dsPICDEM™ 80-Pin Starter Development 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.

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 preface contains general information that will be useful to know before you use the dsPICDEM™ 80-Pin Starter 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 dsPICDEM 80-Pin Starter Development Board as a development tool to emulate and debug firmware on a target board. The manual is organized as follows:

- **Chapter 1: Introduction** – This chapter introduces the dsPICDEM 80-Pin Starter Development Board and provides a brief description of the hardware.
- **Chapter 2: Tutorial** – This chapter details the step-by-step process for getting the dsPICDEM 80-Pin Starter Development Board up and running with the MPLAB® In-Circuit Debugger 2 (MPLAB ICD 2).
- **Chapter 3: Demonstration Program Operation** – This chapter describes the operational functionality of the sample code that is preprogrammed into the dsPIC30F device.
- **Chapter 4: dsPICDEM™ Development Board Hardware** – This chapter describes the hardware comprising the dsPICDEM 80-Pin Starter Development Board.
- **Appendix A: Hardware Schematics** – This appendix provides dsPICDEM 80-Pin Starter Development Board hardware layout and schematic diagrams.

CONVENTIONS USED IN THIS GUIDE

This manual uses these documentation conventions:

DOCUMENTATION CONVENTIONS

<table>
<tr><th>Description</th><th>Represents</th><th>Examples</th></tr>
<tr><td colspan="3">Arial font:</td></tr>
<tr><td rowspan="2">Italic characters</td><td>Referenced books</td><td>MPLAB® IDE User’s Guide</td></tr>
<tr><td>Emphasized text</td><td>...is the only compiler...</td></tr>
<tr><td rowspan="3">Initial caps</td><td>A window</td><td>the Output window</td></tr>
<tr><td>A dialog</td><td>the Settings dialog</td></tr>
<tr><td>A menu selection</td><td>select Enable Programmer</td></tr>
<tr><td>Quotes</td><td>A field name in a window or dialog</td><td>“Save project before build”</td></tr>
<tr><td>Underlined, italic text with right angle bracket</td><td>A menu path</td><td><u>File>Save</u></td></tr>
<tr><td rowspan="2">Bold characters</td><td>A dialog button</td><td>Click OK</td></tr>
<tr><td>A tab</td><td>Click the Power tab</td></tr>
<tr><td>N‘Rnnnn</td><td>A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.</td><td>4‘b0010, 2‘hF1</td></tr>
<tr><td>Text in angle brackets < ></td><td>A key on the keyboard</td><td>Press <Enter>, <F1></td></tr>
<tr><td colspan="3">Courier font:</td></tr>
<tr><td rowspan="7">Plain Courier</td><td>Sample source code</td><td><code>#define START</code></td></tr>
<tr><td>Filenames</td><td><code>autoexec.bat</code></td></tr>
<tr><td>File paths</td><td><code>c:\mcc18\h</code></td></tr>
<tr><td>Keywords</td><td><code>_asm, _endasm, static</code></td></tr>
<tr><td>Command-line options</td><td><code>-Opa+, -Opa-</code></td></tr>
<tr><td>Bit values</td><td><code>0, 1</code></td></tr>
<tr><td>Constants</td><td><code>0xFF, ‘A’</code></td></tr>
<tr><td>Italic Courier</td><td>A variable argument</td><td><code>file.o</code>, where <code>file</code> can be any valid filename</td></tr>
<tr><td>Square brackets [ ]</td><td>Optional arguments</td><td><code>mcc18 [options] file [options]</code></td></tr>
<tr><td>Curly brackets and pipe character: { | }</td><td>Choice of mutually exclusive arguments; an OR selection</td><td><code>errorlevel {0|1}</code></td></tr>
<tr><td rowspan="2">Ellipses...</td><td>Replaces repeated text</td><td><code>var_name [, var_name...]</code></td></tr>
<tr><td>Represents code supplied by user</td><td><code>void main (void)
{ ...
}</code></td></tr>
</table>

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 on the Microchip web site (www.microchip.com).

RECOMMENDED READING

This user's guide describes how to use the dsPICDEM 80-Pin Starter Development Board. Other useful Microchip documents that are available and recommended as supplemental reference resources include:

Readme for dsPICDEM 80-Pin Starter Development Board

For the latest information on using dsPICDEM 80-Pin Starter Development Board, read the “`Readme for` dsPICDEM 80-Pin Starter Development 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.

dsPIC30F Family Reference Manual (DS70046)

Consult this document for detailed information on dsPIC30F device operation. This reference manual explains the operation of the dsPIC30F Digital Signal Controller (DSC) family architecture and peripheral modules but does not cover the specifics of each device. Refer to the appropriate device data sheet for device-specific information.

dsPIC30F/dsPIC33F Programmer’s Reference Manual (DS70157)

This manual is a software developer’s reference for the dsPIC30F and dsPIC33F 16-bit DSC family of devices. It describes the instruction set in detail and also provides general information to assist in developing software for these dsPIC® DSC families.

dsPIC33F Family Data Sheet (DS70165)

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

- Device memory map
- Device pinout and packaging details
- Device electrical specifications
- Overview of peripherals included in the device

PIC24H Family Data Sheet (DS70175)

Consult this document for detailed information on the PIC24H 16-bit MCU family. Reference information found in this data sheet includes:

- Device memory map
- Device pinout and packaging details
- Device electrical specifications
- Overview of peripherals included in the device

PIC24FJ128GA Family Device Data Sheet (DS39474)

Consult this document for detailed information on the PIC24FJ128GA 16-bit MCU. Reference information found in this data sheet includes:

- Device memory map
- Device pinout and packaging details
- Device electrical specifications
- Overview of peripherals included in the device

dsPIC30F6011A/6012A/6013A/6014A Data Sheet (DS70143)

Consult this document for detailed information on dsPIC30F6011A, dsPIC30F6012A, dsPIC30F6013A and dsPIC30F6014A Digital Signal Controllers. Reference information found in this data sheet includes:

- Device memory map
- Device pinout and packaging details
- Device electrical specifications
- Overview of peripherals included in the device

MPLAB® ASM30, MPLAB® LINK30 and Utilities User's Guide (DS51317)

This document details Microchip Technology's language tools for dsPIC DSC devices based on GNU technology. The language tools discussed are:

- MPLAB ASM30 Assembler
- MPLAB LINK30 Linker
- MPLAB LIB30 Archiver/Librarian
- Other Utilities

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

This document details the use of Microchip's MPLAB C30 C Compiler for dsPIC DSC 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.

To obtain any of these documents, contact the nearest Microchip sales location (see back page) or visit the Microchip web site at www.microchip.com.

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 change 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 (October 2005)

- Initial Release of this Document.

Revision B (March 2006)

- Updated document to include dsPIC33F Digital Signal Controllers, and PIC24F and PIC24H MCU information.

Chapter 1. Introduction

1.1 INTRODUCTION

The dsPICDEM 80-Pin Starter Development Board is a development kit and evaluation tool for dsPIC high-performance DSCs and PIC24 MCUs.

> **Note:** The term dsPIC DSC used throughout this manual refers to both the dsPIC30F and dsPIC33F device families. Unless specified otherwise, these devices can be used interchangeably. Similarly, the term PIC24 MCU refers to both the PIC24F and PIC24H device families.

1.2 HIGHLIGHTS

This chapter discusses:

- dsPICDEM 80-Pin Starter Development Board Kit Contents
- dsPICDEM 80-Pin Starter Development Board Functionality and Features
- dsPICDEM 80-Pin Starter Development Board Demonstration Program
- Reference documents

1.3 dsPICDEM 80-PIN STARTER DEVELOPMENT BOARD KIT CONTENTS

The following items comprise the dsPICDEM 80-Pin Starter Development Board Kit:

- The dsPICDEM 80-Pin Starter Development Board printed circuit board (see Figure 1-1).
- A preprogrammed dsPIC30F6014A device soldered onto an adapter board, which plugs into the Emulation Header on the dsPICDEM 80-Pin Starter Development Board (see Figure 1-2).
- dsPICDEM 80-Pin Starter Development Board CD-ROM containing various demonstration programs provided by Microchip.

FIGURE 1-1: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD

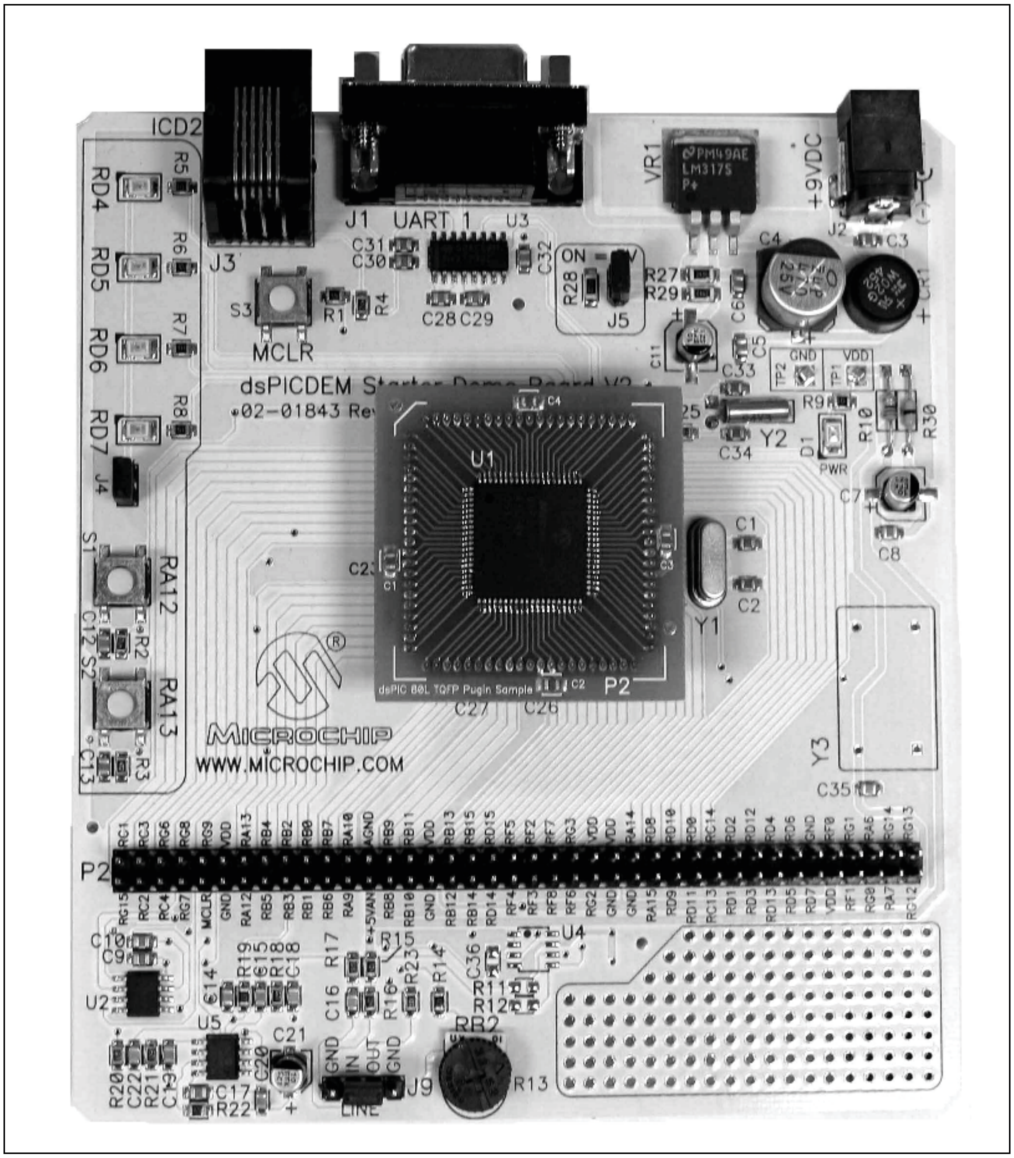
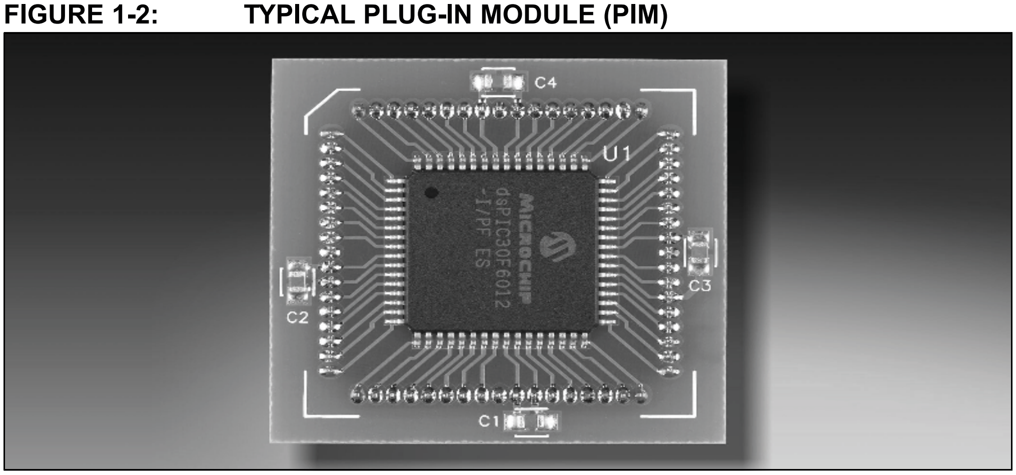


FIGURE 1-2: TYPICAL PLUG-IN MODULE (PIM)



For information on the components used on the dsPICDEM 80-Pin Starter Development Board see **Chapter 4. "dsPICDEM™ Development Board Hardware"**.

1.4 FUNCTIONALITY AND FEATURES

The dsPICDEM 80-Pin Starter Development Board provides the following capabilities:

Development Board Power

- On-board variable voltage regulator for 3.3V and 5.0V output with direct input from 9V, AC/DC wall adapter
- 9 VDC power source input jack for development board
- Power-on indicator LED

MPLAB ICD 2 and MPLAB ICE 4000 Connections

- MPLAB ICD 2 programming connector
- Emulation header for connection to MPLAB ICE 4000
- Pad location for 80-pin TQFP dsPIC DSC device

Serial Communication Channel

- Single RS-232 communication channel

Analog

- One 10 kΩ Potentiometer (RP2)
- Microchip MCP41010 Digital Potentiometer
- Microchip MCP6022 Operational Amplifier
  - Output configured as low-pass filter for digital potentiometer
  - Input configured as low-pass filter for sampling input signals with the ADC

Device Clocking

- 7.37 MHz crystal (Y1) for dsPIC DSC device

Miscellaneous

- Reset push button switch (S3) for resetting the dsPIC DSC device
- Four red LEDs (RD4-RD7)
- Two push button switches (S1-S2) for external input stimulus
- 80-pin dual-row header with labeled pinouts.
- Prototype area for user hardware
- Supports 100-to-80-pin dsPIC33F and PIC24 Plug-in Modules

1.5 dsPICDEM 80-PIN STARTER DEVELOPMENT BOARD DEMONSTRATION PROGRAM

The dsPICDEM 80-Pin Starter Development Board is supplied with a pre-loaded demonstration program that exercises principal CPU functions and peripheral options that allow interaction with the program as follows:

- Demonstrates interrupt handling by using switches S1 and S2 to blink LEDs RD4 and RD5, respectively.
- Demonstrates digital-to-analog conversion by generating an audio tone on LINE OUT.
- Demonstrates analog-to-digital conversion by adjusting Potentiometer RP2 and transmitting the resulting digital value to the HyperTerminal on a PC.

Refer to **Chapter 3. “Demonstration Program Operation”** for details on the demonstration code operation.

1.6 REFERENCE DOCUMENTS

The following documentation is available to support the use of the dsPICDEM 80-Pin Starter Development Board:

- *"dsPIC30F Family Reference Manual"* (DS70046)
- *"dsPIC30F Family Reference Manual Errata"* (DS80169)
- *"dsPIC30F/33F Programmer's Reference Manual*" (DS70157)
- *"dsPIC30F6011A/6012A/6013A/6014A Data Sheet"* (DS70143)
- *"dsPIC33F Family Data Sheet"* (DS70165)
- *"PIC24H Family Data Sheet"* (DS70175)
- *"PIC24FJ1285A Data Sheet* (DS39747)
- *MPLAB® C30 C Compiler User's Guide"* (DS51284)
- *"MPLAB® ASM30, MPLAB® LINK30 and Utilities User's Guide"* (DS51317)
- *"Using MPLAB® ICD 2"* poster (DS51265)
- *"MPLAB® ICE Emulator User's Guide*" (DS51159)

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. Tutorial

2.1 INTRODUCTION

This chapter is a self-paced tutorial to get you started using the dsPICDEM 80-Pin Starter Development Board.

2.2 HIGHLIGHTS

Items discussed in this chapter include:

- Tutorial Overview
- Creating the Project
- Building the Code
- Programming the Chip
- Debugging the Code
- Summary

2.3 TUTORIAL OVERVIEW

The tutorial program in `Eg1_BlinkLed.s` is written in assembly code. This program blinks an LED when a key is pressed. The source file is used with a linker script file (`p30f6014a.gld`) and an include file (`p30f6014a.inc`) to form a complete project. This simple project uses a single source code file; however, more complex projects might use multiple assembler and compiler source files as well as library files and precompiled object files.

There are four 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.
4. Debugging the code with the MPLAB ICD 2.

Note:	The following tutorial instructions assume the use of the dsPIC30F6014A device, which is supplied with the dsPICDEM 80-Pin Starter Development Board. However, this information applies to any of the dsPIC30F, dsPIC33F, PIC24F and PIC24H devices supported by the board.

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 7.20 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.

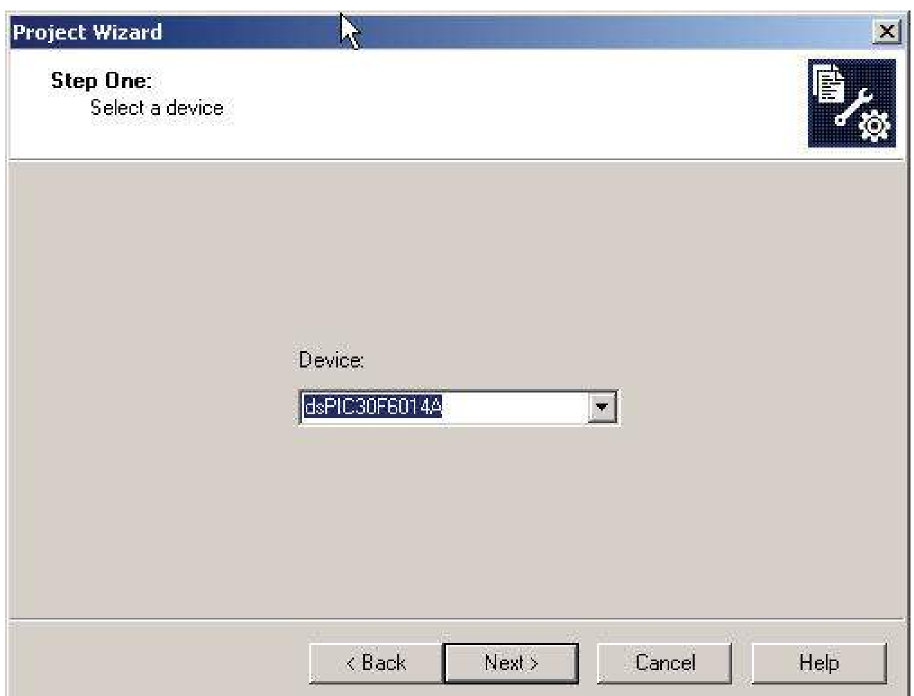
A workspace contains one or more projects and information on the selected device, debug tool and/or programmer, open windows and their location and other MPLAB IDE configuration settings.

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 Development Kit Software CD-ROM, copy the `Eg1_BlinkLed.s` file into this folder.

2.4.1 Select a Device

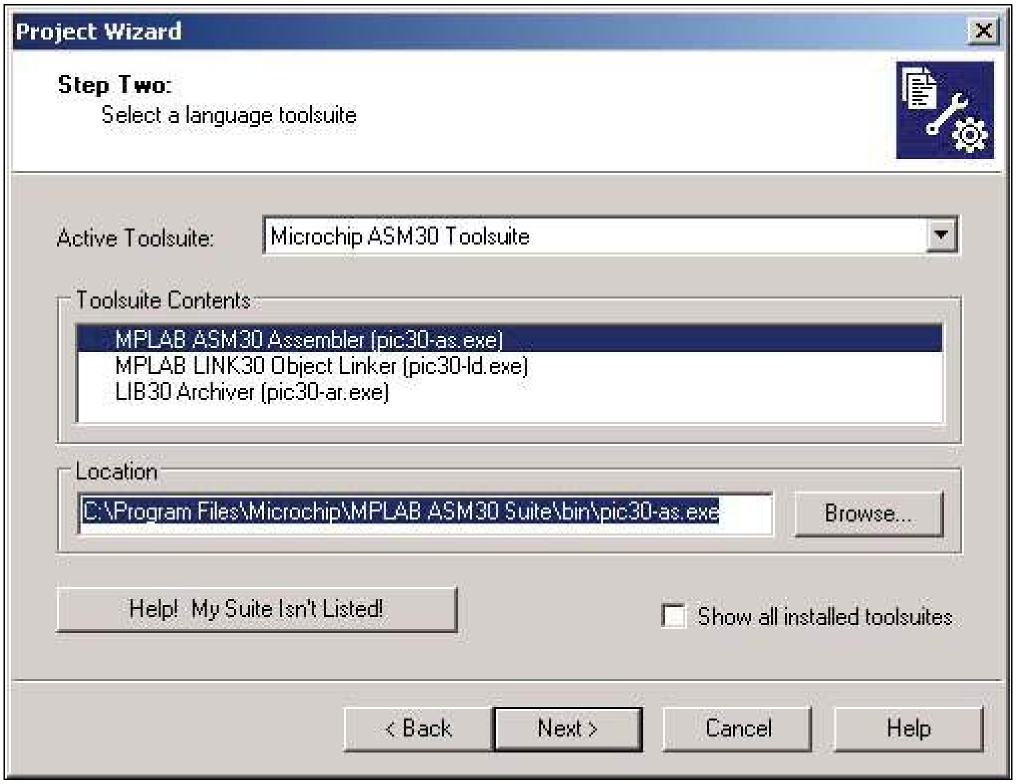
1. Start MPLAB IDE.
2. Close any workspace that might be open (*File>Close Workspace*).
3. From the *Project* menu, select *Project Wizard.*
4. From the Welcome screen, click **Next** to display the Project Wizard Step One dialog (see Figure 2-1).

FIGURE 2-1: PROJECT WIZARD, STEP 1, SELECT A DEVICE



5. From the **Device:** pull-down list, select `dsPIC30F6014A` and click **Next >**. The Project Wizard Step Two dialog displays as shown in Figure 2-2.

FIGURE 2-2: PROJECT WIZARD, STEP 2, SELECT LANGUAGE TOOLSUITE



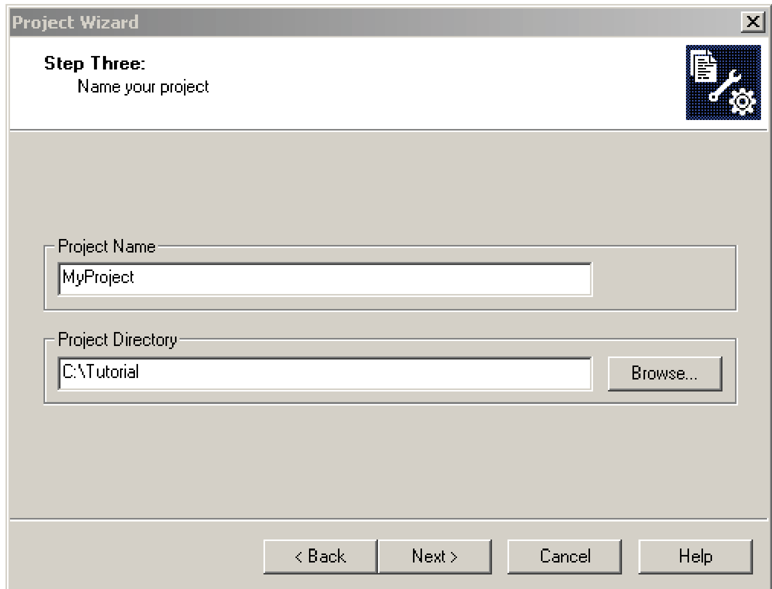
2.4.2 Select Language Toolsuite

1. From the **Active Toolsuite** pull-down menu, select Microchip ASM30 Toolsuite. This toolsuite includes the assembler and linker that will be used (the C compiler is not used).
2. In the **Toolsuite Contents** block, select MPLAB ASM 30 Assembler (pic30-as.exe).
3. In the **Location** block, click **Browse...** and navigate to:
   `C:\Program Files\Microchip\MPLAB ASM30 Suite\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 ASM30 Suite\Bin\pic30-ld.exe`

Note:	If you have the MPLAB C30 Toolsuite installed, browse to the `C:\program files\microchip\MPLAB C30\bin\` location.

5. Click **Next >** to continue. The Project Wizard Step Three dialog displays (see Figure 2-3).

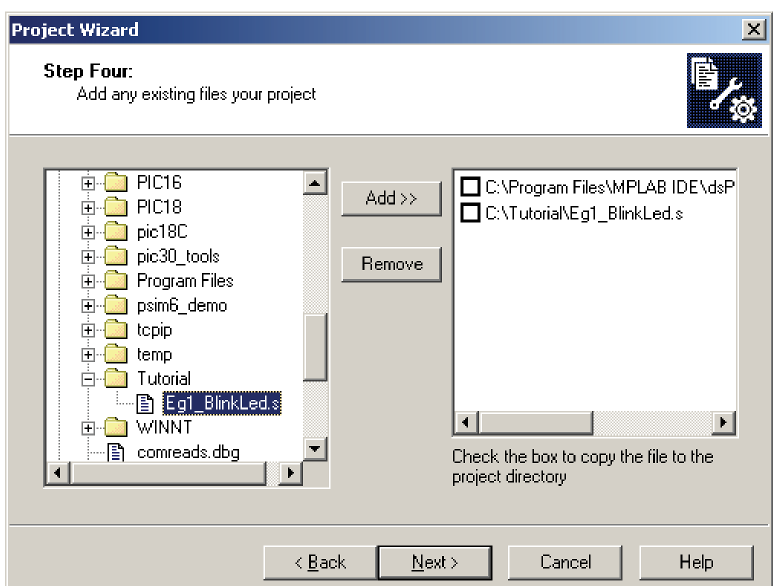
FIGURE 2-3: PROJECT WIZARD, STEP 3, NAME YOUR PROJECT



2.4.3 Name Your Project

1. In the Project Name text box, type **MyProject.**
2. 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 (see Figure 2-4).

FIGURE 2-4: PROJECT WIZARD, STEP 4, ADD FILES TO PROJECT

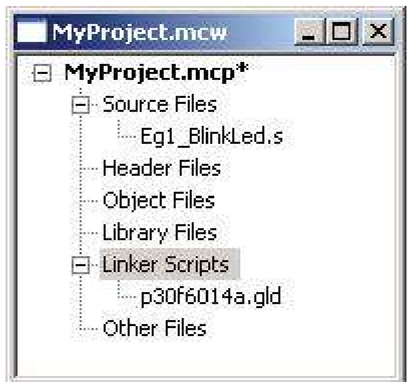


2.4.4 Add Files to Project

1. From the list of folders on the PC, locate the C:\Tutorial folder and select the `Eg1_BlinkLed.s` file.
2. Click **Add>>** to include the file in the project.
3. Expand the `C:\Program Files\Microchip\MPLAB ASM30 Suite\Support\gld` folder and select the `p30f6014a.gld` file.
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.**

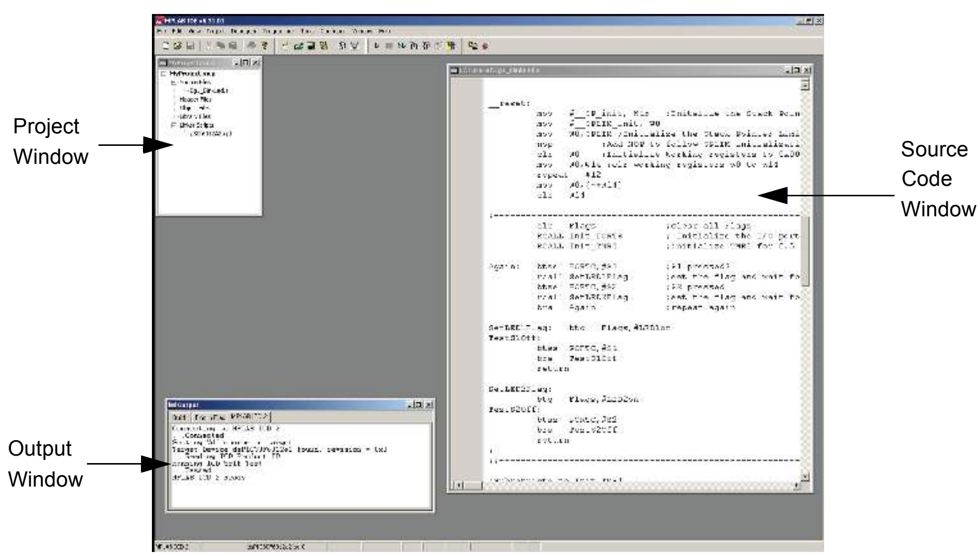
After the project wizard completes, the MPLAB project window shows the `Eg1_BlinkLed.s` file in the Source Files folder and the `p30f6014a.gld` file in the Linker Scripts folder (see Figure 2-5).

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 `Eg1_BlinkLed.s` file 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 assembling the `Eg1_BlinkLed.s` file to create an object file `Eg1_BlinkLed.o` and then linking the object file to create the `Eg1_BlinkLed.hex` and `Eg1_BlinkLed.cof` output files. 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.

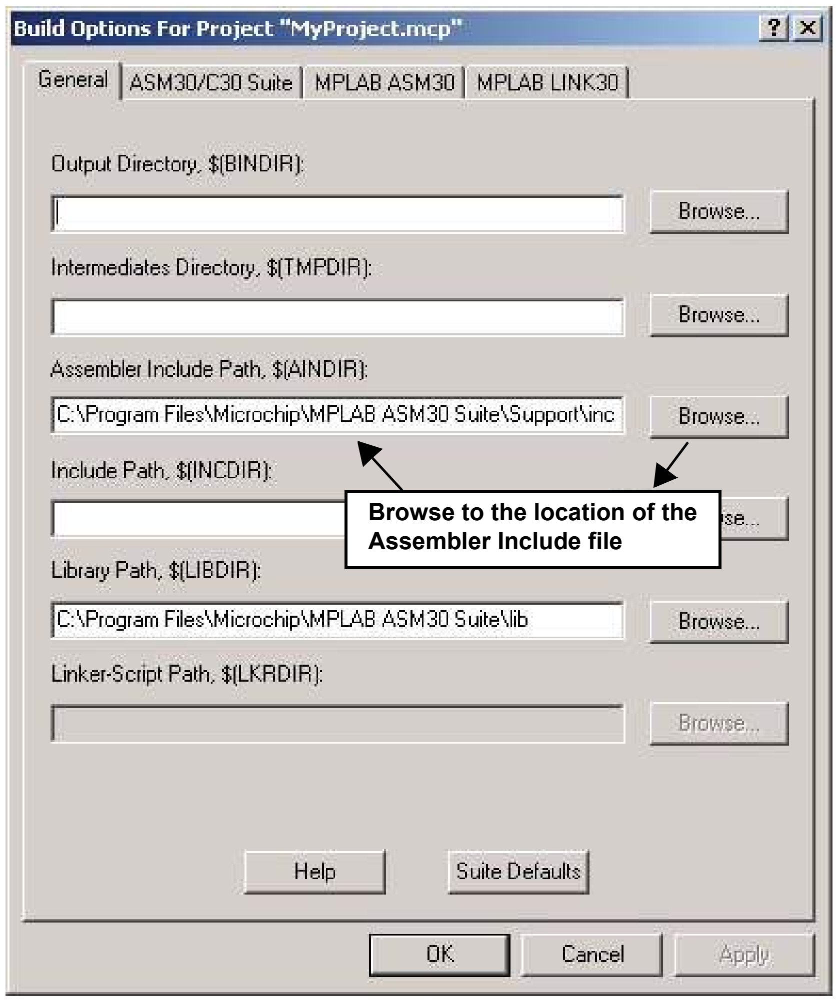
The following line is near the top of the `Eg1_BlinkLed.s` file:

```
.include "p30f6014a.inc"
```

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 (see Figure 2-7).

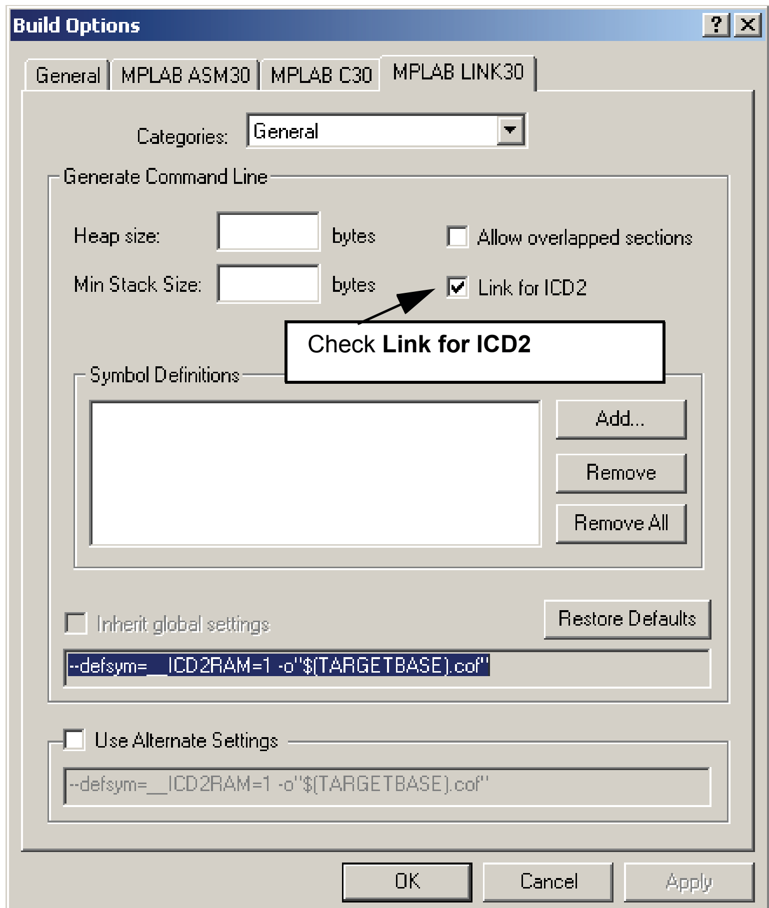
FIGURE 2-7: BUILD OPTIONS



2.5.1 Identify Assembler Include Path

1. Select the **General** tab.
2. At the Assembler Include Path, $(AINDIR):box, click **Browse...** and navigate to:
   `C:\Program Files\Microchip\MPLAB ASM30 Suite\Support\inc`
   This path tells MPLAB IDE where to find the include files.
3. Select the **MPLAB LINK30** tab to view the linker settings (see Figure 2-8).

FIGURE 2-8: MPLAB® LINK30 BUILD OPTIONS



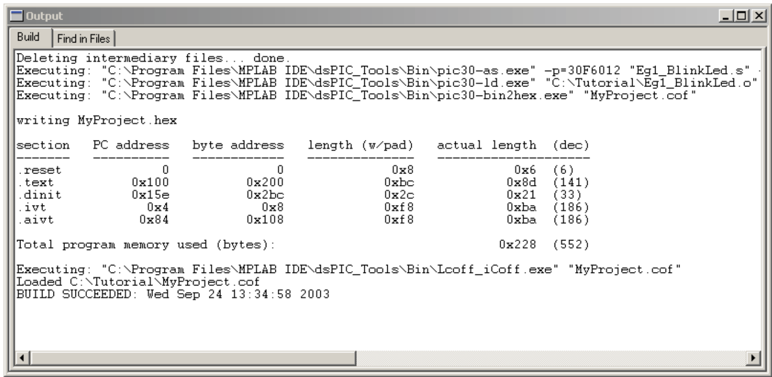
2.5.2 Link for MPLAB ICD 2

1. Check **Link for ICD 2**.
2. Click **OK**. The text box closes while the linker reserves space for the debug code used by the MPLAB ICD 2.
3. Click **OK** again to save these changes. The project is now ready to build.

2.5.3 Build the Project

1. From the *Project* menu, select *Make*. The Build Output window displays.
2. Observe the progress of the build.
3. When the BUILD SUCCEEDED message displays (see Figure 2-9), you are ready to program the device.

FIGURE 2-9: BUILD OUTPUT



2.6 PROGRAMMING THE CHIP

The MPLAB ICD 2 In-Circuit Debugger is used to program and debug the dsPIC30F6014A device in-circuit on the dsPICDEM 80-Pin Starter 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).

Use the procedures in the following section to program the dsPIC30F6014A device.

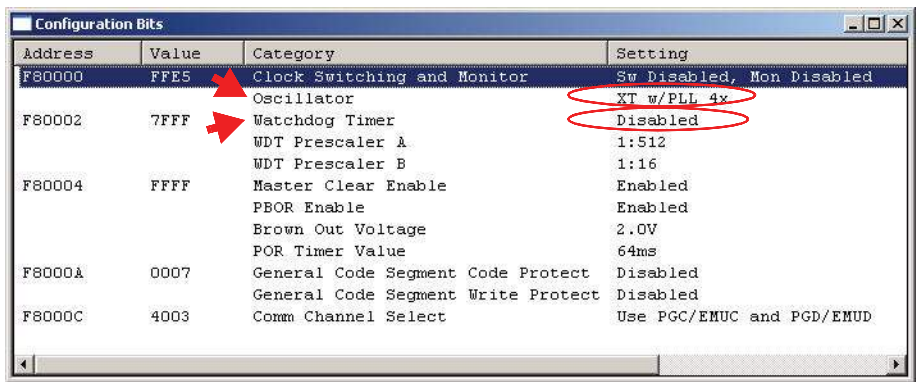
2.6.1 Set Up The Device Configuration

1. Use the *Configure>Configuration Bits* menu to display the configuration settings.
2. Set up the configuration bits, as shown in Figure 2-10.

   The settings that will most likely need to change are:

Oscillator	XT w/PLL 4x
Watchdog Timer	Disabled

FIGURE 2-10: CONFIGURATION SETTINGS



Address	Value	Category	Setting
F80000	FFE5	Clock Switching and Monitor	Sw Disabled, Mon Disabled
		Oscillator	XT w/PLL 4x
F80002	7FFF	Watchdog Timer	Disabled
		WDT Prescaler A	1:512
		WDT Prescaler B	1:16
F80004	FFFF	Master Clear Enable	Enabled
		PBOR Enable	Enabled
		Brown Out Voltage	2.0V
		POR Timer Value	64ms
F8000A	0007	General Code Segment Code Protect	Disabled
		General Code Segment Write Protect	Disabled
F8000C	4003	Comm Channel Select	Use PGC/EMUC and PGD/EMUD

2.6.2 Connect the MPLAB ICD 2 In-Circuit Debugger

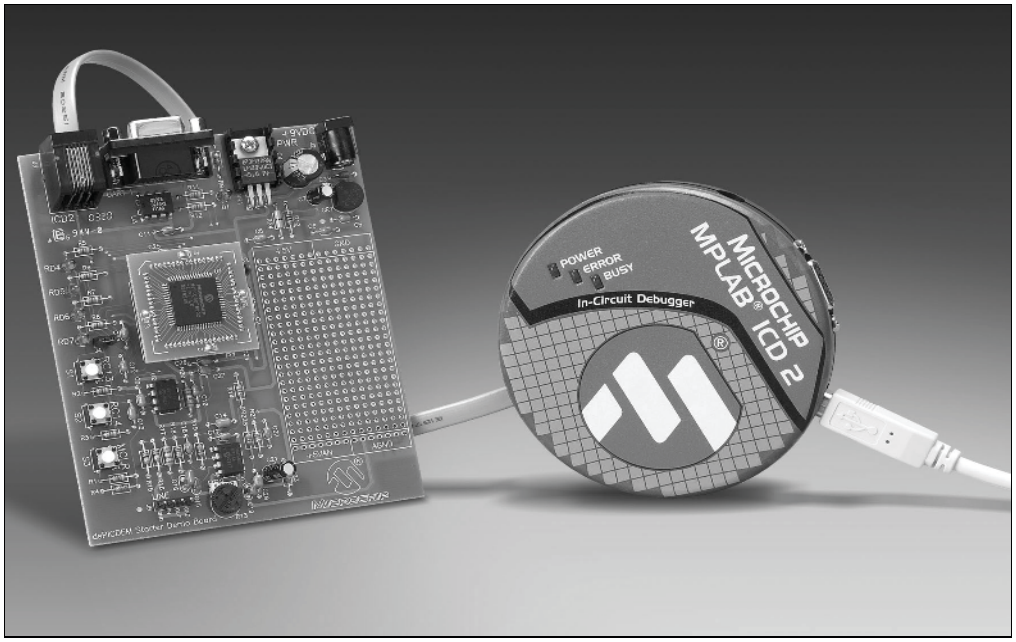
1. Connect the MPLAB ICD 2 to the PC with the USB cable (see Figure 2-11).
2. Connect the MPLAB ICD 2 to the dsPICDEM 80-Pin Starter Development Board with the short RJ-11 (telephone) cable.

CAUTION

Before you apply power to the board, observe these voltage precautions:
If a dsPIC33F device is being used, J5 should be OPEN or OFF to enable 3.3V to the VDD or supply voltage. Operating a dsPIC33F device at 5.0V will cause a catastrophic failure of the device.
If a dsPIC30F device is being used, J5 can be open or closed. You will get 3.3V or 5.0V voltage to the VDD pin.

3. Apply power to the board.

FIGURE 2-11: TYPICAL dsPIC® DSC DEVELOPMENT BOARD CONNECTED TO MPLAB® ICD 2

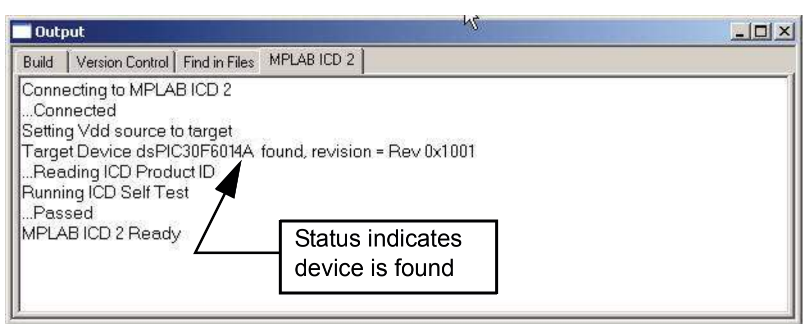


2.6.3 Enable MPLAB ICD 2 Connection

1. From the _Debugger_ menu, click _Select Tool>MPLAB ICD 2_ to set the MPLAB ICD 2 as the debug tool in MPLAB IDE.
2. From the _Debugger_ menu, select _Connect_ to connect the debugger to the device. MPLAB IDE should report that it found the dsPIC30F6014A device, as shown in Figure 2-12.

Note:	MPLAB IDE may need to download new firmware if this is the first time the MPLAB ICD 2 is being used with a dsPIC30F device. Allow it to do so. If any errors are shown, double click the error message to get more information.

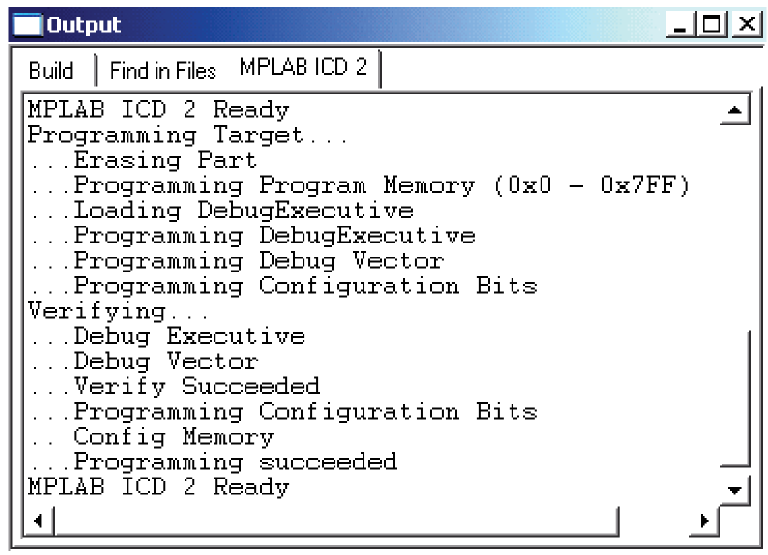
FIGURE 2-12: ENABLING MPLAB® ICD 2



2.6.4 Program the dsPIC30F6014A Device

1. From the *Debugger* menu, select *Program* to program the part. The output window (Figure 2-13) 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 2-13: PROGRAMMING THE dsPIC® DSC DEVICE



3. Use the *Debugger>Run* menu to run the code. LED1 should start blinking when S1 is pressed.

2.7 DEBUGGING THE CODE

The MPLAB ICD 2 In-Circuit Debugger is used to run, halt and step the code. A breakpoint can be set so that the program halts once the code has executed the instruction at the breakpoint. The contents of the RAM and registers can be viewed whenever the processor has been halted.

The MPLAB ICD 2 In-Circuit Debugger uses the following function keys to access the main debugging functions:

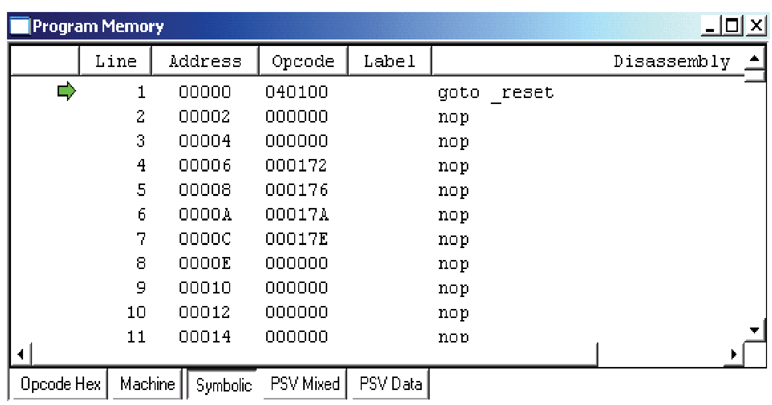
<F5>	Halt
<F6>	Reset
<F7>	Single Step
<F9>	Run

In addition, there are more functions available by right clicking on a line of source code. The most important of these are "Set Breakpoint" and "Run to Cursor".

2.7.1 Display the Code

1. From the *View* menu, select the *Program Memory* menu.
2. On the Program Memory window, select the **Symbolic** tab, as shown in Figure 2-14.

FIGURE 2-14: PROGRAM MEMORY WINDOW



3. Press <F5> to halt the processor and press <F6> to reset. The program memory now shows a green arrow pointing to the line of code at address 00000, the reset location.

   The instruction at this location is `goto _reset`. This code is added by the linker to make the program branch to the start of the code in the `Eg1_BlinkLed.s` file. The code uses the `_reset` label at the start of the executable code and declares the label as global to have visibility outside the source file. See Example 2-1.

EXAMPLE 2-1: CODE START-UP

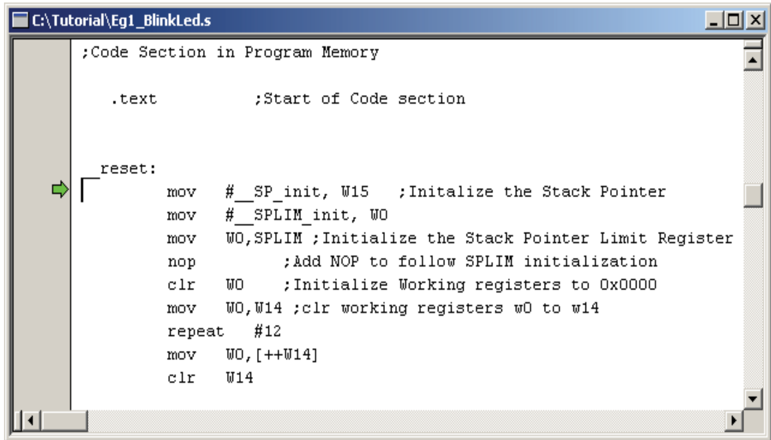
```
.global __reset
..text
    __reset:       mov    #__SP_init, W15 Pointer
                   mov    #__SPLIM_init, W0
                   mov    W0, SPLIM
```

The linker also provides values for the `__SP_init` and `__SPLIM_init` constants to initialize the Stack Pointer (W15) since the linker determines what RAM is available for the stack.

2.7.2 Step the Program

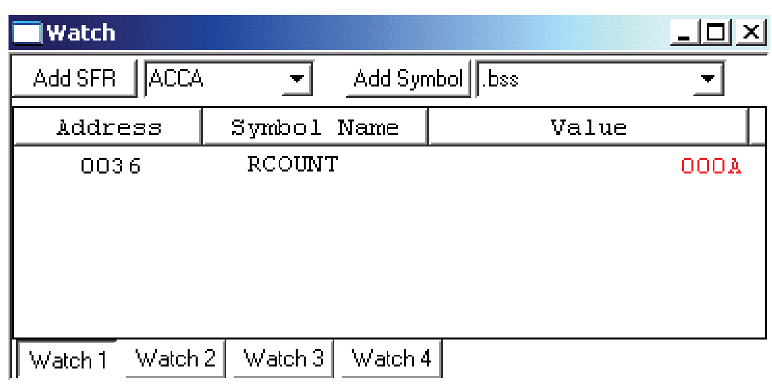
1. Press <F7> to single step the code. The green arrow moves to the code at `__reset` in the `Eg1_BlinkLed.s` source code, as shown in Figure 2-15.

FIGURE 2-15: SOURCE CODE WINDOW



2. Right click the line of code `mov W0,W14` and choose *Run to Cursor*. The green arrow moves to `repeat #12` because it has executed the prior lines of code up to and including `mov W0,W14`.
3. From the *View* menu, select *Watch* to open a Watch window, and select **RCOUNT** in the **Add SFR** pull-down list.
4. Click **Add SFR** to add the RCOUNT register to the Watch window.
5. Press <F7> a few times and watch the RCOUNT value decrement (see Figure 2-16). RCOUNT is the repeat loop counter and decrements to zero as the instruction in a repeat loop is executed several times.

FIGURE 2-16: WATCH WINDOW DISPLAY



2.7.3 Set Breakpoint

1. To set a breakpoint, right click a code line and select *Set Breakpoint* from the pop-up menu.

> **Note:** An alternate method is to simply double click the line. This feature may need to be enabled in the *Edit>Properties* menu.

As an example, find the following line of code and set a breakpoint on this line:

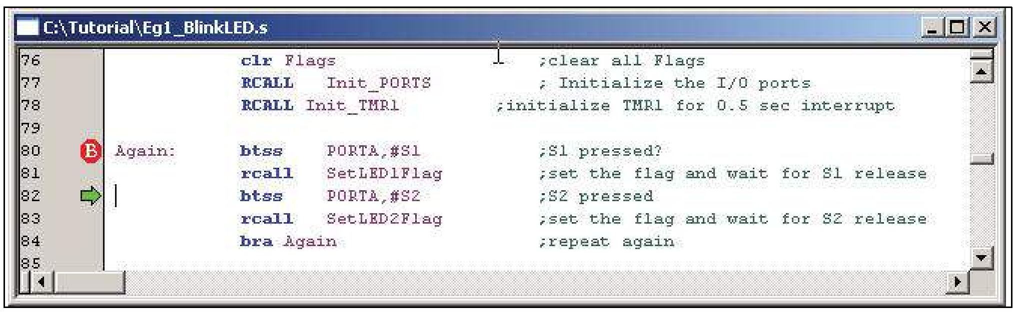
```
Again:   btss   PORTA,#S1
```

A red stop sign should appear in the gutter (gray bar on the left) of the source code window.

2. Press <F9> to run the code. The program halts on the instruction following the breakpoint as shown in Figure 2-17.

> **Note:** The instruction on which the code halts could be elsewhere in the code if the breakpoint is set on a branch or call instruction. Refer to Section 12 titled “Important Notes” in the Readme for `MPLAB ICD 2.txt` file located in the `C:\MPLAB IDE\READMES` directory for additional operational information on the MPLAB ICD 2.

FIGURE 2-17: SETTING BREAKPOINT



In this example, every time <F9> is pressed to run the code, it sends one character to the display and stops at the breakpoint. After the first four spaces, the characters will start to appear on the LCD display.

2.8 SUMMARY

This tutorial demonstrates the main features of MPLAB IDE and MPLAB ICD 2 as they are used with the dsPICDEM 80-Pin Starter Development Board. 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 MPLAB ICD 2
- Program the chip with MPLAB ICD 2
- View the code execution in program memory and source code
- View registers in a Watch window
- Set a breakpoint and make the code halt at a chosen location
- Use the function keys to Reset, Run, Halt and Single Step the code

Chapter 3. Demonstration Program Operation

3.1 INTRODUCTION

The dsPICDEM 80-Pin Starter Development Board is shipped with example applications programmed into the dsPIC DSC device. These examples exercise several of the dsPIC DSC peripherals such as the 12-bit Analog-to-Digital Converter (ADC) and UART interfaces. This chapter provides an overview of the demonstration code. Detailed information on the dsPICDEM 80-Pin Starter Development Board hardware is presented in **Chapter 4. "dsPICDEM™ Development Board Hardware"** and **Appendix A. "Drawings and Schematics"**.

3.2 HIGHLIGHTS

Items discussed in this chapter are:

- Demonstration Program Summary
- Demonstration Code Operation
- Board Self-test

3.3 DEMONSTRATION PROGRAM SUMMARY

The preprogrammed demonstration program includes two functionally separate code modules:

- Demonstration code module
- Board self-test code module

These two code modules have been combined into one composite program and coded into the device. The board self-test code module has been included on the CD as a library archive only and is briefly discussed at the end of this section. The following sections present the operation of each module.

When power is applied to the dsPICDEM 80-Pin Starter Development Board, the dsPIC DSC device begins executing the demonstration program, which consists of three distinct functional tasks:

- Interrupt processing
- Analog-to-digital conversion
- Digital-to-analog conversion

3.3.1 Interrupt Processing

To illustrate interrupt processing, the demonstration program uses switches S1 and S2 as signals to drive LEDs RD4 and RD5 (output devices). When switch S1 is pressed (to represent an interrupt), LED RD4 blinks at a 1 Hz rate (once per second) until switch S1 is pressed again. Similarly, when switch S2 is pressed, LED RD5 blinks until switch S2 is pressed again. Timer 1 is set up to interrupt every half second.

The dsPIC DSC device functionality used in this demonstration program includes:

- Setting up I/O ports
- Setting up timer interrupts
- Handling interrupts

To observe this demonstration, close jumper J4 to enable the LEDs, then operate the switches.

3.3.2 Analog-to-Digital Conversion

To illustrate analog-to-digital conversion, the analog value of potentiometer R13 is converted by the Analog-to-Digital Converter, ADC12, to a digital value that is transmitted via UART1 to a PC.

When the HyperTerminal accessory in Microsoft Windows® is connected to the serial port on the dsPICDEM 80-Pin Starter Development Board, it receives and displays a stream of three-digit HEX codes that correspond to the 12-bit output value of ADC12. As the potentiometer R13 is adjusted, the displayed HEX code changes within a range from 000 to FFF.

The dsPIC30F device functionality used for this demonstration includes:

- Conversion of an analog signal to a 12-bit digital signal
- Conversion of the 12-bit ADC value to HEX and ASCII format
- UART communication handling

To implement this demonstration, connect the J1 connector on the dsPICDEM 80-Pin Starter Development Board to the RS-232 serial port on the PC with a DB9 cable. Using the HyperTerminal program available as a Microsoft Windows communications accessory, configure the serial port to 2400 baud, 8 bits with 1 stop bit, no parity and no flow control.

3.3.3 Digital-to-Analog Conversion

To illustrate digital-to-analog conversion, the dsPICDEM 80-Pin Starter Development Board uses the MCP41010 digital potentiometer and MCP6022 Operational Amplifier (configured as a low-pass filter) to deliver an audio tone to the LINE OUT pin. The digital input is derived from a table of HEX values in data memory. The demo program cycles through the table and delivers the selected value to the digital potentiometer via the Serial Peripheral Interface (SPI) module on the dsPIC DSC device. The table values cover the full range of the digital potentiometer.

The program communicates a new table value to the digital potentiometer every 125 microseconds, which generates a 400 Hz audio signal out of the low-pass filter. Switches S1 and S2 are used to change the output frequency to 800 Hz and 1600 Hz, respectively.

The dsPIC DSC device functionality used for this demonstration includes:

- Mapping of data memory to program memory with PSV addressing
- Initialization of the SPI port
- Loading and transmission of data using hardware SPI

To observe this demonstration, connect an oscilloscope probe to pin 2 of J9 (the LINE OUT pin).

3.4 DEMONSTRATION CODE OPERATION

The following sections describe in more detail how the demonstration programs interact with and take advantage of key dsPIC DSC, DSP and peripheral features. Full details on the peripheral functionality and associated tasks are presented later in this document.

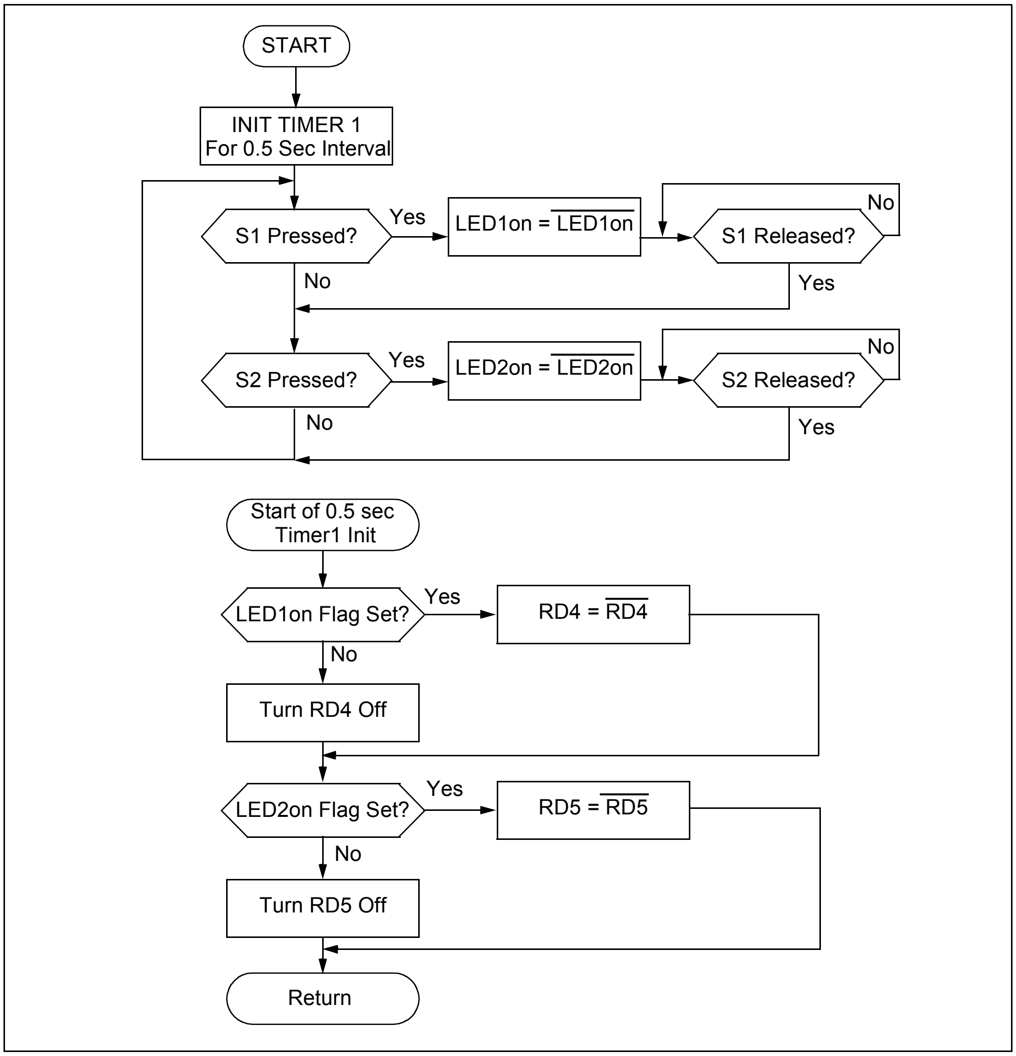
3.4.1 Interrupt Processing

The demonstration code samples switches S1 and S2 and uses their status to operate the LEDs associated with processor ports RD4 and RD5, respectively. If S1 is pressed, it sets program flag "`LED1on`". If S1 is pressed again, it resets program flag `LED1on`. Similarly, if S2 is pressed, it toggles program flag `LED2on`.

Another interrupt routine checks flags `LED1on` and `LED2on` every 500 milliseconds. If the `LED1on` is true, the LED labeled RD4 is toggled on and off every 0.5 seconds, causing the LED to blink. If `LED1on` is not true, the LED remains off.

This demo program is illustrated in Figure 3-1.

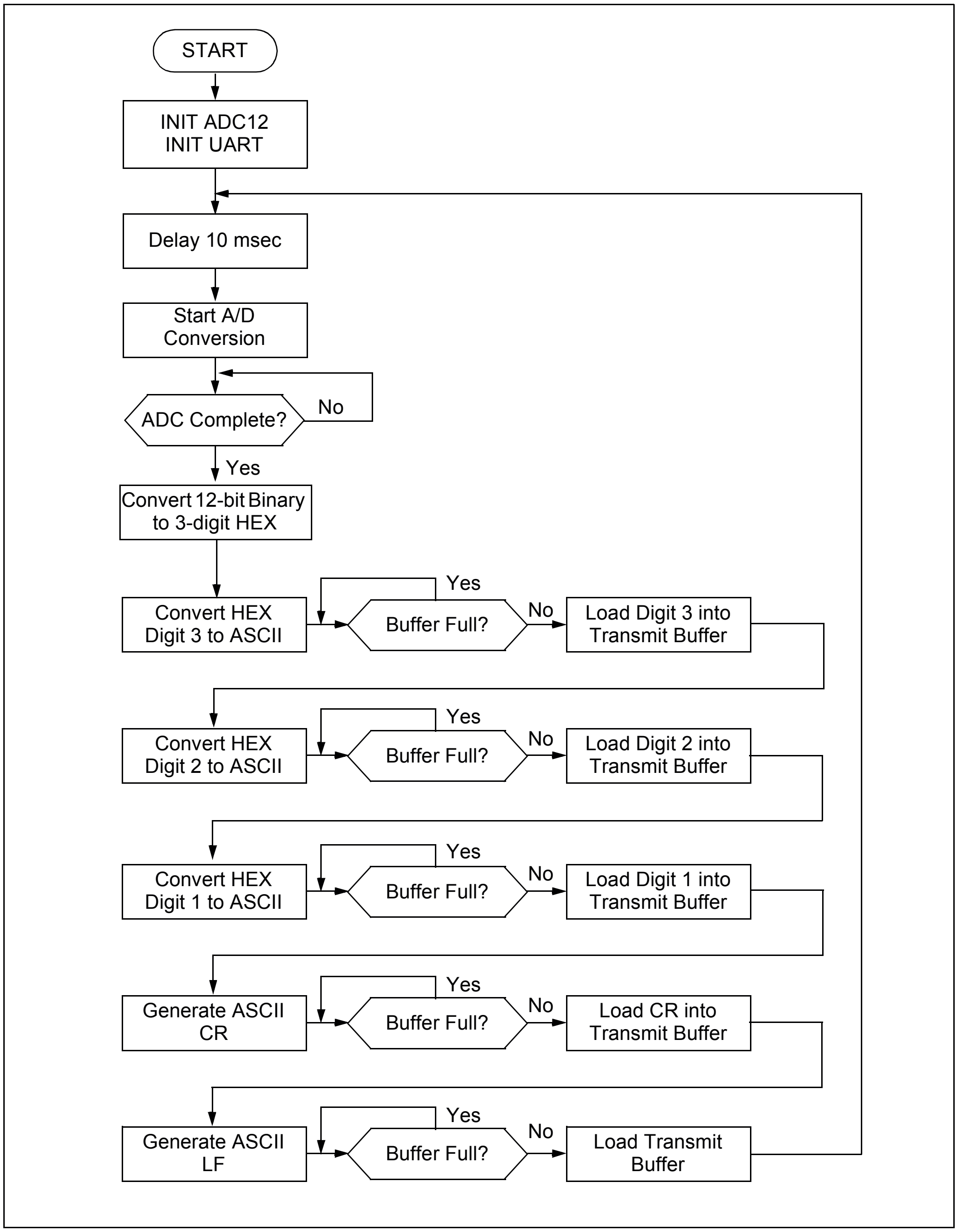
FIGURE 3-1: INTERRUPT PROCESSING FLOW DIAGRAM



3.4.2 Analog-to-Digital Conversion

This program consists of two subroutines which (1) perform the A/D conversion and (2) transmit the converted value over an RS-232 serial connection (see Figure 3-2). The A/D conversion routine samples the analog output of Potentiometer RB2. The transmit routine converts the 12-bit binary value from ADC12 to a three-digit HEX code, converts the HEX code to an ASCII character and loads the ASCII value into the transmission buffer of UART1. UART1 transmits each ASCII character with a CR and LF to delimit each sample as a separate line on the receiving terminal.

FIGURE 3-2: ANALOG-TO-DIGITAL CONVERSION FLOW DIAGRAM



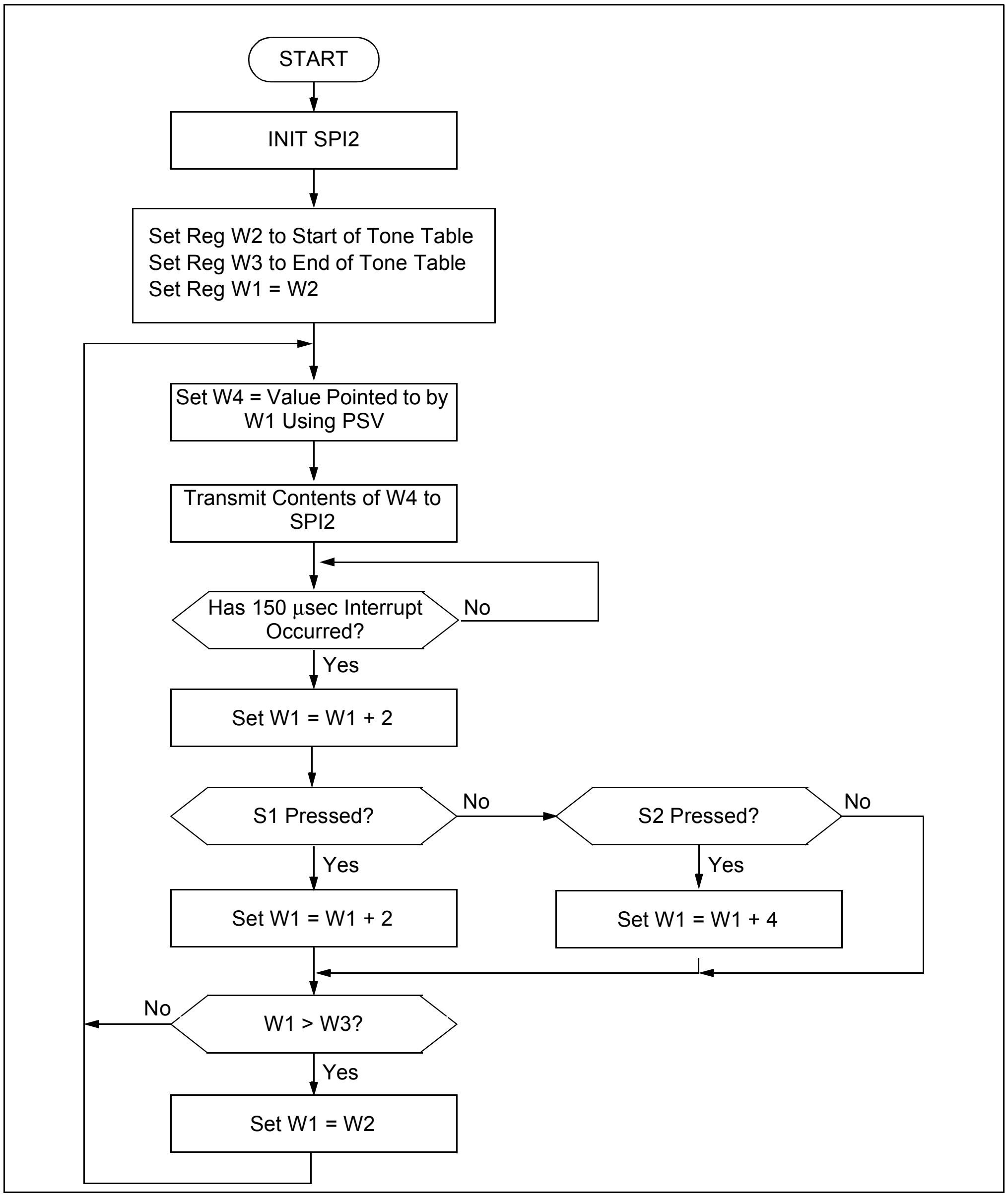
3.4.3 Digital-to-Analog Conversion

This program uses Digital Potentiometer MCP41010 on the dsPICDEM 80-Pin Starter Development Board as a D/A converter to generate a sine-wave signal (audio tone) to the LINE OUT pin. The digital potentiometer is driven by the output of the serial peripheral interface SPI2 of the dsPIC30F6014A device, which receives its input from the program.

The program retrieves HEX values from a table in data memory and delivers it to the SPI. Thirty-two stored values cover the full range of the digital potentiometer. As the analog output of the digital potentiometer passes through the MCP6022 Operational Amplifier (configured as a low-pass filter) it results in a 400 Hz sine wave based on a new table value every 125 μsec covering all 32 table values. The sine wave is placed on the LINE OUT pin of the development board.

Figure 3-3 illustrates the digital-to-analog conversion process. Switches S1 and S2 are used to change the output frequency to 800 Hz and 1600 Hz, respectively, by skipping over some of the table values.

FIGURE 3-3: DIGITAL-TO-ANALOG CONVERSION PROGRAM FLOW



3.5 BOARD SELF-TEST

The board self-test is provided for completeness only. Users do not need to run this test.

1. Power the board using a 9V DC supply and the barrel power connector. The LED marked D1 turns ON.

   If D1 does not light:

   - the LED is dead, or
   - the regulator is dead, or
   - the DC supply is not connected to the AC wall plug
2. Using a DMM set for DCV, check that 3.3V or 5.0V is available at location marked V_{DD} and GND on the 80-pin header.
3. Connect a shorting plug on the RS-232 connector J1. This shorting plug should have pins 2 and 3 connected to one another.
4. Short pins 2 and 3 on line connector J9 using a 0.1″ jumper.
5. Make sure J4 has a 0.1″ jumper on it.
6. To enter the Self-Test mode, hold down S1, press and release $\overline{\text{MCLR}}$, then release S1.

The following four tests should run:

Test	Description
UART Test	This automatic test transmits 5 characters and receives them through the serial port. During the test, LED RD4 blinks at a very fast rate (8 blinks/sec). However, this test completes so quickly that, in most instances, no noticeable blink of RD4 will occur.
Keypad Test	During this test, LED RD5 blinks very fast. You must respond by pressing S1 and S2. When you press S1, RD4 lights. When you press S2, RD7 lights. If both key presses are acknowledged by the dsPIC® DSC, then the test passed. If you get no response or an incorrect response within 4 seconds, then the test is considered failed. In either case the test automatically proceeds to the Potentiometer test.
Potentiometer Test	During this test, LED RD6 blinks rapidly. You must first respond by turning Potentiometer R13 fully clockwise (RD4 will light) and then fully counterclockwise (RD7 will light). Then you must move the potentiometer wiper to a center position causing RD5 to light up. When this happens, the test is complete. This test must be completed in 8 seconds or else the test is considered failed.
Tone Test	This procedure automatically tests the digital potentiometer and analog operational amplifier. A sine wave, generated using the digital potentiometer, is sent through the Op Amp circuit to the ADC of the dsPIC DSC device. The sine wave is analyzed to determine if a smooth sine wave has been generated. If all works well, the test passes. If there is a fault in the op amp or digital potentiometer, then this test fails.

If any of these tests fail, then at the end of the Tone test the LED corresponding to the failed test will blink slowly (2 blinks/sec). For example, if RD4 blinks, it means that the UART test failed. The table below correlates the blinking LED with each test and indicates the possible cause for the failure:

Blinking LED	Test Failed	Reasons for Failure
RD4	UART	UART driver chip failed; UART shorting jumper not connected on J1
RD5	Keypad	S1 and S2 not working properly
RD6	Potentiometer	Potentiometer R13 faulty
RD7	Digital Potentiometer/Op Amp	Digital Potentiometer/Op Amp failed

If all tests passed, then none of the LEDs will blink.

NOTES:

Chapter 4. dsPICDEM™ Development Board Hardware

4.1 HARDWARE OVERVIEW

This chapter describes the dsPICDEM 80-Pin Starter Development Board hardware. The dsPICDEM 80-Pin Starter Development Board features the hardware elements shown in Figure 4-1 and identified in Table 4-1

FIGURE 4-1: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD

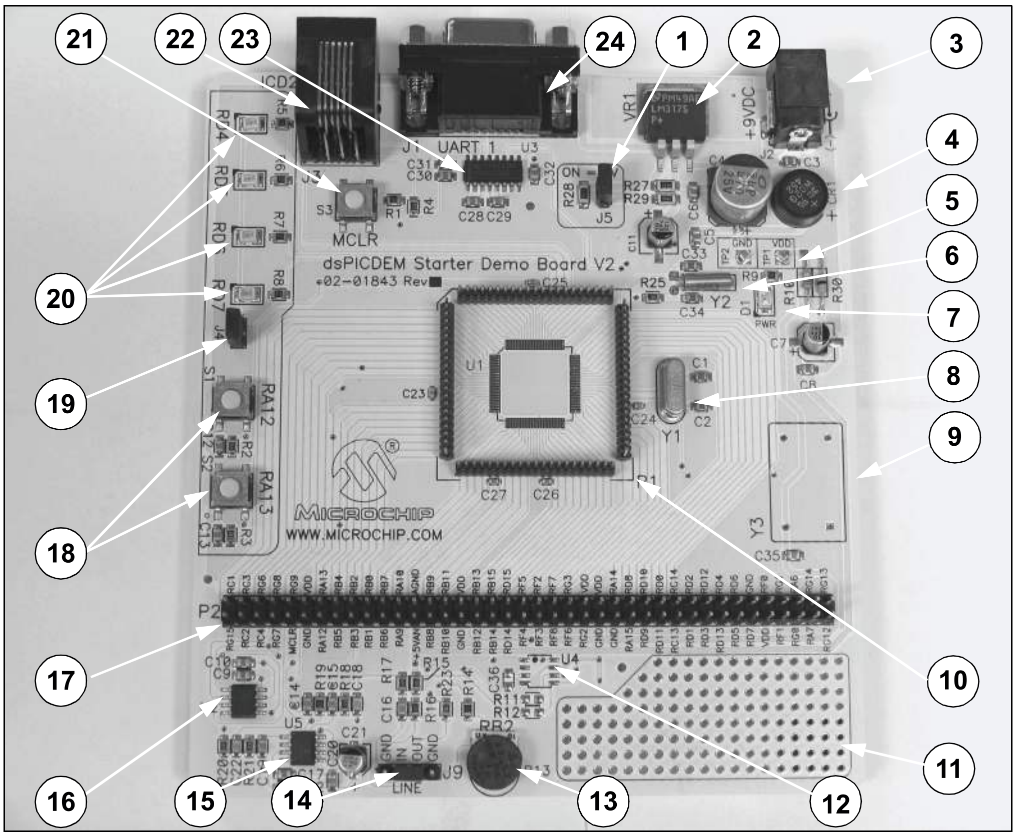


TABLE 4-1: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD HARDWARE ELEMENTS

No.	Hardware Element	No.	Hardware Element
1	Power Supply Selector (Section 4.1.10)	**13**	Analog Potentiometer (Section 4.1.2)
2	Voltage Regulator (Section 4.1.10)	**14**	Line In/Out Header (Section 4.1.16)
3	Power Jack (Section 4.1.17)	**15**	Low-Pass Filter (Section 4.1.6)
4	Diode Bridge (Section 4.1.10)	**16**	Digital Potentiometer (Section 4.1.5)
5	Test Points (Section 4.1.10)	**17**	I/O Port Header (Section 4.1.9)
6	32.768 kHz Crystal Oscillator (Section 4.1.12)	**18**	Push Button Switches (Section 4.1.3)
7	Power-on LED (Section 4.1.11)	**19**	LED Activation Header (Section 4.1.4)
8	7.37 Crystal Oscillator (Section 4.1.12)	**20**	LED Indicators (Section 4.1.4)
9	External Oscillator Socket (Section 4.1.12)	**21**	Master Clear Switch (Section 4.1.13)
10	dsPIC® DSC/PIC24 Device Header (Section 4.1.8)	**22**	ICD2 Jack (Section 4.1.7)
11	Prototyping Area (Section 4.1.14)	**23**	UART (Section 4.1.1)
12	Factory Test Socket	**24**	RS-232 Serial Port (Section 4.1.1)

4.1.1 RS-232 Serial Port

One RS-232 serial communication channel is provided on the board. This channel is labeled J1. The dsPIC DSC or PIC24 MCU UART channel 1 U1RX and U1TX pins are connected to an RS-232 level shifting MAX3232CD (U3), as shown in Figure A-3. The serial port is configured as DCE and can be connected to a PC using a straight through cable.

4.1.2 Analog Potentiometer

An analog potentiometer (R13) is connected to analog channel AN2 on the dsPIC DSC or PIC24 MCU device. The voltage output range for the potentiometer is 0-5 VDC. The voltage source is provided by the +5VAN regulator, as shown in Figure A-6.

4.1.3 Push Button Switches

Two push button switches (S1 and S2) are connected to port pin RA12 and RA13, respectively, on the dsPIC DSC or PIC24 MCU device, as shown in Figure A-3. The signal lines are normally pulled up to VDD through 4.7K resistors. Pressing the switch shorts the line to ground. Port pins RA12 and RA13 are configured as input pins.

4.1.4 LED Indicators

Four LED indicators (D2 to D5) are connected to port pins RD4 to RD7, respectively, on the dsPIC DSC or PIC24 MCU device. The anode of each LED is tied to VDD through a 470 ohm resistor, as shown in Figure A-3. The cathodes are shorted and connected to GND by an activation header (J4). The LEDs are labeled RD4 through RD7 on the board to correspond to their respective port pins.

4.1.5 Digital Potentiometer

A single channel digital potentiometer (U2) is provided on the development board. The MCP41010_SO150 digital potentiometer is controlled by the SPI2 communication channel on the dsPIC DSC or PIC24 MCU device. The output of the digital potentiometer is applied to a 2nd-order, low-pass filter, with a cutoff frequency of approximately 4 kHz. The output of the LP filter is connected to the LINE OUT pin of J9, as shown in Figure A-6.

4.1.6 Low-Pass Filter

A Microchip MCP6022_SO8 Operational Amplifier is configured as a 2nd-order, low-pass filter for speech or voice input filtering, as shown in Figure A-6. The input to the filter is at the LINE IN pin of J9.

4.1.7 ICD 2 Connector

By way of the modular connector ICD (J3), the MPLAB ICD 2 can be connected for low-cost programming and debugging of the dsPIC DSC or PIC24 MCU device.

4.1.8 Device Header

Header P1 supports the processor adaptor boards. The processor adaptor boards enable quick change out of the device.

4.1.9 I/O Port Header

Header P2 is a two-row header with appropriate labels for I/O ports. This header allows the user to easily probe appropriate I/O lines.

4.1.10 Power Supply

The power supply furnishes +5V or +3.3V for the board (see the schematic in Figure A-4). Source power is provided by a +9V, AC/DC wall adapter through Diode Bridge CR1. An LM317 voltage regulator provides power (V_{DD} and AV_{DD}) to the respective processor pins and prototyping area. A ground trace connects all V_{SS} points.

4.1.11 Power-on Indicator

A red LED (D1) indicates the presence of power (see Figure A-4).

4.1.12 Oscillators

The board provides two crystal oscillators. Y1 operates at 7.37 kHz, and Y2 operates at 32.768 kHz. A socket is provided for an external oscillator (Y3). The oscillator circuits are shown in Figure A-4.

4.1.13 Reset Switch

The MCLR Reset switch (S3) connected to the processor $\overline{\text{MCLR}}$ pin provides a hard reset to the dsPIC DSC or PIC24 MCU device.

4.1.14 Prototyping Area

A prototyping area and associated header is provided which enables additional ICs and attachment boards to be added.

4.1.15 Sample Device

A sample part programmed with the demonstration code is included in the dsPICDEM 80-Pin Starter Development Board kit. The 80-pin TQFP is soldered onto an adapter board that plugs into the device header connection (see Figure 4-2).

4.1.16 Line In/Out Connector (J9)

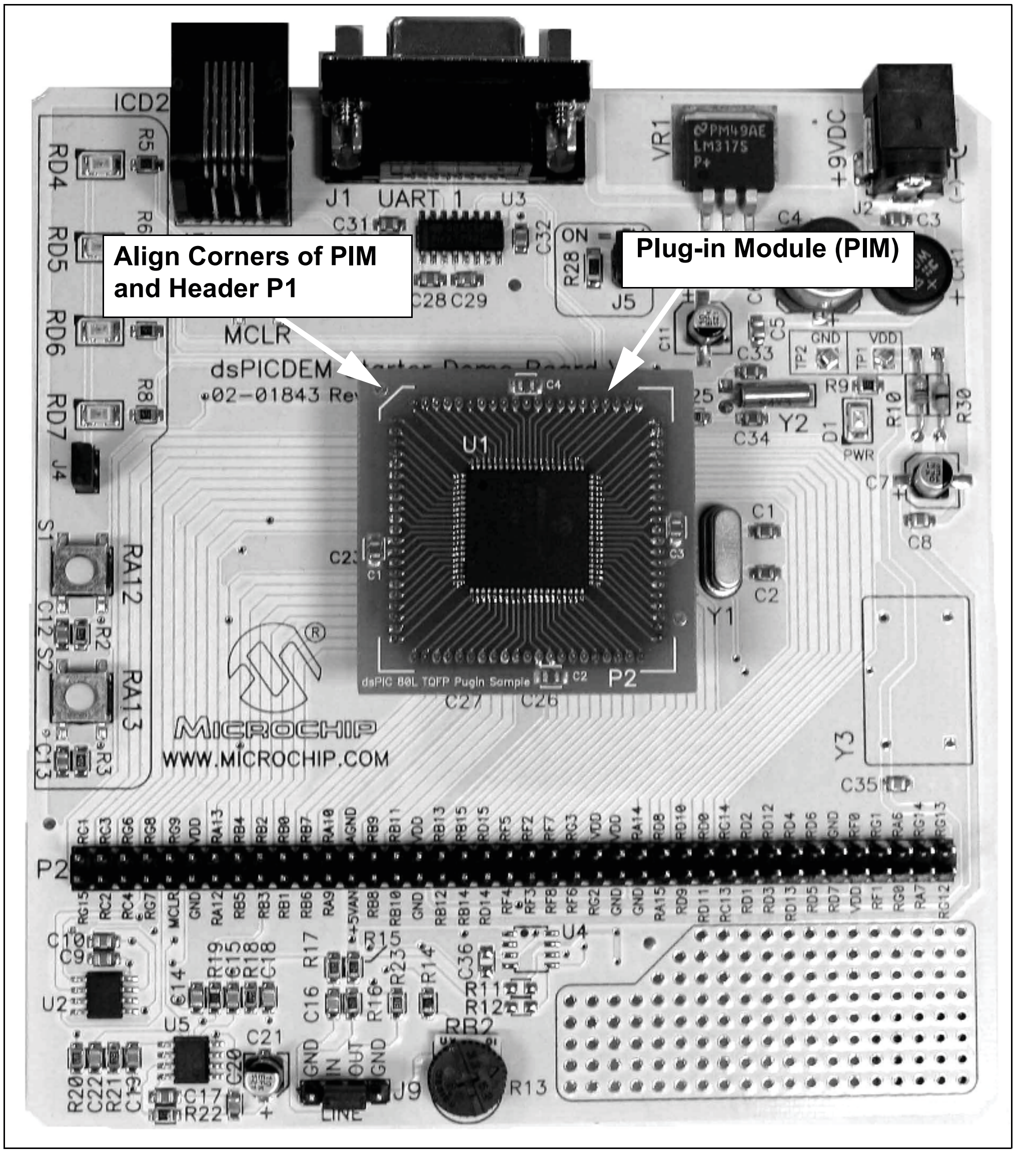
Pins provide line input and output connections for the low-pass filter, as shown in Figure A-6.

- LINE_OUT – Output signal from digital potentiometer
- LINE_IN – Input signal for ADC

4.1.17 9 VDC Input Jack (J2)

An input jack for 9V external power supply.

FIGURE 4-2: ADAPTER BOARD PLUGS INTO HEADER ON MAIN BOARD

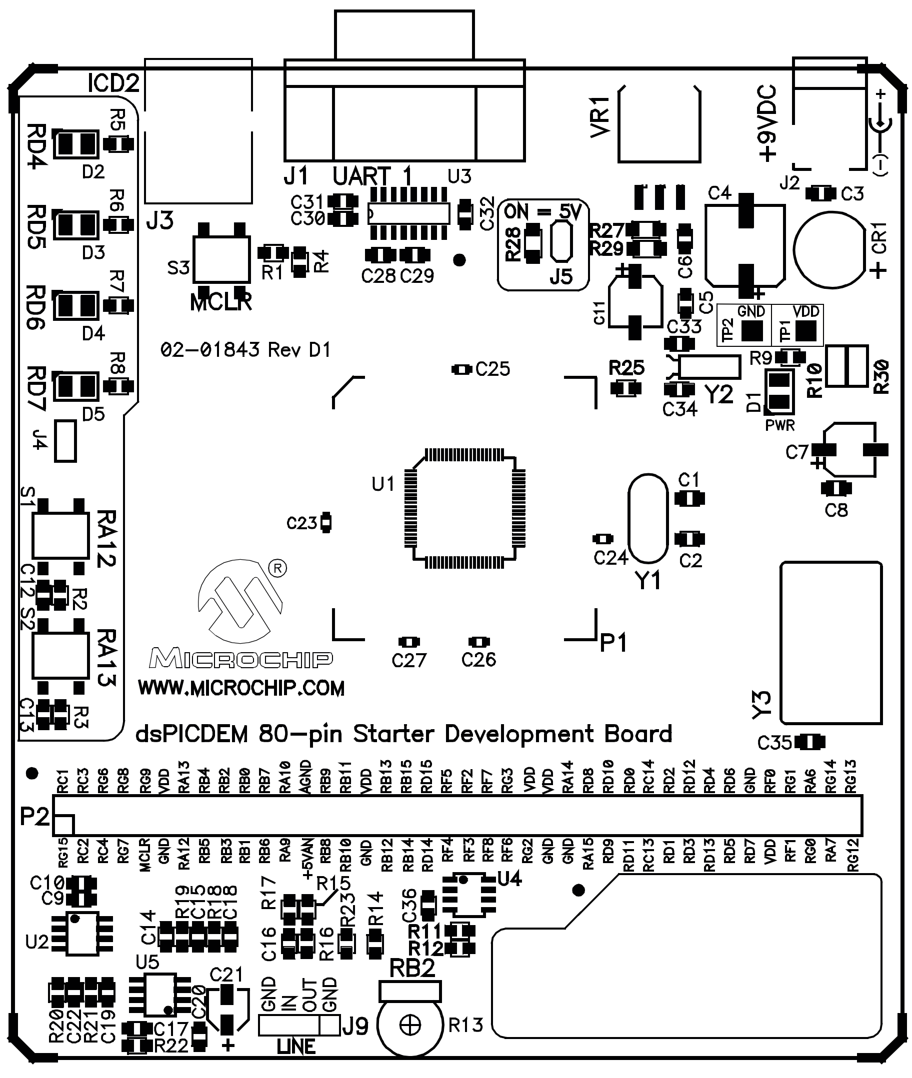


Appendix A. Drawings and Schematics

A.1 dsPICDEM 80-PIN STARTER DEVELOPMENT BOARD LAYOUT

Figure A-1 shows the parts layout for the dsPICDEM 80-Pin Starter Development Board.

FIGURE A-1: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD LAYOUT



A.2 dsPICDEM 80-PIN STARTER DEVELOPMENT BOARD SCHEMATIC

Figure A-2 provides a schematic diagram of the dsPICDEM 80-Pin Starter Development Board.

FIGURE A-2: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD SCHEMATIC (SHEET 1 OF 5)

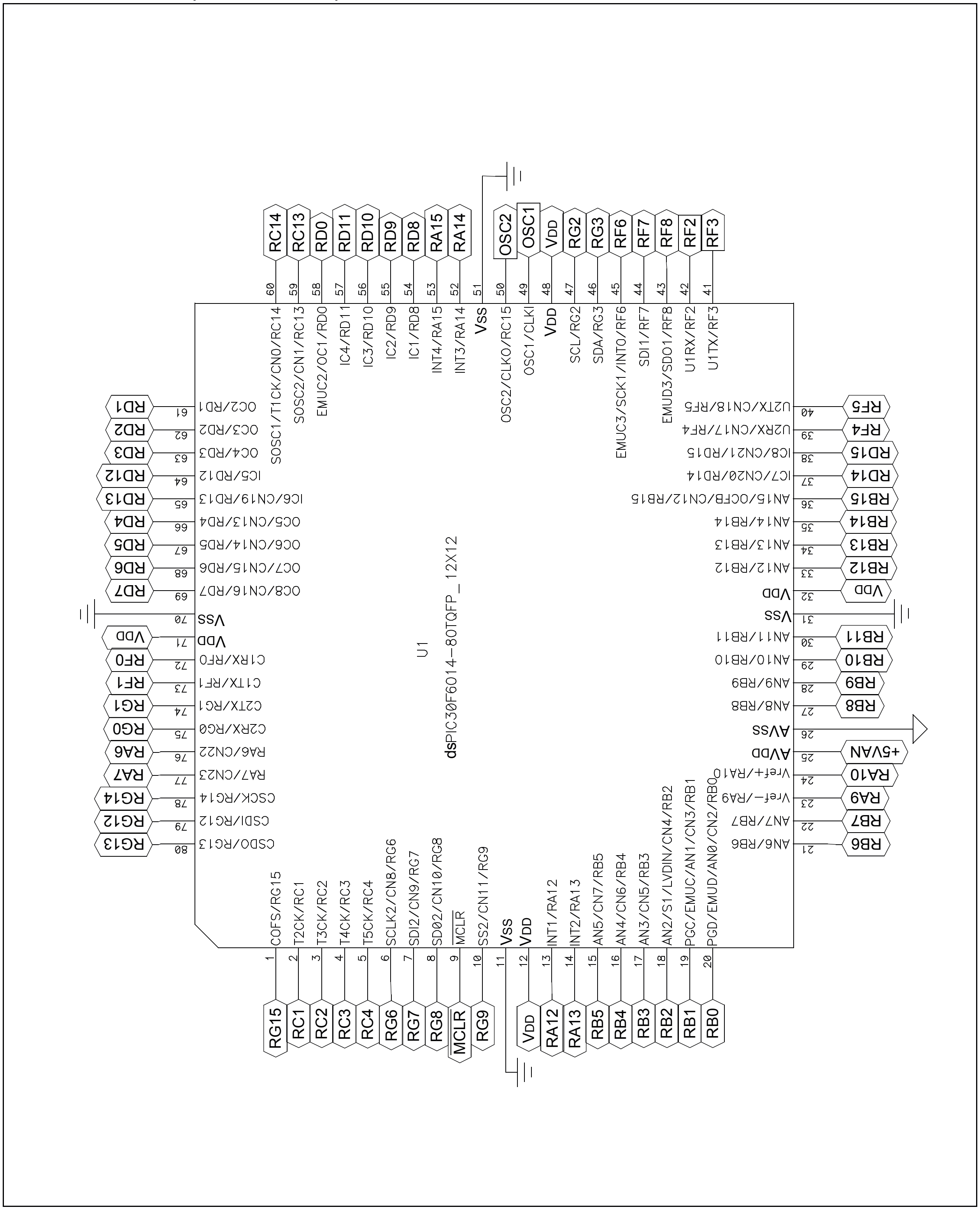


FIGURE A-3: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD SCHEMATIC (SHEET 2 OF 5)

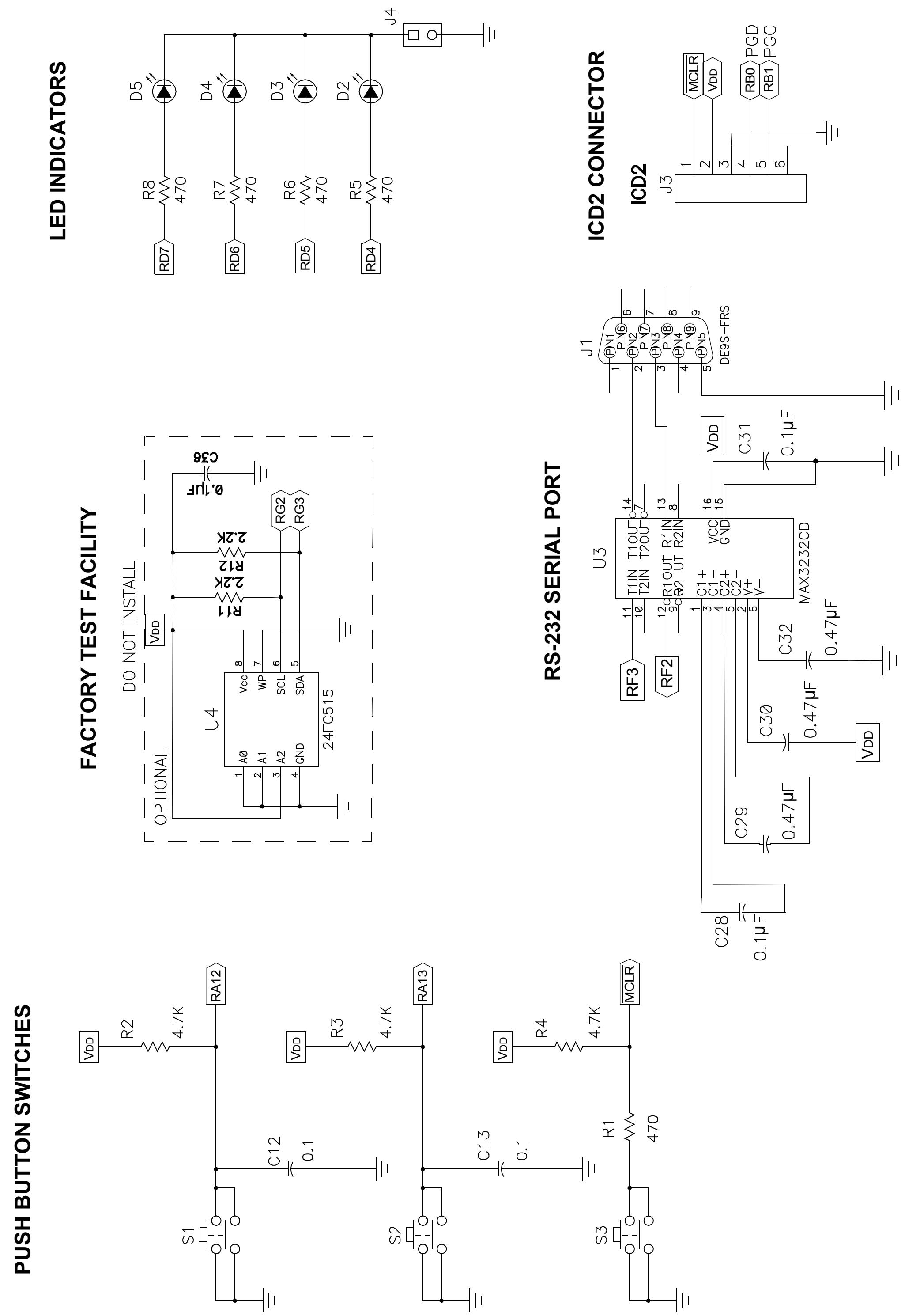


FIGURE A-4: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD SCHEMATIC (SHEET 3 OF 5)

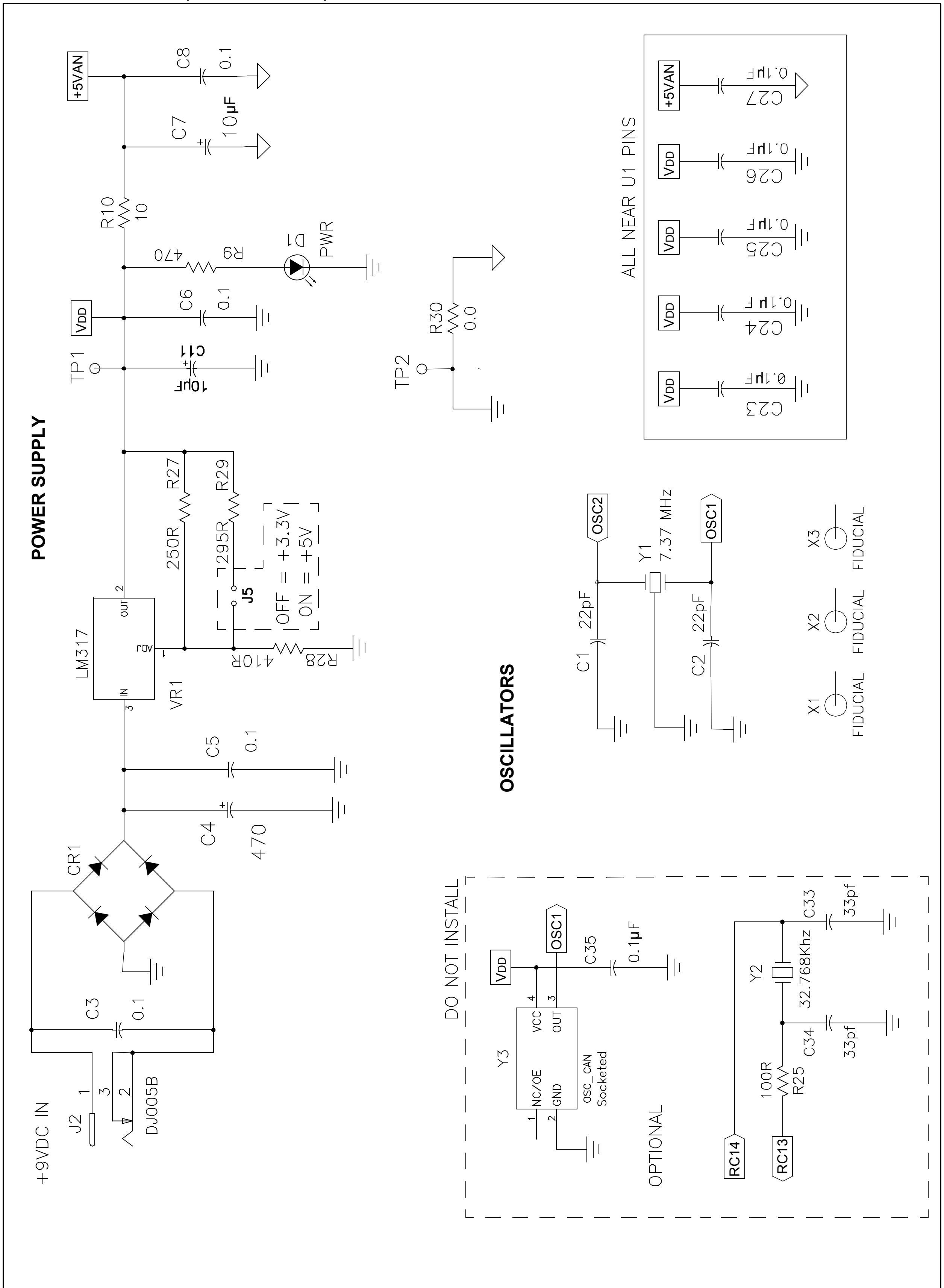


FIGURE A-5: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD SCHEMATIC (SHEET 4 OF 5)

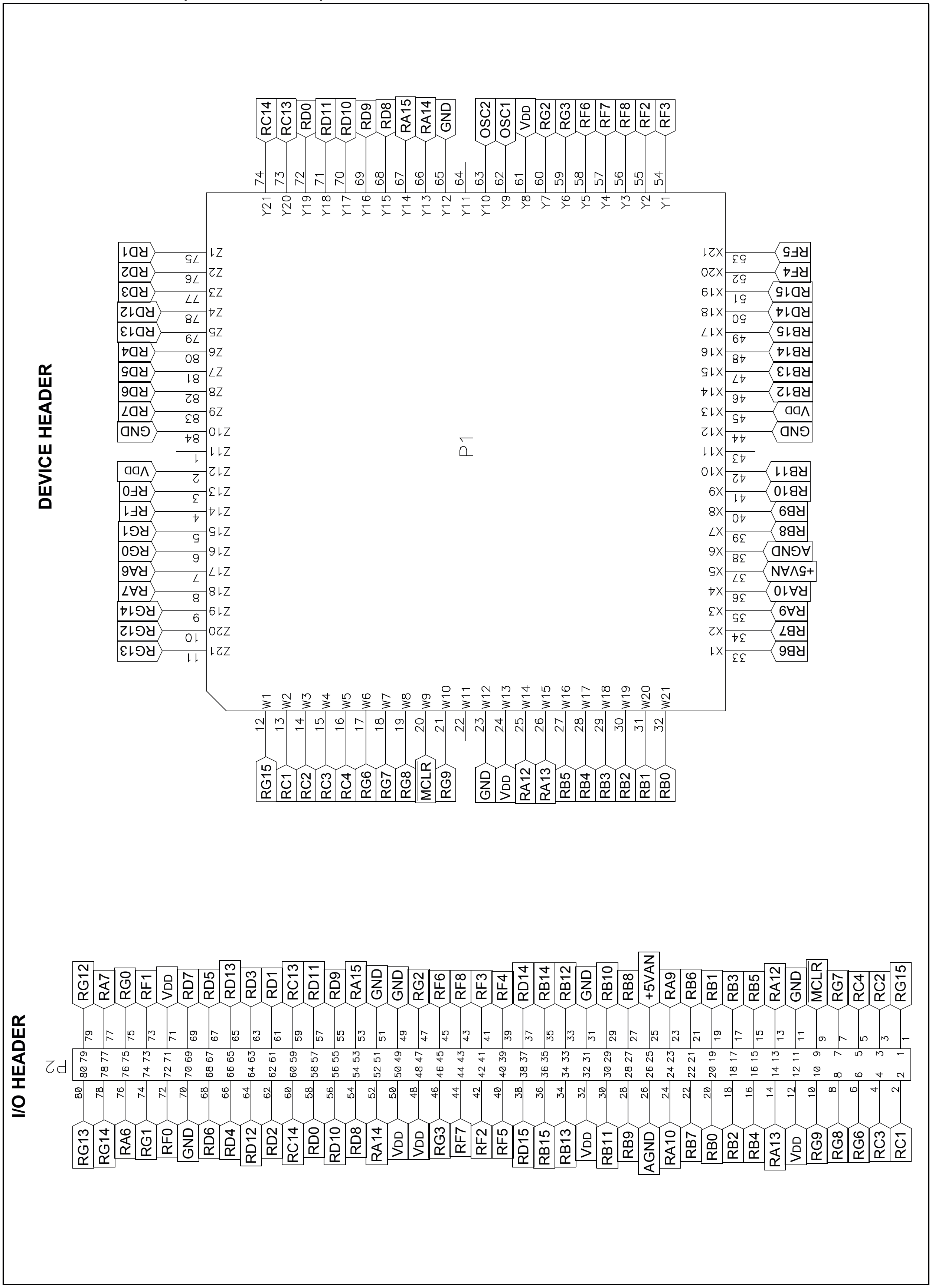
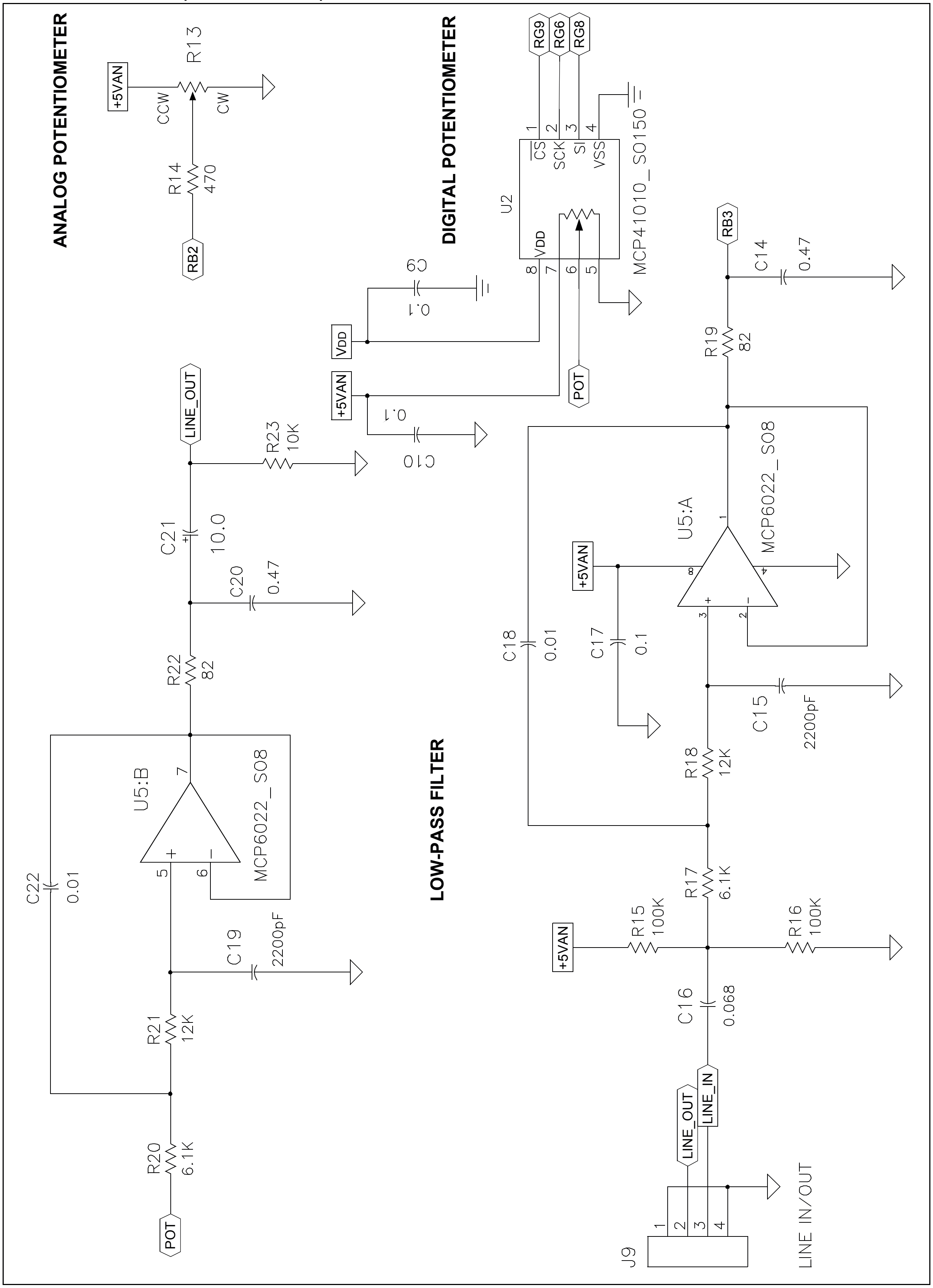


FIGURE A-6: dsPICDEM™ 80-PIN STARTER DEVELOPMENT BOARD SCHEMATIC (SHEET 5 OF 5)



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