RX63N Group

Speaker Enhancement Algorithms

R01AN1868EU0100
Rev.1.00
December 9, 2013

Introduction

This document introduces the sample project for the speaker enhancement algorithms developed for RX600 series devices by Berkeley Design Technology, Inc (BDTI).

Target Device

RX63N

- This sample application is designed to operate on the YRDKRX63N demonstration board.

Related Documents

- BDTI Speaker Compensation Application Note: BDTI_AppNote_RX63N_Speaker_Compensation.pdf
- R01AN1465ES0100: RX Family RX DSP Library version 2.0 (CCRX)
- R01AN1707EU0100: Audio Player Sample Application: MP3, WAV, ADPCM – This application note contains Renesas sample code that supports playback of MP3 and IMA-ADPCM file types.
- R01AN1816EU0100: Ogg Vorbis Decoder Sample Application – This application note contains Renesas sample code that supports playback of Ogg Vorbis file types.
- FAT FS; FAT files system module. Open-source software available from http://elm-chan.org/fsw/ff/00index_e.html

Contents

1. Overview

This document describes how to open the speaker enhancement sample project in Renesas e^2 studio and download the sample code to the RX63N RDK board. For detailed information about the algorithms and how to tune them for other applications, refer to the BDTI application note. The BDTI application note is located in the documents folder of the sample project: BDTI_AppNote_RX63N_Speaker_Compensation.pdf.

1.1 Hardware Requirements

The following hardware is required for this demo:

- YRDKRX63N demonstration board.
- Micro SD memory card with .wav audio files (not included with RDK)
- (Recommended) External stereo speaker or headphones with 1/8" stereo jack: The effects of the enhancement algorithms are typically more noticeable with an external speaker. See section 6.1 for further information on speaker recommendations.

1.2 Development Environment

The following Renesas software tools are required for this demo:

- Renesas e^2 studio IDE: This project was developed using v2.1.0.21.
- RX Compiler CC-RX: This project was developed using v1.02.01

These tools can be downloaded from the Renesas website here:
http://am.renesas.com/products/tools/ide/ide_e2studio/downloads.jsp

1.3 MCU Resources Used by this Application

This application requires use of a few of the RX6xx microcontroller's peripheral modules to communicate with the SDCard memory and to run the demo. The following hardware resources are required:

1. One "Serial Peripheral Interface (RSPI)" channel. (Required for SDCard communication.)
2. One "Compare Match Timer (CMT)" channel. (Used for timed delays in SDCard driver code.)
3. The "Data Transfer Controller (DTC)" for streaming PWM timer data to the TPU timers.
4. Three "TPU" timer channels.
5. "Real-time clock (RTC)". Not essential for audio playback, but it is used for file data and time stamping by the application.
6. 12-bit ADC. The "ADC12" is used for measuring the audio playback volume setting by potentiometer VR1.
7. One serial "SCI" channel, used as a UART for optional RS232 communications to support an external player control UI.

1.4 Supported Toolchains

The demo source code is available for the following toolchain:

- Renesas RX Toolchain v1.02.01

1.5 Integer Types

This project uses ANSI C99 “Exact width integer types” in order to make the code clearer and more portable. These types are defined in stdint.h.

2. Importing the sample project

The application is distributed as an e^2 studio archive file located in the application note archive file. Extract the application note archive file (an_r01an1868eu0100_rx63n_sound.zip) to a known location, for example C:\Renesas. In the extracted folder, you will find the e^2 studio project archive file:

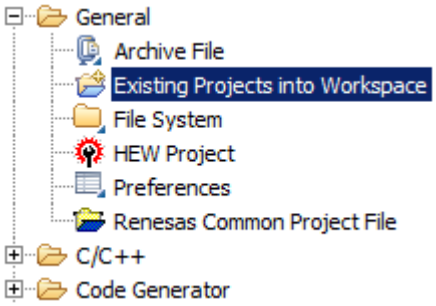
- BDTI_RX_Speaker_Compensation.zip

Note that this is not a standard archive file and it should not be extracted using standard archive tools. Follow the instructions below to import the archive file using the project import feature in Renesas e^2 studio.

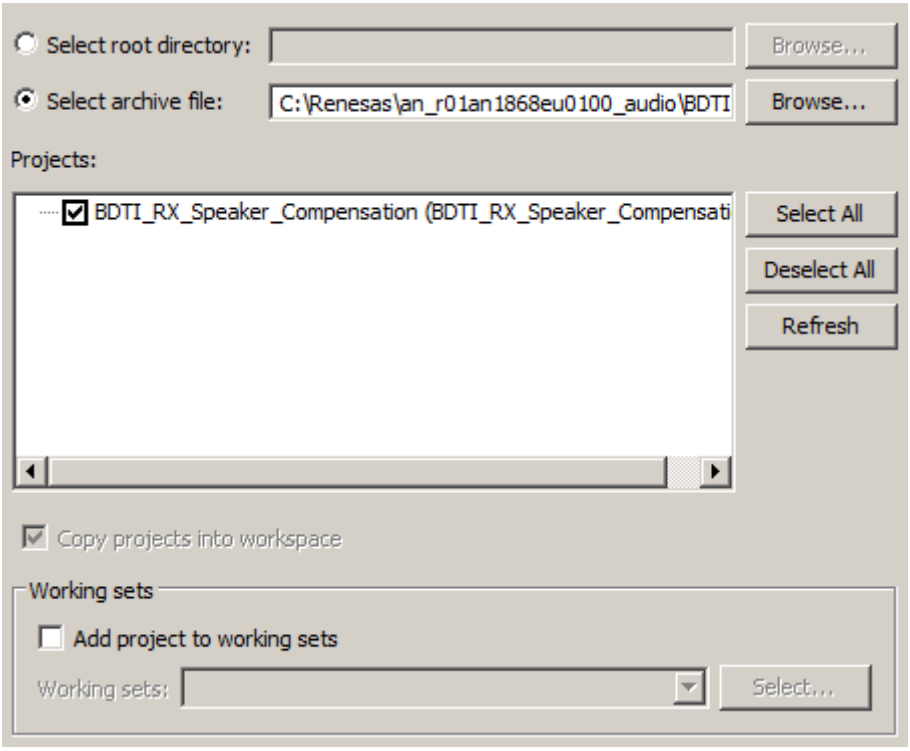
2.1 Import the sample project into Renesas e^2 studio

Follow these steps to import the speaker enhancement sample project into Renesas e^2 studio.

1. Open Renesas e^2 studio**: Start > All programs > Renesas Electronics e2 studio > Renesas e2 studio**.
2. In the Workspace Launcher dialog box, type **C:\Workspace\RX_Speaker**. This will create a new folder for your workspace. You should see an empty workspace in e^2 studio.
3. In e^2 studio, go to **File > Import**.
4. Open the **General** folder, and select **Existing Projects into Workspace**. Click **Next**.



5. Click the radio button for **Select archive file**, then **Browse** to the project archive file **BDTI_RX_Speaker_Compensation.zip**. Click **Finish**.



6. You should see the project **BDTI_RX_Speaker_Compensation** in your workspace.

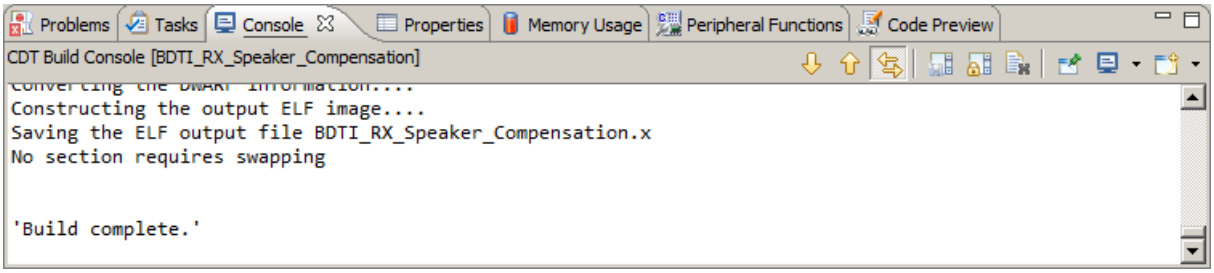
3. Build and Download

Now that the project has been imported, follow these steps to build the code and download it to the RX63N RDK board.

1. Set the active build configuration to HardwareDebug. Highlight the project, then go to **Project > Build Configurations > Set Active > HardwareDebug (debug on hardware)**.

   NOTE: If the "Set Active" option is not available, make sure the project folder is highlighted in the project explorer.

2. Build the project: **Project > Build Project**. You should see a message in the console window indicating that the build is complete.



3. Make sure SW5 is set to debug (OFF, OFF, OFF, ON). Connect the J-LINK USB port on the RDK board to your computer using the provided USB A-miniB cable.

   NOTE: There are two USB ports on the RX63N RDK board. Make sure to the J-LINK USB port located above the LCD next to the DB9 serial connector, not the USER USB port on the bottom right.

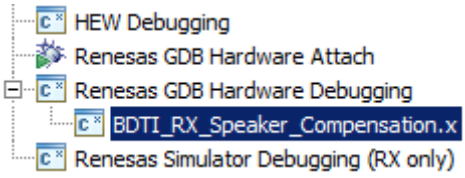
4. Insert a micro SD card with .wav (uncompressed PCM) audio files. The SD card slot is located in the bottom left corner of the RDK. See section 4 for detailed information on supported file formats.

   NOTE: Take care inserting or removing the micro SD Card from the slot on the YRDKRX63N. It should go in or out in a straight direction aligned with the slot. The micro SD Card is fragile and can be damaged or cracked by excessive off-center pressure. For further information on loading the SD card, refer to section 6.2.

5. To use an external speaker or headphones, remove the jumper JP7 connecting the on board speaker and connect the external speaker or headphones to the AUDIO OUT jack on the right side of the board.

   NOTE: External speakers or headphones are not required, but the effects of the enhancement algorithms are typically more noticeable with an external speaker. See section 6.1 for further information on speaker recommendations.

6. Connect to the board: Go to **Run > Debug Configurations**. Open **Renesas GDB Hardware Debugging** and select **BDTI_RX_Speaker_Compensation.x**. Click **Debug**.



7. Click Resume. If execution breaks at main, click Resume again. The LCD will display the message "RENESAS YRDKRX63N PCM Audio" and prompt you to press SW3 to continue.

8. Press **SW3**. SW3 is located to the left of the LCD screen.

9. Follow the instructions on the screen to navigate the demo using the debugger.

10. When the music is playing, you can press SW2 and SW3 to switch between using the BDTI algorithms and not using them. The different audio qualities in these two modes should be easily distinguishable.

    NOTE: Turn the potentiometer VR1 to adjust volume. See section 6.4 for recommendations.

11. To select a different folder, press the reset button (SW4) to reset the RX63N RDK board.

12. Switch to standalone mode at any time by clicking Terminate. Make sure to click Terminate before disconnecting the USB cable.

4. Supported Audio File Formats

Audio files in the 16-bit PCM .wav format can be selected from the browser for playback.

Table 1 Supported Audio File Formats

Audio file type	File extension	Decoded Sample size	44.1 kHz	32.0 kHz	22.05 kHz	11.025 kHz	Stereo	Mono
Uncompressed PCM	.wav	16-bits	○	○	○	○	○	○

5. Important Software for Speaker Enhancement

On top of the original Renesas audio sample application, the package adds two important components:

- BDTI speaker compensation software for the RX600 processor: The software is written in C. The source code files can be found under the subfolder “BDTI_RX_Speaker_Compensation/source/src/bdti”.

  NOTE: For detail about the BDTI speaker compensation software, refer to the BDTI application note in the documents folder of the BDTI_RX_Speaker_Compensation project.

- Renesas RX DSP (Digital Signal Processing) library version 2.0: There are four variants. One and only one of them should be linked into the project. For details about the RX DSP library refer to the application note R01AN1465ES0100: RX Family RX DSP Library version 2.0 (CCRX).

6. Audio Demo FAQ

6.1 What speaker would you recommend?

External speakers or headphones are recommended because the effects of the algorithms will be more noticeable using a better quality speaker.

NOTE: The speaker compensation algorithms are tuned to perform wave shaping based on the speaker response characteristics. This project is tuned for the speaker on the RDK, and an external speaker would have a different ideal configuration. Even though the tuning will not be ideal with external speakers, the difference between playback with and without enhancement will be more distinct. Refer to the BDTI application note in the documents folder of the sample project (BDTI_AppNote_RX63N_Speaker_Compensation.pdf) for further details on tuning the algorithms for a different speaker.

6.2 How do I load audio files on the micro SD Card?

Audio files may be copied to the micro SD-Card by any PC with a SD-Card slot. They can be located in any directory with the limitation that the fully qualified path string to the file must be 64 characters or less. The fully-qualified path string includes the drive letter or number, colon, backslash, all subdirectories leading to the file, and the filename itself. For example: "E:\audio\music\somefile.wav" (without quotes) is a valid path, containing 27 characters. (In the audio player demo application, the drive letter "E:" will be represented as a number; "1:").

6.3 Why do the file names look strange on the SD card?

While browsing the files it may be noticed that some file names are displayed as shortened versions. The file-system in this application is limited to showing file names in the 8.3 format, due to patent restrictions on long filenames. Only the file name displayed has been changed; the actual file name stored on the media remains unchanged with its original long filename.

6.4 How do I control Volume?

Once an audio file of the uncompressed PCM type has been found and playback has been started, the volume control becomes active. LEDs on the board will illuminate to provide a visual indicator of the current volume setting. Volume control is provided by the potentiometer "VR1" on the YRDK board. Turn VR1 clockwise to increase the volume or counter-clockwise to decrease it.

NOTE: Volume control is accomplished by scaling down the PWM output, which can reduce dynamic range. For best sound quality, turn the volume all the way up (fully clockwise) and adjust volume on external speakers.

Website and Support

Renesas Electronics Website
http://www.renesas.com/

Inquiries related to the RX device or the RX Audio Demo
http://www.renesas.com/contact/

Inquiries related to BDTI speaker enhancement algorithms
http://www.bdti.com/contact

Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Dec.09.13	All	First edition released

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2. Processing at Power-on
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   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
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   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.
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5. Differences between Products
   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.
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