PICDEM™ 2 Plus
User's Guide

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PICDEM™ 2 PLUS USER'S GUIDE

Table of Contents

PICDEM™ 2 Plus User's Guide

NOTES:

Chapter 1. Introduction

1.1 WELCOME

Thank you for purchasing the PICDEM 2 Plus demonstration board from Microchip Technology Incorporated. The PICDEM 2 Plus is a simple board which demonstrates the capabilities of the 18, 28 and 40-pin PIC16 and PIC18 devices.

The PICDEM 2 Plus can be used stand-alone with a programmed part, with an in-circuit emulator (e.g., MPLAB® ICE) or with an in-circuit debugger (e.g., MPLAB ICD 2). Sample programs are provided to demonstrate the unique features of the supported devices.

The PICDEM 2 Plus Kit comes with the following:

1. PICDEM 2 Plus Demonstration Board (Figure 1-1)
2. Sample devices
3. CD-ROM, which contains:
   a) Sample programs
   b) PICDEM 2 Plus Demonstration Board User's Guide
   c) Application Notes

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.

PICDEM™ 2 Plus User's Guide

1.2   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. In-Circuit Debugger (ICD) connector.
5. 5 KΩ pot for devices with analog inputs.
6. Three push button switches for external stimulus and Reset.
7. Green power-on indicator LED.
8. Four red LEDs connected to PORTB.
9. Jumper J6 to disconnect LEDs from PORTB.
10. 4 MHz canned crystal oscillator.
11. Unpopulated holes provided for crystal connection.
12. 32.768 kHz crystal for Timer1 clock operation.
13. Jumper J7 to disconnect on-board RC oscillator (approximately 2 MHz).
14. 32K x 8 Serial EEPROM.
15. LCD display.
16. Piezo buzzer.
17. Prototype area for user hardware.
18. Microchip TC74 thermal sensor.

FIGURE 1-1: **PICDEM 2 PLUS HARDWARE**
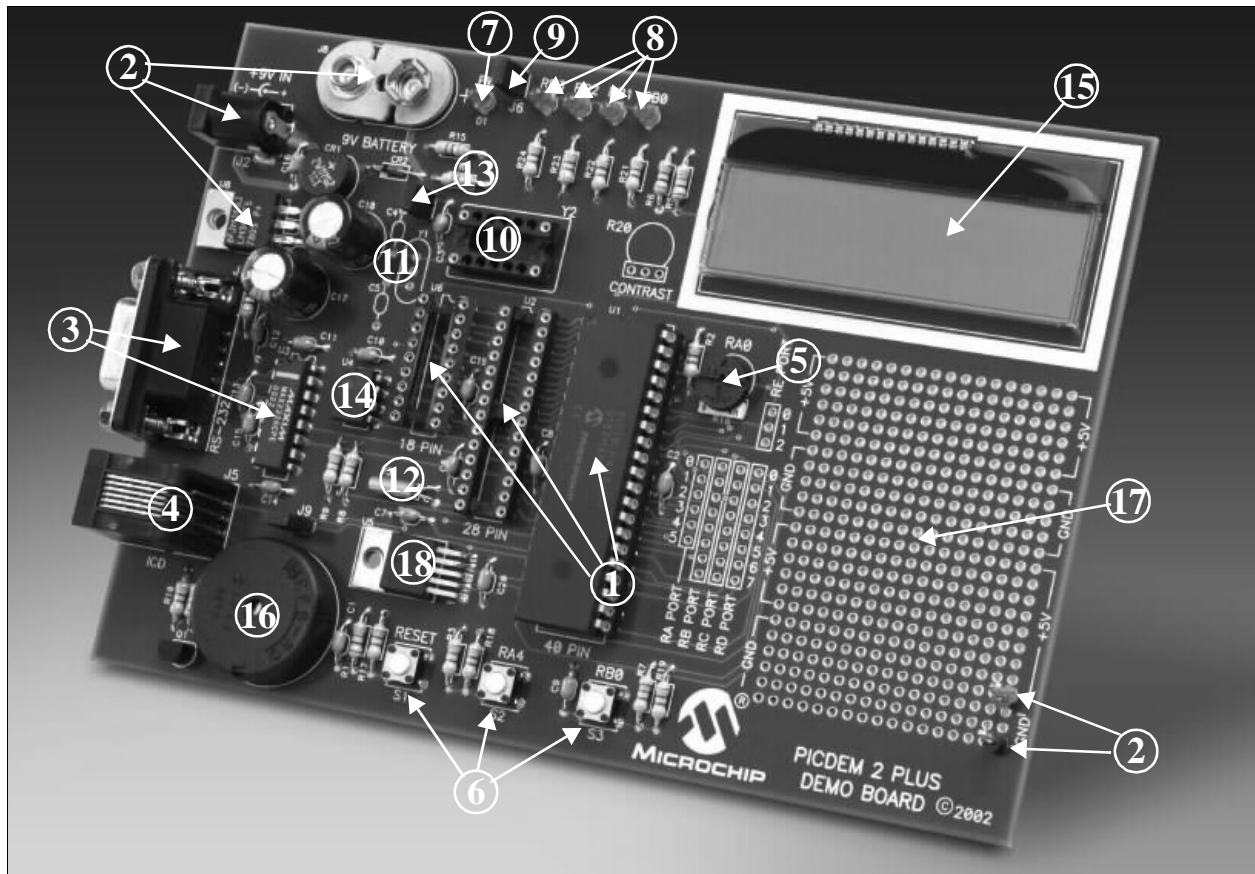
1.3 SAMPLE DEVICES

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

1.4 SAMPLE PROGRAMS

The PICDEM 2 Plus Kit includes a CD-ROM with sample demonstration programs. These programs may be used with the included sample devices, with an In-Circuit Emulator (ICE) or with an In-Circuit Debugger (ICD). For each type of device (PIC16 or PIC18), demo source code (several ASM files) and compiled code (one Hex file) are provided.

1.5   PICDEM 2 PLUS USER'S GUIDE

This document describes the PICDEM 2 Plus demonstration board, tutorial and demonstration software. Detailed information on individual microcontrollers may be found in the device's respective data sheet. Detailed information on In-Circuit Emulator (ICE) or In-Circuit Debugger (ICD) systems may be found in the respective tool's user guide.

Chapter 1: Introduction – This chapter introduces the PICDEM 2 Plus and provides a brief description of the hardware.

Chapter 2: Getting Started – This chapter goes through a basic step-by-step process for getting your PICDEM 2 Plus up and running as a stand-alone board or with an ICE or ICD.

Chapter 3: Tutorial – This chapter provides a detailed description of the tutorial program.

Appendix A: Hardware Description: This appendix describes in detail the hardware of the PICDEM 2 Plus board.

1.6   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).

- Individual Data Sheets and Reference Manuals:
    - *PIC16F87X Data Sheet* (DS30292)
    - *PIC18FXX2 Data Sheet* (DS39564)
    - *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™ User's Guide with MPLINK™ Linker and MPLIB™ Librarian* (DS33014)
- *PRO MATE$^®$ II User's Guide* (DS30082)
- *PICSTART$^®$ Plus User's Guide* (DS51028)
- *MPLAB$^®$ ICE User's Guide* (DS51159)
- *MPLAB$^®$ ICD 2 Quick Start Guide* (DS51268)
- *Microchip Third Party Guide* (DS00104)

Chapter 2. Getting Started

The PICDEM 2 Plus may be used as a stand-alone board with a preprogrammed device, with an In-Circuit Emulator (ICE) or with an In-Circuit Debugger (ICD). For a list of PICmicro microcontroller compatible ICEs or ICDs, please refer to the *Development Systems Ordering Guide* or the *Microchip Third Party Guide.*

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

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

- Place the preprogrammed sample device in the appropriate socket on the PICDEM 2 Plus board.
- Place a jumper on J6 (to enable the LEDs).
- Verify that the board is set up for a 4 MHz canned oscillator (i.e., no jumper on J7; a 4 MHz oscillator in Y2; Y1, C4 and C5 are empty).
- Apply power to the PICDEM 2 Plus. For information on acceptable power sources, see Appendix A.

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

1. Program source code.

   User source code may be used to program the device or, if this has previously been done, the sample program may be restored from the file on the included CD-ROM.

2. An assembler, such as MPASM™ assembler (available with MPLAB IDE), or a compiler, such as 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 or MPLAB C18 C compiler may be used. Both are compatible with MPLAB IDE. However, other assemblers/compilers may be used. For a list of these PICmicro® MCU compatible language tools, please refer to the *Microchip Third Party Guide.*

3. A device programmer, such as PRO MATE® II, MPLAB® PM3[1], PICSTART® Plus or MPLAB® ICD 2 (programmer functionality available with MPLAB IDE v6.00 or greater).

   Once the sample program is in Hex file format, a programmer may be used to program a Flash device. Microchip Technology's PRO MATE II device programmer, PICSTART Plus development programmer or MPLAB ICD 2 may be used. All are compatible with MPLAB IDE. However, other programmers may be used. For a list of these PICmicro MCU compatible programmers, please refer to the *Microchip Third Party Guide.*

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


Note 1: The MPLAB PM3 device programmer will be available in Q2 2004. Check the Microchip web site (www.microchip.com) for further information.

2.2 PICDEM 2 PLUS USED WITH AN IN-CIRCUIT EMULATOR OR IN-CIRCUIT DEBUGGER

To use PICDEM 2 Plus with an In-Circuit Emulator (ICE) or In-Circuit Debugger (ICD), refer to the tool's user guide for instructions on how to power-up and configure the ICE/ICD, as well as how to connect to target boards (e.g., Figure 2-1).

FIGURE 2-1:   PICDEM 2 PLUS CONNECTED TO MPLAB ICD 2 USING USB
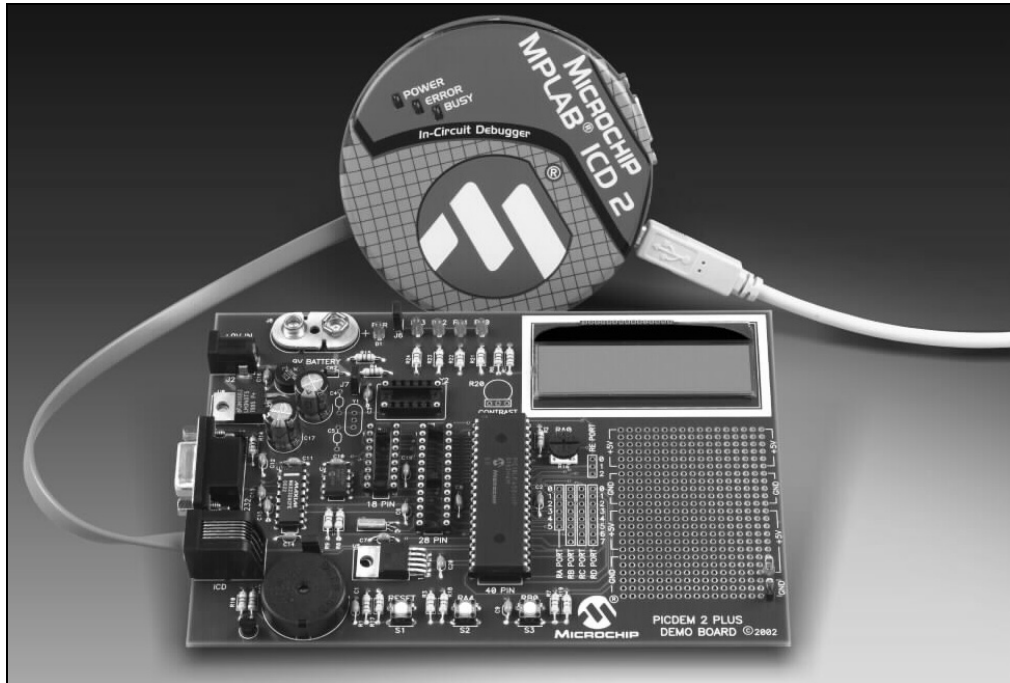
Configure the PICDEM 2 Plus for the desired oscillator as described in Table 2-1. Refer to the ICE/ICD user's guide for any oscillator configuration requirements.

TABLE 2-1:   OSCILLATOR SELECTION

Oscillator Selection on PICDEM 2 Plus	Modification on PICDEM 2 Plus
RC	J7 installed, Y2 empty, Y1 empty
Crystal	J7 removed, Y2 empty, crystal in Y1, caps in C4 and C5
Canned Oscillator	J7 removed, oscillator in Y2 (Y1, C4, C5 empty)
Resonator – no internal caps	J7 removed, Y2 empty, resonator in Y1, caps in C4 and C5
Resonator – with internal caps	J7 removed, Y2 empty, resonator in Y1, C4 and C5 empty

Chapter 3. Tutorial

The tutorial program is preprogrammed into the sample device, (i.e., `p16demo.hex` for a PIC16 device and `p18demo.hex` for a PIC18 device). Also, this program is on the included CD-ROM program disk for user reference, (i.e., if the sample device has been reprogrammed with another program, the tutorial may be reprogrammed into the device).

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

3.1   TUTORIAL PROGRAM OPERATION

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

1. **Voltmeter**
   This mode uses the A/D module to measure the voltage of the R16 pot 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.

2. **Buzzer**
   This mode turns on the Piezo buzzer, using the CCP1 module I/O pin, RC2. The period and duty cycle of the CCP1 frequency can be changed while the buzzer is on. The changes in period and duty cycle are recognized immediately in the buzzer tone. To change the period and/or the duty cycle, press RB0 under the "Buzzer" menu. The buzzer will then sound off with the default setting of 80h for the period and duty cycle. The cursor will flash over the period's first digit, indicating that the PR2 register is ready to be incremented. To change the duty cycle, press RA4 once and the cursor will now flash over the duty cycle's first digit, indicating it is now ready to increment the CCPR1L register. The next press of RA4 will exit the buzzer function.
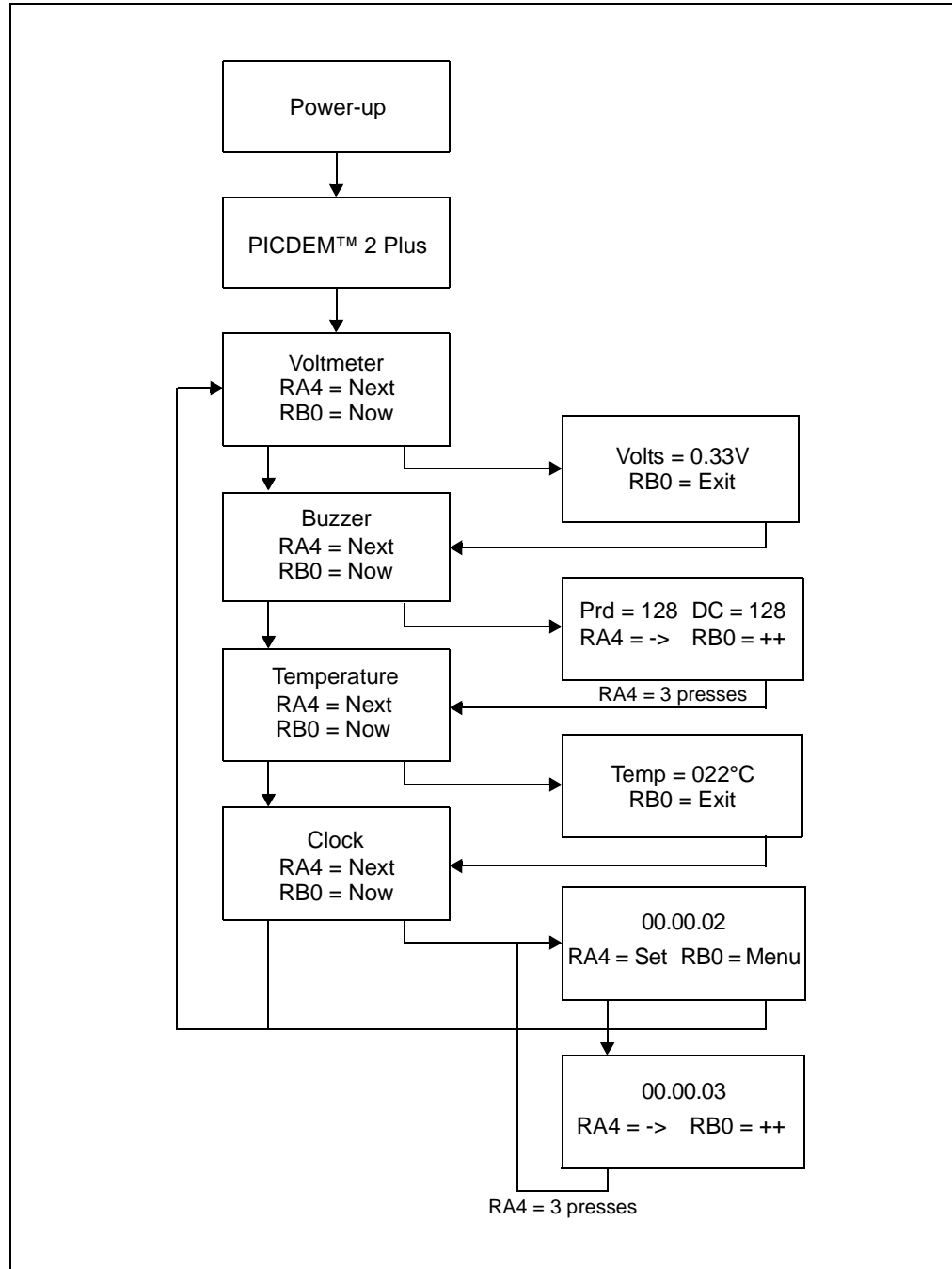
3. **Temperature**
   This mode uses a TC74 thermal sensor to measure ambient temperature in Celsius and then display that temperature on the LCD. Communication between the PICmicro MCU and sensor is accomplished using the MSSP module. This mode is exited by pressing RB0. This mode contains code that will write to the external on-board EEPROM. Every two seconds, the code will write to a defined EEPROM address and store the current temperature in that address.

4. **Clock**
   Once this mode is entered from the main menu, a real-time clock will start counting from 00:00:00. The Timer1 module and a 32 kHz clock crystal are used to establish a real-time clock. By pressing RA4, the clock time can be set to the user's preference. When RA4 is pressed to set the time, the cursor will flash over the hours ten digit. Press RA4 again and the cursor will now flash over the minutes ten digit. RB0 is used to increment hours and minutes whenever the cursor is flashing over either. After the minutes have been set, press RA4 and the time will be set and the LCD is returned to an active clock display.

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

PICDEM™ 2 Plus User's Guide

FIGURE 3-1: **TUTORIAL PROGRAM FLOW CHART**

```
                        ┌──────────────┐
                        │   Power-up   │
                        └──────┬───────┘
                               │
                        ┌──────▼───────┐
                        │ PICDEM™ 2 Plus│
                        └──────┬───────┘
                               │
                        ┌──────▼───────┐        ┌──────────────────┐
                    ┌──▶│   Voltmeter  │───────▶│   Volts = 0.33V  │
                    │   │  RA4 = Next  │        │   RB0 = Exit     │
                    │   │  RB0 = Now   │◀───────┤                  │
                    │   └──────┬───────┘        └──────────────────┘
                    │          │
                    │   ┌──────▼───────┐        ┌──────────────────┐
                    │   │    Buzzer    │───────▶│ Prd = 128  DC = 128│
                    │   │  RA4 = Next  │        │ RA4 = ->   RB0 = ++│
                    │   │  RB0 = Now   │◀───────┤                  │
                    │   └──────┬───────┘        └──────────────────┘
                    │          │                  RA4 = 3 presses
                    │   ┌──────▼───────┐        ┌──────────────────┐
                    │   │ Temperature  │───────▶│   Temp = 022°C   │
                    │   │  RA4 = Next  │        │   RB0 = Exit     │
                    │   │  RB0 = Now   │◀───────┤                  │
                    │   └──────┬───────┘        └──────────────────┘
                    │          │
                    │   ┌──────▼───────┐        ┌──────────────────┐
                    │   │    Clock     │───────▶│     00.00.02     │
                    │   │  RA4 = Next  │        │ RA4 = Set  RB0 = Menu│
                    │   │  RB0 = Now   │◀───────┤                  │
                    │   └──────────────┘        └──────────────────┘
                    │                                   │
                    │                           ┌──────────────────┐
                    └───────────────────────────│     00.00.03     │
                                                │ RA4 = ->   RB0 = ++│
                                                └──────────────────┘
                                         RA4 = 3 presses
```

3.2 SOURCE CODE AND APPLICATION NOTES

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

Application Notes are also included on the CD-ROM for additional examples of use.

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 as a Stand-Alone Board – Preprogrammed Device"**.

NOTES:

Appendix A. Hardware Detail

The PICDEM 2 Plus hardware is extremely simple and is intended to illustrate the ease of use of various PICmicro MCUs. The PICDEM 2 Plus features the following 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 red LEDs are connected to PORTB of each processor type. The PORTB pins are set high to light the LEDs. These LEDs may be disconnected from PORTB by removing jumper J6.

One green LED is provided to determine whether there is power to the PICDEM 2 Plus board (LED on) or not (LED off).

A.3   POWER SUPPLY

There are three ways to supply power to the PICDEM 2 Plus:

• 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.

> **Note:**   The PICDEM 2 Plus kit does not include a power supply.

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

MPLAB ICD 2 users may use the ICD to power the target board to 5V, up to 200 mA, if the MPLAB ICD 2 is connected to the PC with a serial cable.

A.4   RS-232 SERIAL PORT

An RS-232 level shifting IC has been provided with all 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 debounce capacitors, whereas S2 does not, allowing the user to investigate debounce techniques.

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

A.6 OSCILLATOR OPTIONS

- RC oscillator (2 MHz approximately) supplied. This oscillator may be disabled by removing jumper J7.
- Pads provided for user furnished crystal and two capacitors.
- Removable 4 MHz canned oscillator.
- 32.768 kHz (watch type) crystal for Timer1.

A.7 ANALOG INPUT

A 5 KΩ potentiometer is connected through a series 470 ohm 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 2 can be connected for low-cost debugging. The ICD connector utilizes RB6 and RB7 of the microcontroller for in-circuit debugging.

A.9 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 it's 2-wire I^{2}C™ compatible serial port. This device has an address of `1001101b`.

A.10 SERIAL EEPROM

A 24L256 256K (32K x 8) serial EEPROM is included on the board to illustrate I^{2}C bus concepts.

A.11 LCD

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

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

A.12   SAMPLE DEVICES

A sample part programmed with a simple program is included in the
PICDEM 2 Plus kits.

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	RA3:RA1	RC3/RC4	RC2	RB6/RB7	RC3/RC4	Yes
40-pin	RB3:RB0	RC6/RC7	$\overline{\text{MCLR}}$	RA4	RB0	RA0	RA3:RA1 RD3:RD0	RC3/RC4	RC2	RB6/RB7	RC3/RC4	Yes

A.13 BOARD LAYOUT AND SCHEMATICS

The following figures show the parts layout (silkscreen) and schematics for the PICDEM 2 Plus board.

FIGURE A-1: **PICDEM 2 PLUS PARTS LAYOUT**
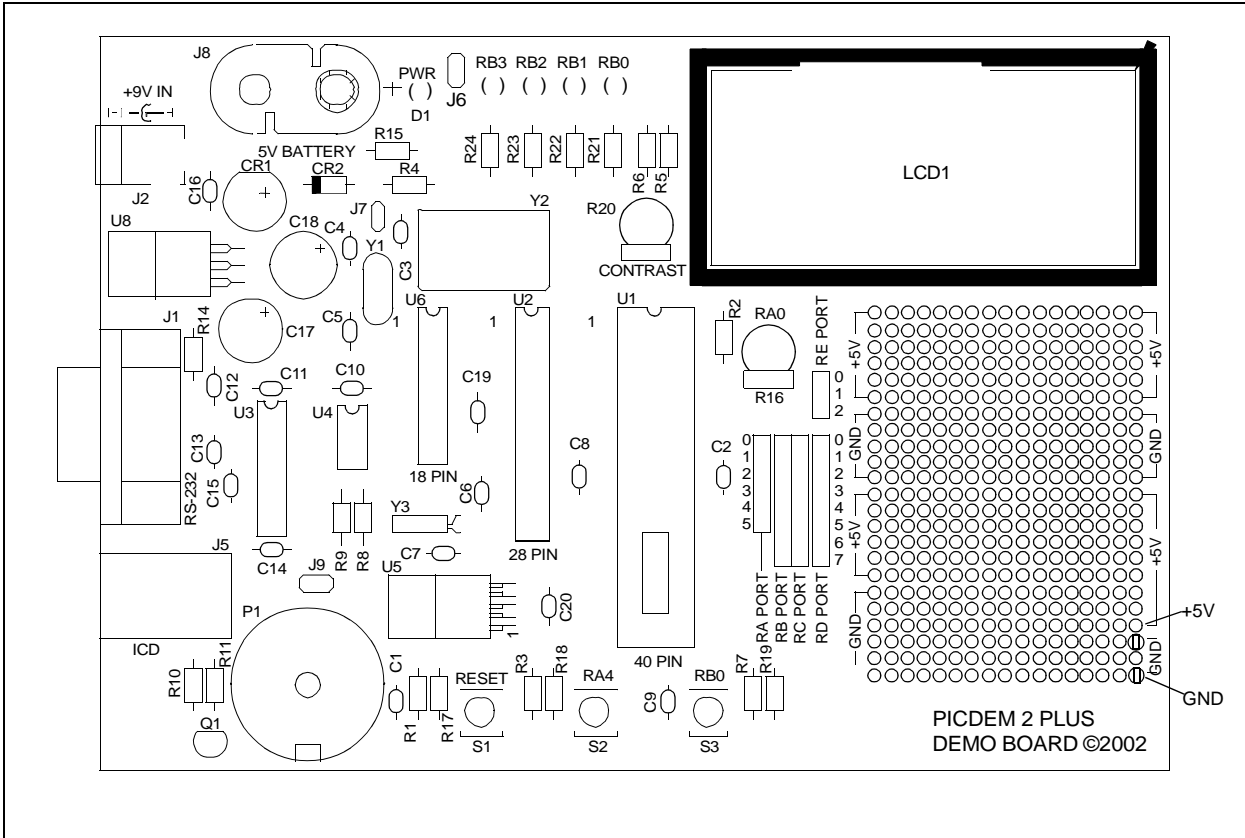
FIGURE A-2: PICDEM 2 PLUS SCHEMATIC
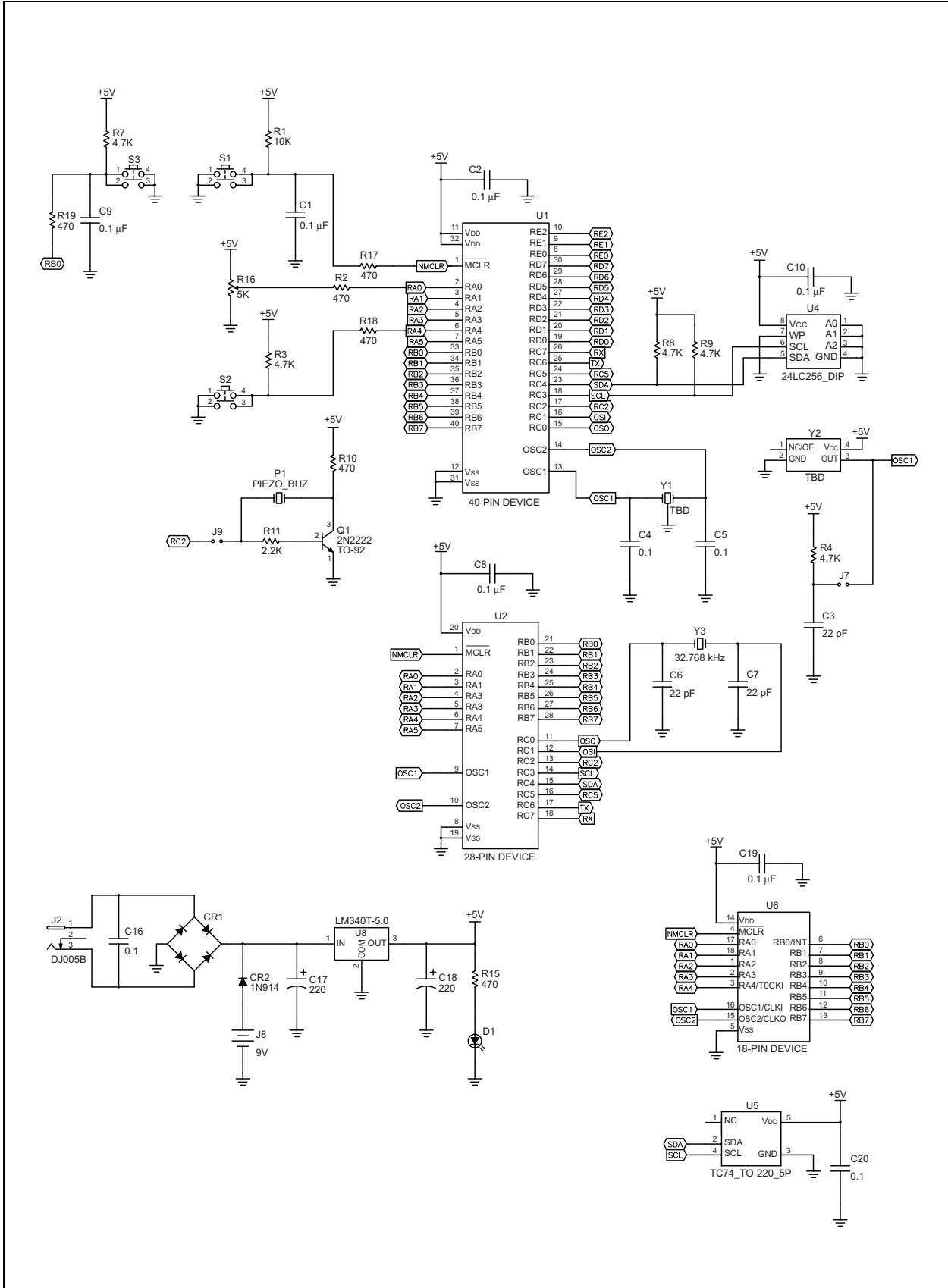
FIGURE A-3: **PICDEM 2 PLUS SCHEMATIC (CONTINUED)**

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Corporate Office
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Fax: 949-263-1338

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Tel: 650-215-1444
Fax: 650-961-0286

Toronto
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ASIA/PACIFIC

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Epping 2121, NSW
Australia
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Unit 706B
Wan Tai Bei Hai Bldg.
No. 6 Chaoyangmen Bei Str.
Beijing, 100027, China
Tel: 86-10-85282100
Fax: 86-10-85282104

China - Chengdu
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Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-86766200
Fax: 86-28-86766599

China - Fuzhou
Unit 28F, World Trade Plaza
No. 71 Wusi Road
Fuzhou 350001, China
Tel: 86-591-7503506
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China - Hong Kong SAR
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223 Hing Fong Road
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Fax: 86-21-6275-5060

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Tel: 91-80-2290061 Fax: 91-80-2290062

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Kanagawa, 222-0033, Japan
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Korea
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Samsung-Dong, Kangnam-Ku
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Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Austria
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Austria
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Lautrup hoj 1-3
Ballerup DK-2750 Denmark
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France
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Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany
Steinheilstrasse 10
D-85737 Ismaning, Germany
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy
Via Quasimodo, 12
20025 Legnano (MI)
Milan, Italy
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands
P. A. De Biesbosch 14
NL-5152 SC Drunen, Netherlands
Tel: 31-416-690399
Fax: 31-416-690340

United Kingdom
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44-118-921-5869
Fax: 44-118-921-5820

01/26/04