RX Family

Sample program that uses Sound Playback/Compression System (Original ADPCM Codec) [M3S-S2-Tiny] Module Firmware Integration Technology

R20AN0291EJ0101
Rev.1.01
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Introduction

This document explains the sample program of ADPCM Encoder/Decoder library (hereafter referred to as "S2 library"). S2 Library can playback/record to use RX Family.

The sample program works on each Renesas Starter Kit. The Middleware Evaluation Board is needed to playback/record for Renesas Starter Kit. Please refer to the [Section 2. Development environment] to know about the Middleware Evaluation Board.

Target Device

RX64M Group, RX610 Group, RX210 Group, RX111 Group, RX65N Group

Contents

1. Structure of Application Note

Table 1 S2 library product files

name			Description
r20an0291ej0101_rx_s2.pdf			This document
readme_r20e.txt			Sample program Information
workspace			
	Sample program(sample)		
		rx64m_rsk	Sample program for RX64M (e^2 studio)(*)
		rx610_rsk	Sample program for RX610 (e^2 studio)(*)
		rx210_rsk	Sample program for RX210 (e^2 studio)(*)
		rx111_rsk	Sample program for RX111 (e^2 studio)(*)
		rx65n_rsk	Sample program for RX65N (e^2 studio)(*)

(*)It is possible to convert e^2 studio project to CS+ project.

2. Development environment

Please ensure that when developing with this product, you have the same or newer versions than those listed below.

[Software]

-Integrated Development Environment

e^2 studio V5.2

-Coding Tool

Renesas RXC Toolchain V2.04.01

[Debug tools]

-Emulator debugger

E1 emulator

-Emulator software

RX E1/E20 Emulator Debugger V.1.02.00

[Board]

Renesas Starter Kit+ for RX64M CPU Board	type : R0K50564MC010BR
Renesas Starter Kit for RX610 CPU Board	type : R0K56108C000BE
Renesas Starter Kit for RX210 CPU Board	type : R0K52108C000BE
Renesas Starter Kit for RX111 CPU Board	type : R0K505111S000BE#WS
Renesas Starter Kit+ for RX65N CPU Board	type : RTK5005651C01000BR

Middleware Evaluation Board Renesas

— Please download Middleware Evaluation Board Manual from Renesas Website

http://www.renesas.com/products/mpumcu/rx/Application_Notes.jsp

- Document No : R21AN0004EJ
- Document Title : RX600 Series Usage of Renesas Starter Kit for RX610 Middleware Evaluation Board

Amplifer Board Hokuto Denshi type : AMP386A

This board can be used for sound playback. Please refer to the following Website.

http://www.hokutodenshi.co.jp/7/amp386a.htm

3. Sample program

This section explains the sample program The sample program is in the form of e^2 studio workspace. Please change the initialization of the microcomputer and its peripherals according to the user system.

3.1 Operation method

Sample program waits inputting switch on the board in main function.

Pushing SW, the sample program works like below.

Table 2 Operation list

Operations	Sample Program Works
Pushing SW2 (Refer to 3.3 SW2 : Voice play back program)	Voice play back Sample program plays back decoding ADPCM data reading from ROM using PWM or DA output.
Pushing SW1 (Refer to 3.4 SW1: Voice recode program)	Voice recode Sample program recodes PCM data comes from A/D input, and the PCM data is converted to ADPCM data writes to RAM.

3.2 Environment

Sample program is running on each Renesas Starter Kit Renesas CPU board. (Hereafter CPU board).

Each sample programs structures are below.

Table 3 sample programs structures

Sample program	PWM signal output(*)	D/A converter analog output(*)	A/D converter analog input
RX64M	P24(MTIOC4A)	P03(DA0) 12bitD/A	P43(AN003) 12bitA/D
RX610	P21(TIOCA3)	P66(DA0) 10bitD/A	P40(AN0) 10bitA/D
RX210	P24(TIOC4A)	P03(DA0) 10bitD/A	P45(AN005) 12bitA/D
RX111	P17(MTIOC3A)	P03(DA0) 8bitD/A	P43(AN003) 12bitA/D
RX65N	P24(MTIOC4A)	P03(DA0) 12bitD/A	P43(AN003) 12bitA/D

(*)PWM output setting and D/A output setting are changed in sample program code.

User has to connect own system to Middleware Evaluation Board. These pins are able to access using CPU board Application Header and Microcontroller header. Please refer to the Application Note of Middleware Evaluation Board.

3.3 Environment for FIT Module

Sample program projects are built using FIT module plug-in function included in e^2 studio.

3.3.1 Using FIT Modules

This sample program use following FIT Modules.

- RX Family Sound Playback/Compression System (Original ADPCM Codec) [M3S-S2-Tiny] Module Firmware Integration Technology
  (R20AN0037)
- RX Family Board Support Package Module Using Firmware Integration Technology
  (R01AN1685)

Please refer to the document included each FIT modules when user needs more details information about each FIT modules.

3.3.2 Method of converting e^2 studio to CS+ project

e^2 studio project can be converted to CS+ project to use *.rcpc file included in e^2 studio project. This section shows method of converting.

- Start CS+, push the "GO" button in "e2 studio / CubeSuite / …".
- Select "e2 studio project file (*.rcpc) " and, open the *.rcpc file.
- "Project convert settings" window would open, and please select project in the project tree.
- Project settings on the right side of project tree, please select MCU "RX64M" -> "R5F564MLDxFC" and push the "OK" button. CS+ outputs the converted project.
- Please select "CC-RX" in the project tree.
- Please select "RXv2 architecture" in the "common option" tab -> "CPU" -> "command set architecture"
- Please change the settings as following.
  "Link Option"tab -> "Input"tab -> "Binary data file"

  [changing]
  %ProjectFolder%/../%ProjectName%/adpcm/sound_adpcm.dat}(ADPCM_ADDR1)
  %MainProjectDir%/%ProjectName%/adpcm/sound_adpcm.dat(ADPCM_ADDR1)

  [after changing]
  Delete the no need "}" character and no need path.
  %ProjectFolder%/../%ProjectName%/adpcm/sound_adpcm.dat(ADPCM_ADDR1)

.

- Build the project
- Please set the debug tools fitting for your environment. User can confirm working sample program after this.

3.4 SW2 : Voice play back program

3.4.1 Outline

This sample program will play back sound when SW2 is pushed. Voice is played back using PWM output function.

The function "R_decode_main" decodes ADPCM data and stores PCM data to ring buffer. Timer interrupt function loads this PCM data and outputs. This process will continue when all ADPCM data will have loaded. The PCM data is loaded every 90.7 us from buffer in timer interrupt function. Sampling frequency of voice data is 11.025 kHz.

[Note] *90.7micro sec (Near equal 11.025kHz)

The size and the storage area of the sound data are defined by the following macros.

Size of sound data (twice ADPCM data size)	: Macro name PCM_DATA_SIZE1
Start address in storage area	: Macro name ADPCM_ADDR1

User can choose the D/A output or the PWM output by a value of the SOUND_OUTPUT_MODULE macro in r_s2_driver.h. Please define a value of either following.

When use D/A output	: Defines SOUND_DA macro
When use PWM output	: Defines SOUND_PWM macro

While this sample software requires polling on a short time basis in the main loop to prevent buffer under-run of the PCM data buffer, this is not practical user system. The user can consider other mechanisms such as buffer expansion in periodic interrupt or via RTOS to meet buffer expansion requirements of the system.

3.4.2 Flow

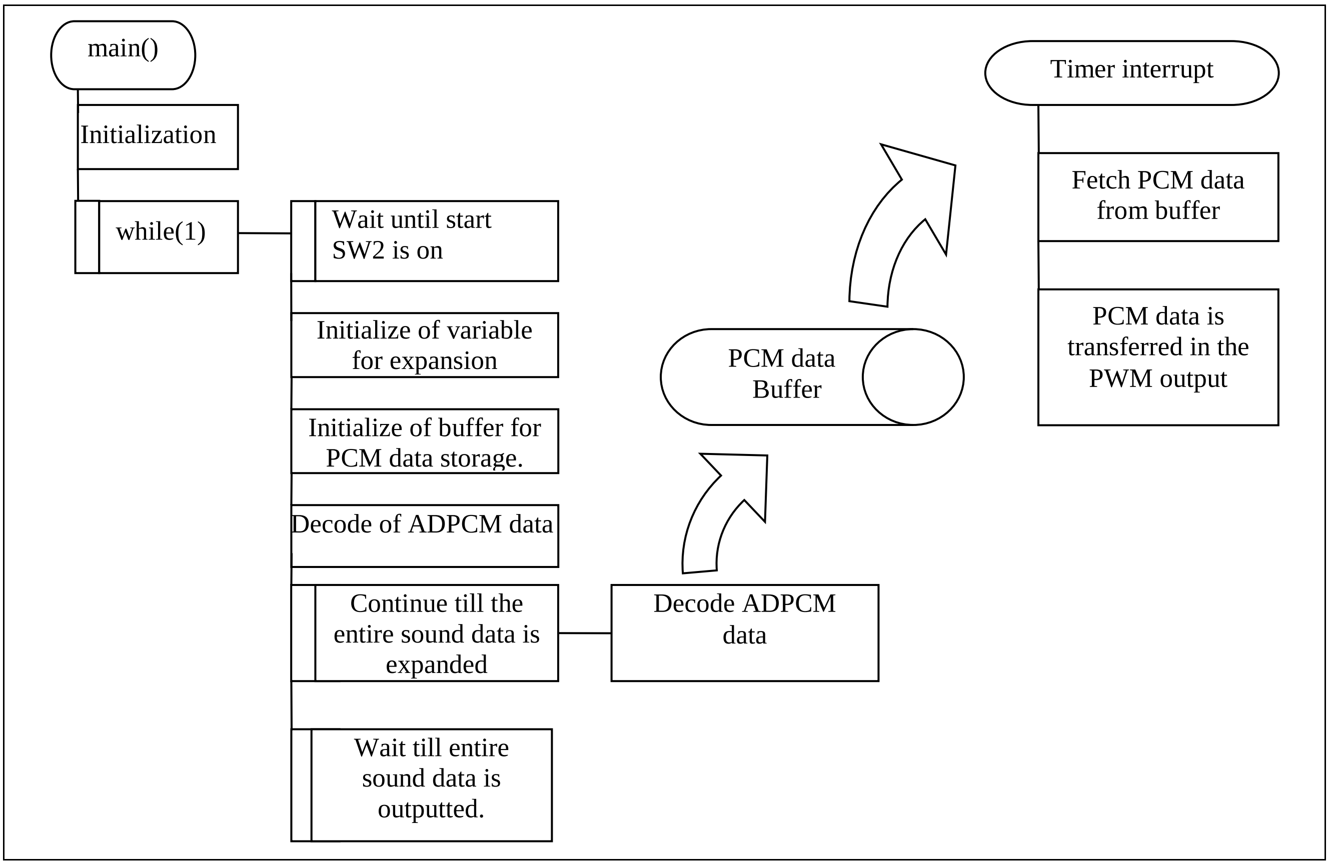
main()
Initialization
while(1)
Wait until start SW2 is on
Initialize of variable for expansion
Initialize of buffer for PCM data storage.
Decode of ADPCM data
Continue till the entire sound data is expanded
Decode ADPCM data
Wait till entire sound data is outputted.
PCM data Buffer
Timer interrupt
Fetch PCM data from buffer
PCM data is transferred in the PWM output

Figure 1 Flow

3.4.3 Function List

Table 4 Function list

No.	Function Name	Outline
1	main	Main function..
1.1	R_StartSelect	Wait switch inputting.
1.2	R_decode_main	Decode ADPCM data on ROM, and store PCM data to ring buffer.
1.2.1	decode_interval_timer_init	Initializes setting of timer for sampling frequency.
1.2.2	SOUND_MODULE_INIT(*)	Initializes setting of PWM/DA output.
1.2.3	R_InitDecInfo	Decoded information structure (DECINFO) initialization.
1.2.3.1	R_adpcm_initDec	The Work Area for expansion is initialized. - This is a library function.
1.2.4	R_InitRingBuffer	Initializes setting of the ring buffer to store decoded data.
1.2.5	R_DecodeProc	Converts ADPCM data into PCM data and stores the decoded data in a ring buffer. ADPCM Input pointer is updated here.
1.2.5.1	R_adpcm_RefreshDec	Refreshes the input ADPCM data buffer and output PCM data buffer. - This is a library function
1.2.5.2	R_adpcm_decode	4bit ADPCM data is converted into 16bit PCM data. - This is a library function.
1.2.5.3	R_RingBufferSetData	Check the state of the ring buffer before writing data.
1.2.5.3.1	R_RingBufferPush	Decoded PCM data is pushed to a ring buffer.
1.2.5.3.1.1	SOUND_OUTPUT_DATA_CNV(*)	Convert PCM data (16bits) into PWM output data/DA 10bit output data.
1.2.6	SOUND_MODULE_START(*)	Start timer for PWM/DA output.
1.2.7	decode_interval_timer_start	Start timer for sampling frequency.
1.2.8	SOUND_MODULE_STOP(*)	Stop for PWM/DA output.
1.2.9	decode_interval_timer_stop	Stop timer for sampling frequency.
1.2.10	SOUND_MODULE_SLEEP(*)	PWM timer/DA converter does transition to the module stop state.
1.2.11	decode_interval_timer_sleep	Timer for sampling frequency does transition to the module stop state..
2	R_interrupt_decode_timer	Output decoded PCM data every cycle of the sampling frequency using PWM/DA.
2.1	R_SetPCMdata	Send sound data (PCM) to PWM/DA output.

(*)These are the macro that function is defined. These change by a value of SOUND_OUTPUT_MODULE macro.

Table 5 Function macro list

Function Macro Name.	When SOUND_OUTPUT_MODULE defines SOUND_DA	When SOUND_OUTPUT_MODULE defines SOUND_PWM
SOUND_MODULE_INIT	decode_da_converter_init	decode_pwm_init

SOUND_OUTPUT_DATA_CNV	R_Convert16to10(RX610、RX210)
	R_Convert16to12(RX64M,RX65N)
	R_Convert16to8(RX111)
		R_Convert16toPWM

SOUND_MODULE_START	decode_da_converter_start	decode_pwm_start
SOUND_MODULE_STOP	decode_da_converter_stop	decode_pwm_stop
SOUND_MODULE_SLEEP	decode_da_converter_sleep	decode_pwm_sleep

3.4.4 Function Chart

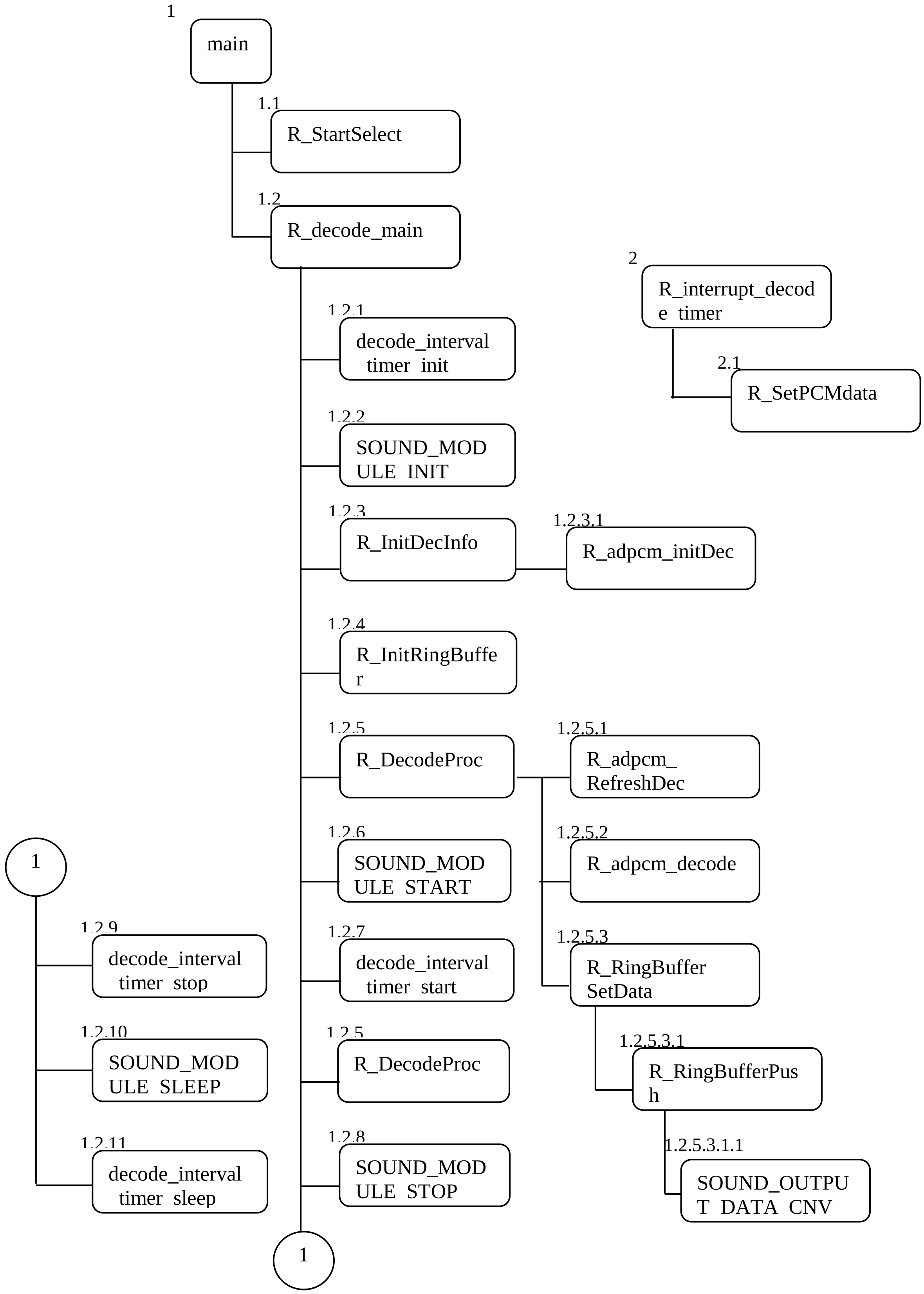

Figure 2 Function chart

3.4.5 Sound data modification procedure

The sample sound data is included in sample program. This section introduces how to change this sample sound data to user sound data below.

(1) Creation of sound data

Prepare sound data with specification as given in this table.

Table 6 Specification of sound data

Quantization bits	16bit
Channel	Mono
Sampling frequency	11.025kHz
File format	WAV

(2) Encoding of sound data

Make the ADPCM data (binary form) from the Wave (.wav) file using the bundled "ADPCM_TOOL(ADPCM.exe)". Please refer the manual of the tool "ADPCM_TOOL" for its usage.

(3) Change in sample program

・**PCM_DATA_SIZE1**

The value of the macro "PCM_DATA_SIZE1" should be set in "r_s2_driver.h" file of the sample program. It should be set according to the size of the sound data used. A set value has to be at least twice the size of ADPCM data (compression data).

[E.g. When size of ADPCM data is 0x1ef1 bytes, setting will be]

```
 #define PCM_DATA_SIZE1 0x3de2 /* size of sound data after decode(compressed data) */
```

・**ADPCM_ADDR1**

Set the value of address "ADPCM_ADDR1" in "r_s2_driver.h" file of the sample program as per the location of ADPCM data. "ADPCM_ADDR1" address has to be smaller than mirror area defined size "PCM_DATA_SIZE1".

[If ADPCM data starts from address 0xFFF80000]

```
 #define ADPCM_ADDR1   0xFFF80000   /* top address of ADPCM sound data storage */
```

(4) Loading of sound data

Download ADPCM data to the address set to "ADPCM_ADDR1". ADPCM data is the data created using the ADPCM_TOOL. Please refer Integrated Development Environment manual for the downloading procedure.

3.4.6 10 bit sound data

The sound data expanded by the R_adpcm_decode() function is 16 bit in length. According to the system being used, change the bit length of the sound data. In the sample program of RX610 and RX210, the data of 16 bit length has been converted into 10 bit length using the R_Convert16to10() function. (When 10-bits D/A convertor etc. are used, this can be used.)

The data of length 16bit is converted into data of length 10 bit by the following functions.

Argument: 16 bit PCM data before conversion

Return value: 10 bit DA data after conversion

```
  return (uint16_t)(((data + 0x20) >> 6) + 512);
```

3.4.7 Settings for PWM output

This section explains settings for PWM output and operation.

- <Specification>

Sample program uses 2 channels as Interval timer and PWM function. Interval timer's periodic interrupt sets calculated duty value to timer general register (PWM function) from PCM data.

The duty value is calculated in the following formula. (r_s2_decode.c function name: R_Convert16toPWM)

```
return (uint16_t)(((int32_t)( data + 32768 )* PWM_SAMPLING) >> 16);
```

— Meaning of this formula.

- Meaning of +32768
  Adjusting input value (data).
  The input value (data) type is int16_t. And the value type is uint16_t.
- Meaning of PWM_SAMPLING and " >> 16"
  input value (data) : 0xffff (timer max count) = x : PWM_SAMPLING (timer count for 100kHz)
  x = (input value (data) * PWM_SAMPLING) / 0xffff
  = (input value (data) * PWM_SAMPLING) >> 16;

(1) [In the case of RX64M]

- <Resource>
  Multi-Function Timer Pulse Unit 3 (Channel: 1, 4)
  Output pin (MTIOC4A)

Table 7 Settings for PWM output

Channel.	Item	Outline
1	Operation	Periodic operation for sampling sound data.
	Output port	None
	Operation mode	Normal mode
	Operation clock	120MHz
	Cycle time	Sampling frequency for sound (Near equal 11.025kHz) Timer cycle is TGRA compare match.
	Interrupt	In use.
4	Operation	PWM function
	Output port	Exist (MTIOC4A)
	Operation mode	PWM mode 1 TGRA and TGRC used together for buffer operation.
	Operation clock	120MHz
	Cycle time	100kHz(Shorter cycle than channel 1 frequency) PWM frequency is TGRB compare match.
	PWM output settings	Low level output at TRGA compare match. High level output at TRGB compare match.
	Buffer transfer timing from TRGC to TRGA	TCNT register clear.(= TRGB compare match)
	Duty	Updating in channel 1 interrupt.
	Interrupt	Not in use.

==Limitation==
Please change the 0-orm register for RX64M CPU Board to confirm working the D/A output sample program.

Table 8 Implement change

Signals	Registers		Notes
	R189	R277	
DA0	Implement	No implement	To confirm D/A output sample program
LED0	No implement	Implement	Default

(2) [In the case of RX610]

- <Resource>
  16-Bit Timer Pulse Unit 2ch (Channel: 1, 3)
  Output pin (TIOCA3)

Table 9 Settings for PWM output

Channel.	Item	Outline
1	Operation	Periodic operation for sampling sound data.
	Output port	None
	Operation mode	Normal mode
	Operation clock	50MHz
	Cycle time	Sampling frequency for sound (Near equal 11.025kHz) Timer cycle is TGRA compare match.
	Interrupt	In use. (function name: R_int_timer_TGI1A)
3	Operation	PWM function
	Output port	Exist (TIOCA3)
	Operation mode	PWM mode 1 TGRA and TGRC used together for buffer operation.
	Operation clock	50MHz
	Cycle time	100kHz(Shorter cycle than channel 1 frequency) PWM frequency is TGRB compare match.
	PWM output settings	Low level output at TRGA compare match. High level output at TRGB compare match.
	Buffer transfer timing from TRGC to TRGA	TCNT register clear.(= TRGB compare match)
	Duty	Updating in channel 1 interrupt.
	Interrupt	Not in use.

(3) [In the case of RX210]

- <Resource>
  Multi-Function Timer Pulse Unit 2 (Channel: 1, 4)
  Output pin (TIOC4A)

Table 10 Settings for PWM output

Channel.	Item	Outline
1	Operation	Periodic operation for sampling sound data.
	Output port	None
	Operation mode	Normal mode
	Operation clock	25MHz
	Cycle time	Sampling frequency for sound (Near equal 11.025kHz) Timer cycle is TGRA compare match.
	Interrupt	In use.
4	Operation	PWM function
	Output port	Exist (TIOC4A)
	Operation mode	PWM mode 1 TGRA and TGRC used together for buffer operation.
	Operation clock	25MHz
	Cycle time	100kHz(Shorter cycle than channel 1 frequency) PWM frequency is TGRB compare match.
	PWM output settings	Low level output at TRGA compare match. High level output at TRGB compare match.
	Buffer transfer timing from TRGC to TRGA	TCNT register clear.(= TRGB compare match)
	Duty	Updating in channel 1 interrupt.
	Interrupt	Not in use.

(4) [In the case of RX111]

- <Resource>
  Multi-Function Timer Pulse Unit 2 (Channel: 1, 3)
  Output pin (MTIOC3A)

Table 11 Settings for PWM output

Channel.	Item	Outline
1	Operation	Periodic operation for sampling sound data.
	Output port	None
	Operation mode	Normal mode
	Operation clock	24MHz
	Cycle time	Sampling frequency for sound (Near equal 11.025kHz) Timer cycle is TGRA compare match.
	Interrupt	In use.
3	Operation	PWM function
	Output port	Exist (MTIOC3A)
	Operation mode	PWM mode 1 TGRA and TGRC used together for buffer operation.
	Operation clock	24MHz
	Cycle time	100kHz(Shorter cycle than channel 1 frequency) PWM frequency is TGRB compare match.
	PWM output settings	Low level output at TRGA compare match. High level output at TRGB compare match.
	Buffer transfer timing from TRGC to TRGA	TCNT register clear.(= TRGB compare match)
	Duty	Updating in channel 1 interrupt.
	Interrupt	Not in use.

(5) [In the case of RX65N]

- <Resource>
  Multi-Function Timer Pulse Unit 3 (Channel: 1, 4)
  Output pin (MTIOC4A)

Table 12 Settings for PWM output

Channel.	Item	Outline
1	Operation	Periodic operation for sampling sound data.
	Output port	None
	Operation mode	Normal mode
	Operation clock	120MHz
	Cycle time	Sampling frequency for sound (Near equal 11.025kHz) Timer cycle is TGRA compare match.
	Interrupt	In use.
4	Operation	PWM function
	Output port	Exist (MTIOC4A)
	Operation mode	PWM mode 1 TGRA and TGRC used together for buffer operation.
	Operation clock	120MHz
	Cycle time	100kHz(Shorter cycle than channel 1 frequency) PWM frequency is TGRB compare match.
	PWM output settings	Low level output at TRGA compare match. High level output at TRGB compare match.
	Buffer transfer timing from TRGC to TRGA	TCNT register clear.(= TRGB compare match)
	Duty	Updating in channel 1 interrupt.
	Interrupt	Not in use.

==Limitation==
Please change the 0-orm register for RX65N CPU Board to confirm working the D/A output sample program.

Table 13 Implement change

Signals	Registers		Notes
	R192	R306	
DA0	Implement	No implement	To confirm D/A output sample program
LED0	No implement	Implement	Default

3.5 SW1: Voice recode program

3.5.1 Outline

This sample program will recode sound when SW1 is pushed. Voice is recoded using A/D converter.

The function "R_encode_main" initializes encoder and starts timer. After that, this program samples input signals every 125us. (Sampling frequency = 8kHz) A/D input data is passed to this function to convert to ADPCM, and encoded ADPCM data will be stored RAM. Encode process will continue until ADPCM data reaches size "MAX_DATA_LENGTH".

The size of the ADPCM data is defined by the following macro.

Size of ADPCM data	Macro name: MAX_DATA_LENGTH

3.5.2 Flow

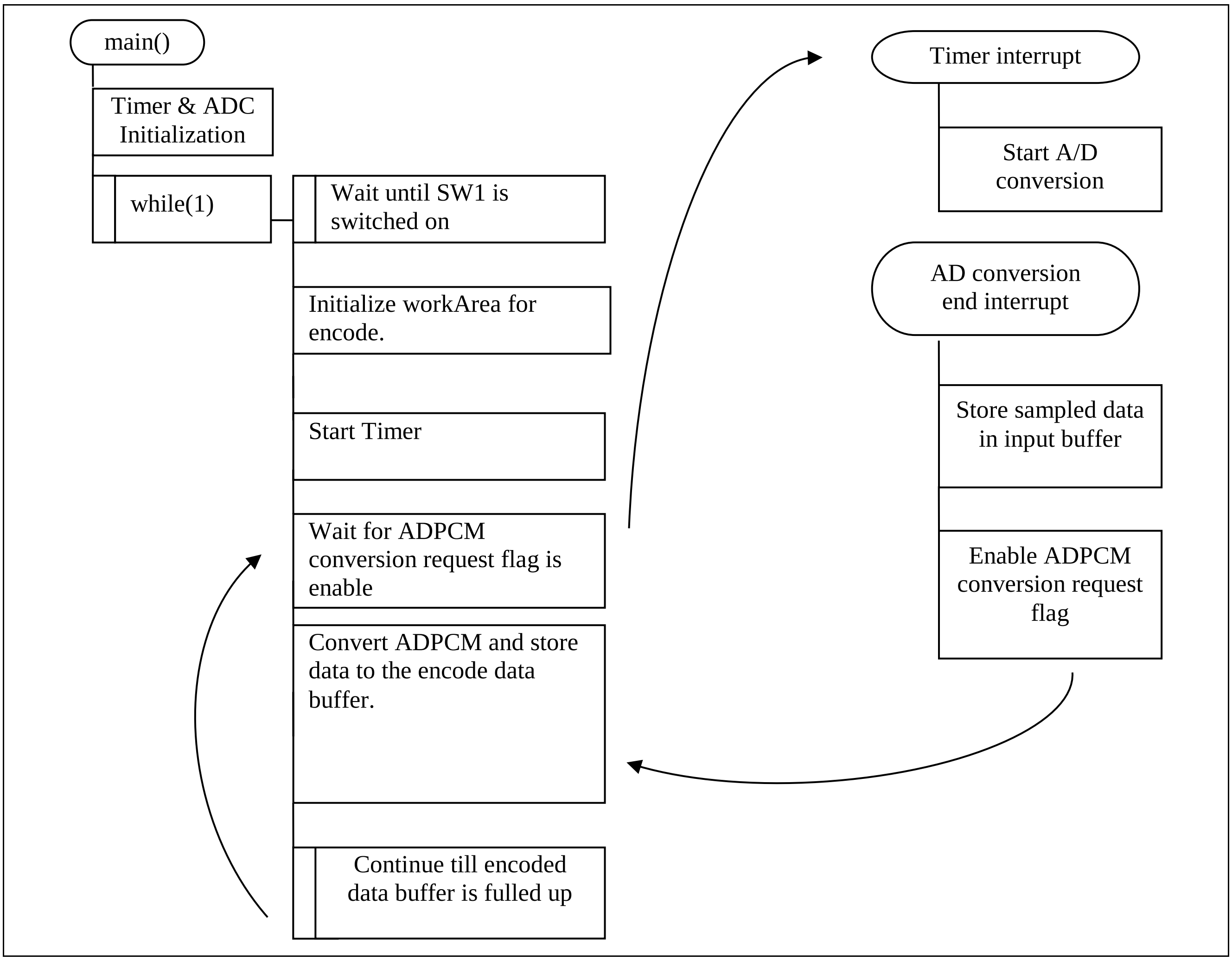
main()
Timer & ADC Initialization
while(1)
Wait until SW1 is switched on
Initialize workArea for encode.
Start Timer
Wait for ADPCM conversion request flag is enable
Convert ADPCM and store data to the encode data buffer.
Continue till encoded data buffer is fulled up
Timer interrupt
Start A/D conversion
AD conversion end interrupt
Store sampled data in input buffer
Enable ADPCM conversion request flag

Figure 3 Flow

3.5.3 Function list

Table 14 Function list

No.	Function Name	Outline
1	main	Main function..
1.1	R_StartSelect	Wait switch inputting.
1.3	R_encode_main	Encode A/D data to ADPCM data. ADPCM data will be stored in RAM area.
1.3.1	R_adpcm_initEnc	The work area for encoding is initialized. - This is a library function
1.3.2	encode_ad_converter_init	Enable A/D converter operation.
1.3.3	encode_interval_timer_init	Initialize timer for sampling frequency.
1.3.4	encode_interval_timer_start	Start timer for sampling frequency.
1.3.5	R_convert_to_ADPCM	Converts the PCM data into ADPCM data by calling the library functions.
1.3.5.1	R_adpcm_refreshEnc	Refreshes the input PCM data buffer and the output ADPCM data buffer. - This is a library function
1.3.5.2	R_adpcm_encode	Encodes the 16-bit PCM data into 4-bit ADPCM data. - This is a library function
1.3.6	encode_interval_timer_stop	Stop timer for sampling frequency.
1.3.7	encode_ad_converter_stop	Stop A/D converter operation.
1.3.8	encode_interval_timer_sleep	Timer for sampling frequency does transition to the module stop state.
1.3.9	encode_ad_converter_sleep	AD converter does transition to the module stop state.
3.	R_interrupt_encode_timer(*)	Timer interrupt. Start A/D conversion every cycle of the sampling frequency.
3.1	encode_ad_converter_start	Start A/D conversion.
4	R_interrupt_encode_ad_convert	A/D conversion end interrupt. Takes a sample of the input signal.

(*)In sample program,AD conversion makes setting to automatically start from a timer function.This function does not execute because the interrupt of the timer does not set.

3.5.4 Function chart

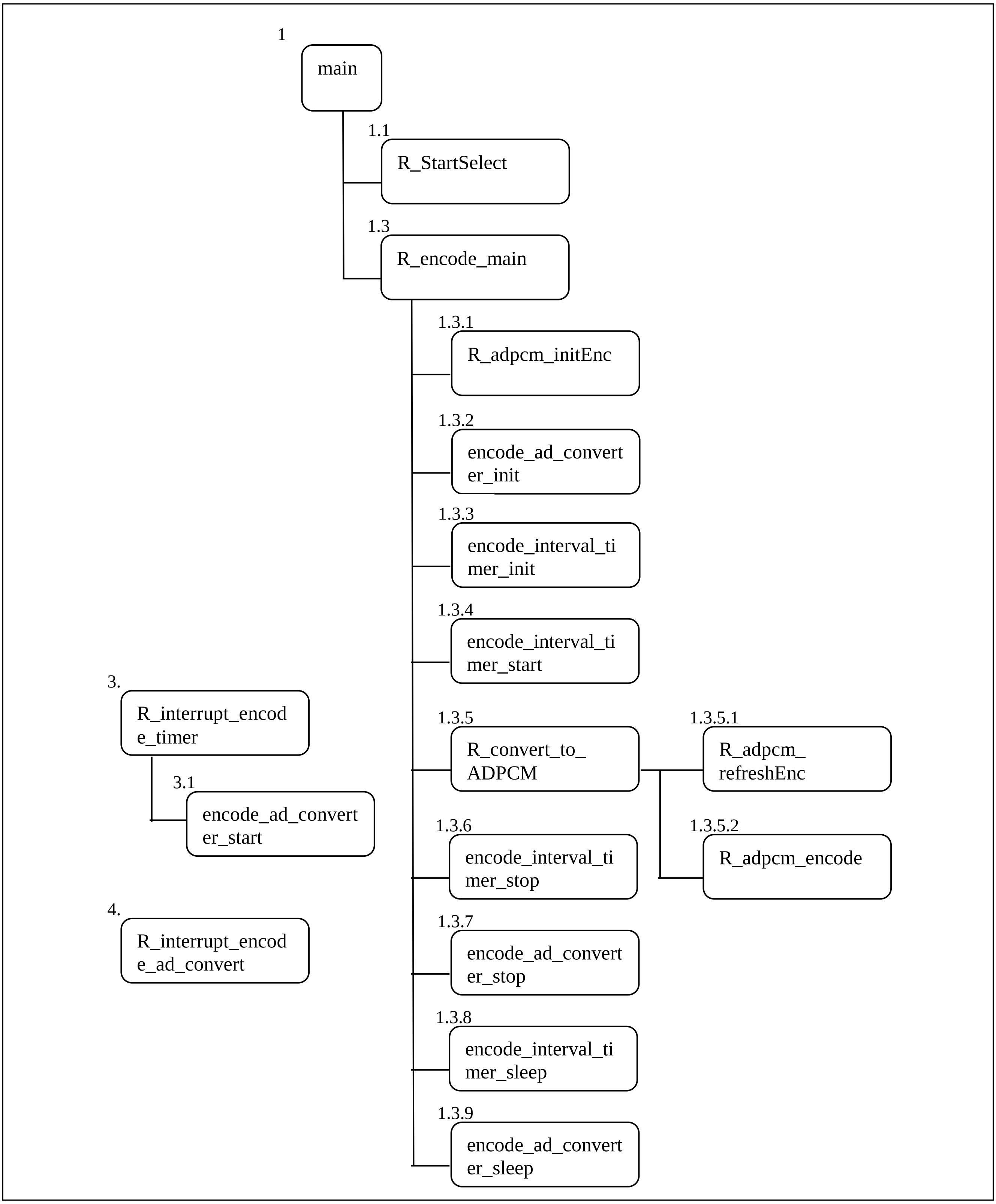

Figure 4 Function chart

3.5.5 Sound data retrieval procedure

This section explains sound data retrieval procedure for the sample program. The sound data encoded by the sample program can be retrieved using the following procedure.

(1) Uploading of ADPCM data

The encoded data array g_EncodedData can be seen in the memory window in Integrated Development Environment. Upload this entire encoded data array and save it as a binary file. Please refer to the manual of Integrated Development Environment for the uploading procedure.

(2) Converting to WAV file

Make the Wave file (.wav) from the ADPCM data (binary form) using the bundled "ADPCM_TOOL (ADPCM.exe)". Please refer the manual of the tool "ADPCM_TOOL" for its usage.

3.5.6 Sound data retrieval procedure

(1) MAX_DATA_LENGTH

The value of the macro "MAX_DATA_LENGTH" should be set in "r_s2_driver.h" file of the sample program. It should be set according to the size of the RAM available for storage of ADPCM encoded data. More is the size available for ADPCM data storage, more will be the length of the sound sample that can be encoded.

[E.g. when available size for storage of ADPCM data is 1500 bytes, setting will be]

```
#define MAX_DATA_LENGTH    (1500u)  /* Max. size of ADPCM encoded data */
```

3.5.7 Verification of sound data

The wave file generated from the uploaded ADPCM binary file can be verified to be similar in nature to the input file.

4. Software update information

Table 15 update information

This document version	S2 library version	change
1.01	3.04	Updated S2 library Added RX65N RSK sample program
1.00	3.01	Applied FIT spec Added RX64M RSK, RX111 RSK sample programs

Website and Support

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

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

Revision History

Rev.	Date	Description Page	 Summary
1.01	Oct 01, 2016	—	Updated sample program’s
1.00	Jul 01, 2014	—	First edition issued

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit 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 accordance 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 Microprocessing unit or Microcontroller unit products 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.

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