PICDEM™ 4
User's Guide

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Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999 and Mountain View, California in March 2002. The Company’s quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, non-volatile memory and analog products. In addition, Microchip’s quality system for the design and manufacture of development systems is ISO 9001 certified.

PICDEM 4 User's Guide

Table of Contents

Appendix A. Hardware Detail

PICDEM 4 User's Guide

Chapter 1. Introduction

1.1 WELCOME

Thank you for purchasing the PICDEM 4 demonstration board from Microchip Technology Incorporated. The PICDEM 4 demonstrates the capabilities of the 8-, 14-, and 18-pin PIC16XXXX and PIC18XXXX devices.

The PICDEM 4 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 4 Kit comes with the following:

1. PICDEM 4 Demonstration Board (Figure 1-1)
2. Sample Devices
3. CD-ROM, which contains:
   a) Sample Programs
   b) PICDEM 4 Demonstration Board User's Guide
   c) Application Notes

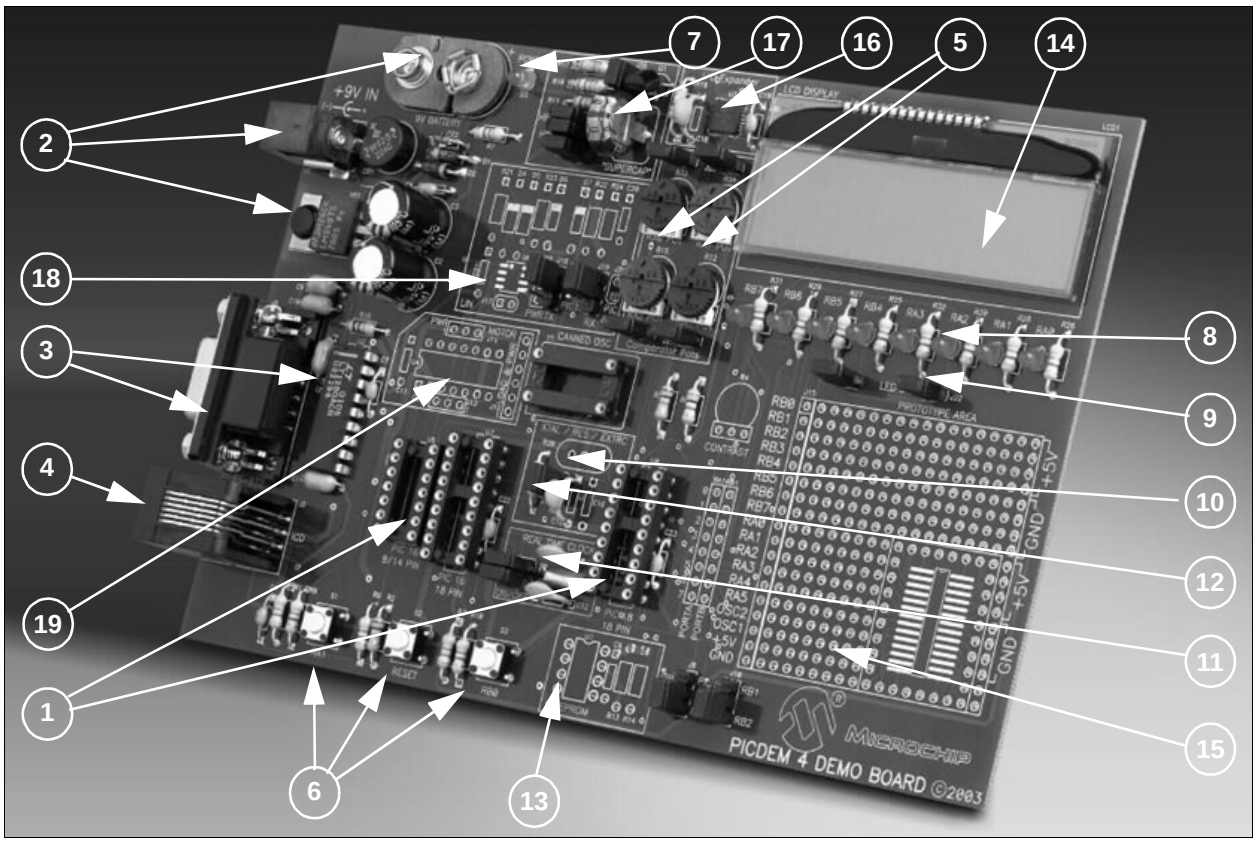
If you are missing any part of the kit, please contact your nearest Microchip sales office listed in the back of this publication for help.

1.2 PICDEM 4 DEMONSTRATION BOARD

The PICDEM 4 demonstration board has the following hardware features:

1. 8-, 14- and 18-pin DIP sockets. (Although 3 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 connection and associated hardware for direct connection to RS-232 interface.
4. In-Circuit Debugger (ICD) connector.
5. Four 5 kΩ pots for devices with analog inputs and comparators.
6. Three push button switches for external stimulus and RESET.
7. Green power-on indicator LED.
8. Eight red LEDs connected to PORTA and PORTB.
9. Jumpers J21 and J22 to disconnect LEDs from PORTA and PORTB.
10. Unpopulated holes provided for crystal connection.
11. 32.768 kHz crystal for Timer1 Real-Time Clock operation.
12. Jumper J14 to disconnect on-board RC oscillator (R20 and C15, approx. 2 MHz).
13. Unpopulated holes for EEPROM.
14. 2 x 16 LCD display.
15. Prototype area for user hardware.
16. PIC16LF72 I/O expander.
17. Supercapacitor circuitry.
18. Unpopulated holes for a LIN transceiver.
19. Unpopulated holes for a motor driver.

FIGURE 1-1: PICDEM 4 HARDWARE



1.3 SAMPLE DEVICES

Two FLASH devices are included. The device types may change, but will generally include PIC16XXXX and PIC18XXXX 18-pin DIP devices.

1.4 SAMPLE PROGRAMS

The PICDEM 4 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 (PIC16XXXX or PIC18XXXX), demo source code (several ASM files) and compiled code (one HEX file) are provided.

1.5 PICDEM 4 USER'S GUIDE

This document describes the PICDEM 4 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's guide.

Chapter 1: Introduction – This chapter introduces the PICDEM 4 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 4 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 Detail – This appendix describes in detail the hardware of the PICDEM 4 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 download from the Microchip web site (www.microchip.com).

- *Technical Library CD-ROM* (DS00161) or individual data sheets:
  - *PIC16F627A/628A/648A Data Sheet* (DS40044)
  - *PIC18F1220/1320 Data Sheet (DS39605)*
  - *PICmicro™ Mid-Range MCU Family Reference Manual* (DS33023)
  - *PICmicro® 18C MCU Family Reference Manual* (DS39500)
- *MPLAB® IDE Simulator, Editor User's Guide* (DS51025)
- *MPASM User's Guide with MPLINK and MPLIB* (DS33014)
- *PRO MATE® II User's Guide* (DS30082)
- *PICSTART® Plus User's Guide* (DS51028)
- *MPLAB® ICE Emulator User's Guide* (DS51159)
- *MPLAB® ICD 2 In-Circuit Debugger Quick Start Guide* (DS51268)
- *Microchip Third Party Guide* (DS00104)

NOTES:

Chapter 2. Getting Started

The PICDEM 4 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 4 AS A STAND-ALONE BOARD – PREPROGRAMMED DEVICE

The PICDEM 4 may be demonstrated immediately by following the steps listed below:

- Place the preprogrammed sample device in the appropriate socket on the PICDEM 4 board.
- Apply power to the PICDEM 4. For information on acceptable power sources, see Appendix A.

Note: In the event that the preprogrammed PICDEM 4 demonstration board does not operate, check the following conditions:

- J8/J10 must be connected for the appropriate device
- J3, J4, J7, J9, and J24 - J27 must be ON
- J23 and J28 must be OFF

The status of all other jumpers will not affect the preprogrammed demonstration.

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 (PIC18XXXX 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, PICSTART Plus, or MPLAB ICD 2 (programmer functionality available with MPLAB IDE v6.00 or greater).

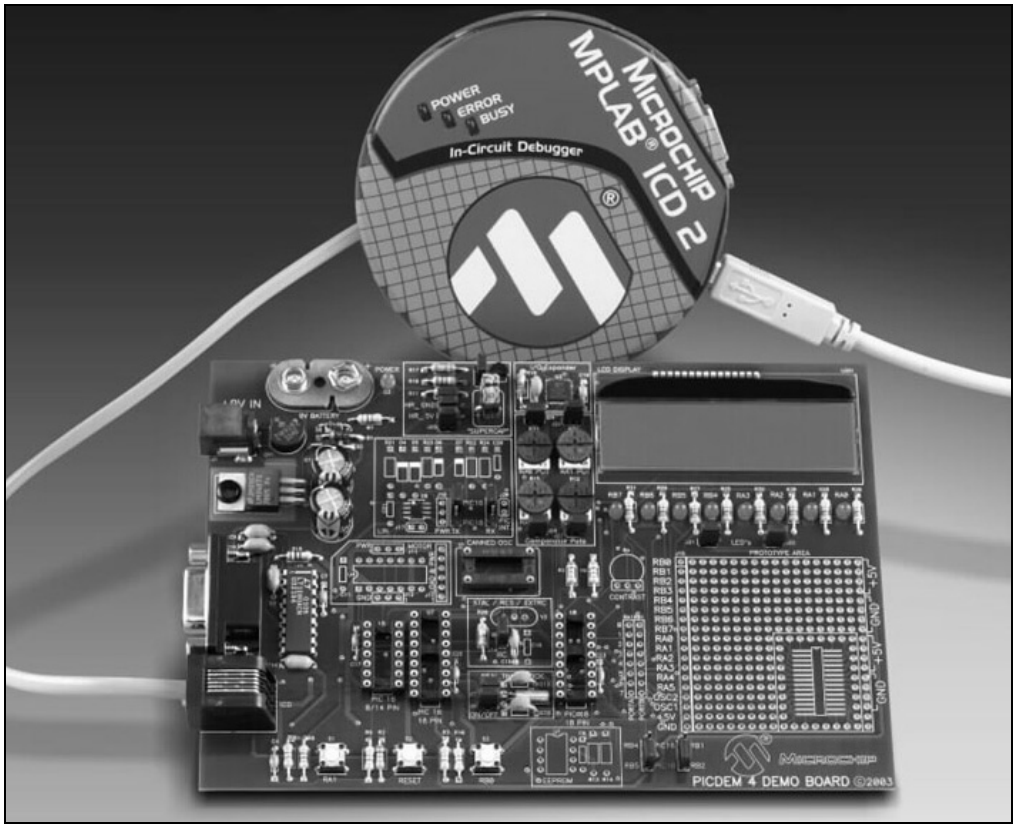
   Once the sample program is in HEX file format, a programmer may be used to program a FLASH device. Microchip Technology's PRO MATE II device programmer, PICSTART Plus development programmer, or MPLAB ICD 2 may be used. All are compatible with MPLAB IDE. However, other programmers may be used. For a list 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.

2.2 PICDEM 4 USED WITH AN IN-CIRCUIT EMULATOR OR IN-CIRCUIT DEBUGGER

To use PICDEM 4 with an In-Circuit Emulator (ICE) or In-Circuit Debugger (ICD), refer to the tool's user's 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 4 CONNECTED TO MPLAB ICD 2 USING USB



Configure the PICDEM 4 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 4	Modification on PICDEM 4
RC	J14 ON, Y3 empty, Y1 empty
Crystal	J14 OFF, Y1 empty, crystal in Y3, caps in C15 and C16
Canned Oscillator	J14 OFF, oscillator in Y1 (Y3, C15, C16 empty)
Device Internal Oscillator	J14 OFF, Y1 empty, Y3 empty
Resonator - no internal caps	J14 OFF, Y1 empty, resonator in Y3, caps in C15 and C16
Resonator - with internal caps	J14 OFF, Y1 empty, resonator in Y3, C15 and C16 empty

Chapter 3. Tutorial

The tutorial program is preprogrammed into the sample device (for example, `p16PDEM4_Demo.hex` for a PIC16XXXX device and `p18PDEM4_Demo.hex` for a PIC18XXXX 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 4 hardware, please refer to Appendix A.

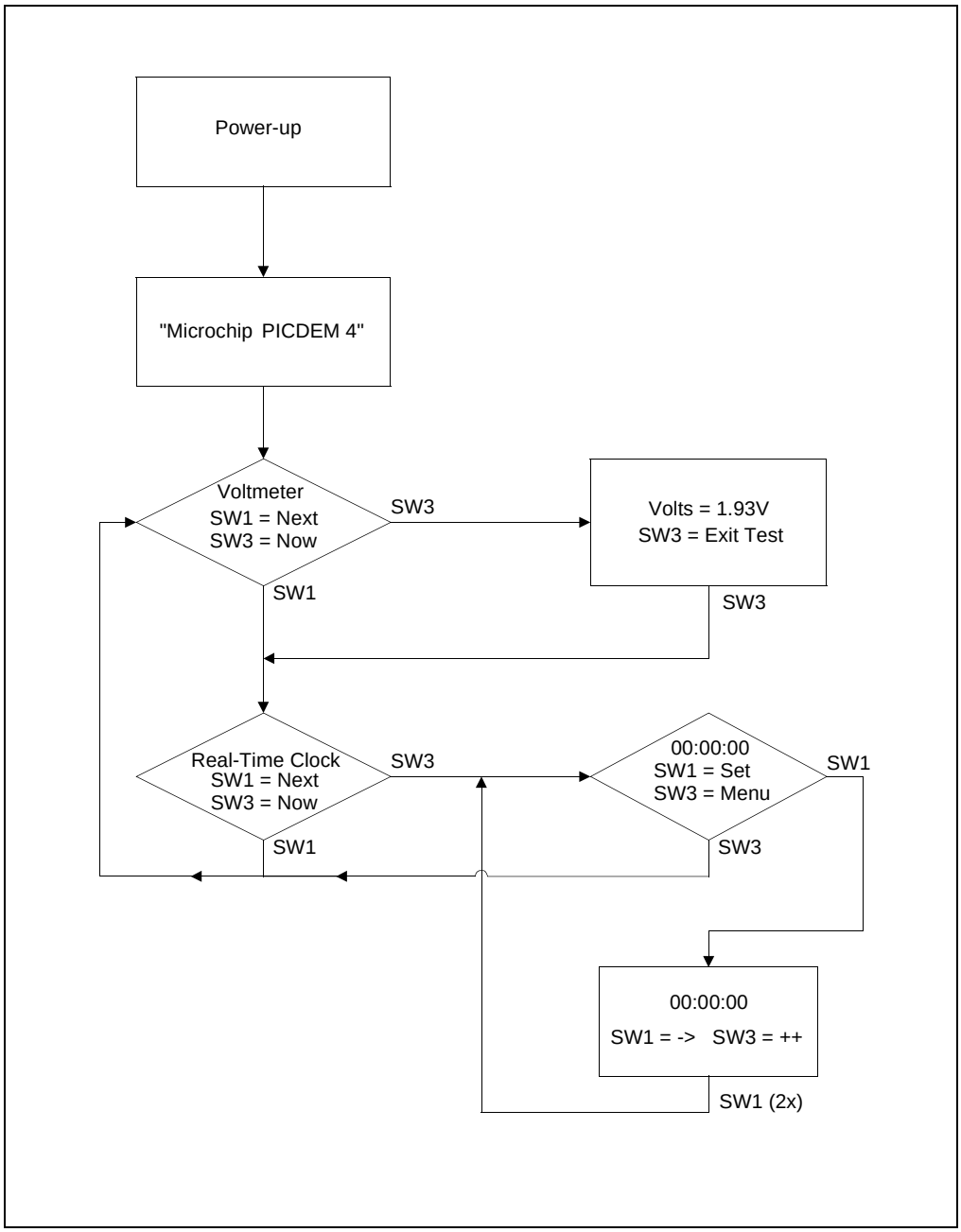
3.1 TUTORIAL FIRMWARE OPERATION

The PIC18F tutorial firmware is made up of two components, which are individually displayed on the LCD. The PIC® microcontroller's internal RC oscillator is used as the system clock source.

1. **Voltmeter**
   This mode uses the A/D module to measure the voltage of the R33 pot and displays a voltage between 0.00V and 5.00V on the LCD. Voltage is continually updated until the mode is exited by pressing SW3 (RB0).
2. **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 is used to establish a Real-Time Clock. By pressing SW1, the clock time can be set to the user's preference. After SW1 has been pressed, the cursor will flash over the hours digits. Press SW1 and the cursor will now flash over the minutes digits. SW3 is used to increment hours and minutes whenever the cursor is flashing over either. After the minutes have been set, press SW1 and the time will be set and the LCD is returned to an active clock display.

The PIC16F tutorial firmware is made up of one component, which uses the comparator module and potentiometers R12, R15, R33, and R34. Turning the potentiometers will vary the voltages to the PIC16 inputs, thereby changing the results of the comparator outputs. The LCD will be used for displaying these results.

FIGURE 3-1: PIC18F TUTORIAL PROGRAM FLOW CHART



3.2 SOURCE CODE AND APPLICATION NOTES

In addition to the assembled tutorial programs (HEX files), source code used to create these HEX files is included on the PICDEM 4 CD-ROM. Both source code and related HEX file are found in device specific directories.

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

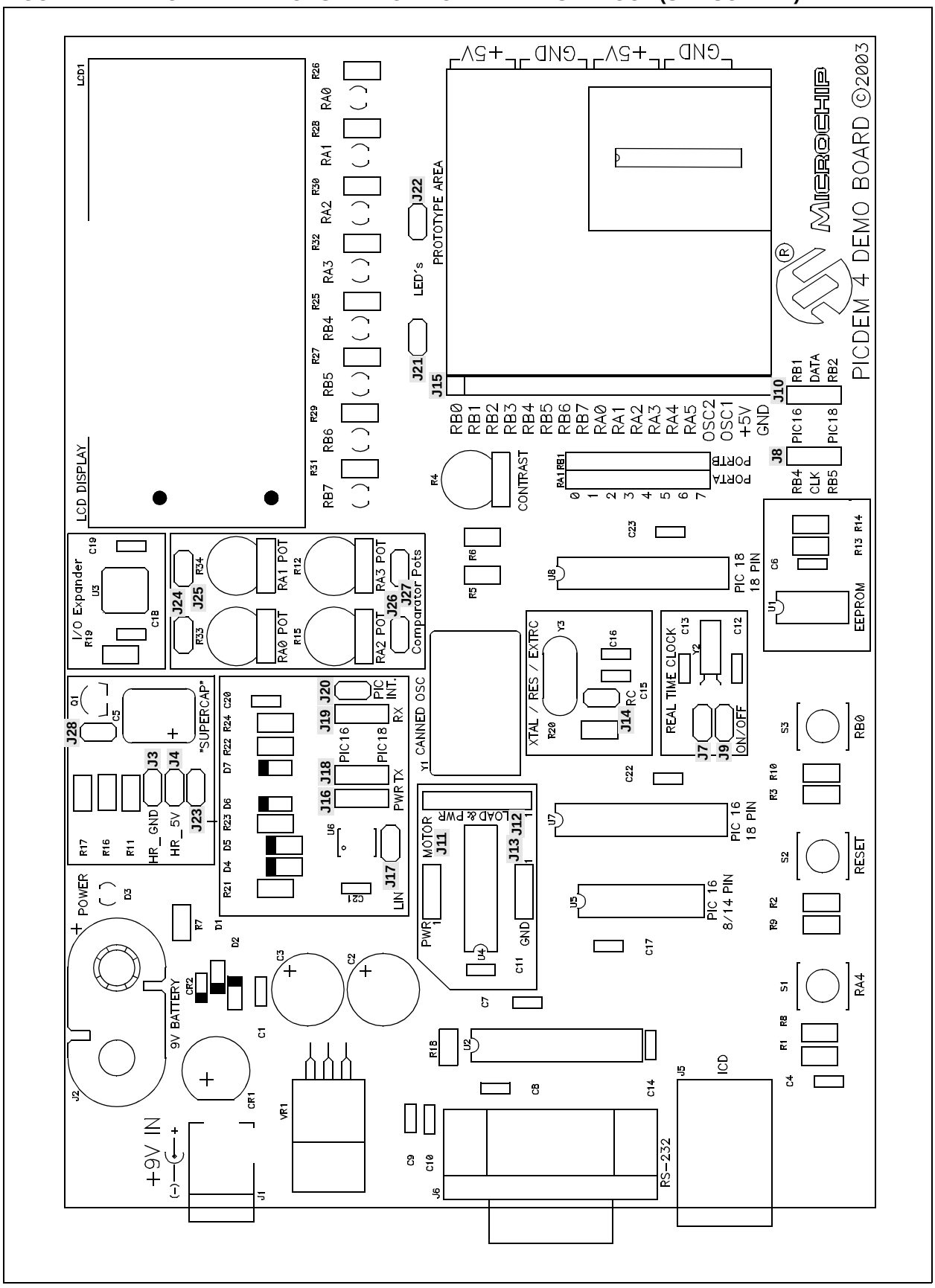
For information on how to reprogram the device with new or modified code, or how to restore the tutorial program, please see Section 2.1.

Appendix A. Hardware Detail

The PICDEM 4 hardware is uncomplicated and is intended to illustrate the ease of use of various PICmicro MCUs. The PICDEM 4 features the following hardware elements.

Note: Many of the following hardware sections will require specific demo board jumper configurations. If a jumper is not listed in a particular section, then that jumper has no effect on the circuitry within the hardware section you are working. Figure A-1 shows a diagram of the PICDEM 4 silkscreen with all necessary jumpers highlighted. Also, refer to the schematic for circuit connections.

FIGURE A-1: PICDEM 4 DEMONSTRATION BOARD PARTS LAYOUT (SILKSCREEN)



A.1 PROCESSOR SOCKETS

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

- 8- or 14-pin socket (U5) used for 8- or 14-pin devices (8-pin devices are inserted in the upper 8 pins of U5)
- 18-pin PIC16 socket (U7)
- 18-pin PIC18 socket (U8)

A.2 LED DISPLAY

Eight red LEDs are connected to PORTA and PORTB of U7 and U8, while five of the eight LEDs are connected to U5. PORTA and PORTB pins are set high to light the LEDs. These LEDs may be disconnected from PORTA and PORTB by removing jumpers J21 and J22.

One green LED is provided to determine whether there is power to the PICDEM 4 board (LED on) or not (LED off).

A.3 POWER SUPPLY

There are three ways to supply power to PICDEM 4:

- A 9V battery can be plugged into J2.
- A 9V, 100 mA unregulated AC or DC supply can be plugged into J1. 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 1:	There are two jumpers (J3 and J4) associated with the power supply circuit. These jumpers must be on for all functions, with the exception of the Supercapacitor Circuit. Refer to **Section A.12 "Supercapacitor"** for further details.
2:	The PICDEM 4 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 4 (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 LT1280ACN.

Unlike previous demo boards, the RS-232 chip has an ON/OFF pin which is connected to I/O pin RB3. For RS-232 operation, these jumpers must be configured as follows:

PIC16

- J18/19 - Upper two pins ON
- J20 - OFF (if populated)

PIC18

- J18/19 - Lower two pins ON

A.5 SWITCHES

Three switches provide the following functions:

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

Switch S2 has a debounce capacitor, whereas S1 and S3 do 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 J14.
- Pads provided for user furnished crystal/resonator and two capacitors (Y3).
- Socket provided for a canned oscillator (Y1).
- 32.768 kHz (watch type) crystal for Timer1 (Y2). This oscillator can be disabled by removing jumpers J7 and J9.

A.7 ANALOG INPUT

There are four 5 kΩ potentiometers (R12, R15, R33, R34) on the PICDEM 4 board. These are all connected to PORTA (RA0-RA3), and can be adjusted from V_{SS} to V_{DD} to provide an analog input to the devices with an A/D or Comparator module.

Potentiometers R12, R15, R33, and R34 all have individual jumpers. For a potentiometer to function, its specific jumper must be on. The jumper removed will allow for other I/O functions to take place. For all of the potentiometers to be functional, these jumpers must be configured as follows:

- J22 - OFF (PORTA LEDs)
- J24 - ON
- J25 - ON
- If J26 is ON, then J23 is OFF
- If J27 is ON, then J28 is OFF

The above conditions will enable all potentiometers.

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. For ICD operation, the Real-time Clock connections to the microcontroller must be disabled. For ICD operation, these jumpers must be configured as follows:

- J7 - OFF (RTC)
- J9 - OFF (RTC)
- J21 - OFF (PORTB LEDs)

A.9 SERIAL EEPROM

For EEPROM operation, these jumpers must be configured as follows:

PIC16

- J8/10 - Upper two pins ON
- J21 - OFF (PORTB LEDs)

PIC18

- J8/10 - Lower two pins ON
- J21 - OFF (PORTB LEDs)

For more information on the serial EEPROM, please refer to the most recent version of the *Technical Library CD-ROM*.

A.10 MOTOR

There are three headers (J11, J12, and J13) for the motor driver circuit. These will allow for external power and load connections. For motor control operation, these jumpers must be configured as follows:

J11

- Left 2 pins: Board PWR
- Right 2 pins: External PWR

J13

- Left 2 pins: Board GND
- Right 2 pins: External GND

J12

- Connect External Power Source and Load. Lower pin (1) is PWR, top pin is GND.
- J19 - OFF

A.10.1 PICDEM 4 Motor Control Demo

The TC4467 devices are a family of four output CMOS buffers/MOSFET drivers. The PICmicro MCU PWM output is connected to these drivers to create a variety of possible driving conditions. The following figures show a few of these possible configurations. The driver can directly drive the small load, or can act as a MOSFET driver for a bigger load request.

FIGURE A-2: SINGLE OUTPUT MODE PWM

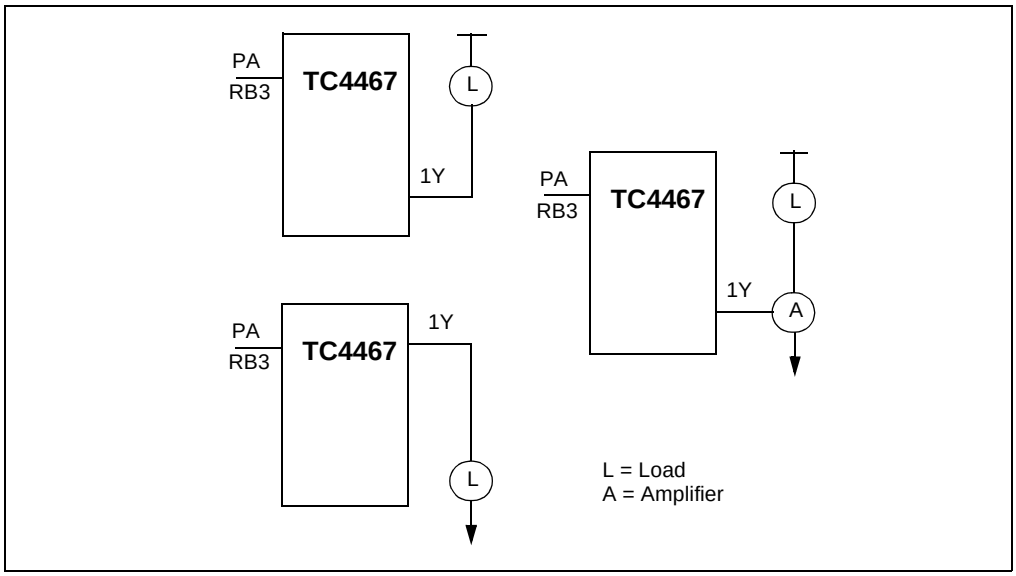


FIGURE A-3: DIRECT H-BRIDGE DRIVER IN ECCP HALF-BRIDGE OUTPUT MODE

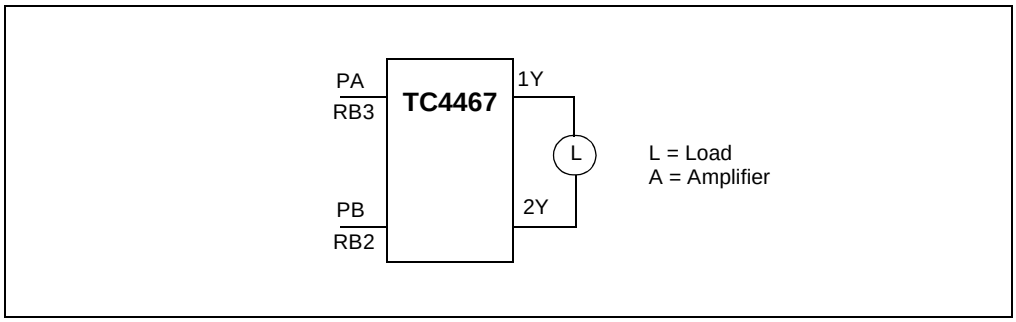


FIGURE A-4: HALF-BRIDGE MODE PWM

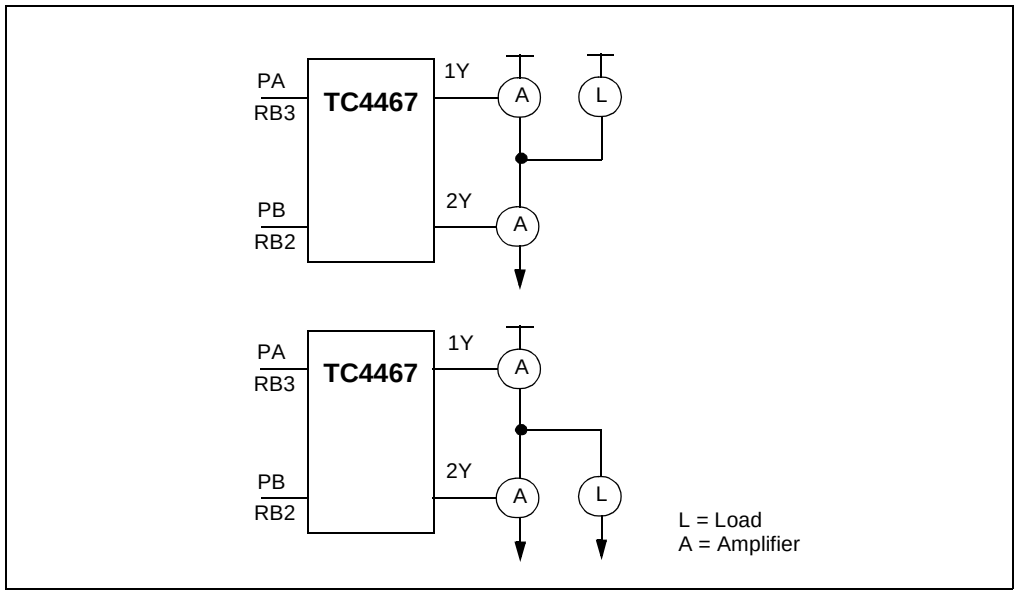
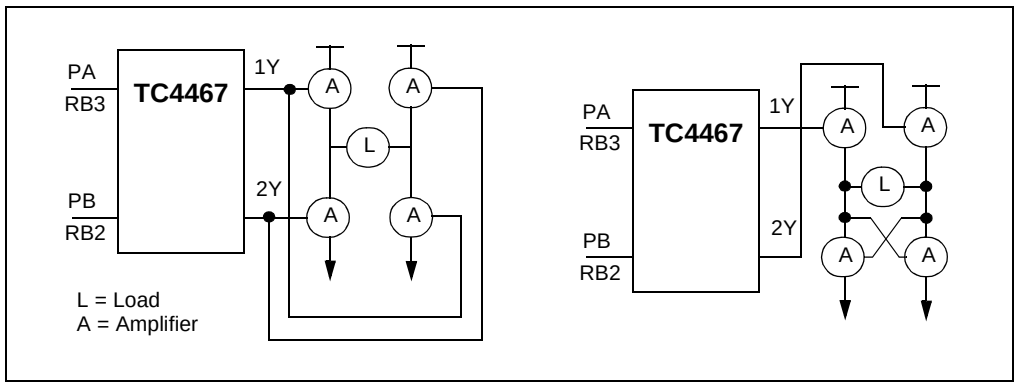


FIGURE A-5: DUAL OUTPUT PWM IN H-BRIDGE CONFIGURATION



A.11 LIN

The PICDEM 4 is designed with an optional LIN circuit (not populated). This circuit provides the essential circuitry to interface a PICmicro microcontroller to a Local Interconnect Network (LIN). The circuit includes a MCP201 LIN transceiver, reverse voltage protection, and over voltage protection.

Jumpers J16, J17, J18, J19, and J20 are provided to set up and connect a PICmicro microcontroller on PICDEM 4 to the LIN bus. External jumper J16 provides the connection to the LIN bus. With the MCP201 installed, power to the PICDEM 4 can be supplied from the LIN bus battery connection via J16; shorting J17 enables bus power to the circuitry beyond the LIN interface circuit (refer to the MCP201 voltage regulator specifications for maximum conditions).

Jumpers J18, J19, and J20 provide connections to the microcontroller on the PICDEM 4. Shorting the appropriate pins (shown on the schematic) can connect either a PIC16 or PIC18 device to the LIN transceiver. J18 connects the LIN TX pin to either a PIC16 or PIC18 microcontroller. J19 connects the LIN RX pin to either a PIC16 or PIC18 microcontroller. J20 provides an additional receive connection for PIC16 devices. For LIN operation, these jumpers must be configured as follows:

- J17 - ON

PIC18

- J18/J19 - Lower two pins ON
- J21 - OFF

PIC16

- J18/J19 - Upper two pins ON
- J20 - ON
- J21 - OFF

A.12 SUPERCAPACITOR

The 0.33F (C5) Supercapacitor is used to demonstrate the low power capabilities of PICmicro devices. This circuit requires all other peripherals to be disconnected from the circuit. The Supercapacitor code, included on your PICDEM 4 CD, is configured so that the device will remain in SLEEP most of the time, while a 32 kHz watch crystal (Y2) connected to Timer1 keeps the PICmicro MCU running.

The device wakes up every second and toggles a port pin, and a second port pin indicates the power start-up. If a power source is present, a high level is maintained; otherwise, in the absence of power, the pin will go low.

In the event of a power failure, the Supercapacitor will supply the PICmicro MCU with power through an internal protection diode on a port pin. If the user desires to measure the Supercapacitor supply time, they will have to observe the power signals with an oscilloscope or another demo board.

Note: The Supercapacitor circuit described in this manual is used only to demonstrate the low power capability of the device. The Supercapacitor is used as an example for the low power source. **DO NOT use this circuit as a general design practice.**

For Supercapacitor operation, these jumpers must be configured as follows:

- J3 - OFF (Power Supply)
- J4 - OFF (Power Supply)
- J22 - OFF (PORTA LEDs)
- J23 - ON (Supercapacitor)
- J26 - OFF (Potentiometer)
- J27 - OFF (Potentiometer)
- J28 - ON (LVD)

A.13 REAL-TIME CLOCK

This circuit allows the user to configure a PICmicro MCU in either the U7 or U8 socket for timekeeping, using a 32.768 kHz clock crystal connected to Timer1's T1OSO and T1OSI pins. ICD operation will not be functional when the Real-Time Clock circuit is enabled. For RTC operation, these jumpers must be configured as follows:

- J7 - ON
- J9 - ON
- J21 - OFF

A.14 LCD DISPLAY

An LCD display with two lines, 16 characters per line, is connected to the I/O Expander (U3), which can be driven by all three device sockets.

A 10K pot may be installed into R4 to adjust contrast on the LCD. If this is done, R5 and R6 need to be removed.

The LCD is connected to the I/O Expander by three control lines (E, R/W, RS), and four data lines (DB7:DB4). For LCD operation, these jumpers must be configured as follows:

PIC16

- J8/10 - Upper two pins ON
- J21 - OFF (PORTB LEDs)

PIC18

- J8/10 - Lower two pins ON
- J21 - OFF (PORTB LEDs)

A.15 DEVICE CONFIGURATION OVERVIEW

Table A-1 lists the I/O features and port connections for each processor type.

TABLE A-1: PORT CONNECTIONS

Connection Type	Device		
	PIC12/PIC16 8- or 14-Pin	PIC16 18-Pin	PIC18 18-Pin
LEDs	RA0:RA2, RB4, RB5	ALL	ALL
RS-232	RB1/RB4	RB2/RB5	RB1/RB4
S1	RA4	RA4	RA4
S2	RA5	RA5	RA5
S3	RB0	RB0	RB0
R33 Pot	RA0	RA0	RA0
R34 Pot	RA1	RA1	RA1
R15 Pot	RA2	RA2	RA2
R12 Pot	N/A	RA3	RA3
LCD	RB1/RB4	RB1/RB4	RB1/RB4
EEPROM	RB1/RB4	RB1/RB4	RB1/RB4
ICD	N/A	RB6/RB7	RB6/RB7
LIN	N/A	RB2/RB5/RB1	RB1/RB4
MOTOR	RB2/RB3	RB2/RB3	RB2/RB3
RTC	N/A	RB6/RB7	RB6/RB7
CANNED OSC	OSC1	OSC1	OSC1
RC OSCILLATOR	OSC1	OSC1	OSC1
CRYSTAL/RESONATOR	OSC1/OSC2	OSC1/OSC2	OSC1/OSC2
SUPERCAPACITOR CIRCUITS	N/A	RA2/RA3	RA2/RA3

A.16 BOARD LAYOUT AND SCHEMATICS

The following figures show the parts layout (silkscreen) and schematics for the PICDEM 4 board.

FIGURE A-6: PICDEM 4 PARTS LAYOUT

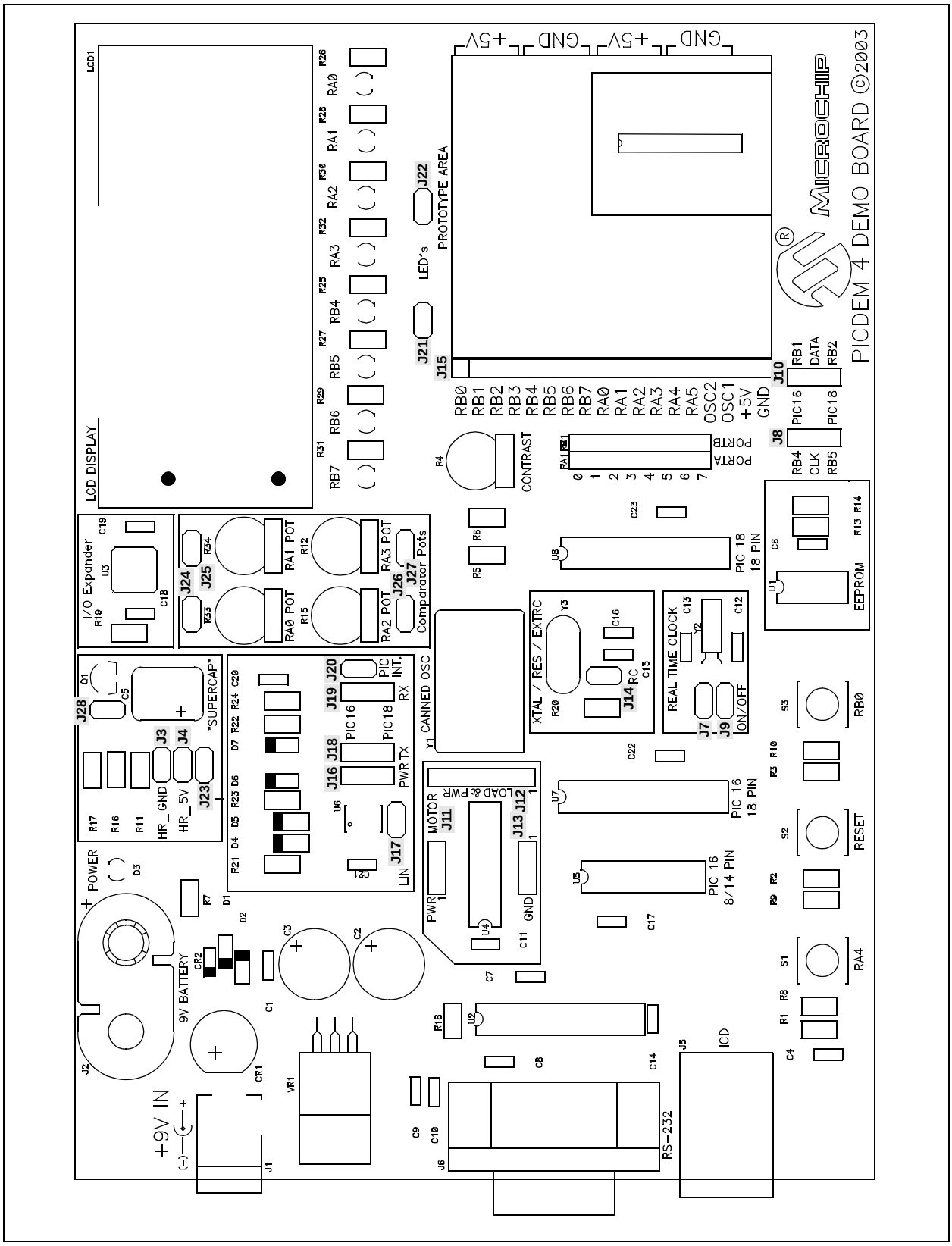


FIGURE A-7: PICDEM 4 SCHEMATIC SHEET 1

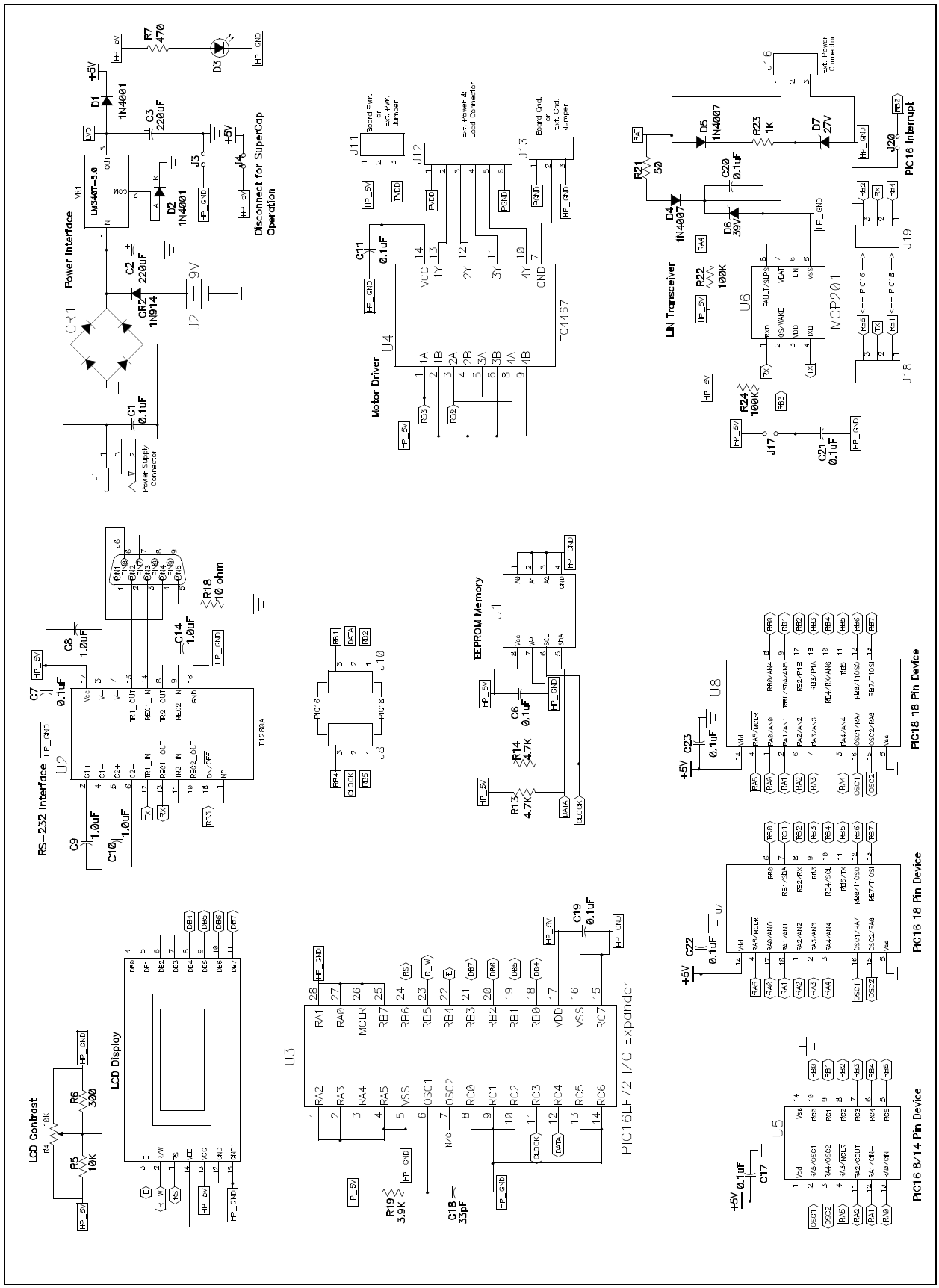
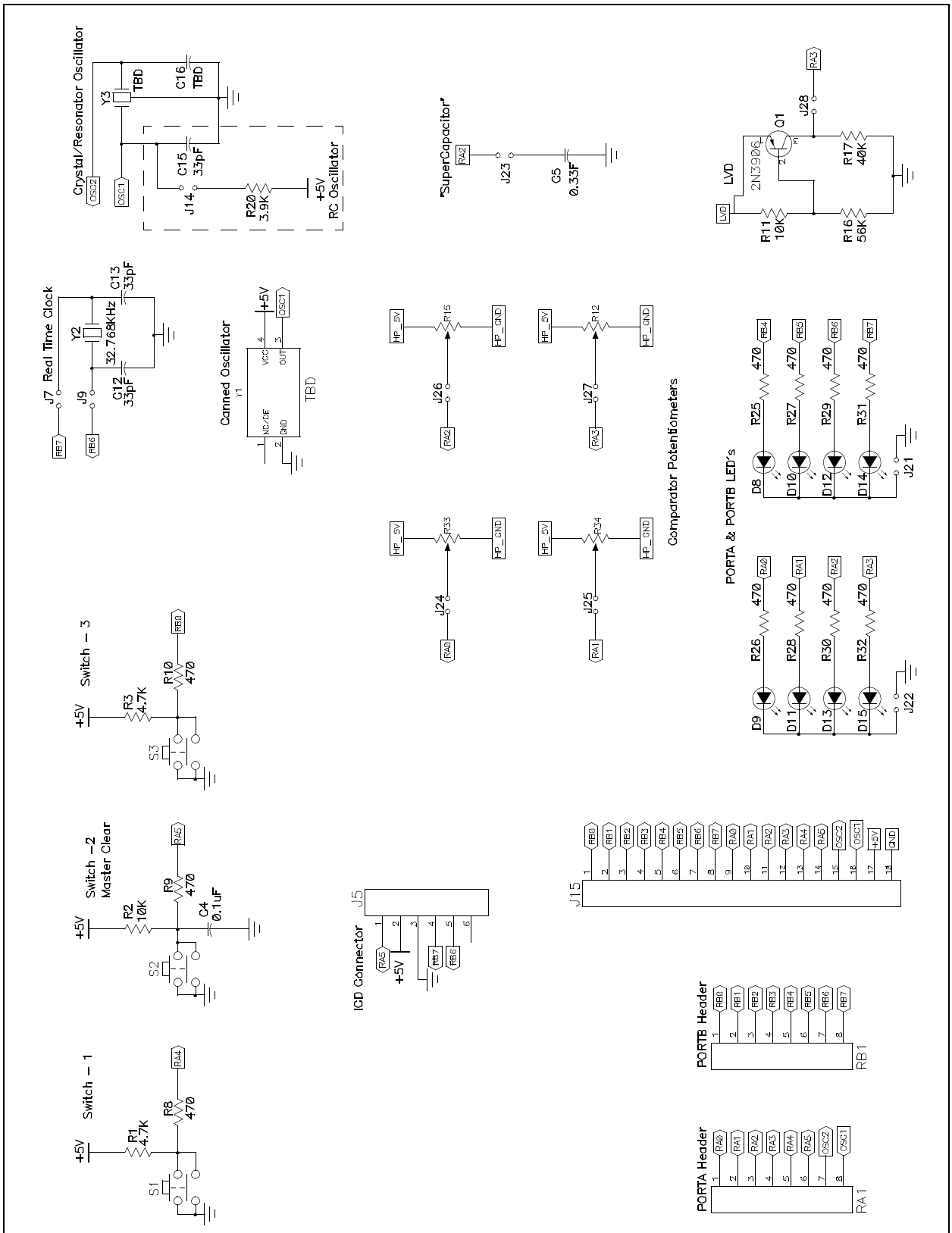


FIGURE A-8: PICDEM 4 SCHEMATIC SHEET 2



Note: The Supercapacitor circuit described in this manual is used only to demonstrate the low power capability of the device. The Supercapacitor is used as an example for the low power source. **DO NOT use this circuit as a general design practice.**

Index

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