



**PIC32 Bluetooth[®] Audio
Development Kit
Reference Guide**

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Object of Declaration: DV320032, PIC32 Bluetooth® Audio Development Kit

EU Declaration of Conformity

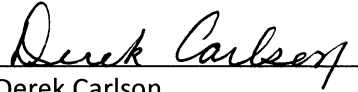
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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA



Derek Carlson
VP Development Tools

16-July-2013
Date

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Preface

NOTICE TO CUSTOMERS

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

Documents are identified with a “DS” number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is “DSXXXXXXXXA”, where “XXXXXXXX” 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 using the PIC32 Bluetooth[®] Audio Development Kit. Items discussed in this chapter include:

- [Document Layout](#)
- [Conventions Used in this Guide](#)
- [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 PIC32 Bluetooth[®] Audio Development Kit as a development tool to emulate and debug firmware on a target board. This document includes the following chapters:

- **Chapter 1. “Introduction”** provides a brief overview of the development kit, highlighting its features and uses.
- **Chapter 2. “Hardware and Software Performance”** provides the hardware descriptions of the development kit.
- **Chapter 3. “Interoperability Testing Results”** provides a manufacturer test result matrix for the development kit.
- **Chapter 4. “Demonstrations”** describes the available demonstrations for the development kit.
- **Chapter 5. “Bluetooth Stack Overview”** provides a brief overview of the Microchip Bluetooth Stack for PIC32, which is used by the development kit.

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- **Appendix A. “Board Layout and Schematics”** provides a block diagram, board layout, and detailed schematics of the development kit.
- **Appendix B. “Bill of Materials (BOM)”** provides the bill of material descriptions and the reference, manufacturer, and part numbers for the components used in the development kit hardware.
- **Appendix C. “Planned Enhancements”** provides a list of planned enhancements for the development kit.
- **Appendix D. “Frequently Asked Questions (FAQ)”** provides questions and answers for common issues that may be encountered while using the development kit.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Italic characters	Referenced books	<i>MPLAB IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	<u>File > Save</u>
Bold characters	A dialog button	Click OK
	A tab	Click the Power tab
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Plain Courier New	Sample source code	#define START
	Filenames	autoexec.bat
	File paths	c:\mcc18\h
	Keywords	_asm, _endasm, static
	Command-line options	-Opa+, -Opa-
	Bit values	0, 1
	Constants	0xFF, 'A'
<i>Italic Courier New</i>	A variable argument	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets []	Optional arguments	mcc18 [options] <i>file</i> [options]
Curly brackets and pipe character: { }	Choice of mutually exclusive arguments; an OR selection	error level {0 1}
Ellipses...	Replaces repeated text	var_name [, var_name...]
	Represents code supplied by user	void main (void) { ... }
Notes	A Note presents information that we want to re-emphasize, either to help you avoid a common pitfall or to make you aware of operating differences between some device family members. A Note can be in a box, or when used in a table or figure, it is located at the bottom of the table or figure.	Note: This is a standard note box.
		CAUTION This is a caution note. Note 1: This is a note used in a table.

RECOMMENDED READING

This document describes how to use the starter kit. The following Microchip documents are available and recommended as supplemental reference resources.

PIC32MX330/350/370/430/450/470 Family Data Sheet (DS60001185)

Consult this document for detailed information on PIC32 devices. Reference information found in this data sheet includes:

- Device memory maps
- Device pinout and packaging details
- Device electrical specifications
- List of peripherals included on the devices

Section 27. “USB On-The-Go” (DS61126)

This section of the *“PIC32 Family Reference Manual”* provides a detailed description and overview of the functionality of the USB OTG module.

Microchip Bluetooth® Stack for PIC32 (DS Number Pending)

This application note provides information on the profiles, protocols, and decoders available in the Bluetooth Stack for PIC32 devices.

MPLAB® XC32 C/C++ Compiler User’s Guide (DS50001686)

This document details the use of Microchip’s MPLAB XC32 C/C++ Compiler to develop an application.

MPLAB® X IDE User’s Guide (DS50002027)

Refer to this document for more information pertaining to the installation and implementation of the MPLAB X IDE software, as well as the MPLAB SIM Simulator software that is included with it.

PICkit™ 3 In-Circuit Debugger/Programmer User’s Guide (DS50002116)

This document describes how to use the PICkit 3 as a development tool to emulate and debug firmware on a target board, as well as how to program devices.

PICkit 3 In-Circuit Debugger/Programmer Online Help File

A comprehensive help file for the debugger is included with MPLAB X IDE. Usage, troubleshooting and hardware specifications are covered. This may be more up-to-date than the printed documentation. Also, limitations are listed for various devices.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at: <http://www.microchip.com>. This web site makes files and information easily available to customers. Accessible by most Internet browsers, 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 listings
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listings of seminars and events; and listings of Microchip sales offices, distributors and factory representatives

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The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools
- **Emulators** – The latest information on the Microchip in-circuit emulator, MPLAB REAL ICE™
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 3
- **MPLAB X IDE** – The latest information on Microchip MPLAB X IDE, the Windows® Integrated Development Environment for development systems tools
- **Programmers** – The latest information on Microchip programmers including the PICkit™ 3 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>

PIC32 Bluetooth® Audio Development Kit Reference Guide

DOCUMENT REVISION HISTORY

Revision A (September 2013)

This is the initial release of the PIC32 Bluetooth® Audio Development Kit Reference Guide.

Chapter 1. Introduction

Thank you for purchasing the Microchip Technology PIC32 Bluetooth Audio Development Kit (P/N: DV320032). This development kit provides a complete turn-key solution to develop Bluetooth A2DP audio streaming solutions and applications. The development board included in the kit is coupled with two daughter boards: the Bluetooth HCI Radio Daughter Board that demonstrates a low cost Bluetooth implementation, and the Audio DAC Daughter Board that demonstrates a high-quality 16/24-bit, 32-192 kHz audio conversion/amplification for line-out or headphones. The kit ships with demonstration code that enables wireless streaming digital audio from any Bluetooth enabled smartphone or portable music player or over USB.

Key features include:

- PIC32MX450F256L, 80 MHz, 256 KB Flash, 64 KB RAM
- HCI Bluetooth Module Daughter Board (QDID certified module)
- 16-bit/24-bit, 32-192 kHz DAC/Amp Daughter Board
- USB Host/Device audio support
- USB charging
- Two-inch color LCD
- Headphone/Line-out
- Audio control function
- Bluetooth/USB audio software support for:
 - Apple® (see the following Note)
 - Samsung audio
 - Google/Android AOA audio
 - Bluetooth audio with SBC and AAC decode
 - Bluetooth Stack QDID certified

Currently, there are several Bluetooth® demonstrations with several more planned in the coming weeks and months. We are continually adding more and more features and functionality.

Note: Demonstration programs and support for Apple USB streaming audio is available by special request to certified Apple developers. For more information, please contact your local Microchip field sales support office or visit applesupport@microchip.com.

USB streaming audio from an Apple product requires a special authentication module, which is compatible with the PIC32 Bluetooth Audio Development Kit. This module is available for purchase by certified Apple developers through the Avnet MFi Procurement website (<https://mfi.avnet.com/MFI/>). To obtain software for this and other Microchip hardware, which is enabled for Apple products, please contact your Microchip sales office.

The PIC32 Bluetooth Audio Development Kit supports the PICkit™ 3 In-Circuit Debugger/Programmer for full emulation, programming and debug capabilities.

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1.1 QUALIFICATION

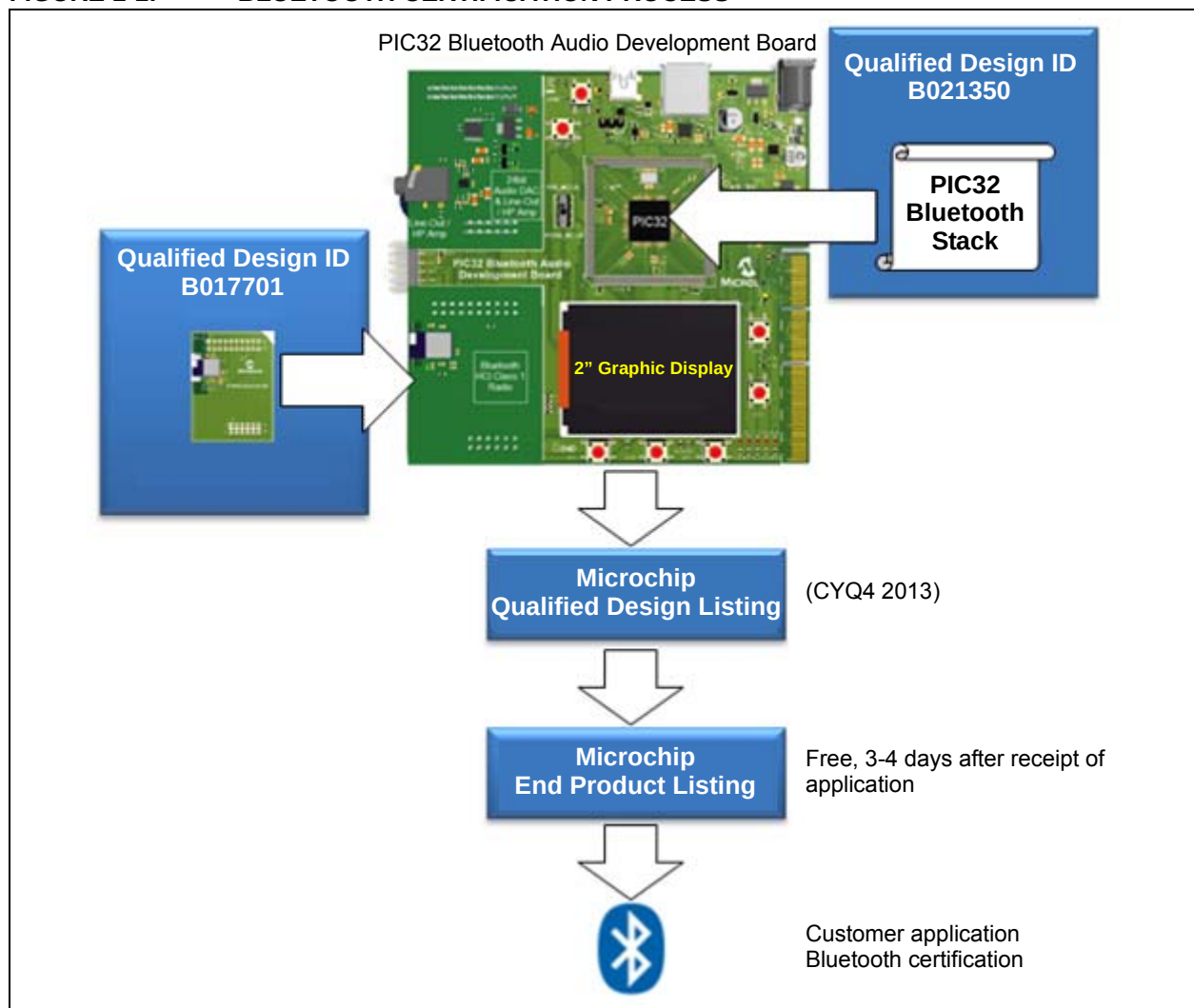
Bluetooth qualified design information is provided in [Table 1-1](#). See [Figure 1-1](#) for the Bluetooth certification process.

TABLE 1-1: BLUETOOTH QUALIFIED DESIGN INFORMATION

Component	Qualified Design ID (QD ID)	Qualified Design Listing (QDL)
Bluetooth Radio Module FLC-BTM805B https://www.bluetooth.org/tpg/listings.cfm (Search: B017701) https://www.bluetooth.org/tpg/EPL_Detail.cfm?ProductID=25584	B017701	N/A
Bluetooth Stack https://www.bluetooth.org/tpg/QLI_viewQDL.cfm?qid=21350	B021350	N/A
Bluetooth Audio Development Board System Bluetooth Stack plus Radio Module	N/A	CYQ4 2013

Note: The Bluetooth software stack and the Bluetooth radio module hardware on the PIC32 Bluetooth Audio Development Board have Qualified Design IDs. Microchip is currently in the process of securing a Qualified Design Listing for the PIC32 Bluetooth Audio Development Board reference design, which includes the integration of the two (ETA: CYQ4 2013). Once the Microchip QDL is granted, customers can obtain an End Product Listing (EPL), free of cost from the Bluetooth Special Interest Group usually within 3-4 days confirming that their product is Bluetooth-certified.

FIGURE 1-1: BLUETOOTH CERTIFICATION PROCESS



1.2 KIT CONTENTS

The PIC32 Bluetooth Audio Development Kit (P/N: DV320032) contains the following items:

- PIC32 Bluetooth Audio Development Board (P/N: DM320032)
- Bluetooth HCI Radio Module Daughter Board (P/N: AC320032-1)
- 24-bit stereo DAC Line-out/Headphone Amplifier Daughter Board (P/N: AC320032-2)
- On-board preprogrammed PIC32MX450F256L or PIC32MX470F512L (see the following **Note**)

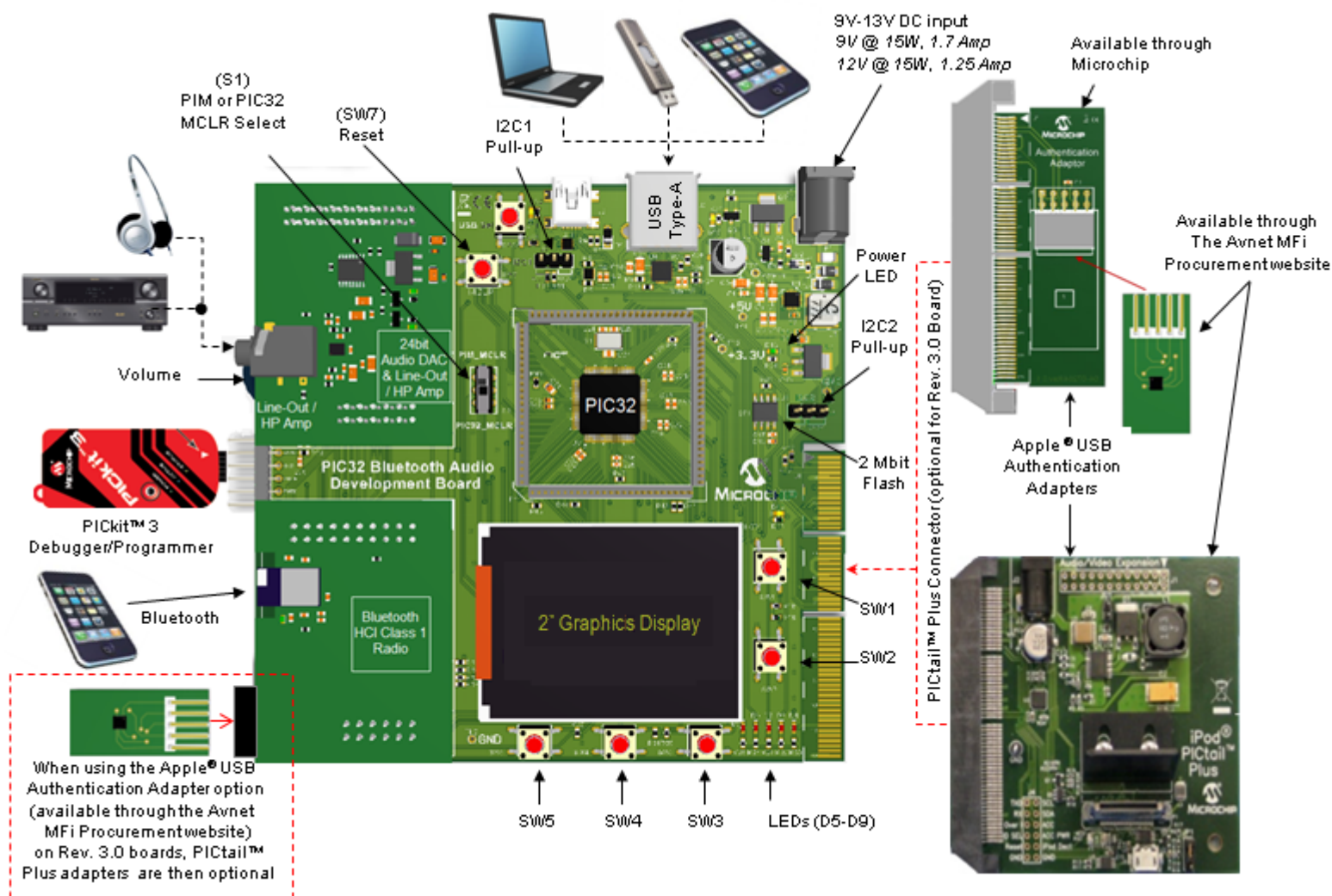
Note: The PIC32 Bluetooth Audio Development Kit has been designed to function with a PIC32MX470F512L device at location U1. However, initial units will be shipped with U1 populated with a PIC32MX450F256L until the PIC32MX470F512L devices are available.

For those customers who have a development kit populated with the PIC32MX450F256L, you can update to the new device using a PIC32MX470F512L Plug-in Module (PIM) mounted on the U1A headers. When using the PIM, ensure that switch S2 is in the PIM_MCLR position. When not using the PIM, ensure that switch S2 is in the default PIC32_MCLR position.

1.3 FEATURES

Figure 1-2 illustrates the features of the PIC32 Bluetooth Audio Development Kit.

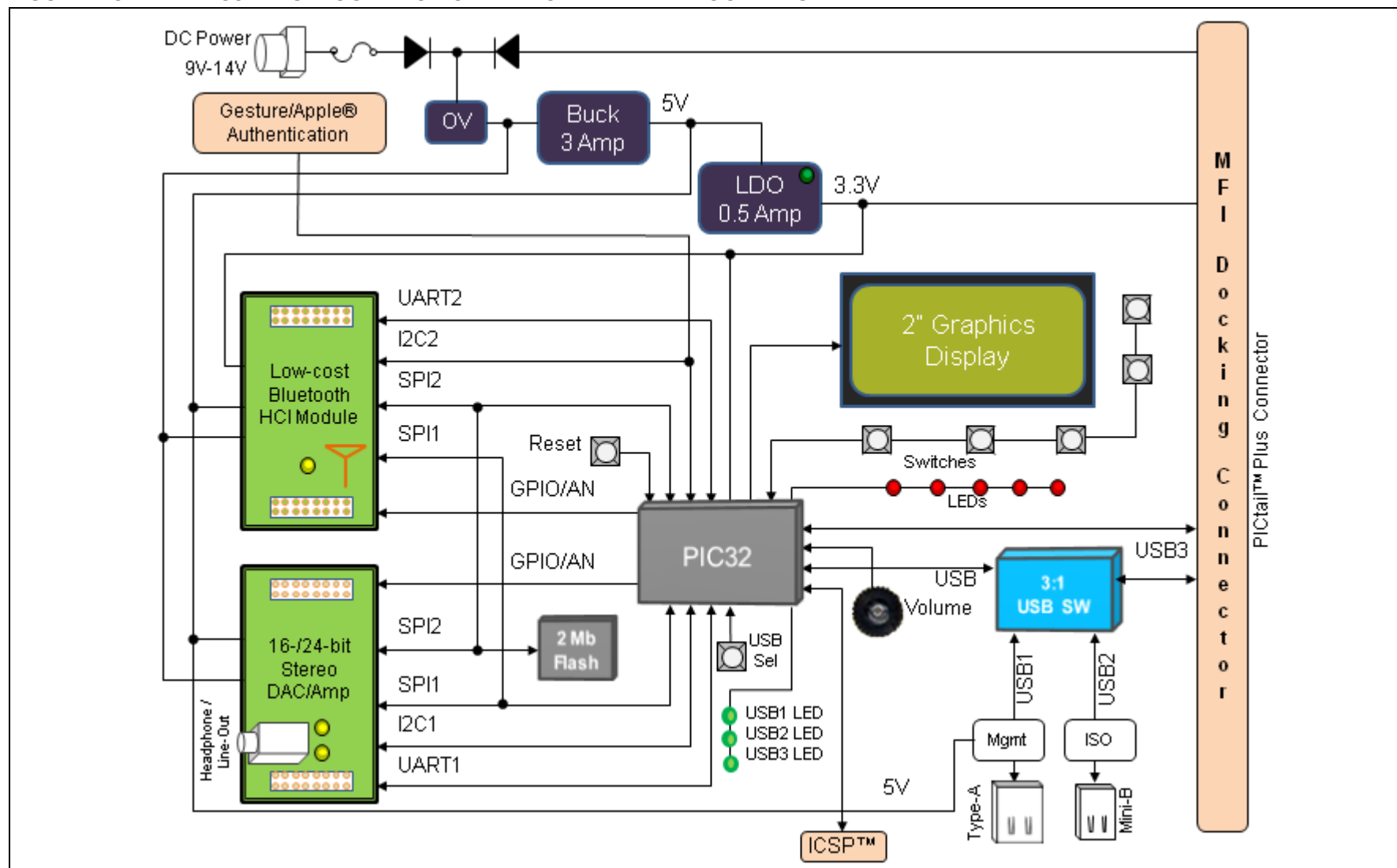
FIGURE 1-2: PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT LAYOUT AND FEATURES



1.3.1 Development Kit Block Diagram

Figure 1-3 shows a block diagram of the PIC32 Bluetooth Audio Development Kit.

FIGURE 1-3: PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT BLOCK DIAGRAM



1.4 PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT FUNCTIONALITY AND FEATURES

The PIC32 Bluetooth Audio Development Kit has the following key features, as indicated by the corresponding number in [Figure 1-4](#):

1. PIC32MX450F256L or PIC32MX470F512L 32-bit microcontroller (U1).
2. Hardware selection of PIM or board mounted microcontroller (S1).
3. 6.9V to 14V DC power input (provides +3.3V and +5V (regulated) to kit hardware).
4. Overvoltage protection circuit (14.4V trip) and fused overcurrent protection.
5. Power indicator LED (D13).
6. USB Type-A connector to support USB audio and MP3.
7. USB 3:1 multiplexer (for connecting the PIC32 device to a Type-A, mini-B, or off-board USB source).
8. USB charge management IC (auto-negotiating USB quick charge current up to 2.5 amps and support for simultaneous audio and charging).
9. 2" 176 x 220 RGB graphics TFT display.
10. Device Reset push button.
11. Six user-definable push buttons (SW1 - SW6).
12. Potentiometer for master volume control (i.e., not synchronized with audio device volume control).
13. Five user application indicator LEDs (D5 - D9).
14. I2C pull-up headers (selectable to either 3.3V or 5V).
15. 2 Mb SPI serial EEPROM.
16. PICtail™ Plus connector with support for an external USB Apple authentication adapter.

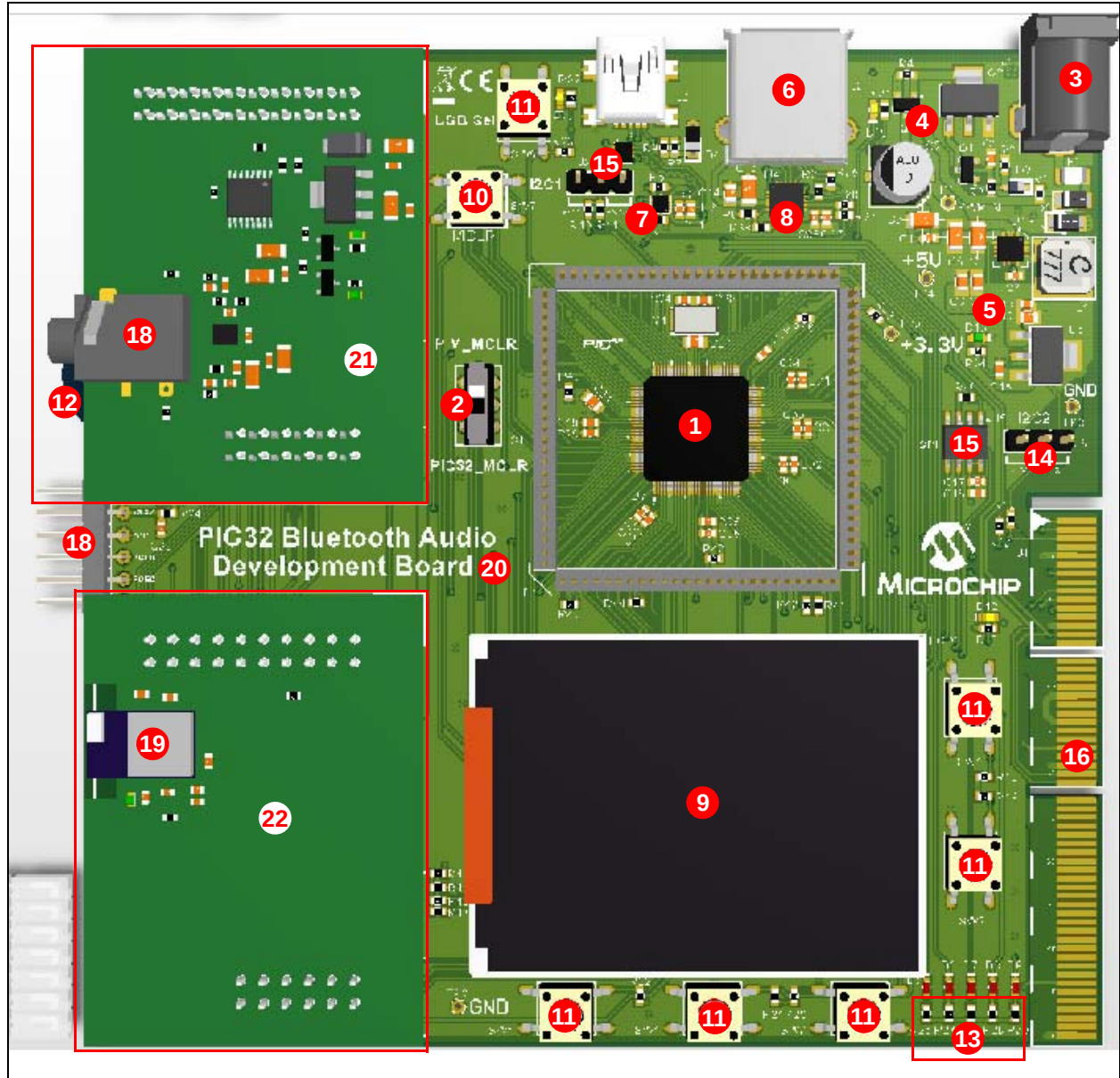
Note: For USB Apple connected audio devices, a special authentication device is required, which is only available to licensed Apple certified developers. Please contact a Microchip sales office for information.

17. PICkit 3 In-Circuit Debugger/Programmer connector.
18. 16-bit/24-bit Stereo DAC and 70 mW line-out/headphone connector.
19. Certified HCI Class 1 Bluetooth radio module.
20. PIC32 Bluetooth Audio Development Board (DM320032).
21. 24-bit Audio DAC/AMP Daughter Board (AC320032-2).
22. Bluetooth HCI Radio Module Daughter Board (AC320032-1).

Note: Items 20, 21, and 22 are included with the PIC32 Bluetooth Development Audio Kit (DV320032).

Also, to utilize MPLAB REAL ICE™ or MPLAB ICD 3 with the development kit, an RJ-11 to ICSP adapter is required, which is available from microchipDirect (P/N: AC164110) (www.microchipdirect.com).

FIGURE 1-4: PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT LAYOUT (TOP VIEW)

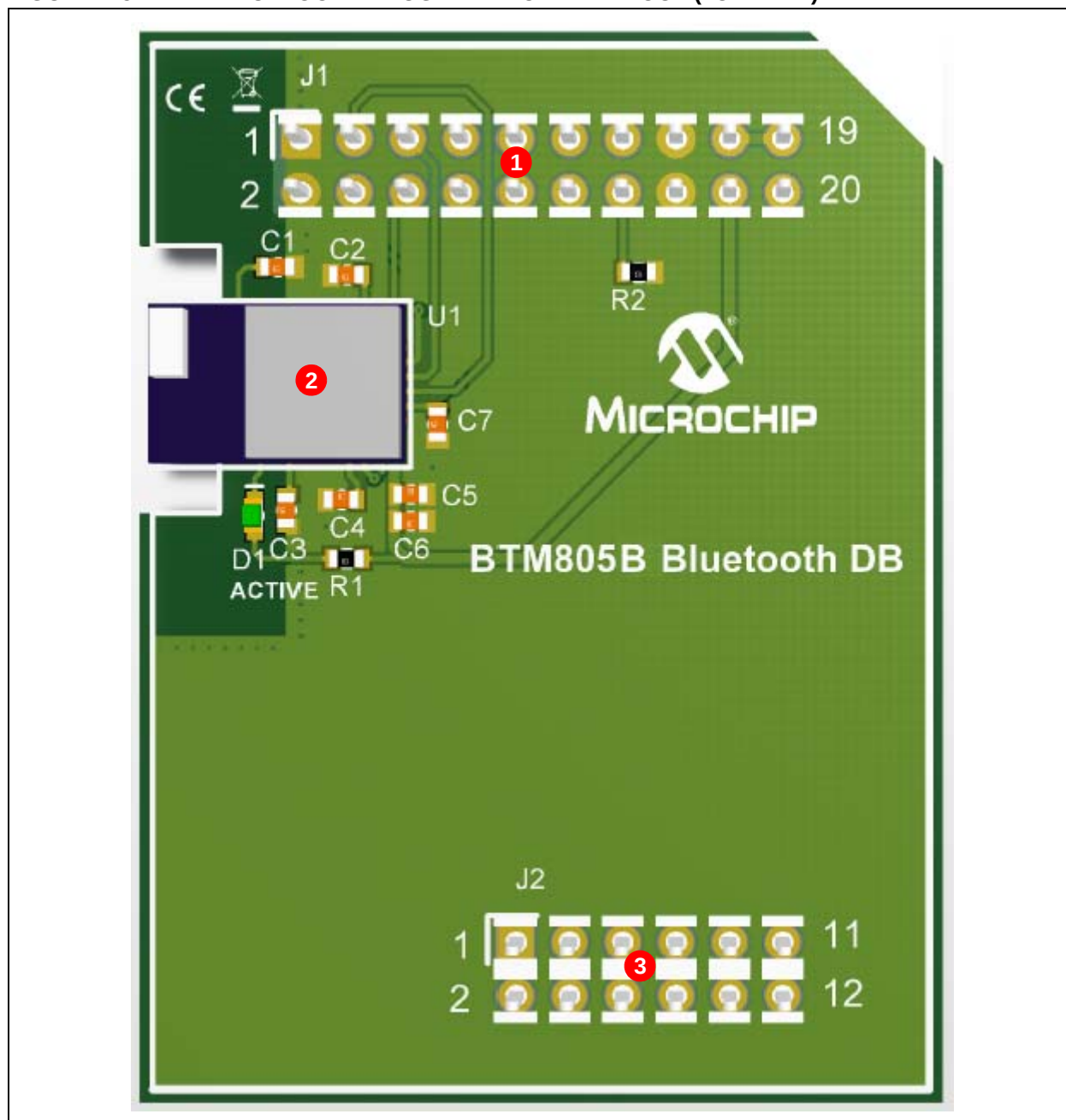


1.5 BLUETOOTH MODULE DAUGHTER BOARD FUNCTIONALITY AND FEATURES

The Bluetooth HCI Radio Module Daughter Board (BTM805B) (P/N: AC320032-1) has the following key features, as indicated by the corresponding number in [Figure 1-5](#):

1. Female 20-pin dual-row header (J1).
2. Bluetooth Module - FLC-BTM805CL2B (U1).
3. Female 12-pin dual-row header (J2).

FIGURE 1-5: BLUETOOTH DAUGHTER BOARD LAYOUT (TOP VIEW)

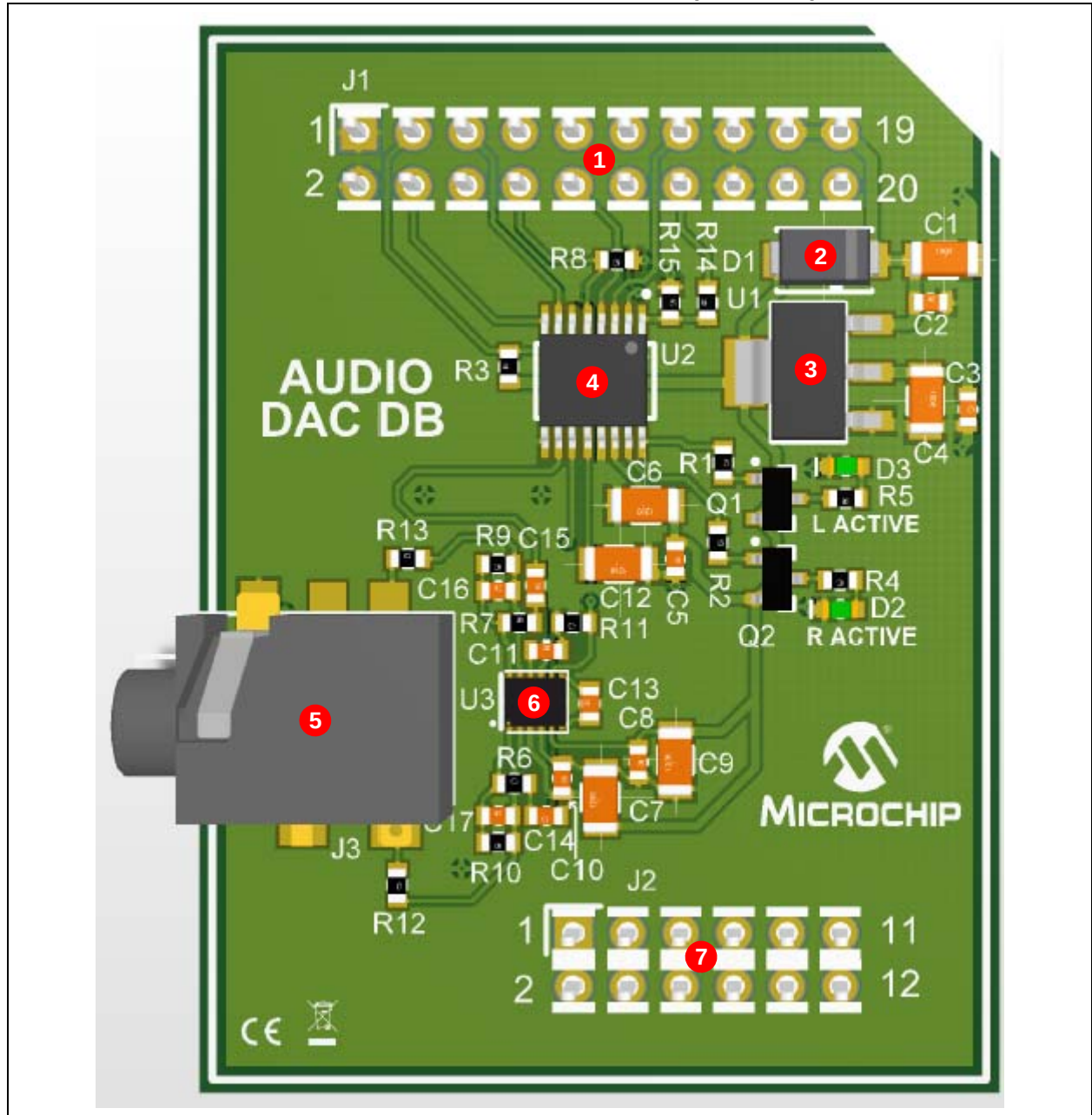


1.6 AUDIO DAC DAUGHTER BOARD FUNCTIONALITY AND FEATURES

The Audio DAC/AMP Daughter Board (P/N: AC320032-2) has the following key features, as indicated by the corresponding number in [Figure 1-6](#):

1. Female 20-pin dual-row header (J1).
2. Reverse flow diode (D1).
3. DAC/AMP 5V LDO regulator (U1).
4. 16/24-bit DAC - AK4384VT (U2).
5. Audio headphone/line out connector (J3).
6. Headphone/Line out amplifier - AK4201 (U3).
7. Female 12-pin dual-row header (J7).

FIGURE 1-6: AUDIO DAC DAUGHTER BOARD LAYOUT (TOP VIEW)



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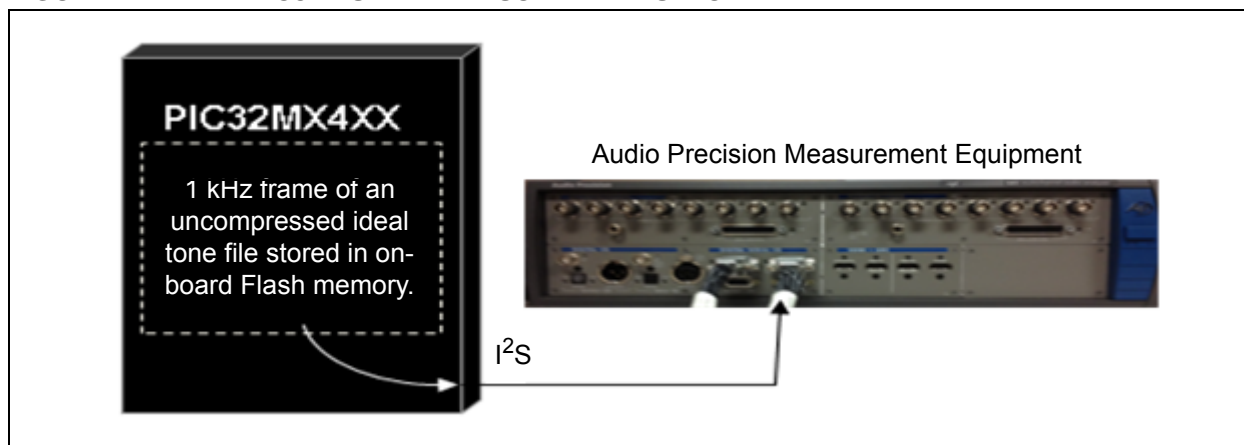
NOTES:

Chapter 2. Hardware and Software Performance

This chapter describes the hardware and software performance of the PIC32 Bluetooth Audio Development Kit.

2.1 HARDWARE AND SOFTWARE SBC AUDIO QUALITY PERFORMANCE

FIGURE 2-1: PIC32 I²S THD MEASUREMENT SETUP



2.1.1 THD+N (16-bit I²S Data Uncompressed)

[Table 2-1](#) represents the THD+N as measured on the PIC32 I²S port. Data was measured using an uncompressed ideal 1 kHz tone file stored in PIC32 Flash and sent directly out onto the I²S port and measured with an Audio Precision Model 585 Multi-channel Audio Analyzer.

TABLE 2-1: THD+N RAW UNCOMPRESSED PIC32 I²S

THD+N (dB) for 16-bit I ² S Data at 0 dBFS (Uncompressed Data)							
fs	128X	192X	256X	384X	512X	768X	Measurement BW
8.00	-97.11	-97.18	-97.11	-97.14	-97.12	-97.14	20 Hz - 4 kHz
16.00	-94.46	-94.53	-94.78	-94.46	-94.47	-94.55	20 Hz - 8 kHz
32.00	-95.75	-95.79	-95.75	-95.81	-95.69	-96.13	20 Hz - 16 kHz
44.10	-96.32	-96.94	-96.67	-97.47	-97.45	-97.14	20 Hz - 20 kHz
48.00	-94.73	-94.46	-94.42	-94.44	-94.43	-94.29	20 Hz - 20 kHz
88.20	-98.85	-98.12	-98.79	-98.26	-98.83	-98.47	20 Hz - 20 kHz
96.00	-94.76	-94.83	-94.64	-94.58	-94.76	-94.13	20 Hz - 20 kHz
176.40	—	—	—	—	—	—	N/A
192.00	—	—	—	—	—	—	N/A

Note 1: Data in shaded cells is pending.

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2.1.2 THD+N (16-bit Uncompressed Audio Data-to-PIC32-to-Amp Out)

Table 2-2 represents the THD+N as measured at the output of the analog amplifier and measured with an Audio Precision Model 585 Multi-channel Audio Analyzer.

FIGURE 2-2: ANALOG THD+N MEASUREMENT SETUP

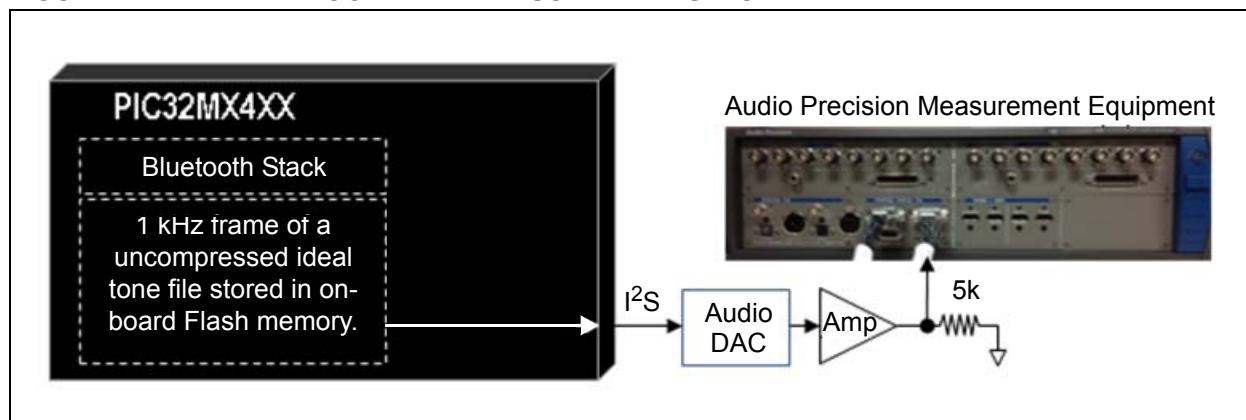


TABLE 2-2: THD+N RAW UNCOMPRESSED PIC32 TO ANALOG AMPLIFIER

THD+N (dB) for Analog: 1.6 Vrms to 5 kΩ (Uncompressed Data) (see Note 2)							
fs	128X	192X	256X	384X	512X	768X	Measurement BW
8.00	Not Supported by DAC		-90.85	-90.73	-91.59	-90.15	20 Hz - 4 kHz
16.00			-87.45	-86.69	-86.84	-86.74	20 Hz - 8 kHz
32.00			-85.23	-81.21	-83.89	-83.95	20 Hz - 16 kHz
44.10			-90.85	-87.14	-87.94	-87.12	20 Hz - 20 kHz
48.00			-82.40	-83.12	-84.15	-84.93	20 Hz - 20 kHz
88.20	-92.59	-92.72	-92.32	-92.16	Not Supported by DAC		20 Hz - 20 kHz
96.00	-89.56	-89.94	-89.79	-89.92			20 Hz - 20 kHz
176.40	—	—	Not Supported by DAC				N/A
192.00	—	—					N/A

Note 1: Data in shaded cells is pending.

2: THD+N = SUM (PIC32 + Audio DAC + Audio Amplifier).

2.1.3 THD+N (16-bit Compressed Audio Data from Smartphone to Analog Amplifier Output)

This table represents the THD+N as measured at the output of the analog amplifier and measured with an Audio Precision Model 585 Multi-channel Audio Analyzer.

FIGURE 2-3: TOTAL SYSTEM SBC + ANALOG THD+N MEASUREMENT SETUP

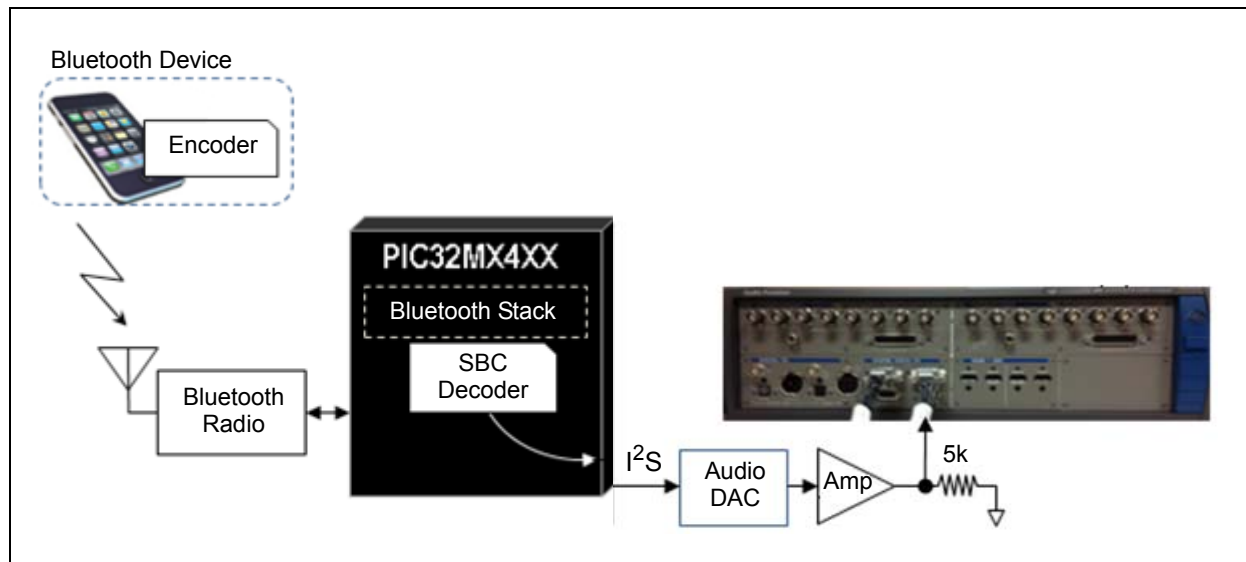


TABLE 2-3: TOTAL SYSTEM THD+N COMPRESSED SMARTPHONE TO PIC32 SBC DECODER TO ANALOG AMPLIFIER

THD+N (dB) for Smartphone to Analog: 1.6 Vrms to 5 kΩ (SBC Compressed Data)							
fs	128X	192X	256X	384X	512X	768X	Measurement BW
44.10	Not supported by DAC		-70.37	-70.55	-70.65	-70.92	20 Hz - 20 kHz

Note: THD+N = SUM (Smartphone Encoder + Bluetooth Radio + PIC32 SBC Decoder + Audio DAC + Audio Amplifier).

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NOTES:

Chapter 3. Interoperability Testing Results

This chapter describes the interoperability testing results for the PIC32 Bluetooth Audio Development Kit.

3.1 TEST CONDITIONS SUMMARY

The following conditions were used during interoperability testing:

- HCI Bluetooth Class 1 Radio (FLC-BTM805CI2B)
- 10 meter test range (standard office cubicle walls/environment)
- 15 meter line of sight minimum
- 100 devices, models, and OS version combinations (as of June 2013)
- 18 individual manufacturers

Note: Typical range of 20-30 meters, as tested with the iPhone 4S.

3.2 MICROCHIP BLUETOOTH COMPATIBILITY TEST MATRIX

TABLE 3-1: BLUETOOTH INTEROPERABILITY TEST RESULTS

Manufacturer	Phone Type	OS Version	Connect	Stream Audio
Asus	Nexus 7 Wi-Fi	Android v4.2.2	Yes	Yes
Apple	iPhone 4s 4G	v5.1.1	Yes	Yes
	iPad	n/a	Yes	Yes
	iPhone 4	v6.1.3	Yes	Yes
	iPhone 4	iOS 6.1.3	Yes	Yes
	iPhone 4	v6.1(10B14-AT&T)	Yes	Yes
	iPhone 4	v4.3.3	Yes	Yes
	iPhone 4	iOS v6.1.3	Yes	Yes
	iPhone 4s	v5.1.1	Yes	Yes
	iPhone 4S	v6.1.3	Yes	Yes
	iPhone 3GS	v6.1.3	Yes	Yes
	iPhone 5	v6.1.2	Yes	Yes
	iPhone 5	v6.0.2	Yes	Yes
	iPhone 5	v6.1.3	Yes	Yes
	iPhone 5	v6.0.1	Yes	Yes
	iPhone 5	iOS v6.1.4	Yes	Yes
	iPod Touch 5G	iOS v6.1.3	Yes	Yes
	iPAD2	iOS v6.1.3	Yes	Yes
	iPad (MC979LL/A)	iOS v6.1.3	Yes	Yes
	iPod touch 4	v6.1.2	Yes	Yes
	iPad Mini	iOS 6.1.2	Yes	Yes

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TABLE 3-1: BLUETOOTH INTEROPERABILITY TEST RESULTS (CONTINUED)

Manufacturer	Phone Type	OS Version	Connect	Stream Audio
BlackBerry	BlackBerry Z10 (Model STL100-3)	v10.0.10.85	Yes	Yes
	BlackBerry Bold 9780	v6.0.0.723	Yes	Yes
	BlackBerry Bold 9900	v7.1.0.523	Yes	Yes
Dell	Latitude E6220	Windows 7	Yes	Yes
Fujitsu	F12C	Android 2.3.4	Yes	Yes
	F-10D	Android v4.0.3	Yes	Yes
	F-02E (Docomo)	Android v4.1.4	Yes	Yes
	F-05D (Docomo Arrows X LTE)	Android v2.3.5	Yes	Yes
Google/Nexus	Google Android	v4.x	Yes	Yes
	ASUS Nexus 7 tablet	4.2.2	Yes	Yes
	LG Nexus 4	4.2.2	Yes	Yes
	Nexus 4	Android v4.2.2	Yes	Yes
	Nexus S Google Phone	4.1.2	Yes	Yes
	SAMSUNG Nexus S	4.0.4	Yes	Yes
HTC	HTC Sense v2.1	Android v2.3.4	Yes	Yes
	HTC G43	Android v2.1	Yes	Yes
	HTC EVO3d	Android v4.0.3	Yes	Yes
	HTC PC36100	Android v2.3.5	Yes	Yes
	HTC Resound	v4.0.3	Yes	Yes
	HTC Google nexus	v2.3.4	Yes	Yes
	HTC EVO3D	v2.3.5	Yes	Yes
	HTC Sense v2.1	v2.3.4	Yes	Yes
	HTC 1SV	v4.0	Yes	Yes
	HTC Flyer tablet	2.3.4	Yes	Yes
	Incredible S S710e	2.3.3	Yes	Yes
	G11	4.0.4	Yes	Yes
Huawei	Huawei C8.6.50	Android v2.3.3	Yes	Yes
	Ascend G300	4.0.4	Yes	Yes
IBM	ThinkPad T420	Windows 7 Pro 32-bit	Yes	Yes
Kyocera	ISW11K (au)	Android v2.3.5	Yes	Yes
LG	L55C	Android v2.3.4	Yes	Yes
	LG-P769	Android v4.0.4	Yes	Yes
	L38C	Android v2.3.6	Yes	Yes
Motorola	Droid RAZR	Android v4.1.2	Yes	Yes
	Droid3	Android v2.3.4	Yes	Yes
	Razr M	Android v4.1.1	Yes	Yes
	Motorola Verizon	Android v2.3.4	Yes	Yes
	Droid X	Android v2.3.4	Yes	Yes
	Motorola Triumph	Android v2.2.2	Yes	Yes
	Droid X	2.3.4	Yes	Yes
	MT788	4.0.4	Yes	Yes

Interoperability Testing Results

TABLE 3-1: BLUETOOTH INTEROPERABILITY TEST RESULTS (CONTINUED)

Manufacturer	Phone Type	OS Version	Connect	Stream Audio
Nokia	Nokia - 810	Windows 8.0	Yes	Yes
	Lumia920	Windows 8.0.10211.204	Yes	Yes
	Nokia Lumia 900	Windows 7.8	Yes	Yes
	Nokia 5530	—	Yes	Yes
	Lumina 800	WP 7.8	Yes	Yes
Panasonic	P-07D (Docomo)	Android v4.0.4	Yes	Yes
Samsung	Samsung Galaxy Notepad 2	V10.1	Yes	Yes
	Samsung	v4.1	Yes	Yes
	Samsung Galaxy S3	Android 4.0.4	Yes	Yes
	Nexus Samsung Tablet	—	Yes	Yes
	Samsung Galaxy S1	v2.2	Yes	Yes
	Samsung Galaxy S3 SCHI535	v4.1.2	Yes	Yes
	Samsung SCHM828C	v2.2.2	Yes	Connects, but drops
	Galaxy S2	v4.0.4	Yes	Yes
	Samsung Galaxy S3 SGH-T999	v4.1.1	Yes	Yes
	Samsung Note 2	v4.1.1	Yes	Yes
	Galaxy TAB-2 Wi-Fi	Android v4.1.1	Yes	Yes
	Galaxy S2	Android v4.2.1	Yes	Yes
	Galaxy Nexus	Android v4.2.2	Yes	Yes
	GALAXY Nexus	Android 4.2.1	Yes	Yes
	Galaxy SGH-1777	Android v4.0.4	Yes	Yes
	SCH1535	v4.1.2	Yes	Yes
	Galaxy Vibrant	v4.2.2	Yes	Yes
	Samsung focus	Windows v7.8	Yes	Yes
	Galaxy S3	v4.1.1	Yes	Yes
	Galaxy S2	4.1.1	Yes	Yes
	Galaxy S3	4.0.4	Yes	Yes
	Galaxy Note	4.1.2	Yes	Yes
	Galaxy Note 2	4.1.1	Yes	Yes
	GT-N7100	4.1.2	Yes	Yes
	SCH-i579	2.3.4	Yes	Yes
Sharp	SH-02E	Android 4.0.4	Yes	Yes
	SH-13C (Docomo)	Android v2.3.4	Yes	Yes
Sony	Sony Experia (Dual SIM)	Android v4.0.4	Yes	Yes
	PSVita	2.11	Yes	Yes
	SO-03D (Docomo XPERIA)	Android v2.3.7	Yes	Yes
	SO-05D (Docomo)	Android v4.0.4	Yes	Yes
	LT26ii	4.0.4	Yes	Yes

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NOTES:

Chapter 4. Demonstrations

This chapter describes the demonstrations available for the PIC32 Bluetooth Audio Development Kit.

4.1 BLUETOOTH AUDIO DEMONSTRATIONS

The following demonstrations are available:

TABLE 4-1: DEMONSTRATIONS AND RESOURCE REQUIREMENTS

Demonstration Name	Description	Resource Requirement		Peak MIPS (See Note 3)	Comment
		Flash	RAM		
BT Audio Demo 2.5	Bluetooth Stack (A2DP+AVRCP+SPP+SBC) + Android Open Accessory audio Type-A USB connection support and Samsung® audio with mini-B USB connection support. See Notes 1 and 2 .	227 KB	49 KB	~30	No Apple USB audio support.
BT Audio Demo 2.5A	Bluetooth Stack (A2DP+AVRCP+SPP+SBC) + USB audio for Android Open Accessory + Apple MiFi stack + Apple IAP Type-A USB and Samsung audio mini-B USB connection support. See Notes 1 and 2 .	262.5 KB	54 KB	~30	With Apple USB audio support. Available by special request only to registered Apple certified developers.
BT Audio Demo 3	Bluetooth Stack (A2DP+AVRCP+SPP+AAC decoder) + Graphics. This demonstration uses the higher quality AAC audio decoder in place of the SBC decoder. See Note 1 .	248 KB	51 KB	~65	Bluetooth audio only; no USB audio support.
BT Audio Demo 4	Bluetooth Data Stack (SPP only). This data-only, non-audio demonstration provides no USB audio support. See Note 1 .	140 KB	14 KB	~8	Bluetooth data transport only.
BT Audio Demo 5	Bluetooth Stack (A2DP+AVRCP+SPP+SBC decoder) + Graphics. See Note 1 .	182 KB	41 KB	~30	Bluetooth audio only; no USB support.

Note 1: 33 KB of stated Flash resources includes graphics support.

2: Total system latency: Bluetooth HCI UART → Bluetooth Stack → SBC Decoder → I²S Audio Out Latency = 1.8 ms.

3: This information is being provided for guidance purposes only.

TABLE 4-2: DEMONSTRATION FEATURES MAP

Demonstration Name	Bluetooth Audio	Bluetooth Data	AAC	USB Apple Audio	USB Android/Samsung Audio
BT Audio Demo 2.5	X	—	—	—	X
BT Audio Demo 2.5A	X	—	—	X	X
BT Audio Demo 3	X	—	X	—	—
BT Audio Demo 4	—	X	—	—	—
BT Audio Demo 5	X	—	—	—	—

4.1.1 Bluetooth/USB Audio Demonstration 2.5 with SBC

Bluetooth Stack (A2DP + AVRCP + SPP + SBC decoder) with Android Open Accessory audio Type-A USB connection support plus Samsung audio with mini-B USB connection support.

Note: If USB audio support for Apple is required, use Bluetooth/USB Audio Demonstration 2.5A (see [4.1.2 “Bluetooth/USB Audio Demonstration 2.5A with SBC and Apple Support”](#)).

This Bluetooth/USB Audio Demonstration 2.5 supports three types of streaming audio:

- Streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google®, etc.), PC, or Bluetooth-enabled device

Note: Refer to [Table 3-1](#) in [Chapter 3. “Interoperability Testing Results”](#) for the list of tested Bluetooth-enabled devices.

- Streaming USB audio over a USB Type-A connector on the development kit from any smartphone or music device that supports the Android Open Accessory protocol where the audio source is a USB Device

Note: This type of support excludes Apple and Samsung device playback through the Type-A USB connector. Apple devices require the Bluetooth Audio Demonstration 2.5A with an Apple authentication adapter (see [Figure 1-2](#) in [Chapter 1. “Introduction”](#)). Samsung smartphones and audio devices, which use USB Host mode, are supported over the mini-B USB connection of the development kit.

- Streaming USB audio over a mini-B connector on the development kit from any Samsung smartphone or audio device where the source is a USB Host

4.1.1.1 BASIC FUNCTIONALITY

In the current software implementation, the Bluetooth connection, when established, takes priority over any active USB audio connection (see **Note 1**). The audio source will automatically switch from any currently active USB audio connection to the Bluetooth audio source when enabled. Conversely, if the Bluetooth connection is already active, no USB audio source will be accessible (see **Note 1**); however, the system will switch automatically if the Bluetooth connection is manually unpaired, disconnected, or disabled back to the last connected and currently active USB audio source. In the case where Bluetooth is already active, but the user walks out of Bluetooth range, the system will switch automatically to any active or newly connected USB audio source, but will revert back again to the Bluetooth connection source, when and if, the Bluetooth enabled device comes back into range (see **Notes 1** and **2**). If the smartphone or Bluetooth enabled device, while still in range, disables its Bluetooth, the development kit Bluetooth software will not attempt to automatically reconnect with the device.

Note 1: The last audio device source connected, regardless of Bluetooth or USB audio, will become the active audio source (enhanced scheduled for CYQ4, 2013).

2: A user selectable time-out period option will be added, after which the Bluetooth software will discontinue trying to reconnect to an out-of-range device (enhancement scheduled for CYQ4, 2013).

The Bluetooth software remembers and stores in Flash memory the last 20 unique Bluetooth device IDs to which it successfully paired to facilitate faster automatic reconnection when there is no currently active Bluetooth connection. If Bluetooth is turned OFF on a smartphone that is currently connected and is re-enabled later, the Bluetooth connection can be successfully re-established by issuing the Connect command on the Bluetooth media device. If a Bluetooth connection is lost when the Bluetooth media device is out of range, the Bluetooth connection is automatically re-established when the Bluetooth media device is back in range (unless a new Bluetooth media device establishes the connection in that interval). In addition, when the development kit is powered on, the Bluetooth software will automatically pair and connect to the last Bluetooth enabled device, assuming it is still active; otherwise, it will search for the next most recently connected device in the list of 20 and repeat.

Note: At the time of publication, only one active Bluetooth connection at a time is supported; however, multi-connect features are being examined.

If the user presses and holds SW1, which forces Bluetooth to unpair, the user must manually force their smartphone to “forget” the Bluetooth demonstration name of the development kit to enable their smartphone to rediscover and subsequently re-pair with the development kit. If the user selects SW2 (Bluetooth disconnect), the user does not need to force their smartphone to forget the demonstration name of the development kit and can reconnect at will.

By default, when the development kit is powered on for the first time, it generates a one-time random unique Bluetooth Device Address for any given development kit hardware. Optionally, at design time, the user can hard code any user-specific Bluetooth Device Address into the Flash memory of the development kit. This approach is not recommended during the design and development state, as Bluetooth connection problems may be experienced if another development board with the same Bluetooth Device Address is within range.

With respect to the Type-A and mini-B USB connections and assuming no Bluetooth active connections exist, the last connected USB audio source will take priority over the previous USB source connection. This means both USB sources can be connected at the same time; however, the last connected USB source will take precedence and cause the system to switch to it. If the currently active USB connection is unplugged, the system will automatically switch to the other USB source if it is connected and vice versa.

4.1.1.2 SETTING UP BLUETOOTH AUDIO DEMONSTRATION 2.5

In this demonstration, the smartphone USB connection is Device, and the PIC32 device is Host.

To set up and run this demonstration, follow these steps:

1. Connect to the device using one of the two following options:
 - a) Use the 6-pin male interface for direct connection to the PICkit 3 In-Circuit Debugger/Programmer connector.
 - b) For MPLAB® REAL ICE™ or MPLAB ICD 3, use the RJ-11 to ICSP adapter (P/N AC164110 purchased separately from www.microchipDIRECT.com).
2. Program the device with the hex file, BT Audio Demo 2.5.hex.
3. Run the setup.
4. Enable Bluetooth for the Bluetooth audio device.
5. Select **BT Audio Demo 2.5** from the discovered Bluetooth devices on your smartphone or Bluetooth device.

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6. If prompted by your Bluetooth device for a PIN, enter 0000.
The device should connect and pair, which is indicated by the message “Bluetooth Audio Dev Board” on the display of the development kit.
7. Make sure that the volume control on the development kit is set to maximum (turned fully counter-clockwise).
8. Select the music track and press **Play**.

4.1.1.3 RUNNING USB ANDROID OPEN ACCESSORY AUDIO DEMONSTRATION 2.5

1. Connect any Android operating system audio device to the Type-A USB connector of the development board and/or a Samsung audio device to the mini-B USB connector.
2. Select the music track and press **Play**.

TABLE 4-3: BLUETOOTH/USB AUDIO DEMONSTRATION 2.5 CONTROLS

Component	Label	Bluetooth Mode	USB Mode
Switch	SW1	Volume Up/Force Bluetooth device to unpair	Volume Up
	SW2	Volume Down/Bluetooth device disconnect	Volume Down
	SW3	Next track/Fast Forward	Next track/Fast Forward
	SW4	Play/Pause	Play/Pause
	SW5	Previous Track/Shuffle/Rewind	Previous Track/Shuffle/Rewind
LED	D5	Bluetooth device connected/(Blink of RTOS Bluetooth error)	RTOS error
	D6	RTOS Bluetooth error	RTOS error
	D7	Audio stream indication	Audio stream indication
	D8	N/A	USB device connected
	D9	N/A	N/A
	D5-D9	CPU Exception Error	Exception

4.1.1.3.1 Bluetooth Demo 2.5 Switch Descriptions

Note: *This note only applies to mini-B USB audio connections. This note does not apply to any Bluetooth or Type-A USB connection.*

For active USB Mini-B port connected audio devices, switch button controls SW1 through SW6, perform no functions. This is because in the mini-B USB configuration, the smartphone is the USB Host and the Bluetooth Audio Development Board is the Device, and as such, the command set is limited by the Samsung operating system and the USB configuration mode.

SW1: Volume Up/Force Bluetooth Unpair

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Volume Up*, is a planned enhancement (CYQ4) that will synchronize with the external audio device volume control. Please note that a master unsynchronized volume control knob is located on the upper left side of the board. Currently, only the alternate function, *Bluetooth Unpair*, is implemented.

If the user presses and holds SW1 for more than three seconds, this action will unpair with the currently connected Bluetooth device and causes the PIC32 device to erase the link key that was exchanged between the smartphone and the development board during the initial Bluetooth connect and pairing. When this occurs, the name of the Bluetooth device associated on the smartphone no longer matches the erased keys on the Bluetooth Audio Development Board. To reconnect, the user must manually force the smartphone to “forget” the demonstration name of the Bluetooth Audio Development Board Bluetooth to reset the link keys so that the user’s smartphone can rediscover and subsequently repair.

SW2: Volume Down/Bluetooth Disconnect

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Volume Down*, is a planned enhancement (CYQ4) that will synchronize with the external audio device volume control. A master unsynchronized volume control knob is located on the upper left side of the board. Currently only the alternate function, *Bluetooth Disconnect*, is implemented.

If the user presses and holds SW2 for more than three seconds, this action will cause both the smartphone and the Bluetooth Audio Development Board to disconnect. Unlike the *Force Bluetooth Unpair* button (SW1), this action does not erase the link keys and the user does not need to force their smartphone to “forget” the demonstration name of the Bluetooth Audio Development Board and the user can simply reconnect at will.

SW3: Next/FF

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Next*, is listed first and is activated by a quick press and release. This action causes the audio device to advance to the beginning of the next sequential song.

The alternate *FF* (Fast Forward) function is activated if the user presses and holds SW3 for more than three seconds. This action will cause the audio device to fast forward to the next song on the audio device.

Note: In CYQ4 2013, the alternate *FF* (SW3) function characteristics will be user selectable. Additional user options will include:

- Profile Option 1: (Default) Current software will Fast Forward through the current song to the beginning of the next song, and then cease to Fast Forward even if the Fast Forward button is still held (same as Apple iPhone model).
- Profile Option 2: Fast Forward continuously through all songs until the Fast Forward button is released.
- Profile Option 3: Fast Forward through the current song to the beginning of the next song, play for three seconds, and then resume Fast Forward. This process is repeated until the Fast Forward button is released.
- Profile Option 4: Fast Forward through the current song, and then wrap around to the beginning of same song and repeat until the Fast Forward button is released.

SW4: Pause/Play/Shuffle

This is a multi-purpose button that alternates between *Pause* and *Play* with each button press and release. *Play* causes the audio device to start or resume music play and *Pause* will cause it to temporarily stop until the button is pressed. Shuffle is activated and deactivated alternately by pressing and holding the SW4 more than 3 seconds. Shuffle mode, when activated, will play randomize song selections. The Shuffle feature will be available in CYQ4 2013.

SW5: Previous/Rewind

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Previous*, is listed first and is activated by a quick press and release. This action causes the audio device to return to the beginning of the previous song.

The alternate *Rewind* function is activated when the user presses and holds SW5 for more than three seconds. This action causes the audio device to begin to rewind towards the beginning of the current song on the audio device.

Note: In CYQ4 2013, the alternate *Rewind* (SW5) function characteristics will be user selectable. Additional user options will include:

- Profile Option 1: (Default) Current software will Rewind through the current song to the beginning of the current song, even if the Rewind button is still being pressed and held (same as Apple iPhone model).
- Profile Option 2: Rewind continuously through all songs until the Rewind button is released.
- Profile Option 3: Rewind through the current song to the beginning of the next song, play for three seconds, and then resume Rewind. This process is repeated until the Rewind button is released.
- Profile Option 4: Rewind through the current song, and then wrap around from the beginning to the end of same song and continue Rewind until the Rewind button is released.

4.1.2 Bluetooth/USB Audio Demonstration 2.5A with SBC and Apple Support

Bluetooth Stack (A2DP + AVRCP + SPP + SBC decoder) with Android Open Accessory plus iAP/MFi Apple audio Type-A USB connection support, plus Samsung audio mini-B USB connection support.

Note: USB connected Apple devices require a iAP/MFi software component and special authentication hardware. Authentication hardware is only available to registered Apple developers from the Avnet MFi Procurement website: <https://mfi.avnet.com/MFi/>

Refer to [Figure 1-2](#) in [Chapter 1. “Introduction”](#) for a diagram that shows several Apple authentication hardware solutions that are compatible with the development kit.

This demonstration is a superset of Bluetooth/USB Audio Demonstration 2.5. It supports all of the same features as demonstration 2.5 with the addition of Apple USB audio with the inclusion of the iAP/MFi software components, as denoted with the “a” suffix in the demonstration name.

This demonstration is available by special request from Microchip to registered Apple developers. Please contact your local Microchip sales office for details.

This Bluetooth/USB Audio Demonstration 2.5A supports three types of streaming audio:

- Streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device

Note: Refer to [Table 3-1](#) in [Chapter 3. “Interoperability Testing Results”](#) for the list of tested Bluetooth-enabled devices.

- Streaming USB audio over a USB Type-A connector on the development kit from any smartphone or music device protocol where the audio source is a USB Device

Note: Samsung smartphones and audio devices, which use USB Host mode, are supported over the mini-B USB connection on the Bluetooth Audio Development Board.

- Streaming USB audio over a mini-B connector on the development board from any Samsung smartphone or audio device where the source is a USB Host

In the current software implementation, the Bluetooth connection, when established, takes priority over any active USB audio connection (see **Note 1**). The audio source will automatically switch from any currently active USB audio connection to the Bluetooth audio source when enabled. Conversely, if the Bluetooth connection is already active, no USB audio source will be accessible (see **Note 1**); however, the system will switch automatically if the Bluetooth connection is manually unpaired, disconnected, or disabled back to the last connected and currently active USB audio source. In the case where Bluetooth is already active, but the user walks out of Bluetooth range, the system will switch automatically to any active or newly connected USB audio source, but will revert back again to the Bluetooth connection source, when and if, the Bluetooth enabled device comes back into range (see **Notes 1 and 2**). If the smartphone or Bluetooth enabled device, while still in range, disables its Bluetooth, the development board Bluetooth software will not attempt to automatically reconnect with the device.

- Note 1:** The last audio device source connected, regardless of Bluetooth or USB audio, will become the active audio source (enhanced scheduled for CYQ4, 2013).
- 2:** A user selectable time-out period option will be added, after which the Bluetooth software will discontinue trying to reconnect to an out-of-range device (enhancement scheduled for CYQ4, 2013).

The Bluetooth software remembers and stores in Flash memory the last 20 unique Bluetooth device IDs to which it successfully paired to facilitate faster automatic reconnection when there is no currently active Bluetooth connection. If Bluetooth is turned OFF on a smartphone that is currently connected and is re-enabled later, it will automatically reconnect when in range or when it comes back into range. In addition, when the development kit is powered on, the Bluetooth software will automatically pair and connect to the last Bluetooth enabled device, assuming it is still active; otherwise, it will search for the next most recently connected device in the list of 20 and repeat.

Note: At the time of publication, only one active Bluetooth connection at a time is supported; however, multi-connect features are being examined.

If the user presses and holds SW1, which forces Bluetooth to unpair, the user must manually force their smartphone to “forget” the Bluetooth demonstration name of the development kit to enable their smartphone to rediscover and subsequently re-pair with the development kit. If the users selects SW2 (Bluetooth disconnect), the user does not need to force their smartphone to forget the demonstration name of the development kit and can reconnect at will.

By default, when the development kit is powered on for the first time, it generates a one-time random unique Bluetooth Device Address for any given development kit hardware. Optionally, at design time, the user can hard code any user-specific Bluetooth Device Address into the Flash memory of the development kit. This approach is not recommended as Bluetooth connection problems may be experienced if another development board with the same Bluetooth Device Address is within range.

With respect to the Type-A and mini-B USB connections and assuming no Bluetooth active connections exist, the last connected USB audio source will take priority over the previous USB source connection. This means both USB sources can be connected at the same time; however, the last connected USB source will take precedence and cause the system to switch to it. If the currently active USB connection is unplugged, the system will automatically switch to the other USB source if it is connected and vice versa.

4.1.2.1 SETTING UP BLUETOOTH AUDIO DEMONSTRATION 2.5A

In this demonstration, the smartphone USB connection is Host, and the PIC32 device is Device.

To set up and run this demonstration, follow these steps:

1. Connect to the device using one of the two following options:
 - a) Use the 6-pin male interface for direct connection to the PICkit 3 In-Circuit Debugger/Programmer connector.
 - b) For MPLAB REAL ICE or MPLAB ICD 3, use the RJ-11 to ICSP adapter (P/N AC164110 purchased separately from www.microchipDIRECT.com).
2. Program the device with the hex file, BT Audio Demo 2.5a.hex.
3. Run the setup.
4. Enable Bluetooth for the Bluetooth audio device.
5. Select **BT Audio Demo 2.5A** from the discovered Bluetooth devices on your smartphone or Bluetooth device.
6. If prompted by your Bluetooth device for a PIN, enter 0000.
The device should connect and pair, which is indicated by the message “Bluetooth Audio Dev Board” on the display of the development kit.
7. Make sure that volume control on the development kit is set to maximum (turned fully counter-clockwise).
8. Select the music track and press **Play**.

4.1.2.2 RUNNING USB SAMSUNG AUDIO DEMONSTRATION 2.5A

1. Connect a USB audio device to the Type-A USB connector of the development board.
2. Select the music track and press **Play**.

TABLE 4-4: BLUETOOTH/USB AUDIO DEMONSTRATION 2.5A CONTROLS

Component	Label	Bluetooth Mode	USB Mode
Switch	SW1	Volume Up/Force Bluetooth device to unpair	Volume Up
	SW2	Volume Down/Bluetooth device disconnect	Volume Down
	SW3	Next track/Fast Forward	Next track/Fast Forward
	SW4	Play/Pause	Play/Pause
	SW5	Previous Track/Shuffle/Rewind	Previous Track/Shuffle/Rewind
LED	D5	Bluetooth device connected/(Blink of RTOS Bluetooth error)	RTOS error
	D6	RTOS Bluetooth error	RTOS error
	D7	Audio stream indication	Audio stream indication
	D8	N/A	USB device connected
	D9	N/A	N/A
	D5-D9	CPU Exception Error	Exception

4.1.2.2.1 Bluetooth Demonstration 2.5A Switch Descriptions

Note: *This note only applies to mini-B USB audio connections. This note does not apply to any Bluetooth or Type-A USB connection.*

For active USB Mini-B port connected audio devices, switch button controls SW1 through SW6, perform no functions. This is because in the mini-B USB configuration, the smartphone is the USB Host and the Bluetooth Audio Development Board is the Device, and as such, the command set is limited by the Samsung operating system and the USB configuration mode.

SW1: Volume Up/Force Bluetooth Unpair

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Volume Up*, is a planned enhancement (CYQ4) that will synchronize with the external audio device volume control. Please note that a master unsynchronized volume control knob is located on the upper left side of the board. Currently, only the alternate function, *Bluetooth Unpair*, is implemented.

If the user presses and holds SW1 for more than three seconds, this action will unpair with the currently connected Bluetooth device and causes the PIC32 device to erase the link key that was exchanged between the smartphone and the development board during the initial Bluetooth connect and pairing. When this occurs, the name of the Bluetooth device associated on the smartphone no longer matches the erased keys on the Bluetooth Audio Development Board. To reconnect, the user must manually force the smartphone to “forget” the demonstration name of the Bluetooth Audio Development Board Bluetooth to reset the link keys so that the user’s smartphone can rediscover and subsequently repair.

SW2: Volume Down/Bluetooth Disconnect

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Volume Down*, is a planned enhancement (CYQ4) that will synchronize with the external audio device volume control. Please note that a master unsynchronized volume control knob is located on the upper left side of the board. Currently only the alternate function, *Bluetooth Disconnect*, is implemented.

If the user presses and holds SW2 for more than three seconds, this action will cause both the smartphone and the Bluetooth Audio Development Board to disconnect. Unlike the *Force Bluetooth Unpair* button (SW1), this action does not erase the link keys and the user does not need to force their smartphone to “forget” the demonstration name of the Bluetooth Audio Development Board and the user can simply reconnect at will.

SW3: Next/FF

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Next*, is listed first and is activated by a quick press and release. This action causes the audio device to advance to the beginning of the next sequential song. The alternate *FF* (i.e., Fast Forward) function is activated if the user presses and holds SW3 for more than three seconds. This action will cause the audio device to fast forward to the next song on the audio device.

Note: In CYQ4 2013, the alternate *FF* (SW3) function characteristics will be user selectable. Additional user options will include:

- Profile Option 1: (Default) Current software will Fast Forward through the current song to the beginning of the next song, and then cease to Fast Forward even if the Fast Forward button is still held (same as Apple iPhone model).
- Profile Option 2: Fast Forward continuously through all songs until the Fast Forward button is released.
- Profile Option 3: Fast Forward through the current song to the beginning of the next song, play for three seconds, and then resume Fast Forward. This process is repeated until the Fast Forward button is released.
- Profile Option 4: Fast Forward through the current song, and then wrap around to the beginning of same song and repeat until the Fast Forward button is released.

SW4: Pause/Play/Shuffle

This is a multi-purpose button that alternates between *Pause* and *Play* with each button press and release. *Play* causes the audio device to start or resume music play and *Pause* will cause it to temporarily stop until the button is pressed. Shuffle is activated and deactivated alternately by pressing and holding the SW4 more than 3 seconds. Shuffle mode, when activated, will play randomize song selections. The Shuffle feature will be available in CYQ4 2013.

SW5: Previous/Rewind

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Previous*, is listed first and is activated by a quick press and release. This action causes the audio device to return to the beginning of the previous song. The alternate *Rewind* function is activated when the user presses and holds SW5 for more than three seconds. This action causes the audio device to begin to rewind towards the beginning of the current song on the audio device.

Note: In CYQ4 2013, the alternate *Rewind* (SW5) function characteristics will be user selectable. Additional user options will include:

- Profile Option 1: (Default) Current software will Rewind through the current song to the beginning of the current song, even if the Rewind button is still being pressed and held (same as Apple iPhone model).
- Profile Option 2: Rewind continuously through all songs until the Rewind button is released.
- Profile Option 3: Rewind through the current song to the beginning of the next song, play for three seconds, and then resume Rewind. This process is repeated until the Rewind button is released.
- Profile Option 4: Rewind through the current song, and then wrap around from the beginning to the end of same song and continue Rewind until the Rewind button is released.

4.1.3 Bluetooth Audio Demonstration 3 with AAC

Bluetooth Audio support only with A2DP + AVRCP + SPP + SBC/AAC decoder.

This demonstration uses the same Bluetooth audio stack as used in Demonstration 2.5, but includes the addition of a higher quality AAC software audio codec than the default SBC audio decoder. AAC stands for Advanced Audio Coding and generally achieves better sound quality than MP3 at similar bit rates. This demonstration does not provide any USB audio support.

This demonstration supports only one type of streaming audio: Streaming wireless Bluetooth audio from any smartphone (Apple, Samsung, Google, etc), PC, or Bluetooth enabled device and uses the advanced AAC audio software codec in place of the default SBC decoder. See [Table 3-1](#) for the list of tested Bluetooth enabled devices.

If the Bluetooth device is connected and paired but the user walks out of Bluetooth range, the system will continuously (see **Note**) search for the last Bluetooth connection source. Then, when and if, the Bluetooth enabled device comes back into range, it will automatically reconnect. If the smartphone or Bluetooth enabled device, while still in range, disables its Bluetooth connectivity, the Bluetooth Audio Development Board Bluetooth software will not attempt to automatically reconnect with the device.

Note: In future software revisions (CYQ4 2013) a user selectable time-out period option will be added, after which the Bluetooth software will discontinue trying to reconnect to an out of range device.

The Bluetooth software remembers and stores in Flash memory the last 20 unique Bluetooth device IDs to which it successfully paired to facilitate faster automatic reconnection when there is no currently active Bluetooth connection. If Bluetooth is turned OFF on a user smartphone that is currently connected and re-enabled later, it will automatically reconnect if in range or when it comes back into range. In addition, when the Bluetooth Audio Development Board is powered on, the Bluetooth software will automatically pair and connect to the last Bluetooth enabled device, assuming it is still active; otherwise, it will search for the next most recently connected device in the list of twenty previously connected device and repeat.

Note: Currently (August 2013), only one active Bluetooth connection at a time is supported; however, multi-connect features are being examined.

By default, when the Bluetooth Audio Development Board is first powered on, the Bluetooth software generates a one-time unique Bluetooth Device Address for any given development board hardware. However, as an option during the design phase, it is possible for the user to hard code into Flash memory, any user-specific Bluetooth Device Address in the Bluetooth Audio Development Board. While this can be done, it is not recommended, as Bluetooth connection problems may occur if another development board with the same Bluetooth Device Address is within range.

4.1.3.1 DEMONSTRATION SETUP

To set up this demonstration, follow these steps:

1. Connect to the device using one of the two following options:
 - a) Use the 6-pin male interface for direct connection to the PICkit 3 connector.
 - b) For MPLAB REAL ICE or MPLAB ICD 3, use the RJ-11 to ICSP adapter (P/N AC164110 purchased separately from www.microchipDIRECT.com).
2. Program the device with the hex file, BT Audio Demo 3.hex.
3. Run the setup.

4.1.3.2 RUNNING BLUETOOTH AUDIO DEMONSTRATION 3

1. Enable Bluetooth for the Bluetooth audio device.
2. Select **BT Audio Demo 2** from the discovered Bluetooth devices on your smartphone or Bluetooth device.
3. If prompted by your Bluetooth device for a PIN, enter 0000.
The device should connect and pair, which is indicated by the message “Bluetooth Audio Dev Board” on the display of the development kit.
4. Make sure that the volume control on the development kit is set to maximum (turned fully counter-clockwise).
5. Select the music track and press **Play**.

TABLE 4-5: BLUETOOTH AUDIO DEMONSTRATION 3 CONTROLS

Component	Label	Bluetooth Only w/AAC (NO USB Audio)
Switch	SW1	Volume Up/Bluetooth device unpair
	SW2	Volume Down/Bluetooth device disconnect
	SW3	Next track/Fast Forward
	SW4	Play/Pause
	SW5	Previous Track/Rewind/Shuffle
LED	D5	Bluetooth device connected/(Blink of RTOS-BT error)
	D6	RTOS/BT error
	D7	Audio stream indication
	D8	N/A
	D9	N/A
	D5-D9	CPU Exception Error

4.1.3.2.1 Bluetooth Demonstration 3 Switch Descriptions

Note: *This note only applies to mini-B USB audio connections. This note does not apply to any Bluetooth or Type-A USB connection.*

For active USB mini-B port connected audio devices, switch button controls SW1 through SW6, perform no functions. This is because in the mini-B USB configuration, the smartphone is the USB Host and the Bluetooth Audio Development Board is the Device, and as such, the command set is limited by the Samsung operating system and the USB configuration mode.

SW1: Volume Up/Force Bluetooth Unpair

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Volume Up*, is a planned enhancement (CYQ4) that will synchronize with the external audio device volume control. Please note that a master unsynchronized volume control knob is located on the upper left side of the board. Currently, only the alternate function, *Bluetooth Unpair*, is implemented.

If the user presses and holds SW1 for more than three seconds, this action will unpair with the currently connected Bluetooth device and causes the PIC32 device to erase the link key that was exchanged between the smartphone and the development board during the initial Bluetooth connect and pairing. When this occurs, the name of the Bluetooth device associated on the smartphone no longer matches the erased keys on the Bluetooth Audio Development Board. To reconnect, the user must manually force the smartphone to “forget” the demonstration name of the Bluetooth Audio Development Board Bluetooth to reset the link keys so that the user’s smartphone can rediscover and subsequently repair.

SW2: Volume Down/Bluetooth Disconnect

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Volume Down*, is a planned enhancement (CYQ4) that will synchronize with the external audio device volume control. Please note that a master unsynchronized volume control knob is located on the upper left side of the board. Currently only the alternate function, *Bluetooth Disconnect*, is implemented.

If the user presses and holds SW2 for more than three seconds, this action will cause both the smartphone and the Bluetooth Audio Development Board to disconnect. Unlike the *Force Bluetooth Unpair* button (SW1), this action does not erase the link keys and the user does not need to force their smartphone to “forget” the demonstration name of the Bluetooth Audio Development Board and the user can simply reconnect at will.

SW3: Next/FF

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Next*, is listed first and is activated by a quick press and release. This action causes the audio device to advance to the beginning of the next sequential song.

The alternate *FF* (i.e., Fast Forward) function is activated if the user presses and holds SW3 for more than three seconds. This action will cause the audio device to fast forward to the next song on the audio device.

Note: In CYQ4 2013, the alternate *FF* (SW3) function characteristics will be user selectable. Additional user options will include:

- Profile Option 1: (Default) Current software will Fast Forward through the current song to the beginning of the next song, and then cease to Fast Forward even if the Fast Forward button is still held (same as Apple iPhone model).
- Profile Option 2: Fast Forward continuously through all songs until the Fast Forward button is released.
- Profile Option 3: Fast Forward through the current song to the beginning of the next song, play for three seconds, and then resume Fast Forward. This process is repeated until the Fast Forward button is released.
- Profile Option 4: Fast Forward through the current song, and then wrap around to the beginning of same song and repeat until the Fast Forward button is released.

SW4: Pause/Play/Shuffle

This is a multi-purpose button that alternates between *Pause* and *Play* with each button press and release. *Play* causes the audio device to start or resume music play and *Pause* will cause it to temporarily stop until the button is pressed. Shuffle is activated and deactivated alternately by pressing and holding the SW4 more than 3 seconds. Shuffle mode, when activated, will play randomize song selections. The Shuffle feature will be available in CYQ4 2013.

SW5: Previous/Rewind

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Previous*, is listed first and is activated by a quick press and release. This action causes the audio device to return to the beginning of the previous song.

The alternate *Rewind* function is activated when the user presses and holds SW5 for more than three seconds. This action causes the audio device to begin to rewind towards the beginning of the current song on the audio device.

Note: In CYQ4 2013, the alternate *Rewind* (SW5) function characteristics will be user selectable. Additional user options will include:

- Profile Option 1: (Default) Current software will Rewind through the current song to the beginning of the current song, even if the Rewind button is still being pressed and held (same as Apple iPhone model).
- Profile Option 2: Rewind continuously through all songs until the Rewind button is released.
- Profile Option 3: Rewind through the current song to the beginning of the next song, play for three seconds, and then resume Rewind. This process is repeated until the Rewind button is released.
- Profile Option 4: Rewind through the current song, and then wrap around from the beginning to the end of same song and continue Rewind until the Rewind button is released.

4.1.4 Bluetooth Data Demonstration 4 with SPP

Bluetooth data support only. Bluetooth Stack with SPP profile.

Note: This demonstration does not support data transfer from an Apple iPhone application. To do so requires the following:

- The iAP software layer addition for the Bluetooth stack
- Special Apple authentication hardware. Authentication hardware is only available to registered Apple developers from the Avnet MFi Procurement website: <https://mfi.avnet.com/MFI/>. Refer to [Figure 1-2](#) in [Chapter 1. “Introduction”](#) for a diagram that shows several Apple authentication hardware solutions that are compatible with the development kit.

In this demonstration, the basic Bluetooth audio profiles and decoders have been removed, (i.e., A2DP, AVRCP, SBC and/or AAC). This demonstration provides basic data transport of non-audio full-duplex data transfers over the Bluetooth link. This demonstration does not provide any USB audio support. The demonstration allows a user to perform terminal emulation and echo characters from an Android smartphone or PC over a Bluetooth connection to the graphic display of the development board, and then back to the PC or smartphone emulation application screen.

If the Bluetooth device is connected and paired but the user walks out of Bluetooth range, the system will continuously (see **Note**) search for the last Bluetooth connection source. Then, when and if, the Bluetooth enabled device comes back into range, it will automatically reconnect. If the smartphone or Bluetooth enabled device, while still in range, disables its Bluetooth connectivity, the Bluetooth Audio Development Board Bluetooth software will not attempt to automatically reconnect with the device.

Note: In future software revisions (CYQ4 2013) a user selectable time-out period option will be added, after which the Bluetooth software will discontinue trying to reconnect to an out of range device.

The Bluetooth software remembers and stores in Flash memory the last 20 unique Bluetooth device IDs to which it successfully paired to facilitate faster automatic reconnection when there is no currently active Bluetooth connection. If Bluetooth is turned OFF on a user smartphone that is currently connected and re-enabled later, it will automatically reconnect if in range or when it comes back into range. In addition, when the Bluetooth Audio Development Board is powered on, the Bluetooth software will automatically pair and connect to the last Bluetooth enabled device, assuming it is still active; otherwise, it will search for the next most recently connected device in the list of twenty previously connected device and repeat.

Note: Currently (August 2013), only one active Bluetooth connection at a time is supported; however, multi-connect features are being examined.

By default, when the Bluetooth Audio Development Board is first powered on, the Bluetooth software generates a one-time unique Bluetooth Device Address for any given development board hardware. However, as an option during the design phase, it is possible for the user to hard code into Flash memory, any user-specific Bluetooth Device Address in the Bluetooth Audio Development Board. While this can be done, it is not recommended, as Bluetooth connection problems may occur if another development board with the same Bluetooth Device Address is within range.

4.1.4.1 BLUETOOTH DATA SMARTPHONE DEMONSTRATION SETUP

Download a terminal emulator echo application. An Android application can be obtained by visiting:

https://play.google.com/store/apps/details?id=mobi.dzs.android.BLE_SPP_PRO&hl=en

4.1.4.2 RUNNING BLUETOOTH DATA SMARTPHONE DEMONSTRATION 4

1. Program the device with the hex file, BT Data Demo 4.hex.
2. Enable Bluetooth on the smartphone.
3. Connect and pair the smartphone with BT Audio Dev Board to the device named **BT Data Demo 4**.
4. If prompted by your Bluetooth device for a PIN, enter 0000.
The device should connect and pair, which is indicated by the message "Bluetooth Audio Dev Board" on the display of the development kit.
5. Open the Android terminal emulator application.
6. Enter characters in the smartphone applications. The characters will be displayed on the LCD of the development board, and are then echoed back by the PIC32 device and displayed on the smartphone screen.

4.1.4.3 BLUETOOTH DATA PC DEMONSTRATION SETUP

Open (or download) a terminal emulator echo application. A PC application can be obtained by visiting:

<http://hyperterminal-private-edition-htpe.en.softonic.com/>

4.1.4.4 RUNNING BLUETOOTH DATA PC DEMONSTRATION 4

1. Program the development board with the hex file, BT Data Demo 4.hex.
2. Enable Bluetooth on the PC.
3. Connect and pair the PC with BT Audio Dev Board to the device named **BT Data Demo 4**.
4. If prompted by your Bluetooth device for a PIN, enter 0000.
The device should connect and pair, which is indicated by the message "Bluetooth Audio Dev Board" on the display of the development kit.
5. Open the terminal emulator application on the PC, ensuring the application is the active window.
6. Enter characters from the PC keyboard. The characters will be displayed on the LCD of the development board, and are then echoed back by the PIC32 device and displayed in the terminal emulator window on the PC.

TABLE 4-6: BLUETOOTH AUDIO DEMONSTRATION 4 CONTROLS

Component	Label	Bluetooth Mode	USB Mode
Switch	SW1	Send message	N/A
	SW2-SW6	N/A	N/A
LED	D5-D9	N/A	N/A

4.1.4.4.1 Bluetooth Demonstration 4 Switch Descriptions

SW1: Send message "SW1 pressed". Pressing this button will send a text string message, "SW1 pressed", that is displayed in the terminal emulator application window of the Bluetooth connected PC or Android device.

4.1.5 Bluetooth Audio Demonstration 5 with SBC

Bluetooth Stack (A2DP + AVRCP + SPP + SBC decoder).

- Note 1:** For USB audio support for Android and Samsung audio devices, use Bluetooth/USB Audio Demonstration 2.5 (see [4.1.1 “Bluetooth/USB Audio Demonstration 2.5 with SBC”](#)).
- 2:** Additionally, If USB audio support for Apple is required, use Bluetooth/USB Audio Demonstration 2.5A (see [4.1.2 “Bluetooth/USB Audio Demonstration 2.5A with SBC and Apple Support”](#)). USB connected Apple devices require an iAP/MFi software component and special authentication hardware. Authentication hardware is available only to registered Apple developers from the Avnet MFi Procurement website: <https://mfi.avnet.com/MFI/>.

This non-USB audio demonstration supports streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device. See [Table 3-1](#) in [3.2 “Microchip Bluetooth Compatibility Test Matrix”](#) for the list of tested Bluetooth-enabled devices.

4.1.5.1 BASIC FUNCTIONALITY

If the Bluetooth device is connected and paired but the user walks out of Bluetooth range, the system will continuously (see **Note**) search for the last Bluetooth connection source. Then, when and if, the Bluetooth enabled device comes back into range, it will automatically reconnect. If the smartphone or Bluetooth enabled device, while still in range, disables its Bluetooth connectivity, the Bluetooth Audio Development Board Bluetooth software will not attempt to automatically reconnect with the device.

Note: In future software revisions (CYQ4 2013) a user selectable time-out period option will be added, after which the Bluetooth software will discontinue trying to reconnect to an out of range device.

The Bluetooth software remembers and stores in Flash memory the last 20 unique Bluetooth device IDs to which it successfully paired to facilitate faster automatic reconnection when there is no currently active Bluetooth connection. If Bluetooth is turned OFF on a smartphone that is currently connected and is re-enabled later, it will automatically reconnect when in range or when it comes back into range. In addition, when the development kit is powered on, the Bluetooth software will automatically pair and connect to the last Bluetooth enabled device, assuming it is still active; otherwise, it will search for the next most recently connected device in the list of 20 and repeat.

Note: At the time of publication, only one active Bluetooth connection at a time is supported; however, multi-connect features are being examined.

By default, when the development kit is powered on for the first time, it generates a one-time random unique Bluetooth Device Address for any given development kit hardware. Optionally, at design time, the user can hard code any user-specific Bluetooth Device Address into the Flash memory of the development kit. This approach is not recommended as Bluetooth connection problems may be experienced if another development board with the same Bluetooth Device Address is within range.

4.1.5.2 SETTING UP AND RUNNING BLUETOOTH AUDIO DEMONSTRATION 5

To set up and run this demonstration, follow these steps:

1. Connect to the device using one of the two following options:
 - a) Use the 6-pin male interface for direct connection to the PICKIT 3 In-Circuit Debugger/Programmer connector.
 - b) For MPLAB® REAL ICE™ or MPLAB ICD 3, use the RJ-11 to ICSP adapter (P/N AC164110 purchased separately from www.microchipDIRECT.com).
2. Program the device with the hex file, BT Audio Demo 5.hex.
3. Run the setup.
4. Enable Bluetooth for the Bluetooth audio device.
5. Select **BT Audio Demo 5** from the discovered Bluetooth devices on your smartphone or Bluetooth device.
6. If prompted by your Bluetooth device for a PIN, enter 0000.
The device should connect and pair, which is indicated by the message “Bluetooth Audio Dev Board” on the display of the development kit.
7. Connect a speaker or headphones to the line-out/headphone jack of the development board.
8. If using an external speaker, make sure that the volume control on the development kit is set to maximum (turned fully counter-clockwise).
9. Select the music track and press **Play**.

TABLE 4-7: BLUETOOTH/USB AUDIO DEMONSTRATION 5 CONTROLS

Component	Label	Bluetooth Mode
Switch	SW1	Volume Up/Force Bluetooth device to unpair
	SW2	Volume Down/Bluetooth device disconnect
	SW3	Next track/Fast Forward
	SW4	Play/Pause
	SW5	Previous Track/Rewind/Shuffle
LED	D5	Bluetooth device connected/(Blink of RTOS Bluetooth error)
	D6	RTOS Bluetooth error
	D7	Audio stream indication
	D8	N/A
	D9	N/A
	D5-D9	CPU Exception Error

4.1.5.2.1 Bluetooth Demo 5 Switch Descriptions

SW1: Volume Up/Force Bluetooth Unpair

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Volume Up*, is a planned enhancement (CYQ4) that will synchronize with the external audio device volume control. Please note that a master unsynchronized volume control knob is located on the upper left side of the board. Currently, only the alternate function, *Bluetooth Unpair*, is implemented.

If the user presses and holds SW1 for more than three seconds, this action will unpair with the currently connected Bluetooth device and causes the PIC32 device to erase the link key that was exchanged between the smartphone and the development board during the initial Bluetooth connect and pairing. When this occurs, the name of the Bluetooth device associated on the smartphone no longer matches the erased keys on the Bluetooth Audio Development Board. To reconnect, the user must manually force the smartphone to “forget” the demonstration name of the Bluetooth Audio Development Board Bluetooth to reset the link keys so that the user’s smartphone can rediscover and subsequently repair.

SW2: Volume Down/Bluetooth Disconnect

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Volume Down*, is a planned enhancement (CYQ4) that will synchronize with the external audio device volume control. Please note that a master unsynchronized volume control knob is located on the upper left side of the board. Currently only the alternate function, *Bluetooth Disconnect*, is implemented.

If the user presses and holds SW2 for more than three seconds, this action will cause both the smartphone and the Bluetooth Audio Development Board to disconnect. Unlike the *Force Bluetooth Unpair* button (SW1), this action does not erase the link keys and the user does not need to force their smartphone to “forget” the demonstration name of the Bluetooth Audio Development Board and the user can simply reconnect at will.

SW3: Next/FF

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Next*, is listed first and is activated by a quick press and release. This action causes the audio device to advance to the beginning of the next sequential song.

The alternate *FF* (Fast Forward) function is activated if the user presses and holds SW3 for more than three seconds. This action will cause the audio device to fast forward to the next song on the audio device.

Note: In CYQ4 2013, the alternate *FF* (SW3) function characteristics will be user selectable. Additional user options will include:

- Profile Option 1: (Default) Current software will Fast Forward through the current song to the beginning of the next song, and then cease to Fast Forward even if the Fast Forward button is still held (same as Apple iPhone model).
- Profile Option 2: Fast Forward continuously through all songs until the Fast Forward button is released.
- Profile Option 3: Fast Forward through the current song to the beginning of the next song, play for three seconds, and then resume Fast Forward. This process is repeated until the Fast Forward button is released.
- Profile Option 4: Fast Forward through the current song, and then wrap around to the beginning of same song and repeat until the Fast Forward button is released.

SW4: Pause/Play/Shuffle

This is a multi-purpose button that alternates between *Pause* and *Play* with each button press and release. *Play* causes the audio device to start or resume music play and *Pause* will cause it to temporarily stop until the button is pressed. Shuffle is activated and deactivated alternately by pressing and holding the SW4 more than 3 seconds. Shuffle mode, when activated, will play randomize song selections. The Shuffle feature will be available in CYQ4 2013.

SW5: Previous/Rewind

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Previous*, is listed first and is activated by a quick press and release. This action causes the audio device to return to the beginning of the previous song.

The alternate *Rewind* function is activated when the user presses and holds SW5 for more than three seconds. This action causes the audio device to begin to rewind towards the beginning of the current song on the audio device.

Note: In CYQ4 2013, the alternate *Rewind* (SW5) function characteristics will be user selectable. Additional user options will include:

- Profile Option 1: (Default) Current software will Rewind through the current song to the beginning of the current song, even if the Rewind button is still being pressed and held (same as Apple iPhone model).
- Profile Option 2: Rewind continuously through all songs until the Rewind button is released.
- Profile Option 3: Rewind through the current song to the beginning of the next song, play for three seconds, and then resume Rewind. This process is repeated until the Rewind button is released.
- Profile Option 4: Rewind through the current song, and then wrap around from the beginning to the end of same song and continue Rewind until the Rewind button is released.

PIC32 Bluetooth® Audio Development Kit Reference Guide

NOTES:

Chapter 5. Bluetooth Stack Overview

This chapter provides a brief overview of the Microchip Bluetooth Stack for PIC32, which is used by the PIC32 Bluetooth Audio Development Kit.

The following sections are included:

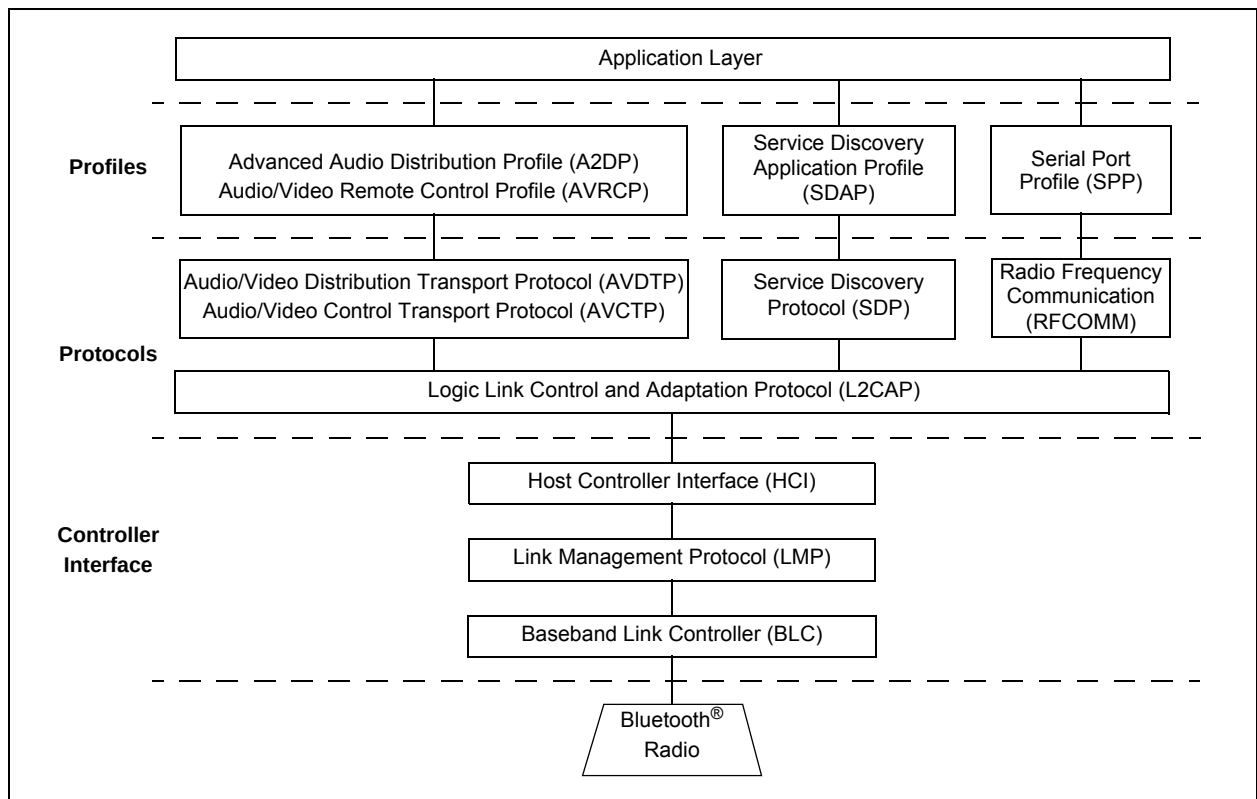
- [5.1 “Bluetooth Stack Block Diagram”](#)
- [5.2 “Bluetooth Stack Component Summary”](#)

5.1 BLUETOOTH STACK BLOCK DIAGRAM

A block diagram for the stack is provided in [Figure 5-1](#).

Note: For a complete description of the stack, refer to the application note, “*Microchip Bluetooth® Stack for PIC32™*” (DS number pending), which is available from the Microchip web site (www.microchip.com).

FIGURE 5-1: MICROCHIP BLUETOOTH® STACK FOR PIC32 BLOCK DIAGRAM



5.2 BLUETOOTH STACK COMPONENT SUMMARY

Note: For a complete description of the profiles, protocols, and audio decoders for the stack, refer to the application note, “*Microchip Bluetooth® Stack for PIC32*” (DS number pending), which is available from the Microchip web site (www.microchip.com).

TABLE 5-1: BLUETOOTH STACK PROFILE VERSIONS

Profile	Current Version Level	CYQ4, 2013
AD2DP	1.3	—
AVRCP	1.4	1.5
SPP	1.2	—
SDP	1.1	—

TABLE 5-2: BLUETOOTH STACK PROTOCOLS

Protocol
HCI
L2CAP
LMP
RFCOMM
AVCTP

TABLE 5-3: BLUETOOTH STACK AUDIO DECODERS

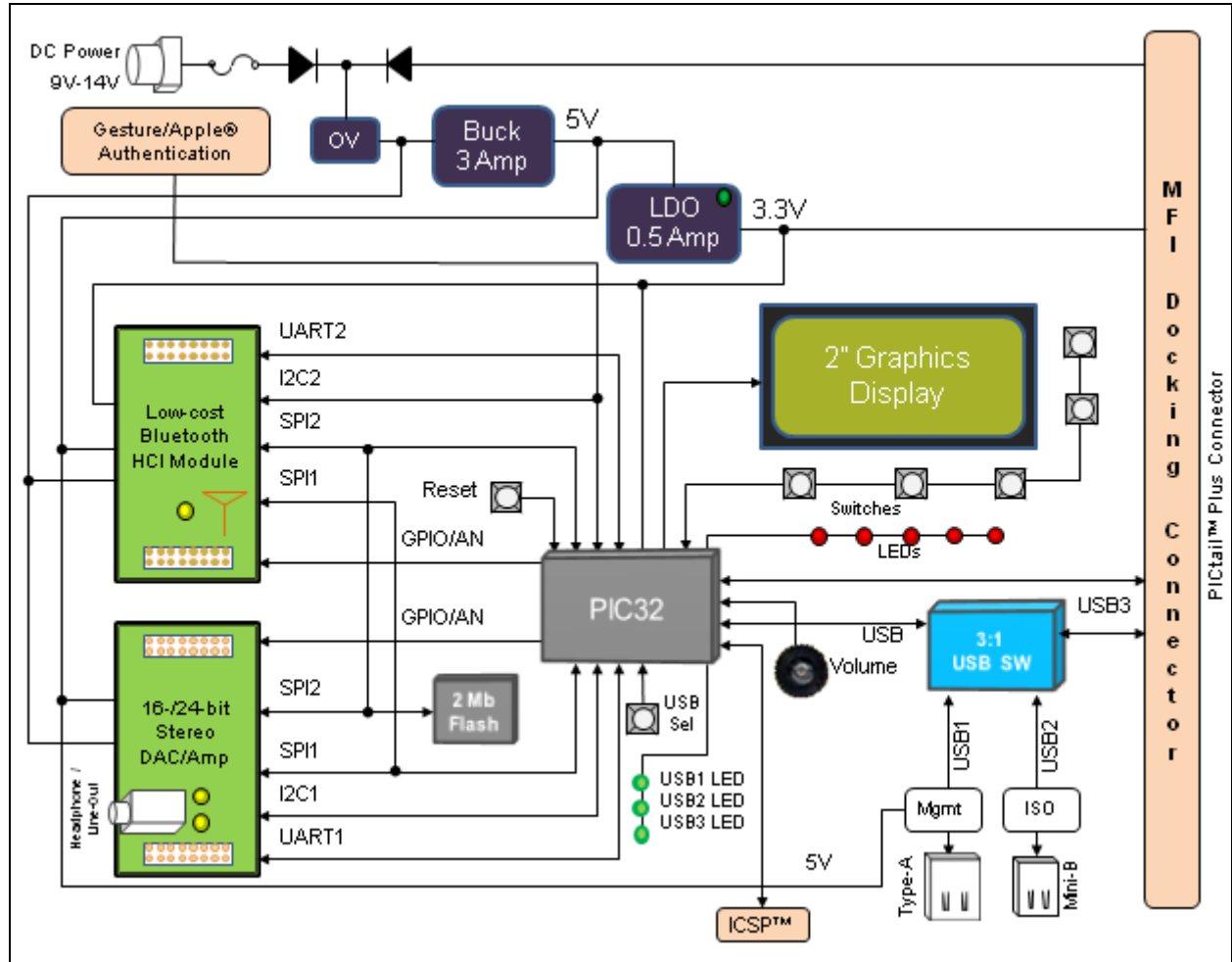
Audio Decoder
SBC
AAC

Note: System latency from Bluetooth UART audio data to audio DAC/AMP output is 1.8 ms.

Appendix A. Board Layout and Schematics

A.1 BLOCK DIAGRAM

FIGURE A-1: HIGH-LEVEL BLOCK DIAGRAM OF THE PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT



PIC32 Bluetooth® Audio Development Kit Reference Guide

A.2 BOARD LAYOUT

FIGURE A-2: PIC32 BLUETOOTH® AUDIO DEVELOPMENT BOARD LAYOUT (TOP ASSEMBLY)

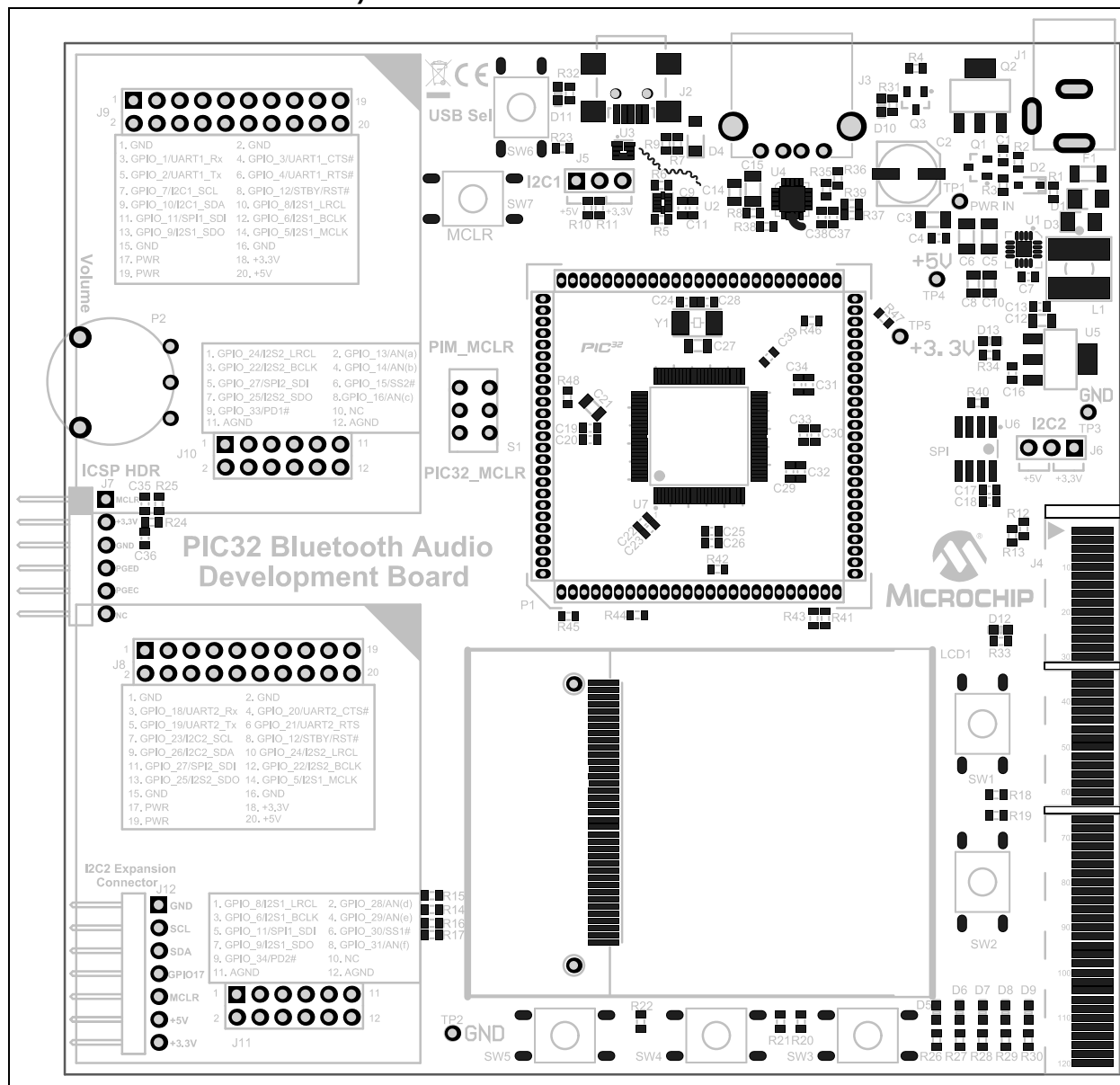


FIGURE A-3: BLUETOOTH HCI RADIO MODULE DAUGHTER BOARD LAYOUT (TOP ASSEMBLY)

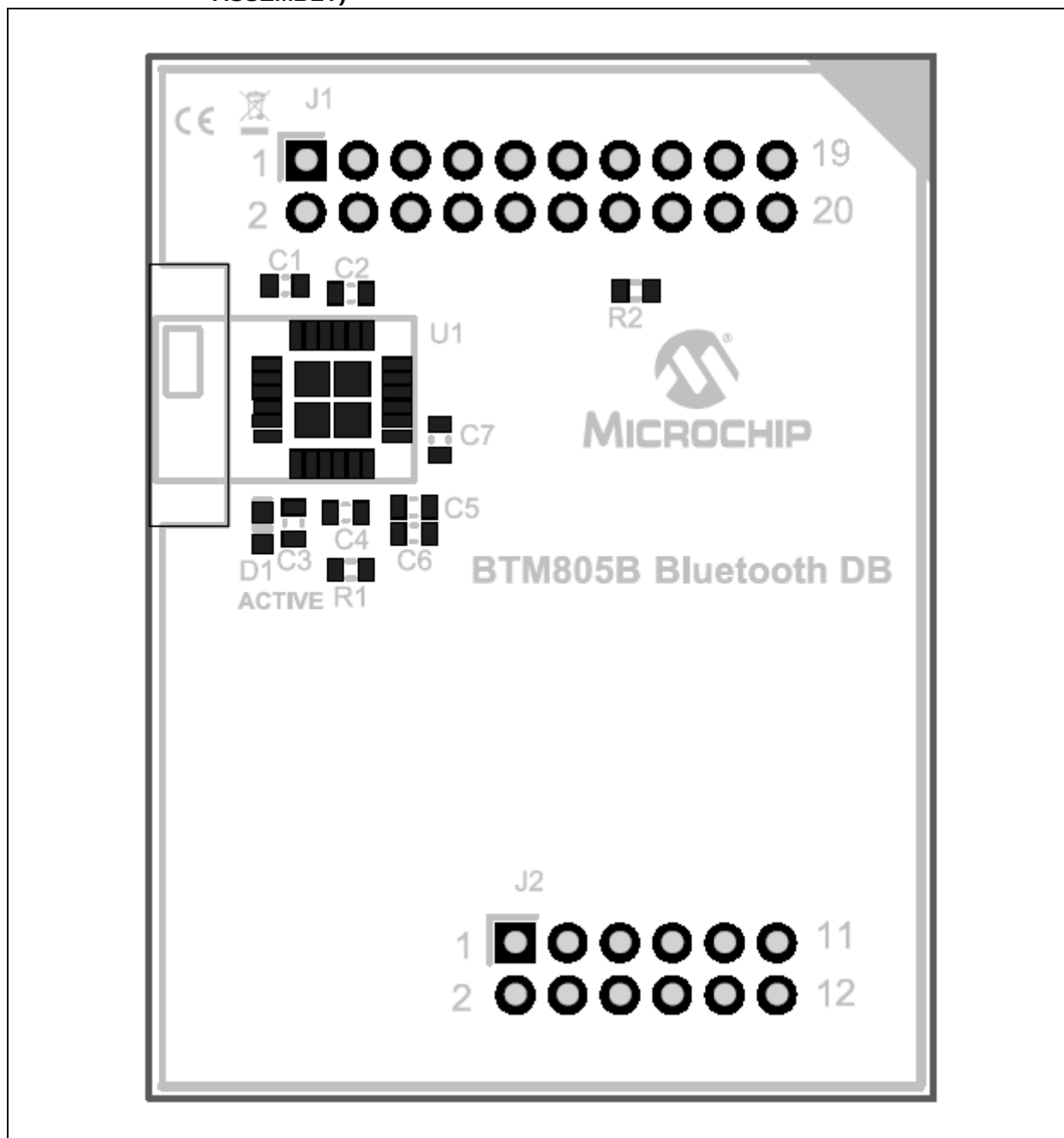
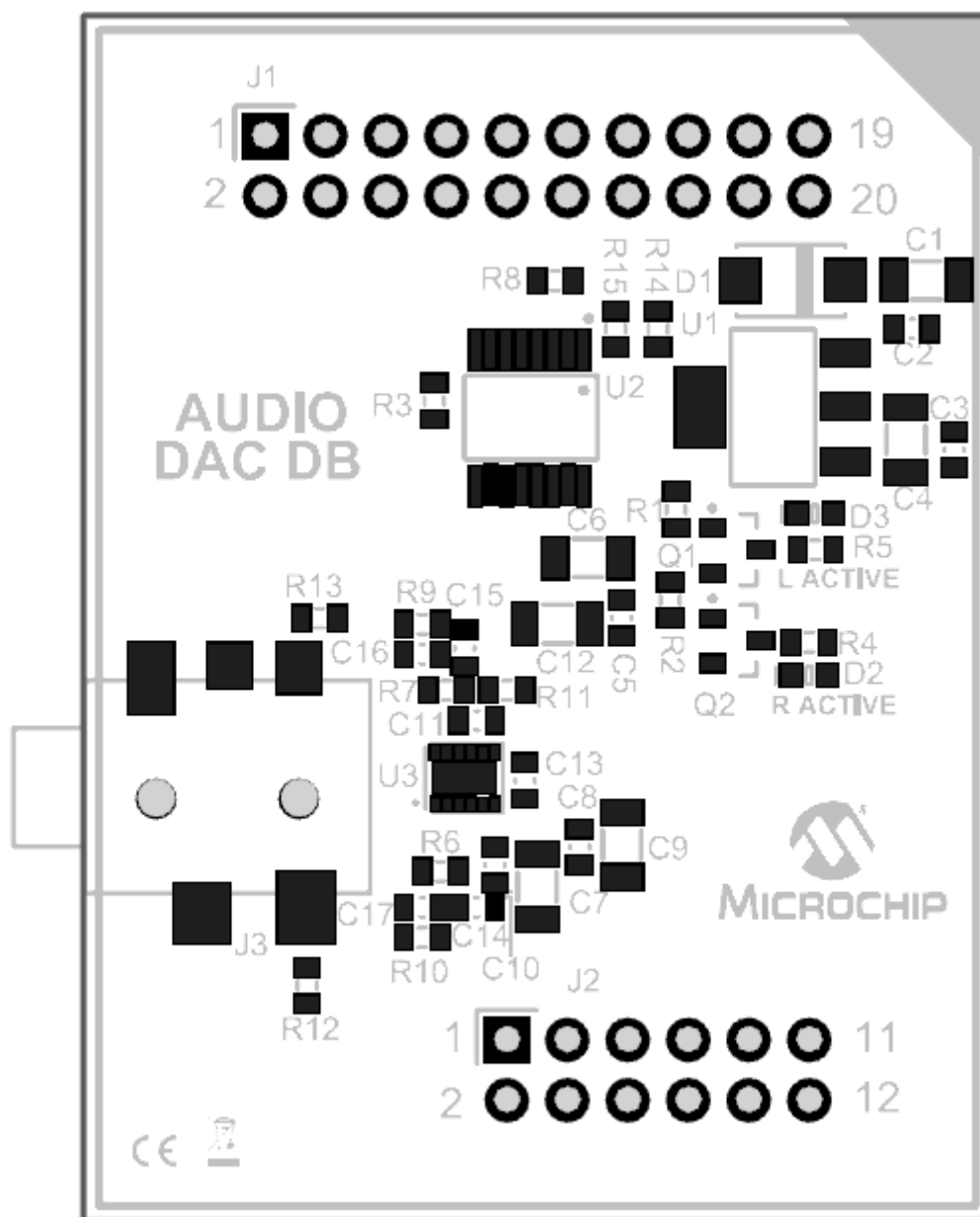


FIGURE A-4: AUDIO DAC/AMP DAUGHTER BOARD LAYOUT (TOP ASSEMBLY)



A.3 SCHEMATICS

FIGURE A-5: PIC32MX CPU WITH 2" GRAPHICS DISPLAY, PICTail™ CONNECTOR, AND SPI FLASH

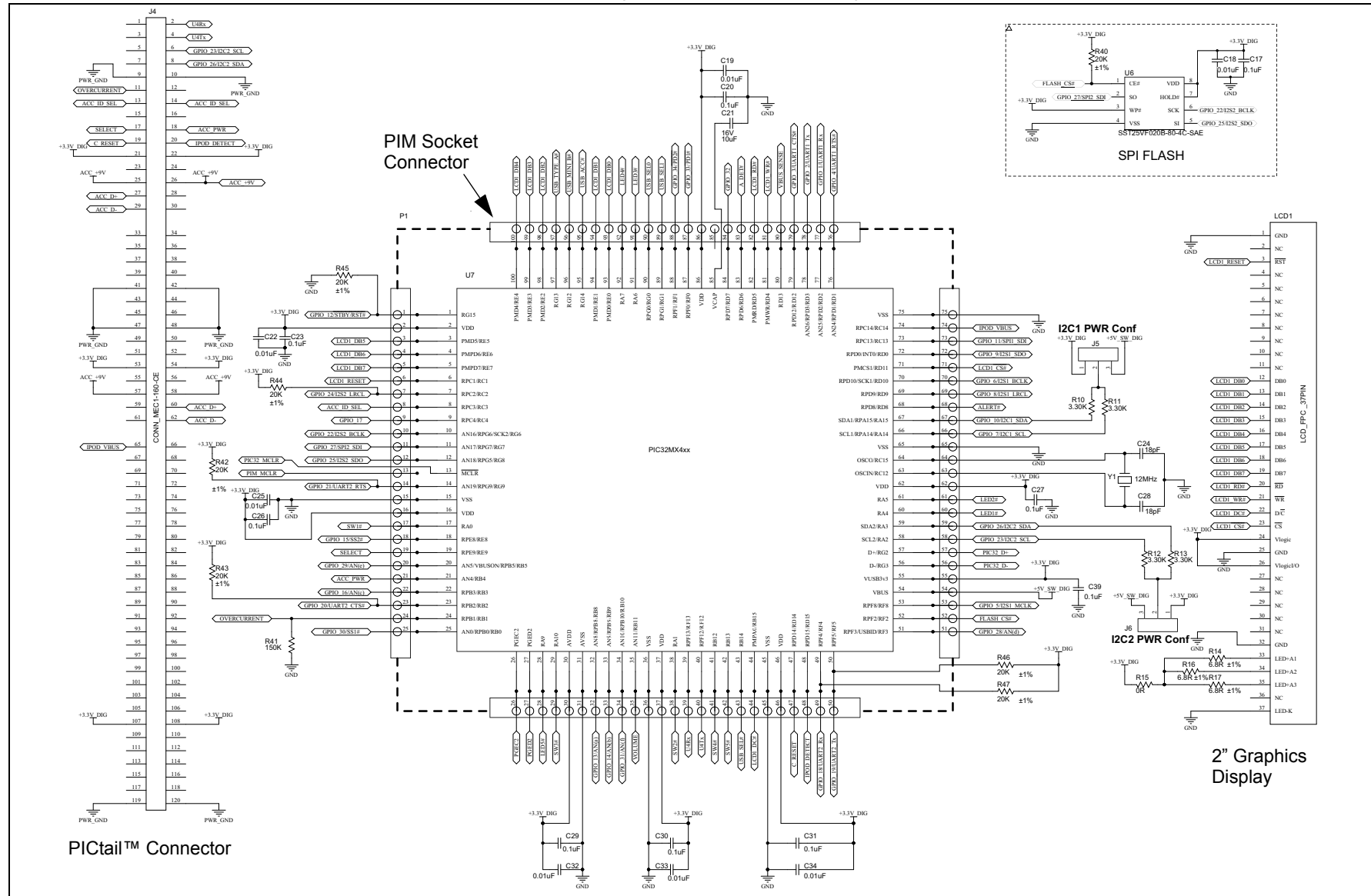


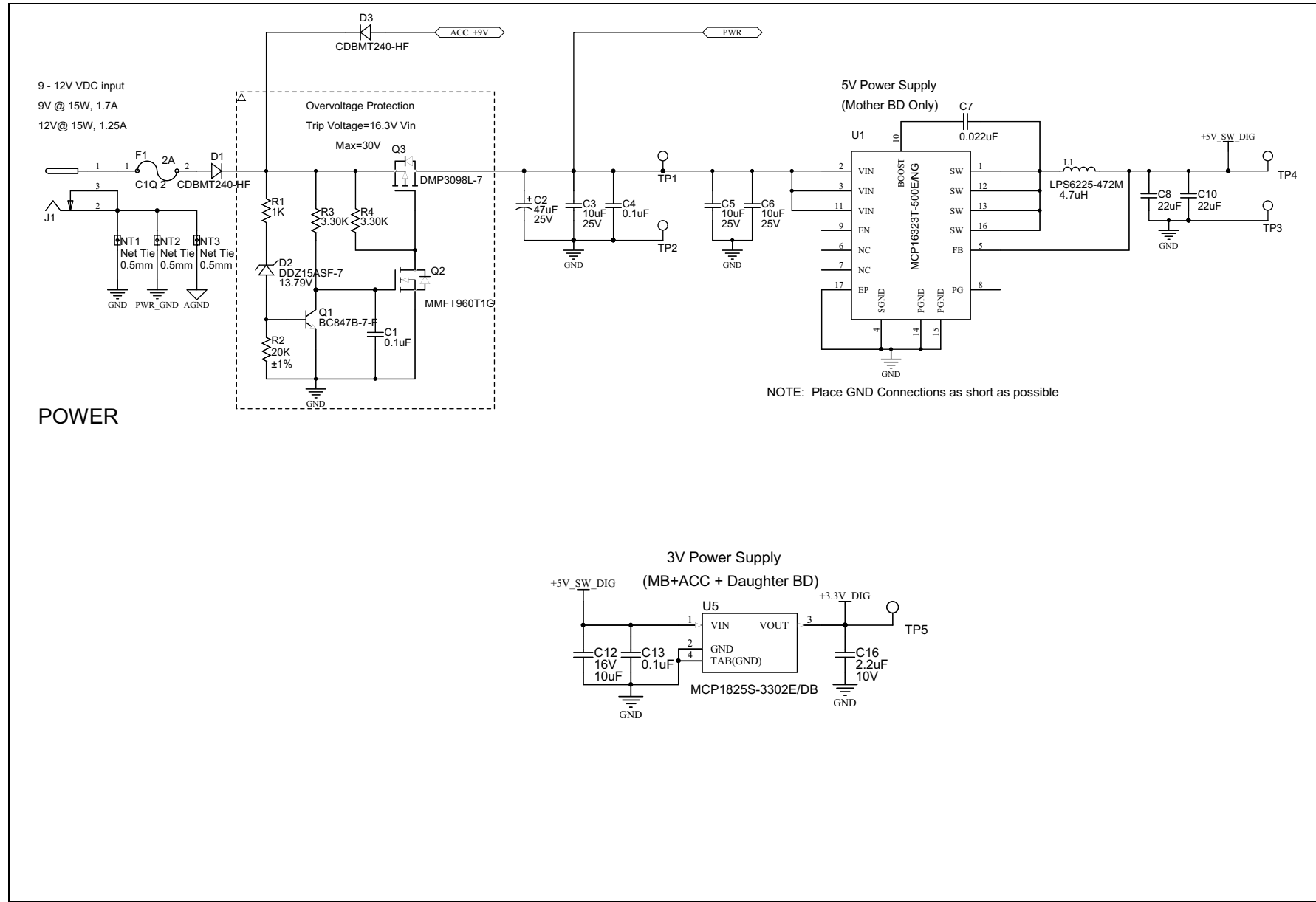
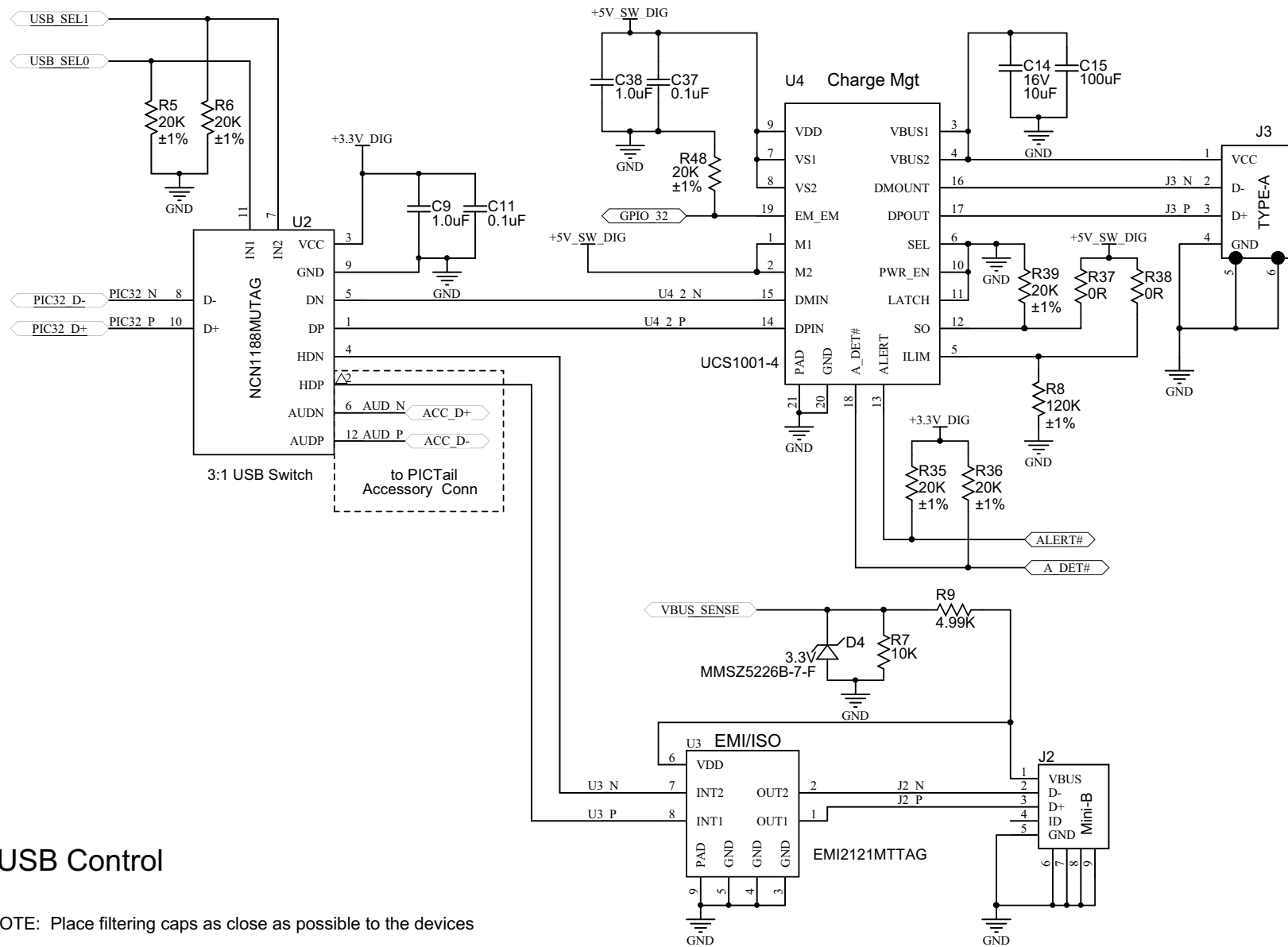
FIGURE A-6: POWER

FIGURE A-7: USB CONTROL

USB Control

NOTE: Place filtering caps as close as possible to the devices

FIGURE A-8: PUSH BUTTONS AND LEDs

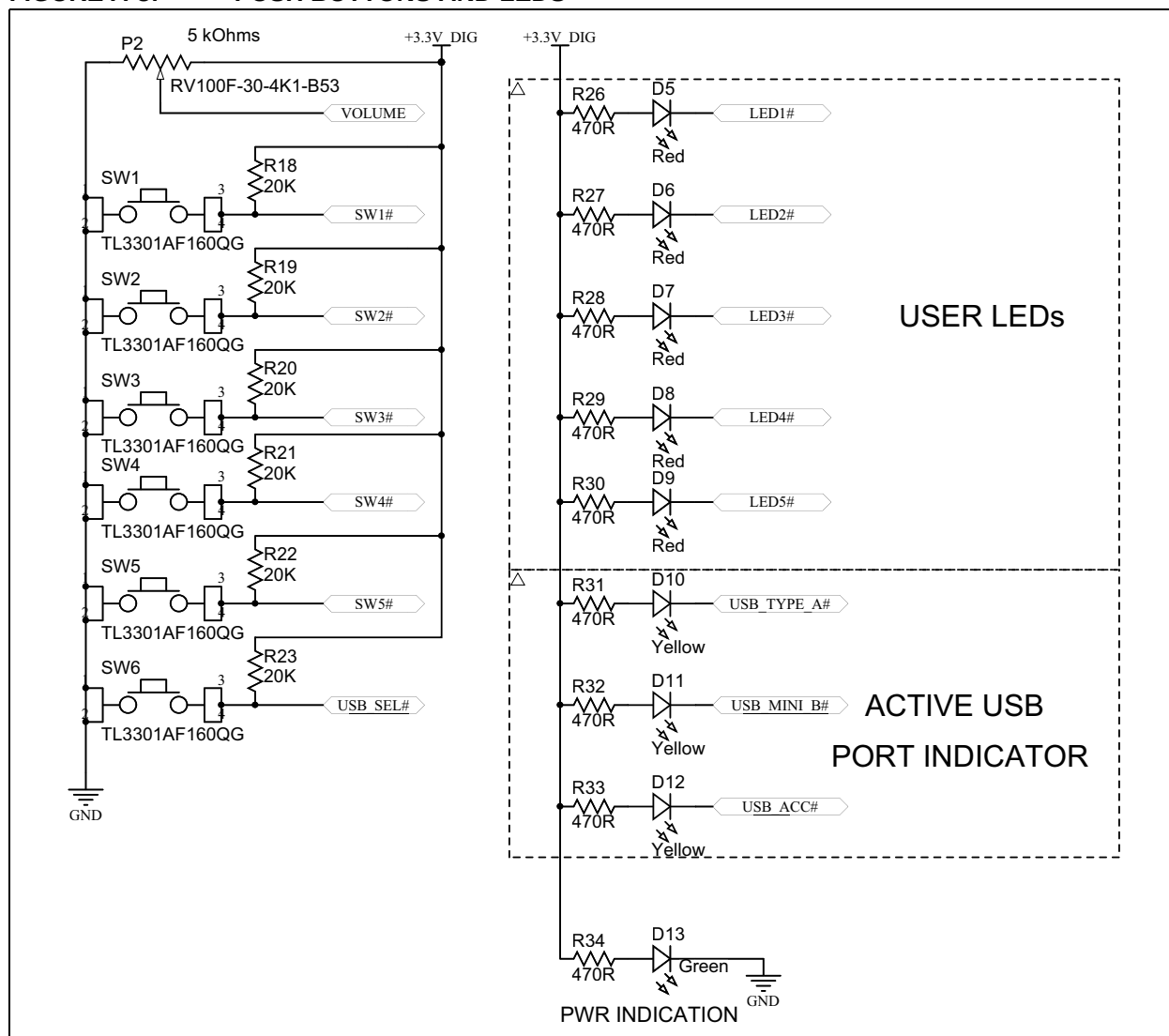


FIGURE A-9: ICSP™

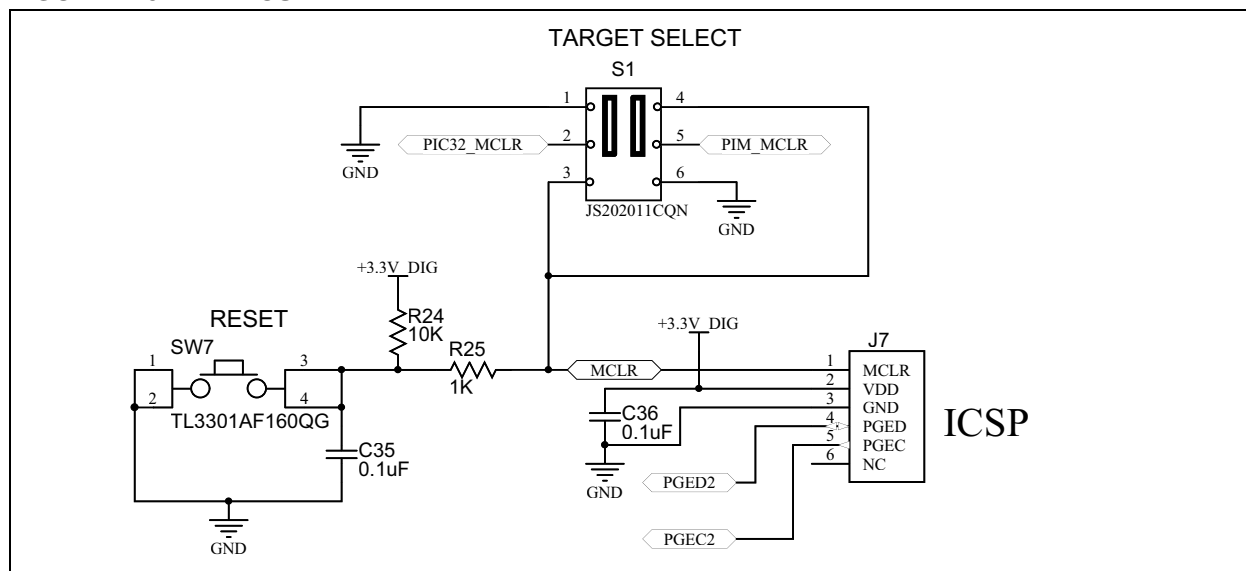


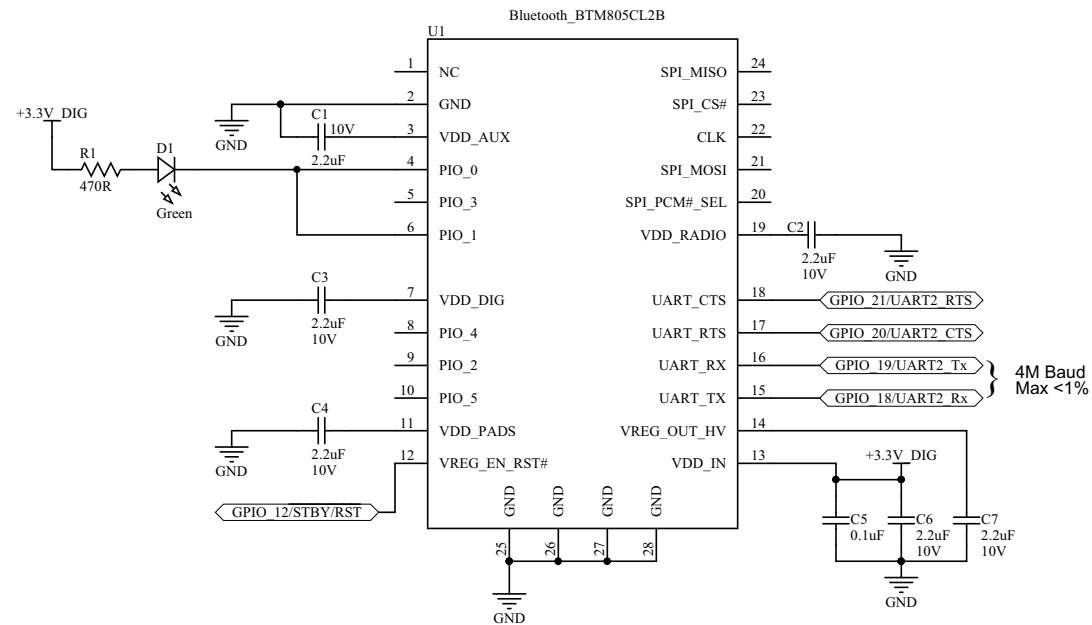
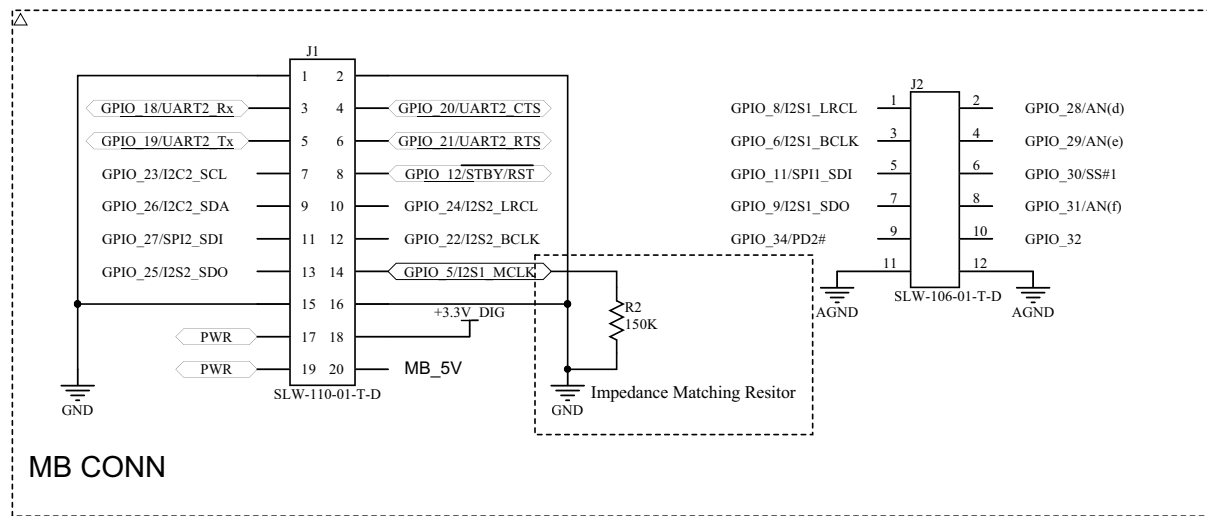
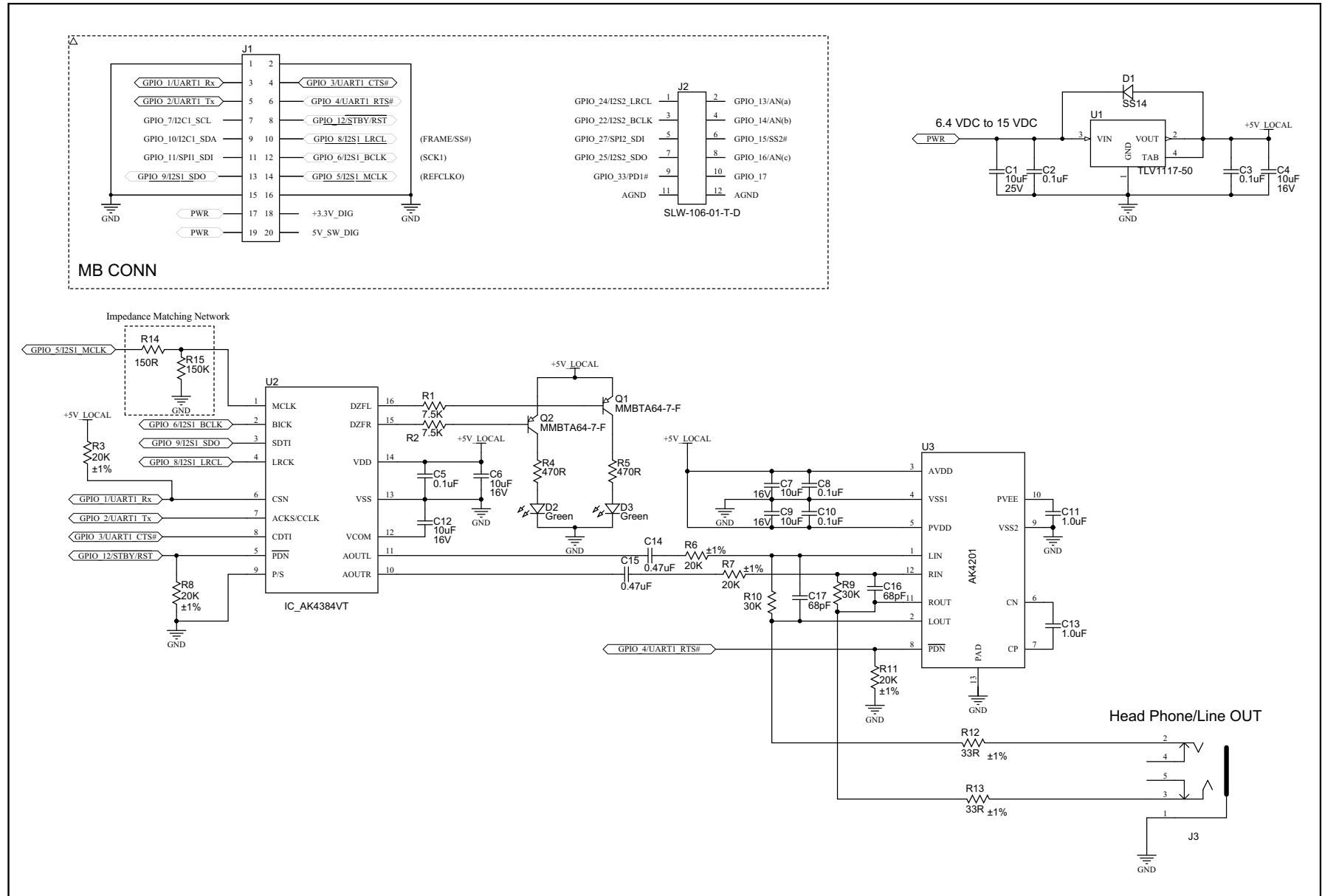
FIGURE A-10: BLUETOOTH HCI RADIO MODULE DAUGHTER BOARD

FIGURE A-11: AUDIO DAC/AMP DAUGHTER BOARD

Appendix B. Bill of Materials (BOM)

B.1 PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT BILL OF MATERIALS

TABLE B-1: PIC32 BLUETOOTH AUDIO DEVELOPMENT BOARD BOM

Reference	Description	Manufacturer	Part No.
C1, C4, C11, C13, C17, C20, C23, C26, C27, C29, C30, C31, C35, C36, C37, C39	Cap, Ceramic, 0.1 μ F, 50V X7R	TDK Corporation	C1608X7R1H104M
C2	CAP ALUM 47 μ F 25V 20% SMD	United Chemi-Con	EMVA250ADA470MF55G
C3, C5, C6	CAP CER 10 μ F 25V 10% X5R 1206	Taiyo Yuden	TMK316BJ106KL-T
C7	CAP CER 0.022 μ F 50V 20% X7R 0603	Murata Electronics North America	GRM188R71H223MA01D
C8, C10	CAP CER 22 μ F 16V 10% X5R 0805	TDK Corporation	C2012X5R1C226K
C9, C38	Cap, Ceramic, 1 μ F, 16V X5R	TDK Corporation	C1608X5R1C105K
C12, C14, C21	Cap, Ceramic, 10 μ F, 16V X5R	Taiyo Yuden	EMK212BJ106MG-T
C15	CAP CER 100 μ F 10V 20% X5R 1206	TDK Corporation	C3216X5R1A107M
C16	CAP CER 2.2 μ F 10V 20% X5R 0603	TDK Corporation	C1608X5R1A225M/0.80
C18, C19, C22, C25, C32, C33, C34	Cap, Ceramic, 0.01 μ F, 50V X7R	TDK Corporation	C1608X7R1H103M
C24, C28	CAP CER 18 pF 50V 5% C0G 0603	Murata Electronics North America	GRM1885C1H180JA01D
D1, D3	DIODE SCHOTTKY 40V 2A SOD123H	Comchip Technology	CDBMT240-HF
D2	DIODE ZENER 13.79V 500 mW SOD323F	Diodes Inc.	DDZ15ASF-7
D4	DIODE ZENER 3.3V 500 mW SOD123	Diodes Inc.	MMSZ5226B-7-F
D5, D6, D7, D8, D9	LED, SMD, RED, 0603 package	Kingbright Corp.	APT1608EC
D10, D11, D12	LED, SMD, YEL, 0603 package	Kingbright Corp.	APT1608YC
D13	LED, SMD, GRN, 0603 package	Kingbright Corp.	APT1608SGC
F1	FUSE 2A 125V 1206 FAST C1Q	Bel Fuse Inc.	C1Q 2
J1	CONN POWERJACK MINI R/A PCMT	Switchcraft Inc.	RAPC712X
J2	Receptacle, Mini-USB, UX60-MB-5ST, Type B	Hirose Electric Co., Ltd.	UX60-MB-5ST
J3	CONN USB TYPE A R/A BLACK	On Shore Technology Inc.	USB-A1HSB6
J4 (DNP)	CONN_MEC1-160-CE		
J5, J6	CONN HEADER 3 POS .100" SGL GOLD	Samtec Inc.	TSW-103-07-G-S

PIC32 Bluetooth® Audio Development Kit Reference Guide

TABLE B-1: PIC32 BLUETOOTH AUDIO DEVELOPMENT BOARD BOM (CONTINUED)

Reference	Description	Manufacturer	Part No.
J5,J6 (+5V)	SHUNT JUMPER .1" BLACK GOLD	3M	969102-0000-DA
J7	CONN HEADER 6 POS .100 R/A 30 AU	FCI	68016-106HLF
J8, J9	CONN HEADER 20 POS .100" DL TIN	Samtec Inc.	TSW-110-07-T-D
J10, J11	Terminal Strip, 2 x 6, 0.100 sp, 0.025 SQ. Post	Samtec Inc.	TSW-106-07-F-D
J12	CONN HEADER 7POS .100" SNGL TH	FCI	68016-107H
L1	4.7 μ H 20% Isat 3.2A	CoilCraft	LPS6225-472M
LCD1	DISPLAY_FPC_37PIN		
P1	CONN HEADER 25 POS SNGL 1.27 mm T/H	OUPHIN	2246-1*25GOOSU
P2	Potentiometers 10mm Linear 5K PC Mount	Alpha (Taiwan)	RV100F-30-4K1-B53
Q1	TRANS BIPO NPN 300MW 45V SOT 23-3	Diodes Inc.	BC847B-7-F
Q2	MOSFET N-CH 60V 300 mA SOT 223	ON Semiconductor	MMFT960T1G
Q3	MOSFET P-CH 30V 3.8A SOT 23-3	Diodes Inc.	DMP3098L-7
R1, R25	RES 1 k Ω 1/10W 1% 0603 SMD	Stackpole Electronics Inc.	RMCF0603FT1K00
R2, R5, R6, R18, R19, R20, R21, R22, R23, R35, R36, R39, R40, R42, R43, R44, R45, R46, R47, R48	RES 20.0 k Ω 1/10W 1% 0603 SMD	Yageo	RC0603FR-0720KL
R3, R4, R10, R11, R12, R13	Res, 3.3K 1/10W 1%	Stackpole Electronics Inc.	RMCF0603FT3K30
R7, R24	RES 10 k Ω 1/10W 1% 0603 SMD	Stackpole Electronics Inc.	RMCF0603FT10K0
R8	RES 120 k Ω 1/10W 1% 0603 SMD	Yageo	RC0603FR-07120KL
R9	RES 4.99 k Ω 1/10W 1% 0603 SMD	Yageo	RC0603FR-074K99L
R14, R16, R17	RESISTOR 6.8 Ω 1/10W 1% 0603	Panasonic Electronic Components	ERJ-3RQF6R8V
R15, R37, R38	RES 0.0 Ω 1/10W 0603 SMD	Rohm Semiconductor	MCR03EZPJ000
R26, R27, R28, R29, R30, R31, R32, R33, R34	RES 470 Ω 1/10W 1% 0603 SMD	Rohm Semiconductor	MCR03EZPFX4700
R41	RES 150 k Ω 1/10W 5% 0603 SMD	Yageo	RC0603JR-07150KL
S1	SW SLIDE DPDT 6 VDC 0.3A PCMNT	C&K Components	JS202011CQN
SW1, SW2, SW3, SW4, SW5, SW6, SW7	SWITCH TACT 160 GF H = 5.0 mm SMT	E-Switch	TL3301AF160QG
TP1 (DNP)	TEST POINT PC MINI .040"D WHITE	Keystone Electronics	5002
TP2, TP3 (DNP)	TEST POINT PC MINI .040"D BLACK	Keystone Electronics	5001

TABLE B-1: PIC32 BLUETOOTH AUDIO DEVELOPMENT BOARD BOM (CONTINUED)

Reference	Description	Manufacturer	Part No.
TP4, TP5 (DNP)	TEST POINT PC MINI .040"D RED	Keystone Electronics	5000
U1	IC REG BUCK SYNC 5V 3A 16 VQFN	Microchip Technology Inc.	MCP16323T-500E/NG
U2	IC USB SWITCH 3:1 AUD/MHL 12 UQFN	ON Semiconductor	NCN1188MUTAG
U3	IC FILTER COMMON MODE ESD 8WDFN	ON Semiconductor	EMI2121MTTAG
U4	USB Port PWR controller with CHRG	Microchip Technology Inc.	UCS1001-4
U5	IC LDO REG 500 mA 3.3V SOT 223-3	Microchip Technology Inc.	MCP1825S-3302E/DB
U6	IC FLASH SER 2 MB 80 MHz SPI 8 SOIC	Microchip Technology Inc.	SST25VF020B-80-4C-SAE
U7	IC MCU 32-bit 512 KB FLASH 100 TQFP	Microchip Technology Inc.	PIC32MX470F512L
Y1	CRYSTAL 12 MHz 18 pF SMD	TXC CORPORATION	7A-12.000MAAJ-T
Rubber Feet	BUMPON CYLINDRICAL .312X.215 BLK	3M	SJ61A6

PIC32 Bluetooth® Audio Development Kit Reference Guide

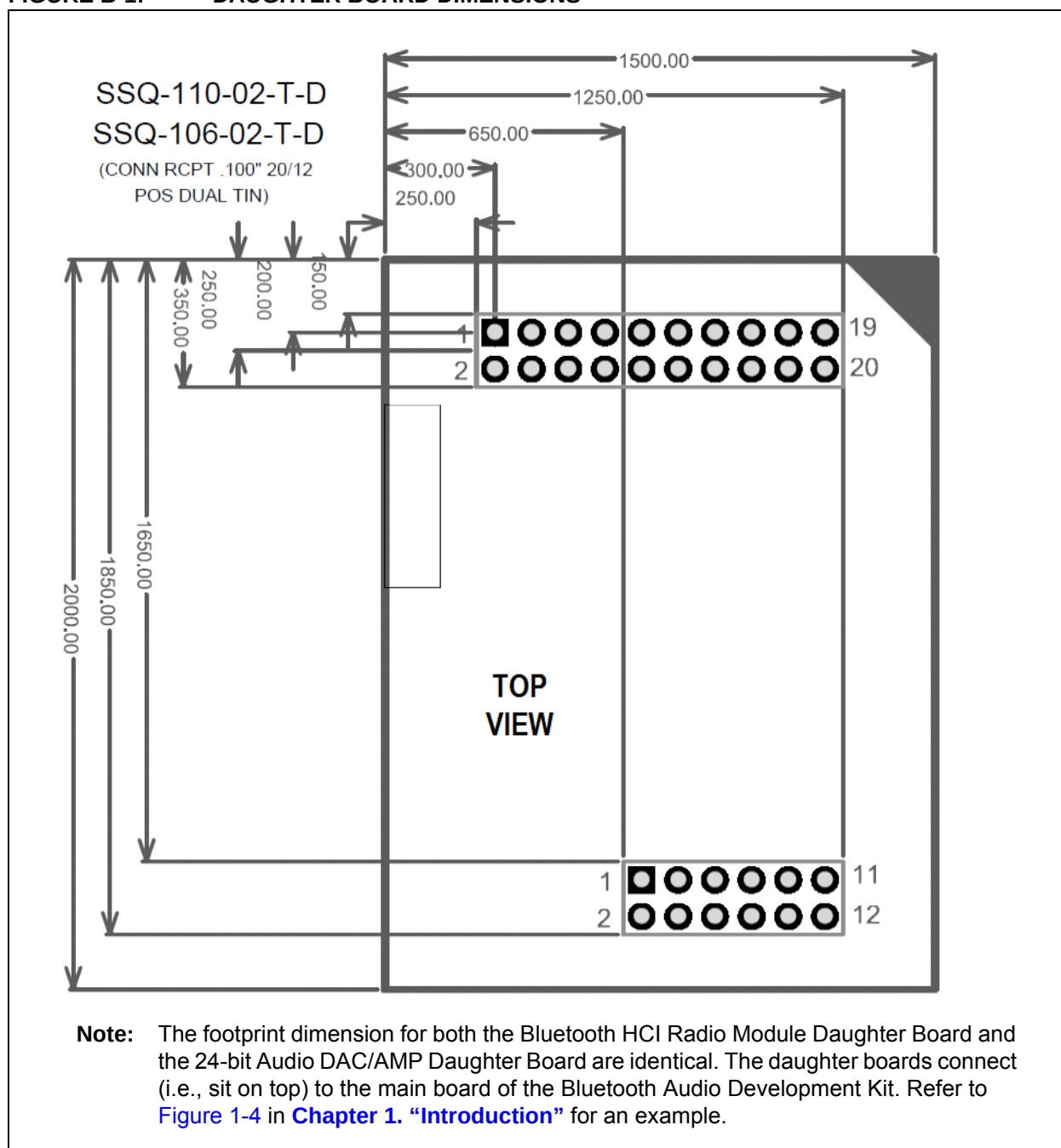
TABLE B-2: BLUETOOTH HCI RADIO MODULE DAUGHTER BOARD BOM

Reference	Description	Manufacturer	Part No.
C1, C2, C3, C4, C6, C7	CAP CER 2.2UF 10V 20% X5R 0603	TDK Corporation	C1608X5R1A225M/0.80
C5	Cap, Ceramic, 0.1 μ F, 50V X7R	TDK Corporation	C1608X7R1H104M
D1	LED, SMD, GRN, 0603 package	Kingbright Corporation	APT1608SGC
J1	CONN RCPT .100" 20 POS DUAL TIN	Samtec Inc.	SLW-110-01-T-D
J2	CONN RCPT .100" 12 POS DUAL TIN	Samtec Inc.	SLW-106-01-T-D
R1	RES 470 Ω 1/10W 1% 0603 SMD	Rohm Semiconductor	MCR03EZPFX4700
R2	RES 150 k Ω 1/10W 5% 0603 SMD	Yageo	RC0603JR-07150KL
U1	Dual-mode Bluetooth HCI	Flaircomm	BTM805CL2B

TABLE B-3: 24-BIT AUDIO DAC/AMP DAUGHTER BOARD BOM

Reference	Description	Manufacturer	Part No.
C1	CAP CER 10 μ F 25V 10% X5R 1206	Taiyo Yuden	TMK316BJ106KL-T
C2, C3, C5, C8, C10	Cap, Ceramic, 0.1 μ F, 50V X7R	TDK Corporation	C1608X7R1H104M
C4, C6, C7, C9, C12	CAP CER 10 μ F 16V 20% X7R 1206	TDK Corporation	C3216X7R1C106M
C11, C13	Cap, Ceramic, 1 μ F, 16V X5R	TDK Corporation	C1608X5R1C105K
C14, C15	CAP CER 0.47 μ F 10V 10% X5R 0603	TDK Corporation	C1608X5R1A474K
C16, C17	CAP CER 68 pF 50V 5% NP0 0603	TDK Corporation	C1608C0G1H680J
D1	DIODE SCHOTTKY 1A 40V SMA	Fairchild Semiconductor	SS14
D2, D3	LED, SMD, GRN, 0603 package	Kingbright Corporation	APT1608SGC
J1	CONN RCPT .100" 20 POS DUAL TIN	Samtec Inc.	
J2	CONN RCPT .100" 12 POS DUAL TIN	Samtec Inc.	SLW-106-01-T-D
J3	CONN JACK STEREO 5 POS 3.5 mm SMD	CUI Inc.	SJ1-3515-SMT
Q1, Q2	TRANSISTOR DARL PNP 30V SOT23-3	Diodes Inc.	MMBTA64-7-F
R1, R2	RES 7.5 k Ω 1/10W 1% 0603 SMD	Stackpole Electronics Inc.	RMCF0603FT7K50
R3, R6, R7, R8, R11	RES 20.0 k Ω 1/10W 1% 0603 SMD	Yageo	RC0603FR-0720KL
R4, R5	RES 470 Ω 1/10W 1% 0603 SMD	Rohm Semiconductor	MCR03EZPFX4700
R9, R10	RES 30K Ω 1/10W 5% 0603 SMD	Yageo	RC0603JR-0730KL
R12, R13	RES 33 Ω 1/10W 1% 0603 SMD	Stackpole Electronics Inc.	RMCF0603FT33R0
R14	RES 150 Ω 1/10W 1% 0603 SMD	Stackpole Electronics Inc.	RMCF0603FT150R
R15	RES 150K Ω 1/10W 5% 0603 SMD	Stackpole Electronics Inc.	RC0603JR-07150KL
U1	IC REG LDO 5V .8A SOT223-4	Texas Instruments	TLV1117-50IDCY
U2	106 dB 192 kHz 24-bit 2-ch $\Delta\Sigma$ DAC	AKM	AK4384VT
U3	Stereo Capless HP-Amp	AKM	AK4201

FIGURE B-1: DAUGHTER BOARD DIMENSIONS



PIC32 Bluetooth® Audio Development Kit Reference Guide

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Appendix C. Planned Enhancements

C.1 PLANNED ENHANCEMENTS

TABLE C-1: DEMONSTRATION FEATURE ENHANCEMENT SCHEDULE

Description	Date of Availability
AVRCP V1.5	CYQ3 2013
Stereo Equalizer Library, which consists of Bluetooth/USB audio libraries with: • Design-time stereo speaker equalization for tuning speakers and enclosures • Run-time adjustable stereo graphics equalizer Note: This demonstration will be a superset of Demonstrations 2.5 and 2.5A (previously described) with the addition of equalizer features.	CYQ3/Q4 2013
Power conservation modes when idle, disconnected, or lost connection.	CYQ3/Q4 2013
Digital volume control	CYQ4 2013
MP3 player with FAT32 and graphics file manager, which consists of Bluetooth/USB audio plus equalizer with: • MP3 decoder and Flash drive audio playback • FAT32 file system library • Graphics file manager	CYQ4 2013
User-definable Bluetooth voice prompts for standard events, such as: • Power on • Power off • Bluetooth connected • Bluetooth disconnected • Bluetooth connect lost	CYQ4 2013
User-selectable switch button control profiles	CYQ4 2013
Audio automatic leveling	<i>Date pending</i>
Automatic switch to last audio connection (Bluetooth or USB)	CYQ4 2013
Soft mute	CYQ4 2013
Repeat and Shuffle over AVRCP	CYQ4 2013
Retry connect time-out	CYQ4 2013
Last audio connection will be the active source, even if not Bluetooth	CYQ4 2013

PIC32 Bluetooth® Audio Development Kit Reference Guide

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Appendix D. Frequently Asked Questions (FAQ)

Question 1: When I connect my smartphone or tablet to the USB connector, the Bluetooth Audio Development Board shuts down, operates intermittently, or resets continuously.

Answer: The Bluetooth Audio Development Board hardware supports smart/fast charging, which requires a power source capable of delivering 9V @ 1.7 amp or 12V @ 1.25 amp. Some smartphones require up to 1.5 amp and tablets up to 2.5 amp of charging current supplied over the Type-A USB connector from the “Bluetooth Audio Development Board”. If the user is using an underrated power source and the externally connected USB device has entered a fast charging/playback mode then the input voltage from the external power source will drop below the operational levels of the on-board regulators resulting in intermittent power cycling and/or loss. Disconnect all USB devices, if the board powers up normally then replace the power source with an appropriate supply.

Question 2: With no USB connected, when I connect the power source, the Bluetooth Audio Development Board does not power up normally, no power LED indication, and/or it operates intermittently.

Answer 1: There is an overvoltage protection circuit that will trip and shut down all power to the development board as long as the input power source voltage level exceeds ~14.4V. This is a safety measure as some of the on-board LDO regulators have a maximum 15V input range specification, specifically the DAC/AMP Daughter Board. To confirm, measure the external power supply input level on the power connector and if it's greater than 13.5V, switch to an appropriate 9-12 volt power supply rated for 9V @ 1.7 amp or 12V @ 1.25 amp, respectively.

Answer 2: If you are attempting to power the development board in an automotive application, the typical accessory or auxiliary power outlet in a vehicle is on the non-regulated side of the electrical system with respect to the alternator. When the engine RPM is sufficiently high enough, the voltage output of the alternator can rise above the 14.4V overvoltage protection circuit trip point. This can be confirmed if the development board works when the vehicle engine is at idle versus a higher RPM.

Answer 3: If the power input is less than 14V and there is still no power LED indication, it is possible that the overcurrent protection fuse is damaged. To confirm, with power applied, use a DVM and measure from each side of the fuse to ground. If both readings are not the same, replace the fuse.

Answer 4: Ensure that the Master Clear ($\overline{\text{MCLR}}$) Reset select slide switch, which is located to the left of the CPU, is in the appropriate position. The default position, if using the soldered down CPU on the board, is PIC32_MCLR. However, if you are using a PIC32 Plug-In Module (PIM), the slide switch must in the PIM_MCLR position.

Question 3: The manual reset button does not reset the board and/or the graphics screen is a solid background color with no text or graphics.

Answer: Ensure that the Master Clear ($\overline{\text{MCLR}}$) Reset select slide switch, which is located to the left of the CPU, is in the appropriate position. The default position, if using the soldered down CPU on the board, is PIC32_MCLR. However, if you are using a PIC32 Plug-In Module (PIM), the slide switch must in the PIM_MCLR position.

Question 4: I cannot establish a Bluetooth connection even though it's discoverable on my smartphone or Bluetooth enabled device.

Answer: Open the Bluetooth settings on your smartphone and from the list of devices, select the detail icon immediately to the right of the Bluetooth device name in question. For Apple devices, select Forget, and for Android, select unpair. At this point, you should be able to rediscover and select the device for connect and pairing. This is the expected recovery behavior, if for example, the user presses SW1 and forces the Bluetooth Audio Development Board to unpair.

Question 5: When connected over the USB port, my Apple audio device will not play music; however, other non-Apple devices seem to work fine.

Answer: Only demonstrations with the “A” suffix, denoting Apple USB compatibility, can be used with USB audio, which contain the iAP/MFi software layers. In addition, special Apple authentication hardware available only to registered Apple developers from the Avnet MFi Procurement web site (<https://mfi.avnet.com/MFI/>) must be attached. Refer to [Figure 1-2](#) in [Chapter 1. “Introduction”](#) for a diagram that shows several Apple authentication hardware solutions that are compatible with the development kit.

Question 6: I do not hear any music even though I successfully connected either to the Bluetooth or USB port.

Answer: The master volume control, located on the upper left side of the development board below the audio headphone/line-out connector, is independent of the Bluetooth, as well as any USB audio device's volume control. Adjust the control counter-clockwise to increase the volume. Visually, the user can determine the cause of the issue based on either of the following two conditions:

- The music “progress bar” on the smartphone, as well as the graphics display on the audio development board, is advancing as expected.
- The “Left” and “Right” green stereo LEDs are not active on the Audio DAC/HP AMP Daughter Board.

Question 7: When I connect and pair with a Bluetooth smartphone it connects and pairs briefly, but then disconnects.

Answer: For Android smartphones this is a standard procedure. After the user manually selects the desired Bluetooth device for the first time from their smartphone, it will briefly connect and pair. However, unlike Apple devices, if the Android device successfully connects and pairs, it will then disconnect, and then move the Bluetooth device to the Android smartphone's “paired” list, at which time the user must again (for a second time), manually select the Bluetooth device from the paired list to reconnect.

Question 8: When I connect my Samsung USB audio device to the mini-B USB connector I cannot play audio from the device.

Answer 1: Ensure that the Bluetooth connection is not active or that a USB Type-A audio device was not the last device connected. Remember that a Bluetooth connection takes priority over a USB connection, and the last USB connected device takes precedence over any other USB connection.

Answer 2: Ensure that you are using a demonstration that includes USB audio support. See [Table 4-1](#) in [Chapter 4, “Demonstrations”](#) for details.

Question 9: What Bluetooth module is used in this development kit?

Answer: The Flaircomm FLC-BTM805CL2B Bluetooth HCI module is used in this development kit. For more information, please visit <http://www.flairmicro.com/en/index.aspx>.

Question 10: Why do multiple Bluetooth Audio Development Board demonstrations with the same name appear in the list of Bluetooth devices on my smartphone?

Answer: If a Bluetooth connection is made with a Bluetooth Audio Development Board demonstration, that device ID (or name) is saved in a list in your smartphone. Each time a user reprograms the development board, a new, random ID is generated for that device name. Then, if the development board is paired with a smartphone, the new ID will be saved on the smartphone, but with the same name. This can make it difficult to distinguish between the duplicate named devices. Therefore, it is recommended to first “forget” the previous device ID (or name) on the smartphone before reprogramming the development board with another demonstration.

Question 11: How many MIPS are used by the Bluetooth stack?

Answer: The MIPS usage is dependent on the particular demonstration, as follows:

- Bluetooth Stack + SBC = ~30 MIPS
- Bluetooth Stack + AAC = ~65 MIPS

Note: PIC32MX430/450/470 devices are being respecified from 80 MIPS to 100 MIPS operation. Please check back in October 2013 for the current status.
--

Question 12: Does the Bluetooth stack and decoders need external memory?

Answer: No, all memory (Flash and RAM) is internal to the PIC32MX device.

Question 13: Is the source code for the Bluetooth stack available?

Answer: The Bluetooth stack and audio decoders are supplied as a library object file, along with a C level API. Users can link this stack into their project and access it through this API.

Question 14: How much does the Bluetooth stack cost?

Answer: There is a one-time license fee of \$299.00 (US) for the Bluetooth stack.

PIC32 Bluetooth® Audio Development Kit Reference Guide

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Worldwide Sales and Service

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China - Chengdu
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China - Chongqing
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Fax: 86-23-8980-9500

China - Hangzhou
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Fax: 86-571-2819-3189

China - Hong Kong SAR
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Fax: 852-2401-3431

China - Nanjing
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Fax: 86-25-8473-2470

China - Qingdao
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Fax: 86-532-8502-7205

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

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Fax: 86-24-2334-2393

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