PIC32 Bluetooth Audio Development Kit

Reference Guide

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

EU Declaration of Conformity

This declaration of conformity is issued by the manufacturer.
The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).
This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.
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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. "Bluetooth Audio 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.

- **Appendix A. “Hardware, 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. “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	*MPLAB IDE User's Guide*
	Emphasized text	...is the *only* 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	*File > Save*
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'`
`Italic Courier New`	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {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.

Bluetooth Audio Development Kit Readme File

For the latest information on using the development kit and its related demonstrations, please consult the Readme file provided in the installation directory. The Readme file contains information on revision updates and known issues that may not be included in this reference guide.

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

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

Note:	Please contact Microchip Marketing for information regarding this document.

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

DEVELOPMENT SYSTEMS CUSTOMER CHANGE NOTIFICATION SERVICE

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

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

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools
- **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

DOCUMENT REVISION HISTORY

Revision A (September 2013)

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

Revision B (February 2014)

This revision includes the following updates:

- Changes in support of Release v2.0 of the demonstration software:
  - **1.1 "Feature Overview"** was updated to include the PIC32MX470F512L)
  - Updated the Bluetooth Qualified Design Information (see Table 1-1)
  - Removed Figure 1-1
  - Updated the Note in **1.3 "Kit Contents"**
  - Updated item 2 and the note for item 16 in **1.5 "PIC32 Bluetooth Audio Development Kit Functionality and Features"**
  - Updated Demonstrations and Resource Requirements (see Table 4-1)
  - Updated the Demonstration Features Map (see Table 4-3)
  - Updated **4.1.1 "Basic Functionality"**
  - Updated the Bluetooth/USB Audio Demonstration 2.5 Controls (see Table 4-4)
  - Updated **4.1.3.1 "Bluetooth USB Demonstration 2.5 Switch Descriptions"**
  - Updated the Bluetooth/USB Audio Demonstration 2.5A Controls (see Table 4-5)
  - Updated **4.2.3.1 "Bluetooth USB Demonstration 2.5A Switch Descriptions"**
  - Updated the Bluetooth/USB Audio Demonstration 3 Controls (see Table 4-6)
  - Updated **4.3.3.1 "Bluetooth Demonstration 3 Switch Descriptions"**
  - Updated the Bluetooth/USB Audio Demonstration 5 Controls (see Table 4-8)
  - Updated **4.5.2.1 "Bluetooth Demonstration 5 Switch Descriptions"**
  - Updated the Bluetooth Stack Profile Versions (see Table 5-1)
  - Updated the Demonstration Feature Enhancement Schedule (see Table C-1)
- Added **4.6 "Bluetooth/USB Audio Demonstration 6 with AAC"**
- Added **4.7 "Bluetooth Audio Demonstration 7 with SBC and EQ"**
- **Appendix A. "Hardware, Board Layout, and Schematics"** updates:
  - Added Development Kit Wire List (see Table A-1)
  - Added Daughter Board Pin Mapping (see Table A-2)
- **Appendix D. "Frequently Asked Questions (FAQ)"** updates:
  - Added Answer 3 to Question 8
  - Added Answer 2 to Question 12
  - Added Question 15

Revision C (May 2014)

This revision includes the following updates.

- Demonstration details were removed and relocated to individual “ReadMe” files, which are included when downloading the demonstrations
- 4.2 “Bluetooth/USB Audio Demonstration 2.5A With SBC And Apple Support” was removed
- Added **4.4.7 “Bluetooth/USB Audio Demonstration 8 with SBC”**
- Added **4.4.8 “Bluetooth Audio Demonstration 9 With SBC and Break-In/Party mode”**
- Added **4.4.9 “Bluetooth/USB Audio Demonstration 10 With SBC and Break-In/Party Mode”**
- Added **4.4.10 “Bluetooth Audio Demonstration 11 With SBC and SPP”**
- Appendix C “Planned Enhancements” was removed

NOTES:

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-bit/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.

1.1 FEATURE OVERVIEW

Key features include:

- PIC32MX450F256L, 100 MHz, 256 KB Flash, 64 KB RAM (v1.0 and v2.0 development boards)
- PIC32MX470F512L, 100 MHz, 512 KB Flash, 128 KB RAM (v3.0 development board only)
- 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®
  - Samsung® audio
  - Google™
  - Android™ Open Accessory (AOA)
  - Bluetooth audio with SBC and AAC decode
  - Bluetooth Stack QDID certified

1.1.1 Bluetooth Demonstrations

Currently, many Bluetooth demonstrations are available and many are planned in the near future. We are continually adding many features and functionality. Some Bluetooth software demonstrations also have functionality for USB audio streaming, and these demonstrations include support for AOA and Samsung data formats.

If USB audio support for Apple is required, support for the Bluetooth Stack (A2DP + AVRCP + SPP + SBC decoder) with Android Open Accessory + Apple MFi stack + Apple iAP Type-A USB connection, plus Samsung audio mini-B USB connection is available. The device requires a iAP/MFi software component and special hardware acquired through the Apple MFi program. For more information about the required hardware, contact applesupport@microchip.com. To obtain software for this and other Microchip hardware, which is enabled for Apple products, contact your Microchip sales office. Refer to Figure 1-1 for a diagram that shows several Apple controlled hardware solutions that are compatible with the development kit.

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

See **Chapter 4. "Bluetooth Audio Demonstrations"** for full details on which demonstrations are offered free-of-charge, and which are available for purchase. In addition, feature tables and brief overviews of each demonstration are provided. Information on configuring and running each demonstration is provided is a separate "ReadMe" file (available from www.microchip.com/pic32btsuites).

1.2 QUALIFICATION

As of February 1, 2014, the Bluetooth Special Interest Group (Bluetooth SIG) has changed the qualification process for all new products. Microchip will continue to provide Qualified Design ID (QDID) for selected components within the design (see Table 1-1). The new Declaration ID will be required by each manufacturer. Previous Qualified Design Listing (QDL) and End Product Listing (EPL) processes are no longer necessary. For more information, please contact your local Microchip sales office, or refer to the training materials provided by the Bluetooth SIG at:

https://www.bluetooth.org/en-us/test-qualification/qualification-overview/listing-process-updates

TABLE 1-1: BLUETOOTH QUALIFIED DESIGN INFORMATION

Component	QDID (See **Note 1**)
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
Bluetooth Stack v1.0.3 (RTOS Version) https://www.bluetooth.org/tpg/QLI_viewQDL.cfm?qid=21350	B021350
Bluetooth Stack v.2.0 (non-RTOS Version)	See **Note 2**

Note 1: The Bluetooth software stack and Bluetooth radio module hardware on the PIC32 Bluetooth Audio Development Kit are available from Microchip. Changes to the architecture may require a unique QDID for an end product and additional testing by the customer. All new products require a Declaration ID available only from the Bluetooth SIG.

2: New rules by the Bluetooth SIG are scheduled to be active in February 2014. The QDID for the v2.0 Bluetooth Stack will comply with these revised standards.

1.3 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.

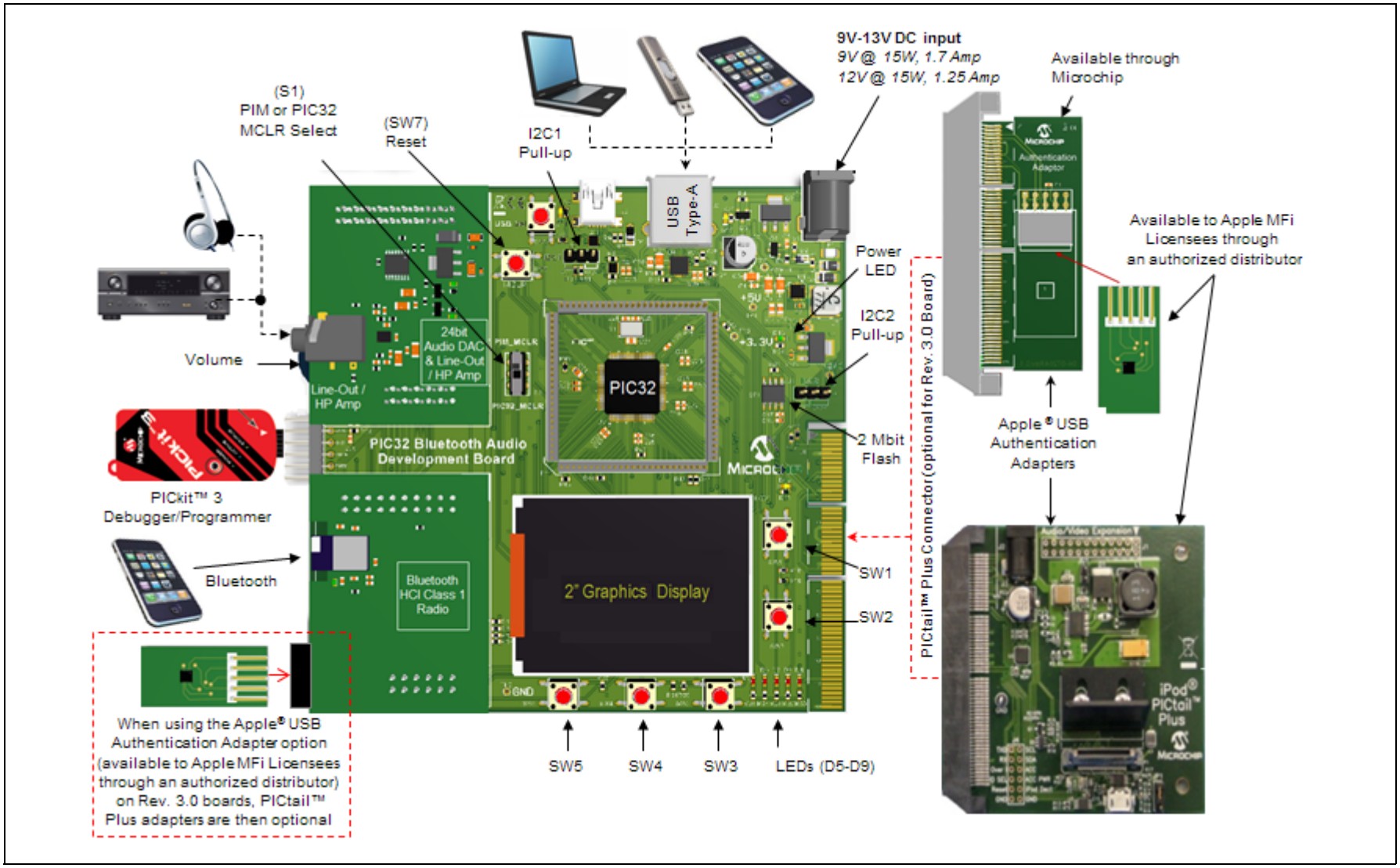
For those customers who have a development kit populated with the PIC32MX450F256L, you can update to the new device using a PIC32MX470F512L Plug-in Module (PIM) mounted on the U1A headers. When using the PIM, ensure that switch S2 is in the PIM_MCLR position. When not using the PIM, ensure that switch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

All demonstrations with the exception of Bluetooth/USB Audio Demonstration 6 will operate on PIC32MX450F256L. It is important to note that the PIC32MX470F512L is *required* for Bluetooth/USB Audio Demonstration 6 with AAC, which incorporates the AAC decoder in addition to Bluetooth SBC and USB audio functions.

1.4 FEATURES

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

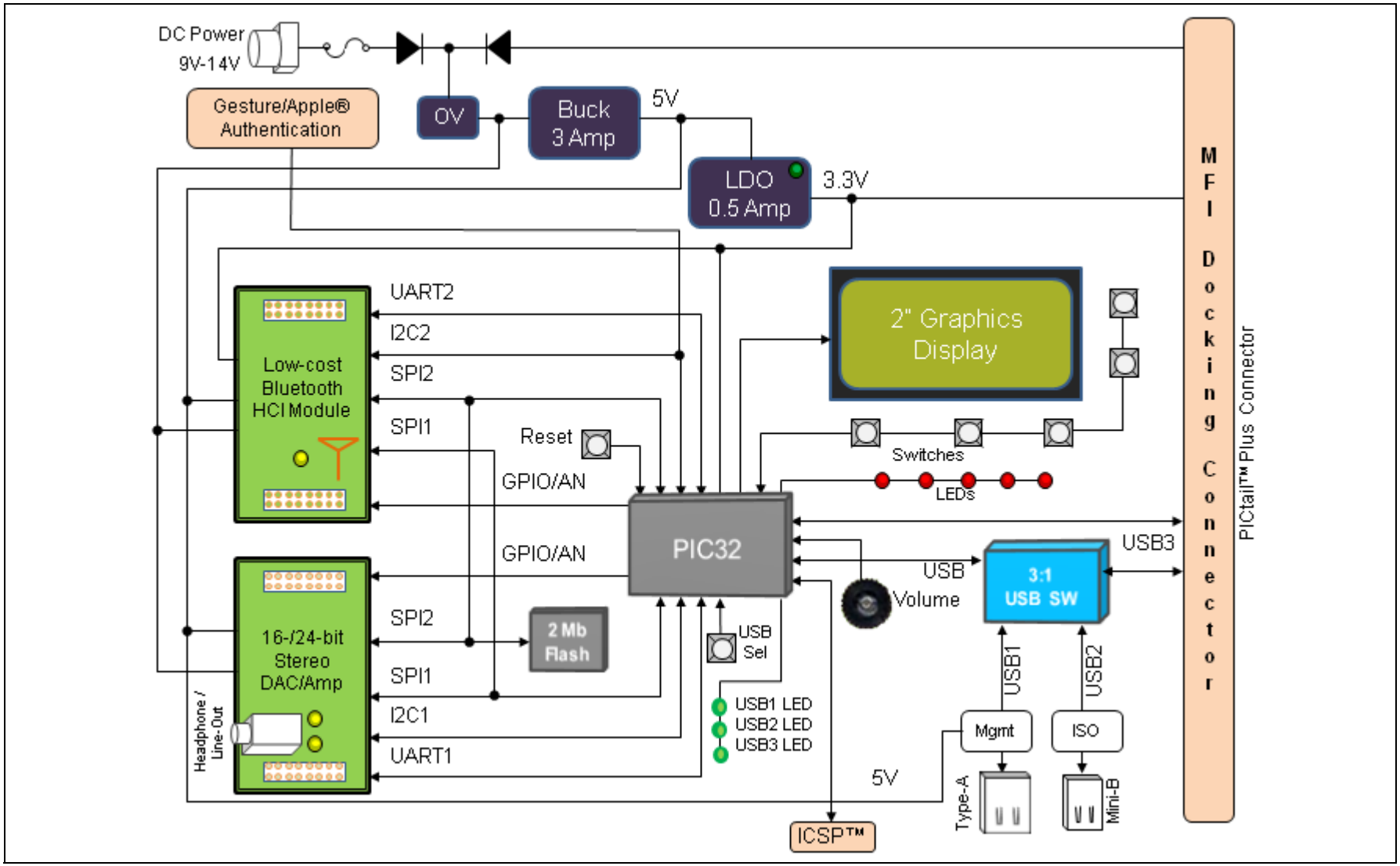
FIGURE 1-1: PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT LAYOUT AND FEATURES



1.4.1 Development Kit Block Diagram

Figure 1-2 shows a block diagram of the PIC32 Bluetooth Audio Development Kit.

FIGURE 1-2: PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT BLOCK DIAGRAM



1.5 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 1-3:

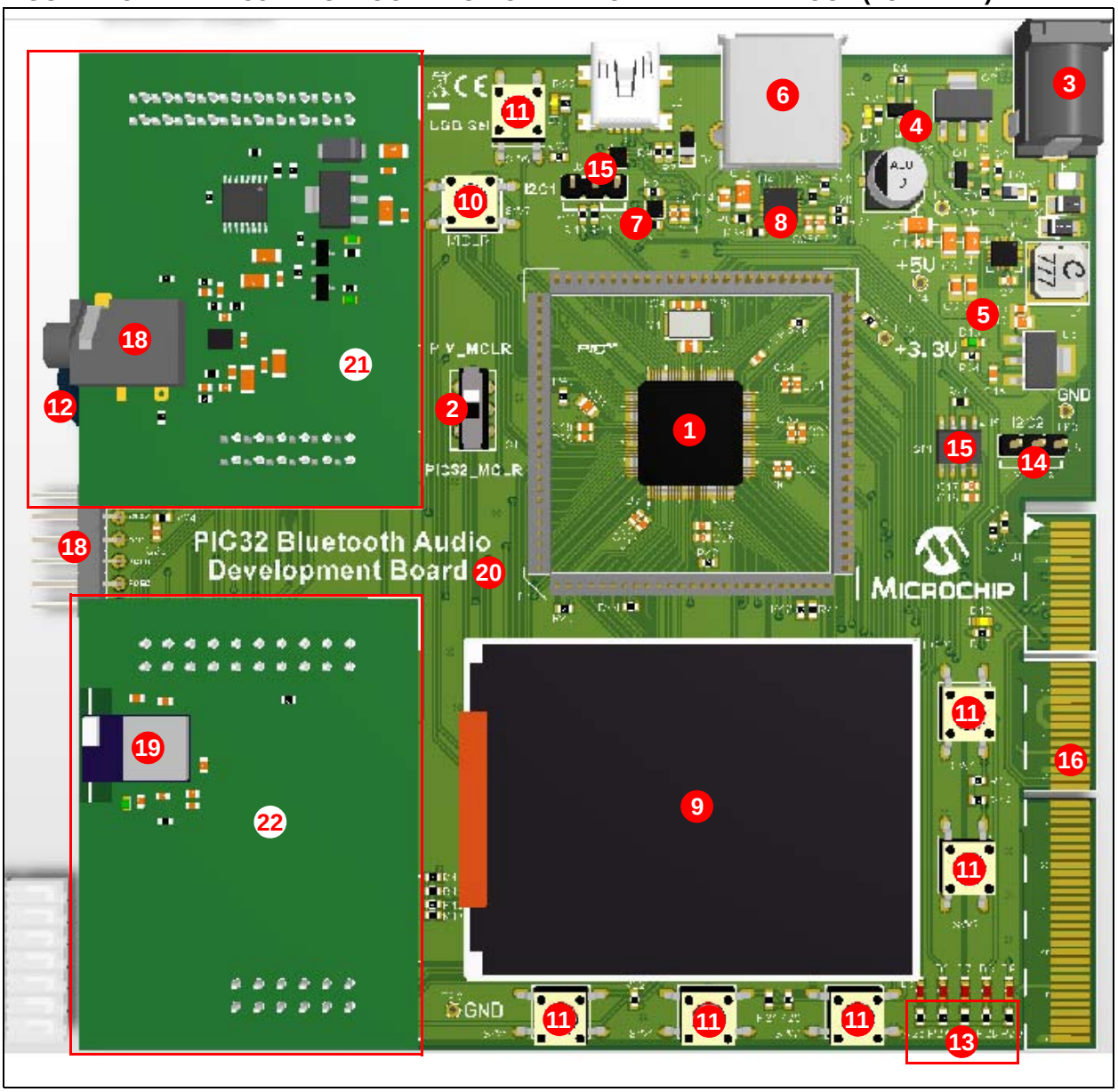
1. PIC32MX450F256L or PIC32MX470F512L 32-bit microcontroller (U1).
2. Hardware selection of PIM or board mounted microcontroller (S1). At all times, S1 should be in the “down” position towards the display, except when a PIM is installed
3. 6.9V to 14V DC power input (provides +3.3V and +5V (regulated) 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. I^2C pull-up headers (selectable to either 3.3V or 5V).
15. SPI Serial EEPROM (2 Mb for v2.0 development boards, 8 Mb for v3.0 development boards).
16. PICtail™ Plus connector with support for an external USB Apple interface PICtail Plus adapter (see **Note**).

> **Note:** For USB Apple connected audio devices, a special Apple controlled hardware device is required, which is only available to Apple MFi licensees. Please contact a Microchip sales office for information.
>
> The PICtail Plus connector is not compliant with all Apple revisions. The Apple controlled hardware device to the PICtail Plus connector is suggested for Rev. 2.0 or earlier boards. Rev. 3.0 or later boards are supported by the Apple controlled hardware adapter connector (J13), which is located at the lower left of the main board of the development kit.

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 1-3: PIC32 BLUETOOTH AUDIO DEVELOPMENT KIT LAYOUT (TOP VIEW)



1.6 BLUETOOTH MODULE DAUGHTER BOARD FUNCTIONALITY AND FEATURES

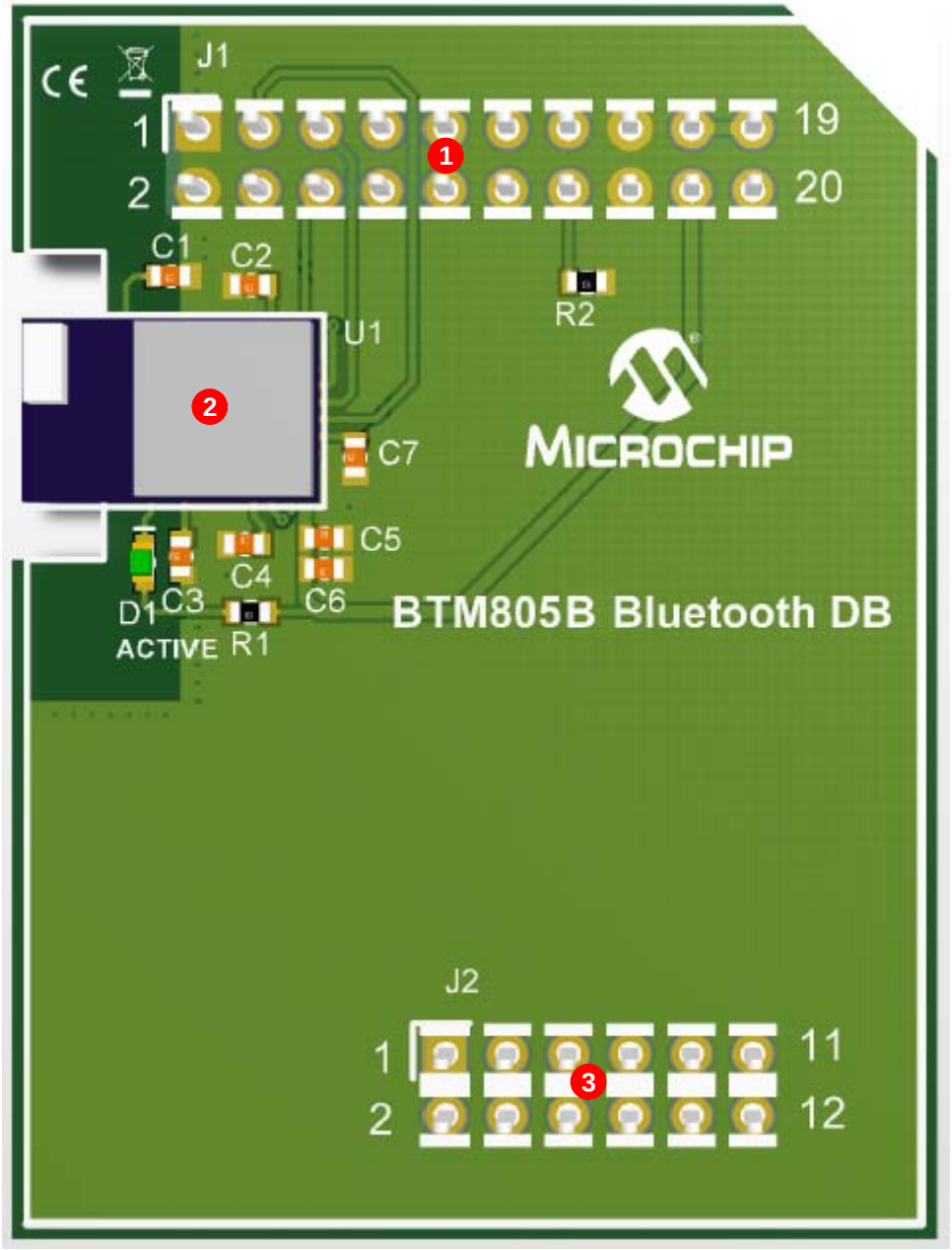
The Bluetooth HCI Radio Module Daughter Board (BTM805B) (P/N: AC320032-1) has the following key features, as indicated by the corresponding number in Figure 1-4:

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

> **Note:** Microchip may support other Bluetooth wireless solutions in this modular design. Please contact your local Microchip sales office for additional information.

3. Female 12-pin dual-row header (J2).

FIGURE 1-4: BLUETOOTH DAUGHTER BOARD LAYOUT (TOP VIEW)

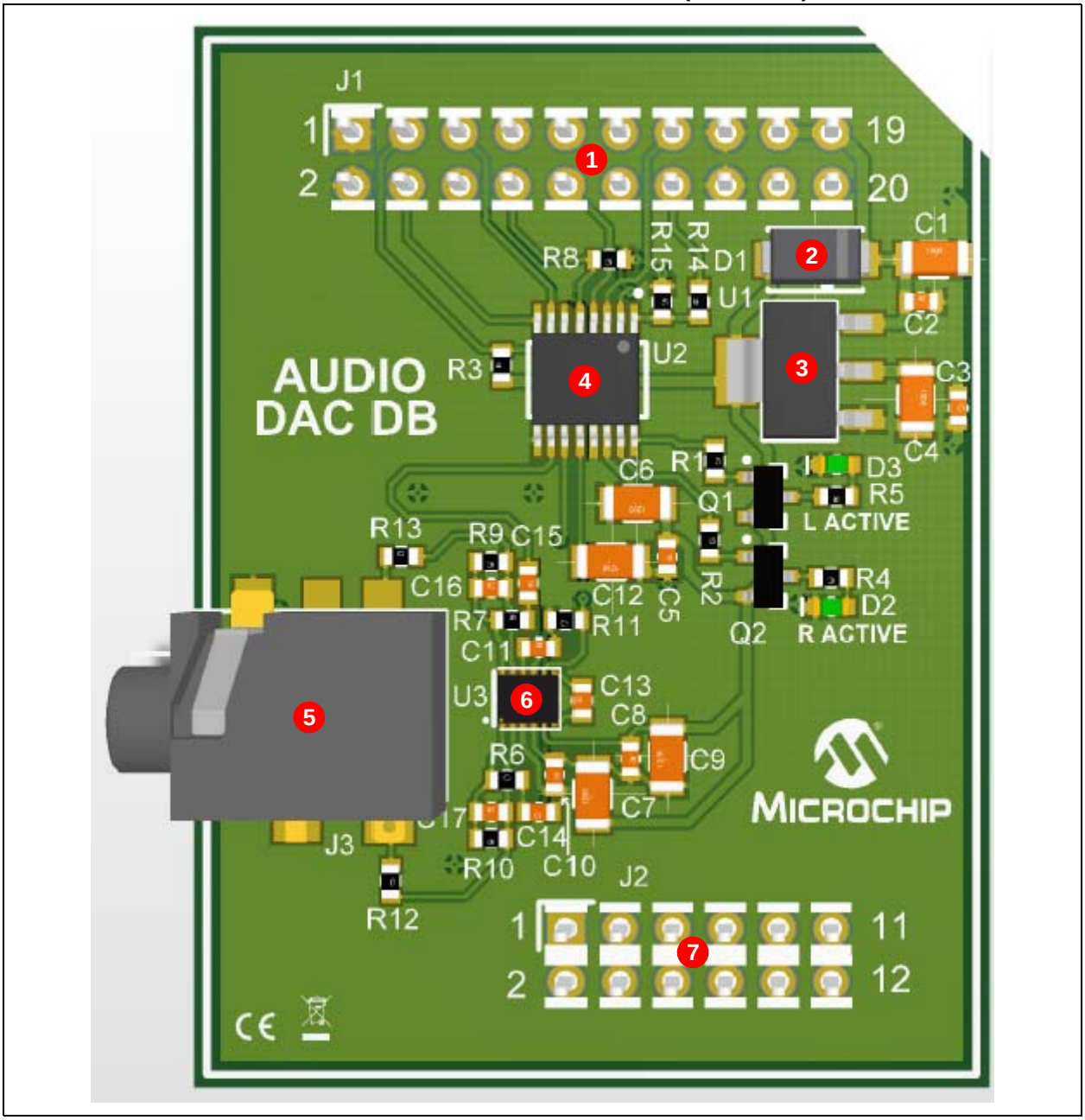


1.7 AUDIO DAC DAUGHTER BOARD FUNCTIONALITY AND FEATURES

The Audio DAC/AMP Daughter Board (P/N: AC320032-2) has the following key features, as indicated by the corresponding number in Figure 1-5:

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 1-5: AUDIO DAC DAUGHTER BOARD LAYOUT (TOP VIEW)



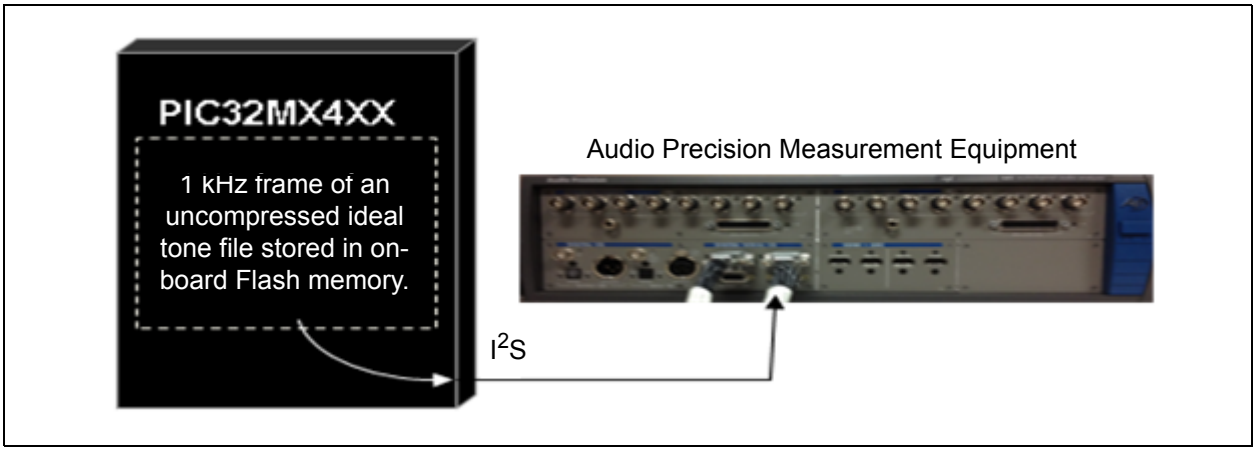
NOTES:

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 provides 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 I²S 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.

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

Table 2-2 provides 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

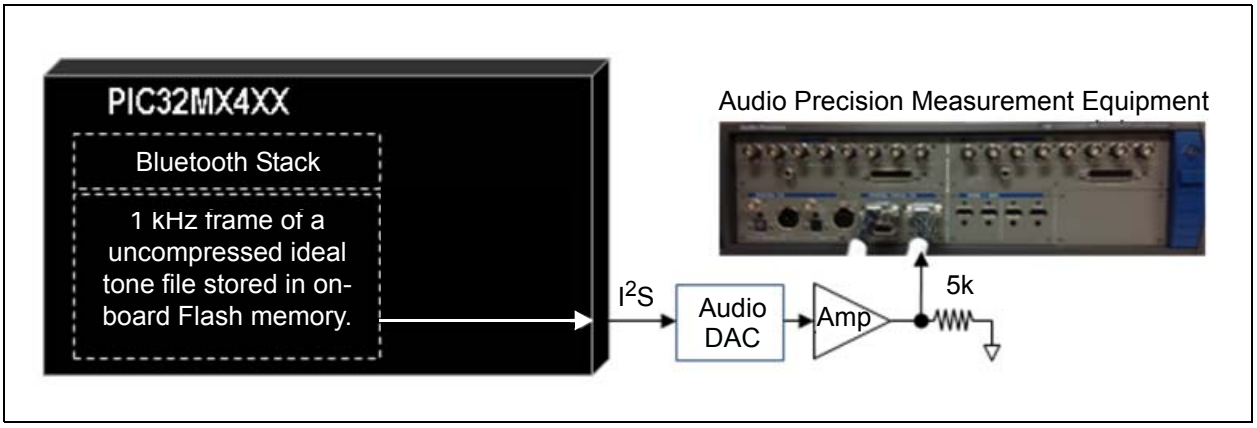


TABLE 2-2: THD+N RAW UNCOMPRESSED PIC32 TO ANALOG AMPLIFIER

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)

Table 2-3 provides 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

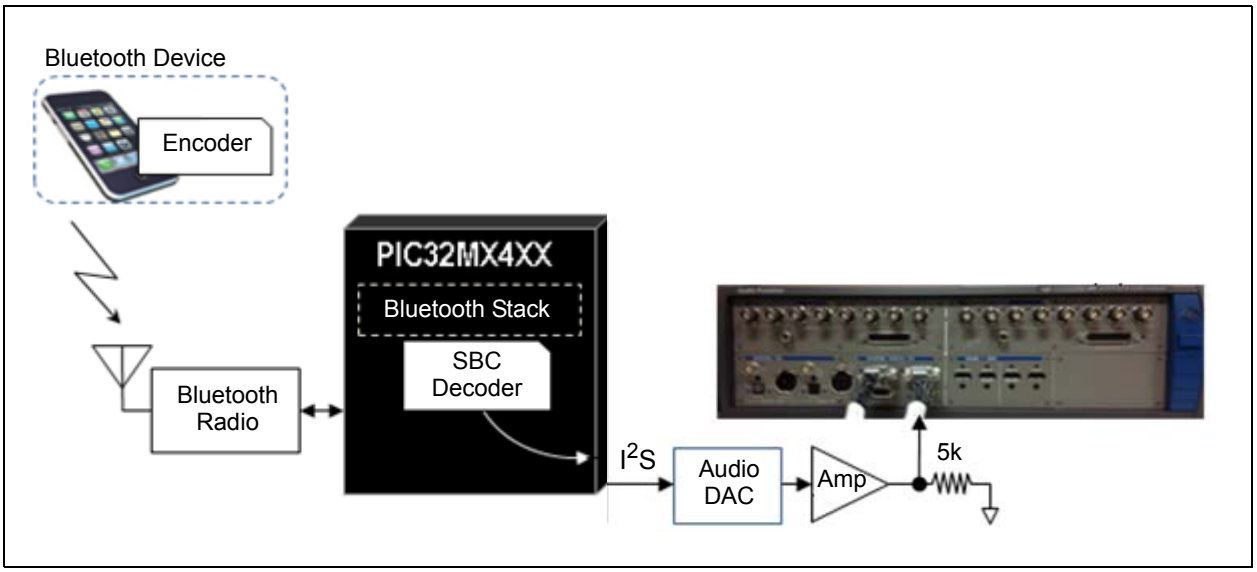


TABLE 2-3: TOTAL SYSTEM THD+N COMPRESSED SMARTPHONE TO PIC32 SBC DECODER TO ANALOG AMPLIFIER

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).

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
	iPad 2	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

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

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

3.3 BLUETOOTH AVRCP FUNCTIONS

Bluetooth devices, which include PCs, audio players, tablets, and cellular phones, continue to evolve. In addition to the Bluetooth driver functions and hardware, differing third-party applications tend to handle the API differently. Even though it appears to be the same operating system and version number (e.g., Android v4.3), different manufacturers have applied support for some functions uniquely.

The problem with this is that identical Bluetooth profile functions provided to different systems may return very different results. These functions may also differ between how the handset device uses the function, and how the Bluetooth equivalent command is interpreted by that same device. This may cause some confusion for users.

For example, the *Fast Forward* function on an Apple iPhone generally will start slowly, and then non-linearly accelerate through the existing track while playing some audio at selected intervals. The *Fast Forward* function will then stop and play as the track is changed, and ignore the Fast Forward button until removed and then pressed again. For those not familiar, this could make for some frustration as each track will essentially require the user to start fast forwarding (and accelerate) through the track again to search in this method.

However, on an Android v4.3-based cellular phone from Samsung, the *Fast Forward* function will appear to work differently. It will start to accelerate through the current track faster than the Apple iPhone, and it will do so linearly. As it reaches the end of the track, it will likely do so at maximum fast forward speed (generally 16x), and continue fast forwarding through the next track. It will ignore the track change other than providing AVRCP track change information. This functionality can make it difficult to stop at the entry point to the next track.

Still different is an Android v4.3 based cellular phone from LG, where on the handset the Fast Forward function is like other Android devices. However, while other AVRCP functions (i.e., *Play*/*Pause*, *Next Track*/*Previous Track*, etc.) work as expected, the system will ignore the *Fast Forward* and *Rewind* functions entirely. In this case, the handset will continue to play as if no command is sent. This could create some additional confusion for users as from their perspective, the handset works and the demonstration software appears to be non-functional.

Other differences between smartphone operating systems can be seen in the track information, progress bar, progress time, and connection operations. Where possible, the differences have been mitigated in software; however, users will still see functional differences.

To resolve some of these issues, a number of compile-time selections are now offered to help refine the button functions on the PIC32 Bluetooth Audio Development Kit. Note that these selections will not change the functionality as observed directly on the handset, so the user may see differences. These options generally apply to the *Fast Forward* and *Rewind* functions, and include both the Apple and Samsung usage models listed previously, as well as some other customer requests. The details of these options are included in the demonstration button descriptions.

Chapter 4. Bluetooth Audio Demonstrations

This chapter provides an overview of the demonstrations that are available for the PIC32 Bluetooth Audio Development Kit. For information about our software, including free versions, documentation, and system architecture details, please visit: www.microchip.com/pic32btsuites

4.1 DEMONSTRATIONS, HEX FILES, AND VOICE PROMPT PROGRAMMER (FREE-OF-CHARGE)

BT Data Demo 4

This demonstration is offered free-of-charge. This is a SPP data demonstration only, which provides no USB audio support and has a special Bluetooth stack for duplex data transmission.

Detailed information on configuring and running this demonstration is available in the related “ReadMe” file that accompanies the demonstration.

Hexadecimal Files

Hex files for all demonstrations are available as binary codes only.

Voice Prompt Programmer

This free utility can be used to install voice prompts and other data in the external Flash memory.

4.2 DEMONSTRATION SUITES (FOR A FEE)

Three demonstration software suites are offered for purchase from microchipDIRECT. Detailed information on configuring and running each demonstration is available in the related “ReadMe” files that accompany each demonstration.

PIC32 Bluetooth Audio Software Suite 1 (SW320014-1)

http://www.microchipdirect.com/ProductSearch.aspx?Keywords=SW320014-1

Suite 1 offers SBC Bluetooth audio and additional features and includes:

- BT USB Audio Demo 2.5
- BT Audio Demo 5
- BT Audio Demo 7
- BT USB Audio Demo 8
- BT Audio Demo 11

PIC32 Bluetooth Audio Software Suite 2 (SW320014-2)

http://www.microchipdirect.com/ProductSearch.aspx?Keywords=SW320014-2

Suite 2 offers AAC Bluetooth audio and additional features. The following demonstrations are offered in addition to *all* demonstrations offered in Suite 1:

- BT Audio Demo 3
- BT USB Audio Demo 6

PIC32 Bluetooth Audio Software Suite 3 (SW320014-3)

> **Note:** Contact Microchip marketing or your local sales office for purchase and license information.

This software suite offers Bluetooth multi-connection “Break-In” demonstrations. The following demonstrations are offered in addition to *all* demonstrations offered in Suite 1:

- BT Audio Demo 9
- BT USB Audio Demo 10

4.3 DEMONSTRATION SUITES AND RESOURCE REQUIREMENTS

Brief descriptions and resource requirements are provided for the v1.0.3, v2.0, and v3.0 demonstrations in the following three tables. In addition, a features map is provided in Table 4-4,

Table 4-1 lists the available v1.0.3 Bluetooth Audio Demonstrations (RTOS version) and their resource requirements.

TABLE 4-1: V1.0.3 DEMONSTRATIONS AND RESOURCE REQUIREMENTS (RTOS VERSION)

Demonstration Name	Description	Resource Requirement		Peak MIPS (See Note 3)	Comment
		Flash (KB)	RAM (KB)		
BT USB 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	49	~30	No Apple USB audio support.
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	51	~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	14	~8	Bluetooth data transport only.
BT Audio Demo 5	Bluetooth Stack (A2DP+AVRCP+SPP+SBC decoder) + Graphics. See **Note 1**.	182	41	~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 → I^2S Audio Out Latency = 1.8 ms.

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

Table 4-2 lists the available v2.0 Bluetooth Audio Demonstrations (non-RTOS version) and their resource requirements.

TABLE 4-2: V2.0 DEMONSTRATIONS AND RESOURCE REQUIREMENTS (NON-RTOS VERSION)

Demonstration Name	Description	Resource Requirement		Peak MIPS (See Note 3)	Comment
		Flash (KB)	RAM (KB)		
BT USB 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.	208	40.5	~30	No Apple USB audio support.
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**.	247	33.1	~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**.	94	4.8	~8	Bluetooth data transport only.
BT Audio Demo 5	Bluetooth Stack (A2DP+AVRCP+SPP+SBC decoder) + Graphics. See **Note 1**.	185	32.8	~30	Bluetooth audio only; no USB support.
BT USB Audio Demo 6	Bluetooth Stack (A2DP+AVRCP+SPP+AAC) + Android Open Accessory audio Type-A USB connection support and Samsung audio with mini-B USB connection support. This demonstration uses the higher quality AAC audio decoder in place of the SBC decoder. See **Notes 1 and 2**.	269	40.9	~65	No Apple USB audio support.
BT Audio Demo 7	Bluetooth Stack (A2DP+AVRCP+SPP+SBC decoder) + Graphic Equalizer + User GUI. This demonstration adds additional user GUI functionality with menus to adjust gain and observe real-time frequency-band feedback. See **Note 1**.	247	50.2	~90	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 → I^2S Audio Out Latency = 1.8 ms.

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

Table 4-3 lists the available v3.0 Bluetooth Audio Demonstrations (non-RTOS version) and their resource requirements.

TABLE 4-3: V3.0 DEMONSTRATIONS AND RESOURCE REQUIREMENTS (NON-RTOS VERSION)

Demonstration Name	Description	Resource Requirement		Peak MIPS (See Note 3)	Comment
		Flash (KB)	RAM (KB)		
BT USB 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**.	271.7	38.8	~30	Bluetooth /USB audio support.
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.	251.5	34.9	~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**.	139.6	7.12	~8	Bluetooth data transport only.
BT Audio Demo 5	Bluetooth Stack (A2DP+AVRCP+SPP+SBC decoder) + Graphics. See **Note 1**.	190.5	34.6	~30	Bluetooth audio only; no USB support.
BT USB Audio Demo 6	Bluetooth Stack (A2DP+AVRCP+SPP+AAC) + Android Open Accessory audio Type-A USB connection support and Samsung audio with mini-B USB connection support. This demonstration uses the higher quality AAC audio decoder in place of the SBC decoder. See **Notes 1 and 2**.	332.7	39.7	~65	Bluetooth /USB audio support.
BT Audio Demo 7	Bluetooth Stack (A2DP+AVRCP+SPP+SBC decoder) + Graphic Equalizer + User GUI. This demonstration adds additional user GUI functionality with menus to adjust gain and observe real-time frequency-band feedback. See **Note 1**.	247	50.2	~90	Bluetooth audio only; no USB support.
BT USB Audio Demo 8	Bluetooth Stack (A2DP+AVRCP+SPP+SBC) +Graphic Equalizer +User GUI Android Open Accessory audio Type-A USB connection support and Samsung audio with mini-B USB connection support. See **Notes 1 and 2**.	255.1	39.42	~90	Bluetooth/USB audio support. Graphic equalizer support.
BT Audio Demo 9	Bluetooth Stack (A2DP+AVRCP+SPP+SBC decoder) + Graphic. This demonstration adds additional user Break-in/Party mode.	203	46.34	~30	Bluetooth audio only; no USB support.
BT USB Audio Demo 10	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.**	203	46.34	~30	Bluetooth/USB audio support
BT Audio Demo 11	Bluetooth Stack (A2DP+AVRCP+SPP+SBC decoder) + Graphics. This demonstration adds additional duplex transmission of data using SPP during audio playback.	215.2	35.7	~38	Bluetooth audio and data transmission support.

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

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

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

Table 4-4 lists the features that are included in each of the demonstrations.

TABLE 4-4: DEMONSTRATION FEATURES MAP

Demonstration Name	Bluetooth Audio	Bluetooth Data	AAC	USB Apple Audio	USB Android/ Samsung Audio	Graphic Equalizer	Volume Sync	Break-in/ Party Mode
BT USB Audio Demo 2.5	X	—	—	—	X	—	X	—
BT USB Audio Demo 2.5A	X	—	—	X	X	—	—	—
BT Audio Demo 3	X	—	X	—	—	—	X	—
BT Audio Demo 4	—	X	—	—	—	—	—	—
BT Audio Demo 5	X	—	—	—	—	—	X	—
BT USB Audio Demo 6	X	—	X	—	X	—	X	—
BT USB Audio Demo 6A	X	—	X	X	X	—	X	—
BT Audio Demo 7	X	—	—	—	—	X	X	—
BT USB Audio Demo 8	X	—	—	—	X	X	X	—
BT USB Audio Demo 8A	X	—	—	X	X	X	X	—
BT Audio Demo 9	X	—	—	—	—	—	X	X
BT USB Audio Demo 10	X	—	—	—	X	—	X	X
BT Audio Demo 11	X	X	—	—	—	—	X	—

4.4 DEMONSTRATION OVERVIEWS

4.4.1 Bluetooth/USB Audio Demonstration 2.5 with SBC

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

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

The Bluetooth/USB Audio Demonstration 2.5 with SBC supports three types of streaming audio:

- Streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device
- 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. For Apple devices, see the following **Note**.
- 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

Note: The USB audio support feature for Apple 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 as 2.5A. See **1.1.1 "Bluetooth Demonstrations"** in **Chapter 1. "Introduction"** for more information.

4.4.2 Bluetooth Audio Demonstration 3 with AAC

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

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

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 in place of 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. The demonstration uses the advanced AAC audio software codec in place of the default SBC decoder for handsets that support AAC via Bluetooth. For devices that do not support the AAC codec, the SBC codec is used.

4.4.3 Bluetooth Data Demonstration 4 with SPP

Note: This demonstration does not support data transfer from an Apple iPhone application.

Bluetooth data support only. Bluetooth Stack with SPP profile.

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

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 the 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 menu.

4.4.4 Bluetooth Audio Demonstration 5 with SBC

Bluetooth audio only support (A2DP + AVRCP + SBC decoder).

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

This non-USB audio demonstration supports streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device.

4.4.5 Bluetooth/USB Audio Demonstration 6 with AAC

Bluetooth Stack (A2DP + AVRCP + AAC/SBC decoder) with Android Open Accessory audio Type-A USB connection support plus Samsung audio with mini-B USB connection support (see **Note 1**).

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

This Bluetooth/USB Audio Demonstration 6 with AAC supports three types of streaming audio:

- Streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device. This includes the addition of a higher quality AAC software audio codec in place of the default SBC audio decoder. AAC stands for Advanced Audio Coding and generally achieves better sound quality than MP3 at similar bit rates. For devices that do not support the AAC codec, the SBC codec is used.
- 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. For Apple devices, refer to **Note 2**.
- 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

Note 1: The Bluetooth/USB Audio Demonstration 6 will operate on the PIC32MX470F512L device. This device is required for Demonstration 6, which incorporates the AAC decoder in addition to Bluetooth SBC and USB audio functions.

2: The USB audio support for Apple is a superset of Bluetooth/USB Audio Demonstration 6. It supports all of the same features as Demonstration 6 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 as 6A. See **1.1.1 "Bluetooth Demonstrations"** in **Chapter 1. "Introduction"** for more information.

4.4.6 Bluetooth Audio Demonstration 7 with SBC and EQ

Bluetooth audio only (A2DP + AVRCP + SBC decoder + integrated Graphic Equalizer).

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

This non-USB audio demonstration supports streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device.

This demonstration enables the real-time output of a 2-channel 6-band graphic equalizer function. The function is supported with new user input modes to set the gain stages, integrated digital filtering, and display of the quantized per-frequency-band magnitude.

4.4.7 Bluetooth/USB Audio Demonstration 8 with SBC

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

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

This Bluetooth/USB Audio Demonstration 8 supports three types of streaming audio:

- Streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device. For Apple devices, refer to the following **Note**.
- 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
- 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

Note: The USB audio support for Apple is a superset of Bluetooth/USB Audio Demonstration 8. It supports all of the same features as demonstration 8 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 as 8A. See **1.1.1 "Bluetooth Demonstrations"** in **Chapter 1. "Introduction"** for more information.

4.4.8 Bluetooth Audio Demonstration 9 With SBC and Break-In/Party mode

Bluetooth audio only support (A2DP + AVRCP + SBC decoder) + Break-in mode.

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

This non-USB audio demonstration supports streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device.

This demonstration also supports multiple mobile connections to a single bluetooth device at the same instance. This demonstration allows users to stream audio in Break-in/Party mode.

4.4.9 Bluetooth/USB Audio Demonstration 10 With SBC and Break-In/Party Mode

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

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

This Bluetooth/USB Audio Demonstration 10 supports three types of streaming audio:

- Streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device
- 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. This demonstration also supports multiple mobile connections to a single Bluetooth device at the same time and allows users to stream audio in Break-in/Party mode.
- 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

4.4.10 Bluetooth Audio Demonstration 11 With SBC and SPP

Bluetooth audio only support (A2DP + AVRCP + SPP + SBC decoder).

Refer to Table 3-1 in **Chapter 3. "Interoperability Testing Results"** for the list of tested Bluetooth-enabled devices.

This non-USB audio demonstration supports streaming wireless Bluetooth audio from any smartphone (i.e., Apple, Samsung, Google, etc.), PC, or Bluetooth-enabled device.

SPP communication is enabled between Bluetooth device and mobile handset for data communication during audio playback. A means of bidirectional data transfer is provided in this demonstration as an example of communication. This communication can be modified to provide any data transfer means needed by an application. In the case of the demonstration application, a means of observation is provided by exchanging some text strings both to and from the handset.

SPP and audio communications are simultaneous but on different channels. A single handset (smart phone) can establish both channels to enable control while streaming music.

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:

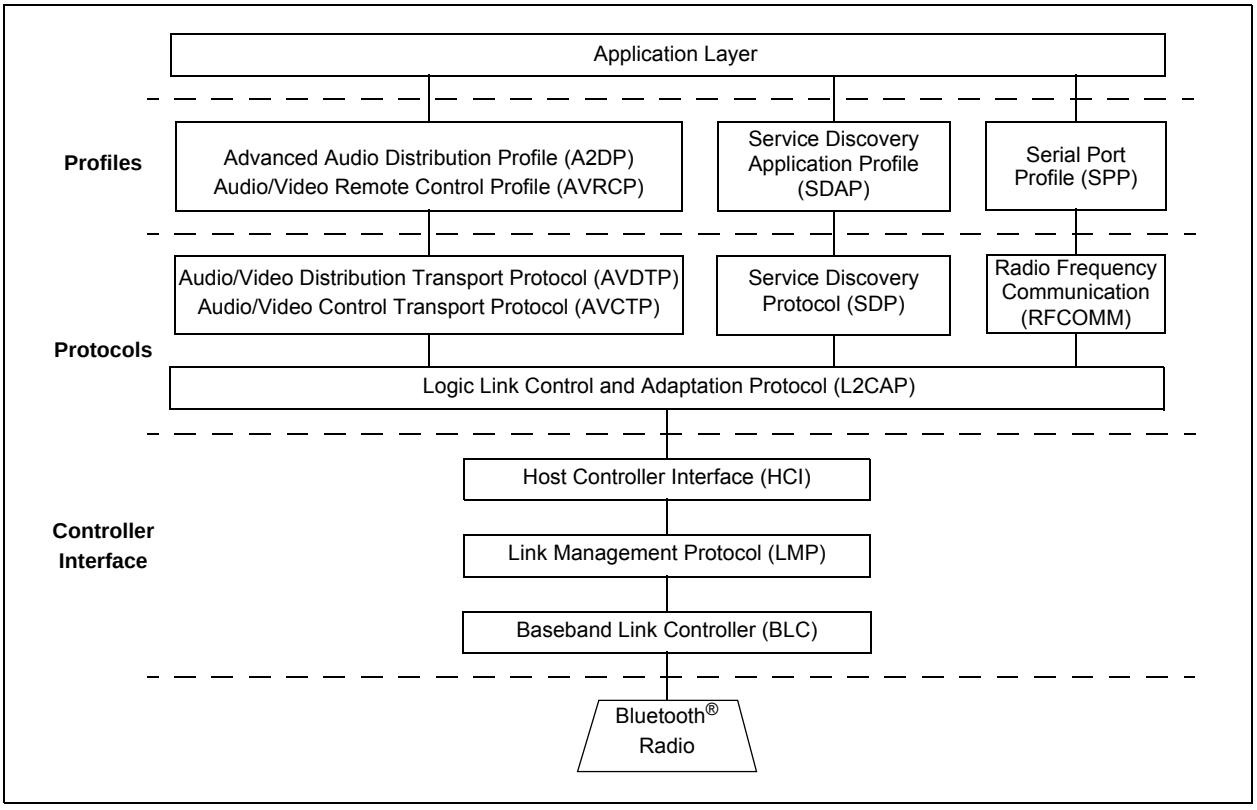
- **5.1 "Bluetooth Stack Block Diagram"**
- **5.2 "Bluetooth Stack Component Summary"**

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 (as of v2.0)
AD2DP	1.3
AVRCP	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. Hardware, Board Layout, and Schematics

A.1 WIRE LIST

TABLE A-1: DEVELOPMENT KIT WIRE LIST

100-pin PIC32MX450/470 Pin Number	44-pin PIC32MX270F256 PIM Pin Number	PIC32MX450/470 Pin Name	Connectors						Schematic Signal Name
			Audio DAC		HCI Bluetooth Module		PICtail Plus Connector J4 Pin Out	Gesture/Apple I^2S Port I2C2 Connector J12 (7-pin)	
			CONN_J9 (20-pin)	CONN_J10 (12-Pin)	CONN_J8 (20-pin)	CONN_J11 (12-pin)			
1	25	RG15	8	—	8	—	—	—	GPIO_12/STBY/RST
2	—	VDD	18	—	18	—	21, 22, 53, 54, 107, 108	7	3.3v_DIG
3	—	PMD5/RE5	—	—	—	—	—	—	LCD1_DB5
4	—	PMD6/RE6	—	—	—	—	—	—	LCD1_DB6
5	—	PMD7/RE7	—	—	—	—	—	—	LCD1_DB7
6	—	RPC1/RC1	—	—	—	—	—	—	LCD1_RESET
7	—	RPC2/RC2	—	1	10	—	—	—	GPIO_24/I2S2_LRCL
8	—	RPC3/RC3	—	—	—	—	13, 14	—	ACC_ID_SEL
9	—	RPC4/RC4	—	—	—	—	—	4	GPIO_17
10	15	AN16/RPG6/SCK2/RG6	—	3	12	—	—	—	GPIO_22/I2S2_BCLK
11	11	AN17/RPG7/RG7	—	5	11	—	—	—	GPIO_27/SPI2_SDI
12	34	AN18/RPG5/RG8	—	7	13	—	—	—	GPIO_25/I2S2_SDO
13	18	$\overline{MCLR}$	—	—	—	—	—	5	PIC32_MCLR#
14	5	AN19/RPG9/RG9	—	—	6	—	—	—	GPIO_21/UART2_RTS
15	6	VSS	1, 2, 15, 16	11, 12	1, 2, 15, 16	11, 12	—	—	DGND
16	10	VDD	18	—	18	—	21, 22, 53, 54, 107, 108	7	3.3v_DIG
17	23	RA0	—	—	—	—	—	—	SW1#
18	—	RPE8/RE8	—	6	—	—	—	—	GPIO_15/SS2#
19	—	RPE9/RE9	—	—	—	—	17	—	SELECT
20	—	AN5/RPB5/RB5	—	—	—	4	—	—	GPIO_29/AN(e)
21	—	AN4/RB4	—	—	—	—	18	—	ACC_PWR
22	—	AN3/RPB3/RB3	—	8	—	—	—	—	GPIO_16/AN(c)
23	36	AN2/RPB2/RB2	—	—	4	8	—	—	GPIO_20/UART2_CTS
24	—	AN1/RPB1/RB1	—	—	—	—	11	—	OVERCURRENT
25	—	AN0/RPB0/RB0	—	—	—	6	—	—	GPIO_30/SS1#
26	13	PGEC2/RB6	—	—	—	—	—	—	PGEC2
27	12	PGED2/RB7	—	—	—	—	—	—	PGED2
28	i2ce -16	RA9	—	—	—	—	—	—	LED5#
29	38	RA10	—	—	—	—	—	—	SW3#
30	17	AVDD	18	—	18	—	—	7	3.3v_DIG
31	16	AVSS	1, 2, 15, 16	11, 12	1, 2, 15, 16	11, 12	—	1	DGND
32	—	AN8/RPB8/RB8	—	2	—	—	—	—	GPIO_13/AN(a)
33	—	AN9/RPB9/RB9	—	4	—	—	—	—	GPIO_14/AN(b)
34		AN10/RPB10/RB10	—	—	—	8	—	—	GPIO_31/AN(f)
35	19	AN11/RB11	—	—	—	—	—	—	VOLUME

TABLE A-1: DEVELOPMENT KIT WIRE LIST

100-pin PIC32MX450/470 Pin Number	44-pin PIC32MX270F256 PIM Pin Number	PIC32MX450/470 Pin Name	Connectors						Schematic Signal Name
			Audio DAC		HCI Bluetooth Module		PICtail Plus Connector J4 Pin Out	Gesture/Apple I2S Port I2C2 Connector J12 (7-pin)	
			CONN_J9 (20-pin)	CONN_J10 (12-Pin)	CONN_J8 (20-pin)	CONN_J11 (12-pin)			
36	29	VSS	1, 2, 15, 16	11, 12	1, 2, 15, 16	11, 12	—	1	DGND
37	28	VDD	18	—	18	—	21, 22, 53, 54, 107, 108	7	3.3v_DIG
38	24	RA1	—	—	—	—	—	—	SW2#
39	—	RPF13/RF13	—	—	—	—	2	—	U4RX
40	—	RPF12/RF12	—	—	—	—	4	—	U4TX
41	43	AN12/RB12	—	—	—	—	—	—	SW4#
42	41	AN13RB13	—	—	—	—	—	—	SW5#
43		AN14/RB14	—	—	—	—	—	—	USB_SEL#
44		PMPA0/RB15	—	—	—	—	—	—	LCD1_D/C#
45	39	VSS	1, 2, 15, 16	11, 12	1, 2, 15, 16	11, 12	—	1	DGND
46	40	VDD	18	—	18	—	21, 22, 53, 54, 107, 108	7	3.3v_DIG
47	—	RPD14/RD14	—	—	—	—	19	—	C_RESET
48	—	RPD15/RD15	—	—	—	—	20	—	IPOD_DETECT
49	—	RPF4/RF4	—	—	3	—	—	—	GPIO_18/UART2_RX
50	37	RPF5/RF5	—	—	5	—	—	—	GPIO_19/UART2_TX
51	—	USBID/RF3	—	—	—	2	—	—	GPIO_28/AN(d)
52	21	RPF2/RF2	—	—	—	—	—	—	FLASH_CS#
53	26	RPF8/RF8	14	—	14	—	—	—	GPIO_5/I2S1_MCLK
54	—	VBUS	—	—	—	—	—	6	5V_SW_DIG
55	—	VUSB3V3	—	—	—	—	—	7	3.3V_DIG
56	9	D-/RG3	—	—	—	—	—	—	PIC32_D-
57	8	D+/RG2	—	—	—	—	—	—	PIC32_D+
58	—	SCL2/RA2	—	—	7	—	6	2	GPIO_23/I2C2_SCL
59	—	SDA2/RA3	—	—	9	—	8	3	GPIO_26/I2C2_SDA
60	i2ce -12	RA4	—	—	—	—	—	—	LED1#
61	i2ce -13	RA5	—	—	—	—	—	—	LED2#
62	—	VDD	18	—	18	—	21, 22, 53, 54, 107,108	7	3.3V_DIG
63	30	OSC1	—	—	—	—	—	—	XTAL (8 MHz)
64	31	OSC2	—	—	—	—	—	—	XTAL (8 MHz)
65	—	VSS	1, 2, 15, 16	11, 12	1, 2, 15, 16	11, 12	—	1	DGND
66	44	SCL1/RPA14/RA14	7	—	—	—	—	—	GPIO_7/I2C1_SCL
67	1	SDA1/RPA15/RA15	9	—	—	—	—	—	GPIO_10/I2C1_SDA
68	—	RPD8/RD8		—	—	—	—	—	ALERT#
69	33	RPD9/RD9	10	—	—	1	—	—	GPIO_8/I2S1_LRCL
70	14	RPD10/SCK1/RD10	12	—	—	3	—	—	GPIO_6/I2S1_BCLK
71	—	PMCS1/RD11		—	—	—	—	—	LCD1_CS#
72	35	RPD0/INT0/RD0	13	—	—	7	—	—	GPIO_9/I2S1_SDO
73	—	RPC13/RC13	11	—	—	5	—	—	GPIO_11/SPI1_SDI
74	—	RPC14/RC14	—	—	—	—	65	—	IPOD_VBUS
75	—	VSS	1, 2, 15, 16	11, 12	1, 2, 15, 16	11, 12	—	1	DGND
76	27	AN24/RPD1/RD1	6	—	—	—	—	—	GPIO_4/UART1_RTS
77	2	AN25/RPD2/RD2	3	—	—	—	—	—	GPIO_1/UART1_Rx
78	3	AN26/RPD3/RD3	5	—	—	—	—	—	GPIO_2/UART1_Tx
79	22	RPD12/RD12	4	—	—	—	—	—	GPIO_3/UART1_CTS
80	20	RD13	—	—	—	—	—	—	VBUS_SENSE

TABLE A-1: DEVELOPMENT KIT WIRE LIST

100-pin PIC32MX450/470 Pin Number	44-pin PIC32MX270F256 PIM Pin Number	PIC32MX450/470 Pin Name	Connectors						Schematic Signal Name
			Audio DAC		HCI Bluetooth Module		PICtail Plus Connector J4 Pin Out	Gesture/Apple I^2S Port I2C2 Connector J12 (7-pin)	
			CONN_J9 (20-pin)	CONN_J10 (12-Pin)	CONN_J8 (20-pin)	CONN_J11 (12-pin)			
81	—	PMWR/RD4	—	—	—	—	—	—	LCD1_WR#
82	—	PMRD/RD5	—	—	—	—	—	—	LCD1_RD#
83	32	RPD6/RD6	—	—	—	—	—	—	A_DET#
84	i2ce -19	RPD7/RD7	—	—	—	—	—	—	GPIO_32
85	—	VCAP	—	—	—	—	—	—	10 µF/0.1 µF Caps Only
86	—	VDD	18	—	18	—	21, 22, 53, 54, 107, 108	7	3.3v_DIG
87	—	RPF0/RF0	—	9	—	—	—	—	GPIO_33/PD1#
88	—	RPF1/RF1	—	—	—	—	—	—	GPIO_34/PD2#
89	i2ce -17	RPG1/RG1	—	—	—	—	—	—	USB_SEL1
90	i2ce -18	RPG0/RG0	—	—	—	—	—	—	USB_SEL0
91	i2ce -14	RA6	—	—	—	—	—	—	LED3#
92	i2ce -15	RA7	—	—	—	—	—	—	LED4#
93	—	PMD0/RE0	—	—	—	—	—	—	LCD1_DB0
94	—	PMD1/RE1	—	—	—	—	—	—	LCD1_DB1
95	—	RG14	—	—	—	—	—	—	USB_ACC#
96	—	RG12	—	—	—	—	—	—	USB_MINI_B#
97	—	RG13	—	—	—	—	—	—	USB_TYPE_A#
98	—	PMD2/RE2	—	—	—	—	—	—	LCD1_DB2
99	—	PMD3/RE3	—	—	—	—	—	—	LCD1_DB3
100	—	PMD4/RE4	—	—	—	—	—	—	LCD1_DB4
—	—	—	—	—	—	—	29, 62	—	ACC_D-
—	—	—	—	—	—	—	27, 60	—	ACC_D+
—	—	—	20	—	20	—	—	6	5V_SW_DIG
—	—	—	17, 19	—	17, 19	—	—	—	Power
—	—	—	1, 2, 15, 16	—	1, 2, 15, 16	—	—	1	DGND
—	—	—		—	—	—	25, 26, 57, 58	—	ACC_+9V

A.2 DAUGHTER BOARD PIN MAPPING

TABLE A-2: DAUGHTER BOARD PIN MAPPING

Audio DAC Daughter Board			
Pin Name	Pin Number		Pin Name
DGND	1	2	DGND
GPIO_1/UART1_Rx	3	4	GPIO_3/UART1_CTS
GPIO_2/UART1_Tx	5	6	GPIO_4/UART1_RTS
GPIO_7/I2C1_SCL	7	8	GPIO_12/STBY/RST
GPIO_10/I2C1_SDA	9	10	GPIO_8/I2S1_LRCL
GPIO_11/SPI1_SDI	11	12	GPIO_6/I2S1_BCLK
GPIO_9/I2S1_SDO	13	14	GPIO_5/I2S1_MCLK
DGND	15	16	DGND
Power	17	18	3.3V_DIG
Power	19	20	5V_SW_DIG

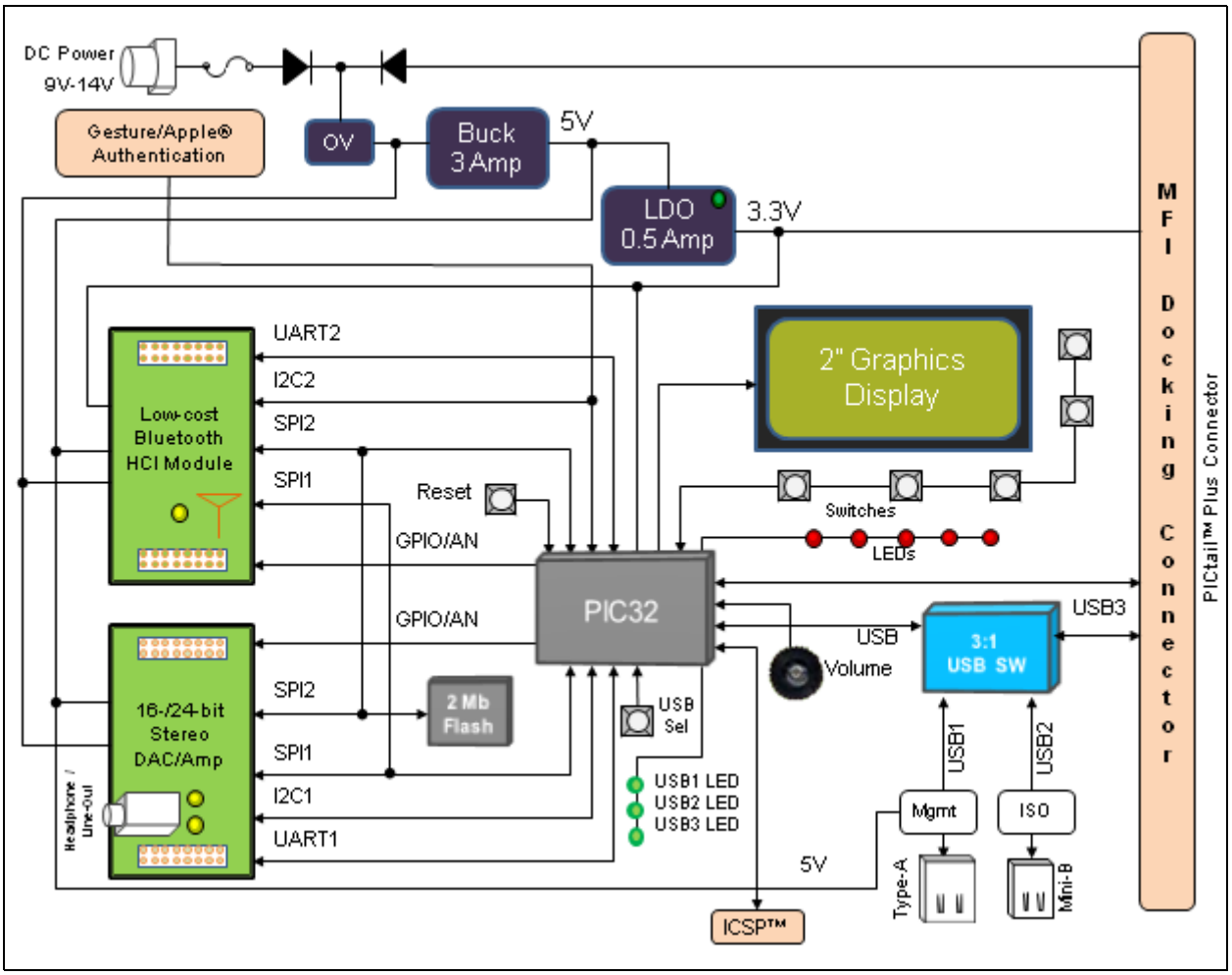
BTM805 Bluetooth Daughter Board			
Pin Name	Pin Number		Pin Name
DGND	1	2	DGND
GPIO_18/UART2_RX	3	4	GPIO_20/UART2_CTS
GPIO_19/UART2_TX	5	6	GPIO_21/UART2_RTS
GPIO_23/I2C2_SCL	7	8	GPIO_12/STBY/RST
GPIO_26/I2C2_SDA	9	10	GPIO_24/I2S2_LRCL
GPIO_27/SPI2_SDI	11	12	GPIO_22/I2S2_BCLK
GPIO_25/I2S2_SDO	13	14	GPIO_5/I2S1_MCLK
DGND	15	16	DGND
Power	17	18	3.3V_DIG
Power	19	20	5V_SW_DIG

GPIO_24/I2S2_LRCL	1	2	GPIO_13/AN(a)
GPIO_22/I2S2_BCLK	3	4	GPIO_14/AN(b)
GPIO_27/SPI2_SDI	5	6	GPIO_15/SS2#
GPIO_25/I2S2_SDO	7	8	GPIO_16/AN(c)
PD1#	9	10	NC
AGND	11	12	AGND

GPIO_8/I2S1_LRCL	1	2	GPIO_28/AN(d)
GPIO_6/I2S1_BCLK	3	4	GPIO_29/AN(e)
GPIO_11/SPI1_SDI	5	6	GPIO_30/SS#1
GPIO_9/I2S1_SDO	7	8	GPIO_31/AN(f)
PD2#	9	10	NC
AGND	11	12	AGND

A.3 BLOCK DIAGRAM

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



A.4 BOARD LAYOUT

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

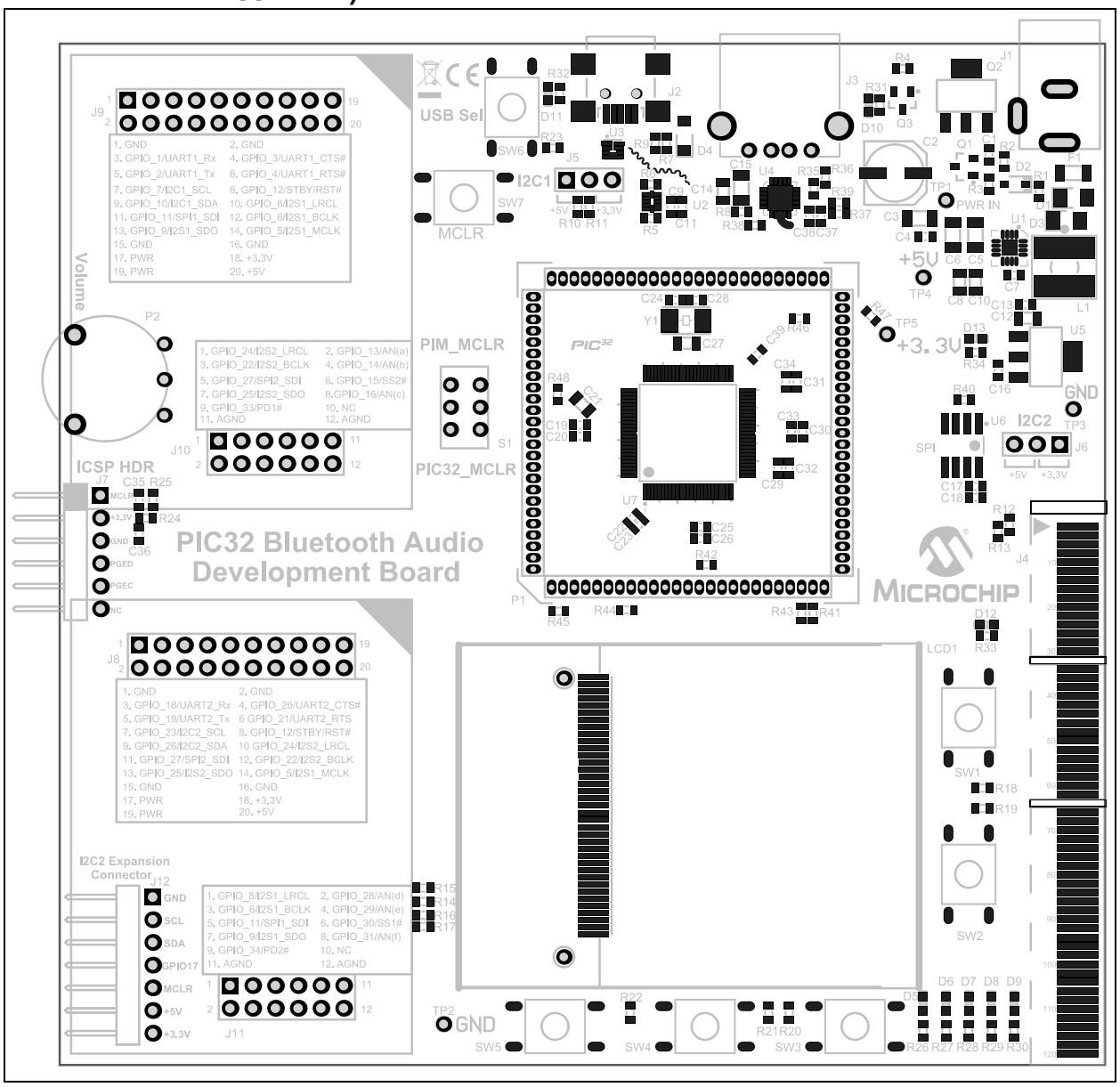


FIGURE A-3: BLUETOOTH HCI RADIO MODULE DAUGHTER BOARD LAYOUT (TOP ASSEMBLY)

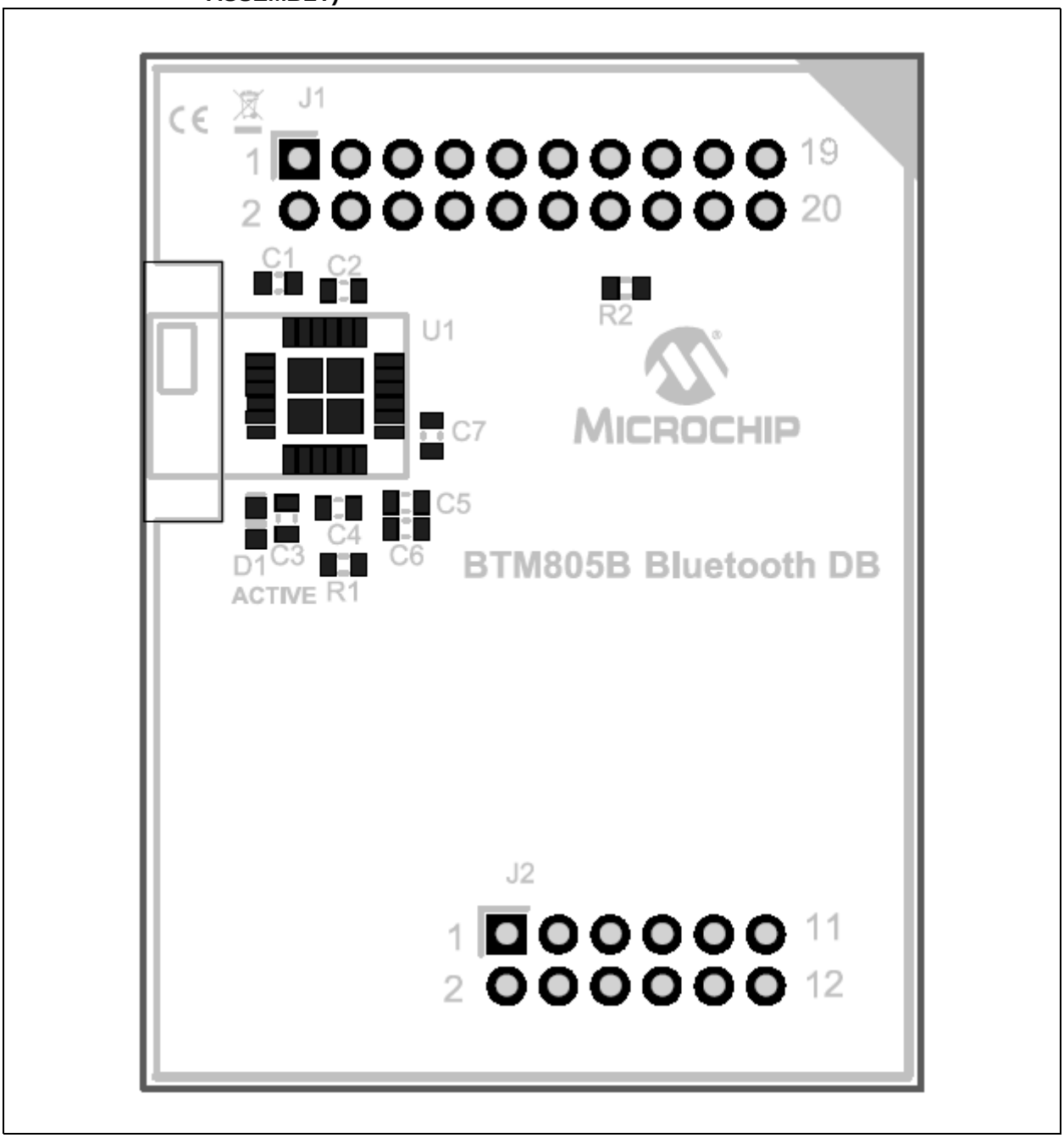
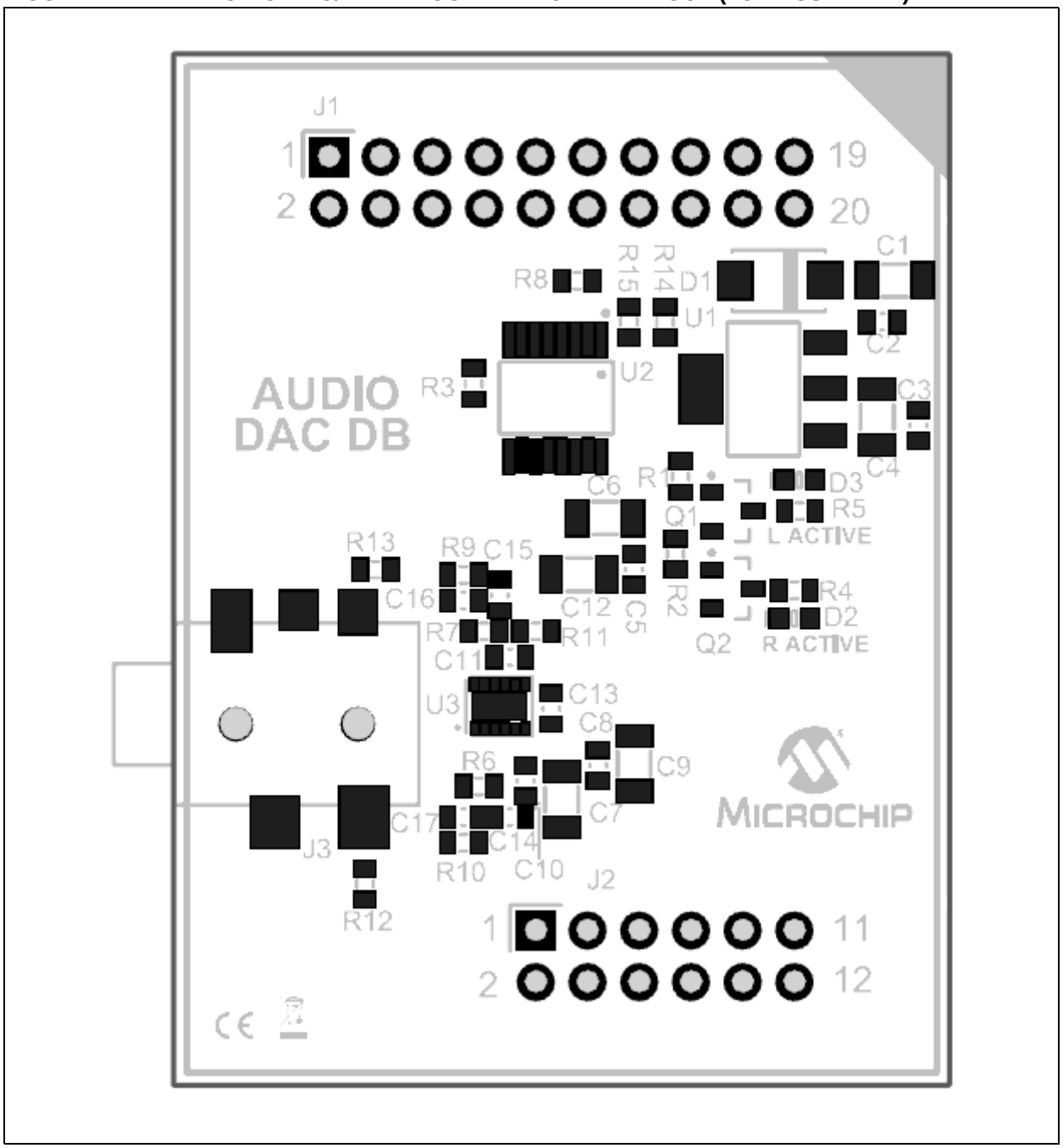


FIGURE A-4: AUDIO DAC/AMP DAUGHTER BOARD LAYOUT (TOP ASSEMBLY)



A.5 SCHEMATICS

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

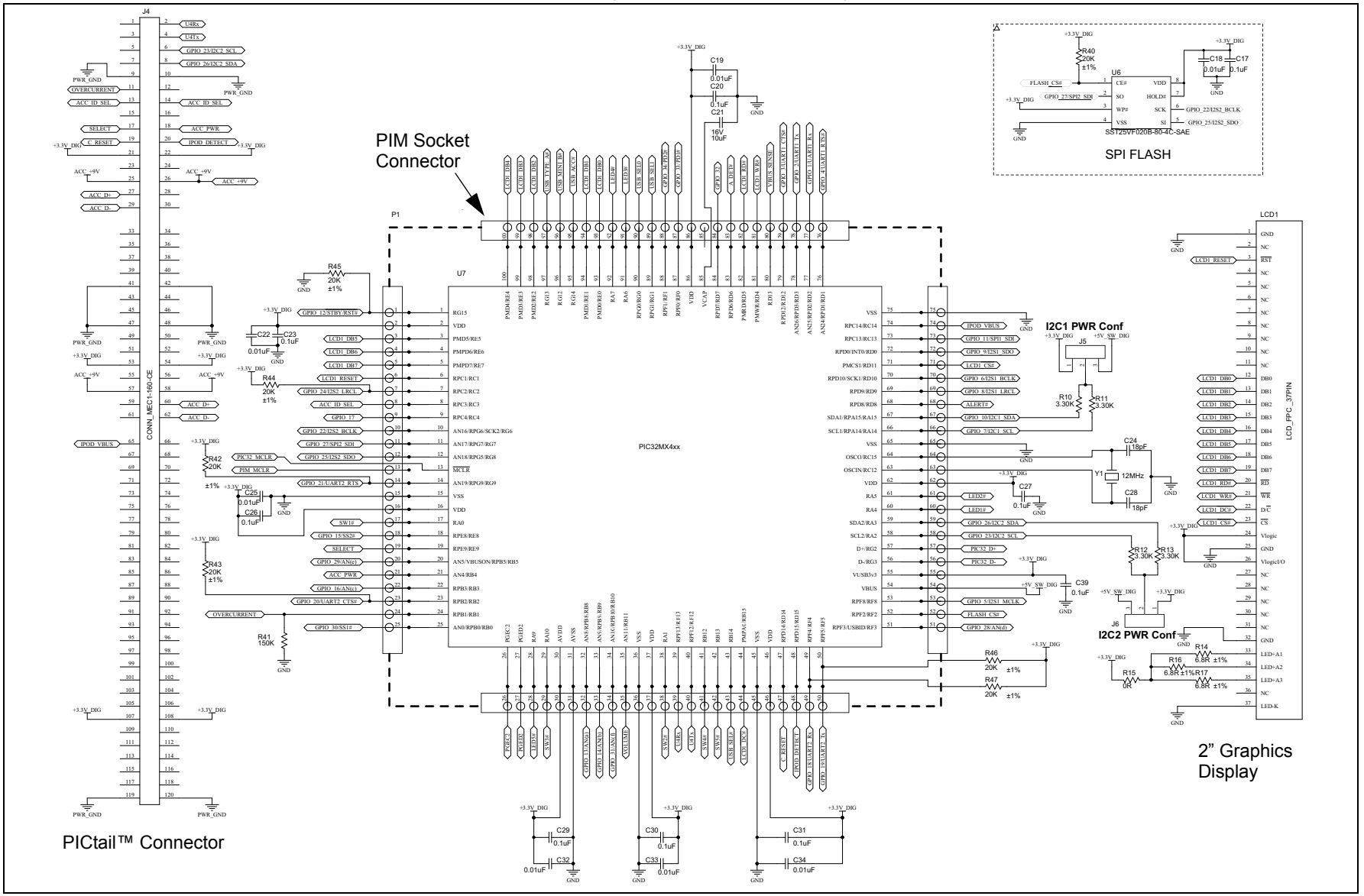


FIGURE A-6: POWER

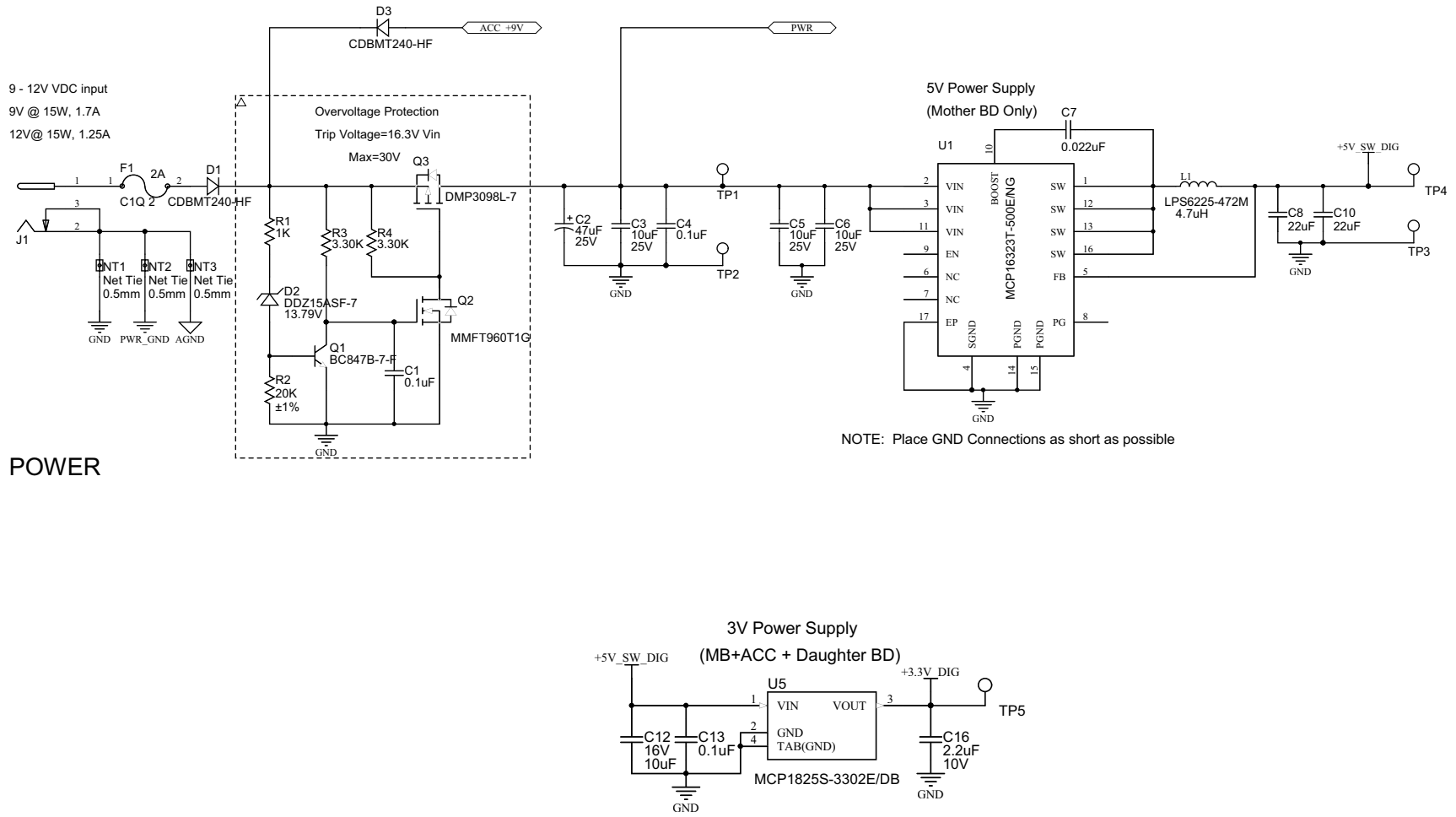
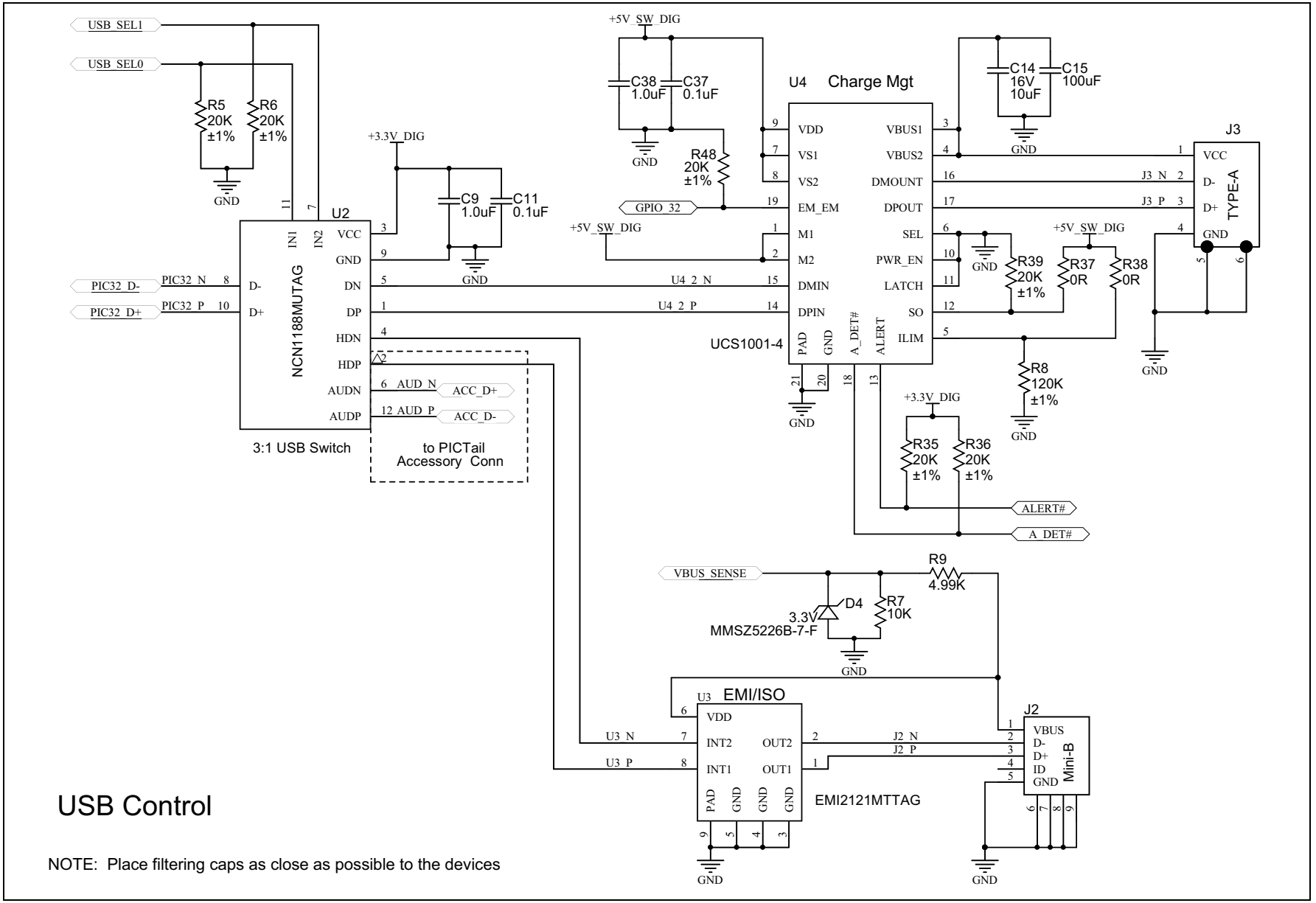


FIGURE A-7: USB CONTROL



USB Control

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

FIGURE A-8: PUSH BUTTONS AND LEDS

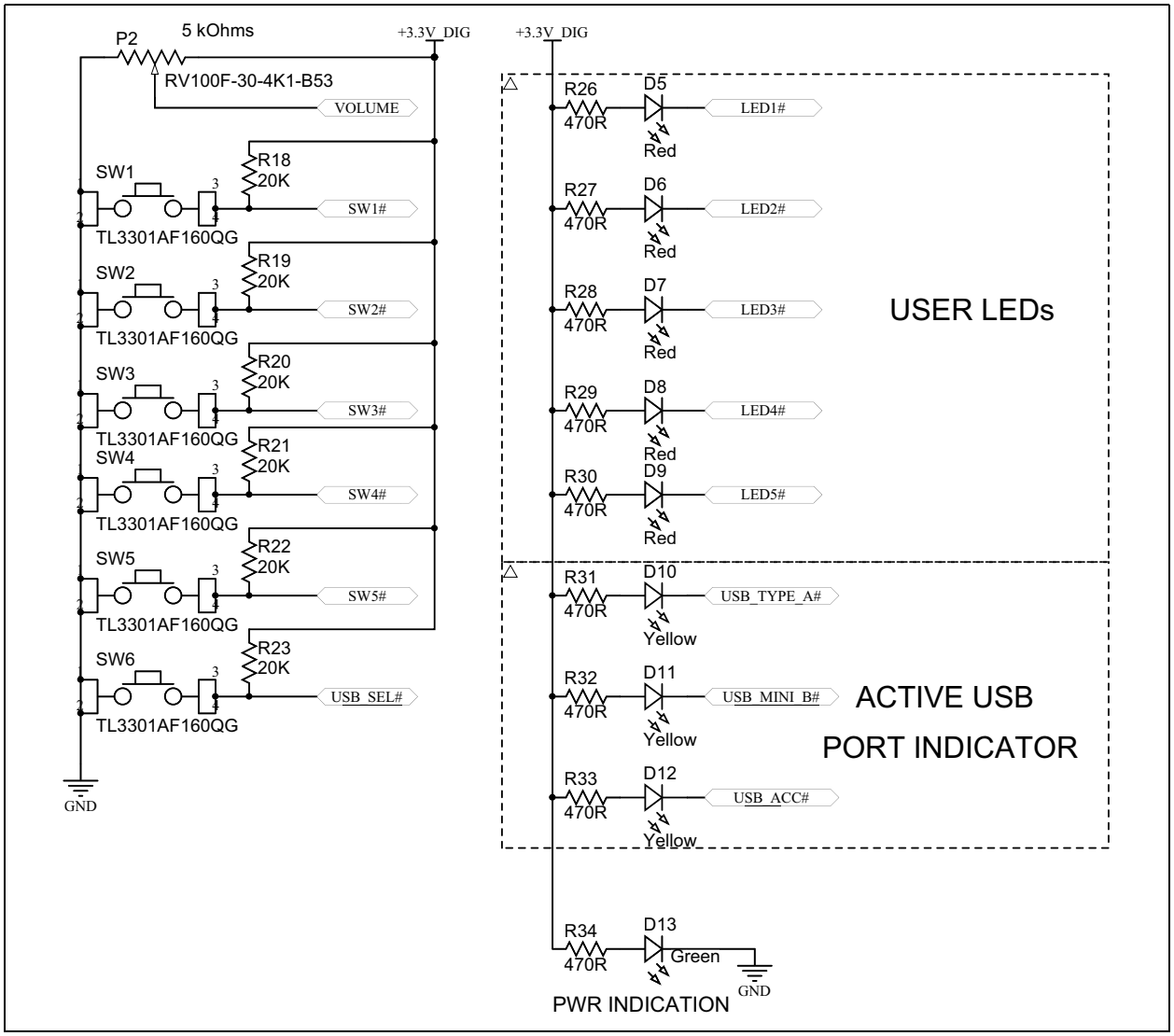


FIGURE A-9: ICSP™

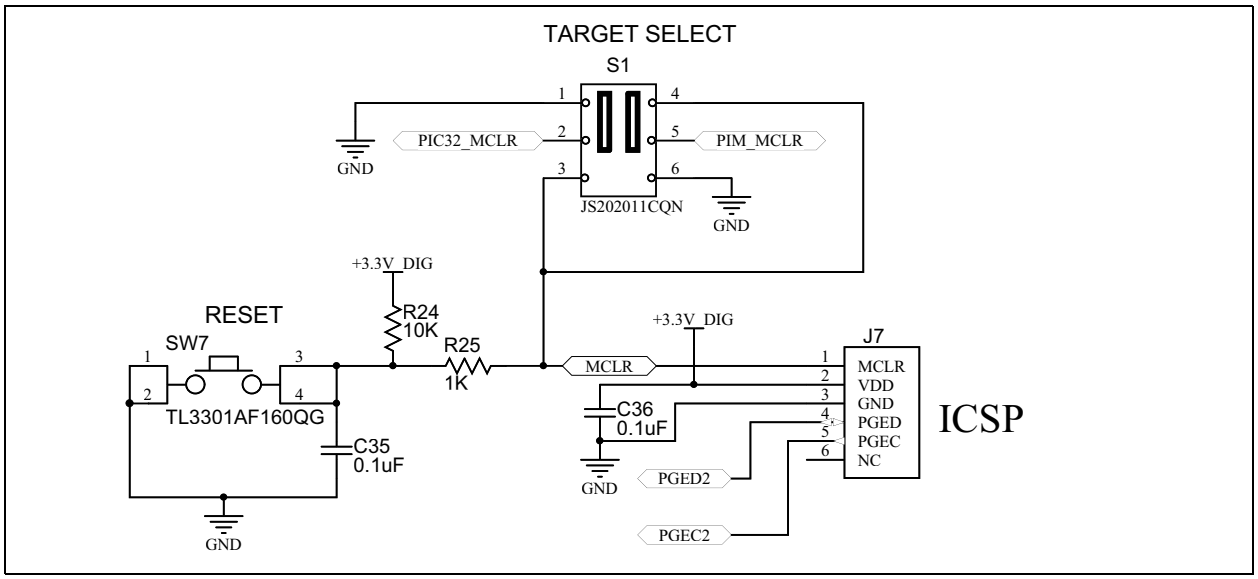
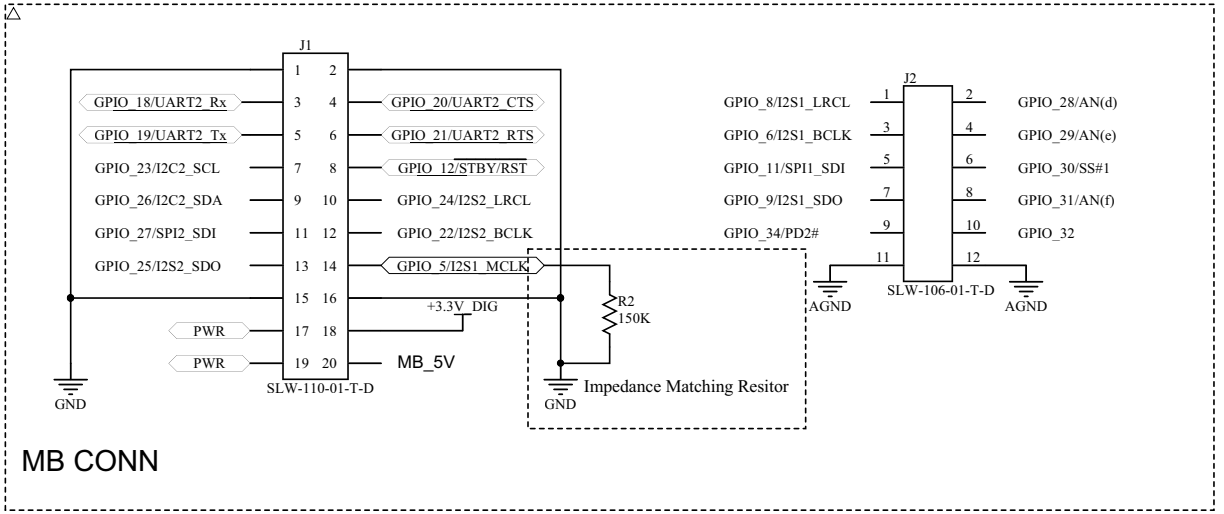


FIGURE A-10: BLUETOOTH HCI RADIO MODULE DAUGHTER BOARD



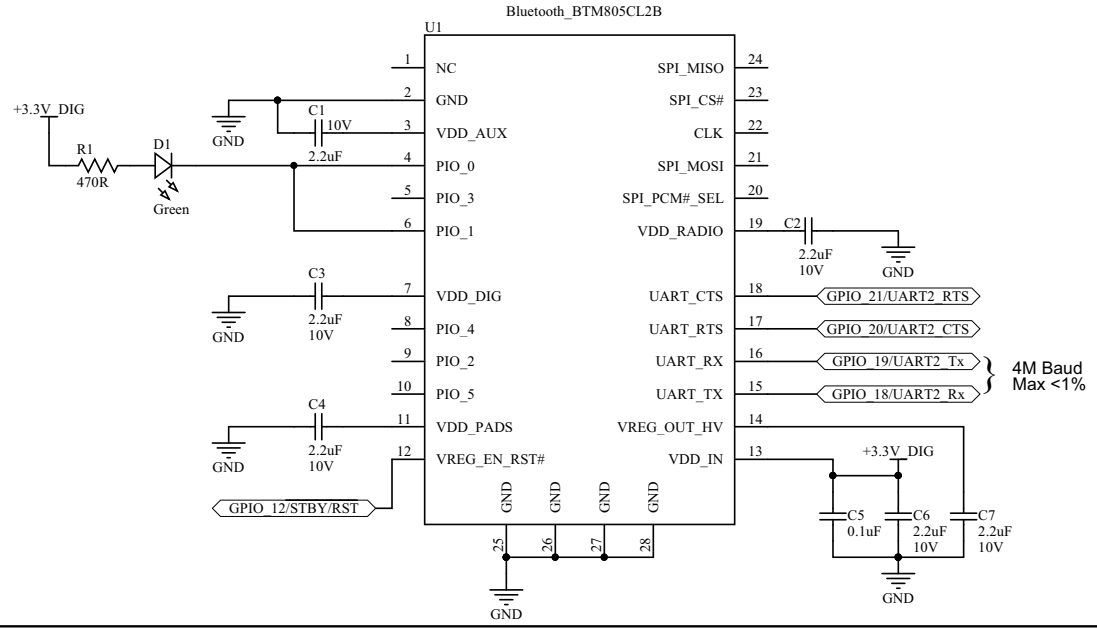
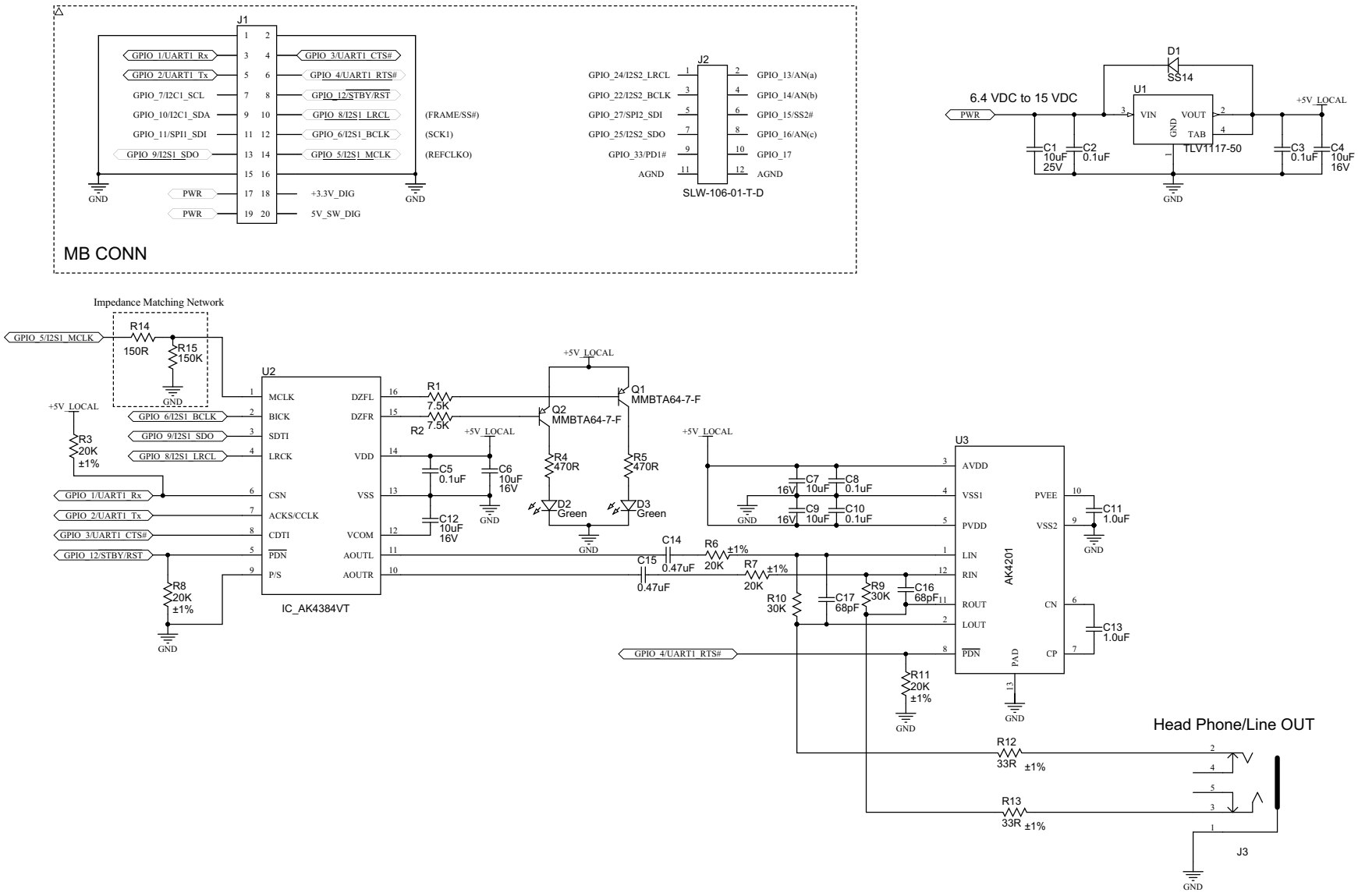


FIGURE A-11: AUDIO DAC/AMP DAUGHTER BOARD



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 µF, 50V X7R	TDK Corporation	C1608X7R1H104M
C2	CAP ALUM 47 µF 25V 20% SMD	United Chemi-Con	EMVA250ADA470MF55G
C3, C5, C6	CAP CER 10 µF 25V 10% X5R 1206	Taiyo Yuden	TMK316BJ106KL-T
C7	CAP CER 0.022 µF 50V 20% X7R 0603	Murata Electronics North America	GRM188R71H223MA01D
C8, C10	CAP CER 22 µF 16V 10% X5R 0805	TDK Corporation	C2012X5R1C226K
C9, C38	Cap, Ceramic, 1 µF, 16V X5R	TDK Corporation	C1608X5R1C105K
C12, C14, C21	Cap, Ceramic, 10 µF, 16V X5R	Taiyo Yuden	EMK212BJ106MG-T
C15	CAP CER 100 µF 10V 20% X5R 1206	TDK Corporation	C3216X5R1A107M
C16	CAP CER 2.2 µF 10V 20% X5R 0603	TDK Corporation	C1608X5R1A225M/0.80
C18, C19, C22, C25, C32, C33, C34	Cap, Ceramic, 0.01 µF, 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

Note 1: Available on v1.0 and v2.0 development boards.
2: Available on v3.0 and later development boards.
3: Available on all v1.0 and select v2.0 and v3.0 development boards.
4: Available on most v2.0 and all v3.0 and later development boards.

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

Reference	Description	Manufacturer	Part No.
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
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 µH 20% Isat 3.2A	CoilCraft	LPS6225-472M
LCD1	DISPLAY_FPC _37PIN		
P1	CONN HEADER 25 POS SNGL 1.27 mm T/H	OUPIIN	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 kΩ 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 kΩ 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 kΩ 1/10W 1% 0603 SMD	Stackpole Electronics Inc.	RMCF0603FT10K0
R8	RES 120 kΩ 1/10W 1% 0603 SMD	Yageo	RC0603FR-07120KL
R9	RES 4.99 kΩ 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

Note 1: Available on v1.0 and v2.0 development boards.

2: Available on v3.0 and later development boards.

3: Available on all v1.0 and select v2.0 and v3.0 development boards.

4: Available on most v2.0 and all v3.0 and later development boards.

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

Reference	Description	Manufacturer	Part No.
R41	RES 150 kΩ 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
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(1)	IC FLASH SER 2 MB 80 MHz SPI 8 SOIC	Microchip Technology Inc.	SST25VF020B-80-4C-SAE
U6(2)	IC FLASH SER 8 MB 80 MHz SPI 8 SOIC	Microchip Technology Inc.	SST25VG08B-80-4I-S2AE
U7(3)	IC MCU 32-bit 256 KB FLASH 100 TQFP	Microchip Technology Inc.	PIC32MX470F256L
U7(4)	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

Note 1: Available on v1.0 and v2.0 development boards.

2: Available on v3.0 and later development boards.

3: Available on all v1.0 and select v2.0 and v3.0 development boards.

4: Available on most v2.0 and all v3.0 and later development boards.

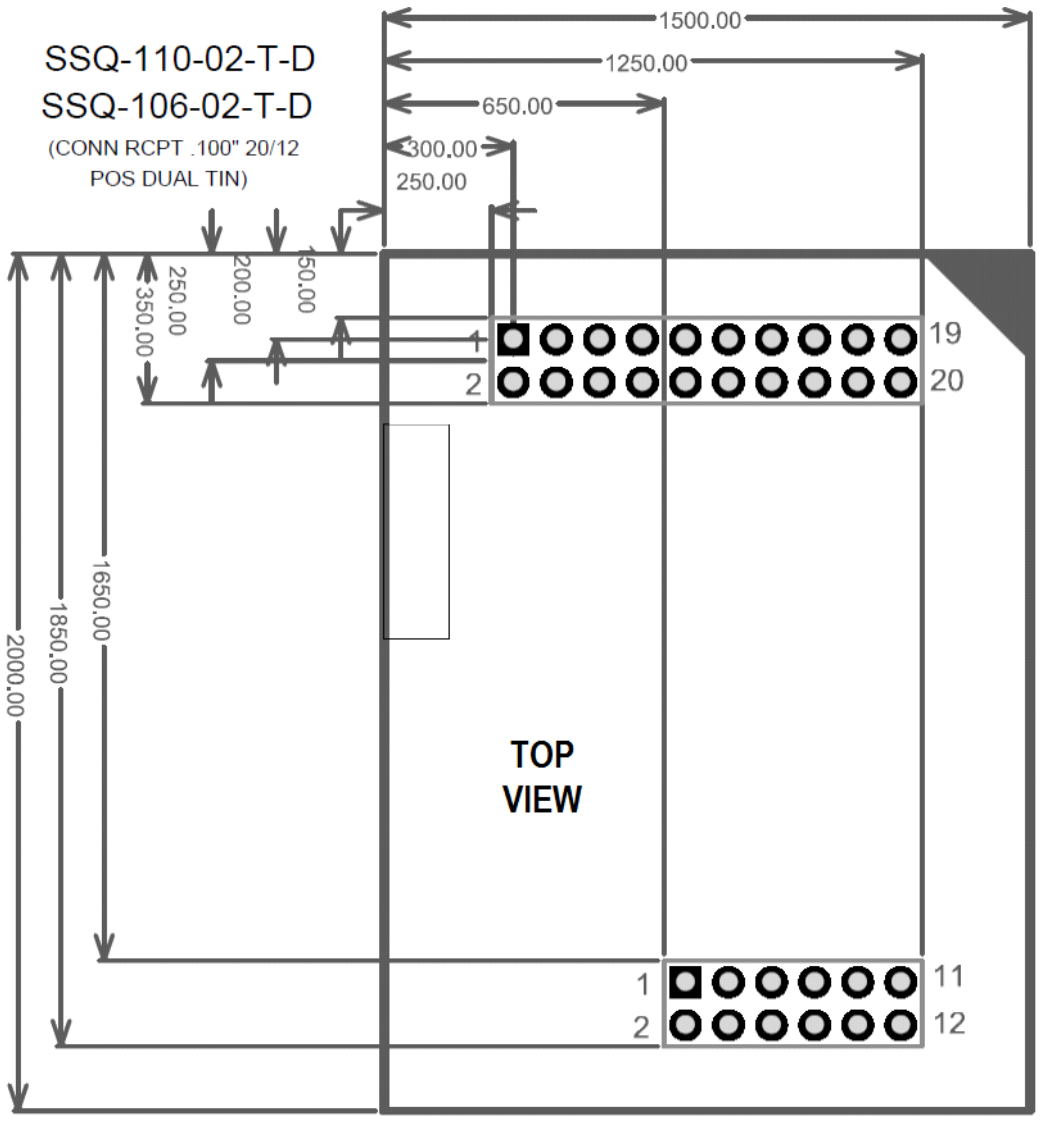
TABLE B-2: BLUETOOTH HCI RADIO MODULE DAUGHTER BOARD BOM

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 µF, 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 kΩ 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 µF 25V 10% X5R 1206	Taiyo Yuden	TMK316BJ106KL-T
C2, C3, C5, C8, C10	Cap, Ceramic, 0.1 µF, 50V X7R	TDK Corporation	C1608X7R1H104M
C4, C6, C7, C9, C12	CAP CER 10 µF 16V 20% X7R 1206	TDK Corporation	C3216X7R1C106M
C11, C13	Cap, Ceramic, 1 µF, 16V X5R	TDK Corporation	C1608X5R1C105K
C14, C15	CAP CER 0.47 µF 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 kΩ 1/10W 1% 0603 SMD	Stackpole Electronics Inc.	RMCF0603FT7K50
R3, R6, R7, R8, R11	RES 20.0 kΩ 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 ΔΣ DAC	AKM	AK4384VT
U3	Stereo Capless HP-Amp	AKM	AK4201

FIGURE B-1: DAUGHTER BOARD DIMENSIONS



Note: The footprint dimension for both the Bluetooth HCI Radio Module Daughter Board and the 24-bit Audio DAC/AMP Daughter Board are identical. The daughter boards connect (i.e., sit on top) to the main board of the Bluetooth Audio Development Kit. Refer to Figure 1-3 in **Chapter 1. "Introduction"** for an example.

NOTES:

Appendix C. 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 hardware available only to Apple MFi licensees must be utilized. For more information, please contact applesupport@microchip.com. Refer to Figure 1-1 in **Chapter 1. “Introduction”** for a diagram that shows several Apple controlled 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 Bard.

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. "Bluetooth Audio Demonstrations"** for details.

Answer 3: Ensure that you are using the proper connector scheme to enable USB master function via the mini-B connector. This should have the form of a cable that connects to the Samsung Type-B micro connector to a Type-A, and then cabling from the Type-A to the USB mini-B connector on the Bluetooth Audio Development Kit. The user must use the mini-B connector and not use the Type-A connector when interfacing to a Samsung device.

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

Answer 2: While the stack does not require external memory, our demonstrations make use of external memory for two items. The demonstration stores some display information, such as fonts within the external memory. The demonstrations also store the optional voice prompt raw audio data in the external memory.

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.

Question 15: Why does Demonstration 6 give loading errors, but other demonstrations compile normally?

Answer: Some Rev. 2.0 boards are equipped with a PIC32MX450F256L device. This device is limited to just more than 256K of Flash memory. Demonstration 6 requires slightly more than this, and will generate a “unable to write to Flash memory” error in MPLAB X IDE, although it will compile and start the load process normally. A PIM board with a PIC32MX470F512L device is available for the board through your Microchip sales channel.

NOTES:

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