dsPICDEM™ STARTER DEMO BOARD USER'S GUIDE

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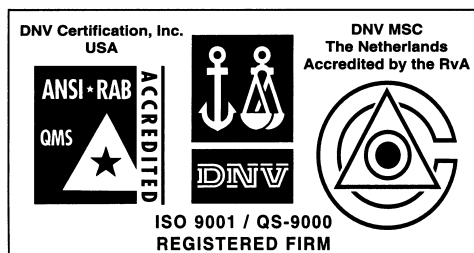
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Table of Contents

NOTES:

Preface

INTRODUCTION

This chapter contains general information about this user's guide and available customer support that will be useful prior to using the dsPICDEM™ Starter Demo Board.

HIGHLIGHTS

Items discussed in this chapter are:

- About this Guide
- Warranty Registration
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support

ABOUT THIS GUIDE

This user's guide describes how to use the dsPICDEM Starter Demo Board. The document is organized as follows:

- **Chapter 1: Introduction** – This chapter introduces the dsPICDEM Starter Demo Board and provides a brief description of the hardware.
- **Chapter 2: Tutorial** – This chapter details the step-by-step process for getting the dsPICDEM Starter Demo Board up and running with the MPLAB® In-Circuit Debugger 2 (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 Hardware** – This chapter describes the hardware comprising the dsPICDEM Starter Demo Board.
- **Appendix A: Hardware Schematics** – This appendix provides dsPICDEM Starter Demo Board hardware layout and schematic diagrams.

Conventions Used in This Guide

This manual uses the following documentation conventions:

TABLE 1:   DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Code (Courier font):		
Plain characters	Sample code Filenames and paths	`#define START` `c:\autoexec.bat`
Square brackets [ ]	Optional arguments	`pic30-as [main.s]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`

Ellipses...	Used to imply (but not show) additional text that is not relevant to the example	`list`
		`["list_option...,`
		`"list_option"]`

0x*nnnn*	A hexadecimal number where *n* is a hexadecimal digit	`0xFFFF, 0x007A`
Italic characters	A variable argument; it can be either a type of data (in lower case characters) or a specific example (in upper case characters)	`pic30-gcc` *filename*
Interface (Arial font):		
Underlined, italic text with right arrow	A menu selection from the menu bar	*File > Save*
Bold characters	A window or dialog button to click	**OK**, **Cancel**
Characters in angle brackets < >	A key on the keyboard	<Tab>, <Ctrl-C>
Documents (Arial font):		
Italic characters	Referenced books	*MPLAB IDE User's Guide*

Documentation Updates

All documentation becomes dated, and this document is no exception. Since Microchip tools are constantly evolving to meet customer needs, some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site to obtain the latest documentation available.

Documentation Numbering Conventions

Documents are numbered with a "DS" number. The 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   =   The document number.

 A   =   The revision level of the document.

WARRANTY REGISTRATION

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in the Warranty Registration Card entitles user's to receive new product updates. Interim software releases are available on the Microchip web site.

RECOMMENDED READING

This user's guide describes how to use the dsPICDEM Starter Demo Board. Other useful documents include:

dsPIC30F Family Reference Manual (DS70046)

Consult this document for detailed information on dsPIC30F device operation. This reference manual explains the operation of the dsPIC30F MCU 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 Data Sheet, Motor Control and Power Conversion Family (DS70082)

Consult this document for detailed information on the dsPIC30F Motor Control and Power Conversion devices. Reference information found in this data sheet includes:

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

dsPIC30F Data Sheet, General Purpose and Sensor Families (DS70083)

Consult this document for detailed information on the dsPIC30F Sensor and General Purpose devices. Reference information found in this data sheet includes:

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

dsPIC30F Programmer's Reference Manual (DS70030)

This manual is a software developer's reference for the dsPIC30F 16-bit MCU family of devices. It describes the instruction set in detail and also provides general information to assist in developing software for the dsPIC30F MCU family.

dsPIC30F Family Overview (DS70043)

This document provides an overview of the functionality of the dsPIC® product family. It helps determine how the dsPIC 16-bit Digital Signal Controller Family fits a specific product application. This document is a supplement to the *dsPIC30F Family Reference Manual.*

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

This document details Microchip Technology's language tools for dsPIC 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 and Libraries (DS51284)

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

Other GNU language tools available from Microchip are:

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

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

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

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 on the Microchip World Wide Web (WWW) site. The web site is used by Microchip as a means to make files and information easily available to customers. To view the site, you must have access to the Internet and a web browser, such as, Netscape Navigator® or Microsoft® Internet Explorer.

The Microchip web site is available by using your favorite Internet browser to reach:

>   http://www.microchip.com

The web site provides a variety of services. Users may download files for the latest development tools, data sheets, application notes, user's guides, articles and sample programs. A variety of information specific to the business of Microchip is also available, including listings of Microchip sales offices, distributors and factory representatives.

Technical Support

• Frequently Asked Questions (FAQ)
• Online Discussion Groups – conferences for products, development systems, technical information and more
• Microchip Consultant Program Member Listing
• Links to other useful web sites related to Microchip products

Engineer's Toolbox

• Design Tips
• Device Errata

Other Available Information

• Latest Microchip Press Releases
• Listing of seminars and events
• Job Postings

DEVELOPMENT SYSTEMS CUSTOMER NOTIFICATION SERVICE

Microchip started the customer notification service to help our customers keep current on Microchip products with the least amount of effort. Once you subscribe, you will receive e-mail notification whenever we change, update, revise or have errata related to a specified product family or development tool of interest.

Go to the Microchip web site at (http://www.microchip.com) and click on Customer Change Notification. Follow the instructions to register.

The Development Systems product group categories are:

• Compilers
• Emulators
• In-Circuit Debuggers
• MPLAB IDE
• Programmers

Here is a description of these categories:

Compilers – The latest information on Microchip C compilers and other language tools. These include the MPLAB® C17, MPLAB C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; 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 Microchip in-circuit debuggers. These include the MPLAB ICD and 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 and MPLAB SIM30 simulators, MPLAB IDE Project Manager and general editing and debugging features.

Programmers – The latest information on Microchip device programmers. These include the PRO MATE® II device programmer and PICSTART® Plus development programmer.

dsPICDEM™ Starter Demo Board User's Guide

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

• Distributor or Representative
• Local Sales Office
• Field Application Engineer (FAE)
• Corporate Applications Engineer (CAE)
• Hotline

Customers should call their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. See the back cover for a list of sales offices and locations.

Corporate Applications Engineers (CAEs) may be contacted at (480) 792-7627.

In addition, there is a Systems Information and Upgrade Line. This line provides system users a list of the latest versions of all of Microchip's development systems software products. Plus, this line provides information on how customers can receive any currently available upgrade kits.

The Hotline Numbers are:

1-800-755-2345 for U.S. and most of Canada.

1-480-792-7302 for the rest of the world.

Chapter 1. Introduction

1.1 INTRODUCTION

The dsPICDEM Starter Demo Board serves as a development kit and evaluation tool for the dsPIC30F High Performance Digital Signal Controllers.

1.2 HIGHLIGHTS

This chapter discusses:

- dsPICDEM Starter Demo Board Kit Contents
- dsPICDEM Starter Demo Board Functionality and Features
- dsPICDEM Starter Demo Board Demonstration Program
- Reference documents

1.3 dsPICDEM STARTER DEMO BOARD KIT CONTENTS

The following items comprise the dsPICDEM Starter Demo Board Kit:

- The dsPICDEM Starter Demo Board printed circuit board (see Figure 1-1).
- A preprogrammed dsPIC30F6012 device soldered onto an adapter board that plugs into the Emulation Header on the dsPICDEM Starter Demo Board (see Figure 1-2). (Some early versions of the dsPICDEM Starter Demo Board may have the dsPIC30F device soldered onto the main board.)
- dsPICDEM Starter Demo Board CD-ROM containing various demonstration programs provided by Microchip.

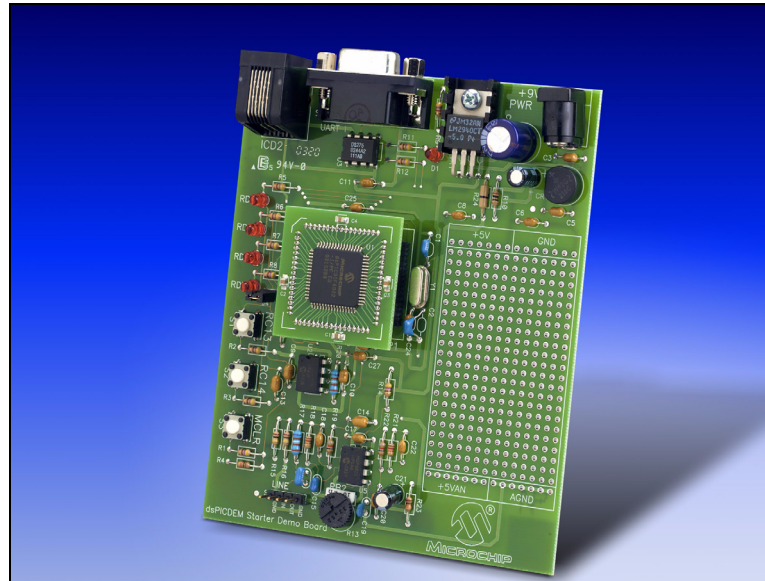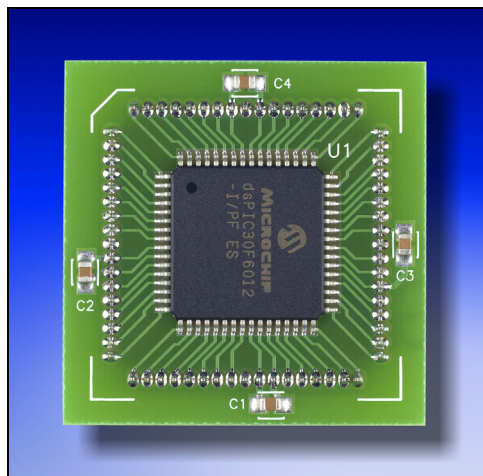**FIGURE 1-1:** **dsPICDEM STARTER DEMO BOARD**

FIGURE 1-2: **TYPICAL PREPROGRAMMED DEVICE ADAPTER BOARD**

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

1.4   dsPICDEM STARTER DEMO BOARD FUNCTIONALITY AND FEATURES

The dsPICDEM Starter Demo Board provides the following capabilities:

Development Board Power

- On-board +5V regulator for V_{DD} and AV_{DD} 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 64-pin TQFP dsPIC 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

- 4.0 MHz crystal (Y1) for dsPIC device

Miscellaneous

- Reset push button switch (S3) for resetting the dsPIC device
- Four red LEDs (RD4-RD7)
- Two push button switches (S1-S2) for external input stimulus
- Prototype area for user hardware

1.5   dsPICDEM STARTER DEMO BOARD DEMONSTRATION PROGRAM

The dsPICDEM Starter Demo 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 manipulating 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 Starter Demo Board:

• *dsPIC30F Family Reference Manual* (DS70046)
• *dsPIC30F Family Reference Manual Errata* (DS80169)
• *dsPIC30F Data Sheet, Motor Control and Power Conversion Family* (DS70082)
• *dsPIC30F Data Sheet, General Purpose and Sensor Families* (DS70083)
• *dsPIC30F Programmer's Reference Manual* (DS70030)
• *dsPIC30F Programmer's Reference Manual Errata* (DS80170)
• *dsPIC30F Family Overview* (DS70043)
• *MPLAB C30 C Compiler User's Guide and Libraries* (DS51284)
• *MPLAB ASM30, MPLAB LINK30 and Utilities User's Guide* (DS51317)
• *MPLAB ICD 2 In-Circuit Debugger Quick Start Guide* (DS51268)
• *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).

NOTES:

Chapter 2. Tutorial

2.1   INTRODUCTION

This chapter is a self-paced tutorial to get you started using the dsPICDEM Starter Demo 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 (`p30f6012.gld`) and an include file (`p30f6012.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.

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 6.31 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 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
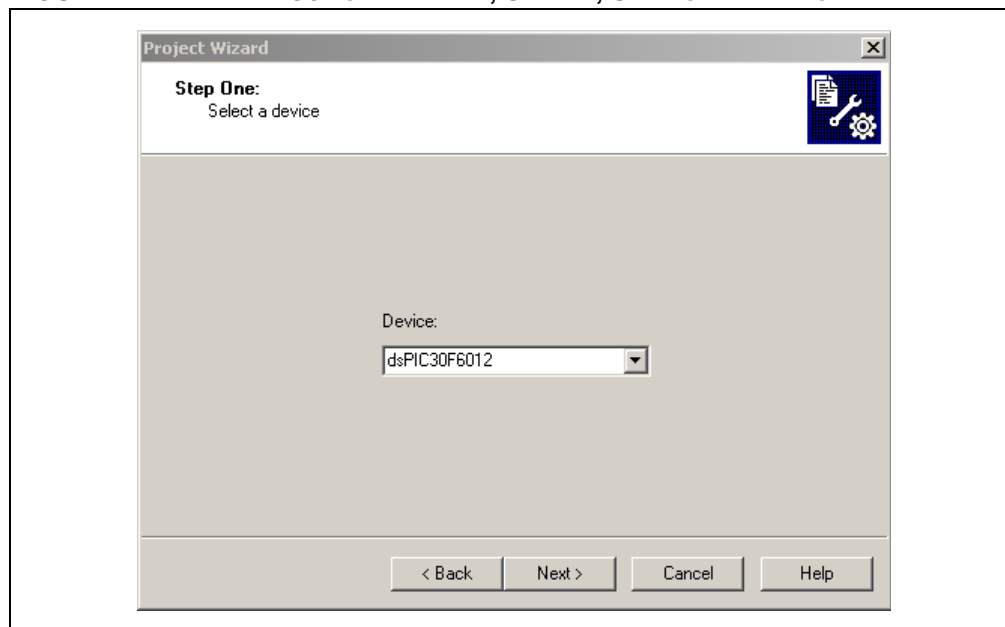
5. From the **Device:** pull-down list, select dsPIC30F6012a2 and click **Next >**. The Project Wizard Step Two dialog will be displayed (see Figure 2-2).

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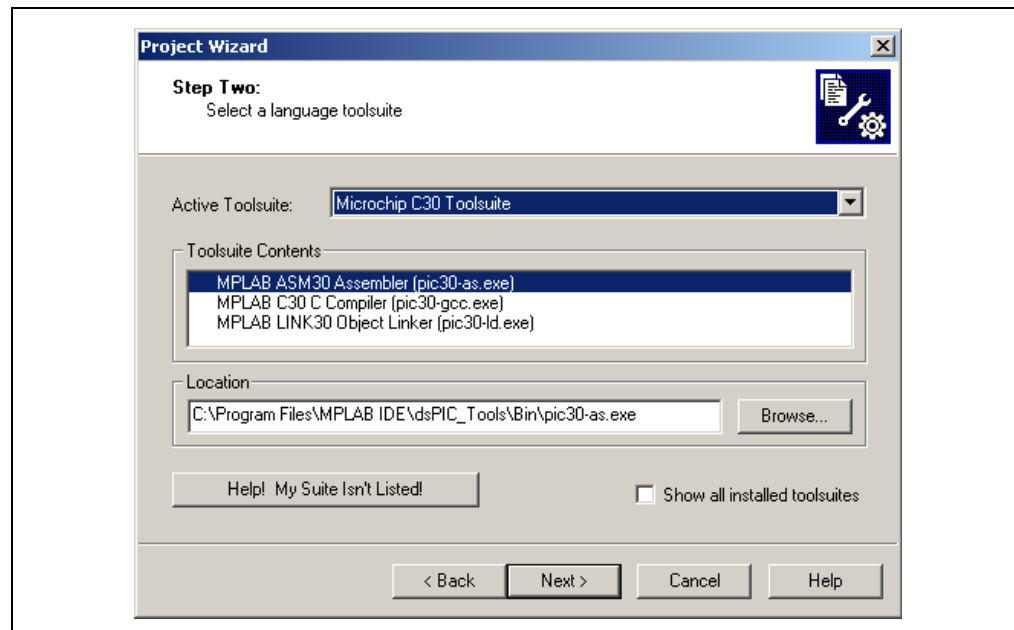

2.4.2   Select Language Toolsuite

1. From the **Active Toolsuite** pull-down menu, select Microchip C30 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:\MPLAB IDE\dsPIC_Tools\Bin\pic30-as.exe

4. With MPLAB LINK 30 Object Linker (pic30-ld.exe) selected in Toolsuite Contents, click **Browse...** and navigate to:
   C:\MPLAB IDE\dsPIC_Tools\Bin\pic30-ld.exe

   Note: If you have the MPLAB C30 Toolsuite installed, browse to the C:\pic30-tools\ 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
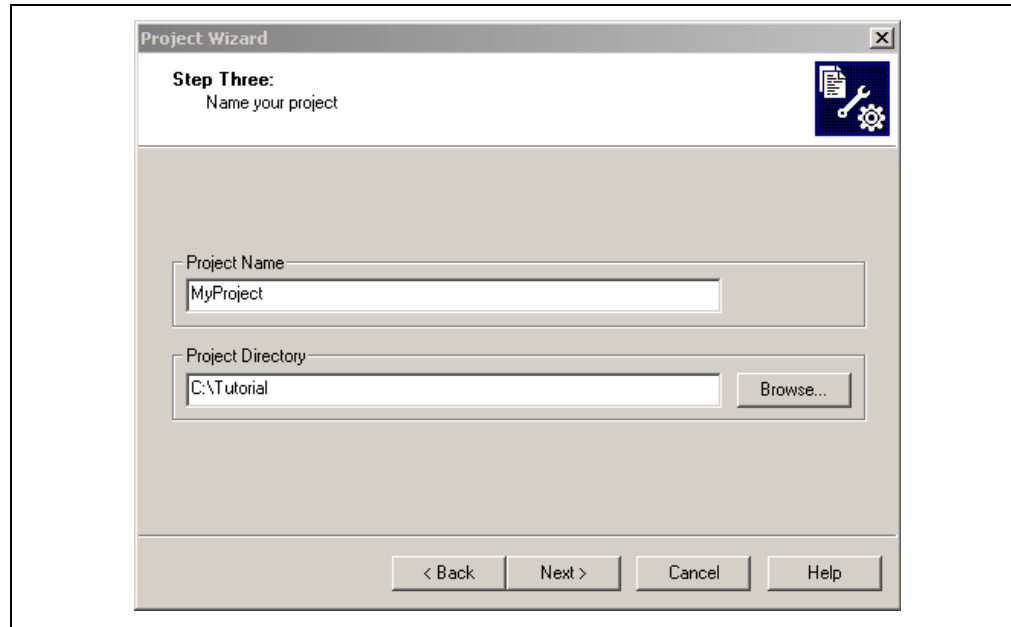
2.4.3   Name Your Project

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**
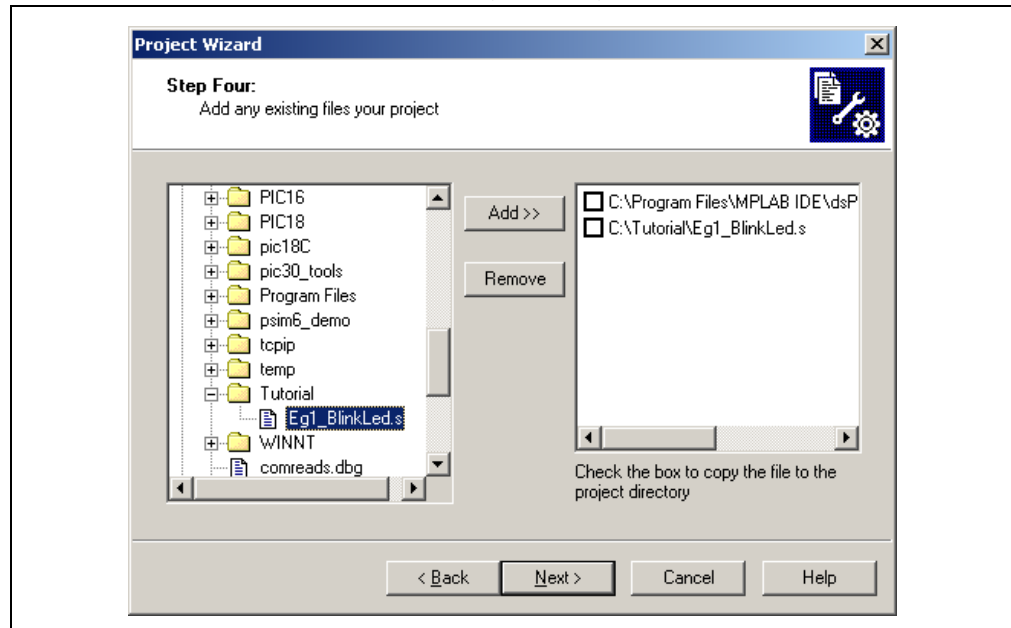
2.4.4   Add Files to Project

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:\MPLAB IDE\dsPIC_Tools\support\gld` folder and select the `p30f6012.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 `p30f6012.gld` file in the Linker Scripts folder (see Figure 2-5).

FIGURE 2-5:   PROJECT WINDOW
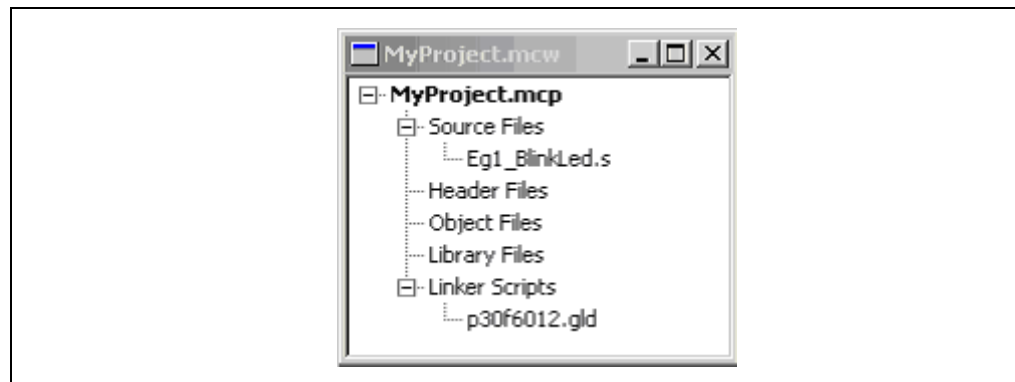
A project and workspace has now been created in MPLAB IDE. `MyProject.mcw` is the workspace file and `MyProject.mcp` is the project file. Double-click the `Eg1_BlinkLed.s` file in the project window to open the file. MPLAB IDE should now look similar to Figure 2-6.

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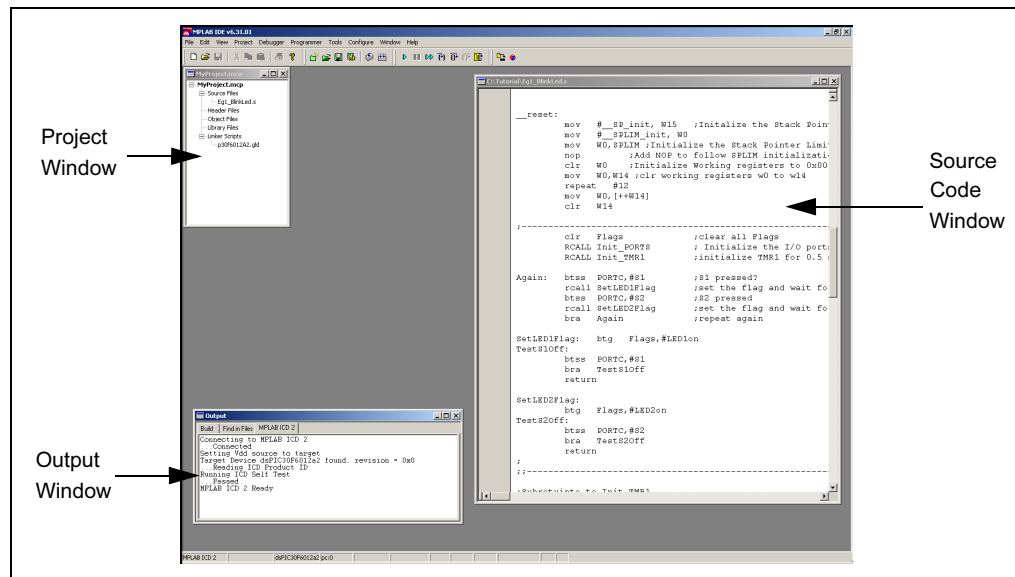
2.5   BUILDING THE CODE

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 "p30f6012.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).
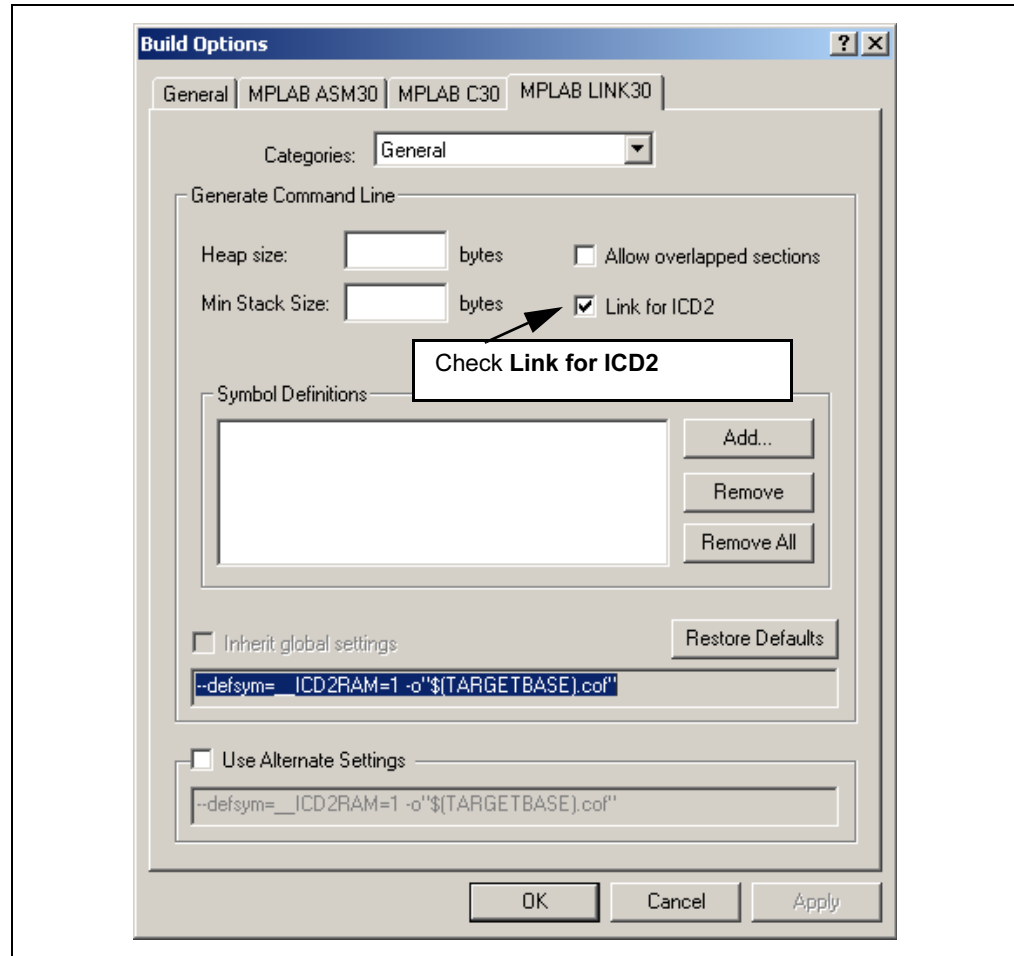
FIGURE 2-7:   BUILD OPTIONS
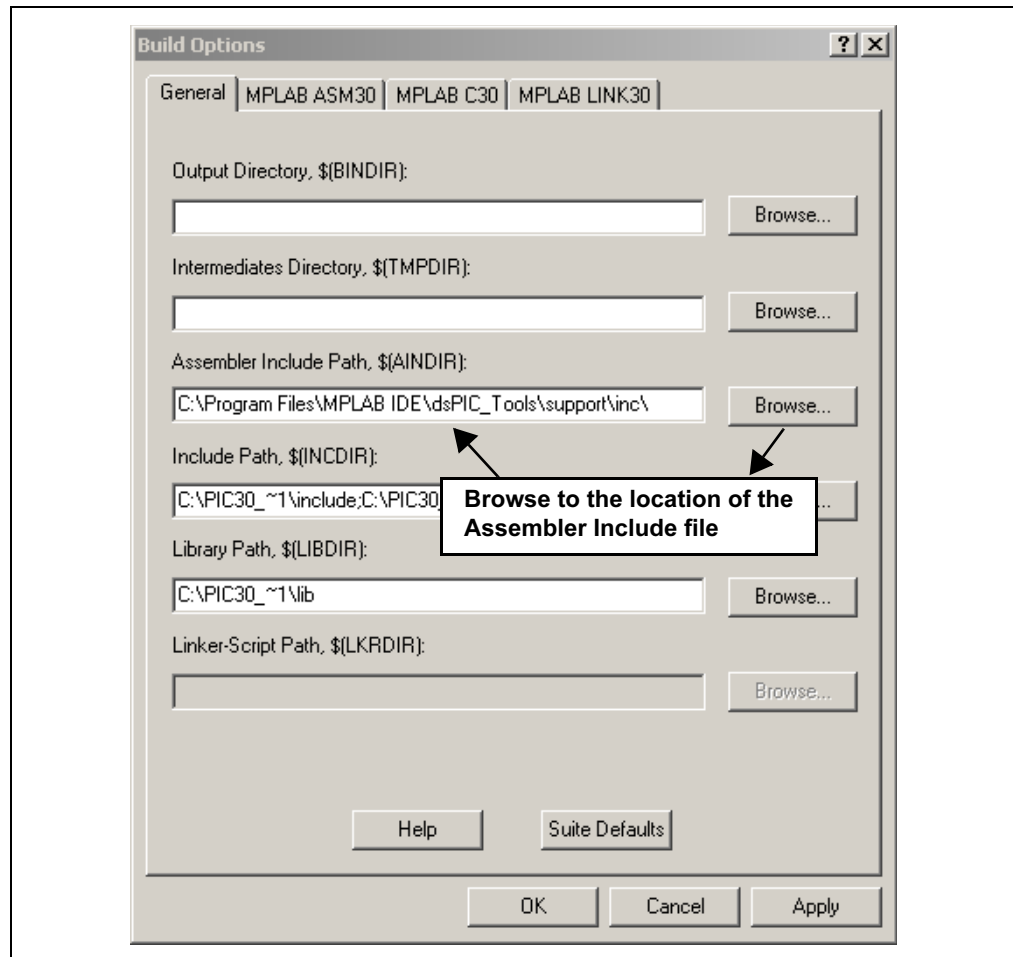
2.5.1 Identify Assembler Include Path

1. Select the General tab.
2. At the Assembler Include Path, $(AINDIR):box, click **Browse...** and navigate to:

   `C:\MPLAB IDE\dsPIC_Tools\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).
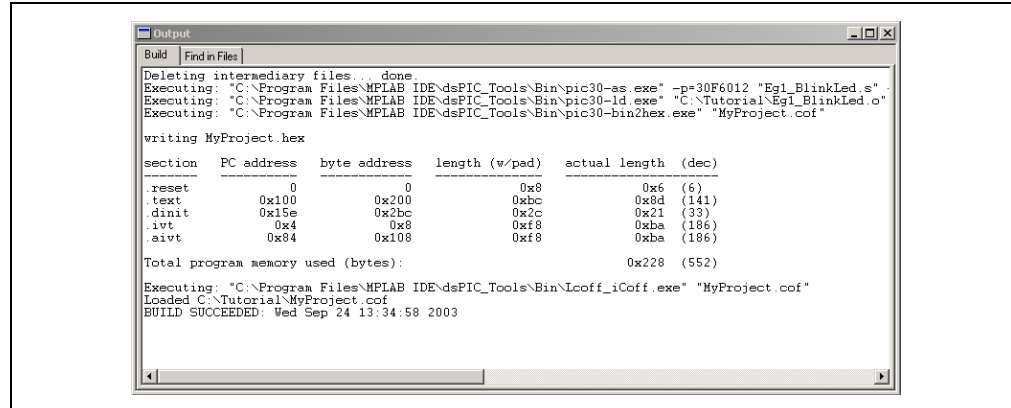
FIGURE 2-8: MPLAB LINK30 BUILD OPTIONS

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 dsPIC30F6012 device in circuit on the dsPICDEM Starter Demo 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 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 dsPIC30F6012 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:

Clock Selection	XTL
Enable WDT	Disabled
Background Debug	Enabled

FIGURE 2-10:   CONFIGURATION SETTINGS

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 Starter Demo Board with the short RJ-11 (telephone) cable.
3.   Apply power to the board.

FIGURE 2-11: **dsPICDEM STARTER DEMO BOARD CONNECTED TO MPLAB ICD 2**
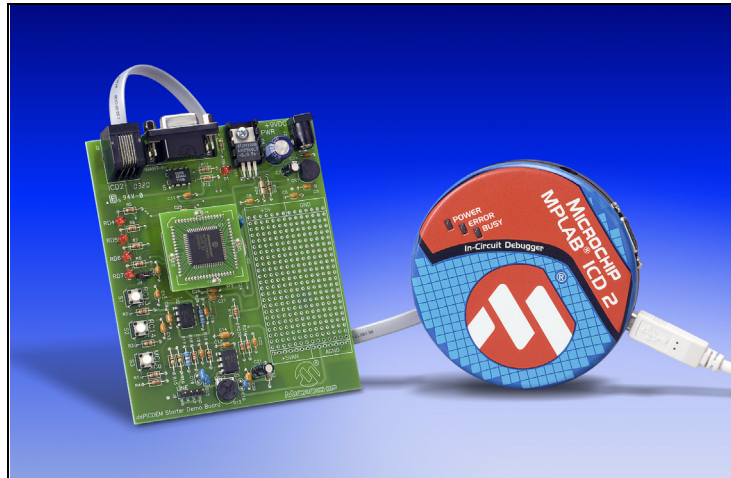

2.6.3   Enable MPLAB ICD 2 Connection

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 dsPIC6012 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**
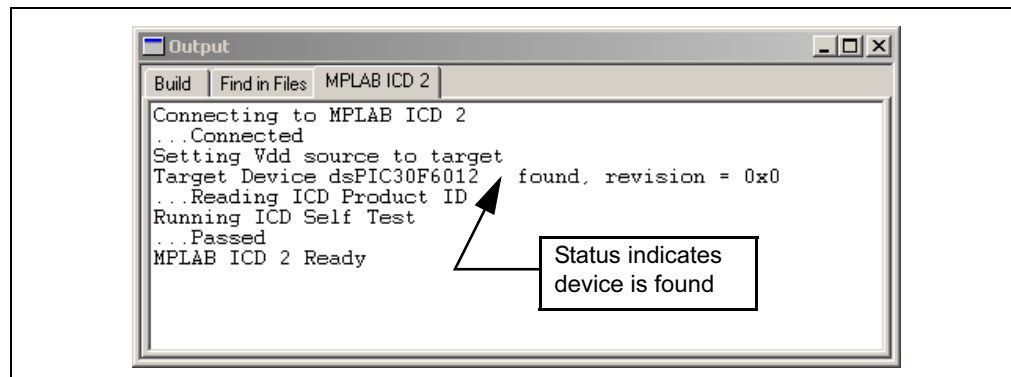
2.6.4   Program the dsPIC6012 Device

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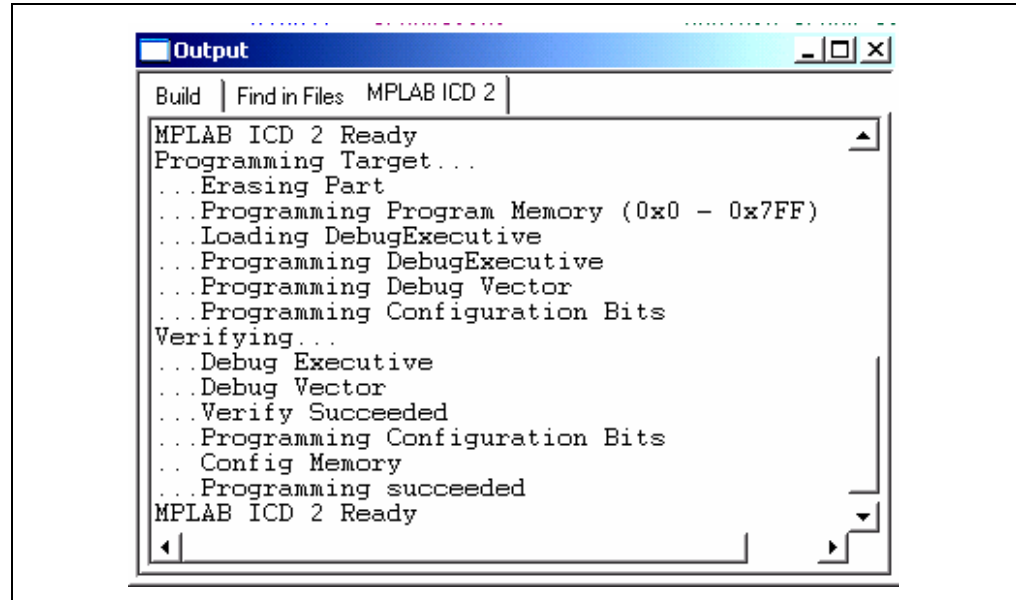
3. Use the *Debugger>Run* menu to run the code. LED1 should start blinking when S1 is pressed.

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:
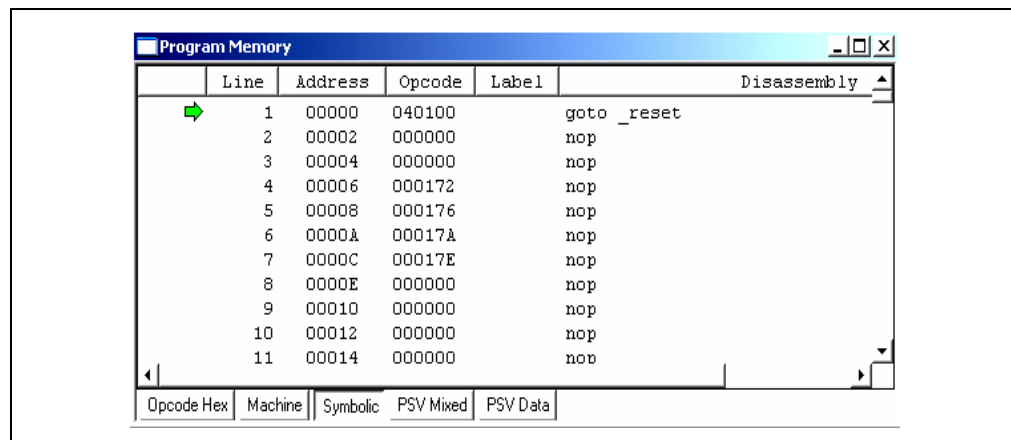
<F5>   Halt

<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 _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 using the *Edit>Properties* menu.

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

```
Again:   btss    PORTG,#S1
```

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

2. Press <F5> 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
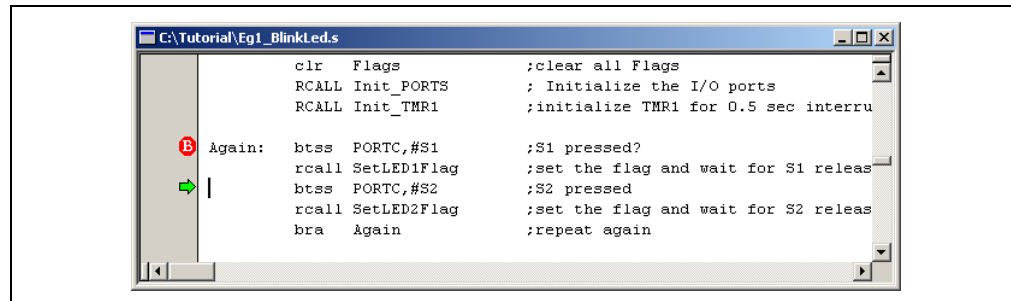
In this example, every time <F5> is pressed to run the code, it sends one character to the display and stops at the breakpoint. After the first four spaces, the characters will start to appear on the LCD display.

2.8   SUMMARY

This tutorial demonstrates the main features of the MPLAB IDE and MPLAB ICD 2 as they are used with the dsPICDEM Starter Demo 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 the MPLAB ICD 2
- Program the chip with the 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 Starter Demo Board is shipped with example applications programmed into the dsPIC device. These examples exercise several of the dsPIC peripherals such as the 12-bit ADC and UART interfaces. This chapter provides an overview of the demonstration code. Detailed information on the dsPICDEM Starter Demo Board hardware is presented in **Chapter 4. "dsPICDEM™ Development Hardware"** and **Appendix A. "Drawings and Schematics"**.

3.2   HIGHLIGHTS

Items discussed in this chapter are:

- Demonstration Program Summary
- Demonstration Code Operation
- Manufacture Test Code Module Summary

3.3   DEMONSTRATION PROGRAM SUMMARY

The preprogrammed demonstation 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 Starter Demo Board the dsPIC 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 interrupt devices 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.

The dsPIC30F 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 swiches.

3.3.2 Analog-to-Digital Conversion

To illustrate analog-to-digital conversion, the analog value of potentiometer R13 is converted by 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 Starter Demo 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 Starter Demo 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 Starter Demo 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 pot via the Serial Processor Interface (SPI) module on the dsPIC30F device. The table values cover the full range of the digital pot.

The program communicates a new table value to the digital potentiometer every 125 microseconds, which corresponds to 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 dsPIC30F device functionality used for this demonstartion includes:

• Mapping of data memory to program memory with PSV addressing
• Initialization of the SPI port
• Loading and transmission of data using harware 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 dsPIC30F MCU, 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 second, 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
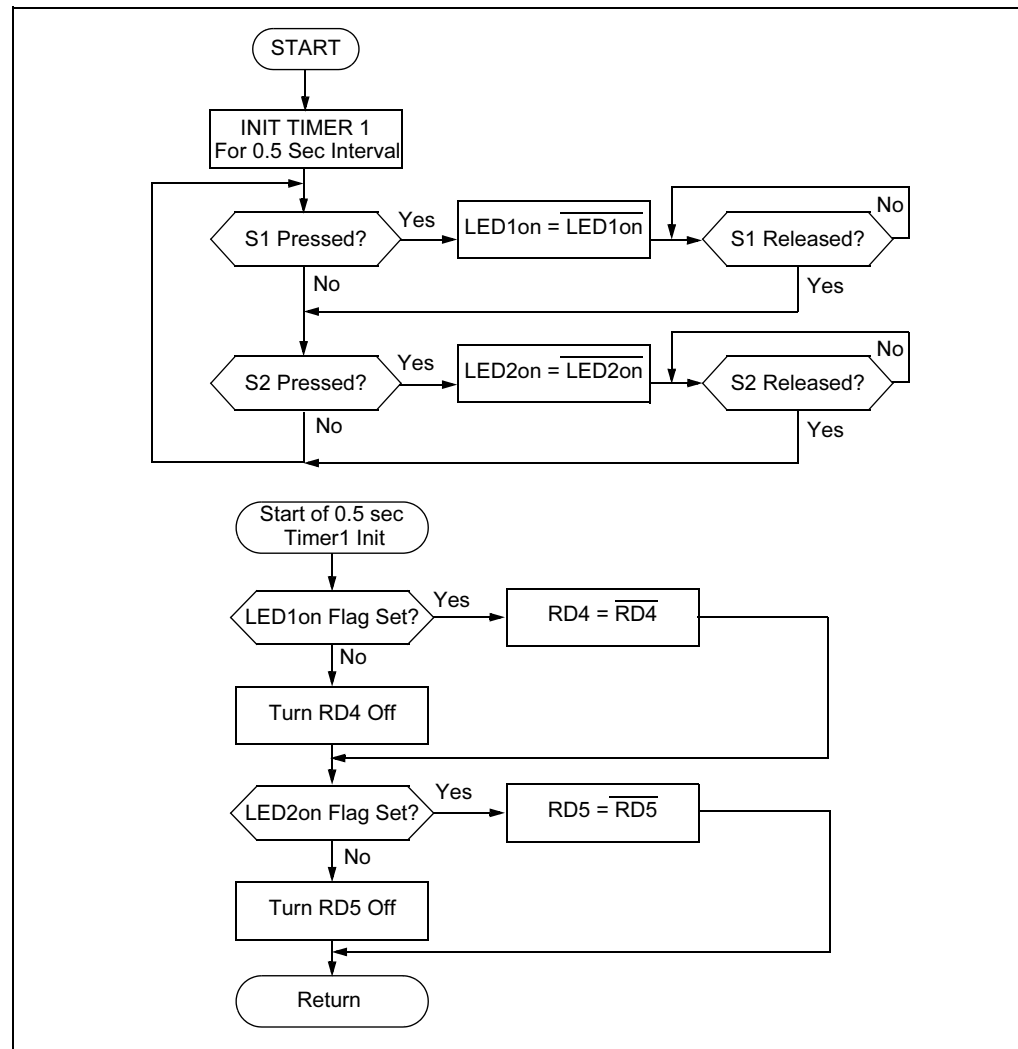
3.4.2   Analog-to-Digital Conversion

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
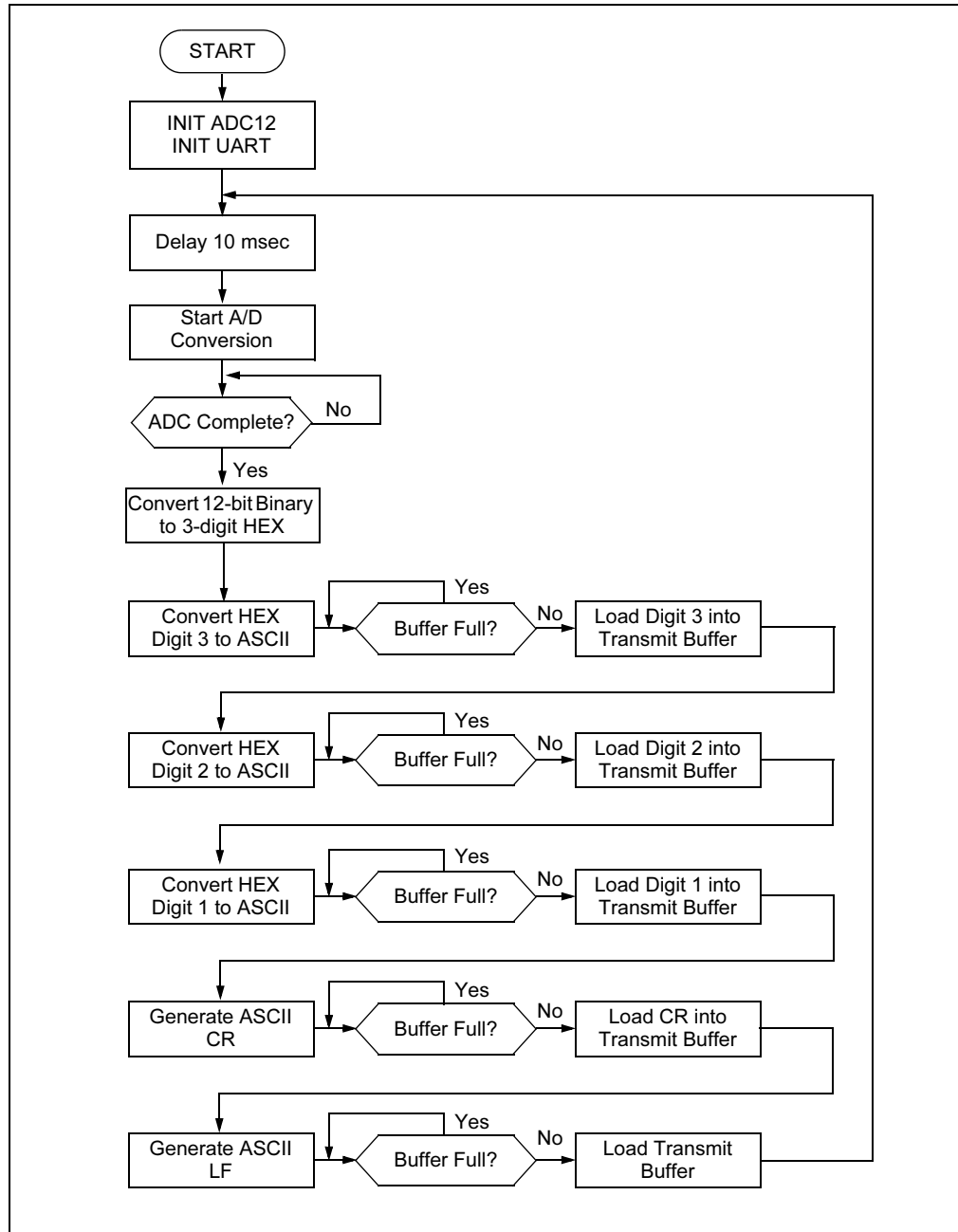
3.4.3 Digital-to-Analog Conversion

This program uses Digital Potentiometer MCP41010 on the dsPICDEM Starter Demo Board as a D/A converter to generate a sine wave signal (audio tone) to the LINE OUT pin. The digital pot is driven by the output of the serial peripheral interface SPI2 of the dsPIC30F6012 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 pot. As the analog output of the digital pot 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 demo 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
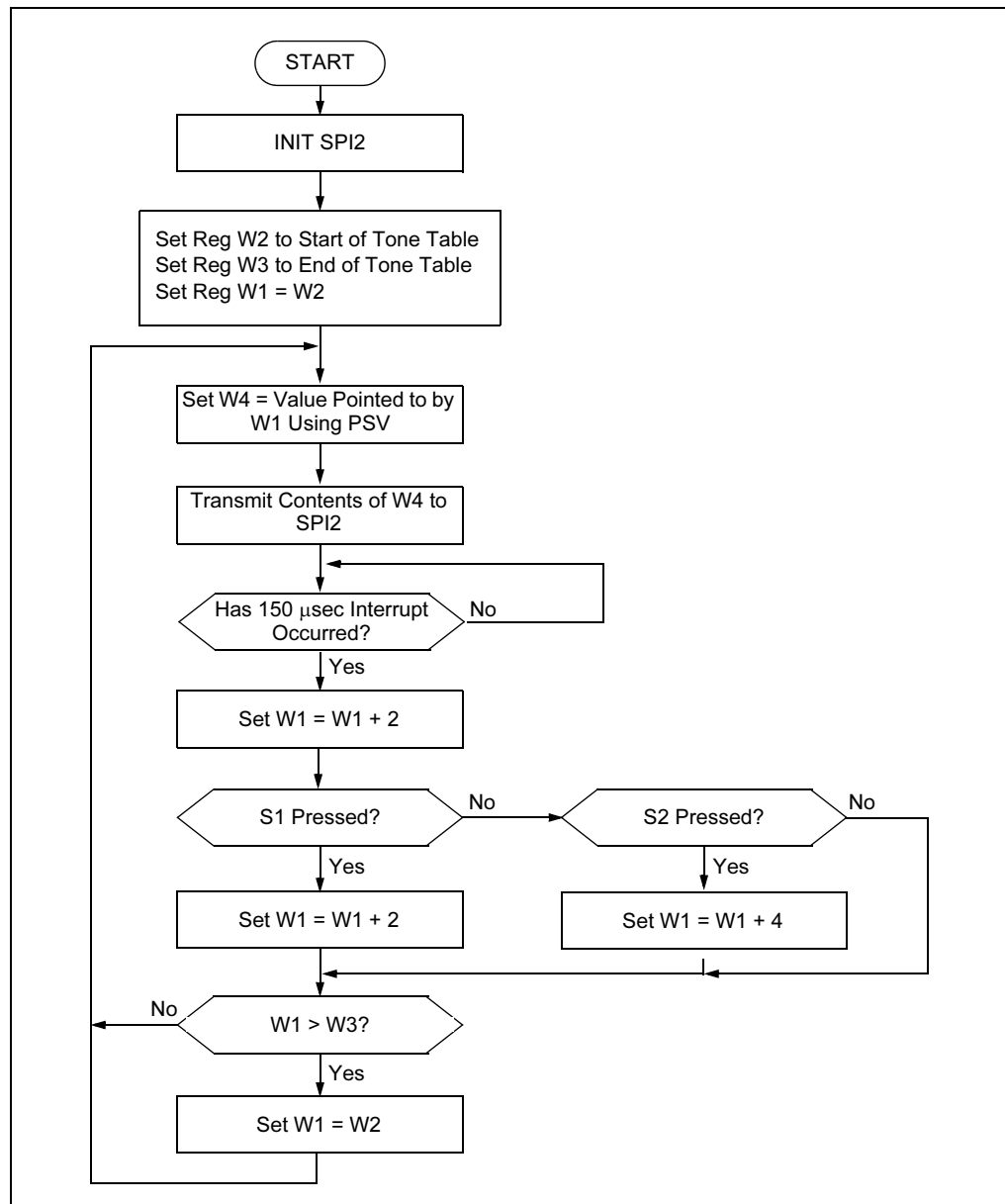
3.5   BOARD SELF TEST

The board self test is provided for completeness only. User's 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 5V is available at location marked 5V and GND (near the breadboard area).

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 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 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, the 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 as failed.
Tone Test	This procedure automatically tests the Digital Potentiometer and Analog Operational Amplifier. A sine wave, generated using the digital pot, is sent through the Op Amp circuit to the ADC of the dsPIC 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 pot 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	Pot R13 faulty
RD7	Digital Pot/Op amp	Digital Pot/Op Amp failed

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

NOTES:

Chapter 4. dsPICDEM™ Development Hardware

4.1 dsPICDEM™ STARTER DEMO BOARD HARDWARE OVERVIEW

This chapter describes the dsPICDEM Starter Demo Board hardware. The dsPICDEM Starter Demo Board features the hardware elements shown in Figure 4-1 and identified in Table 4-1
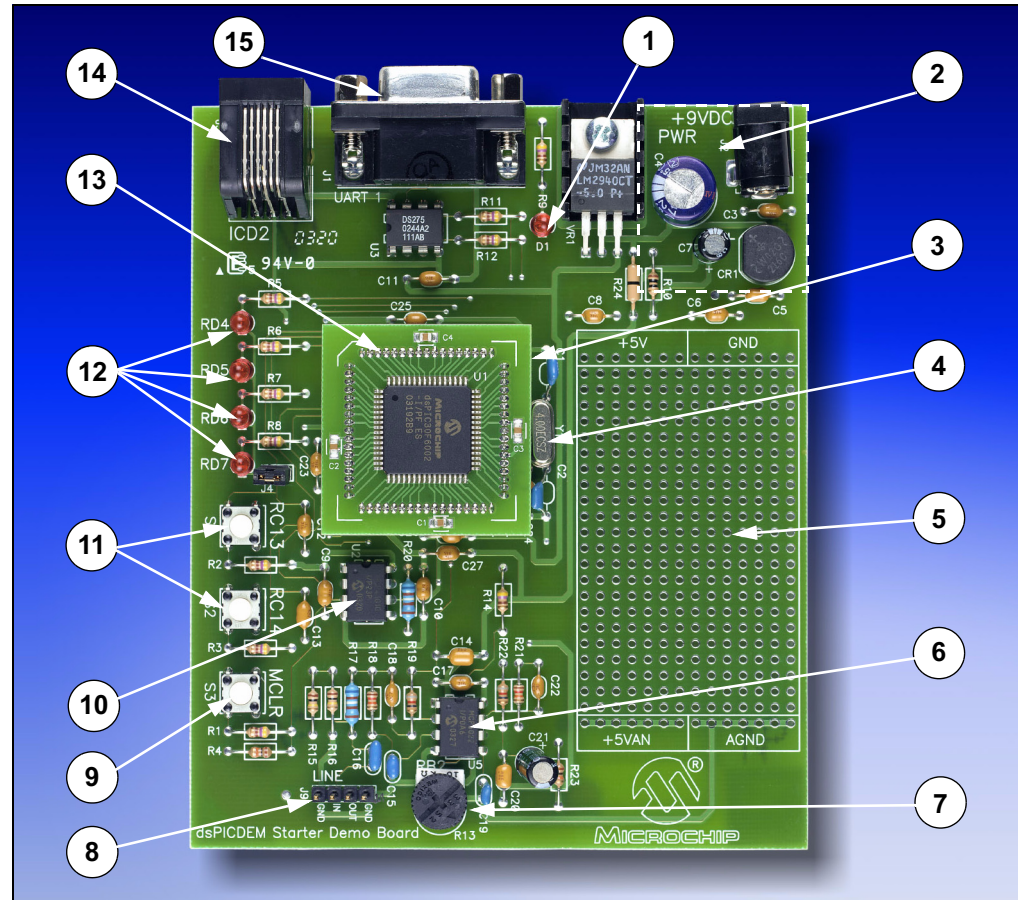
FIGURE 4-1: **dsPICDEM™ STARTER DEMO BOARD**

TABLE 4-1: **dsPICDEM™ STARTER DEMO BOARD HARDWARE ELEMENTS**

No.	Hardware Element	No.	Hardware Element
1	Power On Indicator (Section 4.1.10)	9	Reset Switch (Section 4.1.12)
2	Power Supply (Section 4.1.9)	10	Digital Potentiometer (Section 4.1.5)
3	Sample Device (Section 4.1.14)	11	Pushbutton Switches (Section 4.1.3)
4	Oscillator (Section 4.1.11)	12	LEDs (Section 4.1.4)
5	Prototyping Area (Section 4.1.13)	13	Emulation Header (Section 4.1.8)
6	Low-Pass Filter (Section 4.1.6)	14	ICD 2 Connector (Section 4.1.7)
7	Analog Potentiometer (Section 4.1.2)	15	RS-232 Serial Port (Section 4.1.1)
8	LINE Connector (Section 4.1.15)		

4.1.1 RS-232 Serial Port

The dsPICDEM Starter Demo Board provides one RS-232 serial communication channel. The serial communication channel, labeled J1, is configured as an RS-232 communication channel. The dsPIC UART channel 1 U1RX and U1TX pins are connected to an RS-232 level shifting IC, U3. The serial port is configured as DCE, and can be connected to a PC using a straight through cable.

4.1.2 Analog Potentiometer

One 10 kΩ potentiometer is connected to analog channels AN4, AN5 and AN6. The voltage output range for the potentiometer is 0-5 VDC. The voltage source is provided by the SV regulator on the development board.

4.1.3 Pushbutton Switches

Two switches, S1 and S2 are connected to port pin RC13 and RC14, respectively on the dsPIC device. The signal lines are normally pulled up to +5 VDC through 10 kΩ resistors. Pressing the switch shorts the line to ground. Port pins RC13 and RC14 are configured as input pins.

4.1.4 LEDs

Four red LEDs are connected to port pins RD4 to RD7, respectively on the dsPIC device. These LEDs are labeled RD4 through RD7 on the dsPICDEM Starter Demo Board to correspond to the port pins. The LED anodes are tied to VDD through a 470 ohm resister. The cathodes are shorted and connected to GND by Jumper J4.

4.1.5 Digital Potentiometer

A single channel digital potentiometer, MCP41010 is provided on the development board. The digital potentiometer is controlled by the dsPIC SPI2 communication channel. 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.

4.1.6 Low-Pass Filter

A Microchip MCP6022 Operational Amplifier. The output is configured as a 2nd-order, low-pass filter for speech or voice input filtering. 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, the MPLAB ICD 2 can be connected for low cost programming and debugging of the dsPIC device.

4.1.8 Emulation Header

Header P1 provides for a connection to the ICE 4K In-Circuit Emulator. The emulation header also supports the processor adaptor boards. The processor adaptor boards enable quick change out of the 64-pin TQFP device.

4.1.9 Power Supply

The dsPICDEM™ Starter Demo Board is powered by a +9V, AC/DC wall adapter. A +5 VDC regulator (VDD and AVDD) provides power to the respective processor pins and prototyping area. A ground trace connects all VSS points.

4.1.10   Power On Indicator

A red LED is connected to the input of the regulators to indicate the presence of power.

4.1.11   Oscillator

A crystal oscillator (4.00 MHz) is supplied.

4.1.12   Reset Switch

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

4.1.13   Prototyping Area

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

4.1.14   Sample Device

A sample part programmed with the demonstration code is included in the dsPICDEM Starter Demo Board Development Board kit. The 64-pin TQFP is soldered onto an adapter board that plugs into Emulation header connection on the main board (see Figure 4-2) .

> **Note:**   If you have an early version of the dsPICDEM Starter Demo Board the sample device may be soldered directly onto the main board.

4.1.15   LINE Connector (J9)

Pins provide line input and output connections for the low-pass filter:
- OUT – Output signal from digital potentiometer
- IN – Input signal for ADC

FIGURE 4-2:   ADAPTER BOARD PLUGS INTO HEADER ON MAIN BOARD
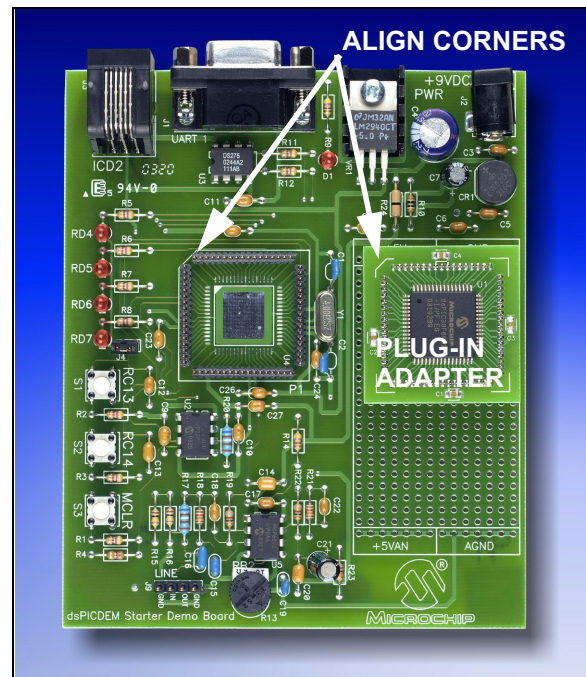
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Appendix A. Drawings and Schematics

A.1   dsPICDEM STARTER DEMO BOARD LAYOUT

Figure A-1 shows the parts layout for dsPICDEM Starter Demo Board.

FIGURE A-1:   dsPICDEM STARTER DEMO BOARD LAYOUT
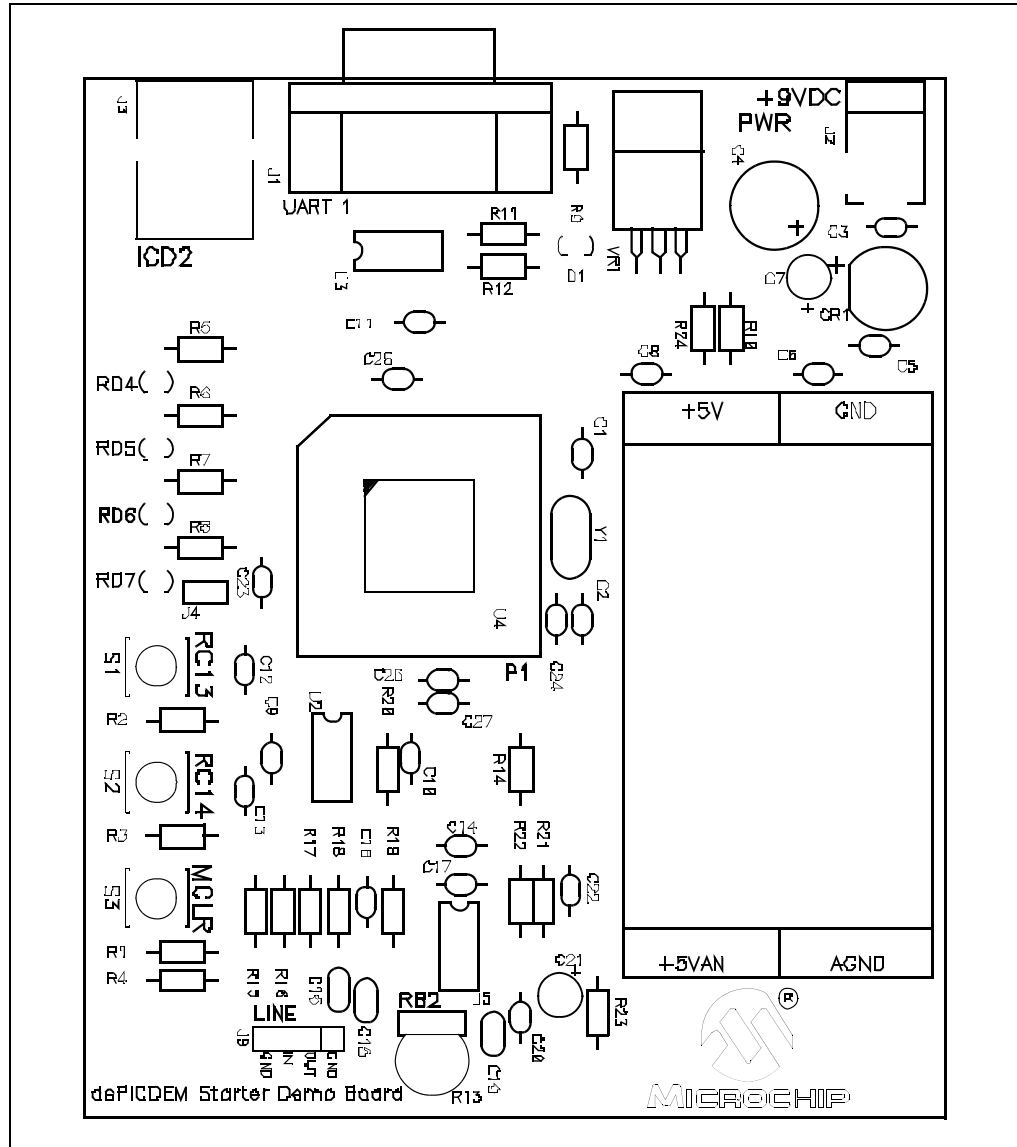
A.2   dsPICDEM STARTER DEMO BOARD SCHEMATIC

Figure A-2 provides a schematic diagram of the dsPICDEM Starter Demo Board.

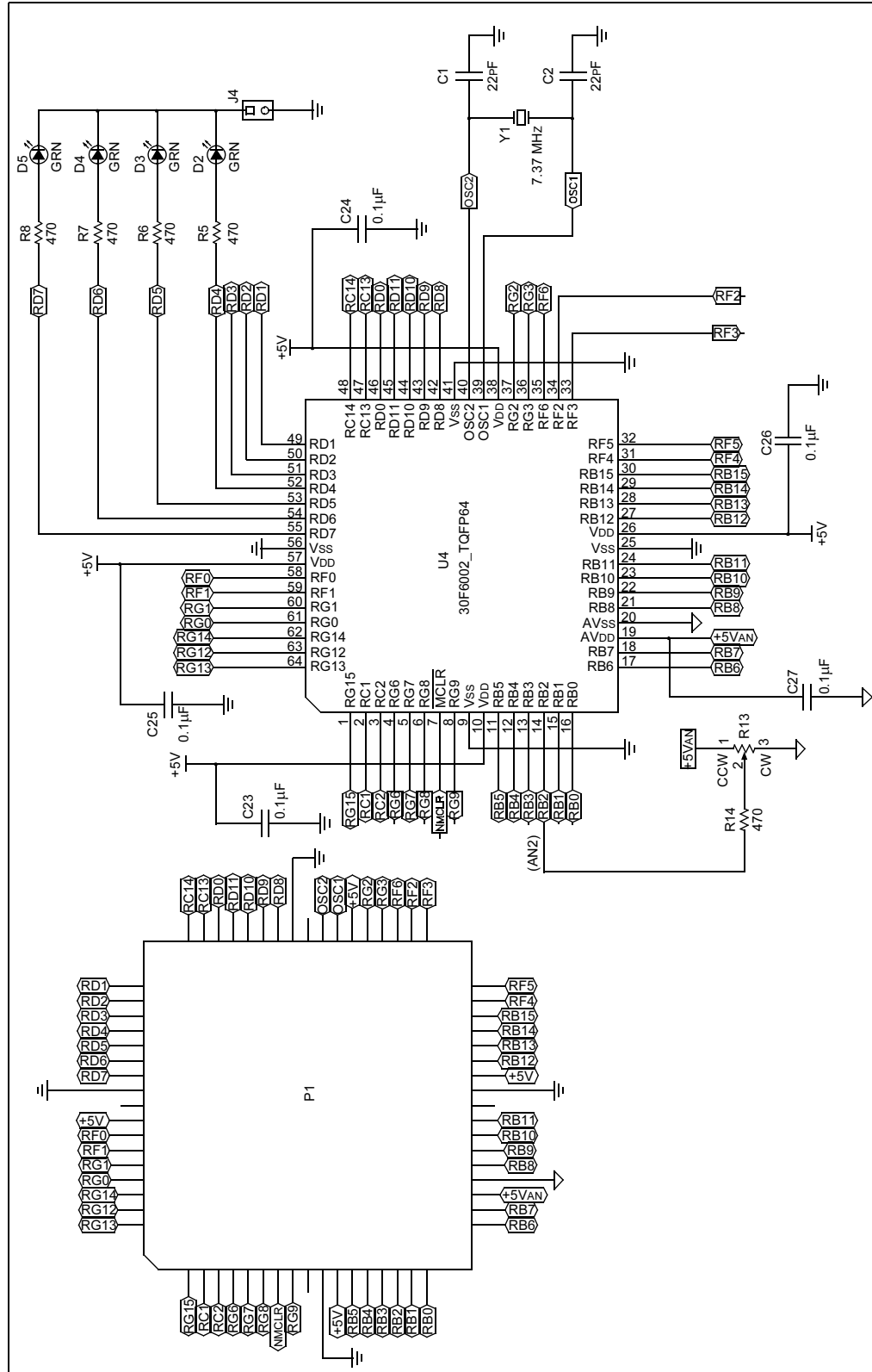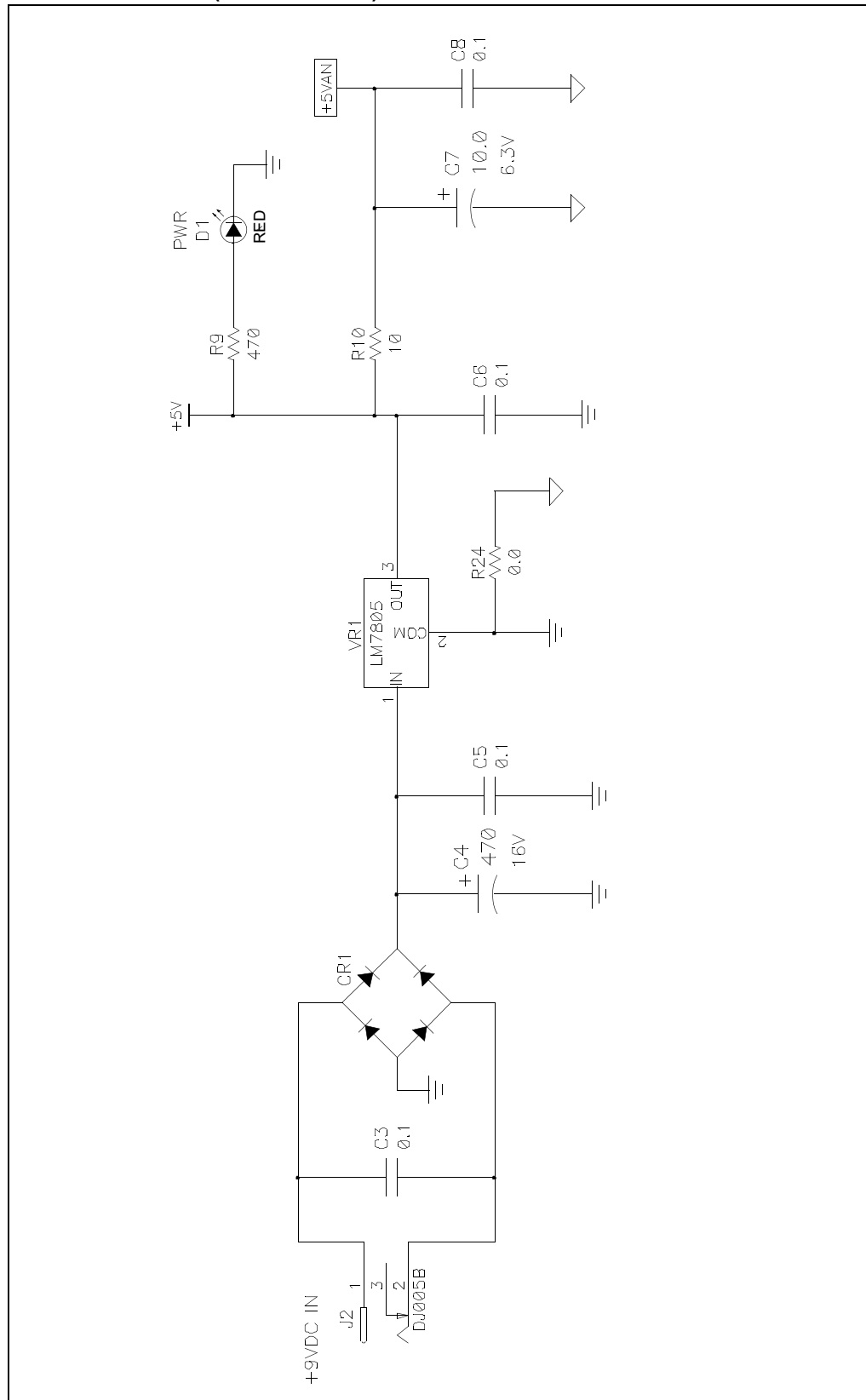**FIGURE A-2:   dsPICDEM STARTER DEMO BOARD SCHEMATIC (SHEET 1 OF 4)**

FIGURE A-3: **dsPICDEM STARTER DEMO BOARD SCHEMATIC (SHEET 2 OF 4)**

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FIGURE A-4: dsPICDEM STARTER DEMO BOARD SCHEMATIC (SHEET 3 OF 4)

FIGURE A-5: **dsPICDEM STARTER DEMO BOARD SCHEMATIC (SHEET 4 OF 4)**

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