RX63N Group

Audio Player Sample Application: MP3, WAV, ADPCM

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Introduction

This document describes a sample application that implements an audio player capable of rendering PCM audio from MP3[1], WAV - PCM, and WAV- IMA ADPCM format files stored on an SD-Card.

Target Device

RX63N Group

This sample application is designed to operate on the following hardware:

- YRDKRX63N demonstration board.

Related Documents

- Renesas MP3 Decoder Middleware Terms and Conditions User Agreement
- MP3 Decoder for RX600 Ver.2.00 User's Manual. Describes the Renesas Micro Computer Middleware R0MRX60SM0010RRC MP3 Decoder.
- FAT FS; FAT files system module. Open-source software available from

  http://elm-chan.org/fsw/ff/00index_e.html

Contents

Note 1:

MP3 file decode capability is licensed technology that requires a license from the technology owner for its commercial use. Therefore, the default build configuration of this software does not include the MP3 playback, and the MP3 decoder library file is not included in the default project. Please contact your Renesas Sales representative to obtain the full version of this project that supports MP3, and for information on how to acquire the MP3 usage rights.

1. Overview

This document describes a sample application that implements an audio player capable of rendering PCM audio from MP3, WAV - PCM, and WAV- IMA ADPCM format files stored on an SD-Card on the YRDKRX63N development board platform. The sample software provides a rudimentary file browser for viewing the contents of an SD-Card storage device. Audio files in the MP3 format (MPEG-1 layer III, and MPEG-2 layer III) can be selected from the browser for playback. In addition, 16-bit PCM encoded, or 16-bit IMA ADPCM .wav format files can be played. Audio is output as a PWM signal from the RX63N MCU, then filtered and amplified by the external audio amplifier for listening with stereo headphones or external speaker. With appropriate modifications, the audio and file system capabilities demonstrated in this sample application can be ported to other Renesas RX family MCUs. This sample software is intended for reference purposes only to demonstrate the concepts and capabilities of audio reproduction using the Renesas RX family MCUs.

1.1 Hardware Requirements

- YRDKRX63N demonstration board.
- Micro SD memory card.
- External stereo speaker or headphones with 1/8" stereo jack (recommended).

1.2 MCU resources used by this application

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

1.3 Supported Toolchains

This sample software is tested and working with the following toolchains:

- Renesas RX Toolchain v1.02

1.4 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.

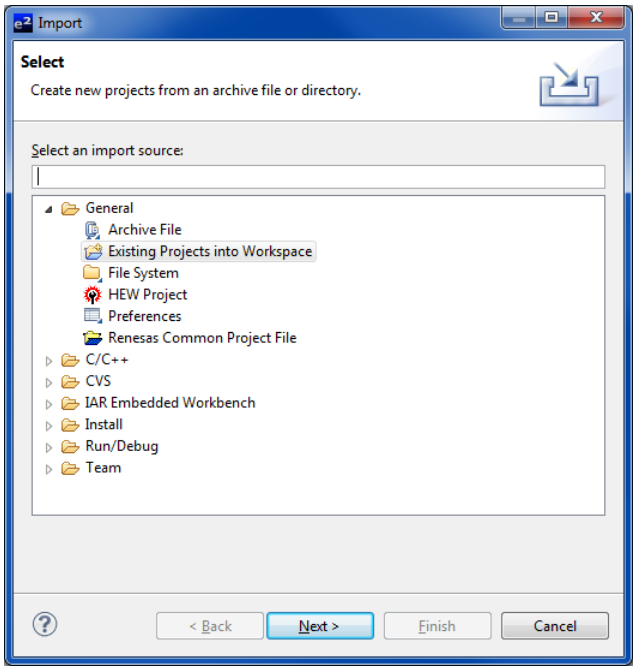
2. Importing the project

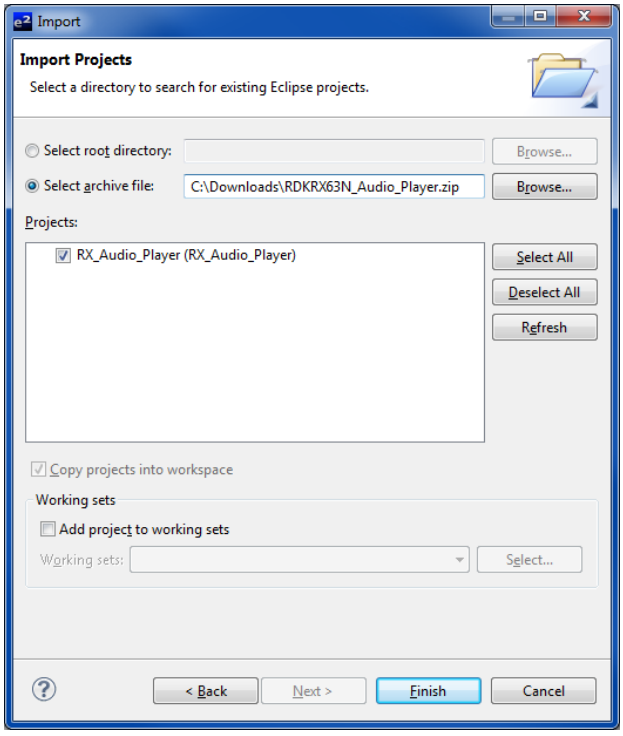
The application is distributed as an archived **e² studio** project. The project archive appears as a ".zip" file but it is not to be manually unzipped. Instead, the project archive is to be "imported" into an exisitng **e² studio** workspace. During import **e² studio** will take care of extracting the project files into the correct location.

Depending on how the application was obtained, for example download from website, it might be contained in a .zip file that also includes this application note. If this is the case then there will be another .zip inside the first that contains the project itself. The outer .zip file should be unzipped, but do not manually unzip the inner project archive.

2.1 Steps to import and build the audio player application

1. With **e² studio** open to the workbench view, select File→Import and the Import tool will open.
2. Under the "General" category, select "Existing Projects into Workspace", then click Next >





3. Click the "Select archive file" option, and then click the Browse button. Using the file browser window that opens, navigate to the location that contains the RX_Audio_Player archive, and select the file. Click "Open", and then the Audio player project will appear in the Projects pane of the import tool.
4. Make sure that the RX_Audio_Player project checkbox is checked, and then click "Finish".
5. A new copy of the RX_Audio_Player project will now be created within your workspace with all source files and settings.
6. If you wish to build this software to include support for MP3 playback, and you have obtained the MP3decoder library from Renesas, then see the instructions in chapter 4 for adding the required MP3 files to the project.
7. You may now select the project from within the Project Explorer view and build the project as normal.
8. Connect to the board using the J-Link USB connector. Under the **e² studio** debug configurations menu, set the appropriate J-Link debug settings and download the code to the MCU.

The list in Table 1 shows the files that are contained in the RX_Audio_File_Player project workspace.

Table 1

Purpose	C source files (or lib)	C header files	Location
Sample Application	main.c browse_files.c led_meter.c	file_time_date.h	RX_Audio_Player |--src |--application
Audio Playback	audio_player.c audio_player_file_ops.c audio_hardware.c adpcm_decoder.c	audio_player.h audio_player_file_ops.h audio_hardware.h adpcm_decoder.h RIFF.h	RX_Audio_Player |--src |--audio
MP3 Decoder[1]	libMP3Frxlittle.lib	mp3f.h	RX_Audio_Player |--MP3 |--inc |--lib
FAT FS file system	ff.c	ff.h ffconf.h diskio.h integer.h	RX_Audio_Player |--src |--FAT
File I/O streams	lowsrc.c disk_iostreams.c mmc_disk.c r_diskio.c	lowsrc.h (custom) disk_iostreams.h mmc_disk.h r_diskio.h diskio_drivers.h	RX_Audio_Player |--src |--iostreams
SD Card driver	mmc_protocol.c cmt_oneshot.c	mmc_protocol.h sdcard.h cmt_oneshot.h	RX_Audio_Player |--src |--mmc |--cmt
Board support	dbsct.c hwsetup.c lcd.c resetprg.c sbrk.c vecttbl.c	platform.h hwsetup.h lcd.h mcu_info.h r_bsp.h sbrk.h stacksct.h yrdkrx63n.h iodefine.h r_bsp_config.h	RX_Audio_Player |--r_bsp |--board | |--rdkrx63n |--mcu |--rx63n
LCD display	r_glyph_register.c r_glyph.c glyph.c st7579_lcd.c font_8x8.c	r_glyph_config.h r_glyph_if.h glyph.h preamble.h config.h st7579_lcd.h	RX_Audio_Player |--r_glyph |--src |--glyph |--drivers |--fonts
RSPI Driver	r_rspi_rx.c	r_rspi_rx_if.h r_rspi_rx_config.h	RX_Audio_Player |--r_rspi_rx |--src
Real-time Clock	rtc.c	rtc.h	RX_Audio_Player |--src |--rtc
On-board Switches	r_switches.c	r_switches_config.h r_switches.h	RX_Audio_Player |--r_switches |--src
Audio volume control	S12ADC.c	S12ADC.h	RX_Audio_Player |--src |--adc

Note 1: Contact a Renesas Sales representative to obtain the MP3 decoder supports files.

3. Adding MP3 playback support

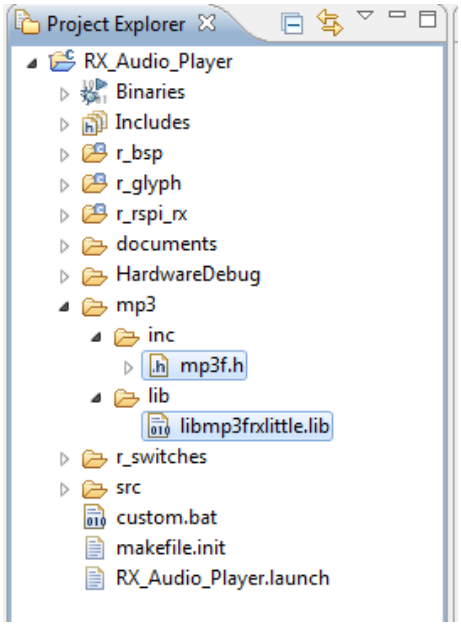
If you have obtained the MP3 decoder library from Renesas, you may build this software to support playback of MP3 encoded audio files. The MP3 library is distributed in a self extracting archive. After extracting the MP3 archive, locate the release note document that lists the contents of the archive. The locations for the required files are listed in the release note, and should be found as shown in Table 2. The other files in the MP3 archive will not be used.

Table 2

Purpose	File name	Location
MP3 Decoder Library	libMP3Frxlittle.lib	rx600_mp3decoder |--mp3 |--lib
MP3 Header	mp3f.h	rx600_mp3decoder |--mp3 |--inc

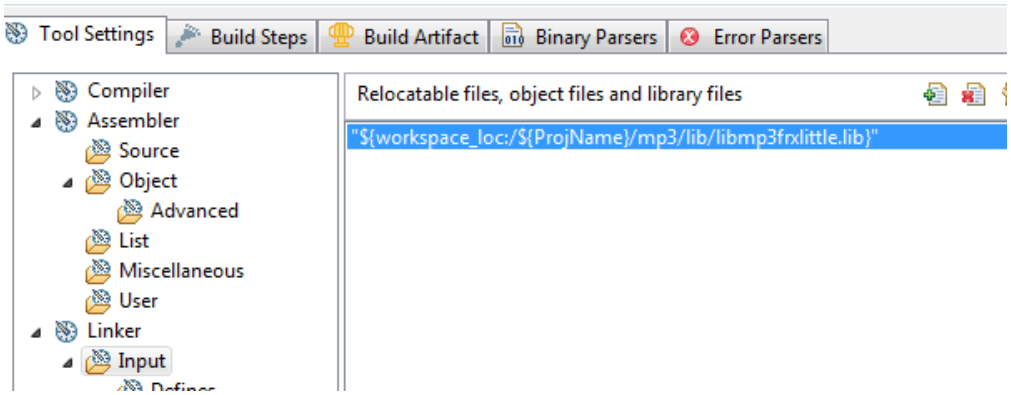
3.1 Copy the MP3 files into the project

In **e² studio,** Copy the "libMP3Frxlittle.lib" and the "mp3f.h" files into their corresponding folders in the RX_Audio_Player project as shown:



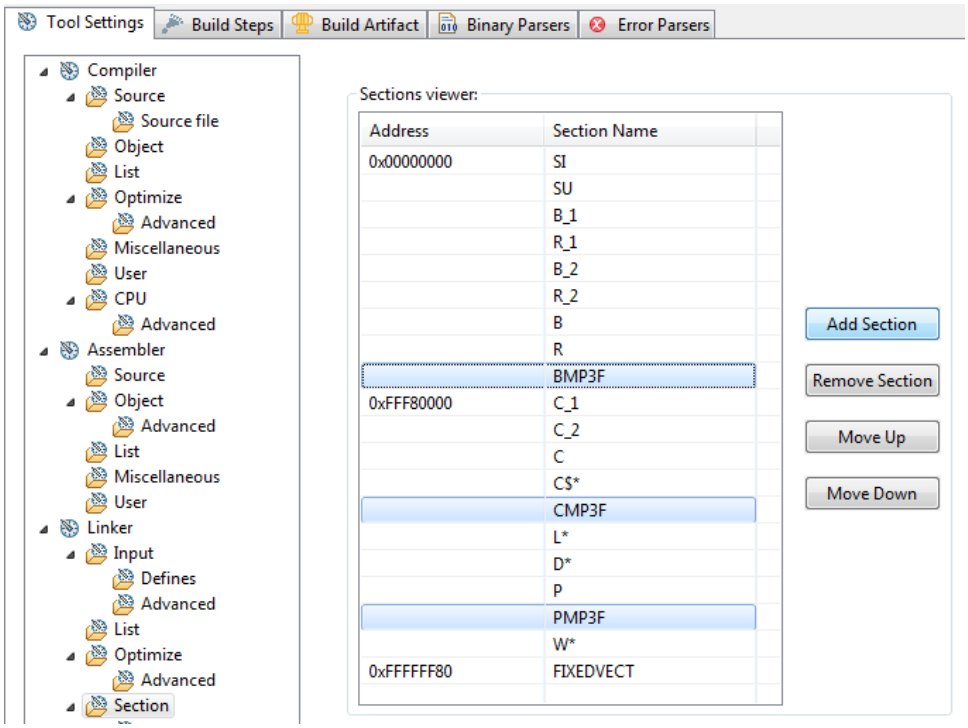
3.2 Configure the project to include the MP3 .lib

In **e² studio,** navigate to the **RX_Audio_Player->Properties->C/C++Build->Settings->Linker->Input** view and click the + icon (Add...) to add the file path to the "libMP3Frxlittle.lib" file.



3.3 Add Linker Sections

Add the following sections; **BMP3F**, **CMP3F**, **PMP3F** to the Linker section table as shown:



Click "**Apply**", then "**OK**"

3.4 Set the MP3 configuration option

The last step before building the project is to enable the MP3 source. Open the "RX_Audio_Player\src\audio\ audio_player_config.h" file and edit the "MP3_ENABLED" option as below:

```
#define MP3_ENABLED (1)
```

This will cause the MP3 portions of the C source code to be included in the build.

4. Supported Audio File Formats

Audio files in the MP3 format (MPEG-1 layer III, and MPEG-2 layer III), 16-bit PCM encoded, or 16-bit IMA ADPCM .wav format files can be selected from the browser for playback.

For ADPCM, only monaural format file playback is supported. ADPCM files need to be in the IMA ADPCM standard format, which includes a RIFF type file header and correct data frame headers. Metadata file tags are not presently supported. IMA ADPCM is considered to be a sub-type of the .wav file format, and so must use the .wav file extension.

Table 3 Supported Audio File Formats

Audio file type	File extension	Decoded Sample size	44.1 kHz	33.075 kHz	32.0 kHz	22.05 kHz.	11.025 kHz.	Stereo	Mono
Uncompressed PCM	.wav	16-bits	○	○	○	○	○	○	○
IMA ADPCM	.wav	16-bits	○	○	○	○	○	x	○
MPEG-1 layer III	.mp3	16-bits	○	x	○	x	x	○	○
MPEG-2 layer III	.mp3	16-bits	x	x	x	○	x	○	○
MPEG2.5	.mp3	16-bits	x	x	x	x	○	○	○

5. Using the sample application

To run the program in the **e² studio** development environment, first build the "RX_Audio_Player" project. Then download the code to the YRDKRX63N using the GDB debugger.

Alternatively, with the sample application software already loaded in the MCU flash, the audio player demo may be run in a stand-alone manner. In this case the board will need to be powered by either a USB cable plugged into the J-Link debugger port, or by providing regulated 5-volt power to one of the board power connectors. If using the J-Link USB port just for power, it is recommended to disable the debugger function by placing a shorting plug on the "J-Link disable" two-pin header located near the USB connector.

When the board is powered on, it will reset, and the audio player application will start. Control of the application is done with the pushbuttons on the YRDKRX63N, and information is displayed on the on-board LCD.

Before starting the application, a micro SD-Card containing the audio files should be inserted in its slot on the YRDKRX63N. If the card is not present when the application starts, the application will wait until the SD-Card is inserted, with a red LED illuminated to indicate the waiting status.

After the SD-Card is successfully recognized, the application immediately proceeds to the file browse function with user control information displayed on the LCD.

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.

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.mp3" (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:").

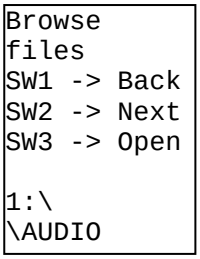
> Note: Take care inserting or removing the micro SD Card from the slot on the YRDKRX63N. It should go in or out in a straight direction aligned with the slot. The micro SD Card is fragile and can be damaged or cracked by excessive off-center pressure.

Once an audio file of the .mp3 or .wav 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.

5.1 Using the file browse function to find and play audio files.

On startup, the sample software proceeds to the file browsing function. Files and directories can be displayed on the LCD one at a time by pressing switches on the YRDKRX6xN board. On entry, the root directory is read and the first file or directory name will be displayed. The switch usage instructions are displayed on the LCD as follows:

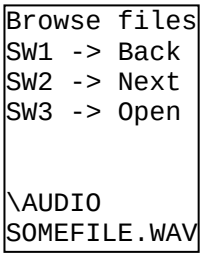
Example display:



Press switch 2 to view the next file or directory entry.
Press switch 3 to open the currently displayed file or directory.

The root (top) directory name is always displayed as 1:\ (drive 1:).
Below that, the first file or directory name in this folder is displayed.

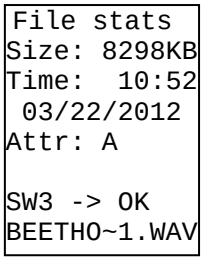
Directory names start with a backslash character ' \ '. If the currently displayed entry is a directory, then pressing switch 2 opens that directory for reading, and the first entry in that directory will displayed. Also, the current directory name will remain visible on the line above.



Press switch 1 to go back up one directory level.
Press switch 2 to view the next file or directory entry.
Press switch 3 to open the currently displayed file or directory.

Current directory name remains displayed.
Current file entry in the directory.

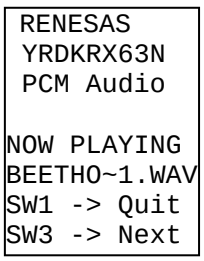
If the currently displayed entry is a file, then pressing switch 3 reads the file statistics and displays them on the LCD. The contents of the file are not examined at this point. When finished viewing the information, press SW3 to proceed. If the file is a supported audio file type (name ends with .wav or .mp3), then the audio player will open the file and begin playing it. If it is any other file type then the browser menu will return.



Basic file statistics known to the file system are displayed.

Press switch 3 to proceed.
Current file entry is displayed. Long file names are displayed truncated to 8.3 format.

After pressing switch 3 in the above example, the audio controls are displayed and the player will start playing the file. Once playback begins, the choices to quit or advance to the next audio selection in the current directory are available. If "Next" is selected, the currently playing audio stops immediately, and the next audio file found will begin playing. Otherwise, playback will continue until the selection has completed, and then the next audio file found will begin playing. Playback continues in an endless loop, cycling through all supported audio files in the current directory. At any time the "Quit" button may be pressed which will stop playback and return to the file browser.



The currently playing file is displayed. Long file names are displayed truncated to 8.3 format.
Press switch 1 to quit playback and return to the file browser.
Press switch 3 to skip to the next audio file.

6. Audio player principle of operation

This project renders audio from the RX6xx MCU as a PWM signal. PCM audio data is acquired from either .wav format (raw PCM or IMA ADPCM) or .mp3 format files stored on a micro-SD card memory in a FAT file-system. The basic scheme of operation is illustrated in Figure 1

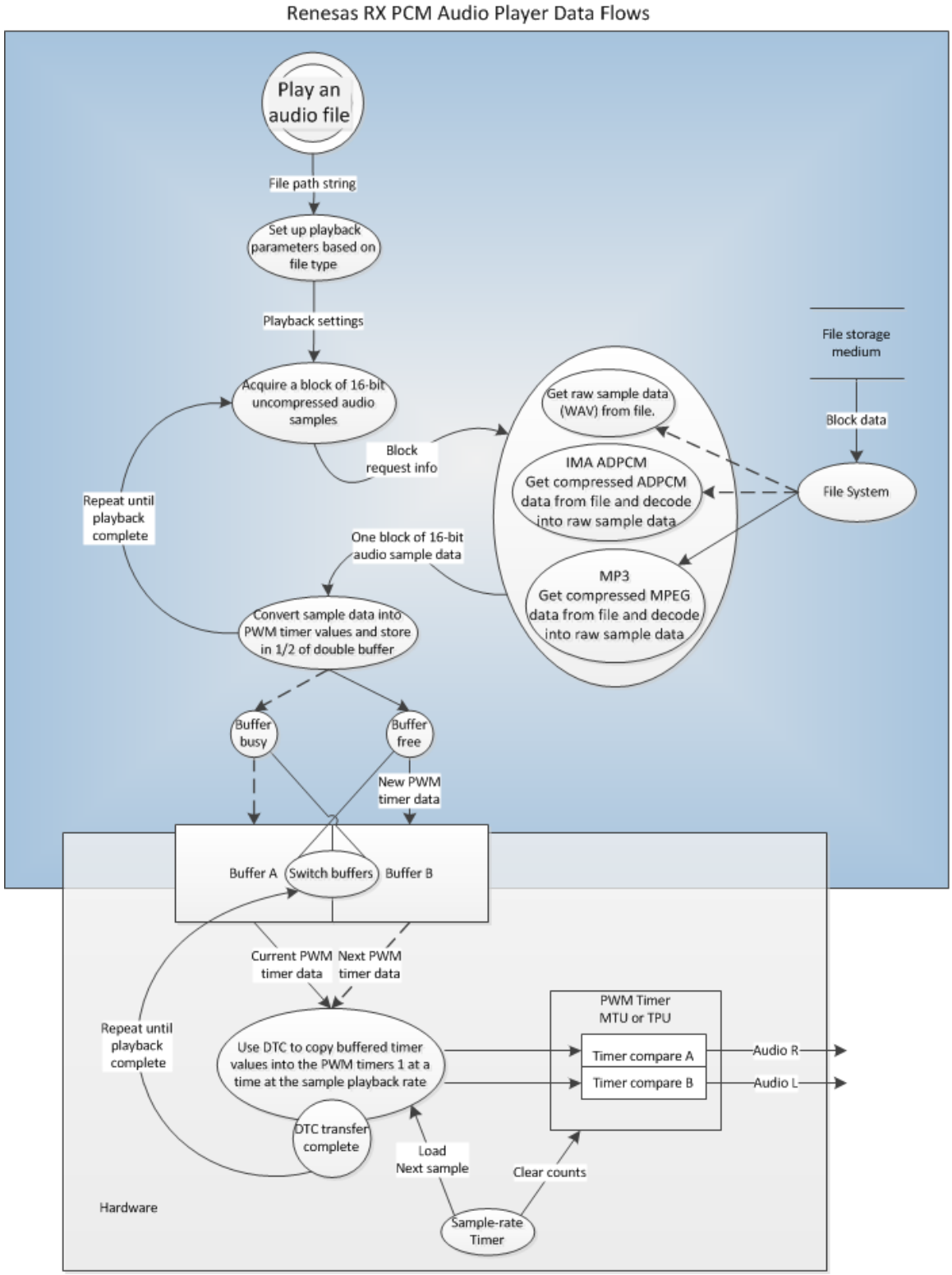


Figure 1 principle of operation

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Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
Rev.1.00	Dec 2, 2013	-	First edition issued

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The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Handling of Unused Pins

   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.

   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment when power is supplied.

   — 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.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   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.

   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

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   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

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