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.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications.

MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer’s risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, Accuron, dsPIC, KeeLog, KeeLog logo, MPLAB, PIC, PICmicro, PICSTART, rPIC and SmartShunt are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL, SmartSensor and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, In-Circuit Serial Programming, ICSP, ICEPIC, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, PICkit, PICDEM, PICDEM.net, PICtail, PIC 32, logo, PowerCal, PowerInfo, PowerMate, PowerTool, REAL ICE, rFLAB, Select Mode, Total Endurance, UNI/O, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2008, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

Printed on recycled paper.
Table of Contents

Preface ........................................................................................................................................... 1

Chapter 1. Introduction
  1.1 Overview ......................................................................................................................... 7
  1.2 DTMF Signal and Frequencies ....................................................................................... 7
  1.3 Principle of Detection ...................................................................................................... 8
  1.4 DTMF Tone Detector ...................................................................................................... 9
  1.5 Applications and Performance ..................................................................................... 12

Chapter 2. Configuring the Analog Front End (AFE)
  2.1 Analog Front End (AFE) Overview .............................................................................. 13
  2.2 Gain Control Register Settings ..................................................................................... 14
  2.3 Si3035 – FCC Options .................................................................................................... 15
  2.4 Si3034 – Global-Based Chipset Options ....................................................................... 15

Chapter 3. Application Programming Interface (API)
  3.1 dsPIC DSC DTMF Generation Library API Functions .................................................. 19

Chapter 4. DTMF Detection Demonstration
  4.1 Setting Up the dsPICDEM.net Board ........................................................................... 23
  4.2 DTMF PSTN Phone Line Demonstration ...................................................................... 23

Appendix A. Drivers
  A.1 DAA/AFE Driver Functions .......................................................................................... 27

Index ........................................................................................................................................... 31

Worldwide Sales and Service ............................................................................................... 32
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 on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This preface contains general information that is useful to know before using the dsPIC® DSC DTMF Detection Library. 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
This user’s guide describes how to use the dsPIC33F DTMF Detection Library as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. “Introduction”** – This chapter explains the basic concepts to help you implement the dsPIC DSC DTMF Detection Library in your application and discusses the principle of DTMF tone detection.

- **Chapter 2. “Configuring the Analog Front End (AFE)”** – This chapter describes the Analog Front End (AFE) on the dsPICDEM.net™ Connectivity Development Board that provides a programmable line interface to support global telephone line interface requirements.

- **Chapter 3. “Application Programming Interface (API)”** – This chapter lists and describes APIs available in the stand-alone dsPIC DSC DTMF Detection Library.

- **Chapter 4. “DTMF Detection Demonstration”** – This chapter analyzes a sample application program that demonstrates the key functionality of the dsPIC DSC DTMF Detection Library.

- **Appendix A. “Drivers”** – This appendix provides information about drivers used with the dsPIC DSC DTMF Detection Library.
CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

<table>
<thead>
<tr>
<th>DOCUMENTATION CONVENTIONS</th>
<th>Description</th>
<th>Represents</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arial font:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italic characters</td>
<td>Referenced books</td>
<td><em>MPLAB® IDE User’s Guide</em></td>
<td></td>
</tr>
<tr>
<td>Initial caps</td>
<td>A window</td>
<td>the Output window</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A dialog</td>
<td>the Settings dialog</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A menu selection</td>
<td>select Enable Programmer</td>
<td></td>
</tr>
<tr>
<td>Quotes</td>
<td>A field name in a window or dialog</td>
<td>“Save project before build”</td>
<td></td>
</tr>
<tr>
<td>Underlined, italic text with right angle bracket</td>
<td>A menu path</td>
<td>File&gt;Save</td>
<td></td>
</tr>
<tr>
<td>Bold characters</td>
<td>A dialog button</td>
<td>Click OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A tab</td>
<td>Click the Power tab</td>
<td></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>
<td></td>
</tr>
<tr>
<td>Text in angle brackets &lt; &gt;</td>
<td>A key on the keyboard</td>
<td>Press &lt;Enter&gt;, &lt;F1&gt;</td>
<td></td>
</tr>
<tr>
<td><strong>Courier New font:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plain Courier New</td>
<td>Sample source code</td>
<td>#define START</td>
<td></td>
</tr>
<tr>
<td>Filenames</td>
<td></td>
<td>autoexec.bat</td>
<td></td>
</tr>
<tr>
<td>File paths</td>
<td></td>
<td>c:\mcc18\h</td>
<td></td>
</tr>
<tr>
<td>Keywords</td>
<td></td>
<td>_asm, _endasm, static</td>
<td></td>
</tr>
<tr>
<td>Command-line options</td>
<td></td>
<td>-Opa+, -Opa-</td>
<td></td>
</tr>
<tr>
<td>Bit values</td>
<td></td>
<td>0, 1</td>
<td></td>
</tr>
<tr>
<td>Constants</td>
<td></td>
<td>0xFF, ‘A’</td>
<td></td>
</tr>
<tr>
<td>Italic Courier</td>
<td>A variable argument</td>
<td>file.o, where file can be any valid filename</td>
<td></td>
</tr>
<tr>
<td>Square brackets [ ]</td>
<td>Optional arguments</td>
<td>mcc18 [options] file [options]</td>
<td></td>
</tr>
<tr>
<td>Curly brackets and pipe character: {</td>
<td>Choice of mutually exclusive arguments; an OR selection</td>
<td>errorlevel {0</td>
<td>1}</td>
</tr>
<tr>
<td>Ellipses...</td>
<td>Replaces repeated text</td>
<td>var_name [, var_name...]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Represents code supplied by user</td>
<td>void main (void) { ... }</td>
<td></td>
</tr>
</tbody>
</table>

WARRANTY REGISTRATION

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

This user’s guide describes how to use the dsPIC DSC DTMF Detection Library. Other useful documents include:

**dsPIC33F Family Reference Manual Sections**

Refer to these documents for detailed information on dsPIC33F device operation. These reference manual sections explain the operation of the dsPIC33F MCU family architecture and peripheral modules, but do not cover the specifics of each device. Refer to the appropriate device data sheet for device-specific information.


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

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

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

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

**MPLAB® C30 C Compiler User’s Guide (DS51284)**

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

Other GNU language tools available from Microchip are:

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

**MPLAB® IDE Simulator, Editor User’s Guide (DS51025)**

Refer to 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, visit the Microchip web site at www.microchip.com.
THE MICROCHIP WEB SITE

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

• **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user’s guides and hardware support documents, latest software releases and archived software

• **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing

• **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

DEVELOPMENT SYSTEMS CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip’s customer 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 C17, MPLAB C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ and MPLAB LIB30 object librarians.

• **Emulators** – The latest information on Microchip in-circuit emulators. This includes the MPLAB ICE 2000, MPLAB REAL ICE and MPLAB ICE 4000.

• **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 2.

• **MPLAB IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB SIM and MPLAB SIM30 simulators, MPLAB IDE Project Manager and general editing and debugging features.

• **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 and PRO MATE® II device programmers and the PICSTART® Plus development programmer.
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 (August 2008)
Initial release of this document.
Chapter 1. Introduction

The dsPIC DSC DTMF Detection Library provides an algorithm that detects the Dual Tone Multi-Frequency (DTMF) signals. This chapter explains the basic concepts to help you implement the dsPIC DSC DTMF Detection Library in your application. This chapter also discusses the principle of DTMF tone detection. Topics covered include:

- Overview
- DTMF Signal and Frequencies
- Principle of Detection
- DTMF Tone Detector
- Applications and Performance

1.1 OVERVIEW

The dsPIC DSC DTMF Detection Library has been developed in accordance with ITU-T Q.24 Multi-Frequency Push-Button Signal Reception recommendations. Full source code is provided to fulfill the following objectives:

- To help you jump start your application with plug-in code
- To facilitate customization to satisfy your specific requirements

To help meet these objectives, a sample application program running on a dsPIC33F device is analyzed in Chapter 4, “DTMF Detection Demonstration”. This sample program demonstrates the remote DTMF signal detection over a dial-up phone line. In this demonstration, the dsPICDEM.net board is dialed from a telephone. The Si3034/Si3035 DAA/AFE telephone interface detects the ring signal and alerts the dsPIC33F device, which initializes the program.

1.2 DTMF SIGNAL AND FREQUENCIES

A DTMF signal consists of two main frequency components:

- Low Frequency
- High Frequency

Figure 1-1 shows a DTMF signal consisting of a burst that combines one tone from the Low Frequency group and another tone from the High Frequency group. The burst can be formed by using any of the 16 possible combinations. The tone burst is followed by a silence period. The minimum tone duration of a DTMF tone and pause period is 40 ms as specified in the ITU-T Recommendation Q.24 AT&T standard.

<table>
<thead>
<tr>
<th>TABLE 1-1: DTMF KEY PAD AND ASSOCIATED FREQUENCIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (Hz)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>697</td>
</tr>
<tr>
<td>770</td>
</tr>
<tr>
<td>852</td>
</tr>
<tr>
<td>941</td>
</tr>
</tbody>
</table>
1.3 PRINCIPLE OF DETECTION

Figure 1-1 shows the shape of a typical DTMF signal. The signal detection process involves the following major stages:
- Tone Detection phase
- Silence Detection phase

The Tone Detection phase analyzes the spectral properties of a signal and validates the DTMF tone. The Tone Detection phase is followed by the Silence Detection phase. The Silence Detection phase measures the minimum silence duration for the tone validation. The shape of a DTMF tone is a result of the combination of these two phases. This tone also includes the Pause period.

1.3.1 Tone Validation Test

The Shape test is a Tone Validation test. It is also called the Silence test. It ensures that the spectral properties and the shape of the incoming signal match the DTMF signal properties. The Shape test improves the rejection capability of the detector by rejecting the speech and music signals that are similar to a DTMF tone. Thus, it avoids false tone detections. However, the most important part of the detection process is the Tone Detection phase, which involves the analysis of the spectral properties of a signal.
1.4 DTMF TONE DETECTOR

Figure 1-2 shows a simplified block diagram of the DTMF Tone Detector system.

**FIGURE 1-2: DTMF TONE DETECTOR BLOCK DIAGRAM**

![Block Diagram of DTMF Tone Detector](image)

The main blocks featured in the DTMF Tone Detector circuit are described in the following sections.

1.4.1 Scale Down

The Scale Down block is used to scale the input signal. Every input sample is scaled down by two bits, thereby changing it from the 16-bit left justified form to the 14-bit right justified form. When the Goertzel DFT algorithm is used to compute the Discrete Fourier Transform (DFT), the intermediate result may overflow or underflow. Therefore, the input signal should be scaled down when computing the DFT. The 16-bit fixed point arithmetic is used for DFT computation.

1.4.2 Buffer Management

The Buffer Management block connects the external peripheral interface to the internal algorithms, such as AGC, Goertzel DFT and Validation. The peripheral interface and the algorithms operate at different intervals. The peripheral interface is designed for a frame-based operation. The frame size of the input signal is 80 samples (i.e., 10 ms). However, the Goertzel DFT algorithm is designed to work on a frame consisting of 100 samples. The Goertzel DFT algorithm is repeated twice so that the processing is periodic with a sample size of 200 samples. Thus, the difference in the frame size is adjusted using the Buffer Management block.

1.4.3 AGC

The AGC block applies gain/attenuation to the input signal. By providing the gain control, the range of the input signal can be matched to the acceptable measurement range of the algorithm.

1.4.4 Goertzel DFT

This is an important block of the DTMF Detector system. The DTMF detection is based on the DFT analysis. It uses the Goertzel DFT algorithm to estimate the DFT. The Goertzel DFT has the following features:

- Unlike the conventional DFT computation method, the Goertzel DFT method does not perform a large computation.
- The Goertzel DFT algorithm supports the frequency detection.
- Instead of the absolute values, only the relative values of the DFT components are required for frequency detection.

The Goertzel DFT algorithm uses two pole IIR filters to estimate the DFT values. The IIR structure for the Goertzel DFT filter is shown in Figure 1-3. It contains two complex-conjugate poles. Using only one real coefficient, it facilitates the computation of the difference equation. The squared magnitude information of the DFT is sufficient for the tone detection.
The Goertzel DFT filter contains two phases: the feedback phase and the feed-forward phase. In the feedback phase, \( v_k[n] \) is computed using the difference equation (see Equation 1-1). The value is computed recursively ‘N-1’ times.

**EQUATION 1-1: FEEDBACK PHASE EQUATION**

\[
v_k[n] = 2 \times \cos((2 \times \pi \times k)/N) \times v_k[n-1] - v_k[n-2] + X[n]
\]

Where,
\[
\begin{align*}
v_k[-1] &= 0 \\
v_k[-2] &= 0 \\
X[n] &= \text{input for } n = 0, \ldots, N-1
\end{align*}
\]

In feed-forward phase, the squared magnitude information about the DFT is obtained using Equation 1-2. It is computed once for every ‘N’ samples.

**EQUATION 1-2: FEED-FORWARD PHASE EQUATION**

\[
|X[k]| \times |X[k]| = y_k[N] \times y_k[N] = v_k[N] \times v_k[N] + v_k[N-1] \times v_k[N-1] - (2 \times \cos((2 \times \pi \times k)/N) \times v_k[N] \times v_k[N-1])
\]

After computing for ‘N’ number of samples, the output of the Goertzel DFT filter converges towards a pseudo DFT value, \( v_k[N] \), which can be used to determine the squared magnitude.

The squared magnitudes are computed for the fundamental frequencies that are listed in Table 1-1 and for their corresponding eight second harmonics. The second harmonics are used to differentiate DTMF tones from speech or music signals.

**FIGURE 1-3: GOERTZEL DFT SIGNAL FLOW GRAPH**

![Goertzel DFT Signal Flow Graph](image)
The choice of ‘N’ depends on the frequency resolution required in the application. The value ‘N’ should be chosen such that the selected coefficient most accurately coincides with the actual DTMF frequencies. Table 1-2 provides a list of frequencies, the corresponding ‘K’ values, and the computed filter coefficients, which are expressed in Q.15 format.

**TABLE 1-2: LIST OF FREQUENCIES AND FILTER COEFFICIENTS**

<table>
<thead>
<tr>
<th>DTMF</th>
<th>K</th>
<th>(K/N)/F_s</th>
<th>cos(2π*k/N)</th>
<th>DTMF</th>
<th>K</th>
<th>(K/N)/F_s</th>
<th>cos(2π*k/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>697</td>
<td>8.7125</td>
<td>697</td>
<td>27979</td>
<td>1394</td>
<td>17.425</td>
<td>1394</td>
<td>15013</td>
</tr>
<tr>
<td>770</td>
<td>9.625</td>
<td>770</td>
<td>26955</td>
<td>1540</td>
<td>19.25</td>
<td>1540</td>
<td>11582</td>
</tr>
<tr>
<td>852</td>
<td>10.65</td>
<td>852</td>
<td>25701</td>
<td>1704</td>
<td>21.3</td>
<td>1704</td>
<td>7549</td>
</tr>
<tr>
<td>941</td>
<td>11.7625</td>
<td>941</td>
<td>24218</td>
<td>1882</td>
<td>23.525</td>
<td>1882</td>
<td>3032</td>
</tr>
<tr>
<td>1209</td>
<td>15.1125</td>
<td>1209</td>
<td>19072</td>
<td>2418</td>
<td>30.225</td>
<td>2418</td>
<td>-10565</td>
</tr>
<tr>
<td>1336</td>
<td>16.7</td>
<td>1336</td>
<td>16324</td>
<td>2672</td>
<td>33.4</td>
<td>2672</td>
<td>-16502</td>
</tr>
<tr>
<td>1477</td>
<td>18.5</td>
<td>1477</td>
<td>13013</td>
<td>2954</td>
<td>36.925</td>
<td>2954</td>
<td>-22318</td>
</tr>
<tr>
<td>1633</td>
<td>20.4125</td>
<td>1633</td>
<td>9315</td>
<td>3266</td>
<td>40.825</td>
<td>3266</td>
<td>-27471</td>
</tr>
</tbody>
</table>

*Note:* The principle of detection is based on the following ITU-T standards:
- ITU-T Q.24: Multi-Frequency Push-Button Signal Reception

1.4.5 Validation

The Validation block is used to validate the input tone. Each tone detected by the Goertzel DFT section is an input to the Validation block. The Validation block evaluates the accuracy of the tone using various validation tests. These validation tests check whether the various coefficient values of the Goertzel DFT algorithm match the requirements specified in the ITU-T Recommendation Q.24, AT&T standard.

Table 1-3 lists the specifications that should be met by an incoming signal in order to be validated as a DTMF tone.

**TABLE 1-3: SPECIFICATIONS FOR DTMF TONE VALIDATION**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal frequencies</td>
<td>High frequency group</td>
<td>1209, 1336, 1477, 1633</td>
</tr>
<tr>
<td></td>
<td>Low frequency group</td>
<td>697, 770, 852, 941</td>
</tr>
<tr>
<td>Frequency tolerance</td>
<td>Operation</td>
<td>≤ 1.5%</td>
</tr>
<tr>
<td></td>
<td>Non-operation</td>
<td>≥ 3.5%</td>
</tr>
<tr>
<td>Power levels per frequency</td>
<td>Operation</td>
<td>0 to -25 dBm</td>
</tr>
<tr>
<td></td>
<td>Non-operation</td>
<td>Max. -55 dBm</td>
</tr>
<tr>
<td>Power level difference between frequencies</td>
<td>—</td>
<td>+4 dB to -8 dB</td>
</tr>
<tr>
<td>Signal reception timing</td>
<td>Signal duration</td>
<td>Min. 40 ms</td>
</tr>
<tr>
<td></td>
<td>Non-operation</td>
<td>Max. 23 ms</td>
</tr>
<tr>
<td>Pause duration</td>
<td></td>
<td>Min. 40 ms</td>
</tr>
</tbody>
</table>
1.5 APPLICATIONS AND PERFORMANCE

The DTMF generation and detection libraries can be used for developing various applications, such as answering machines, public and private telephone exchanges, telephony and line test equipment, remote control of computer, and telephone equipment. Table 1-4 provides the size of the Data Memory, Program Memory, and MIPS required to support the dsPIC DSC DTMF Detection Library.

<table>
<thead>
<tr>
<th>Library</th>
<th>Data Memory (Bytes)</th>
<th>Program Memory (Bytes)</th>
<th>MIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>dsPIC DSC DTMF Detection Library</td>
<td>1.2K</td>
<td>6.2K</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Chapter 2. Configuring the Analog Front End (AFE)

The Analog Front End (AFE) on the dsPICDEM.net Connectivity Development board uses the Silicon Laboratories’ Si3034 and Si3035 chipsets. These chipsets contain an integrated Data Access Arrangement (DAA) that provides a programmable line interface to support global telephone line interface requirements. A careful review of this chapter is essential for understanding how to configure the Analog Front End (AFE) of your application. Topics covered include:

- Analog Front End (AFE) Overview
- Gain Control Register Settings
- Si3035 – FCC Options
- Si3034 – Global-Based Chipset Options

2.1 ANALOG FRONT END (AFE) OVERVIEW

The Si3034 and Si3035 chipsets consist of the following DAA and AFE ICs:

- Si3034 chipset
  - Si3021 AFE
  - Si3014 DAA
- Si3035 chipset
  - Si3021 AFE
  - Si3012 DAA

The Si3021 chipset is configured as the Master device and uses its internal clock circuitry to generate the serial bit clock and frame sync clock at a specific sampling rate. The dsPIC33F is configured as the slave device. The Si3034/Si3035 AFE is configured for the 8 kHz sampling rate, which is used during the DTMF generation-detection phase. The dsPIC33F is configured as the Slave device.

Table 2-1 provides interface connections between the Si3021 AFE and the dsPIC33F devices.

<table>
<thead>
<tr>
<th>Si3021 Pin</th>
<th>dsPIC33F Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCLK</td>
<td>—</td>
<td>AFE Clock Generation Input</td>
</tr>
<tr>
<td>SCLK</td>
<td>CSCK</td>
<td>Bit Clock</td>
</tr>
<tr>
<td>SDO</td>
<td>CSDI</td>
<td>Data Output from Si3021</td>
</tr>
<tr>
<td>SDI</td>
<td>CSDO</td>
<td>Data Input to Si3021</td>
</tr>
<tr>
<td>FSYNC</td>
<td>COFS</td>
<td>Frame Sync to dsPIC33FJ256GP710</td>
</tr>
<tr>
<td>OFHK</td>
<td>CN9</td>
<td>Hardware off-hook (not used)</td>
</tr>
<tr>
<td>RESET</td>
<td>RG8</td>
<td>AFE Device Reset</td>
</tr>
<tr>
<td>RGDT/FSD</td>
<td>SS2/CN11</td>
<td>Not used</td>
</tr>
<tr>
<td>FC/RGDT</td>
<td>SCK2/CN8</td>
<td>Not used</td>
</tr>
</tbody>
</table>
To comply with international telephone interface requirements, the various compile time options can be used to configure the Si3034/Si3035 AFE chip. The `Si3021Drv.h` file includes various options that are necessary to set up the AFE for the dsPIC DSC DTMF Detection Library. Review these options carefully to ensure proper modem operation. Refer to the chipset data sheet for more information on the different control registers and chip operation.

**Note:** The demo application provides drivers to use the Si3021 chipset. The DTMF Detection Library by itself is independent of the Analog Front End (AFE).

### 2.2 GAIN CONTROL REGISTER SETTINGS

The Tx/Rx Gain Control (Register 15) provides options that are common to both the Si3034 and Si3035 chipsets. The option names indicate the Control Register number and the name of the functional bits in the corresponding register.

#### 2.2.1 Si3034/Si3035 – Chipset Options

(dsPICDEM.net 1 and dsPICDEM.net 2 Development Boards)

**TABLE 2-2: Tx/Rx GAIN CONTROL (REGISTER 15)**

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>#define R15_TXM n</code></td>
<td>n = 1, Mutes the transmit signal</td>
<td>0</td>
</tr>
<tr>
<td><code>#define R15_RXM n</code></td>
<td>n = 1, Mutes the receive signal</td>
<td>0</td>
</tr>
<tr>
<td><code>#define R15_ARX n</code></td>
<td><strong>Analog Receive Gain Selection</strong></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>n = 0, 0 dB Gain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 1, 3 dB Gain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 2, 6 dB Gain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 3, 9 dB Gain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 4, 12 dB Gain</td>
<td></td>
</tr>
<tr>
<td><code>#define R15_ATX n</code></td>
<td><strong>Analog Transmit Attenuation selection</strong></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>n = 0, 0 dB attenuation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 1, 3 dB attenuation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 2, 6 dB attenuation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 3, 9 dB attenuation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 4, 12 dB attenuation</td>
<td></td>
</tr>
</tbody>
</table>

#### 2.2.2 International Control Register Setting

(Control Registers 16, 17 and 18)

The Si3034/Si3035 chipset supports four configurable International Control registers. Si3034 is a Global chipset and can be configured for Federal Communications Commission (FCC), Japan Approval Institute for Telecommunications Equipment (JATE) and Common Technical Regulation (CTR_21) or other country specific options. Si3035 is an FCC-only chipset.

Two sets of options are provided based on the chipset used on the dsPICDEM.net Development Boards. The dsPICDEM.net 1 board implements the Si3035 chipset and dsPICDEM.net 2 board implements the Si3034 chipset.
2.3 SI3035 – FCC OPTIONS

Table 2-3 provides the single option for the FCC-based chipset on dsPICDEM.net 1 development board.

**Note:** The SI3035 – FCC options are available only on dsPICDEM.net 1 development board.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#define DEF_Si3034 0</td>
<td>(Global based chipset)</td>
</tr>
<tr>
<td>#define DEF_Si3035 1</td>
<td>(FCC based chipset)</td>
</tr>
<tr>
<td>#define R16_IIRE n</td>
<td>IIR or FIR filter selection for transmit and receive filters</td>
</tr>
<tr>
<td></td>
<td>( n = 0 ), Enable FIR filter</td>
</tr>
<tr>
<td></td>
<td>( n = 1 ), Enable IIR filter</td>
</tr>
<tr>
<td></td>
<td>On power up, default FIR filter is enabled</td>
</tr>
</tbody>
</table>

2.4 SI3034 – GLOBAL-BASED CHIPSET OPTIONS

The SI3034 chipset can be fully programmed to meet international requirements and is compliant with FCC, CTR-21, JATE, and various other country specific Post Telephone and Telegraph (PTT) options. Table 2-4 lists the options supported in the Si3021config.inc file for dsPICDEM.net 2 development board. Review and select these options carefully to ensure optimal performance of the DAA/AFE. After selecting your options, you will need to rebuild the code for these options to take effect. 

**Note:** The Si3034 – Global-based chipset options are available only on dsPICDEM.net 2 development board.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#define DEF_Si3034 1</td>
<td>(Global based chipset)</td>
</tr>
<tr>
<td>#define DEF_Si3035 0</td>
<td>(FCC and JATE based chipset)</td>
</tr>
<tr>
<td>#define R16_OHS n</td>
<td>On-Hook Speed</td>
</tr>
<tr>
<td></td>
<td>( n = 0 ), The Si3034 executes a fast on-hook</td>
</tr>
<tr>
<td></td>
<td>( n = 1 ), The Si3034 executes a slow, controlled on-hook</td>
</tr>
<tr>
<td>#define R16_ACT n</td>
<td>AC Termination Select</td>
</tr>
<tr>
<td></td>
<td>( n = 0 ), Selects real impedance</td>
</tr>
<tr>
<td></td>
<td>( n = 1 ), Selects complex impedance</td>
</tr>
<tr>
<td>#define R16_IIRE n</td>
<td>IIR or FIR Filter Selection for Transmit and Receive Filters</td>
</tr>
<tr>
<td></td>
<td>( n = 0 ), Enable FIR filter</td>
</tr>
<tr>
<td></td>
<td>( n = 1 ), Enable IIR filter</td>
</tr>
<tr>
<td>#define R16_DCT n</td>
<td>DC Termination Select</td>
</tr>
<tr>
<td></td>
<td>( n = 1 ), Japan Mode</td>
</tr>
<tr>
<td></td>
<td>( n = 2 ), FCC Mode</td>
</tr>
<tr>
<td></td>
<td>( n = 3 ), CTR_21 Mode</td>
</tr>
<tr>
<td>#define R16_RZ n</td>
<td>Ringer Impedance Selection</td>
</tr>
<tr>
<td></td>
<td>( n = 0 ), Maximum (high) Ringer impedance</td>
</tr>
<tr>
<td></td>
<td>( n = 1 ), Synthesize ringer impedance</td>
</tr>
<tr>
<td>#define R16_RT n</td>
<td>Used to satisfy country requirements on ring detection. Signals below the lower level will not generate a ring detection; signals above the upper level are guaranteed to generate a ring detection.</td>
</tr>
<tr>
<td></td>
<td>( n = 0 ), 11 to 22 Arms</td>
</tr>
<tr>
<td></td>
<td>( n = 1 ), 17 to 33 Arms</td>
</tr>
</tbody>
</table>
Table 2-5 lists the country specific register settings.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
</table>
| #define R17_LIM n | Current Limit  
|               | n = 0, All other Modes  
|               | n = 3, CTR_21 mode                                                       |
| #define R18_FJM n  | Force Japan DC Termination Mode  
|               | n = 0, Normal Gain  
|               | n = 1, If FCC DC Termination mode is selected, setting this bit will force the Japan DC Termination mode while allowing for a transmit level of -1dBm. |
| #define R18_VOL n   | Line Voltage Adjust  
|                   | Used to adjust the tip and ring voltage. Lowering this voltage will improve margin in low voltage countries. Rising this voltage may improve distortion performance.  
|                   | n = 0, Normal  
|                   | n = 1, -0.125V  
|                   | n = 2, 0.25V  
|                   | n = 3, 0.125V  

Table 2-4: DAA Si3034 Configuration (Continued)
### TABLE 2-5: COUNTRY SPECIFIC REGISTER SETTINGS

<table>
<thead>
<tr>
<th>Register</th>
<th>16</th>
<th>17</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>OHS</td>
<td>ACT</td>
<td>DCT&lt;1:0&gt;</td>
</tr>
<tr>
<td>Argentina</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Australia(1)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Austria</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Bahrain</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Belgium</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Brazil(1)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Canada</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Chile</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>China(1)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Columbia</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Croatia</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>CTR_21(2)</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Denmark</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Ecuador</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Egypt(1)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>El Salvador</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Finland</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Germany</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Greece</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Guam</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Hungary</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Iceland</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>India</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Ireland</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Israel</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Italy</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Japan(1)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Jordan(1)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Kazakhstan(1)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Kuwait</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Latvia</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Lebanon</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
</tr>
</tbody>
</table>

**Note 1:** See DC Termination section in the Si3034 Data Sheet.

**Note 2:** CTR_21 includes the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

**Note 3:** Supported for loop current > 20 mA.
### TABLE 2-5: COUNTRY SPECIFIC REGISTER SETTINGS\(^{(1)}\) (CONTINUED)

<table>
<thead>
<tr>
<th>Register</th>
<th>Country</th>
<th>OHS</th>
<th>ACT</th>
<th>DCT&lt;1:0&gt;</th>
<th>RZ</th>
<th>RT</th>
<th>LIM&lt;1:0&gt;</th>
<th>VOL&lt;1:0&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Macao</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>Malaysia(^{(1, 3)})</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>Malta</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Mexico</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Morocco</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Netherlands</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>New Zealand</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Norway</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Oman(^{(1)})</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Pakistan(^{(1)})</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Peru</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Philippines(^{(1)})</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Poland</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Portugal</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Romania</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Russia(^{(1)})</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Saudi Arabia</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Slovakia</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Slovenia</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Spain</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Sweden</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Switzerland</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Syria(^{(1)})</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Taiwan(^{(1)})</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>UAE</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>0</td>
<td>0 or 1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Yemen</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note 1:** See DC Termination section in the Si3034 Data Sheet.

**Note 2:** CTR_21 includes the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

**Note 3:** Supported for loop current > 20 mA.
Chapter 3. Application Programming Interface (API)

This chapter lists and describes the Application Programming Interface (API) that are available in the stand-alone dsPIC DSC DTMF Detection Library. Topics covered include:

• dsPIC DSC DTMF Generation Library API Functions

3.1 dsPIC DSC DTMF GENERATION LIBRARY API FUNCTIONS

The following functions are available in the DTMF Detection library:

• DTMFDetInit
• DTMFDetection

DTMFDetInit

Description
Initializes the parameters to detect a DTMF signal. The user application must call this function before invoking the DTMFDetection function.

Include
None.

Prototype
void DTMFDetInit(dtmfdet_sHandle *pDTMFDet, dtmfdet_sConfig *pConfig);

Arguments
pDTMFDet Pointer to the state memory for this instance of DTMF Detection.
pConfig Pointer to a structure containing data for initializing the state variables in pDTMFDet structure.

Return Value
None.

Remarks
None.
DTMFGenInit (Continued)

Code Example

dtmfset_sHandle CH1;
dtmfset_sConfig CF1;
CF1.DTMFframeType = NOT_A_DIGIT_FRAME; //Init frametype
CF1.DTMFshapeTest = YES; //Disable the Shape Test
CF1.DTMFcurrentDigit = CURRENT_DIGIT; //Init 20 as the Current
    //Digit
CF1.DTMFdeclaredDigit = DECLARED_DIGIT; //Init 30 as the prev
    //detected digit
CF1.DTMFinputType = LEFT_JUSTIFIED;
DTMFDetInit(&CH1,&CF1);
DTMFDetection

Description

The DTMFDetection function should be invoked by the user application after every 10 ms to process the received samples. This function returns the state of the DTMF detection. The user application reads the digit based on the state information returned by the DTMFDetection function. The function returns any of the following states:

Table 3-1: DTMF Detection State

<table>
<thead>
<tr>
<th>Frame Type</th>
<th>Symbolic Representation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>VALID_DIGIT_FRAME</td>
<td>A valid DTMF digit is just detected.</td>
</tr>
<tr>
<td>1</td>
<td>POSSIBLE_DIGIT_FRAME</td>
<td>This signal may represent a DTMF tone (first detection) yet to make the final decision.</td>
</tr>
<tr>
<td>2</td>
<td>DIGIT_DETECTED</td>
<td>A valid digit is detected.</td>
</tr>
<tr>
<td>3</td>
<td>TONE_SHAPE_TEST</td>
<td>This frame indicates the silence period immediately after a DTMF tone (may be separation between two digits).</td>
</tr>
<tr>
<td>4</td>
<td>PAUSE_AFTER_DIGIT_FRAME</td>
<td>This state indicates the Pause frame after a DTMF tone.</td>
</tr>
<tr>
<td>5</td>
<td>BUFFER_DELAY</td>
<td>This state indicates no operation frame (The input samples are taken and stored in the system buffer).</td>
</tr>
<tr>
<td>6</td>
<td>NOT_A_DIGIT_FRAME</td>
<td>This frame is not a part of a DTMF digit.</td>
</tr>
<tr>
<td>-1</td>
<td>ERROR_FRAME</td>
<td>This state indicates an error in the frame processing operation (possibly wrong arguments).</td>
</tr>
</tbody>
</table>

Include

None.

Prototype

int DTMFDet(dtmfdet_sHandle *pDTMFDet, int *pSamplesBuffer, int *Digit);

Arguments

pDTMFDet Handle to an instance of DTMF Detection.
pSamplesBuffer Pointer to input buffer.
Digit Pointer to store the detected digit.

Return Value

Process State/Type

Remarks

None.

Code Example

dtmfdet_sHandle CH1;
int inSignal[80];
int Digit,State;
State = DTMFDetection(&CH1,&inSignal[0],&Digit);
Chapter 4. DTMF Detection Demonstration

This chapter analyzes a sample application program that demonstrates the key functionality of the dsPIC DSC DTMF Detection Library. This sample demonstration offers hands-on exposure to the library and provides an informal way to gain implementation experience.

The sample program demonstrates the DTMF tone detection over a dial-up phone line. The program is built using MPLAB IDE and MPLAB ICD 2, and is loaded into a dsPIC33F device. The dsPICDEM.net Connectivity Board is used to execute the demonstration program. Topic covered includes:

- Setting Up the dsPICDEM.net Board
- DTMF PSTN Phone Line Demonstration

4.1 SETTING UP THE dsPICDEM.net BOARD

Use the following procedures to set up the board:

1. Make sure the 2X2 shunts on J17 and J19 jumpers are inserted in a manner that ensures vertical alignment and are perpendicular to the LCD display.
2. To apply power to the dsPICDEM.net board, remove the J6 jumper and apply 3.3V to J6 terminal.
3. Do not connect the 9V DC power supply to J14 terminal.
4. Jumper M0 must be kept open.
5. Set up the HyperTerminal connection as follows:
   - Bits per second: 19200
   - Data bits: 8 bits
   - Parity: None
   - Stop bits: 1 Stop bit
   - Flow Control: Hardware Flow Control

4.2 DTMF PSTN PHONE LINE DEMONSTRATION

In this demonstration setup, the dsPIC DSC DTMF Detection Library interacts with a remote telephone over the PSTN, as illustrated in Figure 4-1. The telephone handset is used to dial the dsPICDEM.net board over an analog phone line. The Si3034/Si3035 DAA/AFE interface on the board detects the ring and alerts the dsPIC33FJ256GP710 device, which then executes the DTMF detection algorithm. When the off-hook function is simulated by pressing the S1 switch, the remote telephone communicates with the dsPIC DSC DTMF Detection Library via the DAA/AFE modem circuitry.

Digits can now be generated from the telephone keypad and recognized by the DTMF detection algorithm. The recognized digits are sent to the UART for display. The UART passes the digits to the attached PC running the HyperTerminal.
4.2.1 Demonstration Setup

In this demonstration, the program was assembled and built from ready-to-use source files. Use the following procedures to set up the demonstration.

1. Connect the dsPICDEM.net board (J16) to an analog(1) phone line.
2. Build the program (Debugger>Build All).
3. Load the program in the dsPIC DSC device (Debugger>Program).
4. Reset the program (Debugger>Reset).
5. Run the program (Debugger>Run).
6. From the telephone, dial the phone number to which the dsPICDEM.net board is attached. When you hear the ring on the board, press the S1 switch to go off-hook.
7. On the telephone keypad, enter 0-9, * or #. Observe the series of digits displayed on the HyperTerminal.
8. To end, hang up the phone and press RESET on the board.

**Note:** It is always necessary to reprogram the device with the new code after each build. MPLAB will remind you with a message that states "Program memory has changed since last operation".

Figure 4-2 shows a flow chart that summarizes the remote DTMF detection demonstration.

**Demonstration Summary:**

1. With dsPICDEM.net™ connected to an analog(1) phone line, use a phone handset to dial the board.
2. At the tone, press the S1 switch to go off-hook.
3. Use the phone keypad to input numbers 0-9, # and * characters. Detected characters are displayed on the PC.

**Note 1:** You must connect to an analog phone line only. Using a non-analog line (e.g., digital, PBX Multiline) may damage the modem.
FIGURE 4-2: REMOTE DTMF DETECTION DEMO FLOW

1. Start
2. Initialize DTMF Detection
3. Initialize Si3034/Si3035 DAA/AFE Hardware
4. Dial dsPICDEM.net™ Board
5. Press key on handset
6. Connectivity Board Ringing?
   - No
   - Yes
      a. Press S1 to go off-hook
      b. Feed Digit to dsPIC® DSC DTMF Detection Library
5. Send Detected Digit to UART
6. Display Digit String on HyperTerminal
This section provides information about the drivers used with the dsPIC DSC DTMF Detection Library.

A.1 DAA/AFE DRIVER FUNCTIONS

The dsPIC33F device implements both 8.0 kHz and 7.2 kHz sampling rates when communicating with the DAA/AFE. The following driver functions are provided to operate the Si3021 chipset with different options:

- `Init_Si3021`
- `SetFs7200`
- `SetFs8000`
- `go_on_hook`
- `go_off_hook`
- `speaker_off`

---

**Init_Si3021**

**Function**
Used to initialize different parameters of Si3034/Si3035 AFE. Sets the sampling rate to 8 kHz and also sets different international control registers of this chipset to the selected options.

**Prototype**

```c
void Init_Si3021(void)
```

**Arguments**

None.

**Return Value**

None.

**Code Example**

```c
Init_Si3021();
```
SetFs7200

Function
Used to change the AFE sampling rate to 7.2 kHz. Initially Si3021 is initialized to 8 kHz sampling rate in Init_Si3021. This function must be called by the user application when the data pump requests the user application to change the sampling rate to 7.2 kHz.

Prototype
void SetFs7200(void)

Arguments
None.

Return Value
None.

Code Example
SetFs7200();

SetFs8000

Function
Used to change the AFE sampling rate to 8 kHz. This function must be called by the user application to change the AFE sampling rate from 7.2 kHz to 8 kHz.

Prototype
void SetFs8000(void)

Arguments
None.

Return Value
None.

Code Example
SetFs8000();
**go_on_hook**

**Function**
Used to set the AFE to the On-Hook state.

**Prototype**
void go_on_hook(void)

**Arguments**
None.

**Return Value**
None.

**Code Example**
go_on_hook();

**go_off_hook**

**Function**
Used to set the AFE to the Off-Hook state.

**Prototype**
void go_off_hook(INT SpeakerVolume)

**Arguments**
None.

**Return Value**
None.

**Code Example**
SpeakerVolume = 0x03 -> Low  
SpeakerVolume = 0x63 -> Medium  
SpeakerVolume = 0x00 -> High  
go_off_hook(SpeakerVolume);
**speaker_off**

**Function**
Used to mute the transmit and receive path signals for the call progress AOUT pin of this chipset. This function is used to turn off the transmit and receive signal to the speaker connected to the AOUT pin of the chipset.

**Prototype**
void speaker_off(void)

**Arguments**
None.

**Return Value**
None.

**Code Example**
speaker_off();
# Index

## A
- API Functions
  - DTMFDetection .............................................. 21  
  - DTMFDetInit .................................................. 19  

## C
- Country Settings .............................................. 17  
- CTR-21 Compliance .......................................... 15  
- Customer Notification Service ............................. 5  
- Customer Support ............................................. 6  

## D
- DAA/AFE
  - Configuration Options .................................. 15  
  - Connections to dsPIC30F .................................. 13  
  - Driver Functions .......................................... 27  
  - Gain Control ................................................. 14  
- DAA/AFE Driver Functions
  - go_off_hook .................................................. 29  
  - go_on_hook ................................................... 29  
  - Init_Si3021 .................................................. 27  
  - SetFs7200 ..................................................... 28  
  - SetFs8000 ..................................................... 28  
  - speaker_off .................................................. 30  
- Documentation
  - Conventions .................................................. 3  
  - Layout ......................................................... 2  

## F
- FCC Compliance ................................................. 15  
- Free Software Foundation.................................. 4  

## G
- GNU Language Tools.......................................... 4  

## I
- Internet Address ............................................... 5  

## J
- JATE Compliance ............................................... 15  

## M
- Microchip Internet Web Site ............................... 5  
- MPLAB IDE User’s Guide ..................................... 4  

## P
- PTT Compliance ............................................... 15  

## R
- Reading, Recommended ....................................... 4  

## S
- SetFs8000 ......................................................... 28  

## W
- Warranty Registration ......................................... 3  
- WWW Address ................................................... 5
## WORLDWIDE SALES AND SERVICE

**AMERICAS**

**Corporate Office**
2355 West Chandler Blvd.
Chandler, AZ  85224-6199
Tel:  480-792-7200
Fax:  480-792-7277
Technical Support:
http://support.microchip.com
Web Address:
www.microchip.com

**Atlanta**
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

**Boston**
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

**Chicago**
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

**Dallas**
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

**Detroit**
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

**Kokomo**
Kokomo, IN
Tel: 765-864-8360
Fax: 765-864-8387

**Los Angeles**
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

**Santa Clara**
Santa Clara, CA
Tel: 408-961-6444
Fax: 408-961-6445

**Torronto**
Mississauga, Ontario, Canada
Tel: 905-673-0699
Fax: 905-673-6509

**ASIA/PACIFIC**

**Asia Pacific Office**
Suites 3707-14, 37th Floor
Tower 6, The Gateway Harbour City, Kowloon Hong Kong
Tel: 852-2401-1200
Fax: 852-2401-3431

**Australia - Sydney**
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

**China - Beijing**
Tel: 86-10-8528-2100
Fax: 86-10-8528-2104

**China - Chengdu**
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

**China - Hong Kong SAR**
Tel: 852-2401-1200
Fax: 852-2401-3431

**China - Nanjing**
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

**China - Qingdao**
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

**China - Shanghai**
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

**China - Shenyang**
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

**China - Shenzhen**
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

**China - Wuhan**
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

**China - Xiamen**
Tel: 86-592-2388138
Fax: 86-592-2388130

**China - Xian**
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

**China - Zhuhai**
Tel: 86-756-3210040
Fax: 86-756-3210049

**ASIA/PACIFIC**

**India - Bangalore**
Tel: 91-80-4182-8400
Fax: 91-80-4182-8422

**India - New Delhi**
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

**India - Pune**
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

**Japan - Yokohama**
Tel: 81-45-471-6166
Fax: 81-45-471-6122

**Korea - Daegu**
Tel: 82-53-744-4301
Fax: 82-53-744-4302

**Korea - Seoul**
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or 82-2-558-5934

**Malaysia - Kuala Lumpur**
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

**Malaysia - Penang**
Tel: 60-4-227-8870
Fax: 60-4-227-4068

**Philippines - Manila**
Tel: 63-2-634-9065
Fax: 63-2-634-9069

**Singapore**
Tel: 65-6334-8870
Fax: 65-6334-8850

**Taiwan - Hsin Chu**
Tel: 886-3-572-9526
Fax: 886-3-572-6459

**Taiwan - Kaohsiung**
Tel: 886-7-536-4818
Fax: 886-7-536-4803

**Taiwan - Taipei**
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

**Thailand - Bangkok**
Tel: 66-2-694-1351
Fax: 66-2-694-1350

**EUROPE**

**Austria - Wels**
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

**Denmark - Copenhagen**
Tel: 45-4450-2828
Fax: 45-4485-2829

**France - Paris**
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

**Germany - Munich**
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

**Italy - Milan**
Tel: 39-0331-742611
Fax: 39-0331-466781

**Netherlands - Drunen**
Tel: 31-416-690399
Fax: 31-416-690340

**Spain - Madrid**
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

**UK - Wokingham**
Tel: 44-118-921-5869
Fax: 44-118-921-5820

01/02/08