MPLAB Starter Kit for dsPIC® Digital Signal Controllers User's Guide

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

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ISO/TS 16949:2002

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

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NOTES:

Preface

NOTICE TO CUSTOMERS

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

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before you use the MPLAB Starter Kit for dsPIC® Digital Signal Controllers. 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 starter kit as a development and demonstrative tool for dsPIC33F device's speech and audio processing capabilities. The manual layout is as follows:

- **Chapter 1. Introduction –** This chapter introduces the starter kit and provides an overview of its features.
- **Chapter 2. Speech Record and Playback Demo** – This chapter describes a simple program that demonstrates how to use the starter kit for speech capture and playback.
- **Chapter 3. Develop an Application** – This chapter describes how to debug application software on the starter kit using MPLAB® IDE.

- **Chapter 4. Hardware** – This chapter provides a functional overview of the starter kit and identifies the major hardware components.
- **Appendix A. Schematics** – This appendix provides detailed schematic diagrams of the starter kit.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following 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 New font:</td></tr>
<tr><td rowspan="7">Plain Courier New</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 New</td><td>A variable argument</td><td><code>file</code><code>.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>var_name [, var_name...]</td></tr>
<tr><td>Represents code supplied by user</td><td>void main (void)
{ ...
}</td></tr>
</table>

WARRANTY REGISTRATION

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

RECOMMENDED READING

This user's guide describes how to use the MPLAB Starter Kit for dsPIC Digital Signal Controllers. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

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.

dsPIC33F Family Reference Manual (DS70046)

Refer to this document for detailed information on dsPIC33F device operation. This reference manual explains the operation of the dsPIC33F Digital Signal Controller (DSC) family architecture and peripheral modules, but does not cover the specifics of each device. Refer also to the appropriate device data sheet for device-specific information and specifications.

dsPIC33F Family Data Sheet (DS70165)

This document provides an overview of the functionality of the dsPIC33F product family. It includes device-specific information such as pinout diagrams, register maps, electrical specifications and packaging, in addition to an overview of the CPU and peripheral features.

dsPIC30F/33F Programmer's Reference Manual (DS70157)

This manual is a software developer's reference for the dsPIC30F and dsPIC33F 16-bit DSC devices. It describes the instruction set in detail and also provides general information to assist in developing software for the dsPIC30F/33F DSC family.

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

This document helps you use Microchip Technology's language tools for dsPIC33F and PIC24H devices based on GNU technology. The language tools discussed are the MPLAB ASM30 Assembler, MPLAB LINK30 Linker, MPLAB LIB30 Archiver/Librarian and other 16-bit device utilities.

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

This document helps you use Microchip's MPLAB C30 C compiler to develop your application. MPLAB C30 is a GNU-based language tool, based on source code from the Free Software Foundation (FSF). For more information about FSF, see www.fsf.org.

MPLAB® IDE User's Guide (DS51519)

This document describes how to use the MPLAB IDE integrated development environment, as well as the MPLAB Project manager, MPLAB Editor and MPLAB SIM simulator. Use these development tools to help you develop and debug application code.

dsPIC® DSC Speech Coding Solutions User's Guide (DS70295)

This document describes the dsPIC DSC Speech Encoding/Decoding Libraries including G.711, G.726A and Speex Speech Encoding/Decoding software application solutions. The individual libraries provide toll-quality voice compression and decompression to help generate speech-based embedded applications on the dsPIC30F and dsPIC33F families of digital signal controllers.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

DEVELOPMENT SYSTEMS CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com, click on Customer Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools. These include the MPLAB C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ and MPLAB LIB30 object librarians.
- **In-Circuit Emulators** – The latest information on Microchip in-circuit emulators. These include the MPLAB REAL ICE and MPLAB ICE 2000 in-circuit emulators.
- **In-Circuit Debuggers** – The latest information on Microchip in-circuit debuggers. These include MPLAB ICD 2 and PICkit™ 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 IDE Project Manager, MPLAB Editor and MPLAB SIM simulator, as well as general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 device programmer and the PICSTART® Plus and PICkit 1 and 2 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 (February 2008)

- Initial Release of this Document

NOTES:

Chapter 1. Introduction

Thank you for purchasing Microchip Technology's MPLAB Starter Kit for dsPIC® Digital Signal Controllers. This kit is intended to introduce and demonstrate the features of the dsPIC33F Digital Signal Controllers (DSCs), and, in particular, some of the speech and audio processing capabilities of dsPIC DSC devices. The starter kit demonstrates a low-cost yet effective software technique for processing acceptable voice-quality audio. Also, the board includes a 24-bit audio codec for high-quality audio applications. In addition, the starter kit has on-board in-circuit debug circuitry so that you may develop and debug your own application.

This chapter introduces the starter kit and provides an overview of its features. Topics covered include:

- Overview
- Operational Requirements
- Board Setup

1.1 OVERVIEW

The MPLAB Starter Kit for dsPIC Digital Signal Controllers connects directly to the USB port on a computer. The PC USB connection supplies communications and power to the board.

The starter kit includes debug and programmer circuitry that allows applications to be programmed onto the board's dsPIC33F device and then debugged, all using MPLAB IDE.

Audio input signals from an external microphone or audio equipment are routed to the ADC module in the on-board dsPIC33F device for software processing. Alternatively, applications can use the audio codec for converting the audio signal.

Output signals can be generated by the dsPIC33F device's Output Compare module as a Pulse-Width Modulated (PWM) digital waveform. This PWM signal is converted to an analog signal by a low-pass filter on the starter kit board. Alternatively, applications can output audio data using the audio codec. The output audio signal is then amplified using a headphone amplifier circuit for playback on a headphone.

In addition to the Recommended Reading listed in the Preface, the following manufacturers' data sheets are also recommended as reference sources:

- *National Semiconductor Corporation Data Sheet, LM4811 Boomer® Audio Power Amplifier Series Dual 105mW Headphone Amplifier with Digital Volume Control and Shutdown Mode (DS200061)*
- *Wolfson Microelectronics Data Sheet, WM8510 Mono CODEC with Speaker Driver, Production Data December 2006, Rev. 4.1*

1.2 OPERATIONAL REQUIREMENTS

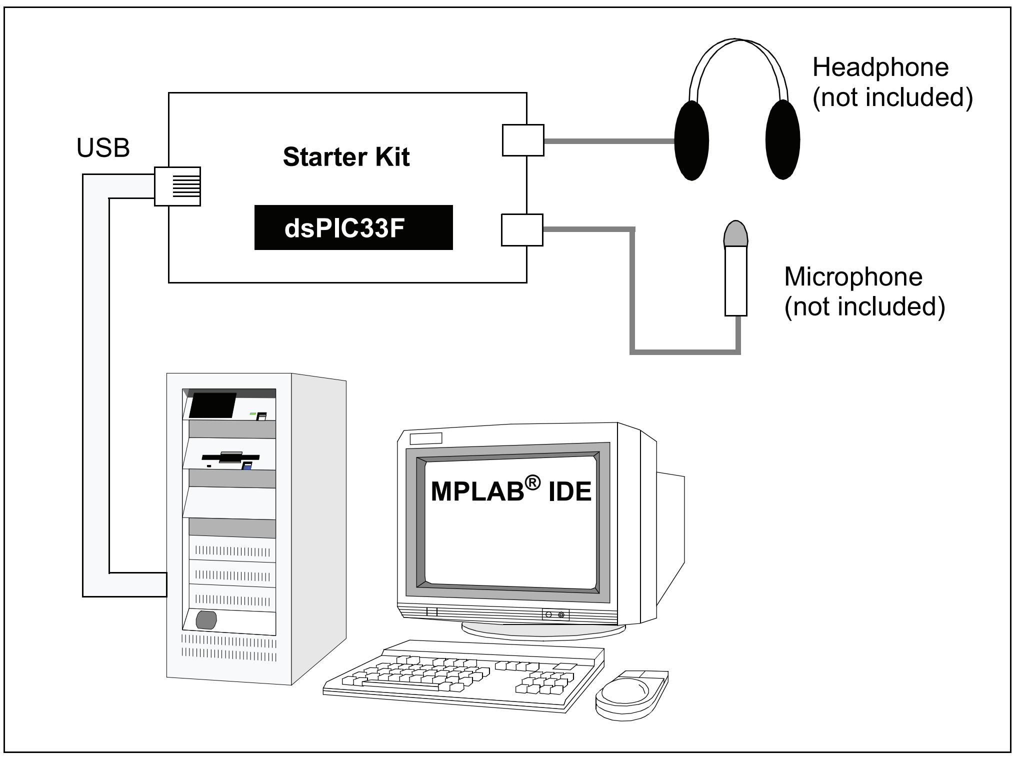
To communicate with and program the MPLAB Starter Kit for dsPIC Digital Signal Controllers, the following hardware and software requirements must be met:

- PC compatible system
- An available USB port on PC or powered USB hub
- CD-ROM drive
- Windows® 2000 SP4, Windows XP SP2, and Windows Vista™ (32-Bit)* Operating Systems
  * Only initial testing has been performed on 32-bit Vista for this release. 64-bit Vista is not supported at this time.
- Headphones (not included) – See **Section 4.3.2.9 "Headphone Output Jack (J8)"** for requirements.
- Microphone (not included) – See **Section 4.3.2.10 "Line/Microphone Input Phone Jack (J9)"** for requirements.

1.3 BOARD SETUP

Figure 1-1 is a drawing of a set up MPLAB Starter Kit for dsPIC Digital Signal Controllers. A microphone and headphone will need to be connected to the board (not included). The USB connection provides communication and power to the board. The demonstration software on the dsPIC33F device plays back speech stored on the board's serial Flash memory and allows recording and playback of recorded speech.

FIGURE 1-1: MPLAB STARTER KIT FOR dsPIC® DIGITAL SIGNAL CONTROLLERS SETUP



Chapter 2. Speech Record and Playback Demo

This chapter describes the Speech Record and Playback Demonstration application that is preloaded on the dsPIC33F device. This application demonstrates how to use the starter kit for speech capture, speech playback, speech encoding and decoding, and using the serial Flash memory to store speech samples. Topics covered include:

- Running the Demo
- Understanding the Demo
- Examining Demo Software Flow
- Other Demo Code Examples

2.1 RUNNING THE DEMO

To run the demo, follow these basic steps:

1. Connect a microphone to socket J9. Connect a headphone to socket J8. Ensure that potentiometer R56 is set to the factory setting, i.e., the arrow on the potentiometer points to the arrow on the board.
2. Power up the starter kit by connecting the board to the USB port of a computer.

   You should briefly see a pop-up balloon in the system tray (lower right of desktop) that states (1) new hardware has been found, (2) drivers are being installed, and (3) new hardware is ready for use. If you do not see these messages and then the starter kit does not work, try reconnecting the USB. If this does not work, see **Section 3.8 "Troubleshooting"**.
3. When powered up, the application will repeatedly play back an introductory message.

To use the application, follow these steps:

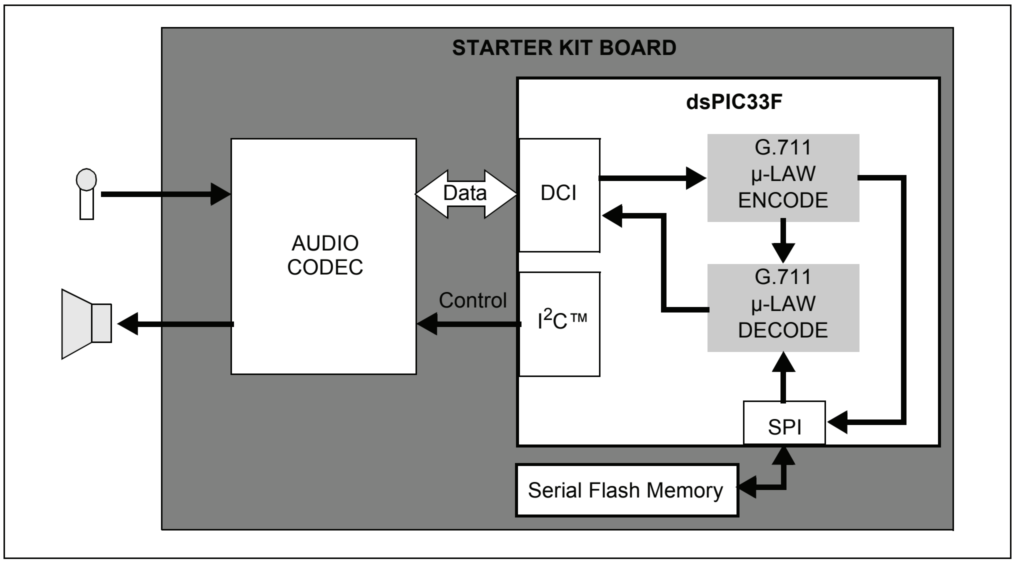
1. To record speech, press switch S1 and wait till the Red LED turns off (the serial Flash memory is being erased) and the Yellow LED turns on. The application will now record the microphone audio signals and store them in the serial Flash memory.
2. Press switch S2 to playback and listen to the stored speech samples. The Green LED turns on during playback.
3. Pressing switch S1 again erases the serial Flash memory and prepares the system for another recording.

2.2 UNDERSTANDING THE DEMO

The dsPIC33F device on the starter kit is pre-programmed with a Speech Record and Playback Demonstration application. The CD that accompanies the starter kit contains the application code. As shown in Figure 2-1, this sample application uses the board to capture an input microphone signal using the audio codec. The application program running on the device does the following:

- Reads an introductory speech message stored on the serial Flash memory and uses the audio codec to play back the audio signal.
- If speech recording is desired, the application compresses the incoming digital signal from 16 bits to 8 bits using the G.711 µ-law encoding algorithm and stores the encoded speech samples on the serial flash memory.
- If playback is desired, the application reads the serial Flash memory device and decodes the read samples using the G.711 µ-law decoding algorithm. The application then uses the audio codec to play back the speech signal.

FIGURE 2-1: SPEECH RECORD AND PLAYBACK DEMO OVERVIEW



The board also features circuitry for audio playback using the Pulse-Width Modulation technique. This technique can be used to implement a low-cost audio playback system. For a demo of this technique, access the starter kit's CD-ROM.

The demo program consists of three basic software elements: WM8510 Codec Driver, G.711 Speech Encoder and Decoder, and Serial Flash Memory Driver.

2.2.1 WM8510 Codec Driver

The WM8510 Codec Driver configures the WM8510 audio codec and provides an interface for reading and writing audio data to the codec. The driver is implemented in `WM8510CodecDrv.c` and the interface is defined in `WM8510CodecDrv.h`. The driver uses the DCI module on the dsPIC33F device module to process data and the I^2C™ module as a codec control bus. The demo application configures the codec for a 8 KHz sampling rate.

2.2.2 G.711 Speech Encoder and Decoder

The G.711 Encoder and Decoder implement the ITU-T G.711 Speech Compression algorithm. This algorithm is an example of a waveform coder and provides a compression ratio of 2:1. The algorithm is implemented in `G711.s` and its interface is defined by `G711.h`

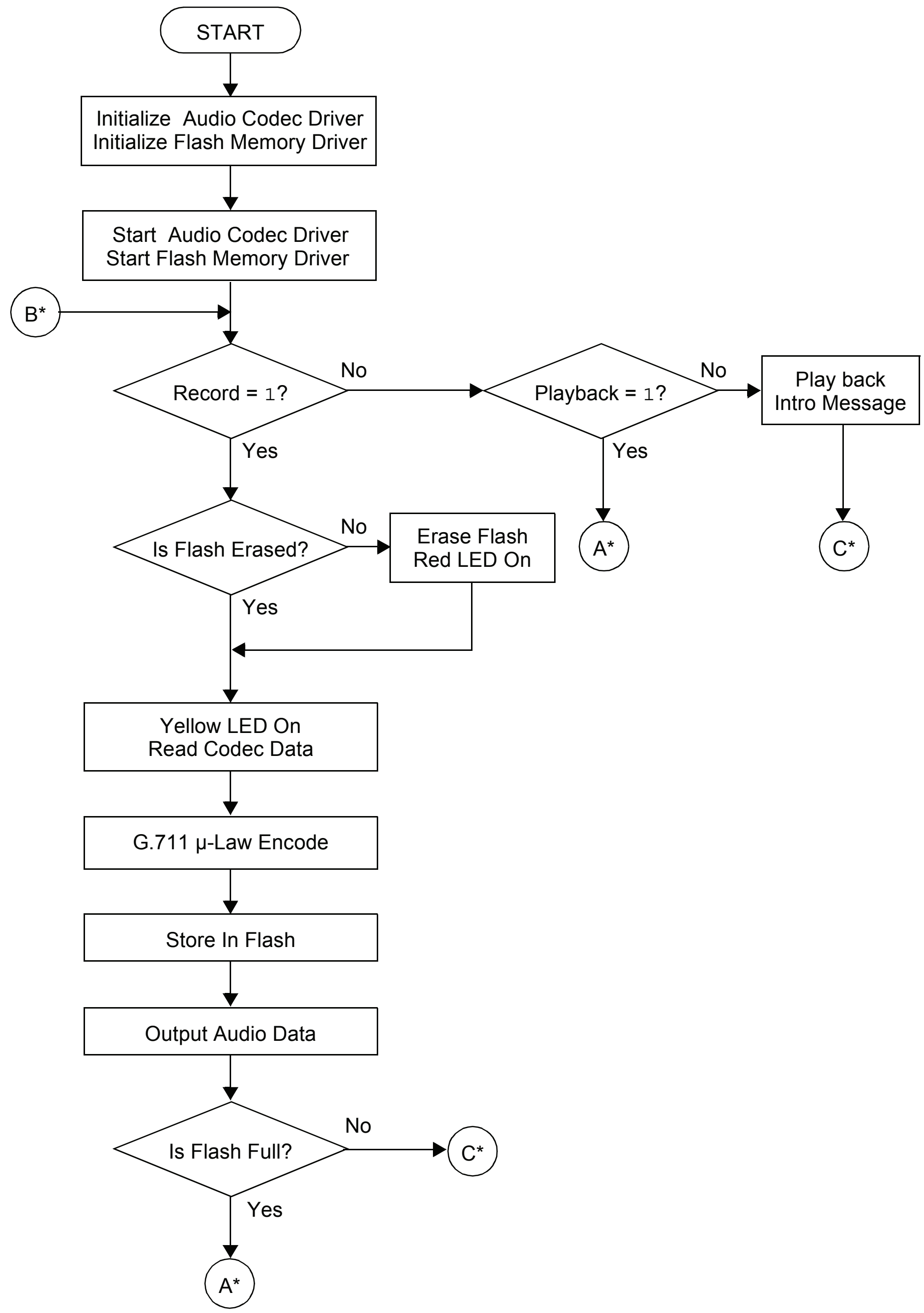
2.2.3 Serial Flash Memory Driver

The Serial Flash Memory driver uses the SPI peripheral on the dsPIC33F device to interface with the external serial Flash memory device. The driver requires a buffer for its operation and this buffer must be allocated by the application. The driver allows the application to perform operations such as read, chip erase, sector erase and status check.

2.3 EXAMINING DEMO SOFTWARE FLOW

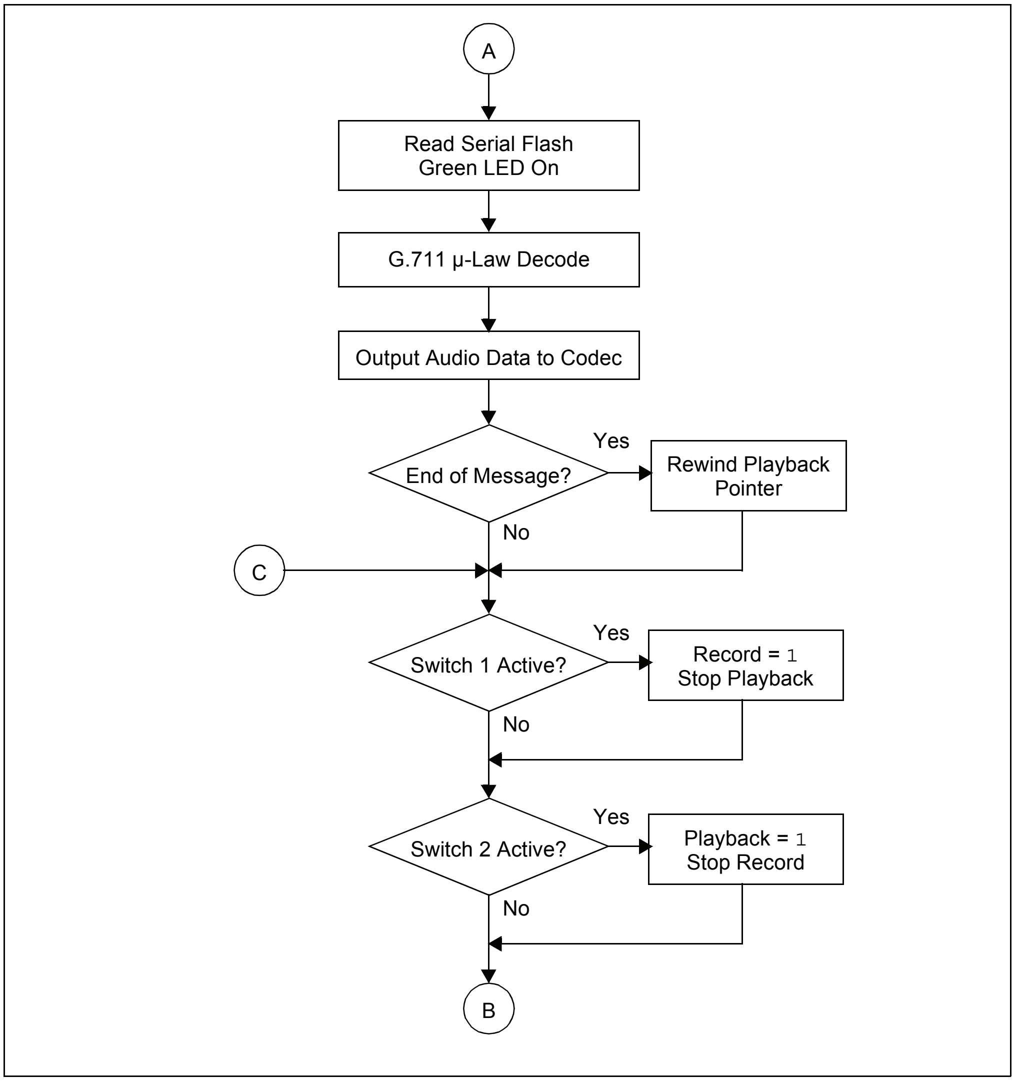
The Speech Record and Playback Demonstration application uses the WM8510 codec, G.711 speech encoding and decoding libraries, and the serial Flash memory drivers to read, output and store speech signals with the starter kit. The application will encode a microphone signal, store the encoded samples in serial flash memory and play back the decoded samples to a headphone output. The G.711 μ-law algorithm is used for encoding and decoding speech samples. Figure 2-2 and Figure 2-3 are flow charts of the demo application.

FIGURE 2-2: APPLICATION FLOW CHART – PART ONE



*Refer to the corresponding letter in **Figure 2-3: “Application Flow Chart – Part Two”** for the continuation of the flow chart.

FIGURE 2-3: APPLICATION FLOW CHART – PART TWO



2.4 OTHER DEMO CODE EXAMPLES

The starter kit software CD includes other demo code examples.

The SASK Record Play Demo with Intro Code Example demonstrates the low-cost speech capture and playback option. It uses the dsPIC DSC 12-bit ADC to capture speech samples. The data is stored in the serial Flash memory. The application then uses the Output Compare module in Pulse-Width Modulation (PWM) mode to generate a PWM signal representing the speech signal.

Note: Jumper J6 should in the OCPWM position to use this demo.

The SASK Intro Speech Prog code example can be used to program the introductory message into the serial Flash. This is useful in a case where the entire serial Flash has been erased and it is desirable to set up the introductory message again.

Note: The SASK Intro Speech Prog code example performs a full chip erase on the serial Flash. In order to prevent accidental serial Flash chip erase when the board is taken in and out of Reset, erase the dsPIC33F program Flash via MPLAB IDE after the running the SASK Intro Speech Prog code example. Refer to the `readme.txt` files in the project folder for more details.

Chapter 3. Develop an Application

The MPLAB Starter Kit for dsPIC® Digital Signal Controllers may be used with MPLAB IDE, the free integrated development environment available on Microchip's website. MPLAB IDE allows the starter kit to be used as an in-circuit debugger as well as a programmer for the featured device.

In-circuit debugging allows you to run, examine and modify your program for the device embedded in the starter kit hardware. This greatly assists you in debugging your firmware and hardware together.

Special starter kit software interacts with the MPLAB IDE application to run, stop and single-step through programs. Breakpoints can be set and the processor can be reset. Once the processor is stopped, the register's contents can be examined and modified.

For more information on how to use MPLAB IDE, reference the following documentation:

- MPLAB® IDE User's Guide (DS51519)
- MPLAB® IDE Quick Start Guide (DS51281)
- MPLAB® IDE On-line Help

This chapter includes the following:

- Installing the Hardware and Software
- Setting Up an Example Application for Debug
- Running the Example Application
- Debugging the Example Application
- Programming the Debugged Application
- Creating Other dsPIC DSC Applications
- Determining Device Support and Reserved Resources
- Troubleshooting
- Settings Dialog, Info Tab

3.1 INSTALLING THE HARDWARE AND SOFTWARE

To install the hardware:

If you have not already set up the hardware to run the demo, follow these steps:

1. Connect a microphone to socket J9. Connect a headphone to socket J8. Ensure that potentiometer R56 is set to the factory setting, i.e., the arrow on the potentiometer points to the arrow on the board.
2. Power up the starter kit by connecting the board to the USB port of a computer.

   You should briefly see a pop-up balloon in the system tray (lower right of desktop) that states (1) new hardware has been found, (2) drivers are being installed, and (3) new hardware is ready for use. If you do not see these messages and then the starter kit does not work, try reconnecting the USB. If this does not work, see **Section 3.8 "Troubleshooting"**.
3. When powered up, the application will repeatedly play back an introductory message.

To install the software:

Run CD-ROM enclosed with the starter kit and install software as directed.

3.2 SETTING UP AN EXAMPLE APPLICATION FOR DEBUG

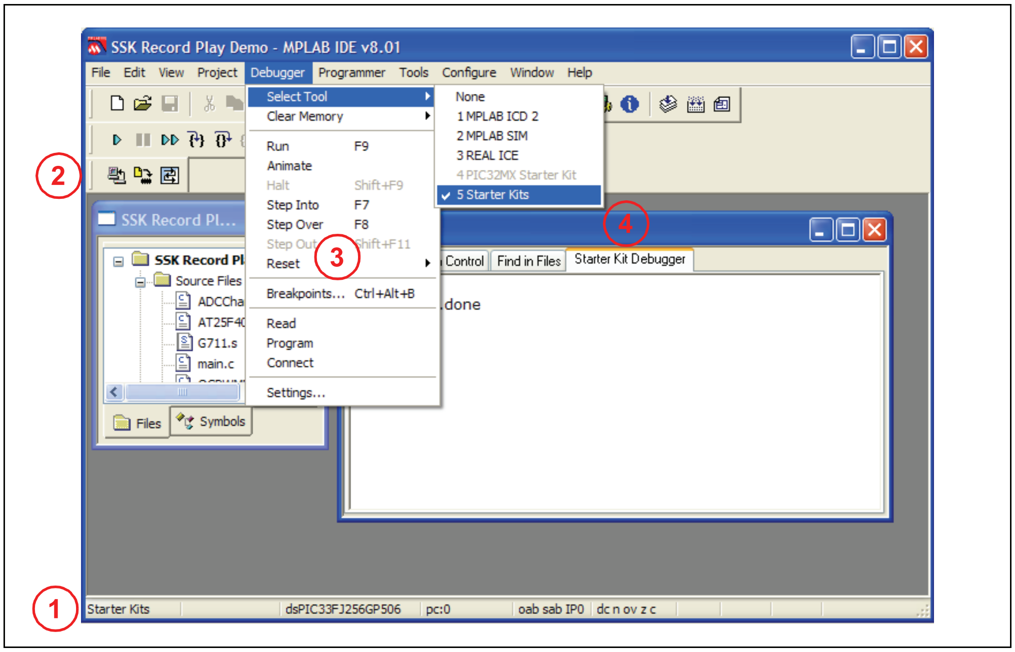
The MPLAB IDE software that is installed on your PC by the starter kit CD-ROM automatically opens an example application that you may use to examine debug features of the starter kit.

To prepare the application for debug:

1. Launch MPLAB IDE. The example application project and related workspace will open. For information on projects and workspaces, see the MPLAB IDE documentation mentioned at the beginning of this chapter.
2. Select *Project>Build All* to build the application code. The build's progress will be visible in the Build tab of the Output window.
3. Select *Debugger>Select Tool>Starter Kits*. MPLAB IDE will change to add starter kit debug features (Figure 3-1): (1) the status bar will show Starter Kits as the debug tool, (2) a Starter Kit debug toolbar will be added, (3) the Debugger menu will change to add Starter Kit debug functions and (4) the Output window will display communication status between MPLAB IDE and the stater kit on the **Starter Kit Debugger** tab.

   Also, several device resources are used for debug. For details, see **Section 3.7 "Determining Device Support and Reserved Resources"**.

FIGURE 3-1: STARTER KIT AS DEBUG TOOL



4. Select *Debugger>Program* to program the application code into the dsPIC33F DCS device on the starter kit. The debug programming progress will be visible in the **Starter Kit** tab of the Output window.

Note:	Debug executive code is automatically programmed in the upper program memory of the starter kit device when the starter kit is selected as a debugger. Debug code must be programmed into the target device to use the in-circuit debugging capabilities of the starter kit.

3.3 RUNNING THE EXAMPLE APPLICATION

The starter kit executes in either real-time (Run) or steps (Step Into, Step Over, Animate.) Real-time execution occurs when you select **Run** in MPLAB IDE. Once the device code is halted, either by **Halt** or a breakpoint, you can step.

The following toolbar buttons can be used for quick access to commonly used debug operations:

Debugger Menu	Toolbar Buttons
Run	
Halt	
Animate	
Step Into	
Step Over	
Reset	

To see how these options function, do the following:

1. Select *Debugger>Reset>Processor Reset* or click the **Reset** button to reset the program.
2. Select *Debugger>Run* or click the **Run** button. Observe how the application operates.
3. Select *Debugger>Halt* or click the **Halt** button to stop the program execution. A green solid arrow will mark the line of code in the File window where the program halted.
4. Select *Debugger>Step Into* or click the **Step Into** button to step the program execution once. The green solid arrow will move down one line of code in the File window. Click the button several times to step through some code.
5. Select *Debugger>Reset>Processor Reset* click the **Reset** button to reset the program again. The arrow will disappear, meaning the device is reset.

3.4 DEBUGGING THE EXAMPLE APPLICATION

For the example code given, everything works fine. However, when you are developing code, it will likely not work the first time and need to be debugged. MPLAB IDE provides an editor and several debug features such as breakpoints and Watch windows to aid in application code debugging.

This section includes:

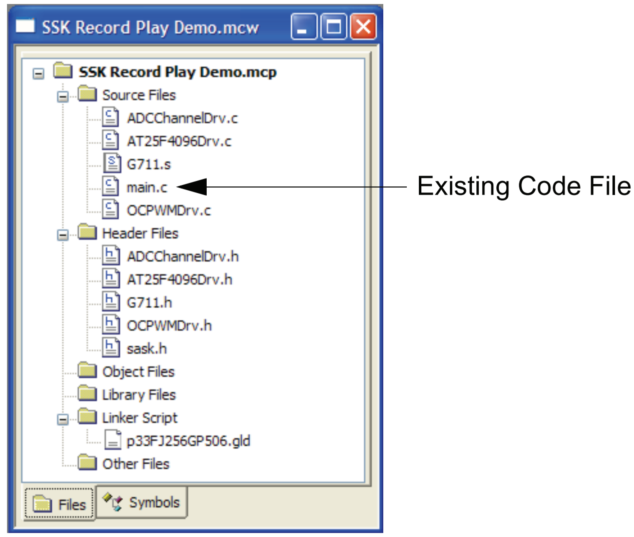
- Editing Application Code
- Using Breakpoints and Mouseovers
- Using Watch Windows

3.4.1 Editing Application Code

To view application code so it may be edited, do one of the following:

- Select _Edit>New_ to create new code or _Edit>Open_ to search for and open an existing code file.
- Double click on a file in the Project window to open an existing code file. See an example Project window in Figure 3-2.

FIGURE 3-2: EXAMPLE PROJECT



For more information on using the editor to create and edit code, see MPLAB Editor Help.

3.4.2 Using Breakpoints and Mouseovers

To set a breakpoint in code:

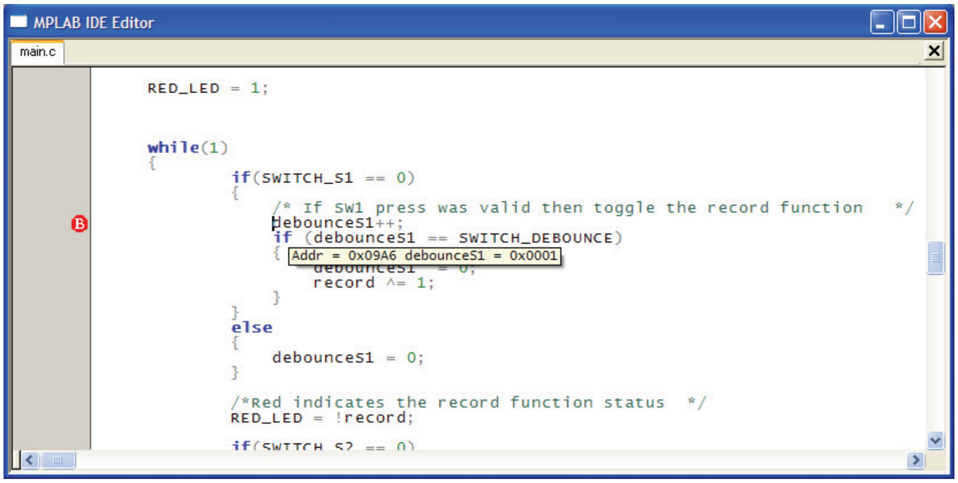
1. **Double Click in the Gutter** – Double click in the window gutter next to the line of code where you want the breakpoint. Double click again to remove the breakpoint.

> **Note:** Double click must be set up for breakpoints. See _Edit>Properities_, ***ASM/C/BAS*** **File Type** tab, checkbox for “Double-click Toggles Breakpoint”.

2. **Pop-up Menu** – Place the cursor over the line of code where you want the breakpoint. Then, right click to pop up a menu and select “Set Breakpoint”. Once a breakpoint is set, “Set Breakpoint” will become “Remove Breakpoint” and “Disable breakpoint”. Other options on the pop-up menu under Breakpoints are for deleting, enabling or disabling all breakpoints.
3. **Breakpoint Dialog** – Open the Breakpoint dialog (_Debugger>Breakpoints_) to set, delete, enable or disable breakpoints. See MPLAB IDE Help for more information on this dialog.

A breakpoint set in code will appear as a red hexagon with a "B" as shown in Figure 3-3.

FIGURE 3-3: EXAMPLE BREAKPOINT



Once code is halted, hovering over variables pops up the current value of those variables (see Figure 3-3.)

> **Note:** This feature must be set up. See *Edit>Properties*, **Tooltips** tab, check the "Enable Variable Mouseover Values" checkbox.

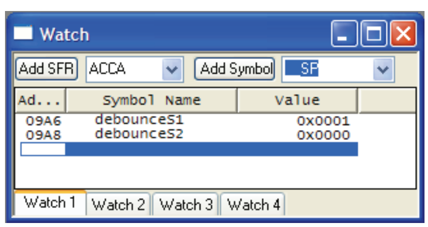
3.4.3 Using Watch Windows

To use a Watch window:

1. The Watch window is made visible on the desktop by selecting *View>Watch*. It contains four selectable Watch views (via tabs) in which to view variables (SFRs, symbols and absolute addresses).
2. Select an SFR or Symbol from the list and click the related **Add** button to add it to the Watch window. Or click in the "Address" column and enter an absolute address.

A Watch window populated with an SFRs and Symbols will look like Figure 3-4. For more on using Watch windows, see MPLAB IDE Help.

FIGURE 3-4: EXAMPLE WATCH



3.5 PROGRAMMING THE DEBUGGED APPLICATION

When the program is successfully debugged and running, the next step is to program the device for stand-alone operation in the finished design. When doing this, the resources reserved for debug are released for use by the application. To program the application, use the following steps:

1. Disable Starter Kits as a debug tool by selecting *Debugger>Select Tool>None*.
2. Select Starter Kits as the programmer in the *Programmer>Select Programmer* menu.
3. Select *Programmer>Program*.

Now the starter kit will run independently.

3.6 CREATING OTHER dsPIC DSC APPLICATIONS

This starter kit is just one way to use Microchip dsPIC DSCs in an application. Other tools and resources exist to support these devices.

- dsPIC DSC Demo Boards – Many boards are available for developing applications. See our website (http://www.microchip.com/) under Design>Development Tools>Demo Boards>dsPIC DSC.
- MPLAB C30 C Compiler, Full Version – More optimization options than the student version for full-scale development. See http://www.microchip.com/c30.
- Application Notes – Example applications with code for using dsPIC DSC features. See our website (http://www.microchip.com/) under Design>App Notes & Source Code>16-bit PIC MCUs & dsPIC DSCs.

3.7 DETERMINING DEVICE SUPPORT AND RESERVED RESOURCES

Due to the built-in in-circuit debugging capability of ICD devices and the ICSP™ function offered by the debugger, the starter kit uses some on-chip resources when debugging. It also uses program memory and file register locations in the target device during debugging. These locations are not available for use by user code. In the MPLAB IDE, registers marked with an "R" in register displays represent reserved registers.

For information on device resources that are needed for in-circuit debugging, please refer to the MPLAB ICD 2 Help, found in MPLAB IDE under *Help>Topics*. The device reserved resource information found under "Resources Used By MPLAB ICD 2" is the same for the starter kit.

3.8 TROUBLESHOOTING

Debug Connection Problems

While using the starter kit as a debugger, you may get the error “Unable to Enter Debug Mode” when programming the device. This can result from communication being lost between the starter kit and MPLAB IDE. To resolve this:

1. Unplug the USB cable from the starter kit.
2. Plug the USB cable back into the starter kit.

MPLAB IDE should automatically reconnect to the starter kit. If this does not work, do the following:

1. Check the USB connection between the PC and starter kit at both ends.
2. If using a USB hub, make sure it is powered.
3. Make sure the USB port is not in use by another device.

Programming Problems

If during the course of developing your own application you can no longer program the device on the starter kit, you may have set device configuration bits to code protect or some other state that prevents programming. To view the settings of the configuration bits, select *Configure>Configuration Bits*.

3.9 SETTINGS DIALOG, INFO TAB

When you select *Debugger>Settings* or *Programmer Settings*, you will open the Starter Kit Settings dialog.

Currently, there is only one (**Info**) tab on this dialog, displaying the following information:

- Firmware Version: The version of firmware on the starter kit board.
- Debug Exec Version: The version of the debug executive that is loaded into the dsPIC33F device program memory to enable debug operation.

NOTES:

Chapter 4. Hardware

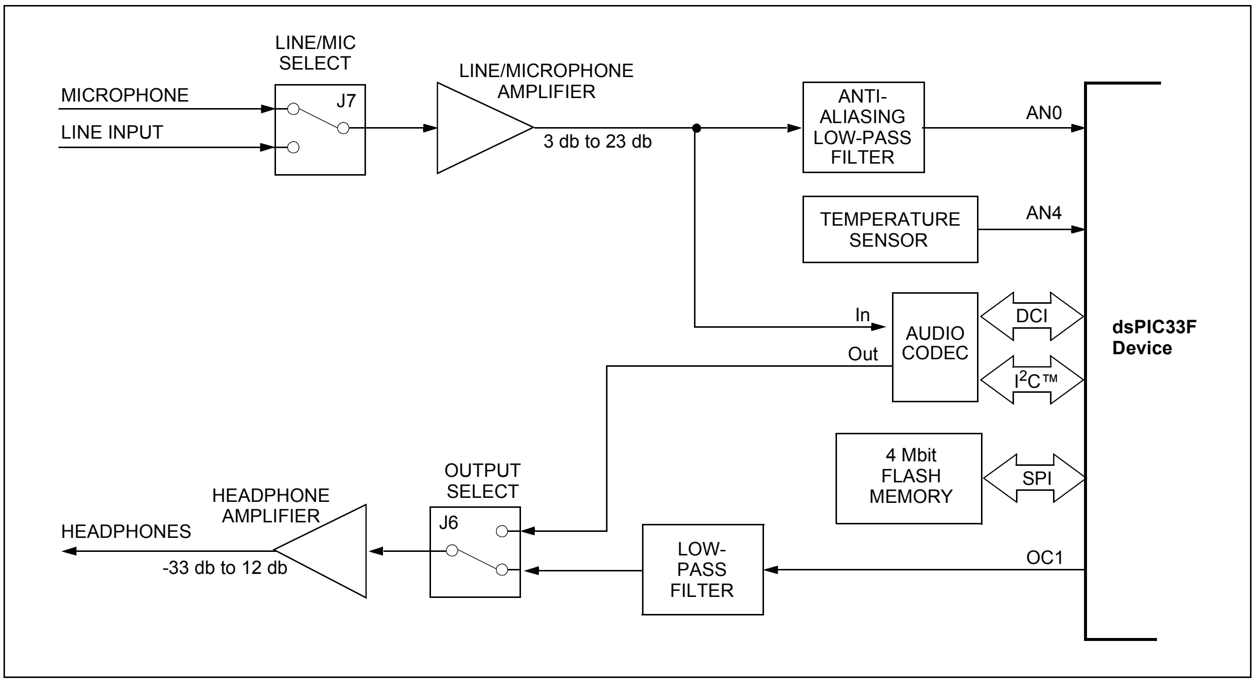
This chapter provides a functional overview of the MPLAB Starter Kit for dsPIC® Digital Signal Controllers and identifies the major hardware components. Topics covered include:

- Audio Functional Overview
- Debug Functional Overview
- Board Components

4.1 AUDIO FUNCTIONAL OVERVIEW

The block diagram shown in Figure 4-1 illustrates the mainstream operation of the starter kit.

FIGURE 4-1: STARTER KIT BLOCK DIAGRAM



4.1.1 Speech Sampling

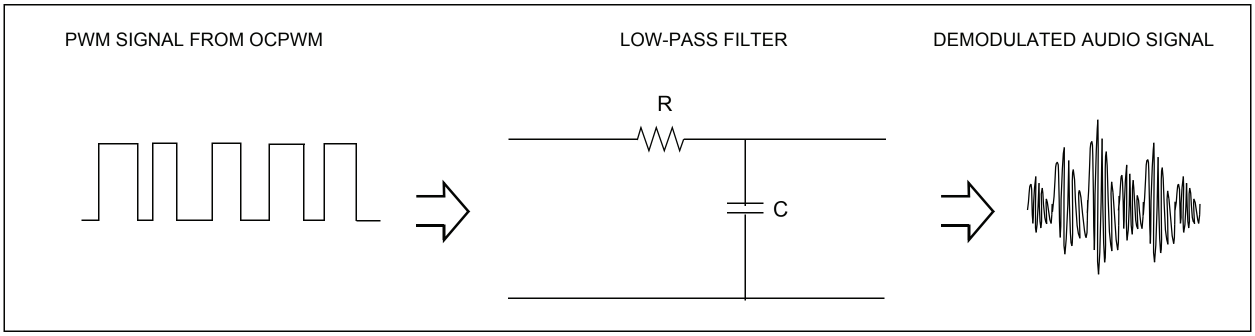
The incoming audio signal can come from a line input or a condenser microphone. The speech sampling input is jumper selected (J7). The selected signal is amplified by a non-inverting AC amplifier (Line/Microphone Amplifier) and routed to the ADC module on the dsPIC33F device through an anti-aliasing filter. This sixth-order Sallen-Key low-pass filter has a cut-off frequency of 3300 Hz. The output of the anti-aliasing filter is connected to input AN0 of the ADC module on the device. If the input to the amplifier is a condenser microphone, a bias voltage provides a working supply voltage for the microphone. The line input does not require this bias voltage.

The amplifier has a variable gain from 3 db to 23 db, which can be adjusted to control microphone sensitivity or boost a low line-input signal. The output of the amplifier is biased at 1.65V.

4.1.2 Speech Playback

The mainstream speech playback interface processes the PWM digital signal from the Output Compare module of the dsPIC33F device. A low-pass filter demodulates the PWM signal as shown in Figure 4-2. The low-pass filter behaves like an integrator whose output signal amplitude depends on the duty cycle of the input PWM waveform. The PWM frequency should be an integral multiple of the audio sampling rate.

FIGURE 4-2: PWM DEMODULATION



The output of the low-pass filter feeds the headphone amplifier The headphone amplifier drives an audio headphone. This amplifier can drive up to 75 mW into a 32 ohm headphone. The amplifier uses a digital volume control that is controlled by I/O lines from the dsPIC33F device.

4.1.3 Codec

The audio codec can be used for a higher-end audio application. The input to the audio codec is the output of the line/microphone pre-amplifier. The output feeds the headphone amplifier. The codec must interact with the application program running on the dsPIC33F device. Commands from the application program control the codec operating parameters (such as communication protocol, sampling rate, volume control, level control, filter settings, etc.). Command information is exchanged over the Inter-Integrated Circuit™ (I^2C™) module on the device.

The codec converts the incoming audio signal to a digital signal for the Digital Converter Interface (DCI) module of the dsPIC33F device. Audio output from the application program is sent to the codec via the DCI module. The codec converts this digital signal to audio for the headphone amplifiers.

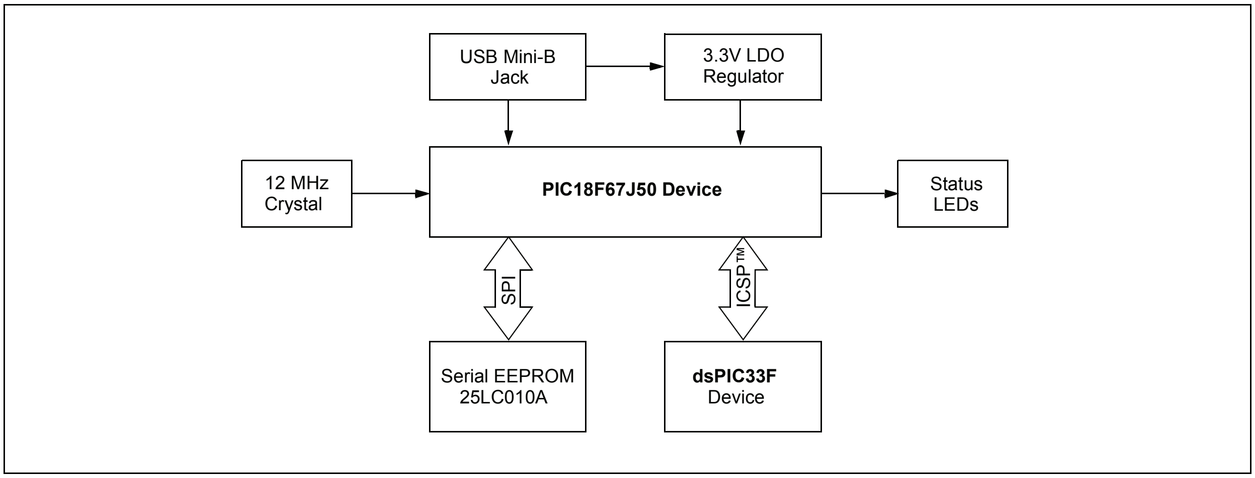
4.1.4 4 Mb Serial Flash Memory

The starter kit includes 4 Mb serial Flash memory that can be used for storing data. The memory interfaces with the SPI bus on dsPIC33F device and might typically be used by applications that require storage of speech samples for playback purposes.

4.2 DEBUG FUNCTIONAL OVERVIEW

The block diagram shown in illustrates the debugging/programming operation of the starter kit.

FIGURE 4-3: STARTER KIT DEBUG BLOCK DIAGRAM



The starter kit, with its built-in debugger/programmer, provides an all-in-one solution for debugging and programming applications using MPLAB IDE. Also, no additional external power supply is needed as power is supplied by the host PC's USB port.

The starter kit's debugging/programming operations are controlled by a PIC18F67J50 MCU running at 48 MHz. The PIC18F67J50's built-in USB engine provides the communications interface between the starter kit and the host PC.

Power to the starter kit is provided via USB whose nominal 5 volt unregulated supply is regulated by a Microchip MC1727 3.3 volt low-dropout (LDO) linear regulator. Proper starter kit main system power is indicated by the green LED 'D1'.

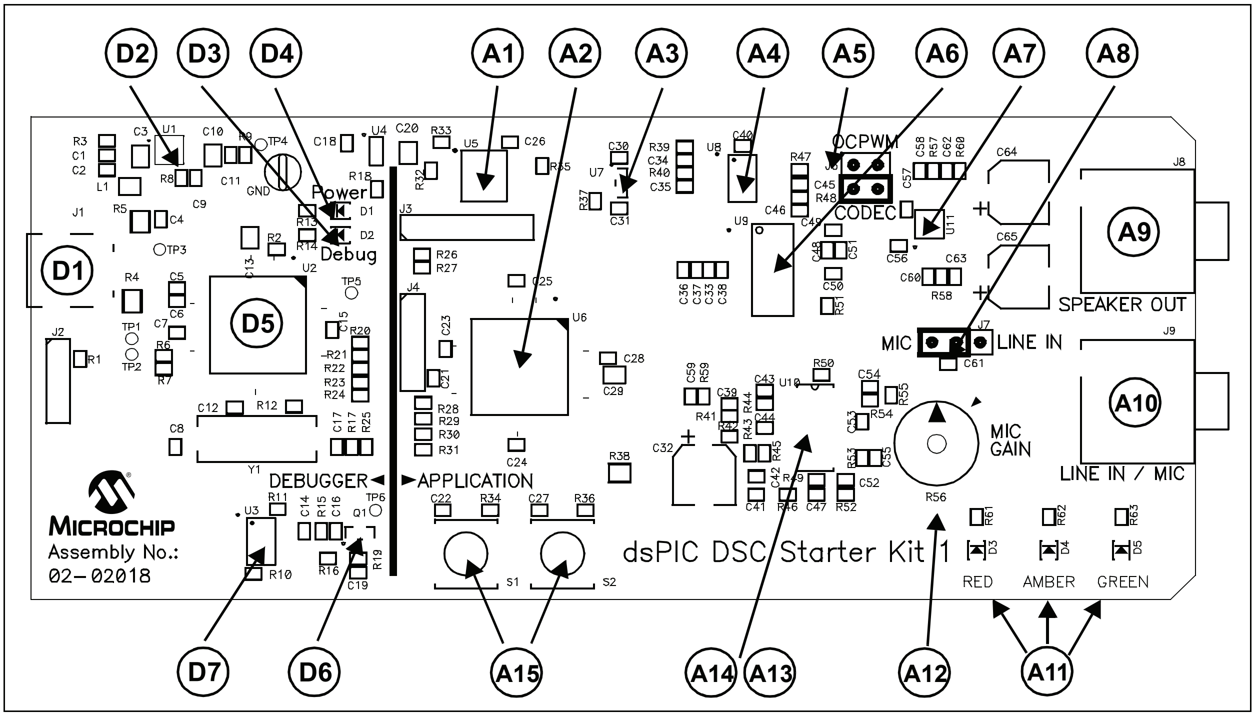
The PIC18F67J50 MCU accomplishes debugging or programming of the target dsPIC33FJ256GP506 by controlling the target's $\overline{MCLR}$, PGC1/EMUC1, and PGD1/EMUD1 signals. Target power is switched on/off via a low V_{CE} saturation PNP transistor configured as a high-side switch. Target clocking is also provided by the PIC18F67J50 MCU.

A Microchip 25LC010A serial EEPROM is used to store the starter kit's serial number and debug control information.

4.3 BOARD COMPONENTS

Figure 4-4 identifies the key starter kit hardware components.

FIGURE 4-4: STARTER KIT



Ref	Component	Ref	Component
D1	Mini-B USB Connector (J1)	A5	Output Select Jumper (J6)
D2	MCP1727 (U1)	A6	Codec (U9)
D3	STATUS LED – Debug (D2)	A7	Headphone Amplifier (U11)
D4	STATUS LED – System Power (D1)	A8	Line/Microphone Input Select Jumper (J7)
D5	PIC18F67J50 MCU (U2)	A9	Headphone Output Jack (J8)
D6	Low Vce Saturation PNP Transistor Switch (Q1)	A10	Line/Microphone Input Phone Jack (J9)
D7	25LC010A Serial EEPROM (U3)	A11	User LEDs (D3,D4 and D5)
A1	Flash Memory (U5)	A12	Microphone Gain Control (R56)
A2	Digital Signal Control (U6)	A13	Line/Microphone Pre-Amplifier (U10:A)
A3	Temperature Sensor (U7)	A14	Anti-Aliasing Low-Pass Filter (U10:B,C,D)
A4	PWM Low Pass Filter (U8:A,B)	A15	User Switches (S2 and S1)
D# = Debug components A# = Audio components			

4.3.1 Debug Components

The following components support the debug function of the starter kit. See **Appendix A. "Schematics"** for debug schematics.

4.3.1.1 MINI-B USB CONNECTOR (J1)

Provides system power and bidirectional communication between the host PC and starter kit.

4.3.1.2 MCP1727 (U1)

3.3V Linear regulator. Regulates the USB unregulated voltage to 3.3 volts (with respect to VSS) and supplies the starter kit with system power.

4.3.1.3 STATUS LED – DEBUG (D2)

When lit, indicates that communication between the starter kit and MPLAB IDE has been successfully established.

4.3.1.4 STATUS LED – SYSTEM POWER (D1)

When lit, indicates that the starter kit is powered via the USB.

4.3.1.5 PIC18F67J50 MCU (U2)

Controls the programming/debugging operations of the target dsPIC33FJ256GP506 digital signal controller.

4.3.1.6 LOW Vce SATURATION PNP TRANSISTOR SWITCH (Q1)

Provides target power (via high-side switching) to the dsPIC33FJ256GP506 (and ancillary circuitry) via control by the PIC18F67J50 programming/debugging MCU.

4.3.1.7 25LC010A SERIAL EEPROM (U3)

Provides nonvolatile parameter storage for the PIC18F67J50 MCU.

4.3.2 Audio Components

The following components support the audio portion of the starter kit. See **Appendix A. "Schematics"** for audio schematics.

4.3.2.1 FLASH MEMORY (U5)

The starter kit includes a serial Flash memory chip (Ref A1). The power supply for U5 is provided by regulator U4. The regulator provides the required amount of current for flash programming operation.

4.3.2.2 DIGITAL SIGNAL CONTROL (U6)

The dsPIC33F256GP506 digital signal controller (Ref A2) provides the computation and processing resource for application development on the starter kit. This DSC features 256 KB of program flash and 16 KB RAM. The application can either use the on-chip FRC or the external 12 MHz signal as clock source.

4.3.2.3 TEMPERATURE SENSOR (U7)

The starter kit includes a temperature sensor (Ref A3) that interfaces to the ADC module on the dsPIC33F device. The temperature sensor is a Microchip TC1047.

4.3.2.4 PWM LOW PASS FILTER (U8:A,B)

The PWM signal from the Output Compare module on the dsPIC33F device on the board is demodulated by the PWM low-pass filter (Ref A4). This fourth-order filter uses two op-amps (U8:A and U8:B) on the MCP6022 quad op-amp IC.

4.3.2.5 OUTPUT SELECT JUMPER (J6)

The Output Select Jumper (Ref A5) determines whether the input signal for the Headphone Amplifiers comes from the PWM filter or the audio codec. Default setting is CODEC.

4.3.2.6 CODEC (U9)

The starter kit includes an audio codec (Ref A6) that interfaces to the DCI module (data interface) and I^2C bus (control interface) of the dsPIC33F device. It is AC coupled to the output of the Line/Microphone Amplifier (MIC2).

The codec is a Wolfson WM8510 and uses a 12 MHz clock signal generated by U2 for clocking.

4.3.2.7 HEADPHONE AMPLIFIER (U11)

The Headphone Amplifier (Ref A7) is a National Semiconductor LM4811 70-mW stereo amplifier with digital volume control. The input to the amplifier is controlled by the setting of Output Select Jumper J6. The output of the amplifier is available at Headphone stereo jack (J8).

Gain is controlled by the logic levels applied through the device I/O ports to the CLK and UP/DN pins of U11. Each time the CLK line goes logic high, the gain increases or decreases by 3 dB, depending on the logic level of UP/DN line. The gain can be adjusted over a range of +12 db to -33 db in 16 discrete gain settings.

4.3.2.8 LINE/MICROPHONE INPUT SELECT JUMPER (J7)

The Line/Microphone Input Select jumper (Ref A8) determines if the Microphone/Line Pre-Amplifier (U10-A) operates as a line amplifier or a microphone amplifier. If the MIC option is selected, a bias voltage of +3.3V is applied to the Microphone/Line Input Socket (J9). Default setting is MIC.

4.3.2.9 HEADPHONE OUTPUT JACK (J8)

The Headphone jack (Ref A9) is a 3.5 mm stereo connector. A 32-ohm headphone can be connected to this socket.

4.3.2.10 LINE/MICROPHONE INPUT PHONE JACK (J9)

The Line/Microphone Input (Ref A10) is a 3.5 mm mono input phone jack (SJ3504). This connection accepts either a condenser microphone or a line level signal.

4.3.2.11 USER LEDS (D3,D4 AND D5)

The starter kit features three general purpose LEDs which are connected to the I/O ports on the dsPIC33F device. The user application can use these LEDs for indication purposes.

4.3.2.12 MICROPHONE GAIN CONTROL (R56)

MIC ADJ Potentiometer R56 (Ref A12) controls the gain of the Line/Microphone Pre-Amplifier (U10:A). The default setting is with the arrow on the potentiometer pointing to the arrow on the board.

> **Note:** Setting the gain too high can cause the output of the amplifier to saturate and clip.

4.3.2.13 LINE/MICROPHONE PRE-AMPLIFIER (U10:A)

The Microphone/Line Pre-amplifier (Ref A13) is implemented using one of the four op-amps on the MCP6024 quad op-amp IC (U10). The output of this non-inverting AC amplifier is biased at 1.65V. The gain of the amplifier is controlled by Potentiometer R56, as given by Equation 4-1.

EQUATION 4-1: INPUT PRE-AMPLIFIER GAIN

$$Gain = 1 + \left(\frac{(R56 + R50)}{R44}\right)$$

4.3.2.14 ANTI-ALIASING LOW-PASS FILTER (U10:B,C,D)

The Anti-Aliasing Low-Pass filter uses three of the four operational amplifiers on the MCP6024 quad op-amp IC (U10). The output of the Line/Microphone Pre-Amplifier (Ref A14) uses an anti-aliasing low-pass sixth order Sallen-Key structure to filter the signal and provide a cut-off frequency of 3300 Hz.

4.3.2.15 USER SWITCHES (S2 AND S1)

The starter kit features two press switches which are connected to the I/O ports on the dsPIC33F device. The function of these switches is defined by the user application.

NOTES:

Appendix A. Schematics

The following schematic diagrams are included in this appendix:

Debug

- Figure A-1: Debug Input and Control Schematic – Part 1
- Figure A-2: Debug Input and Control Schematic – Part 2
- Figure A-3: USB Interface/Target Power Switching Schematic

Audio

- Figure A-4: Speech Processing Schematic
- Figure A-5: Flash Memory Schematics
- Figure A-6: Output Compare Module PWM Filters Schematic
- Figure A-7: Audio Codec Schematic
- Figure A-8: Audio Input Schematic
- Figure A-9: Audio Output Schematic
- Figure A-10: User LEDs, User Switches and Temp Sensor Schematics

FIGURE A-1: DEBUG INPUT AND CONTROL SCHEMATIC – PART 1

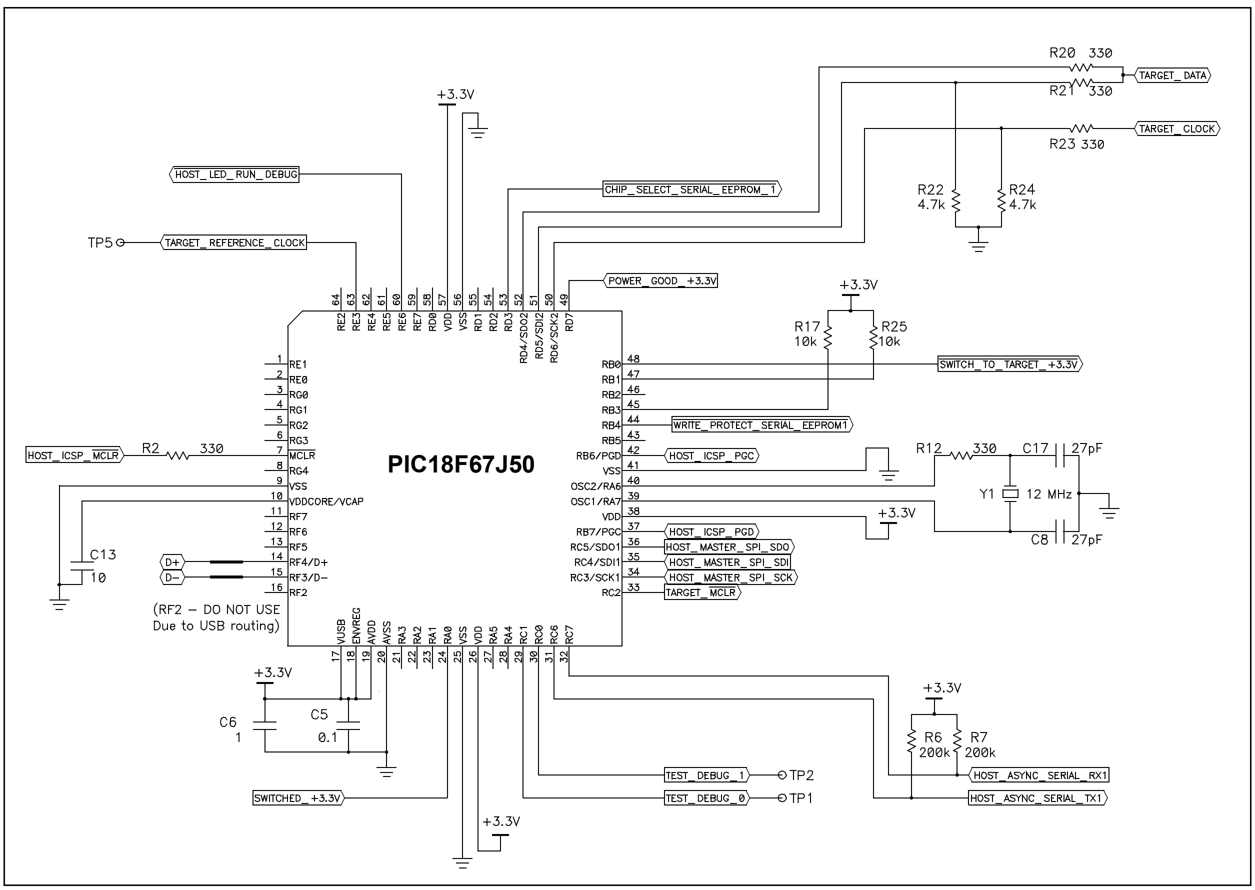


FIGURE A-2: DEBUG INPUT AND CONTROL SCHEMATIC – PART 2

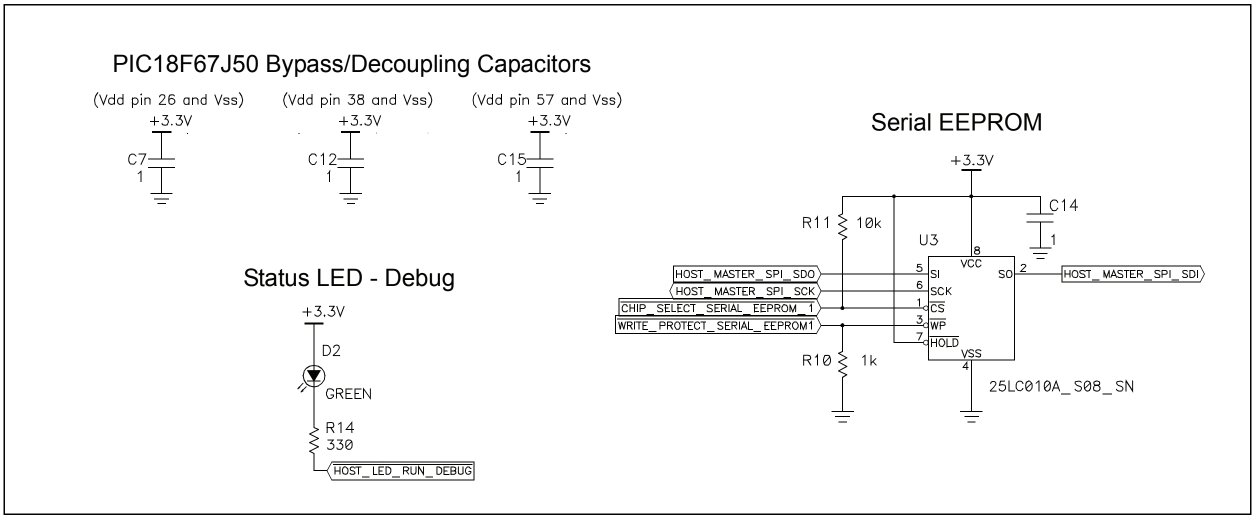


FIGURE A-3: USB INTERFACE/TARGET POWER SWITCHING SCHEMATIC

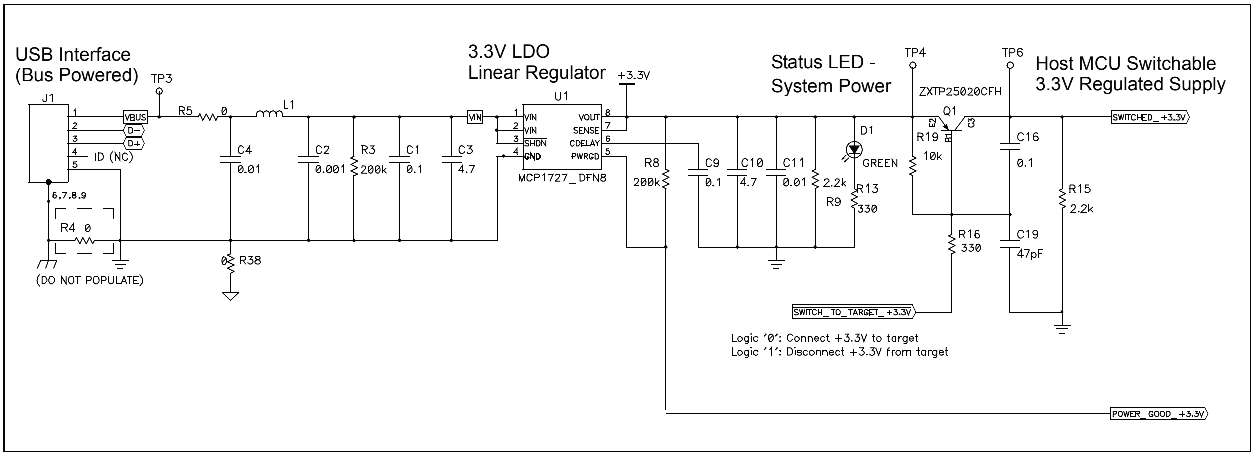


FIGURE A-4: SPEECH PROCESSING SCHEMATIC

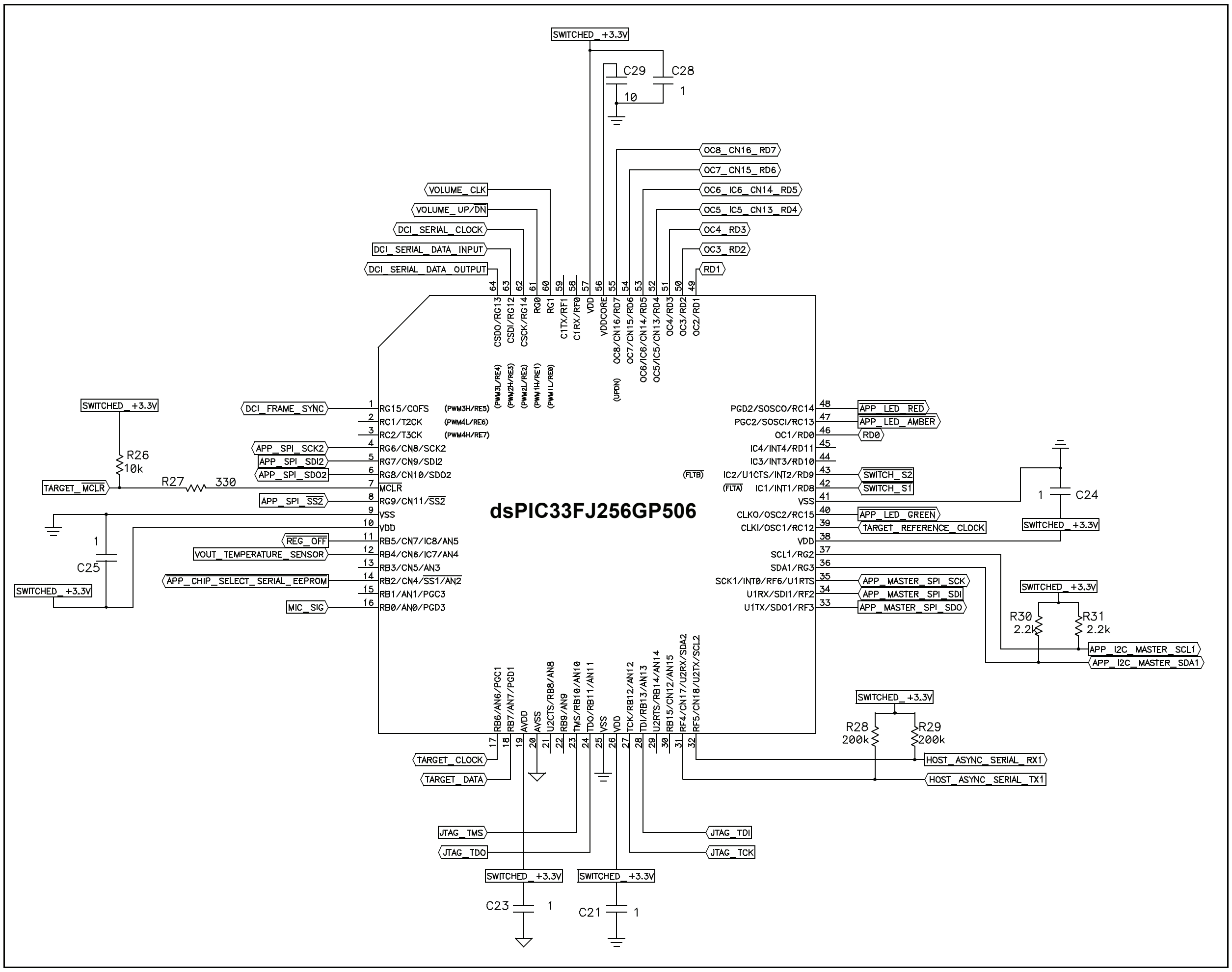


FIGURE A-5: FLASH MEMORY SCHEMATICS

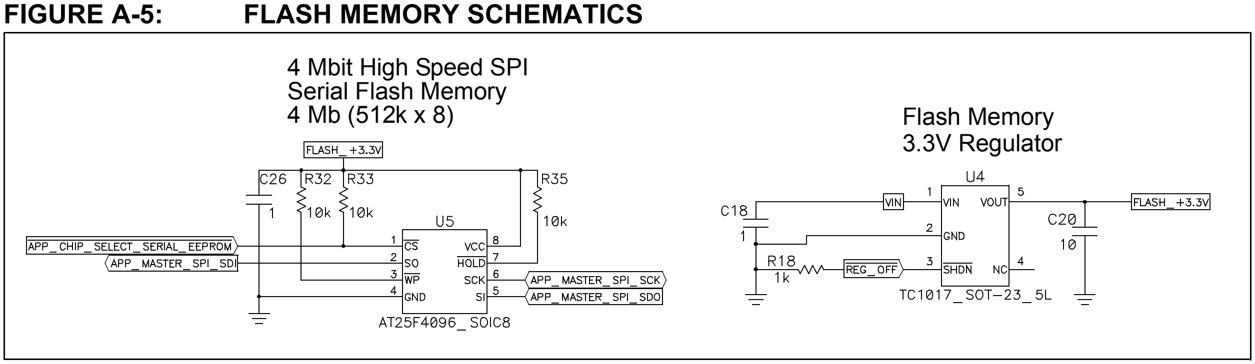


FIGURE A-6: OUTPUT COMPARE MODULE PWM FILTERS SCHEMATIC

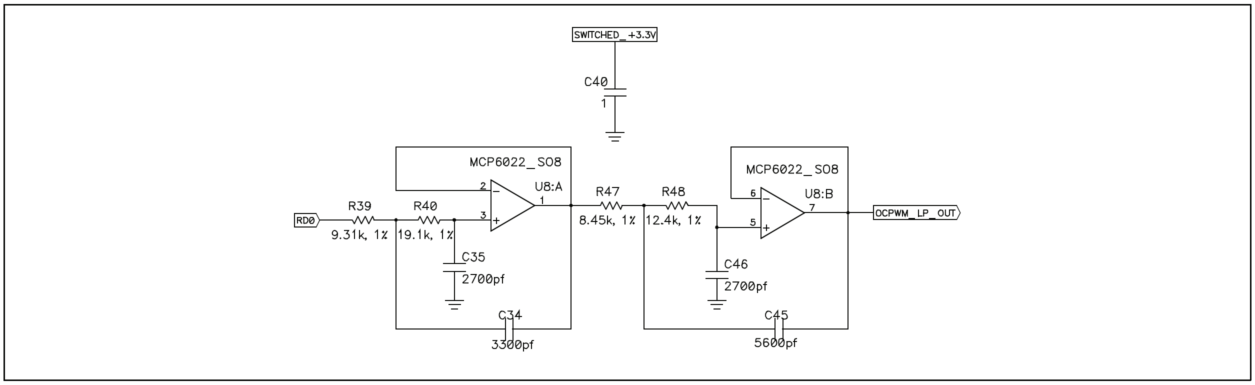


FIGURE A-7: AUDIO CODEC SCHEMATIC

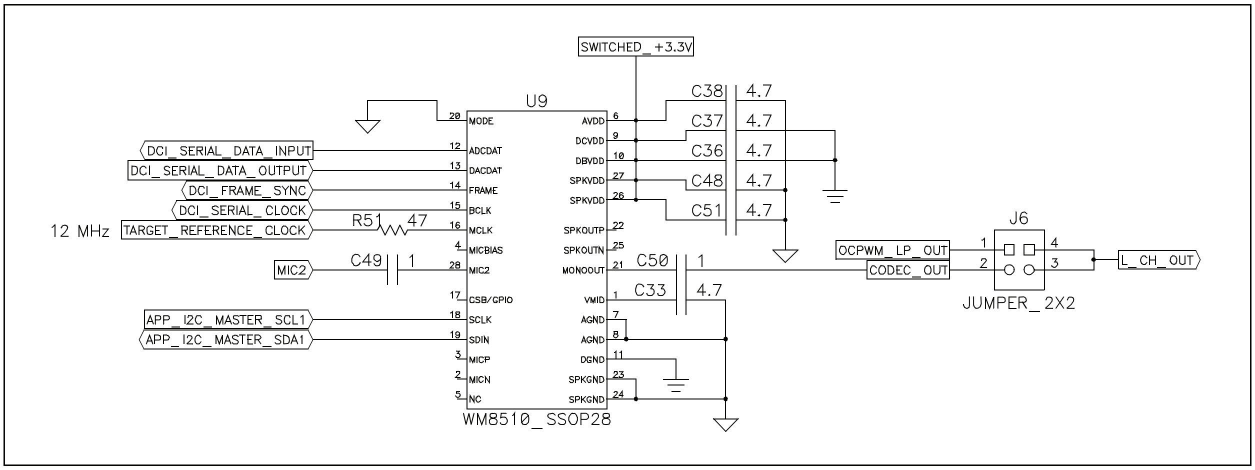


FIGURE A-8: AUDIO INPUT SCHEMATIC

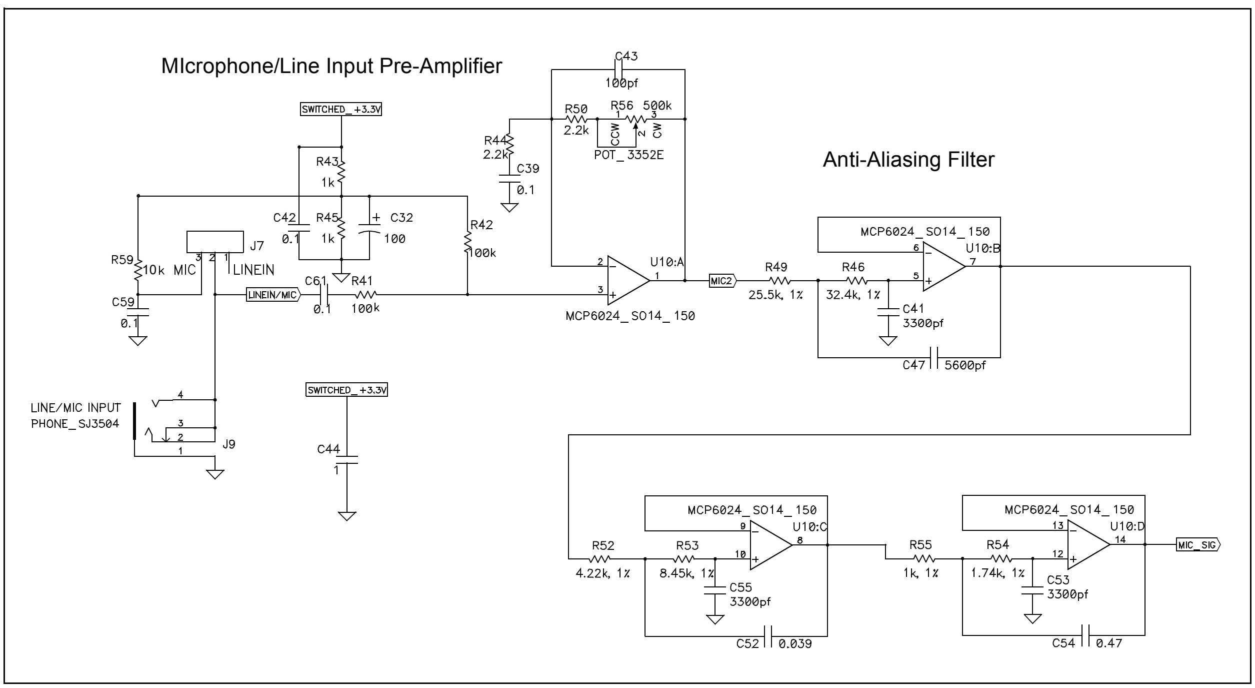


FIGURE A-9: AUDIO OUTPUT SCHEMATIC

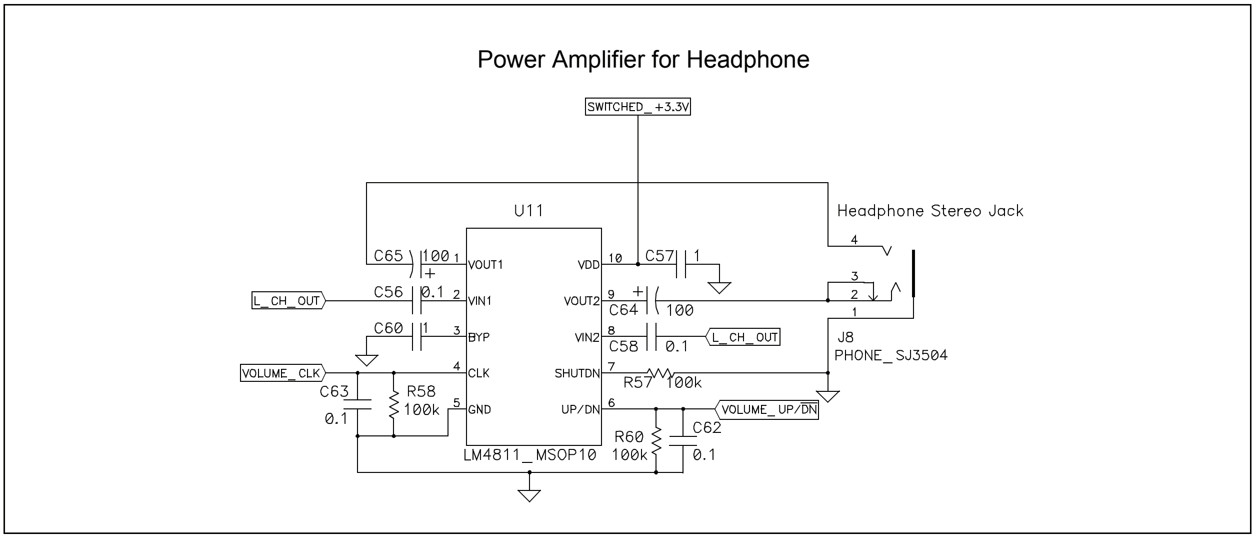
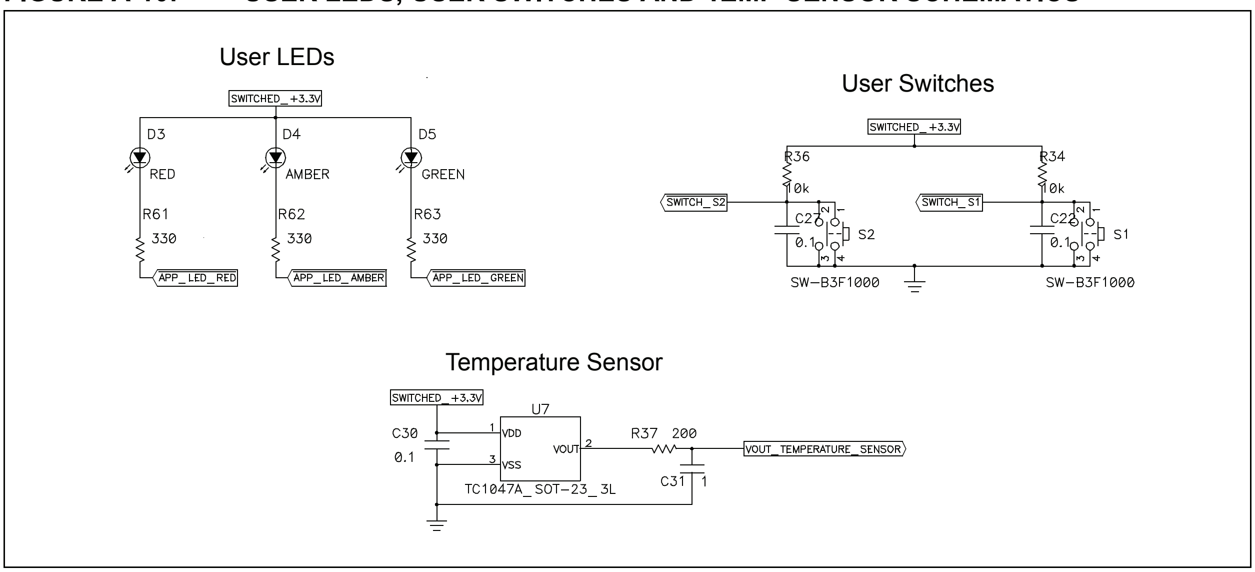


FIGURE A-10: USER LEDS, USER SWITCHES AND TEMP SENSOR SCHEMATICS



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