RX610 Group

RX-Stick Audio Processing Demonstration

REU05B0150-100
Rev.1.00
Oct 20, 2010

Introduction

The following document describes the power of the RX architecture and how features such as its Floating-Point Unit make it possible to perform real-time audio processing.

Target Device

RX610 Group

Contents

1. Introduction

The RX architecture sets a new benchmark for MCU performance, offering 1.65 DMIPS/MHz and incorporating powerful features such as an on-chip Floating Point Unit (FPU), DSP-like instructions, and execution from zero wait state flash memory up to 100 MHz. These features make it possible to use the RX for demanding applications that previously were the domain of DSP's.

This application note provides details about one such demanding application: audio processing. In this demonstration it will be shown how the RX can perform real-time decode and playback of ADPCM compressed audio while at the same time analyzing the spectrum of the audio using an FFT and visualizing the spectrum in a real-time display.

2. Application Highlights

- ADPCM audio samples are stored in on-chip flash memory
- The audio samples are recorded at 16-bit, 44.1 kHz
- Playback of the audio is via the RX610's 10-bit DAC
- A 1024-point FFT is performed on the audio data in real-time as it is played back
- The RX has a sophisticated DMA controller that is used to automatically refresh the LED display without requiring any processor overhead

3. References

The user manual for the RX-Stick is: **REJ10J2168: RX-Stick User Manual**

The hardware manual for the RX610 is: **REJ09B0460: RX610 Group Hardware Manual**

The software manual for the RX610 is: **REJ09B0435: RX Family Software Manual**

3.1 Hardware Manual Relevant Chapters

Address Space – for details on the memory map of the RX

I/O Registers – provides a complete listing of all registers

Clock Generation Circuit – for details on how to setup the bus and peripheral clock on the RX

Interrupt Control Unit - for details on the enabling interrupts from the interrupt controller to the CPU and DMAC

DMA Controller (DMAC) – for information on the DMAC used to drive the LED display

I/O Ports – provides information on how to configure port pins for GPIO or peripheral use

16-Bit Timer Pulse Unit (TPU) – a number of timer channels are used to drive the display and audio playback

D/A Converter – The DAC is used to drive the speaker for audio output.

4. Application Overview

There are four main functional blocks in the application: ADPCM audio decode, audio rendering (playback), spectral analysis (FFT library), and spectral display.

A timer interrupt is set to fire at 44.1 kHz. During the timer interrupt, a single audio sample is read from flash and decoded by the ADPCM decoder. The decoded sample is rendered to the speaker via the DAC on the RX. As the data is decoded, the audio samples are passed to an analysis function that performs spectrum analysis using an FFT. The component frequencies of the audio sample are visualized on the LED display in the form of a real-time spectrum display showing a selected block of frequencies.

4.1 Running the Application

Connect the RX-Stick to your PC, open the workspace “C:\Workspace\RX_Stick_ADPCM_FFT”, and select “Build All” from the Build menu. After the program builds, select “Debug | Download Modules | Download All Modules” from the menus at the top of the screen. Because of the size of the audio data, it will take a minute or two for the download to complete. Once the modules have been downloaded, click the “Reset Go” button on the toolbar (or press Shift-F5) to start the program.

4.2 Mute Button

The pushbutton K1 on the RX-Stick acts as a mute button for the demonstration. Pressing the button mutes the audio. ADPCM decode and spectral analysis and visualization still occur in real time, but the audio samples are not copied to the DAC to drive the speaker. Pressing the button again turns the speaker on. A TPU timer channel is used to debounce the pushbutton.

5. Program Details

The follow sections detail the working of the major blocks of the demo program. Refer to section 6 for flowcharts.

5.1 ADPCM Audio Decode

ADPCM audio decode is performed in a timer interrupt service routine that is triggered by TPU channel 0 at a rate of 44.1 kHz. The ADPCM library works by fetching raw ADPCM data from flash and returning a value suitable for writing to the DAC.

5.2 Audio Render

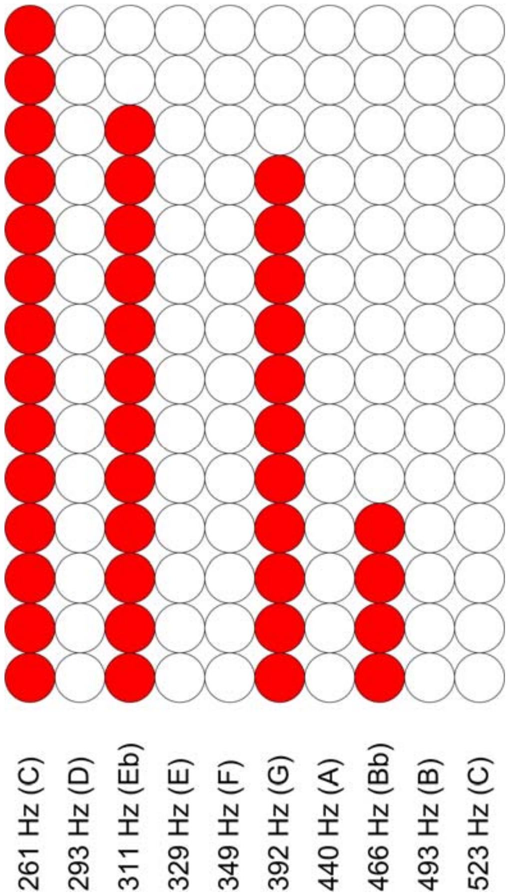
Audio is rendered during an interrupt firing at a rate of 44.1 kHz (the sample rate of the supplied demonstration audio clips). During the interrupt, the next PCM sample is fetched from the PCM buffers filled by the ADPCM decoder. The sample is converted from 16-bit to 10-bit and copied to the DAC, which in turn drives the speaker through an op amp. The render function also copies the sample to the FFT Spectral Analysis block.

5.3 FFT Spectral Analysis

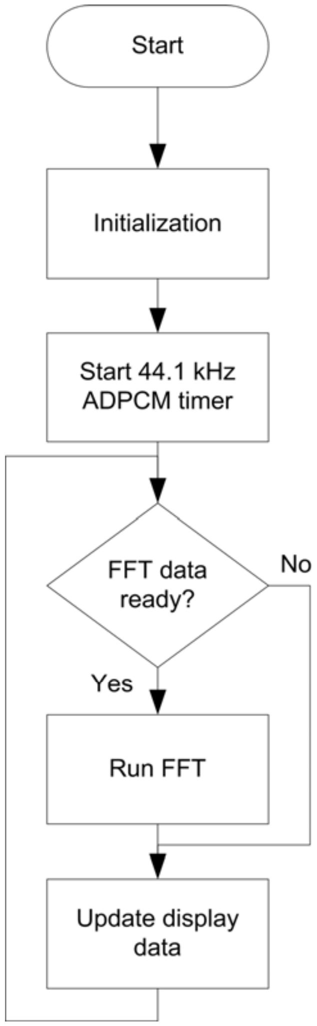
A 1024-point FFT is run periodically on the playing audio to resolve it into its spectral components for frequencies below 1 kHz. The playing audio is downsampled from 44.1 kHz to 2.75 kHz, and the FFT is run on the 1024-sample buffer every 256 samples. Roughly every 93 ms (2.75 kHz /256 samples) the FFT runs and stores its results in the 256 spectrum bins. The values in a small number of these bins that represent a span of roughly 1 octave are used for Spectral Visualization.

5.4 Spectral Visualization

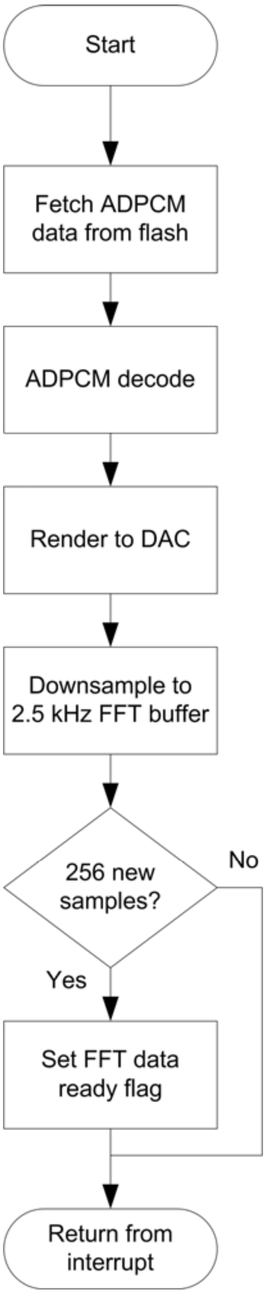
Ten columns on the LED display are used to show the relative magnitude of 10 of the FFT output bins as a simple means of visualizing the frequency components of the audio being played. The bins selected correspond roughly to a one-octave range. The bin values are scaled to fit the 14-pixel high LED display. A TPU timer channel triggers DMA transfers from the screen buffer to the port pins that drive the LED's. Data from the FFT bins is copied to the screen buffer in the foreground task.



6. Program Flowcharts



Main Program Loop Flow



TPU0 Interrupt Service Routine Flow (fires at 44.1 kHz)

Website and Support

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

Inquiries
http://www.renesas.com/inquiry

Revision Record

Rev.	Date	Description	
		Page	Summary
1.0	Oct.20.2010	—	First edition issued

General Precautions in the Handling of MPU/MCU Products

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.

5. Differences between Products

   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.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

Renesas Electronics Corporation

SALES OFFICES http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.
2880 Scott Boulevard Santa Clara, CA 95050-2554, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada
Tel: +1-905-898-5441, Fax: +1-905-898-3220

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
7th Floor, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100083, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 204, 205, AZIA Center, No.1233 Lujiazui Ring Rd., Pudong District, Shanghai 200120, China
Tel: +86-21-5877-1818, Fax: +86-21-6887-7858 / -7898

Renesas Electronics Hong Kong Limited
Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2886-9318, Fax: +852 2886-9022/9044

Renesas Electronics Taiwan Co., Ltd.
7F, No. 363 Fu Shing North Road Taipei, Taiwan, R.O.C.
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
1 harbourFront Avenue, #06-10, keppel Bay Tower, Singapore 098632
Tel: +65-6213-0200, Fax: +65-6278-8001

Renesas Electronics Malaysia Sdn.Bhd.
Unit 906, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics Korea Co., Ltd.
11F., Samik Lavied' or Bldg., 720-2 Yeoksam-Dong, Kangnam-Ku, Seoul 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

Colophon 1.0