Bluetooth/USB Audio Demonstration 2.5 with SBC Demonstration ReadMe

1.1 DESCRIPTION

> **Note:** This ReadMe provides detailed demonstration information. For additional information, please consult the companion document, *"PIC32 Bluetooth Audio Development Kit Reference Guide"* (DS70005140). This reference guide is available for download from www.microchip.com.

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"** of the *"PIC32 Bluetooth Audio Development Kit Reference Guide"* (DS70005140) 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. For more information, see **Section 1.1.1 "Bluetooth Demonstrations"** in the *"PIC32 Bluetooth Audio Development Kit Reference Guide"* (DS70005140).

1.2 BASIC FUNCTIONALITY

1.2.1 Bluetooth Module

The PIC32 Bluetooth Audio Development Kit provides hardware support for the BlueCore® CSR8811™ and the RDA Microelectronics RDA5876 through compile-time switches.

1.2.1.1 CSR8811

The CSR8811 is a single-chip radio and baseband IC for Bluetooth 2.4 GHz systems including Enhanced Data Rate (EDR) to 3 Mbps and Bluetooth low energy. The CSR8811 supports Bluetooth Class 1 transmission, and supports multiple device connection. The PIC32 Bluetooth Audio Development Kit uses a module based on the CSR8811 radio in its default configuration (see **Note**). Software projects using the default board configuration should select the CSR8811 configuration in MPLAB X IDE.

> **Note:** The CSR8811 daughter board is included in the PIC32 Bluetooth Audio Development Kit.

1.2.1.2 RDA5876

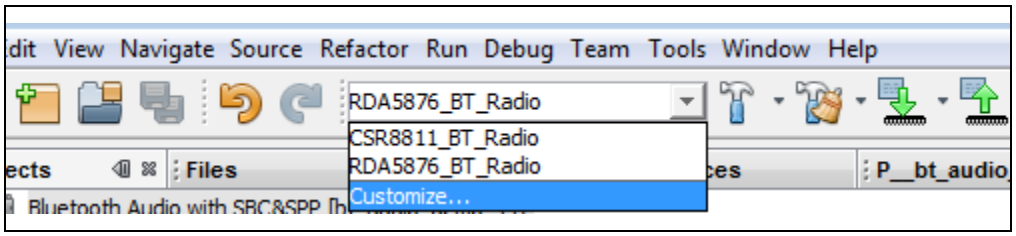
The RDA5876, integrates Bluetooth and a FM radio tuner into one device and is optimized for mobile applications. Bluetooth and FM can work simultaneously and independently, with low-power consumption levels targeted to battery powered devices. For the highest integration level, the required board space has been minimized and customer cost has been reduced. The RDA5876 meets Class 2 and Class 3 transmitting power requirements. The RDA5876 radio solution is a low-cost alternative for single point Bluetooth audio and data applications.

Note:	To request an RDA5876 daughter board, please contact your local Microchip sales office.

1.2.1.3 SELECTING THE CONFIGURATION

A compile-time switch in the application code provides software support for the either the CSR8811 or the RDA5876. This can be done by selecting the desired configuration during compilation, as shown in the following figure.

FIGURE 1-1: CONFIGURATION SELECTION



1.2.2 Connections

The Bluetooth connection, when established, takes priority over any active USB audio connection. 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; 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. 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.

1.2.3 Bluetooth Device IDs

The Bluetooth software remembers and stores in Flash memory the last 10 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 and repeat.

1.2.4 Bluetooth Pair/Unpair

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 (presses and holds) 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.

1.2.5 Bluetooth Device Address

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 specify a Bluetooth Device Address in the application code of the development kit.

The device address is a six byte hexadecimal value. The macro, `BT_DEVICE_DESIGN_ID`, defines the first 4 bytes of the hexadecimal value and `BT_DEVICE_ID_2LSB` defines the last 2 bytes of the hexadecimal value. The last two bytes of the device address can be randomized by enabling `BT_DEVICE_ID_2LSB_RANDOMIZE`. These macros are defined in `HardwareProfile_PIC32_Bluetooth_Audio_Development_Board.h`.

Setting a specific hard-coded device address 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.

1.2.6 USB Connection Priority

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.

1.2.7 Connection Retry Time Limit

A new feature in demonstration v2.0 enables a connection retry time limit. The limit will define a set period (in approximate seconds) that the unit will continue to retry to connect to the Bluetooth device from which it has lost a connection. After this period, the device will discontinue trying to automatically connect. However, the device can still manually establish a previously paired connection, or form a new pair as previously stated. The feature can be enabled in the `user_config.h` file.

1.2.8 Voice Prompt

Starting with v2.0 of the demonstrations, the system is now equipped with a voice prompt option for some actions. To use the voice prompts two elements are required.

First, the voice prompt files must be loaded into the external Flash memory. To do this, Microchip has provided a separate external Flash memory writer project that will enable users to load voice prompts to their development kit. The documentation and project also allow the user to customize the voice prompt starting with their own audio voice or sound (in `*.wav` format) and process walk through the steps to using this data in the correct format.

Second, the user-defined switch in the `user_config.h` file must be enabled to turn on voice prompt audio. Even while the prompts are loaded the function may be disabled at compile time with this switch. If the voice prompts are not loaded or loaded improperly, the function will be automatically bypassed even if this switch is enabled.

In general, voice prompts have a limited memory footprint and are designed to be approximately 1.5 seconds in length. This can be extended with changes in both the external flash memory writer example, as well as the function offsets that are part of the `voice_prompt.c` file in the project.

Voice prompt events are run during the following events:

- Bluetooth connected
- Bluetooth disconnected

In each case, assuming the conditions previously described are met, a voice message will occur with this event. In the code, additional space has been allocated for future events. These can be tied to events that are hardware or Bluetooth-specific, such as 'Bluetooth paired', 'Power ON' or 'Power OFF'.

Note:	Refer to the *"Voice Prompt Programmer User's Guide"*, for information on the process to capture audio, and to format and download voice prompts. This document is available for download from www.microchip.com.

1.2.9 Automatic Soft Mute

It is possible to enter a Soft Mute mode manually within the demonstration to stop audio output. See **Section 1.6 "Bluetooth USB Demonstration 2.5 Switch Descriptions"** for manual entry.

In addition to the manual *Soft Mute*, a user switch is provided to enter Soft Mute mode when fast forwarding and rewinding. When enabled, this action will turn off the audio output during the fast forward period, and then return the system to its previous state when the fast forward sequence ends. This may be particularly effective when using one of the AVRCP profile options like option 3, where the audio track will "skip" as it accelerates through the track, but stop temporarily at a new track and play at normal speed for a short time prior to resuming the *Fast Forward* function. This feature has the same effect in the reverse direction.

To enable this feature, a compile time switch is provided in the `user_config.h` file. To remove this feature, undefine this setting.

1.2.10 Volume Sync

A new feature in demonstration v3.0 enables volume sync mode. The potentiometer of the DAC in the development kit is adjusted to increase or decrease the volume. When the potentiometer is adjusted the volume of the handset is adjusted accordingly.

Note:	This feature is supported by Apple and Android (v4.4 and higher) devices.

To enable this feature, a compile time switch is provided in the `user_config.h` file. To remove this feature, undefine this setting.

1.2.11 Manual Pairing

A new feature in demonstration v3.0 enables manual pairing mode. See **Section 1.6 "Bluetooth USB Demonstration 2.5 Switch Descriptions"** for manual pairing.

A user compile-time switch is provided to enter Manual Pairing mode. When enabled, this feature manually allows the device to be discoverable for pairing for a time period of three minutes. The user can modify the time duration by varying the `PAIRING_TIMEOUT` macro defined in `user_config.h`. The device becomes unavailable for pairing after the time period. The user can pair the device without the requirement of a password or pin number.

This feature also allows the user to make the device unavailable for pairing manually within the stipulated time.

To enable this feature, a compile time switch is provided in the `user_config.h` file. To remove this feature, undefine this setting.

By default, the system is in automatic pairing mode. In this mode, the device will be discoverable at all times. When a handset attempts to pair, the pairing will be accepted by the device and it will not require a password or user intervention to accept the pairing.

Automatic pairing mode is very useful for development purposes, as random Bluetooth addressing is common and forces pairing on each power up. Manual pairing is common for commercial product devices.

1.3 DIAGNOSTICS

1.3.1 Asserts

A new diagnostic feature in demonstration v3.0 enables asserts to identify possible errors. To enable this feature, a compile time switch, `USE_ASSERT`, is provided in the `user_config.h` file. In addition, `USE_ASSERT_TO_DISPLAY` when enabled, displays the error message on the display screen of the development kit.

If `USE_ASSERT` is not defined `USE_ASSERT_TO_DISPLAY` will be disabled. This feature is primarily used for debugging purposes. `USE_ASSERT` is not defined by default, and therefore, asserts are disabled. To enable this feature, a compile-time switch is provided in the `user_config.h` file. To remove this feature, undefine this setting.

1.3.2 Stack Usage

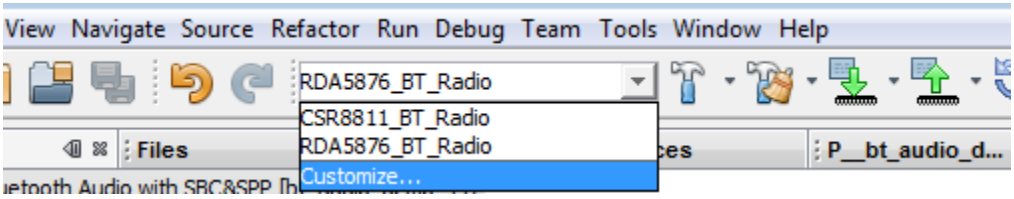
A new diagnostic feature in demonstration v3.0 enables the display of the maximum stack usage on the display screen of the development kit. To enable this feature, a compile time switch, `DISPLAY_MAX_STACK_USAGE`, is provided in the `user_config.h` file. This feature is used to measure the maximum stack usage.

1.4 SETTING UP BLUETOOTH AUDIO DEMONSTRATION 2.5

In this demonstration, the smartphone USB connection is the Device, and the PIC32 device is the 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` for the CSR8811_BT_RADIO or RDA5876_BT_RADIO Bluetooth controller. This can be done by selecting the hardware support from the drop down box during compilation, as shown in the following figure.



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.
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. Ensure that the volume control on the development kit is set to maximum (turned fully counter-clockwise).
8. Select the music track and press **Play**.

1.5 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 1-1: BLUETOOTH/USB AUDIO DEMONSTRATION 2.5 CONTROLS

Component	Label	Bluetooth Mode	USB Mode
Switch	SW1	Shuffle (toggle)/Force Bluetooth Device to Unpair	Volume Up
	SW2	Repeat (toggle)/Bluetooth Device Disconnect	Volume Down
	SW3	Next Track/Fast Forward	Next Track/Fast Forward
	SW4	Play/Pause (toggle)/Soft Mute (toggle)	Play/Pause (toggle)/Soft Mute (toggle)
	SW5	Previous Track/Rewind	Previous Track/Rewind
	SW6	Manual Pairing/Display Stack Usage	N/A
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

1.6 BLUETOOTH USB DEMONSTRATION 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.

1.6.1 SW1: Shuffle (toggle)/Force Bluetooth Unpair

When SW1 is pressed and released quickly (less than three seconds), the system will send an AVRCP signal to the Bluetooth device to toggle the shuffle on and off. This action causes the Bluetooth device to randomly select the next track when enabled. This is often displayed on the player of the Bluetooth device.

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 to reset the link keys so that the user’s smartphone can rediscover and subsequently re-pair.

1.6.2 SW2: Repeat Track (toggle)/Bluetooth Disconnect

When SW2 is pressed and released quickly (less than three seconds), the system will send an AVRCP signal to the Bluetooth device to toggle the repeat mode. Generally, Bluetooth audio devices will have three repeat modes, which are 'repeat off', 'repeat all', and 'repeat single/current track'. The system will rotate through these modes upon each toggle (i.e., quick press-and-release) of SW2.

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 reconnect at will.

1.6.3 SW3: Next Track/Fast Forward

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

The alternate *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: Starting with demonstration v2.0, the *Fast Forward* function on the device is equipped with multiple demonstration profiles. The options are selected using a compile-time switch within the `user_config.h` file. In addition, the profile selected applies to the *Rewind* function. The different profile functions are as follows:

- 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 functionality as Apple iPhone).
- Profile Option 2: *Fast Forward* continuously through all songs until the *Fast Forward* button is released (same functionality as Samsung Android).
- 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.

If no profile option is selected, the *Fast Forward* function will revert back to the handset-specific function. Different operating systems and different handset manufacturers have different use models for this function.

1.6.4 SW4: Play/Pause (toggle)/Soft Mute (toggle)

This is a multi-purpose button that alternates between *Play* and *Pause* with each quick 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.

When SW4 is pressed and held for more than three seconds, it will toggle the *Soft Mute* function. When active, this function will disable the audio output at the DAC driver level, although it will not interfere with the Bluetooth device streaming. A display message will appear indicating that the system is now in Mute mode. To stop the *Soft Mute* function, press and hold the SW4 button again.

1.6.5 SW5: Previous Track/Rewind

This is a multi-purpose button, which has a primary and an alternate function. The primary function, *Previous Track*, is activated by a quick press (less than three seconds) 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: Starting with demonstration v2.0, the *Rewind* function on the device is equipped with multiple demonstration profiles. The options are selected using a compile-time switch within the `user_config.h`. file. In addition, the selected profile applies to the *Fast Forward* function. The different profile functions are as follows:

- 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 functionality as Apple iPhone).
- Profile Option 2: *Rewind* continuously through all songs until the *Rewind* button is released (same functionality as Samsung Android).
- 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 continue rewinding until the *Rewind* button is released.

If no profile option is selected, the *Rewind* function will revert back to the handset-specific function. Different operating systems and different handset manufacturers have different use models for this function.

1.6.6 SW6: Manual Pairing/Display Stack Usage

When SW6 is pressed and held for more than three seconds, it will toggle the *Manual Pairing* function. When active, this function will make the device available for pairing for a time period of three minutes. A display message will appear indicating that the system is now “discoverable” for pairing. To toggle the *Manual Pairing* function, press and hold the SW6 button again. This will make the device unavailable for pairing. A display message will appear indicating that the system is “not discoverable” for pairing.

If DISPLAY_MAX_STACK_USAGE is enabled and SW6 is pressed and held for more than three seconds, a display message will appear indicating the maximum number of stack bytes used.

Note: The `BTAPP_USE_MANUAL_PAIRING` and `DISPLAY_MAX_STACK_USAGE` compile time switches cannot be enabled simultaneously because usage of the SW6 for Manual Pairing has higher priority.

1.7 KNOWN ISSUES

The following issues are known to exist in this demonstration:

- Manual (click and drag) advance through the track can cause the system to lock up on older Bluetooth handsets (Android v2.2 and older)
- Some Android handsets do not support AVRCP commands for Fast Forward, Rewind, Repeat, and Shuffle; these commands are ignored
- Some Android players do not support track position or time information although AVRCP is functioning
- With voice prompts turned ON and programmed, a Bluetooth reconnect event with music already in the queue can cause an audio glitch
- Fast Forward and Rewind button profiles may not react as expected after multiple button functions; default operation is profiles OFF
- This demonstration will not automatically reconnect and stream audio through the DAC; after Bluetooth disconnect a system reset is required
- On rare occasions, the RDA module when in use may disconnect from Bluetooth; the standard CSR module is not affected

1.8 REVISION HISTORY

Version1.0.1

This revision includes the following updates:

- Updates to RTOS files
- XC32 v1.3 complier compatibility improvements

Version 1.0.2

This revision includes the following updates:

- Missing library components were added to enable compilation

Version 1.0.3

This revision includes the following updates:

- Improved the SBC decoder, which at times would lock up at high frequency and high volume
- Improved AVRCP detection to older Bluetooth handsets; automatic retries

Version 2.0

This revision includes the following updates:

- RTOS was removed
- Audio and Voice Prompts for key Bluetooth events were added
- The Bluetooth Stack was updated, which is now compatible with AVRCP 1.5
- AVRCP button control profiles were added, which include various methods of Fast Forward and Rewind response
- The Automatic Mute option during some AVRCP events was added
- A user configuration for automatic time-out of reconnection retry was added
- AVRCP controls for Replay and Shuffle were added
- The Graphics Driver was updated to support future displays
- A top-level user configuration header file (`user_config.h`), which includes global constraints was added

Version 3.0

This revision includes the following updates:

- RDA Bluetooth module support was added
- A global definition for Bluetooth Device ID value (CSR only) was added
- The Manual Pairing feature was added
- Volume Sync for Apple devices and Android (v4.4 and higher) was added
- The common display design defined by `display_config.h` was added
- The Bluetooth Stack was updated for improved connectivity and compatibility with the Break-in/Party mode feature
- The application architecture was updated to be compatible with the USB MFi Stack
- Button handling and drivers were updated to improve debouncing of user I/O

Version 3.0.1

This revision includes the following updates:

- The assert diagnostics were revised, which are now user configurable (default is OFF)
- Stack usage diagnostics were added (default is OFF)
- Options in the `user_config.h` file were revised