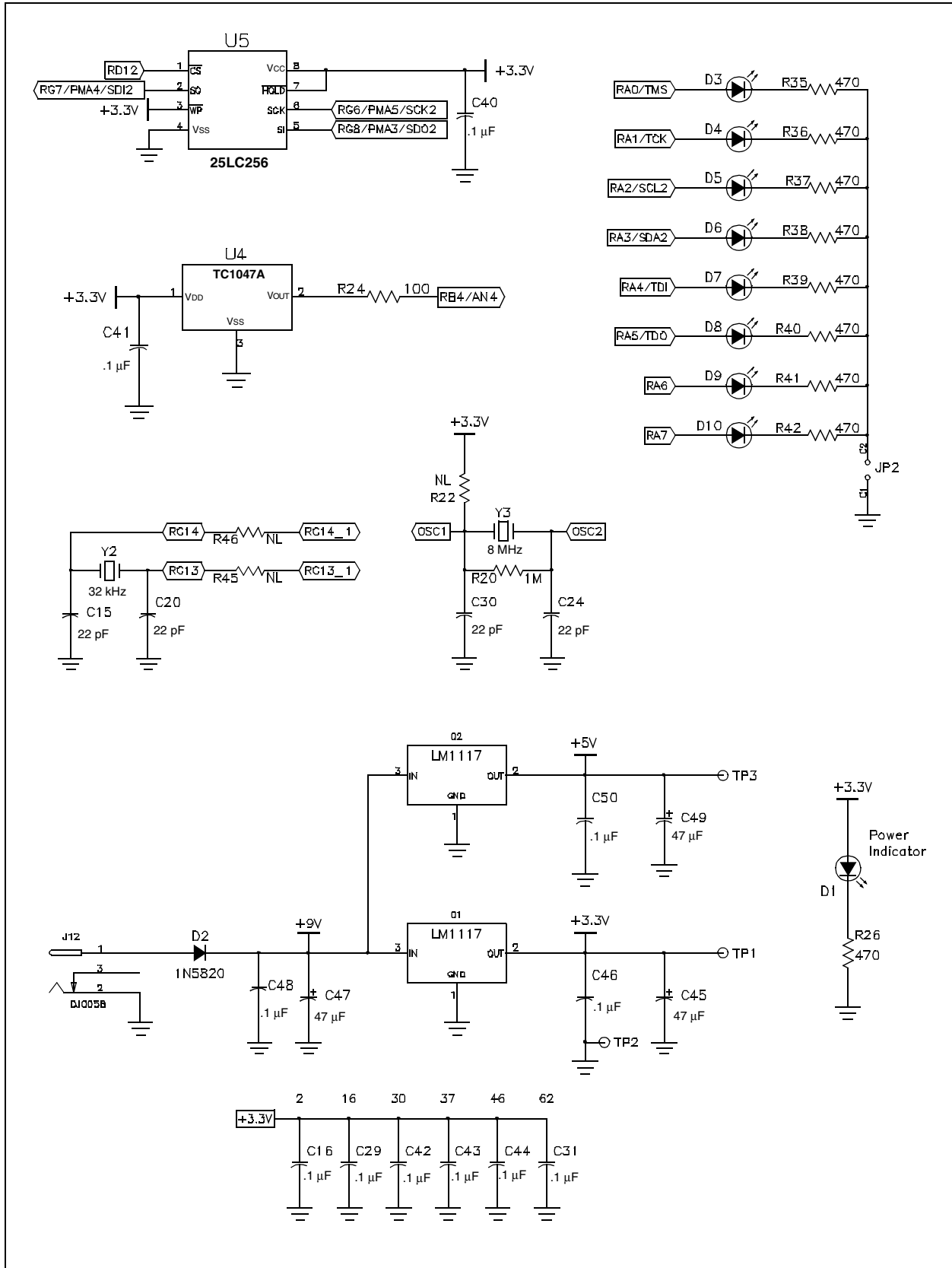
FIGURE A-9: **EXPLORER 16 BOARD SCHEMATIC, SHEET 8 OF 8 (LCDs AND OPTIONAL LCD CONNECTIONS)**
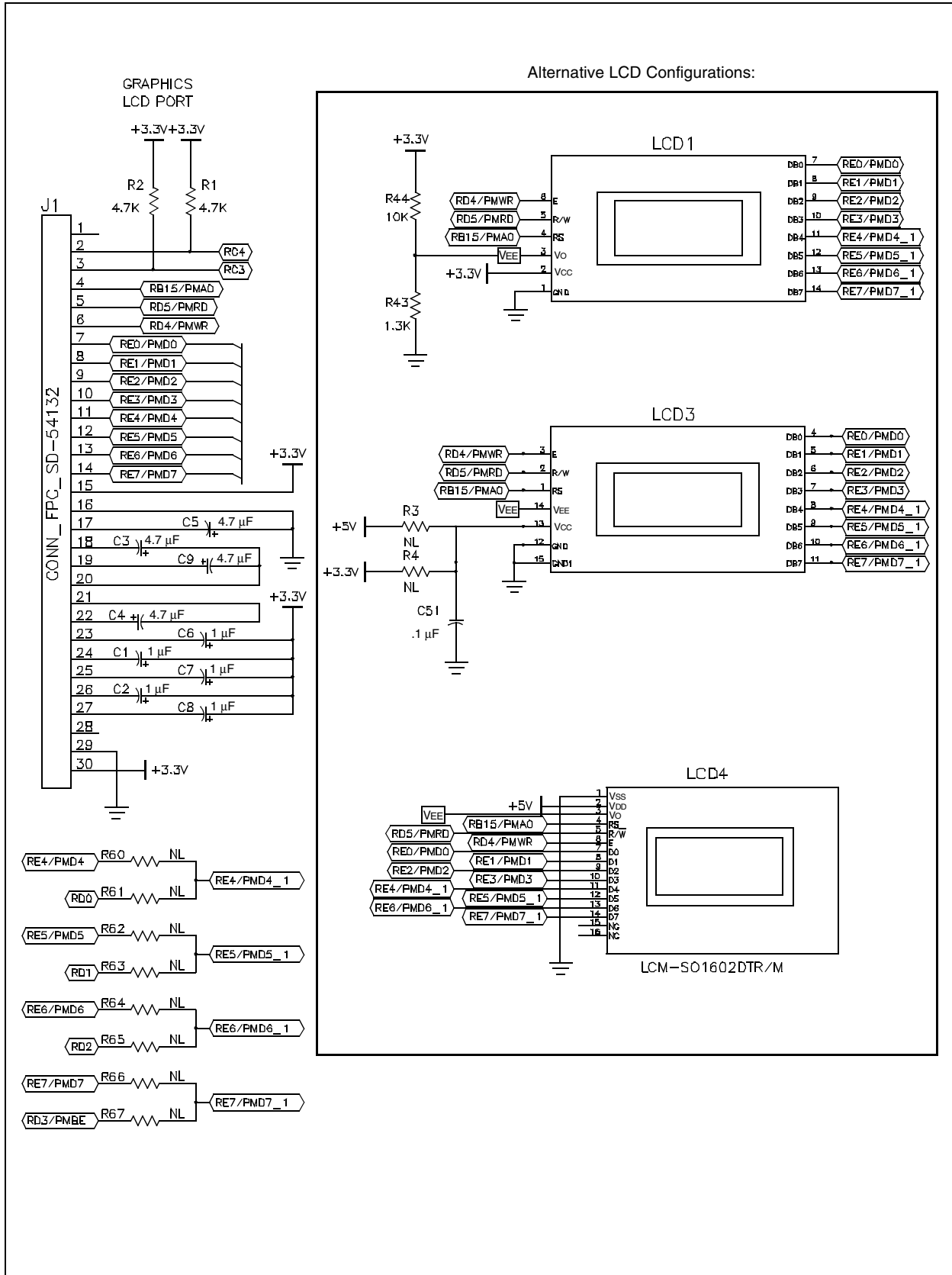
NOTES:

Appendix B. Updating the USB Connectivity Firmware

B.1   INTRODUCTION

The USB subsystem of the Explorer 16 Development Board is preprogrammed with USB bootloader firmware. This provides an easy method for upgrading the PIC18LF4550 firmware to support ICSP, JTAG and SPI connectivity to PIC24 and dsPIC33F devices.

This chapter describes how to upgrade the PIC18LF4550 device's firmware with the PICkit 2 software. The same process can be used to upgrade the PIC18LF4550 device's firmware when updates and new firmware packages become available.

B.2   UPDATING THE PICkit 2 MICROCONTROLLER PROGRAMMER

Before beginning, it will be necessary to obtain and install the PICkit 2 programmer software. Complete instructions for installing and using the programmer software application is provided in the *PICkit™ 2 Microcontroller Programmer User's Guide* (DS51553). The programmer and user's guide, as well as the latest version of the PICkit 2 operating system firmware, are available from the Microchip corporate web site, www.microchip.com.

To update the USB firmware:

1. If not done already, download the latest PICkit 2 operating system software from the Microchip web site.
2. On the Explorer 16 board, install a jumper between pins 9 and 10 of the JTAG connector (J13).
3. Press and release $\overline{\text{MCLR}}$ (S1). This places the USB subsystem in Bootloader mode and makes it ready to accept new code.
4. Connect the Explorer 16 board to the PC via a standard USB cable.
5. Launch the PICkit 2 programmer software. From the menu bar, select *Tools > Download PICkit 2 Operating System* (Figure B-1).
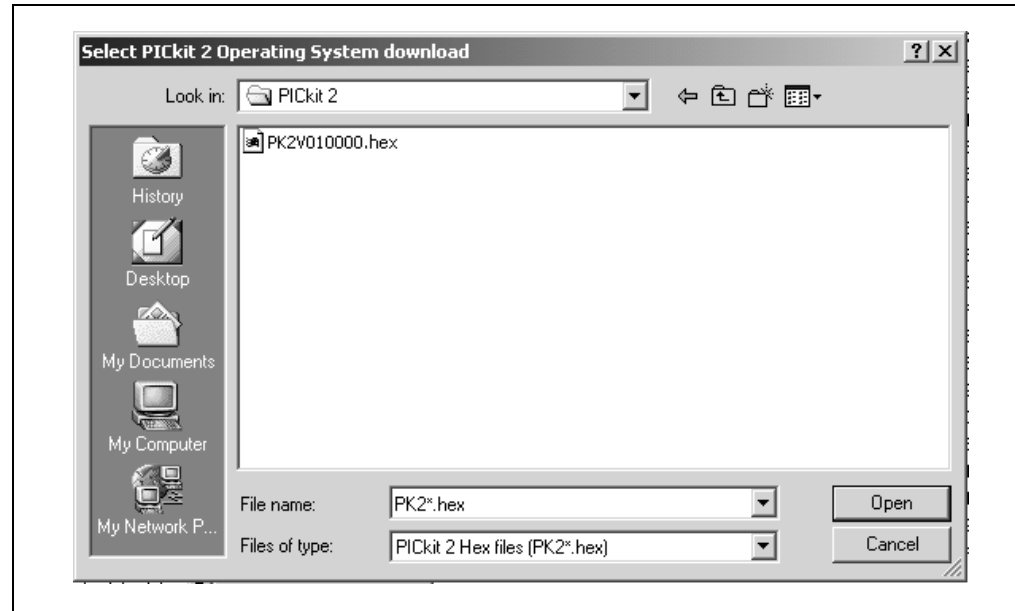
FIGURE B-1:   DOWNLOAD PICkit™ 2 OPERATING SYSTEM
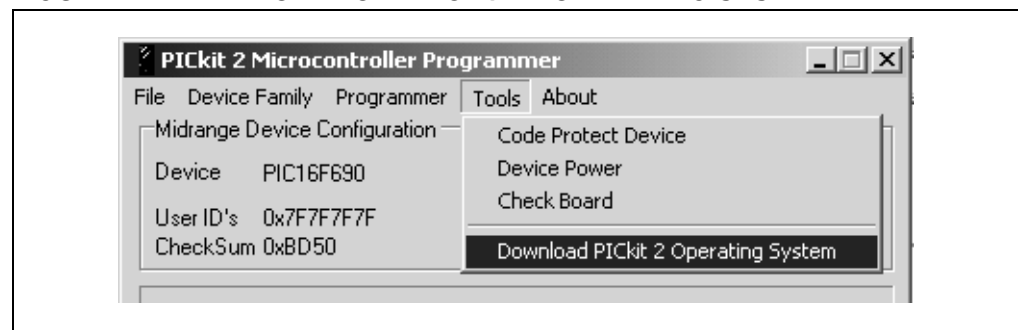
6. Browse to the directory where the latest operating system firmware was saved (Figure B-2).

FIGURE B-2: SELECT PICkit™ 2 OPERATING SYSTEM

7. Select the `PK2_Explorer16_*.hex` file and click the **Open** button.

The progress of the update is displayed in the status bar of the programming software. When the update completes successfully, the status bar displays "Operating System Verified". The update is now complete.

B.3 OTHER USB FIRMWARE UPDATES

It is anticipated that various USB connectivity firmwares will be made available in the future. Users are encouraged to periodically check the Microchip web site (www.microchip.com) for new and revised code.

EXPLORER 16 DEVELOPMENT BOARD USER'S GUIDE

Index

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://support.microchip.com
Web Address:
www.microchip.com

Atlanta
Alpharetta, GA
Tel: 770-640-0034
Fax: 770-640-0307

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Kokomo
Kokomo, IN
Tel: 765-864-8360
Fax: 765-864-8387

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

San Jose
Mountain View, CA
Tel: 650-215-1444
Fax: 650-961-0286

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8528-2100
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8676-6200
Fax: 86-28-8676-6599

China - Fuzhou
Tel: 86-591-8750-3506
Fax: 86-591-8750-3521

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Shunde
Tel: 86-757-2839-5507
Fax: 86-757-2839-5571

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7250
Fax: 86-29-8833-7256

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-2229-0061
Fax: 91-80-2229-0062

India - New Delhi
Tel: 91-11-5160-8631
Fax: 91-11-5160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Yokohama
Tel: 81-45-471- 6166
Fax: 81-45-471-6122

Korea - Gumi
Tel: 82-54-473-4301
Fax: 82-54-473-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Penang
Tel: 60-4-646-8870
Fax: 60-4-646-5086

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-572-9526
Fax: 886-3-572-6459

Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-536-4803

Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-399
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

10/31/05