PICDEM™ 2 Plus 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."

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

Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

QUALITY MANAGEMENT SYSTEM
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ISO/TS 16949:2009

PICDEM™ 2 PLUS DEMONSTRATION BOARD USER'S GUIDE

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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 online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the PICDEM™ 2 Plus 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 Customer Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the PICDEM™ 2 Plus Demonstration Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Introduction"** – Introduces the PICDEM 2 Plus Demonstration Board and provides a brief description of the hardware.
- **Chapter 2. "Getting Started"** – Goes through a basic step-by-step process for getting your PICDEM 2 Plus Demonstration Board up and running as a stand-alone board or with an ICE, ICD or PICkit™ programmer.
- **Chapter 3. "Tutorial"** – Provides a detailed description of the tutorial program.
- **Appendix A. "Hardware Detail"** – Describes in detail the hardware of the PICDEM 2 Plus Demonstration Board.

PICDEM™ 2 Plus Demonstration Board User's Guide

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 PICDEM™ 2 Plus Demonstration Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Readme for PICDEM™ 2 Plus Demonstration Board

For the latest information on using the PICDEM™ 2 Plus Demonstration Board, read the "`Readme for PICDEM™ 2 Plus Demonstration Board.txt`" file (an ASCII text file) in the Readmes subdirectory of the MPLAB IDE installation directory. 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.

Reference Documents

Reference documents may be obtained by contacting your nearest Microchip sales office (listed in the back of this document) or by downloading via the Microchip web site (www.microchip.com). Recommended documents include:

- Individual data sheets and reference manuals:
  - *PIC16(L)F193X Data Sheet (*DS41364*)*
  - *PIC18(L)F2X/4XK22 Data Sheet (*DS41412*)*
  - *PIC16(L)F1826/27 Data Sheet* (DS41391)
  - *PICmicro® Mid-Range MCU Family Reference Manual* (DS33023)
  - *PICmicro® 18C MCU Family Reference Manual* (DS39500)
  - *TC74 Data Sheet* (DS21462)
- *MPLAB® IDE Simulator, Editor User's Guide* (DS51025)
- *MPASM™ Assembler, MPLINK™ Object Linker, MPLIB™ Object Librarian User's Guide* (DS33014)
- *PRO MATE® 3 User's Guide* (DS51464)
- *MPLAB® IDE PICSTART® Plus User's Guide* (DS51028)
- *MPLAB® ICE Emulator User's Guide* (DS51159)
- *MPLAB® ICD 3 In-Circuit Debugger Quick Start Guide* (DS51766)

PICDEM™ 2 Plus Demonstration Board User's Guide

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 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

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 (June 2011)

- Initial Release of this Document.

> **Note:** This board (DM163022-1) has been updated from the previous version (DM163022).The user guide for the previous board version (DM163022) can be found online at the PICDEM 2 Plus web site (DS51275) www.Microchip.com/PICDEM2PLUS.

NOTES:

Chapter 1. Introduction

1.1 INTRODUCTION

Thank you for purchasing the PICDEM™ 2 Plus Demonstration Board from Microchip Technology Incorporated. The PICDEM 2 Plus Demonstration Board is a simple board that demonstrates the capabilities of Microchip's 8-bit, 18-, 28- and 40-pin PIC16FXXX, PIC16F1XXX, and PIC18 devices.

The PICDEM 2 Plus Demonstration Board can be used stand-alone with a programmed part, with an in-circuit emulator (for example, MPLAB® REAL ICE™) or with an in-circuit programmer/debugger (such as MPLAB® ICD 3 or PICkit™ 3). Sample programs are provided to demonstrate the unique features of the supported devices.

1.2 DEVELOPMENT KIT CONTENTS

The PICDEM 2 Plus Demonstration Board kit comes with the following:

• PICDEM 2 Plus Demonstration Board (see Figure 1-1)
• Sample devices (pre-loaded with program demonstration)

If you are missing any part of the kit, please contact your nearest Microchip sales office listed in the back of this publication for help.

1.3 PICDEM™ 2 PLUS DEMONSTRATION BOARD

The PICDEM 2 Plus Demonstration Board has the following hardware features:

1. 18-, 28- and 40-pin DIP sockets
   (although three sockets are provided, only one device may be used at a time)
2. On-board, +5V regulator for direct input from 9V, 100 mA AC/DC wall adapter or 9V battery, or hooks for a +5V, 100 mA regulated DC supply
3. RS-232 socket and associated hardware for direct connection to an RS-232 interface
4. Programmer/debugger connectivity supporting MPLAB ICD 3, MPLAB REAL ICE and PICkit 3
5. PICkit Serial Connector for analysis of serial communications peripherals such as SPI or I^{2}C™
6. 5 kΩ pot for devices with analog inputs
7. Three push button switches for external stimulus and Reset
8. Power-on indicator LED
9. Four LEDs connected to PORTB
10. On-board external oscillators including:
    a) 4 MHz, canned crystal oscillator (Y2)
    b) RC oscillator circuit (R4, C3)
    c) Unpopulated holes for crystal connection (Y1)
    d) 32.768 kHz crystal for Timer1 clock operation (Y3)

11. 32K x 8 Serial EEPROM
12. LCD display
13. Piezo buzzer
14. Prototype area for user hardware
15. Expansion Header for PICtail™ daughter card connectivity or user access to MCU pins
16. Microchip TC74 thermal sensor

FIGURE 1-1: **PICDEM 2 PLUS DEMONSTRATION BOARD HARDWARE**
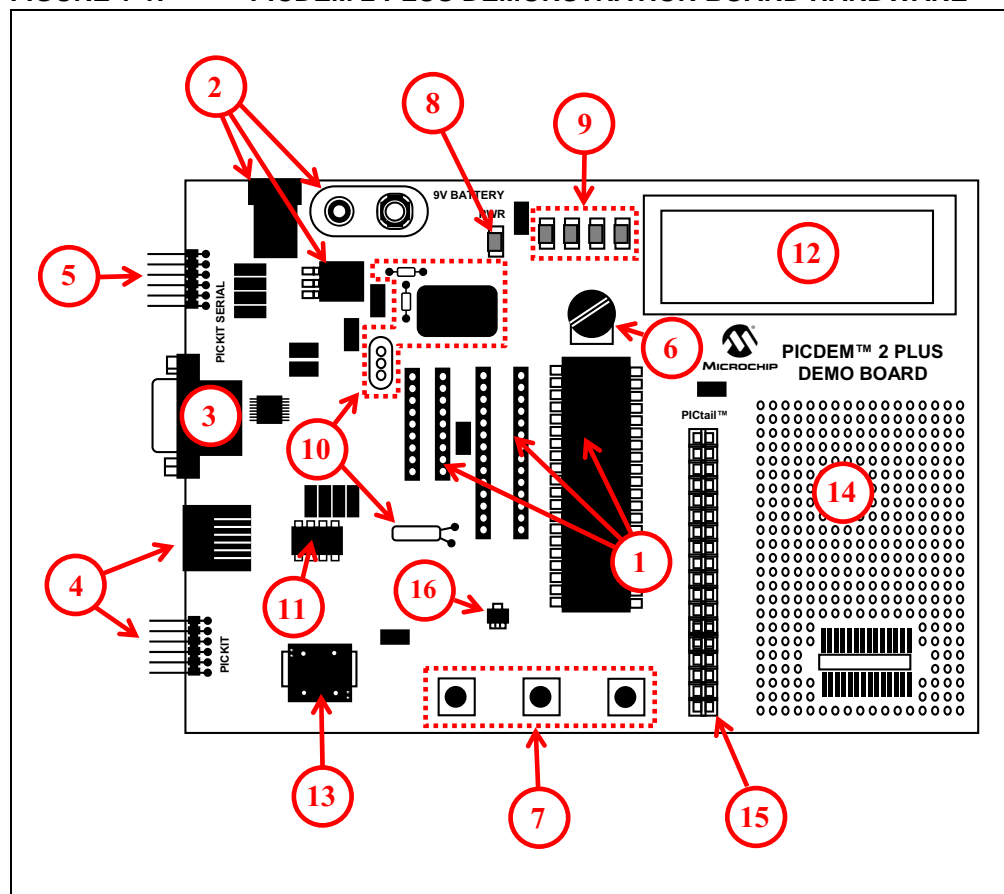
1.4   ON-BOARD JUMPER CONFIGURATIONS

Most of the on-board components have associated jumpers that will allow the user to either connect or disconnect a component(s) from the PIC® MCUs or other mounted components. Table 1-1 and Figure 1-2 detail these connections.

TABLE 1-1:   ON-BOARD JUMPER CONNECTIONS

Jumper	Connection
J6	LEDs to PORTB
J7	On-board RC oscillator to PIC® MCUs
J9	Piezo buzzer to RC2 pin (*on 40-pin mid-range device, this is CCP1)
J10	V$_{CAP}$ connection for devices with on-chip voltage regulator
J12	2.7V source to RA1 (voltage divider off of 9V input voltage)
J14, 15, 16, 17	PICkit™ Serial Header to I^{2}C™ bus
J18,19	Tx and Rx from RS-232 components to PIC MCUs
J20, 21, 22, 23	PIC MCUs to I^{2}C bus
J24	RA4 pin to RC2 pin (*on 40-pin mid-range device, this connects C1OUT to CCP1)

FIGURE 1-2:   PICDEM™ 2 PLUS DEMONSTRATION BOARD JUMPER LOCATIONS
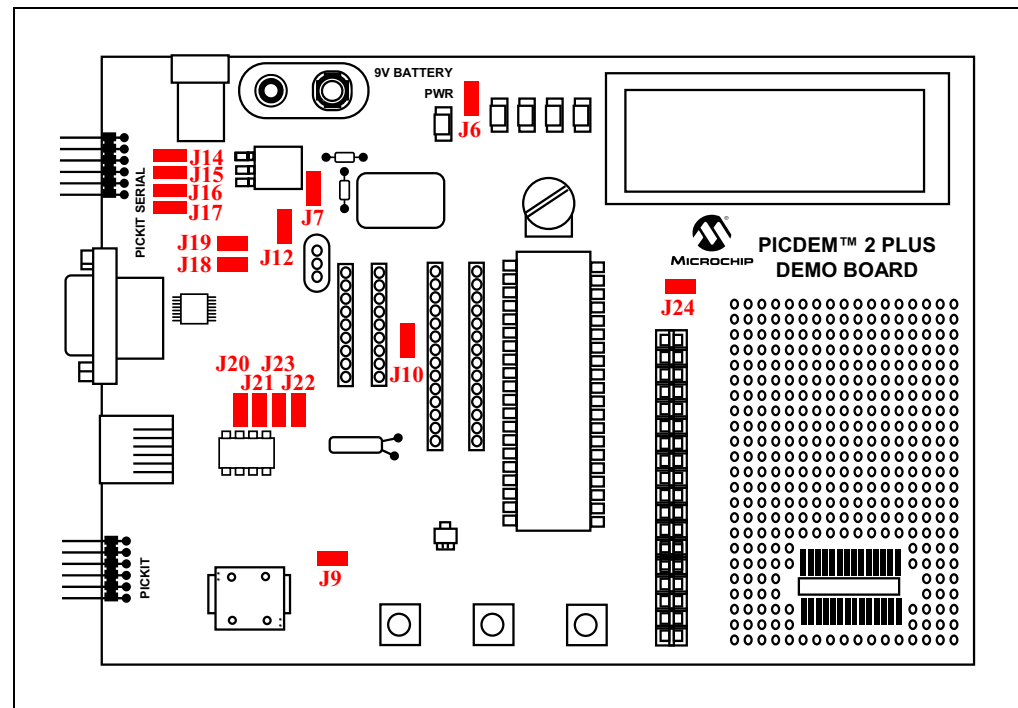
1.5   SAMPLE DEVICES

Two Flash devices are included. The device types may change, but will generally include PIC16 and PIC18 40-pin, DIP devices.

1.6   SAMPLE PROGRAMS

The PICDEM™ 2 Plus Demonstration Board kit sample demonstration programs can be found on the Microchip web site (www.microchip.com/PICDEM2PLUS). These programs may be used with the included sample devices, with a REAL ICE (In-Circuit Emulator), MPLAB® ICD 3 (programmer/debugger) or with a PICkit™ 3 (programmer/debugger). For each type of device (PIC16 or PIC18), demo source code (several `.C` and `.H` files) and compiled code (one `.hex` file) are provided.

Chapter 2. Getting Started

The PICDEM™ 2 Plus Demonstration Board may be used as a stand-alone board with a preprogrammed device, with an In-Circuit Emulator (ICE), with an In-Circuit Debugger (ICD) or with a PICkit™ programming device. For a list of PIC® microcontroller compatible ICEs, ICDs or PICkit programming devices, see the Development Systems Ordering Guide.

2.1 PICDEM™ 2 PLUS DEMONSTRATION BOARD AS A STAND-ALONE BOARD – PREPROGRAMMED DEVICE

The PICDEM 2 Plus Demonstration Board may be demonstrated immediately by following the steps listed below:

- Place the preprogrammed sample device in the appropriate socket on the PICDEM 2 Plus Demonstration Board.
- Confirm the jumpers are populated/removed according to Table 2-1 below.
- Connect the programmer/debugger. See **Section 2.2 "Programming the Device"**.
- Apply power to the PICDEM 2 Plus Demonstration Board. See **Section 2.3 "Powering the Board"**.

TABLE 2-1:   JUMPER SETUP

Jumper	State
J6	OFF
J7	ON
J9	ON
J10	OFF
J12	ON
J14	ON
J15	ON
J16	ON
J17	ON
J18	ON
J19	ON
J20	OFF
J21	OFF
J22	OFF
J23	OFF
J24	OFF

To reprogram the sample device, the following will be necessary:

- Program source code – user source code may be used to program the device, or if this previously has been done, the sample program may be restored from the file included in the PICDEM 2 Plus installer.
- An assembler, such as MPASM™ assembler (available with MPLAB® IDE), or a compiler, such as HI-TECH® C or MPLAB C18 (PIC18 devices only).

Source code must be assembled or compiled into a hex file before it can be programmed into the device. Microchip Technology's MPASM assembler, HI-TECH or C18 C compilers may also be used. Both are compatible with MPLAB IDE.

Other assemblers/compilers may be used. For a list of these PIC MCU compatible language tools, see the Microchip web site (www.microchip.com).

Once the sample program is in hex file format, a programmer can program a Flash device. Microchip Technology's PICkit or ICD 3 programmer may be used. Both are compatible with MPLAB IDE.

Other programmers may be used. For a list of these PIC MCU compatible programmers, see the Microchip web site (www.microchip.com).

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

2.2   PROGRAMMING THE DEVICE

The PICDEM 2 Plus Demonstration Board supports the ability to program a device through multiple options.

2.2.1   PICkit Programming

FIGURE 2-1:   PICkit™ PROGRAMMER AND BOARD CONNECTION HEADER

Microchip's PICkit 3 In-Circuit Debugger/Programmer uses in-circuit debugging logic incorporated into each chip with Flash memory to provide a low-cost hardware debugger and programmer.

Connecting the PICkit programmer to the PICDEM 2 Plus Demonstration Board is quick and easy.

- First connect the PICkit 3 as shown in Figure 2-1.
- Make sure to connect the USB cable to the PICkit 3 and to the computer.
- Enter MPLAB and go to either the **Debugger** or **Programmer** tab. Select the PICkit 3 as shown in Figure 2-2.

FIGURE 2-2: **CONNECTING A PICkit PROGRAMMER**
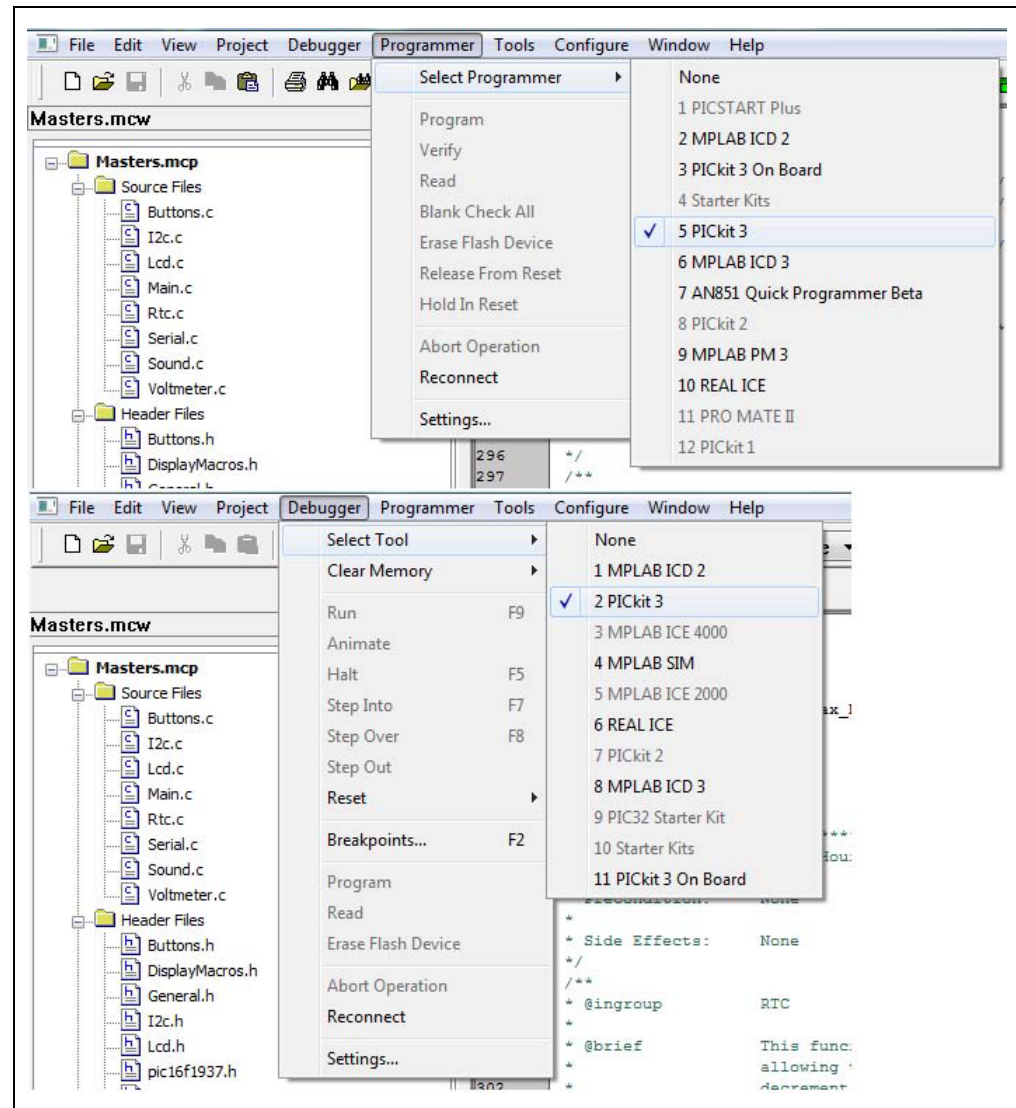
2.2.2   ICD Programming

FIGURE 2-3:   ICD PROGRAMMER AND BOARD CONNECTION HEADER

The MPLAB® ICD 3 In-Circuit Debugger System is Microchip's most cost-effective, high-speed hardware debugger/programmer for Microchip 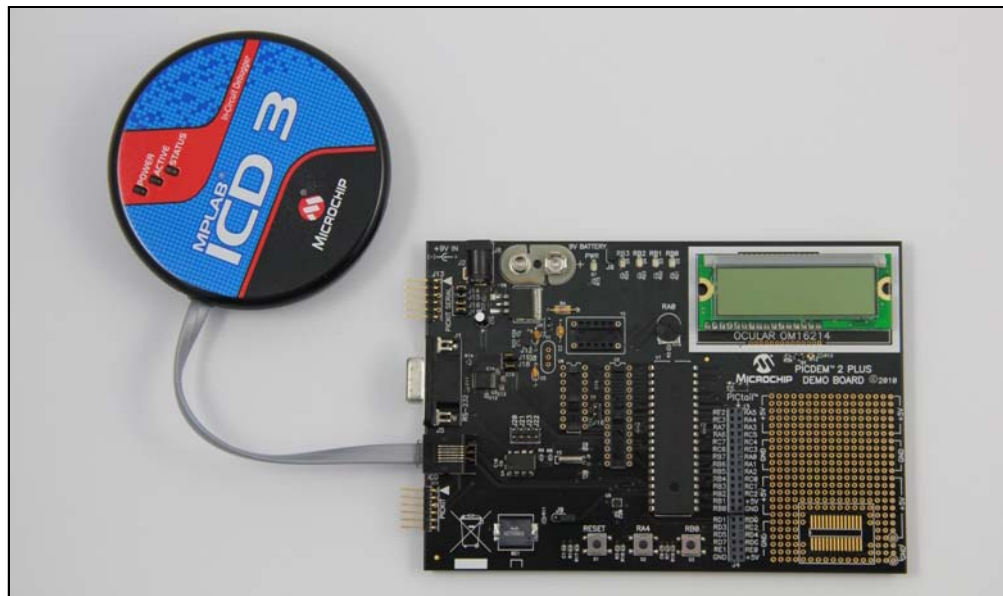Flash Digital Signal Controller (DSC) and microcontroller (MCU) devices. It debugs and programs PIC® Flash microcontrollers and dsPIC® DSCs with the powerful, yet easy-to-use graphical user interface of MPLAB Integrated Development Environment (IDE).

Connecting the ICD 3 to the PICDEM 2 Plus Demonstration Board is quick and easy.

• First connect the ICD 3 as shown in Figure 2-3.
• Make sure to connect the USB cable to the ICD 3 and to the computer.
• Enter MPLAB and go to either the **Debugger** or **Programmer** tab. Select the ICD 3 as shown in Figure 2-4.

FIGURE 2-4: **CONNECTING AN ICD**
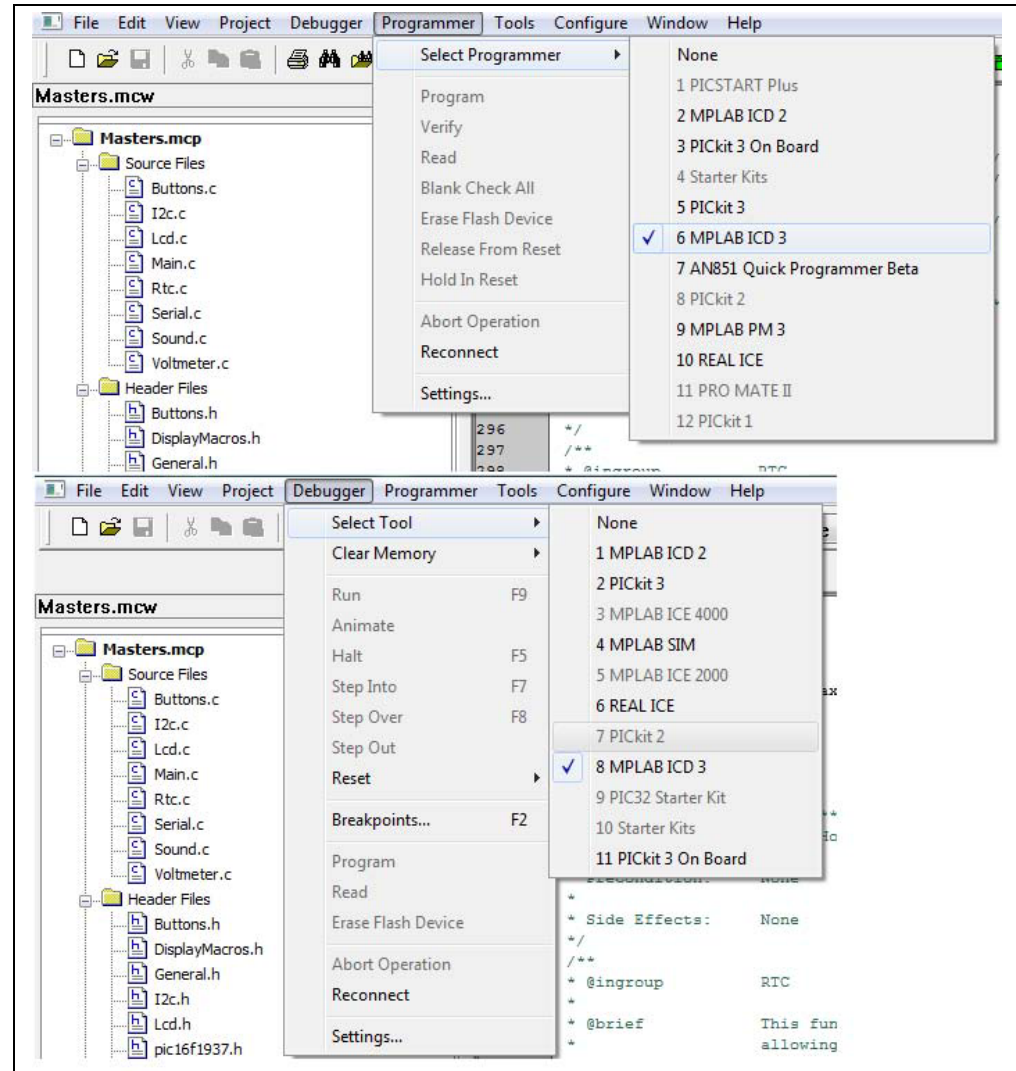
2.3   POWERING THE BOARD

The PICDEM 2 Plus Demonstration Board supports the ability to power the board through multiple options.

2.3.1   External 9V Connector

FIGURE 2-5:   9V EXTERNAL POWER SUPPLY

The PICDEM 2 Plus Demonstration Board can be powered with an external 9V power supply.

• Connect 9V power supply to a wall outlet.
• Connect to board as shown in Figure 2-5. The on-board regulator will reduce the input voltage to 5V for safe PIC device operation.

2.3.2   External 9V Battery

FIGURE 2-6:   9V EXTERNAL BATTERY

The PICDEM 2 Plus Demonstration Board can be powered with an external 9V battery for a power supply.

• Connect the 9V battery to the board [B].
• The on-board regulator will reduce the input voltage to 5V for safe PIC device operation.

2.3.3 Power by Programmer

FIGURE 2-7: 5V SUPPLIED BY PROGRAMMER
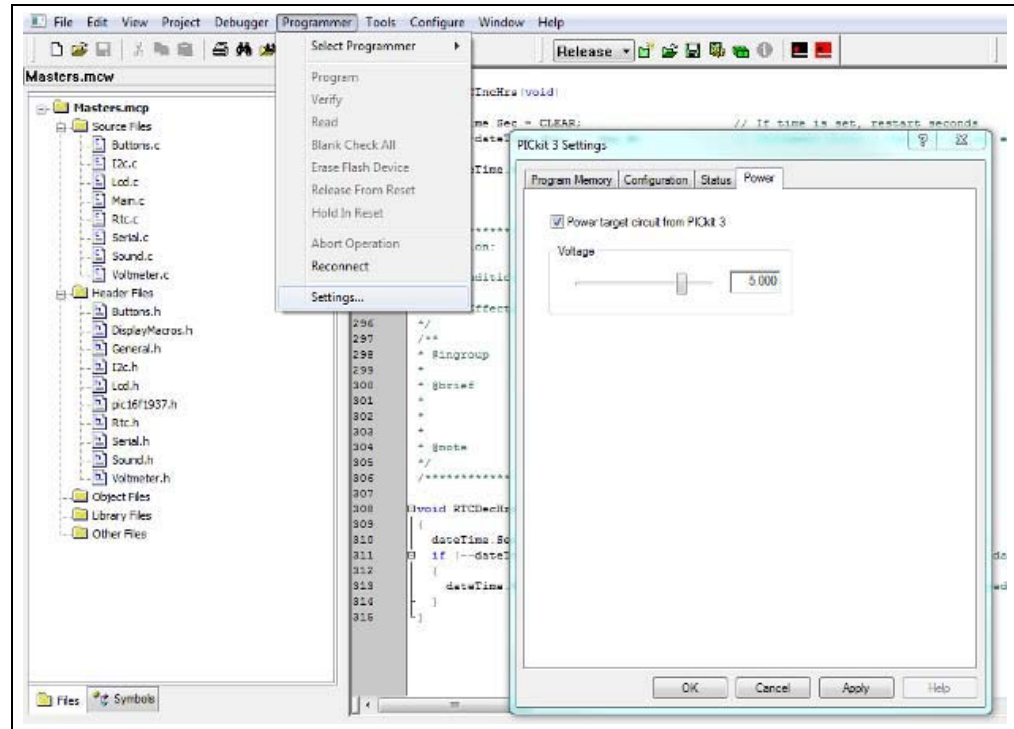
The PICDEM 2 Plus Demonstration Board can also be powered with a PICkit or ICD programming device.

• To power the device with a programmer go to either the **Debuggger**/**Programmer** tab.

• Scroll down to Settings. Then go to the **Power** tab.

• Click the checkbox labeled "Power target circuit from MPLAB (programmer type)". Select 5V as the voltage.

• The board will now be powered through the programmer.

NOTES:

Chapter 3. Tutorial

The tutorial program is preprogrammed into the sample device. The PIC16 device's program was built using the HI-TECH C compiler and the PIC18 device's program was built using the C18 compiler. These programs are included in the PICDEM™ 2 Plus installer file found at www.Microchip.com/PICDEM2PLUS.

In case the device has been reprogrammed to a user's unique code, the device can always be reprogrammed with the tutorial program if installed.

For detailed information on the PICDEM 2 Plus hardware, please refer to **Appendix A. "Hardware Detail"**.

3.1   TUTORIAL PROGRAM OPERATION

The tutorial program is made up of four components, which are individually displayed on the LCD.

3.1.1   Voltmeter

FIGURE 3-1:   VOLTMETER DISPLAY AND COMPONENT

This mode uses the A/D module to measure the voltage of the RA0 pot (R16) and display a voltage between 0.00V and 5.00V on the LCD.

Voltage is continually updated until the mode is exited by pressing RB0.
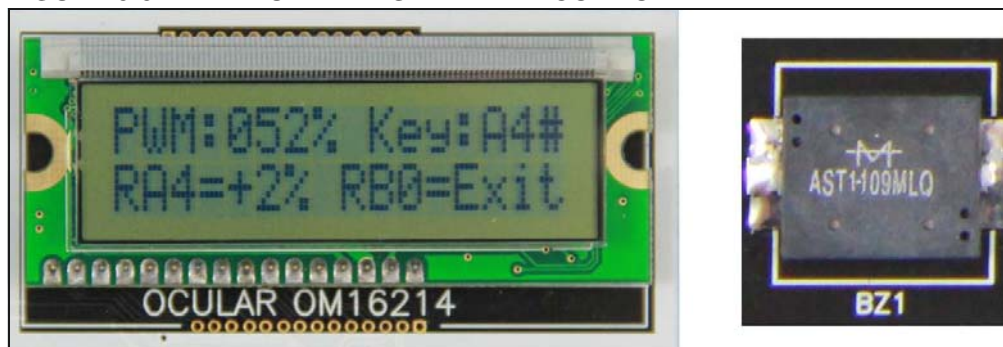
FIGURE 3-2:   TEMPERATURE READINGS
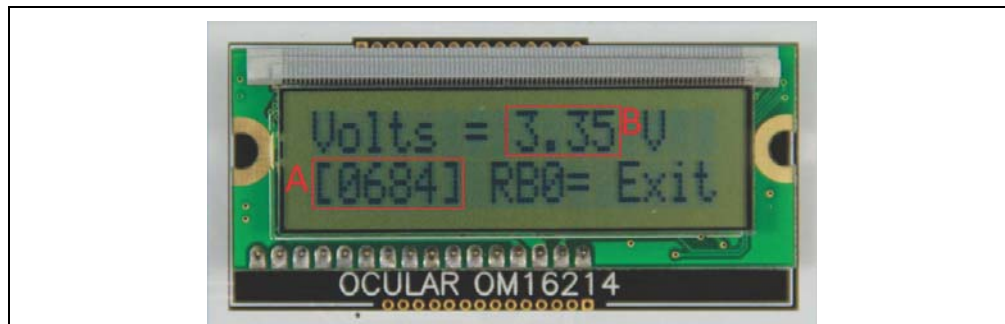
Reading the Voltmeter Display (ADC)

A) (ADRESH:ADRESL) ADC conversion result. Range: 10-bit (0-1023).

B) Voltage representation.

3.1.2 Buzzer

FIGURE 3-3:   **BUZZER DISPLAY AND COMPONENT**

This mode turns on the Piezo buzzer using the CCP1 module I/O pin, RC2.

FIGURE 3-4:   **FIGURE 3-4: BUZZER READINGS**

Reading the Buzzer Display (PWM)

A) PWM Period Percentage. Range (0-100%) Frequency (10 kHz-250 Hz).

   - Please refer to Table 3-1 for a index of Period, PWM%, Frequency and Key.

B) This is the key being played based on the frequency being supplied to the speaker.

C) Increase the PWM period by 2%.
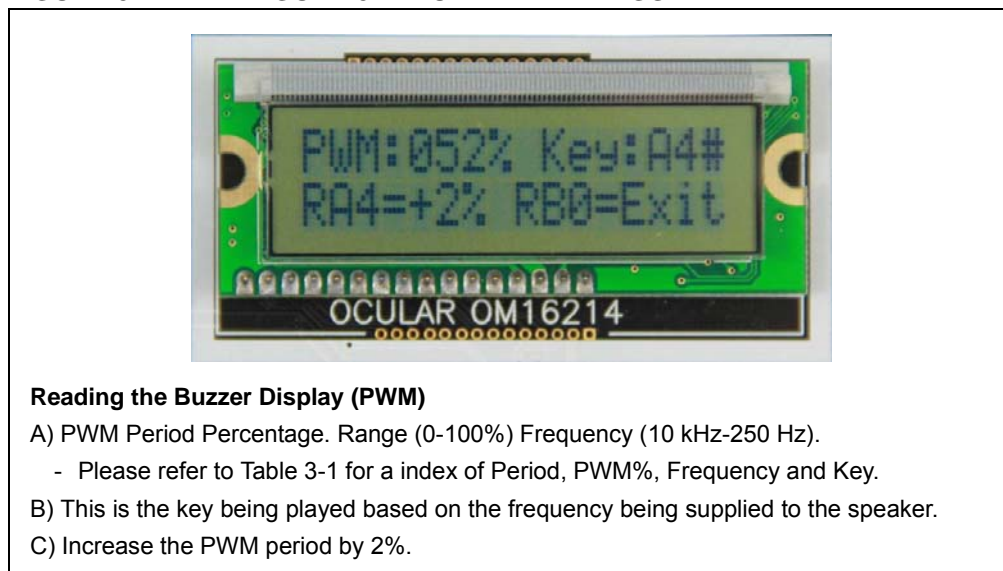
The period and duty cycle of the CCP1 frequency can be changed while the buzzer is on. The changes in period are recognized immediately in the buzzer tone. By changing the period, the buzzer frequency changes.

• To change the period, press RB0 under the "Buzzer" menu.

• The buzzer will sound off with the default frequency of 10 kHz and a period of 05h (0%).

• By pressing the RB4 button the period will increase by 5 (2%).

• The LCD will display the current Key being played by the buzzer based upon the period.

• Press RB0 to exit the buzzer function.

Figure 3-3 shows an example of a signal supplied to the buzzer.

FIGURE 3-5:   BUZZER SIGNAL

TABLE 3-1:   BUZZER INDEX

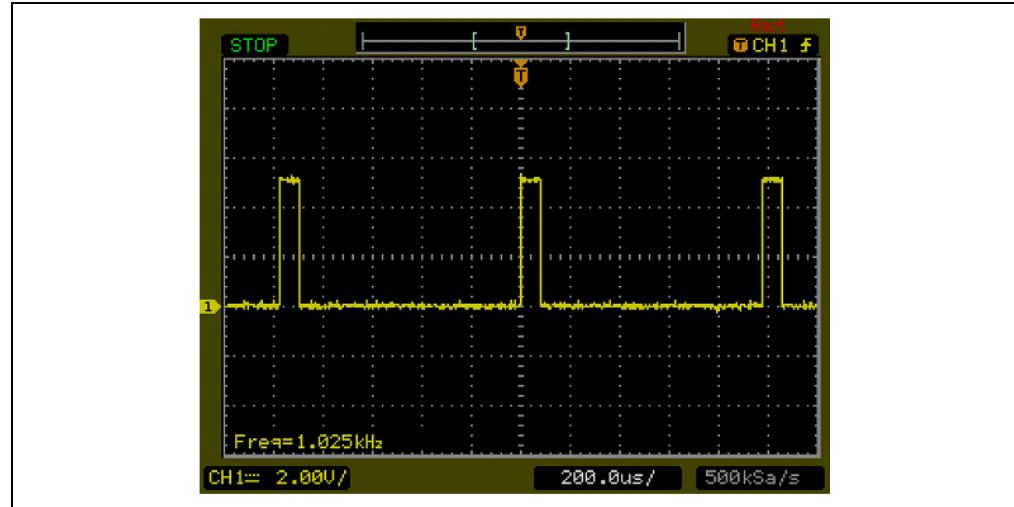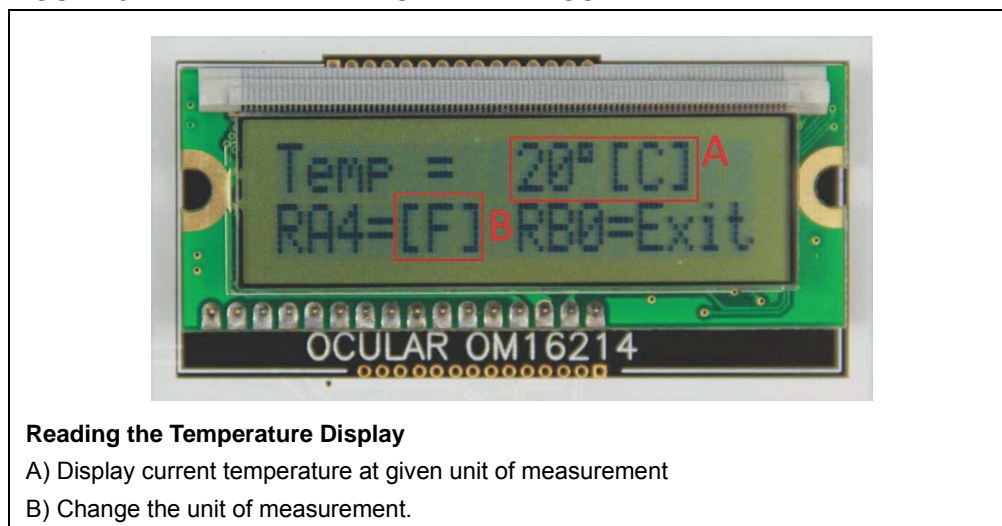| Period	PWM	Frequency	Key
5	0.00%	10 KHz	----
10	2.00%	5 KHz	D8#
15	4.00%	4 KHz	B7
20	6.00%	3 KHz	F7#
25	8.00%	2.45 KHz	D7#
30	10.00%	2 KHz	C7
35	12.00%	1.73 KHz	A6
40	14.00%	1.52 KHz	G6
45	16.00%	1.36 KHz	F6
50	18.00%	1.23 KHz	D6#
55	20.00%	1.16 KHz	D6
60	22.00%	1.03 KHz	C6
65	24.00%	950 Hz	A5#
70	26.00%	880 Hz	A5
75	28.00%	823 Hz	G5#
80	30.00%	775 Hz	G5
85	32.00%	730 Hz	F5#
90	34.00%	690 Hz	F5
95	36.00%	653 Hz	E5
100	38.00%	620 Hz	D5#
105	40.00%	590 Hz	D5
110	42.00%	560 Hz	C5#
115	44.00%	530 Hz	C5
120	46.00%	510 Hz	----
125	48.00%	495 Hz	B4
130	50.00%	478 Hz	----
135	52.00%	460 Hz]	A4#
140	54.00%	442 Hz	A4
145	56.00%	427 Hz	----
150	58.00%	414 Hz	G4#
155	60.00%	400 Hz	----
160	62.00%	390 Hz	G4
165	64.00%	375 Hz	----
170	66.00%	365 Hz	F4#
175	68.00%	355 Hz	----
180	70.00%	345 Hz	F4
185	72.00%	335 Hz	----
190	74.00%	326 Hz	E4
195	76.00%	318 Hz	----
200	78.00%	310 Hz	D4#
205	80.00%	300 Hz	----
210	82.00%	295 Hz	D4
215	84.00%	290 Hz	----
220	86.00%	284 Hz	C4#
225	88.00%	277 Hz	----
230	90.00%	270 Hz	----
235	92.00%	264 Hz	----
240	94.00%	259 Hz	C4
245	96.00%	254 Hz	----
250	98.00%	249 Hz	----
255	100.00%	245 Hz	B3

3.1.3 Temperature

FIGURE 3-6: TEMPERATURE DISPLAY AND COMPONENT

This mode uses a TC74 thermal sensor to measure ambient temperature in Celsius and then display the temperature on the LCD. The user has the option to change the display between Celsius and Fahrenheit by pressing RB4.

Communication between the PIC MCU and sensor is accomplished using the MSSP module. This mode is exited by pressing RB0.

FIGURE 3-7: TEMPERATURE READINGS

Reading the Temperature Display

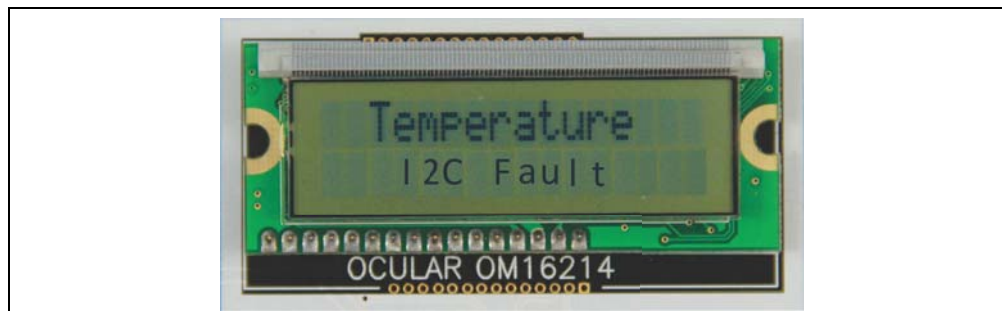A) Display current temperature at given unit of measurement

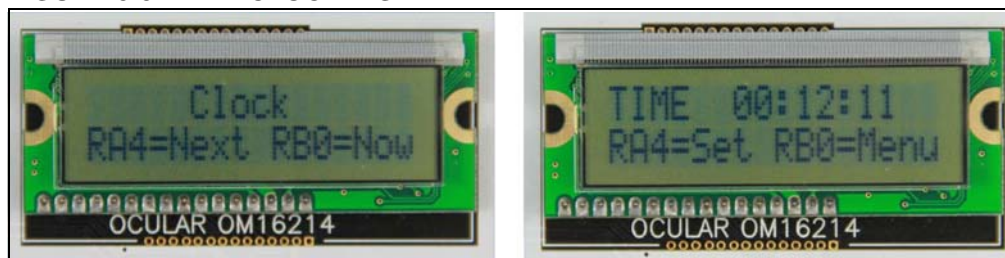B) Change the unit of measurement.

3.1.4 Temperature Fault

If during I^2C communication a time-out Fault occurs the LCD display will indicate the Fault as shown in Figure 3-8.

FIGURE 3-8: TEMPERATURE COMMUNICATION FAULT

3.1.5   Clock

**FIGURE 3-9:   CLOCK DISPLAY**

The Real-Time Clock will start counting from 00:00:00 at the start of the program.

The Timer1 module and a 32 kHz clock crystal are used to establish a Real-Time Clock.

By pressing RA4 within the clock function, the clock time can be set to the user's preference. The user has the option to set the hours or minutes of the clock.

FIGURE 3-10:   INCREMENT/DECREMENT HOURS
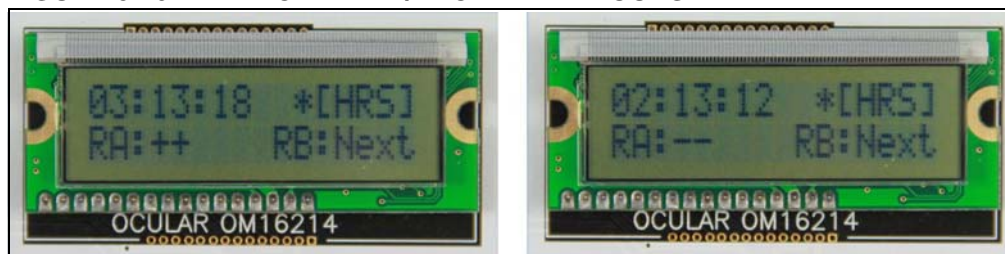
By pressing RA4 within the set function, the user can set the hours. The user first has the option to increment the hours, one hour at a time by pressing RA4. If the user presses RB0 within the increment hour's function, the program will then allow the user to decrement the hours, one hour at a time by pressing RA4. When the user presses RB0 again the program will return to the clock display screen.

FIGURE 3-11:   INCREMENT/DECREMENT MINUTES
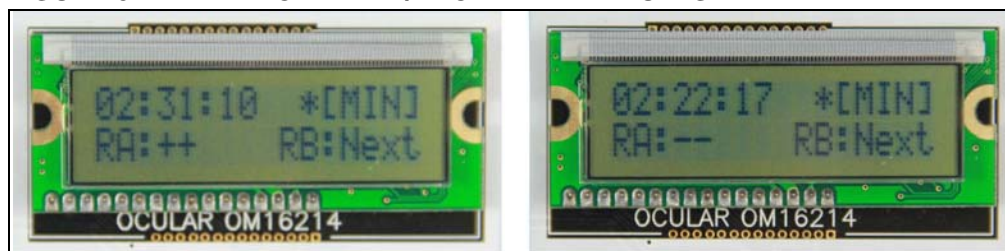
By pressing RB0 within the set function, the user can set the minutes. The user first has the option to increment the minutes, one minute at a time by pressing RA4. If the user presses RB0 within the increment minute's function, the program will then allow the user to decrement the minutes, one minute at a time by pressing RA4. When the user presses RB0 again the program will return to the clock display screen.
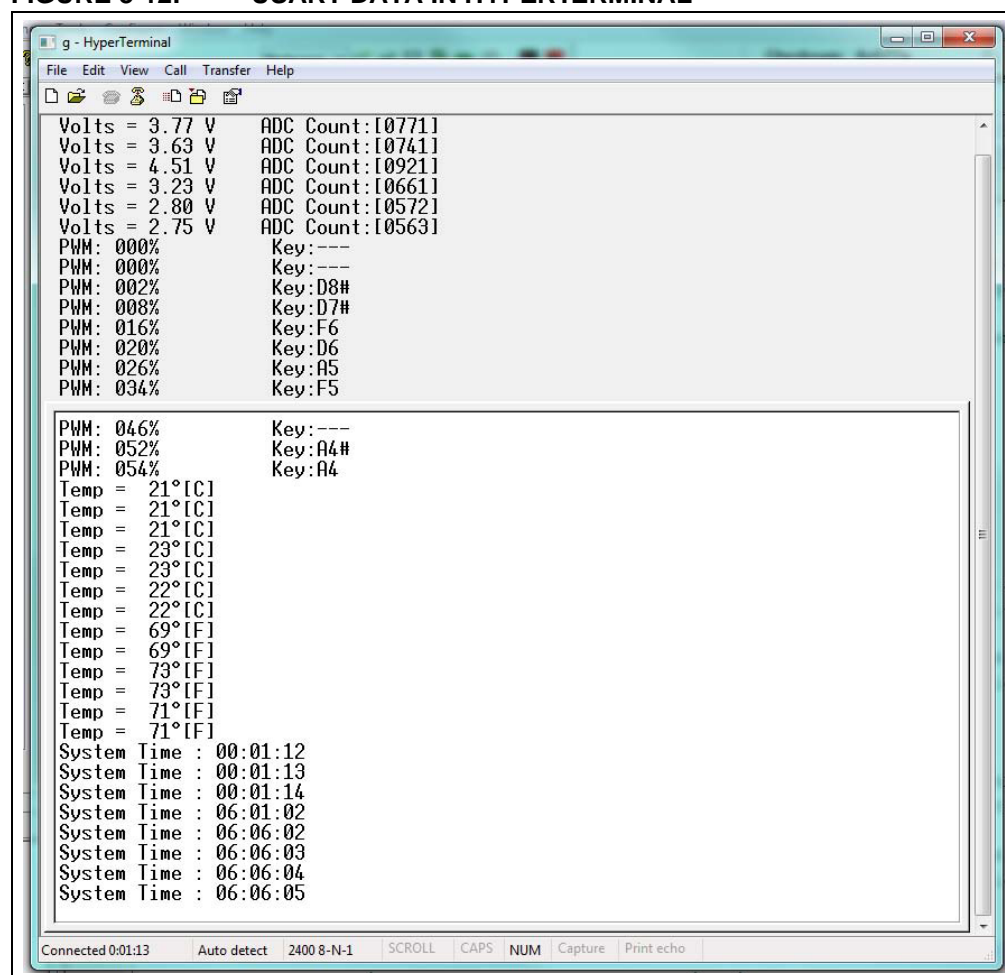
3.1.6 USART

FIGURE 3-12: **USART DATA IN HYPERTERMINAL**

The data displayed on the LCD within all the program functions is also sent to the RS-232 serial port using the USART on the PIC MCU. A HyperTerminal program on the PC will be able to display the same information that is displayed on the LCD.

3.2 SOURCE CODE AND APPLICATION NOTES

In addition to the assembled tutorial program (hex files), source code used to create these hex files are included in the PICDEM 2 Plus installer. Both source code and related hex files are found in device-specific directories.

A digital guide is also included with the installer.

For information on how to reprogram the device with new or modified code, or how to restore the tutorial program, please see **Section 2.1 "PICDEM™ 2 Plus Demonstration Board as a Stand-Alone Board – Preprogrammed Device"**.

FIGURE 3-13:   **TUTORIAL PROGRAM FLOWCHART**
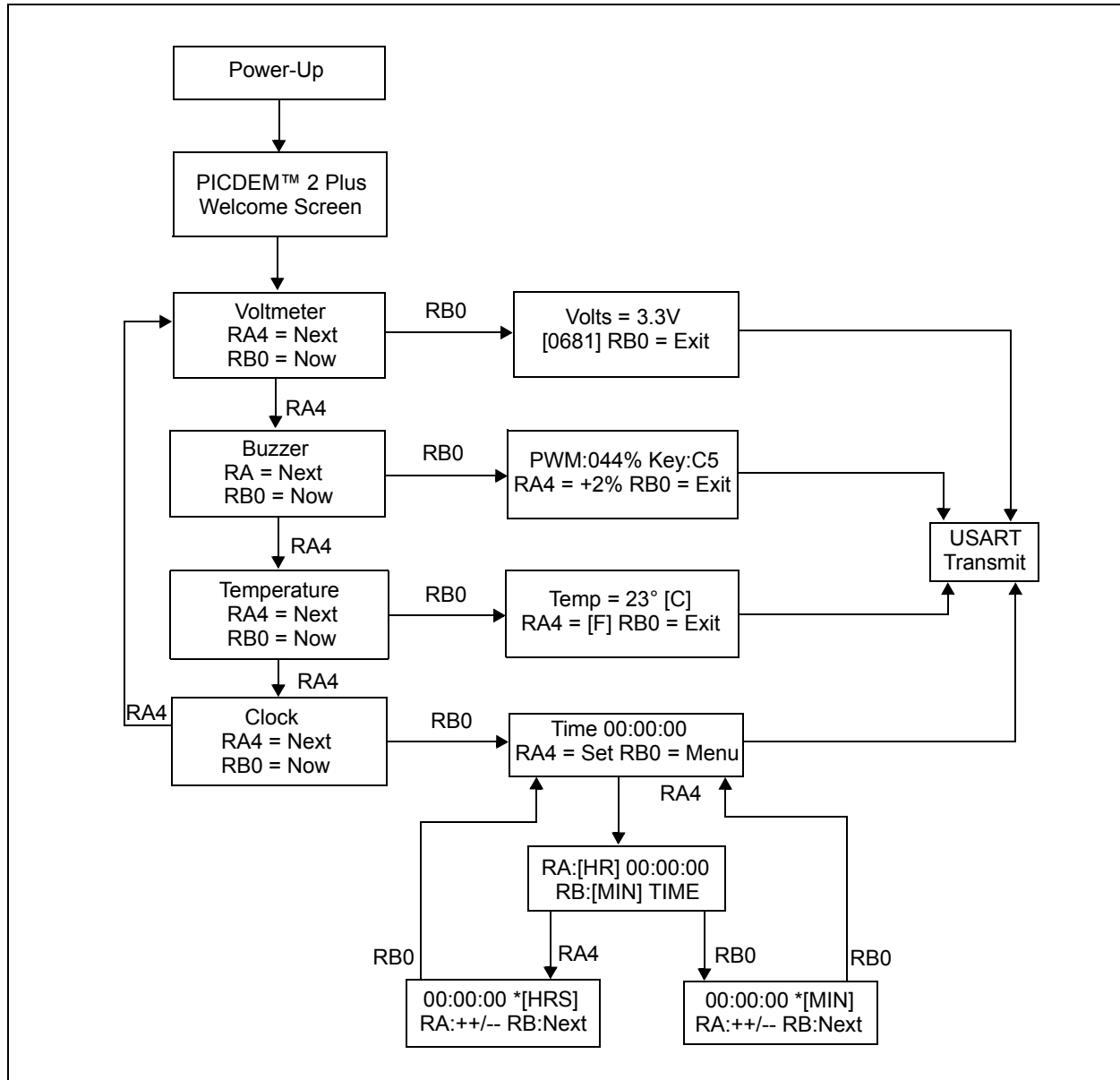
NOTES:

Appendix A. Hardware Detail

The PICDEM™ 2 Plus Demonstration Board hardware is extremely simple and illustrates the ease-of-use of various PIC MCUs. This section describes the PICDEM 2 Plus Demonstration Board hardware elements.

A.1   PROCESSOR SOCKETS

Although three sockets are provided, only one device may be used at a time.

- 18-pin socket
- 28-pin socket
- 40-pin socket

A.2   DISPLAY

- Four green LEDs are connected to PORTB of each processor type.
- PORTB pins are set high to light the LEDs. These LEDs may be disconnected from PORTB by removing jumper J6.
- One red LED is provided to indicate whether there is power to the PICDEM 2 Plus Demonstration Board.
- LED On = Powered. LED Off = Not Powered

A.3   POWER SUPPLY

There are multiple ways to supply power to the PICDEM 2 Plus Demonstration Board:

- A 9V battery can be plugged into J8.
- A 9V, 100 mA unregulated AC or DC supply can be plugged into J2. A power supply can be purchased through Microchip, part #AC162039.
- A +5V, 100 mA regulated DC supply can be connected to the hooks provided.

MPLAB® ICE 2000 users have a regulated +5V power supply available in the logic probe connector and can easily connect to the header (J4) on the PICDEM 2 Plus Demonstration Board. (Red probe to +5V and Black probe to GND.)

MPLAB ICD or PICkit™ programmer users may use the programmer to power the target board to 5V, up to 200 mA, if the MPLAB programmer is connected to the PC.

A.4   RS-232 SERIAL PORT

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

The PIC16/PIC18 RX and TX pins are tied to the RX and TX lines of the MAX232A.

A.5 SWITCHES

Three switches provide the following functions:

- S1 – $\overline{\text{MCLR}}$ to hard reset the processor
- S2 – Active-low switch connected to RA4
- S3 – Active-low switch connected to RB0

Switches S1 and S3 have debounced capacitors, where as S2 does not, allowing the user to investigate debounced techniques.

When pressed, the switches are grounded. When idle, they are pulled high (+5V).

A.6 OSCILLATOR OPTIONS

- 32.768 kHz (watch-type) crystal for Timer1.
- Removable, 4 MHz, canned oscillator.
- Space for a user defined oscillator crystal.

A.7 ANALOG INPUT

A 5Ω potentiometer is connected through a series 470Ω resistor to AN0.

The pot can be adjusted from V$_{DD}$ to GND to provide an analog input to the parts with an A/D module.

A.8 ICD CONNECTOR

By way of the modular connector (J5), the MPLAB ICD can be connected for low-cost debugging. The ICD connector utilizes RB6 and RB7 of the microcontroller for in-circuit debugging.

A.9 PICkit™ CONNECTOR

By way of the header connector (J11), the MPLAB PICkit can be connected for low-cost debugging.

A.10 TEMPERATURE SENSOR

This is a serial digital thermal sensor (TC74) connected to the 28- and 40-pin microcontrollers via RC3 and RC4.

Communication is accomplished with the TC74 via its 2-wire I^{2}C compatible serial port. This device has an address of '0b1001101'.

A.11 SERIAL EEPROM

A 24L256 (32K x 8) serial EEPROM is included on the board to illustrate I^{2}C bus concepts.

A.12 LCD

An LCD display with two lines, 16 characters each, is connecting to the 28 and 40-pin sockets. There are three control lines (RA3:RA1) and four data lines (RD3:RD0).

A 5kΩ pot may be installed into R20 to adjust contrast on the LCD. If this is done, R5 and R6 need to be removed.

A.13 SAMPLE DEVICES

A sample part programmed with a simple program is included in the PICDEM 2 Plus Demonstration Board kit. Table A-1 lists the I/O features and port connections for each processor type.

TABLE A-1:   PORT CONNECTIONS

Device	LEDs	RS-232	S1	S2	S3	Pot R16	LCD	EEPROM	Buzzer	ICD	Temp Sensor	Y1/Y2
18-pin	RB3:RB0	N/A	$\overline{\text{MCLR}}$	RA4	RB0	RA0	N/A	N/A	N/A	RB6/RB7	N/A	Yes
28-pin	RB3:RB0	RC6/RC7	$\overline{\text{MCLR}}$	RA4	RB0	RA0	RC3/RC4	RA3:RA1	RC2	RB6/RB7	RC3/RC4	Yes
40-pin	RB3:RB0	RC6/RC7	$\overline{\text{MCLR}}$	RA4	RB0	RA0	RC3/RC4	RA3:RA1 RD3:RD0	RC2	RB6/RB7	RC3/RC4	Yes

A.14   BOARD LAYOUT AND SCHEMATICS

The following figures show the part layout (silkscreen) and schematics for the PICDEM 2 Plus Demonstration Board.

FIGURE A-1:   **PICDEM™ 2 PLUS DEMONSTRATION BOARD PARTS LAYOUT**

FIGURE A-2: **PICDEM™ 2 PLUS DEMONSTRATION BOARD SCHEMATIC**
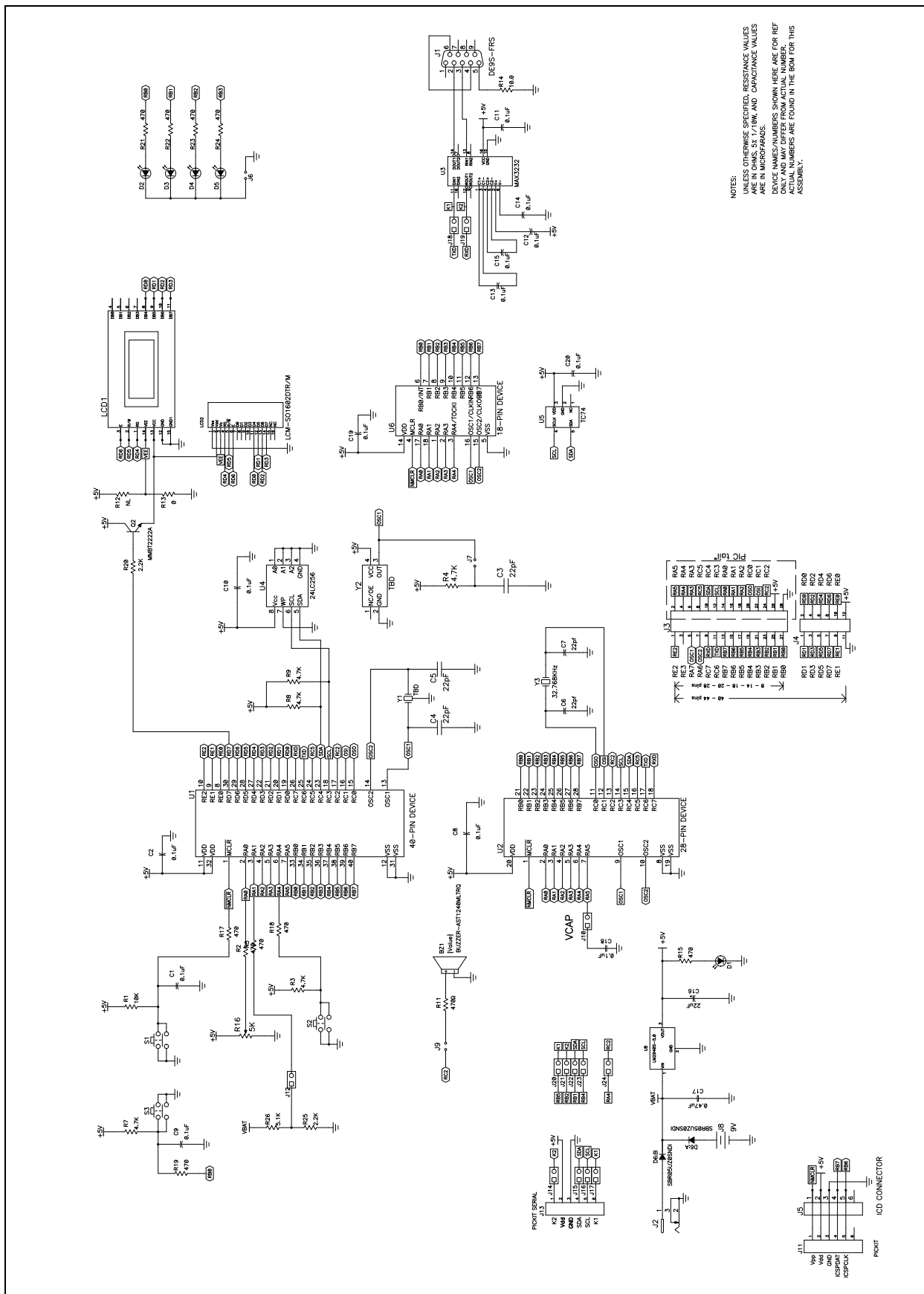
FIGURE A-3: PICDEM™ 2 PLUS PIC16F1937 PINOUT
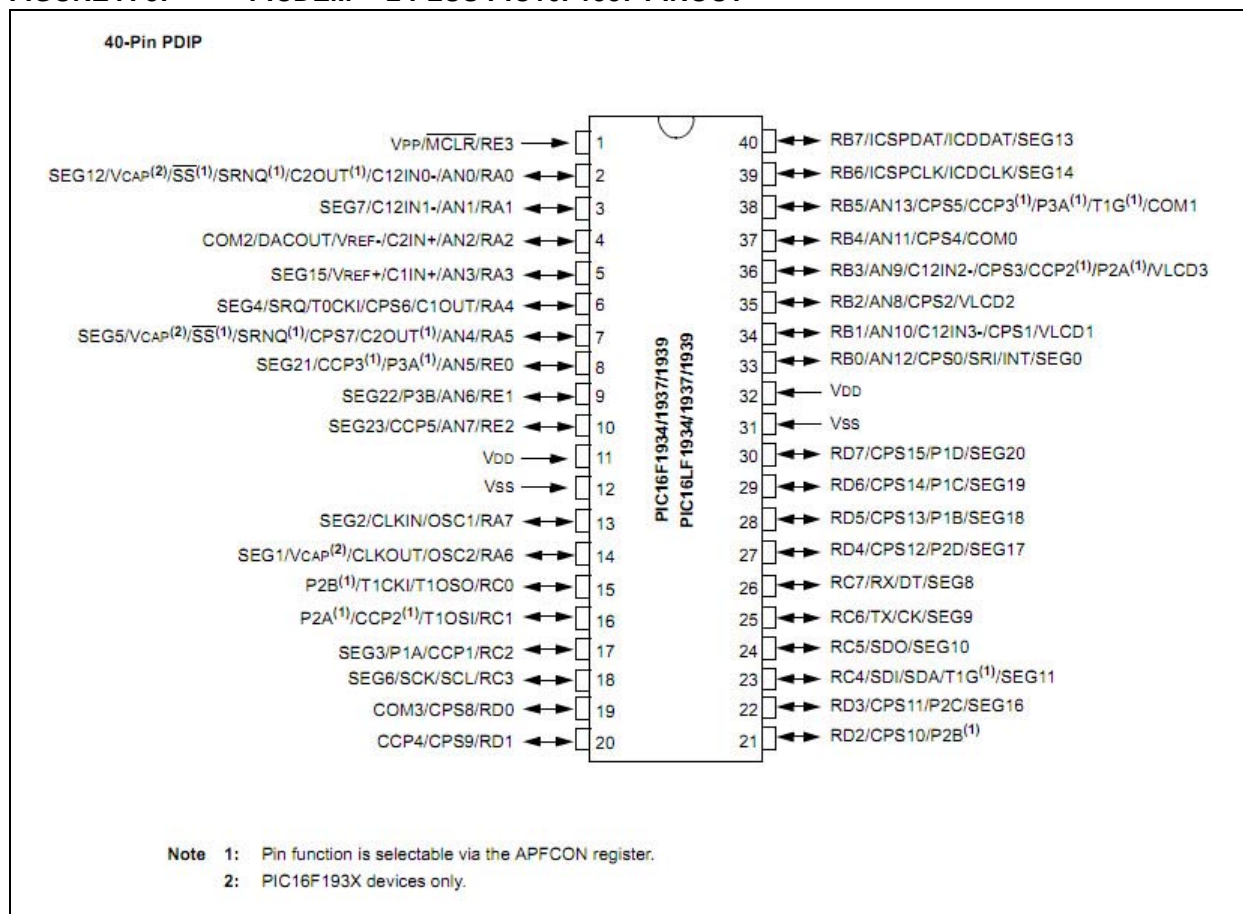
FIGURE A-4: PICDEM™ 2 PLUS PIC18F86K22 PINOUT
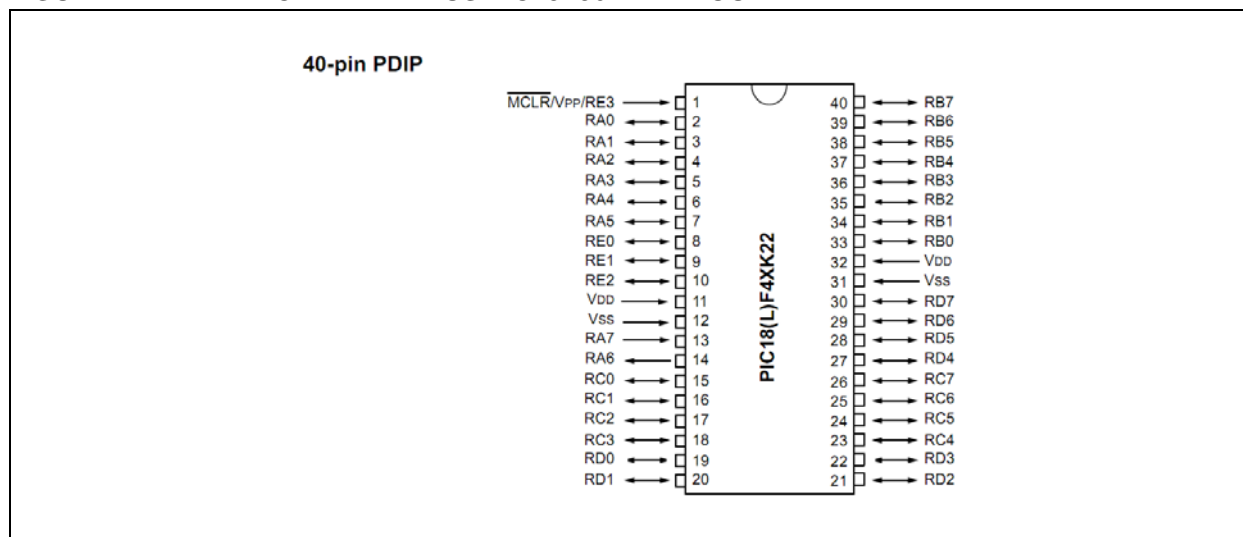
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