RL78/G14

R20AN0194EJ0102
Rev.1.02
Oct 01, 2015

Sound Playback/Compression Demonstration for RL78/G14 CPU Board

Introduction

These data describe the information on the demonstration which reproduces a sound using the Renesas Demonstration Kit for RL78G14 or the middleware evaluation board which is RL78/G14 64pin CPU board.

Audio data is stored in MMC formatted by FAT file system as a file. A file is audio voice compressed by ADPCM.

A file is read from MMC using 3 lines serial I/O (CSI) of the serial array unit which RL78/G14 are a built-in circumference function. RL78/G14 read a file and elongates and a sound is reproduced with the sampling rate of 8 kHz, 11.025 kHz, 16 kHz, and 22.050 kHz.

This demonstration aims at offering the technical information for building a voice reproduction system relatively cheap. This demonstration is used combining the following middleware products and middleware evaluation boards.

Moreover, the sample program is attached and which produce audio playback using the following middleware products.

Function	Middleware Product Name	Website
Audio playback	M3S-S2-Tiny (abbr,S2) (Document No. :R20AN0122)	http://www.renesas.com/mw/s2
File system	M3S-TFAT-Tiny (abbr,TFAT) (Document No. :R20AN0159)	http://www.renesas.com/mw/tfat
MMC driver(*1)	SPI mode MultiMediaCard driver (Document No. :R20AN0158)	

(Note 1)The SD(less 2GB size) card that has compatible command for MMC is available on this software.

Target Device

RL78/G14

Contents

1. Application Note structure....4
2. Development Environment....5
2.1 Hardware....5
2.2 Software....5
2.2.1 CS+ for CA, CX....5
2.2.2 CS+ for CC....5
2.2.3 IAR Embedded Workbench....5
3. Demonstration Manual (YRDKRL78G14)....6
3.1 System Block Diagram....6
3.2 Demonstration Set in Appearance....6
3.3 The List of Demonstration Parts Set....7
3.4 Setup....7
3.4.1 Adjust parts on RL78/G14 CPU Board....7
3.4.2 Program Writing....7
3.4.3 Connection Check....8
3.4.4 Prepare ADPCM Data....8
3.5 Operation method....9
3.5.1 File selection and voice reproduction....9
3.5.2 Compression mode....10
3.5.3 File selection and voice reproduction mode....11
3.6 Change the sound output functions.....12
4. Demonstration Manual (RL78/G14 64pin CPU Board)....13
4.1 System Block Diagram....13
4.2 The List of Demonstration Parts Set....14
4.3 Setup....14
4.3.1 Adjust parts on RL78/G14 64pin CPU Board....14
4.3.2 Program Writing....14
4.3.3 Connection Check....15
4.3.4 Prepare ADPCM Data....15
4.4 Operation method....16
4.4.1 File selection and voice reproduction....16
4.4.2 Compression mode....16
4.4.3 File selection and voice reproduction mode....17
4.5 Volume adjustment of a reproduction sound....17
4.6 Arrange the volume when recording.....17
4.7 Change the sound output functions....17
5. Notes....18

5.1 Notes of Applilet3 output code 18
5.2 For about tentative measure for IAR compile bug 18

1. Application Note structure

Table1 Application Note structure

Folder/File	Contents
r20an0194ej0102_rl78_s2.pdf	Application Note (this document)
workspace	
Document(doc)	
English(en)	
r20an0194ej0102_rl78_s2.pdf	Application Note (this document)
Japanese(ja)	
r20an0194jj0102_rl78_s2.pdf	Application Note
Sample Program (sample)	
For YRDKRL78G14(yrdkrl78g14)	
CS+ for CA	For CS+ for CA, CX
CS+ for CC	For CS+ for CC
IAR	For IAR Embedded Workbench
For RL78G14 64pin CPU Board (rl78g14_board)	
CS+ for CA	For CS+ for CA, CX
CS+ for CC	For CS+ for CC
IAR	For IAR Embedded Workbench
Sound data (sound)	
adpcm_data.zip	sampling.txt and sample sound data(*.dat)
Reference(ref)	
r20ut0684ej0010_rl78g14.pdf	RL78/G14 64pin CPU board schematic
r20ut0685ej0010_rl78g14.pdf	RL78/G14 64pin CPU board User's Manual(English)
r20ut0685jj0010_rl78g14.pdf	RL78/G14 64pin CPU board User's Manual(Japanese)
Schematic_Design__RL78_MiddlewareEvaluation_Board-V3_2.pdf	Middleware Evaluation Board schematic

2. Development Environment

Please use the same or a later version of the toolchain listed below:

2.1 Hardware

(Board 1)

Renesas Demonstration Kit for RL78G14	Renesas (type：YRDKRL78G14)

(Board 2)

RL78/G14 64pin CPU Board	Renesas (type : R0K50104LC000BR)
Middleware Evaluation Board	Renesas

2.2 Software

2.2.1 CS+ for CA, CX

- - Integrated Development Environment
  CS+ for CA,CX V3.00.01
- C compiler
  CA78K0R V1.71
- Code Gererator tool
  CS+ for CA,CX Code Generator for RL78 V2.07

2.2.2 CS+ for CC

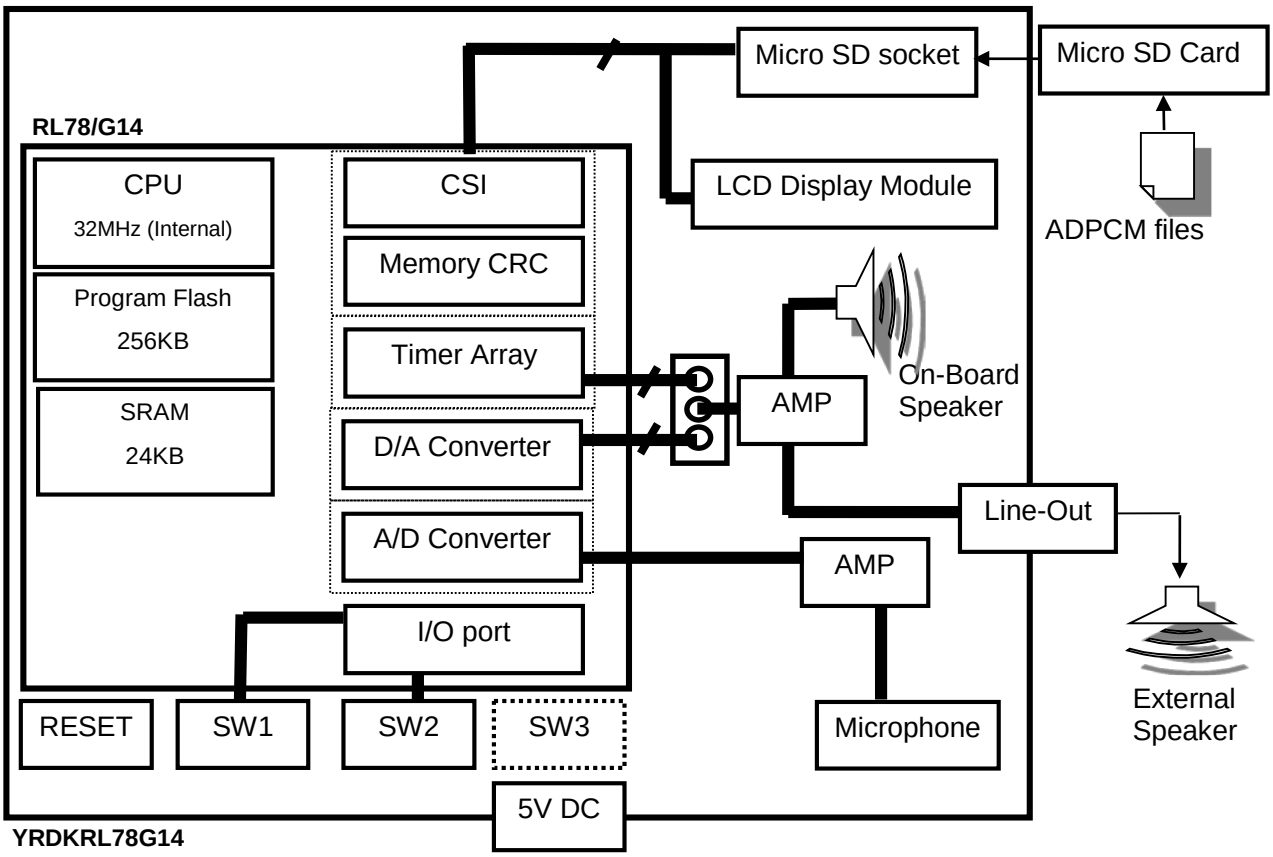
- - Integrated Development Environment
  CS+ for CC V3.01.00
- C compiler
  CC-RL V1.01
- Code Gererator tool
  CS+ for CC Code Generator for RL78 V2.07

2.2.3 IAR Embedded Workbench

- Integrated Development Environment and C compiler
  IAR Embedded Workbench for Renesas RL78 V.2.10.1
- Code Gererator tool
  Applilet3 for RL78 V1.09.00 Renesas

3. Demonstration Manual (YRDKRL78G14)

3.1 System Block Diagram



【Note】SW3 is not used in this demonstration.

Fig 1. System block diagram

3.2 Demonstration Set in Appearance

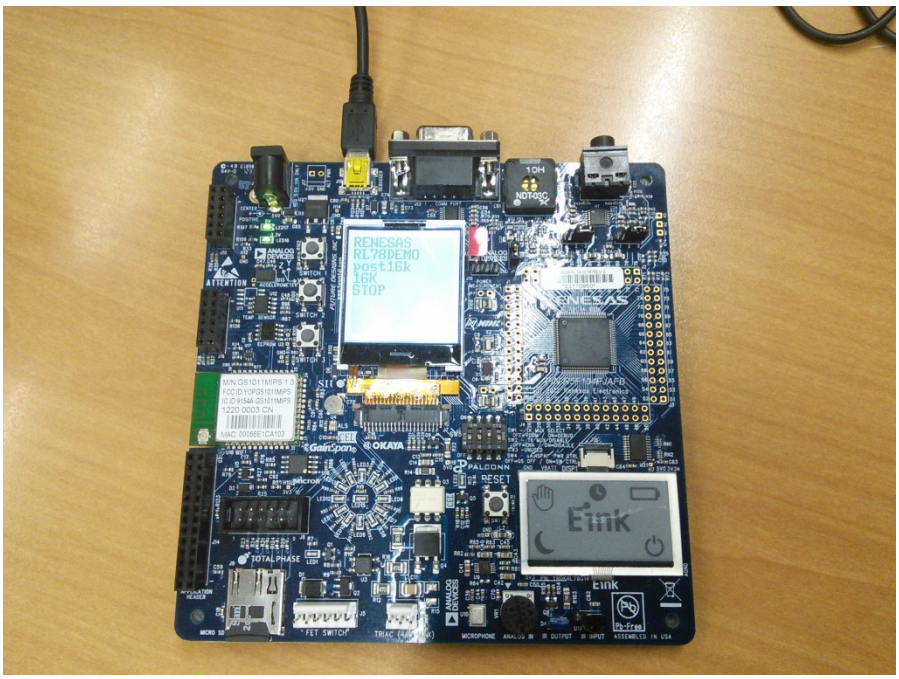


Fig.2 Demonstration Set in Appearance

3.3 The List of Demonstration Parts Set

Table 1 The list of demonstration parts set

Part name	Reference information
YRDKRL78G14	It is supplied with Renesas Demonstration Kit for RL78G14. 【Note】Reference
USB Cable	
Micro SD Card (smaller than 2GB)	Need the command compatibility for the Multi Media Card. Please purchase separately.
AC adapter(DC5V center plus)	It is not necessary if user connects PC to Board using USB cable directly. Please buy this if necessary.

【Note】Website of Renesas Demonstration Kit for RL78G14

http://am.renesas.com/products/tools/introductory_evaluation_tools/renesas_demo_kits/yrdkrl78g14/index.jsp

Support page of Renesas Demonstration Kit for RL78G14

http://renesasrulz.com/?loc=US

3.4 Setup

3.4.1 Adjust parts on RL78/G14 CPU Board

Please confirm switch and jumper pin settings on board.

- SW5-1 : ON
- SW5-2 : OFF
- JP1: 2-3 short
- JP2: 2-3 short
- JP3: 2-3 short

3.4.2 Program Writing

- Start the project file for CS+ or IAR workspace file sample code(workspace\sample\yrdkrl78g14) of this data attachment
- YRDKRL78G14 is connected with PC by USB cable.
- Build the project.
- Write the generated object file.

3.4.3 Connection Check

- Micro SD card is inserted in the SD card socket.
- Confirm that LCD display module displays as "RENESAS RL78DEMO."

3.4.4 Prepare ADPCM Data

Using ADPCM TOOL of S2 attachment, ADPCM file is generated from WAVE file. Refer to ADPCM TOOL description (r21an0002jj0100_adpcm_tool.pdf) for the directions for ADPCM TOOL. Please save the generated ADPCM file at the root directory of MMC. Please set ".dat" to extension of ADPCM file. ".dat" is default output format of ADPCM TOOL.

In this demonstration, the sampling rate of ADPCM is based on the information read in the text file saved at the root directory of MMC. When you prepare ADPCM data, please store a sampling rate configuration file (sampling.txt) in the root directory of MMC. Please indicate the sampling rate at the time of a file name and reproduction in the following formats in a sampling rate configuration file. The sampling rate which can be indicated is four kinds, 8 kHz, 11.025 kHz, 16 kHz, and 22.050 kHz. Please write value to the "sampling.txt" if 8kHz = "08k", 11.025kHz = "11k", 16kHz = "16k", 22.050kHz = "22k".

ADPCM data sample is in the Zip file "sound/adpcm_data.zip".

Format:<ADPCM file name><space> <Sampling rate><Line feed code"LF">

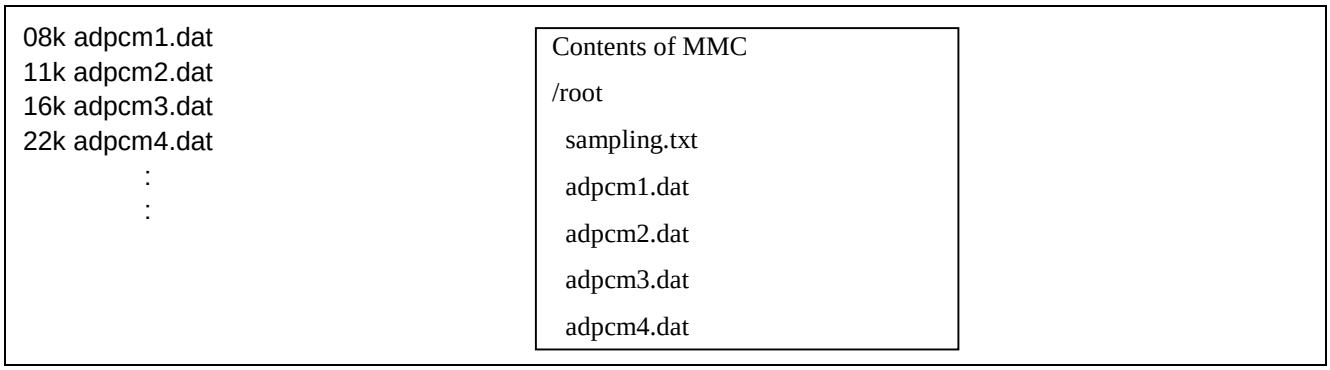


Fig.3 The example of a sampling rate configuration file

Notice:

If user uses Windows PC, the Line feed code is "CRLF".

When edits "Sampling.txt", please adjust the Line feed code to "LF" using function of text editor.

3.5 Operation method

3.5.1 File selection and voice reproduction

■Display explanation of LCD display module

Selection of a file and voice reproduction are performed using SW1 and SW2 on board. The LCD display module shows the character string for 10 seconds "RENESAS <line break> RL78DEMO" after starting.

This demo status moves to record mode when push the SW1 during this 10 seconds.

And moves to playback mode when push the SW2 during this 10 seconds, or passes 10 seconds.

3.5.2 Compression mode

■Display explanation of LCD display module

Selection of a file and voice Compression are performed using SW1 and SW2 on board. An eight-line display is possible for LCD display module, and it displays title on the 1st and 2nd line, the file name (without extension display) on the 3rd line, and the state of the sampling rate, and demonstration to the 4th line, and the state of demonstration to the 5th line.

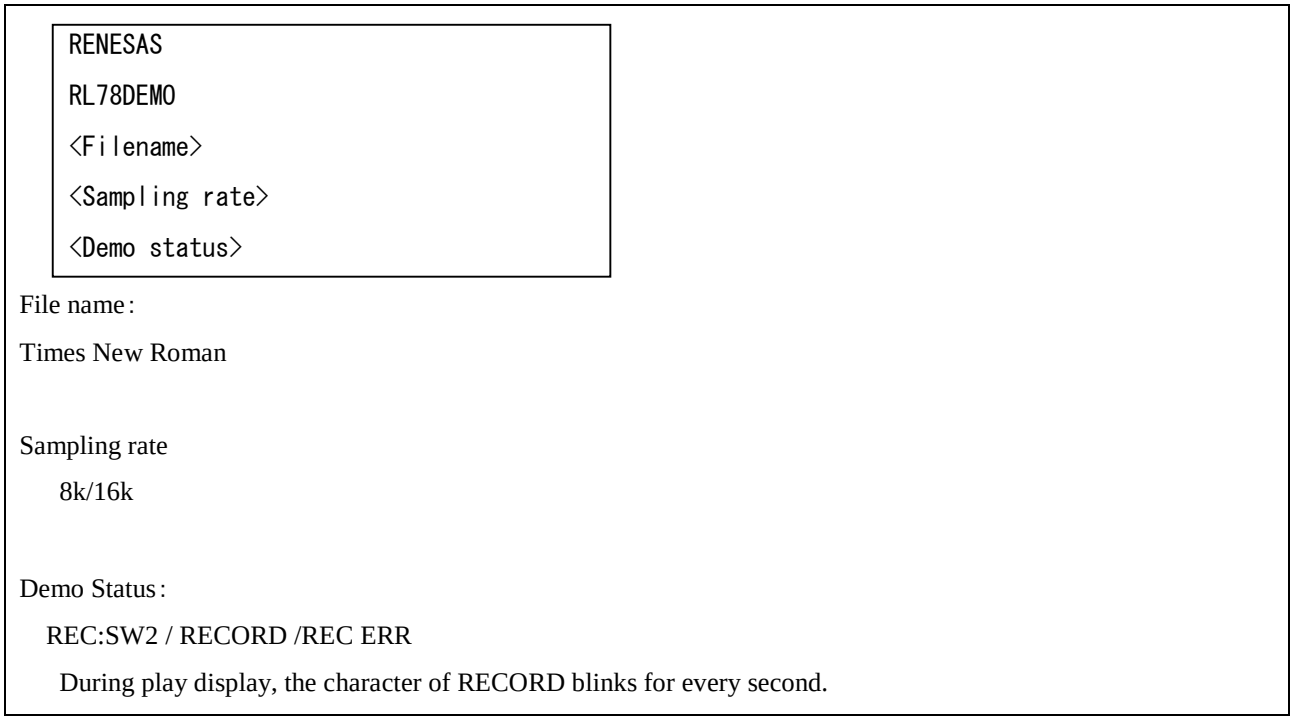


Fig 4 display image of Compression mode

■During demonstration

Unplug MMC: In under reproduction, it displays "NO CARD" promptly after error detection.

In under stop, it displays "NO CARD".

Plug MMC: Display file list

■W1, SW2 operate explanation

<SW1: Change the sampling late>

Push SW1: Set the sampling rate to 8kHz or 16kHz when recording.

<SW2: Start/Stop recording operation>

Push SW2 Start recording using displayed sampling rate.

*Save to the SD card and stop recording when push the SW2 in recording.

3.5.3 File selection and voice reproduction mode

■ Display explanation of LCD display module

Selection of a file and voice reproduction are performed using SW1 and SW2 on board.

when this demo status moves to playback mode, the file list of root directories of MMC is displayed. A two-line display is possible for LCD display module, and it displays the selected file name (without extension display) on the 1st line and the state of the sampling rate and demonstration to the 2nd line.

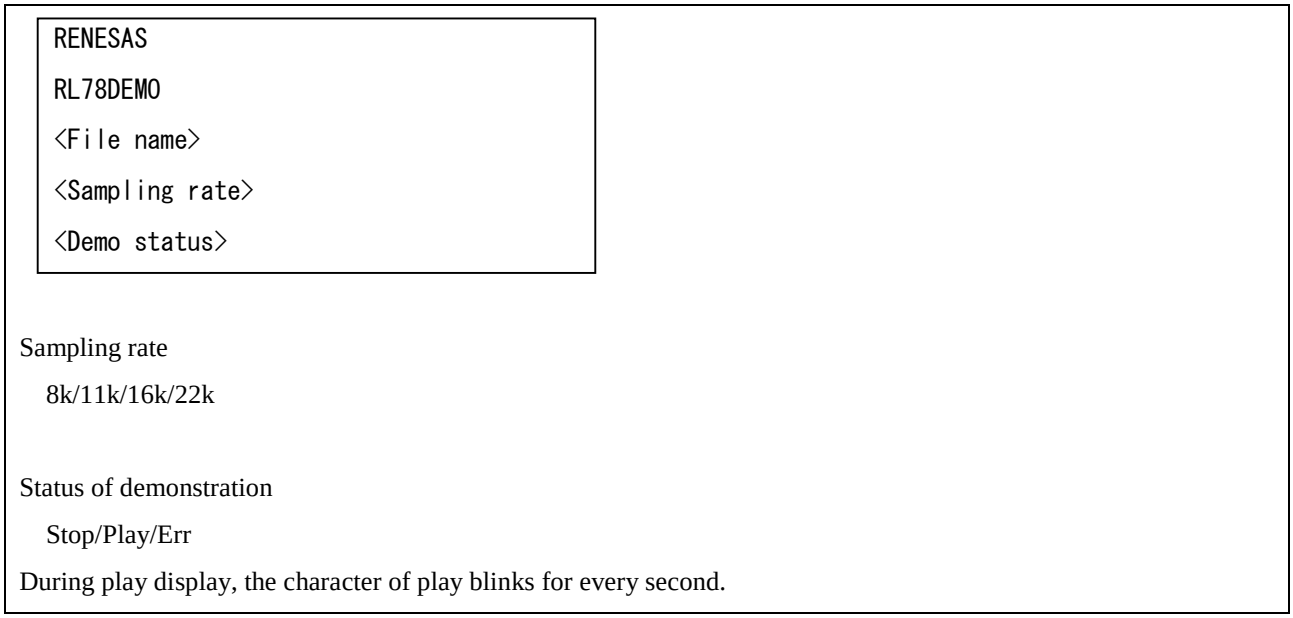


Fig.4 The display image of files list

■The LCD display module showing at the time of MMC plug

＜Initial status＞

Starts where MMC is put : Title display → File list display
There is no sampling.txt, or sampling.txt is illegal format, display “NO CARD”

Starts where MMC is extracted : Title display → Display ”NO CARD”

＜During demonstration >

Unplug MMC: In under reproduction, it displays "NO CARD" promptly after error detection.
In under stop, it displays "NO CARD".

Plug MMC: Display file list

■SW1, SW2 operate explanation

＜SW1：List operation>

SW1 press Read 1 piece of file information from MMC and then update the display.

＜SW2：Voice reproduction / stop operation＞

SW2 press A file on display is reproduced.

※ When SW2 is pushed during reproduction, the file under reproduction is stopped and a file on display is reproduced.

※ When you want to stop reproduction, please push reset.

3.6 Change the sound output functions.

This demo playbacks the sound using D/A output or PWM output.

This demo's (board/software) default setting is D/A output.

It is possible to use the PWM output when user changes the YRDKRL78G14 jumper settings and software settings.

Followings are the changing point.

[Jumper settings in Board]

JP1: 1-2 short

JP2: 1-2 short

JP3: 1-2 short

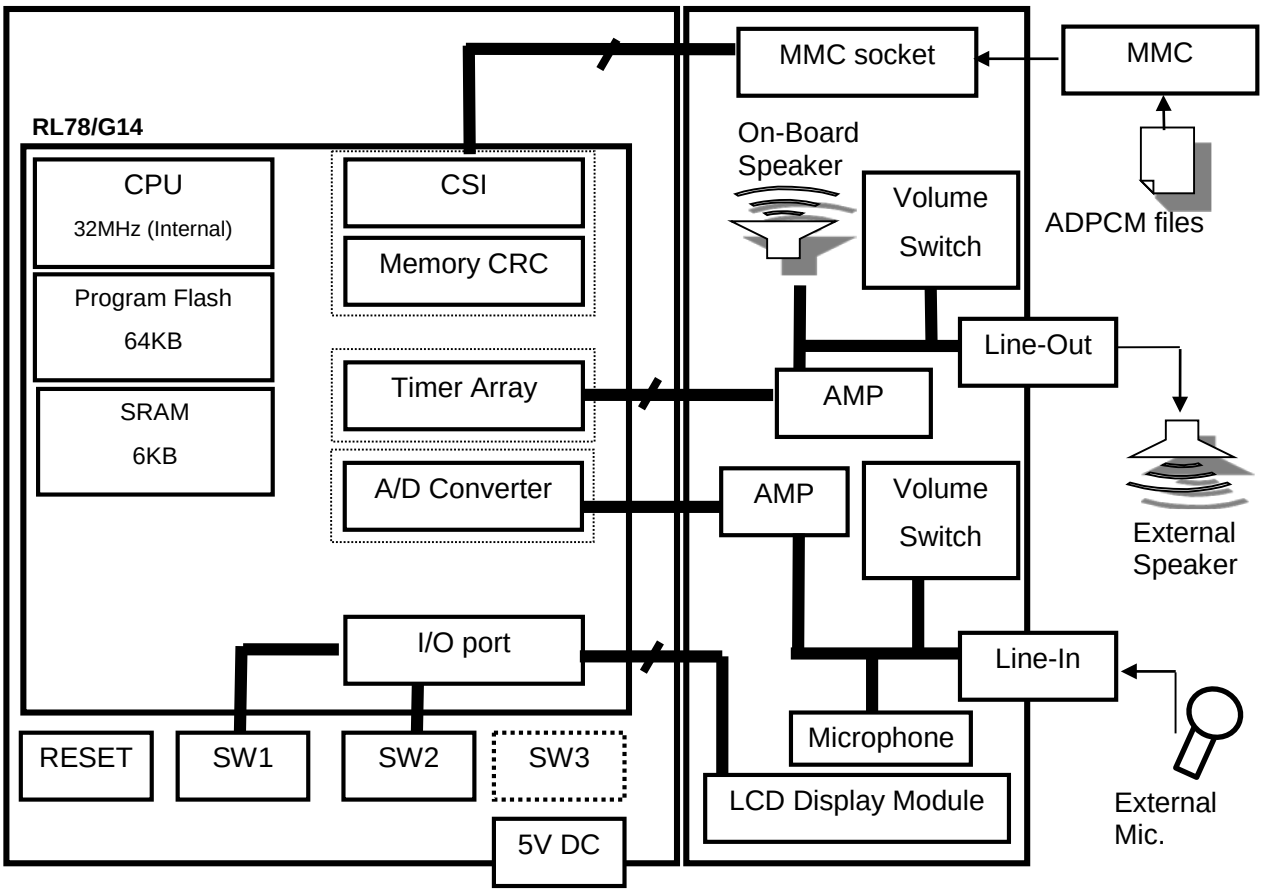
[Software settings]

Open the "src\sample\r_s2_driver.h" and change the SOUND_OUTPUT_MODULE macro to SOUND_PWM

```
//#define SOUND_OUTPUT_MODULE  SOUND_DA
#define SOUND_OUTPUT_MODULE  SOUND_PWM
```

4. Demonstration Manual (RL78/G14 64pin CPU Board)

4.1 System Block Diagram



【Note】SW3 is not used in this demonstration.

Fig 1. System block diagram

Demonstration Set in Appearance

Fig.2 Demonstration Set in Appearance

4.2 The List of Demonstration Parts Set

Table 1 The list of demonstration parts set

Part name	Reference information
RL78/G14 64pinCPU board	Please contact Renesas customer support.
LCD display module	
Middleware evaluation board for RL78/G14 CPU Board	
MultimediaCard	Please purchase separately.
Phillips screwdriver for volume operation	Please purchase separately.
E1 emulator	Please purchase separately.
AC adapter(DC5V center plus)	Please purchase separately.

4.3 Setup

4.3.1 Adjust parts on RL78/G14 64pin CPU Board

Sample code that is included this application note is confirmed working on RL78/G14 64pin CPU board and Middleware evaluation board. Please adjust each parts on RL78/G14 64pin CPU board like below.

- Remove R60, Implement R63, for MMC connection
- Remove R52, Implement R55, for MMC connection
- Remove R71, Implement R74, for MMC connection
- Remove R51, Implement R54, for MMC connection
- Implement JA1, JA2 connector, for Middleware evaluation board connection
- Short R21, for Middleware evaluation board 3.3 power supply
- Short J13 (2-3), for select regulator output
- Open J10, for select regulator output 3.3V power supply
- Short JP1 (on Middleware evaluation board) to PWM-center

4.3.2 Program Writing

- Start the project file for CS+ sample code of this data attachment (OOO.mtpj)
- RL78/G14 64pin CPU board is connected with PC by E1 emulator.
- Build the project.
- Write the generated object file.

4.3.3 Connection Check

- RL78/G14 64pin CPU board and JA1 and JA2 of a middleware evaluation board are connected. MMC is inserted in the MMC socket of middleware evaluation board.
- LCD display module is inserted in LCD display module socket of middleware evaluation board.
- An AC/DC adaptor is inserted in 5VDC connector of RL78/G14 64pin CPU board.
- Confirm that LCD display module displays as "RENESAS RL78DEMO."

4.3.4 Prepare ADPCM Data

Please refer to the section 3.3.4.

4.4 Operation method

Operation method is same with YRDKRL78G14, please refer to the section 3.4.

This section shows difference of displays.

4.4.1 File selection and voice reproduction

No difference from YRDKRL78G14

4.4.2 Compression mode

An two-line display is possible for LCD display module.

When stop the recording, sampling rate is in the 1st line, demo status (REC:SW2) is in 2th line.

When recording, file name is in the 2nd line, demo status (RECORD).

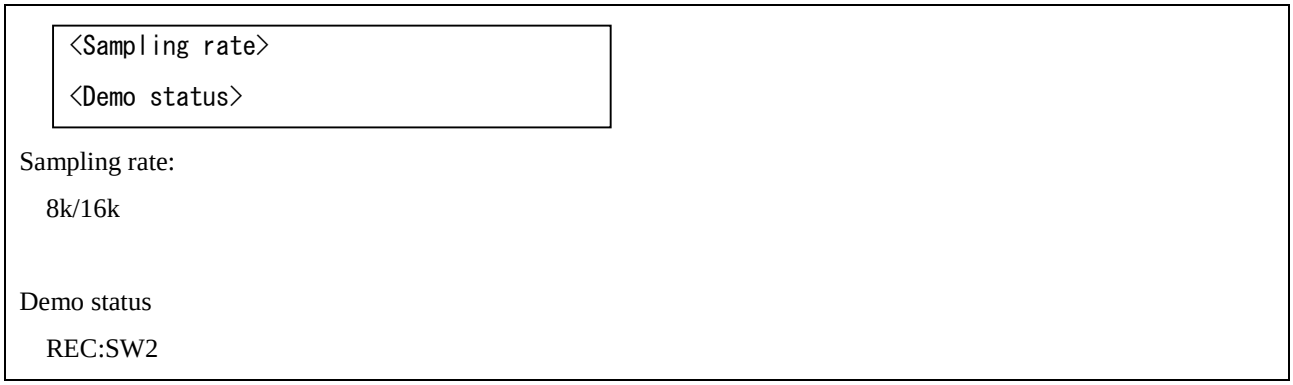


Fig 4 Image of the demo status "stop recording"

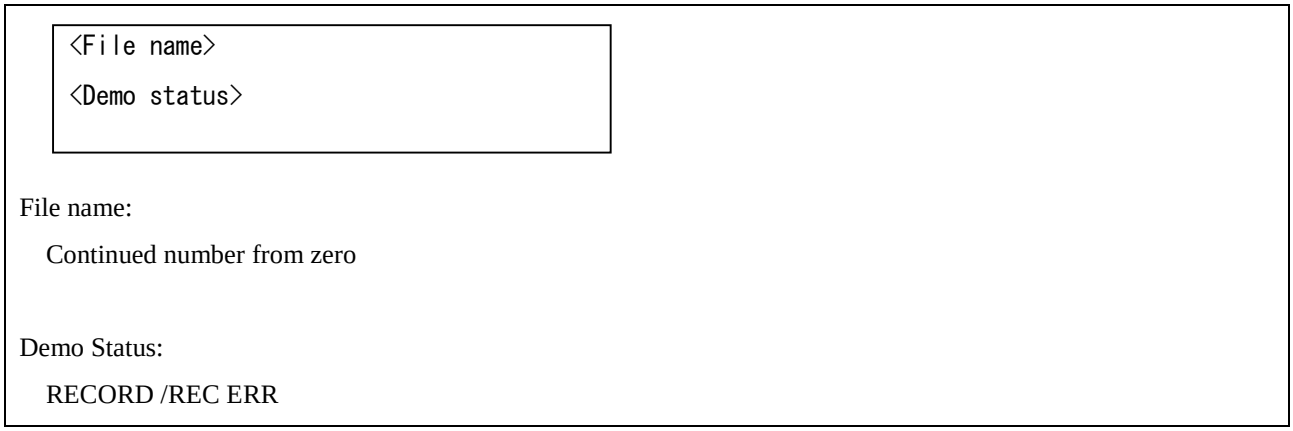
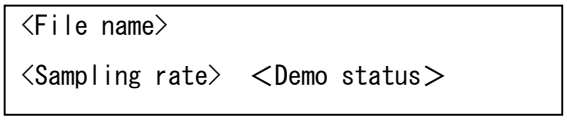


Fig 5 Image of the demo status "recording"

4.4.3 File selection and voice reproduction mode

A two-line display is possible for LCD display module, and it displays the selected file name (without extension display) on the 1st line and the state of the sampling rate and demonstration to the 2nd line.



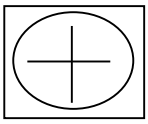
Sampling rate:
8k/11k/16k/22k

Status of demonstration
Stop/Play/Err
During play display, the character of play blinks for every second.

Fig.4 The display image of files list

4.5 Volume adjustment of a reproduction sound

The volume of voice reproduction can be adjusted by operating VR switch(VR2) on a middleware evaluation board.



If it turns to the right volume, it becomes larger and the volume can be made smaller if it turns to the left.

Volume switch

Fig 5. Reproductive volume methods for coordination

4.6 Arrange the volume when recording.

The volume of voice can be adjusted by operating VR switch(VR1) on a middleware evaluation board.

4.7 Change the sound output functions

RL78/G14 64pin board has no D/A output functions, so only use PWM output.

5. Notes

5.1 Notes of Applilet3 output code

In IAR Embedded Workbench application project, the error will occur. The error is conflict the standard data type between "r_stdint.h" (renesas middleware header file) and "r_cg_macrodriver.h" (Applilet3 output file).

This means the standard data type file stdint.h included by r_stdint.h has different data type that "r_cg_macrodriver.h" defines.

So, we prepare the fixed "r_cg_macrodriver.h" for no conflict.

Please over-write "r_cg_macrodriver.h" to the same name file that is in application project from IAR sample program folder "IAR\code_generator\user_src".

5.2 For about tentative measure for IAR compile bug

The compiler used in the development setting in this application project is reported some bugs from IAR.

Please refer to the following IAR website that shows details.

IAR systems : New versions and product updates

https://www.iar.com/iar-embedded-workbench/renesas/rl78/product-news/

And, Renesas issues technical update for about IAR compiler.

Renesas : IDEs and Project Managers

http://www.renesas.com/products/tools/ide/Technical_Update.jsp

Document title : Operating Precautions IAR Embedded Workbench for RL78 V2.xx

Document No. : R20UT3407

S2 library is applied tentative measure for this issue.

· Some instructions that have one operand of type imm[BC] can in some cases generate wrong offsets to BC if the offset is a constant (not a label). [EW25763]

This tentative measure has effective for user used compiler version.

- User uses V2.10.1
  Needed tentative measure. Please use S2 library in “no change”.

- User uses version other than the above
  There is a possibility that a compiler is fixed.
  Not needed tentative measure. Please delete the tentative measure code.
  Please update S2 library code like following.

adpcm_encoder_rl78.s87 :line 131-162

```
_R_adpcm_initEnc:

  push bc
  push de

  movw bc, ax
  clrw ax

;    movw    0800H[bc], ax      ;Source code for IARRL78 V2.10.1
    movw    0008H[bc], ax      ;Source code for IARRL78 V2.1x or Later
versions


;    mov     a, #2   ;Source code for IARRL78 V2.10.1
;    mov     0A00H[bc], a  ;Source code for IARRL78 V2.10.1
    mov     000AH[bc], #2  ;Source code for IARRL78 V2.1x or Later versions




  movw ax, #2*2
  addw ax, #LWRD(adpcm_stepsizeTable)
  movw de, ax
  movw ax, [de]
;    movw    0C00H[bc], ax      ;Source code for IARRL78 V2.10.1
    movw    000CH[bc], ax      ;Source code for IARRL78 V2.1x or Later
versions



  pop  de
  pop  bc

  ret
```

Website and Support

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

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

All trademarks and registered trademarks are the property of their respective owners.

Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.02	Oct 01, 2015	—	Changed CubeSuite+ to CS+ for CA,CX Supported CS+ for CC.
1.01	Sep 01, 2014	—	Added sample program for YRDKRL78G14 Supported IAR Embedded Workbench Added RECORD function
1.00	Nov 09, 2012	—	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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
3. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from such alteration, modification, copy or otherwise misappropriation of Renesas Electronics product.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots etc.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; and safety equipment etc.

   Renesas Electronics products are neither intended nor authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems, surgical implantations etc.), or may cause serious property damages (nuclear reactor control systems, military equipment etc.). You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application for which it is not intended. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for which the product is not intended by Renesas Electronics.
6. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You should not use Renesas Electronics products or technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. When exporting the Renesas Electronics products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, who distributes, disposes of, or otherwise places the product with a third party, to notify such third party in advance of the contents and conditions set forth in this document, Renesas Electronics assumes no responsibility for any losses incurred by you or third parties as a result of unauthorized use of Renesas Electronics products.
11. This document may not be reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

RENESAS

SALES OFFICES

Renesas Electronics Corporation

http://www.renesas.com

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

Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

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.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, 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 India Pvt. Ltd.
No.777C, 100 Feet Road, HALII Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

© 2015 Renesas Electronics Corporation. All rights reserved.

Colophon 5.0