RL78/G14 + ISL80505 + ISL6294

Talking Pen

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Introduction

This document describes a Renesas microcontroller RL78/G14 application for the talking pen.

Target Device

Microcontrollers and Microprocessors

- RL78/G14 (R5F104AGASP)

Power Management

- ISL80505 (Low Dropout Voltage Regulator)
- ISL6294 (Single-cell Li-ion Battery Charger)

When applying the sample program covered in this document to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

Contents

1. Description

1.1 Abstract

Talking pen is a high-tech product using the latest international optical image recognition technology. It uses the advanced OID hiding and retrieving technology, that sets a new milestone in the educational electronics industry.

The talking pen solution is based on Renesas low power consumption, high function general-purpose microcontroller RL78/G14 and an LDO ISL80505 and a single-cell Li-ion battery charger ISL6294.

1.2 Specifications and Main Technical Parameters

Technical Parameters

- Operating Voltage: 3.7 V ~ 4.2 V (600 mAh polymer lithium battery with protective circuit)
- Sound Ratio: Over 80 dB
- Operating Angle of Probe: Vertical deviation within 40 cones
- USB Compatibility: 2.0
- Operating Temperature: 0°C ~ 65°C
- Operating Humidity: 5 ~ 99% RH (No condensate water)

Specifications

- Functions:

  Download the sound data from the computer through USB <=> UART.
  Get the underlying codes by reading the stickers through the optical ID decoder and image sensor.
  Read the corresponding sound files from the micro SD card.
  Play the sound files by using ADPCM middleware via TAU PWM on the speaker.
  Intersil LDO and battery charger device are used for discharging or charging the battery.

2. RL78/G14 Microcontroller

2.1 RL78/G14 Block Diagram

Figure 2.1 shows the block diagram of the RL78/G14 (30-pin products).

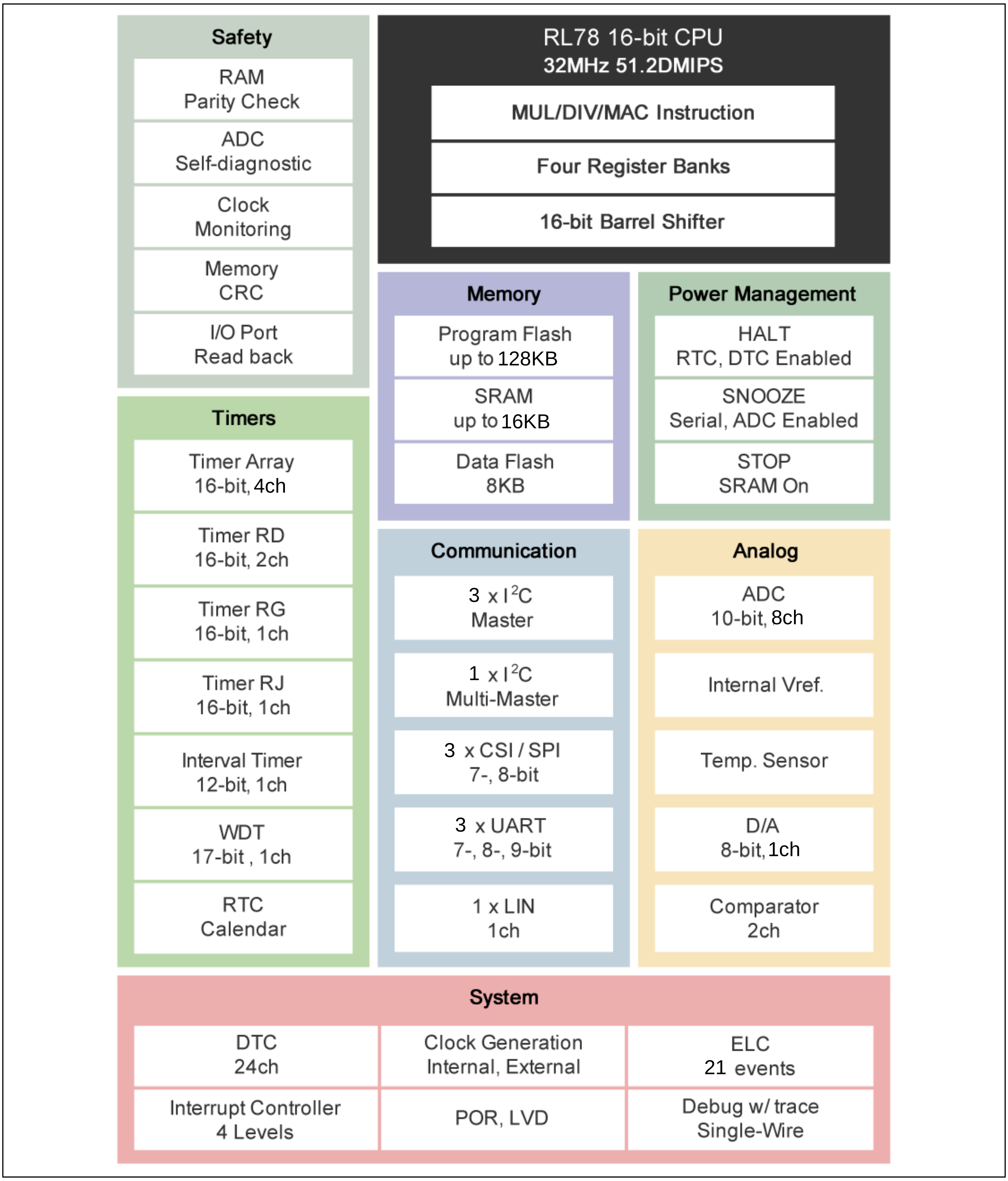


Figure 2.1 RL78/G14 (30-pin products) Block Diagram

2.2 Key Features

- Minimum instruction execution time: Can be changed from high speed (0.03125 µs @ 32 MHz operation with high-speed on-chip oscillator) to ultra-low speed (30.5 µs @ 32.768 kHz operation with subsystem clock)
- General-purpose registers: (8-bit register × 8) × 4 banks
- ROM: 128 KB, RAM: 16 KB, data flash: 8 KB
- Selectable high-speed on-chip oscillator clock: 64/48/32/24/16/12/8/6/4/3/2/1 MHz (TYP.)
- On-chip debug function
- On-chip selectable power-on-reset (POR) circuit
- On-chip voltage detector (LVD)
- On-chip watchdog timer (operable with the dedicated low-speed on-chip oscillator)
- On-chip key interrupt function
- On-chip clock output/buzzer output controller
- On-chip BCD (binary-coded decimal) correction circuit
- I/O port: 26
- Timer
  16-bit timer: 8 channels
  12-bit interval timer: 1 channel
- Serial interface
  CSI: 3 channels
  UART: 3 channels
  Simplified I^2C communication: 3 channels
  Multi-master I^2C communication: 1 channel
- 8/10-bit resolution A/D converter: 8 channels
- 8/10-bit resolution D/A converter: 1 channel
- Comparator: 2 channels
- Data transfer controller (DTC)
- Event link controller (ELC)
- Standby function: HALT mode or STOP mode or SNOOZE mode
- Power supply voltage: V_{DD} = 1.6 to 5.5 V
- Operating ambient temperature: TA = -40 to +85°C

RL78/G14 microcontrollers balance the industry’s lowest level of consumption current (CPU: 66 µA/MHz, standby (STOP): 240 nA) and a high calculation performance of 51.2 DMIPS (32 MHz). The built-in high-function timer supports three-phase motor control using three-phase complementary PWM output. They have an on-chip oscillator, data flash, A/D and D/A converters, comparator, and more. Built-in safety features (function that detects illegal operation of hardware) enable support for the household appliance safety standard (IEC/UL 60730). With a broad 30 to 100-pin lineup and up to 512 KB on-chip flash memory, these microcontrollers can be used in a wide variety of applications such as motor control and consumer and industrial equipment.

2.3 Pin Configuration

Figure 2.2 shows the pin configuration of the RL78/G14 (30-pin products).

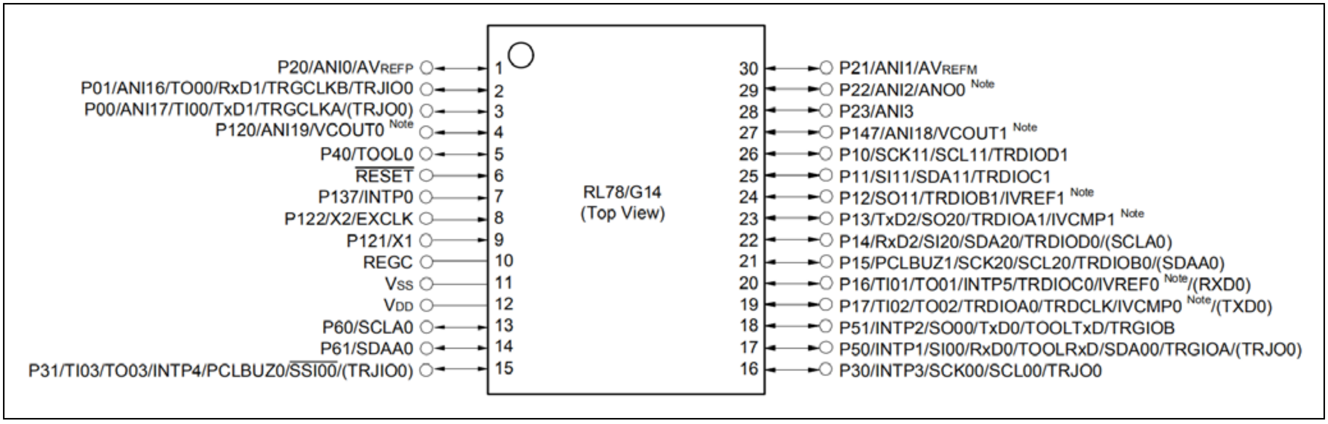


Figure 2.2 RL78/G14 (30-pin products) Pin Configuration

Note: Mounted on the 96 KB or more code flash memory products.

3. System Outline

3.1 Principle Introduction

Through optical ID decoder and image sensor, the talking pens can read underlying codes, which have been printed on the additional layers or the stickers of the books. The MCU gets the decoded contents via a 2-wire interface and then plays the corresponding sound files.

The sound data can be sent to the MCU via USB<==>UART and stored into the micro SD card. The MCU searches the corresponding sound file via SPI and plays it by using ADPCM middleware via TAU PWM on the speaker.

The ISL80505 is a single output Low Dropout voltage regulator (LDO) capable of sourcing up to 500 mA and output current with the input from 1.8 V to 6 V.

The ISL6294 is a complete charger for the single-cell Li-ion/polymer battery with the programmable end-of-charge current.

Figure 3.1 shows the system block diagram.

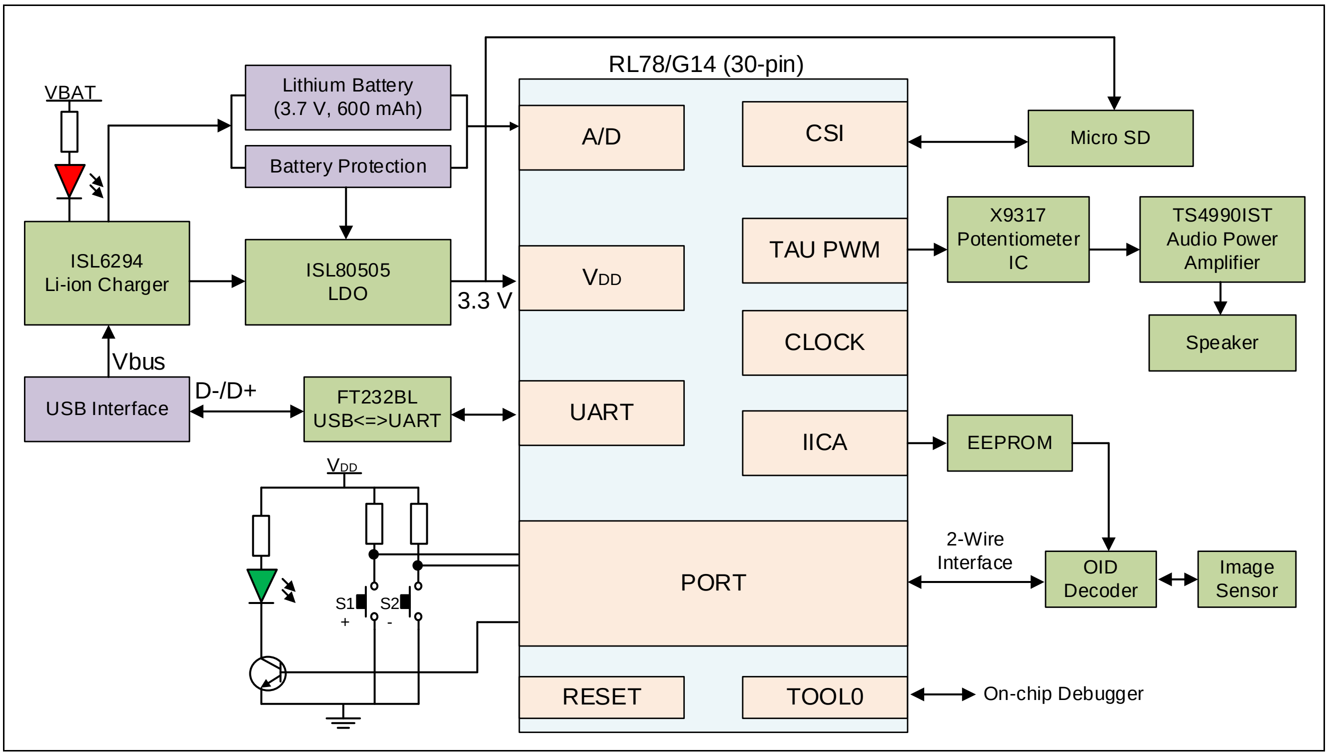


Figure 3.1 System Block Diagram

3.2 Peripheral Functions to be Used

Table 3.1 lists the peripheral functions to be used and their usages.

Table 3.1 Peripheral Functions to be Used

Peripheral Function	Usage
Channel 2, 3 of SAU0 (UART1)	Download the sound files from the computer
Channel 0 of SAU1 (CSI20)	Read or write the sound data into the micro SD card
A/D converter	Test the battery voltage
Channel 0 of TAU0 (interval timer)	1 ms interval timer
Channel 1 of TAU0 (interval timer)	ADPCM sampling timer for voice output with M3S-S2-Tiny library
Channel 2, 3 of TAU0 (PWM output)	Master and slave channel of PWM output function for voice output with M3S-S2-Tiny library
12-bit interval timer	Operate as a 250 ms counter
Serial interface IICA	Write the OID sensor device information into the EEPROM

3.3 Pins to be Used

Table 3.2 lists the pins to be used and their functions.

Table 3.2 Pins to be Used

Pin Name	Description
TxD1/P01	Communicate with the computer
RxD1/P00	
SO20/P13	Micro SD card input
SI20/P14	Micro SD card output
SCK20/P15	Micro SD card clock
P16	Micro SD card chip detection
P17	Micro SD card chip selection
P50	Operate as serial data between the OID decoder and MCU
P30	Operate as serial clock between the OID decoder and MCU
P23	Control the power supply to the OID module
P21	Control the power supply to the peripheral functions
SCLA0/P60	Write the OID sensor device information into the EEPROM
SDAA0/P61	
TO03/P31	PWM output for the speaker
P147	Chip selection for the digitally controlled potentiometer
P10	Control the direction of the wiper movement of the potentiometer
P11	Move the wiper of the potentiometer
P12	Enable / disable the output of the audio power amplifier
ANI0/P20	Battery voltage detection
P22	Control the green LED
P51	[-] key input: turn down the volume
P137	[+] key input: turn up the volume
P122	Power presence indication
REGC	Regulator capacitance
P40/TOOL0	On-chip debug
RESET	Hardware reset
V_{SS}	Ground
V_{DD}	Power supply voltage

3.4 Operating Instructions

3.4.1 Prepare the EEPROM Data

(1) Set all S6 switches to “ON” position.

(2) Set the S4 switch to “ON” position to power on the board.

The OID sensor device information will be written into the EEPROM. If the write operation is successfully performed, the green LED will be turned on.

(3) Set the S4 switch to “OFF” position.

3.4.2 Get the Index Code

(1) Set all S6 switches to “OFF” position.

(2) Connect to the computer via USB.

(3) Set the S4 switch to “ON” position.

(4) Open the tool “IndexCode.exe”.

(5) When the talking pen recognizes a sticker, the underlying code will be displayed in the window.

(6) Please record the index code of the sticker.

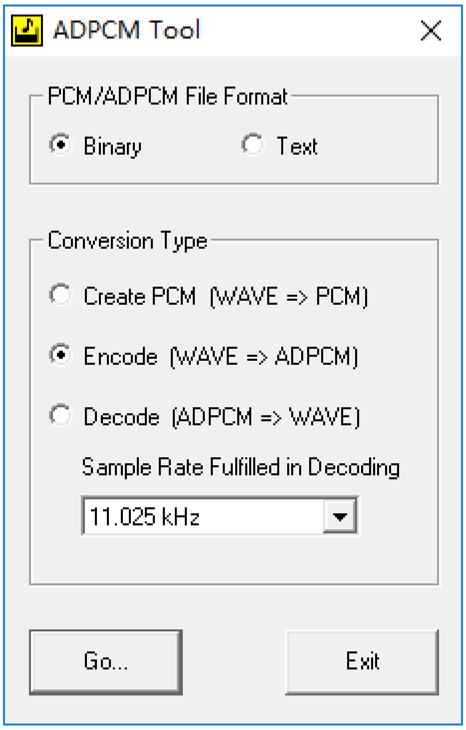
(7) Set the S4 switch to “OFF” position.

3.4.3 Prepare the Sound File

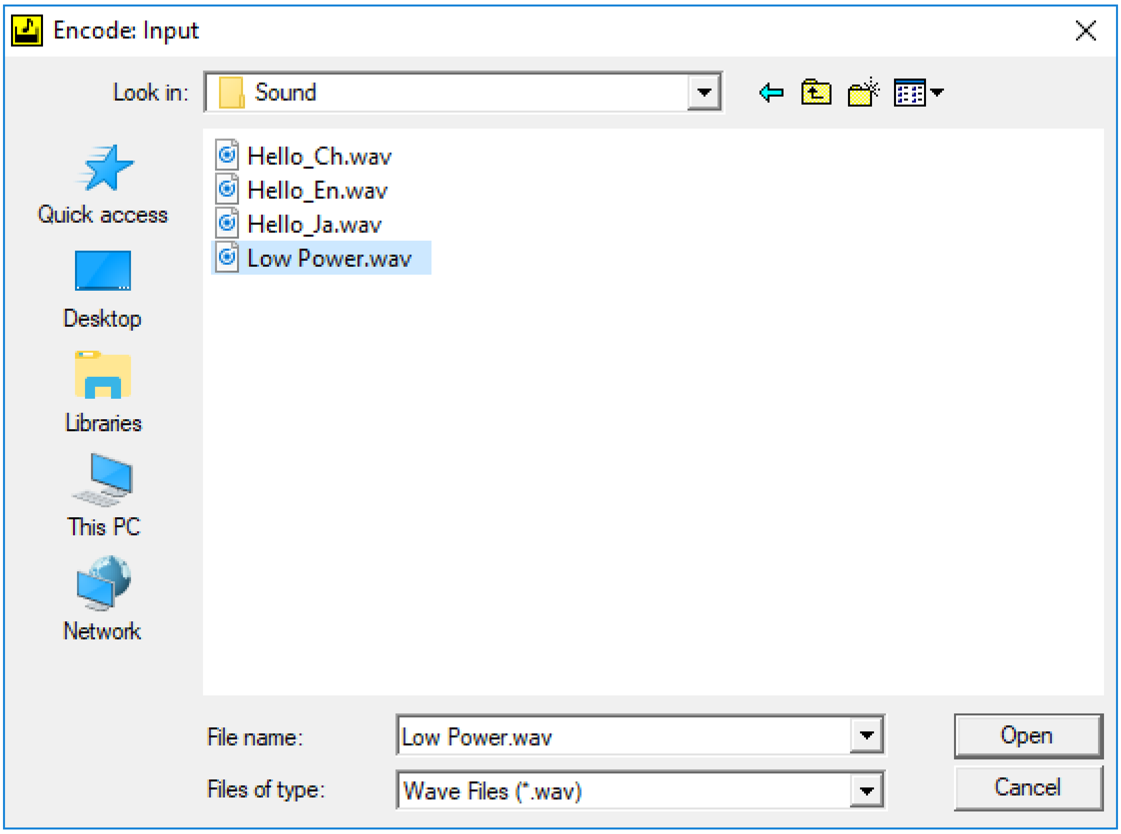
(1) Prepare the audio files in WAV format to be played. The bit rate of the audio file must be 176 kbps (sample rate: 11025 Hz, channel: mono).

(2) Open the tool "ADPCM.exe".

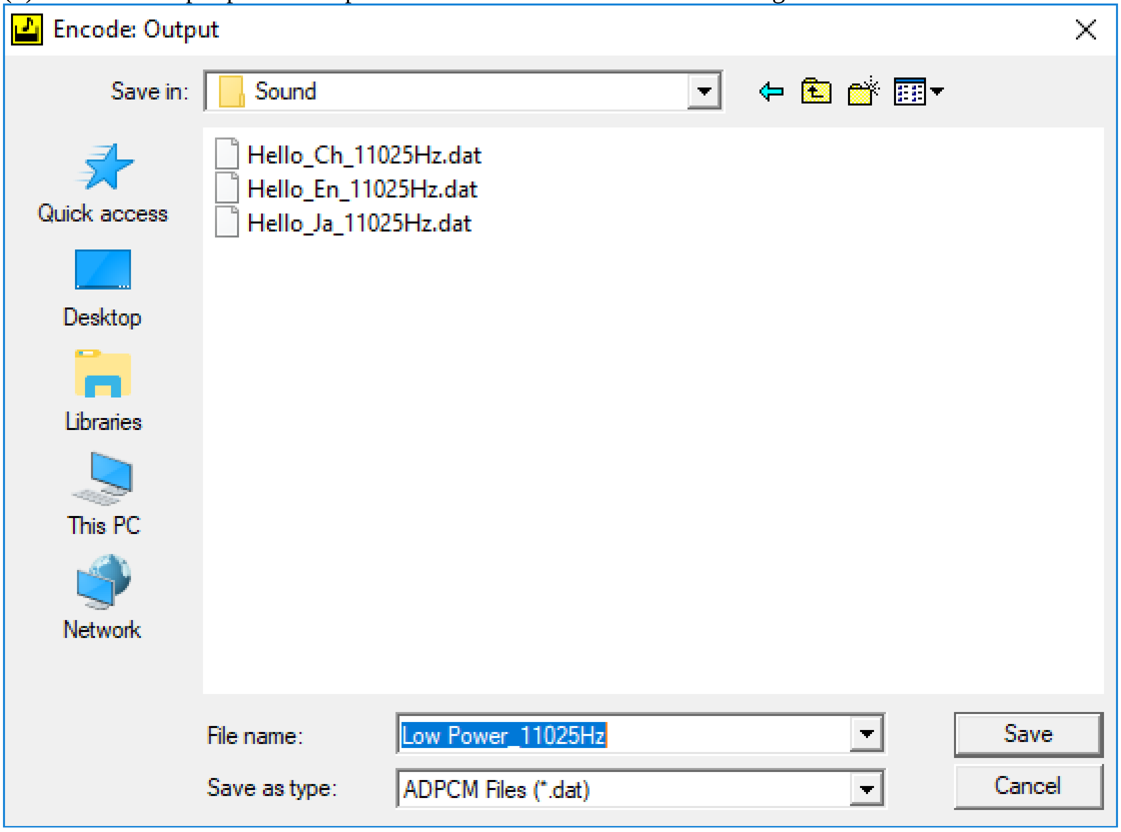
(3) Set as shown in the figure below.



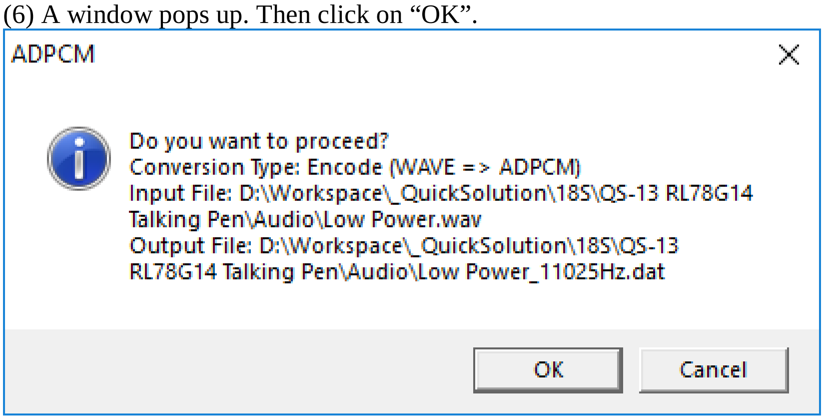
(4) Click on "Go..." and select the audio file. Then click on "Open".



(5) Select the output path and input the file name of the sound file to be generated. Then click on “Save”.



(6) A window pops up. Then click on “OK”.



(7) The generated sound file in DAT format will be found in the output path above.

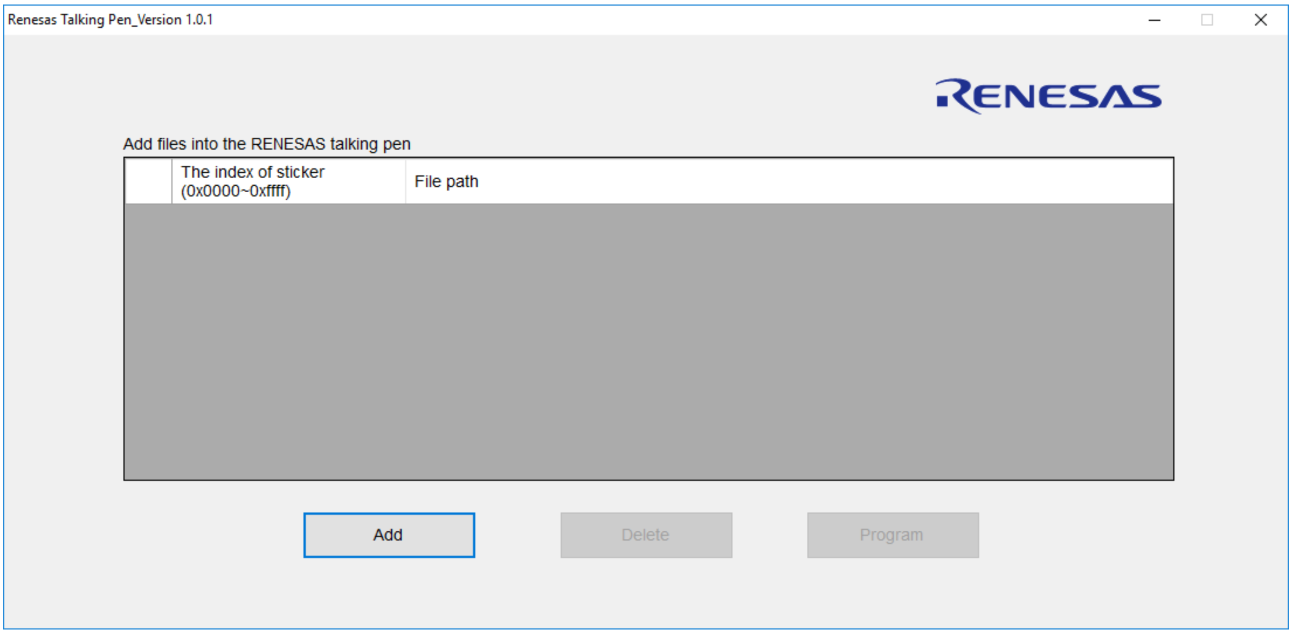
3.4.4 Store the Sound Data into the Micro SD Card

(1) Set all S6 switches to "OFF" position.

(2) Connect to the computer via USB.

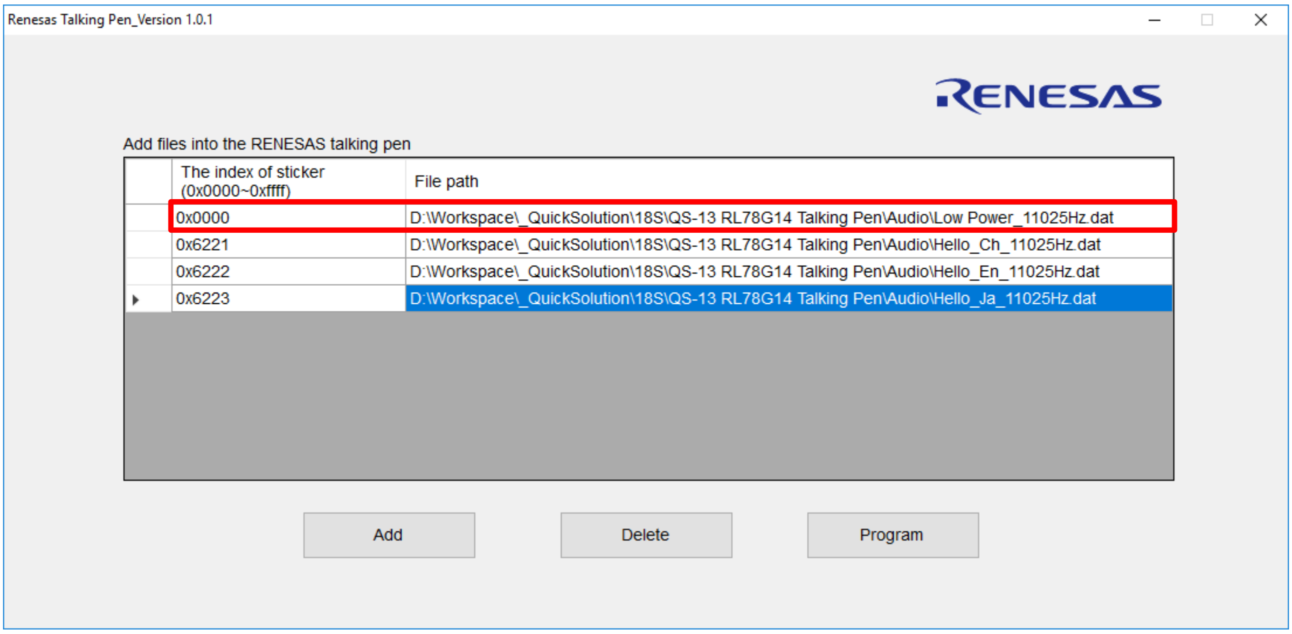
(3) Set the S4 switch to "ON" position.

(4) Open the tool "RenesasTalkingPen.exe".

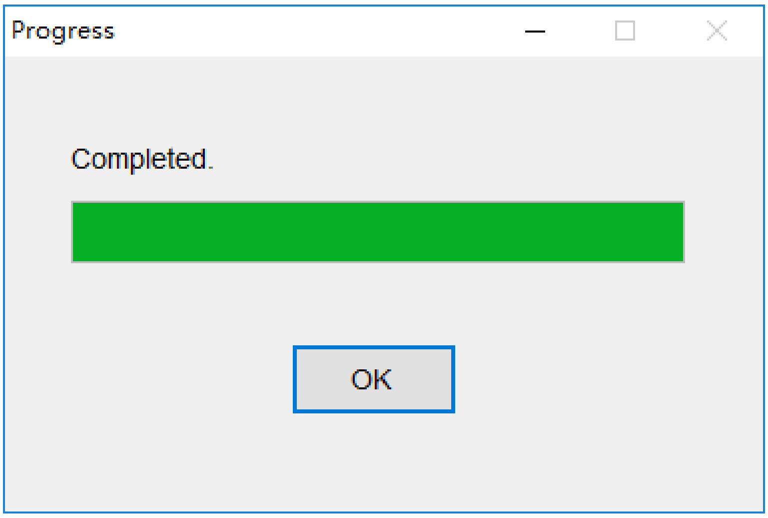


(5) Click on the "Add" button to select the sound files. And then input the index codes for these files.

It must be noted that, the "Low Power_11025Hz.dat" must be added first. This file is for the low-power mode. And its index code is 0x0000.



(6) Click on the “Program” button to store the sound data into the micro SD card.



(7) Set the S4 switch to “OFF” position.

3.4.5 Working Operation

(1) Set all S6 switches to "OFF" position.

(2) Set the S4 switch to "ON" position. Then the green LED will blink every 2 seconds.

(3) When the talking pen reads the underlying codes on the stickers, it will play the corresponding sound files.

(4) Press S1 key to turn up the volume. Press S2 key to turn down the volume.

(5) If the battery power is less than 3.7 V, the talking pen will play the sound "low power". Then the system will be shut down.

(6) If there is no operation for 3 minutes, the system will be shut down.

(7) To restart the talking pen in shut down state, set the S4 switch to "OFF" position and then back to "ON" position again. The talking pen will be restarted.

(8) Set the S4 switch to "OFF" position to stop using the talking pen.

3.4.6 Charging Operation

(1) Set the S4 switch to "OFF" position.

(2) Connect to a 5 V adapter.

The red LED is always on when charging.

4. Hardware

Scan the port level to judge whether the key is pressed or not. The green LED is controlled by the MCU and blinks every 2 seconds, representing that the talking pen is in a working state. The ISL6294 controls the charging of the battery. The red LED is connected to the CHG pin of the ISL6294. When the battery is being charged, the output level of the CHG pin is low and the red LED is on. The ISL80505 controls the discharging of the battery. The MCU communicates with the computer through UART <=> USB, via the chip FT232BL, and retrieves the sound files from the computer. The RL78/G14 reads or writes the sound data into the micro SD card through CSI20. The X9317 is used to control the volume of the speaker. The speaker receives the amplified PWM signals from the audio power amplifier TS4990. The SN9P701 is the second generation of the OID decoder. It reads the information from the EEPROM before communicating with the image sensor. If the image sensor has read the underlying codes on the stickers, the SN9P701 will decode it and send the decoded code to the MCU.

Figure 4.1 and Figure 4.2 show the pictures of the board.

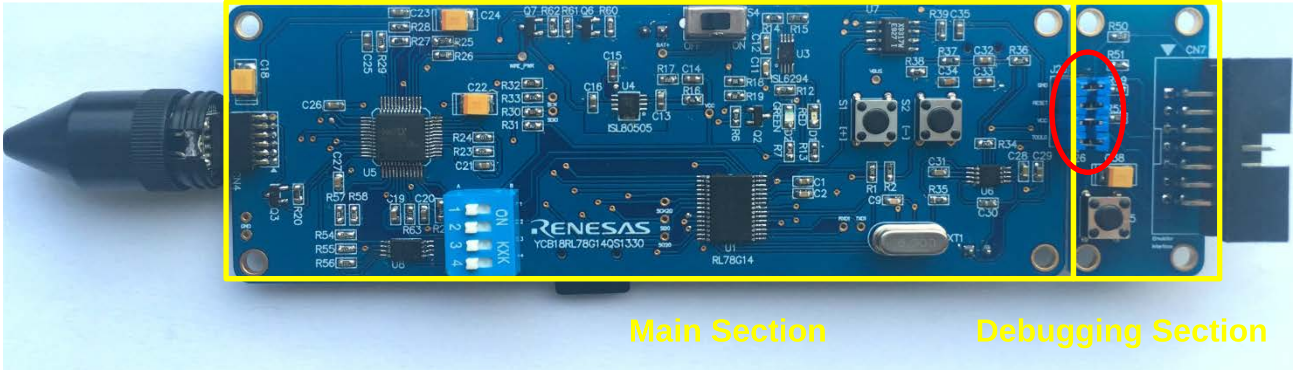


Figure 4.1 Talking Pen Board (Top)

There should be 4 jumpers on J26 when debugging. Since there is a V-cut between the main and debugging sections of the board, the debugging area can be removed if it is not necessary.

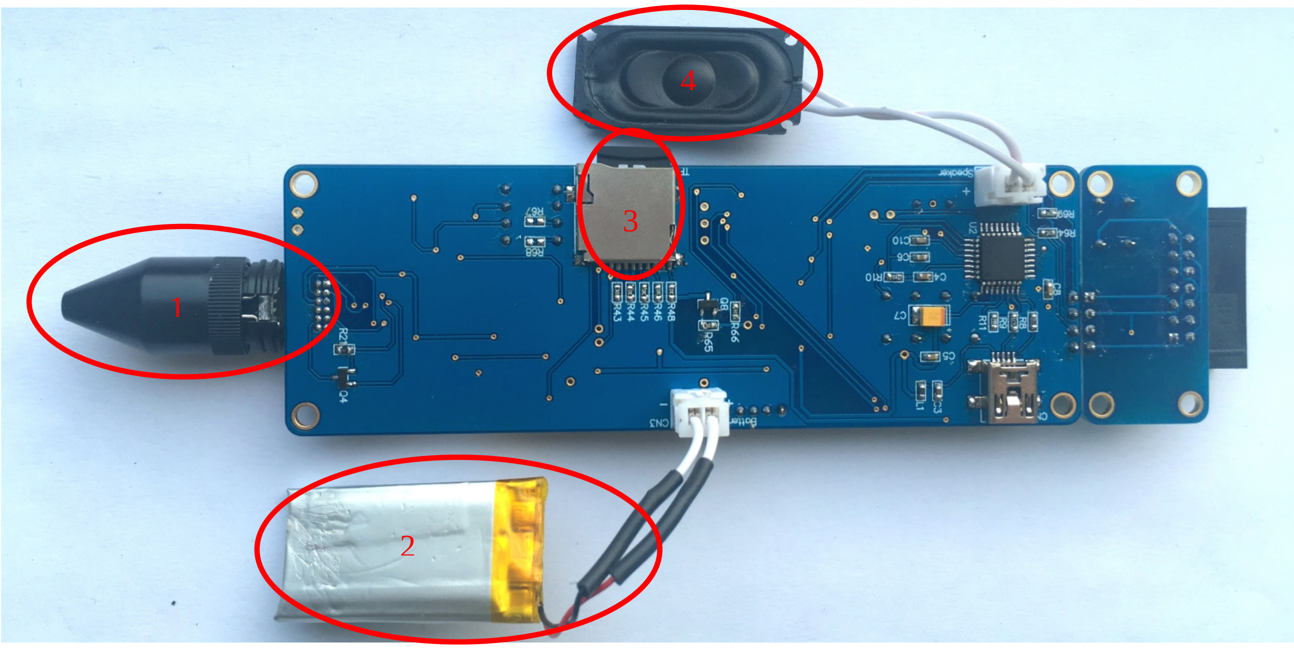


Figure 4.2 Talking Pen Board (Bottom)

When the board is prepared, these four objects should be added.

1	Sonix 2nd generation probe
2	600 mAh polymer lithium battery with protective circuit
3	2 GB micro SD card
4	Loudspeaker 8Ω 2W

Attention should be paid to the insertion direction of the probe. Please insert the No.1 pin of the probe (marked with a small triangle) into the No.1 pin of the CN4 on the board (marked with a small triangle).

4.1 LDO Circuit

Figure 4.4 shows the schematic of the LDO circuit.

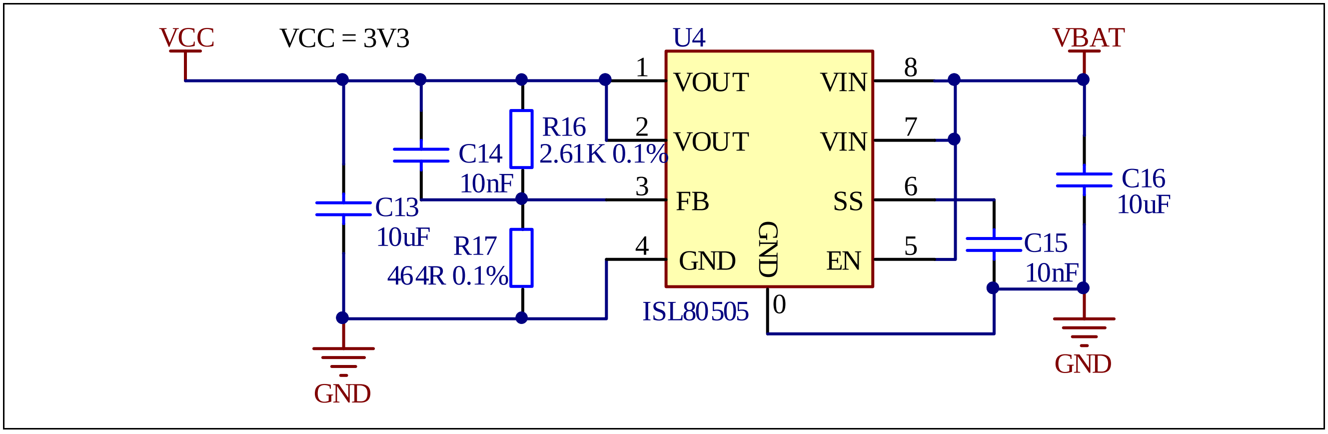


Figure 4.4 LDO Circuit

The ISL80505 is a single output Low Dropout voltage regulator (LDO) capable of sourcing up to 500 mA output current. This LDO operates from input voltage of 1.8 V to 6 V. The output voltage of the ISL80505 can be programmed from 0.8 V to 5.5 V.

4.2 Battery Charging Circuit

Figure 4.5 shows the schematic of the battery charging circuit.

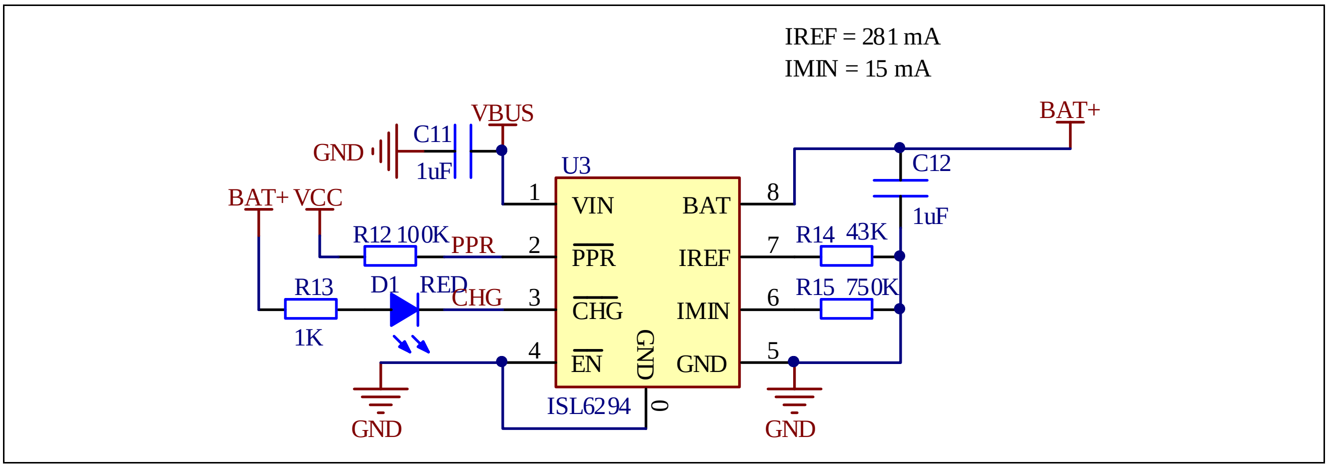


Figure 4.5 Battery Charging Circuit

The ISL6294 is a cost-effective, fully integrated high input voltage single-cell Li-ion battery charger. The charger uses a CC/CV charge profile required by Li-ion batteries. The charger accepts an input voltage up to 28 V but is disabled when the input voltage exceeds the OVP threshold, typically 6.8 V, to prevent excessive power dissipation. The 28 V rating eliminates the overvoltage protection circuit required in a low input voltage charger.

The charge current and the end-of-charge (EOC) current are programmable with external resistors. When the battery voltage is lower than typically 2.55 V, the charger preconditions the battery with typically 20% of the programmed charge current. When the charge current reduces to the programmable EOC current level during the CV charge phase, an EOC indication is provided by the CHG pin, which is an open-drain output. An internal thermal foldback function protects the charger from any thermal failure.

Two indication pins (PPR and CHG) allow simple interface to a microprocessor or LEDs. When no adapter is attached or when disabled, the charger draws less than 1 µA leakage current from the battery.

The charged current and EOC current should be programmed according to the actual battery used. The equations are shown as follows:

$$I_{REF} = \frac{12089}{R_{14}}$$

$$I_{MIN} = \frac{11000}{R_{15}}$$

Where I_{REF} and I_{MIN} are in mA. R_{14} and R_{15} are in kΩ.

Remarks:

1. Programmed charged current is from 100 mA to 900 mA (DFN) or from 100 mA to 600 mA (SOIC).

2. The range of I_{MIN} covers 5% (or 10 mA, whichever is higher) to 50% of I_{REF}.

5. Software

5.1 Integrated Development Environment

The sample code described in this chapter has been checked under the conditions listed in the table below.

Table 5.1 Operation Check Conditions

Item	Description
Microcontroller used	RL78/G14 (R5F104AG)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 64 MHz CPU/peripheral hardware clock: 32 MHz Low-speed on-chip oscillator clock: 15 kHz
Operating voltage	3.3 V (can run on a voltage range of 2.7 V to 5.5 V) LVD: Reset mode Rising edge: 3.13 V (3.07 V ~ 3.19 V) Falling edge: 3.06 V (3.00 V ~ 3.12 V)
Integrated development environment (CS+)	CS+ V7.00.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.07.00 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio V7.0.0 from Renesas Electronics Corp.
C compiler (e^2 studio)	CC-RL V1.07.00 from Renesas Electronics Corp.

5.2 Option Byte

Table 5.2 summarizes the settings of the option bytes.

Table 5.2 Option Byte Settings

Address	Value	Description
000C0H/010C0H	01101110B	Watchdog timer counter operation disabled (counting stopped after reset)
000C1H/010C1H	00110011B	LVD: Reset mode Rising edge: 3.13 V (3.07 V ~ 3.19 V) Falling edge: 3.06 V (3.00 V ~ 3.12 V)
000C2H/010C2H	11111000B	HS mode, f_{HOCO}: 64 MHz CPU clock f_{CLK}: 32 MHz
000C3H/010C3H	10000100B	Enables on-chip debugging

5.3 Operation Outline

5.3.1 Operating Mode

The tasks of the whole system are listed as below: EEPROM write task, micro SD card initialization task, index code recognition task, and operation task.

Figure 5.1 shows the block diagram for the tasks transition.

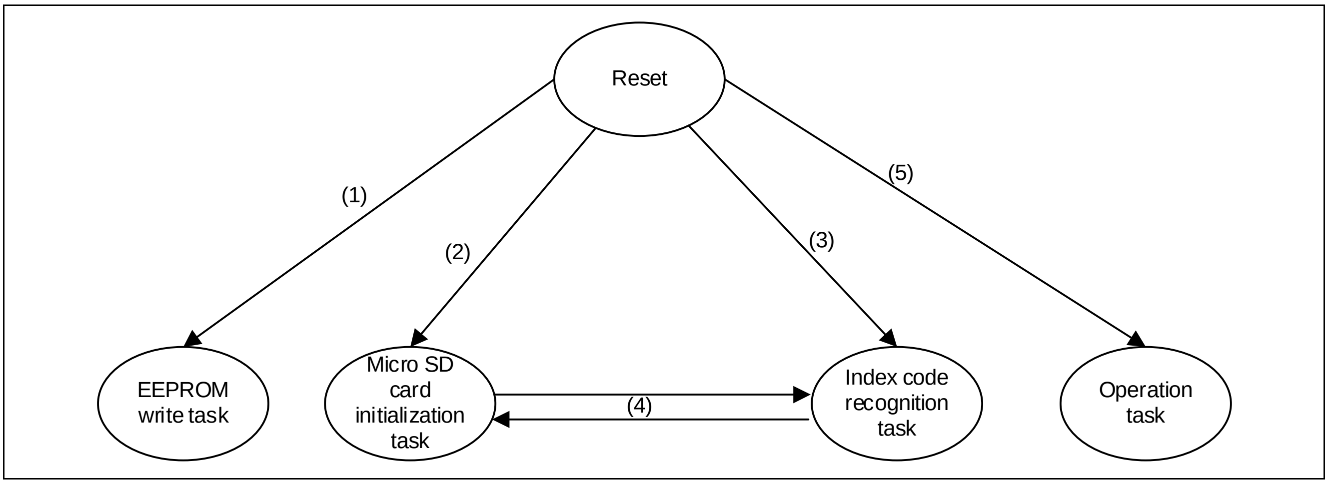


Figure 5.1 Tasks Transition Block Diagram

(1) If both P6.0 and P6.1 are pulled up, the system will enter EEPROM write task.

The OID sensor device information will be written into the EEPROM. If the write operation is successfully performed, the green LED will be turned on.

(2) If both P6.0 and P6.1 are pulled down, and the output of the PPR port is low level, and the MCU gets the CONNECT command from the “RenesasTalkingPen.exe”, the system will enter micro SD card initialization task.

In this task, the MCU will get the sound data from the computer and store these data into the micro SD card.

(3) If both P6.0 and P6.1 are pulled down, and the output of the PPR port is low level, and the MCU gets the CONNECT command from the “IndexCode.exe”, the system will enter index code recognition task.

When the talking pen recognizes the stickers, the underlying codes will be displayed in the window of the “IndexCode.exe”.

(4) The system will enter the corresponding task according to the CONNECT command from the different executable files.

(5) If both P6.0 and P6.1 are pulled down, and the output of the PPR port is high level, the system will enter operation task.

There are three statuses in this task: normal, low-power and shut-down.

Figure 5.2 shows the diagram for the operation task.

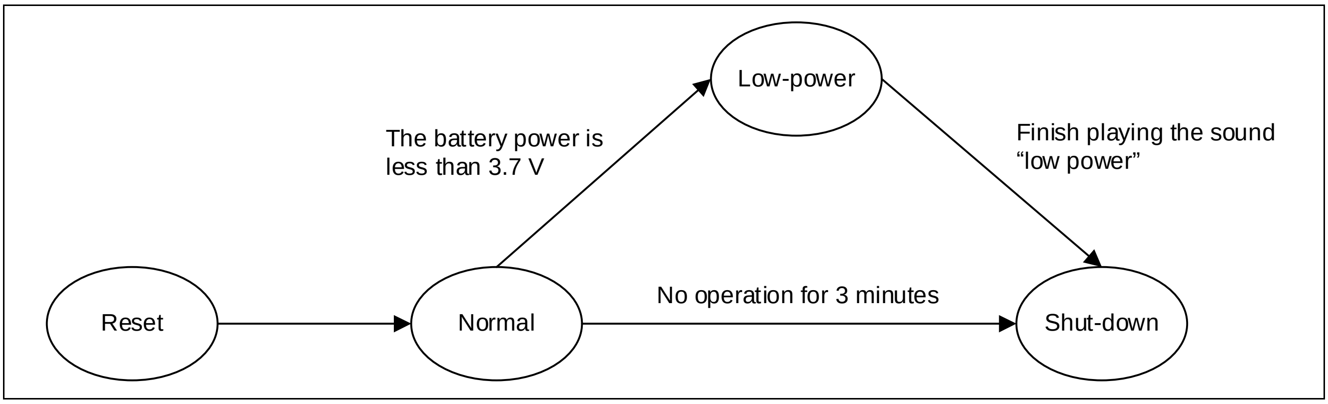


Figure 5.2 Operation Task

<1> Reset

When the talking pen is powered on in the operation task, the system will enter the normal mode.

<2> Normal

a) The green LED blinks every 2 seconds.

b) When the talking pen recognizes the stickers, it will play the corresponding sound files.

c) Change the volume of the speaker by pressing the keys.

d) Test the battery voltage through the A/D converter.

<3> Low-power

The talking pen plays the sound "low power".

<4> Shut-down

The system turns all peripheral functions off and enters the STOP mode.

5.4 Flow Chart

Figure 5.3 shows the flowchart for the main processing routine.

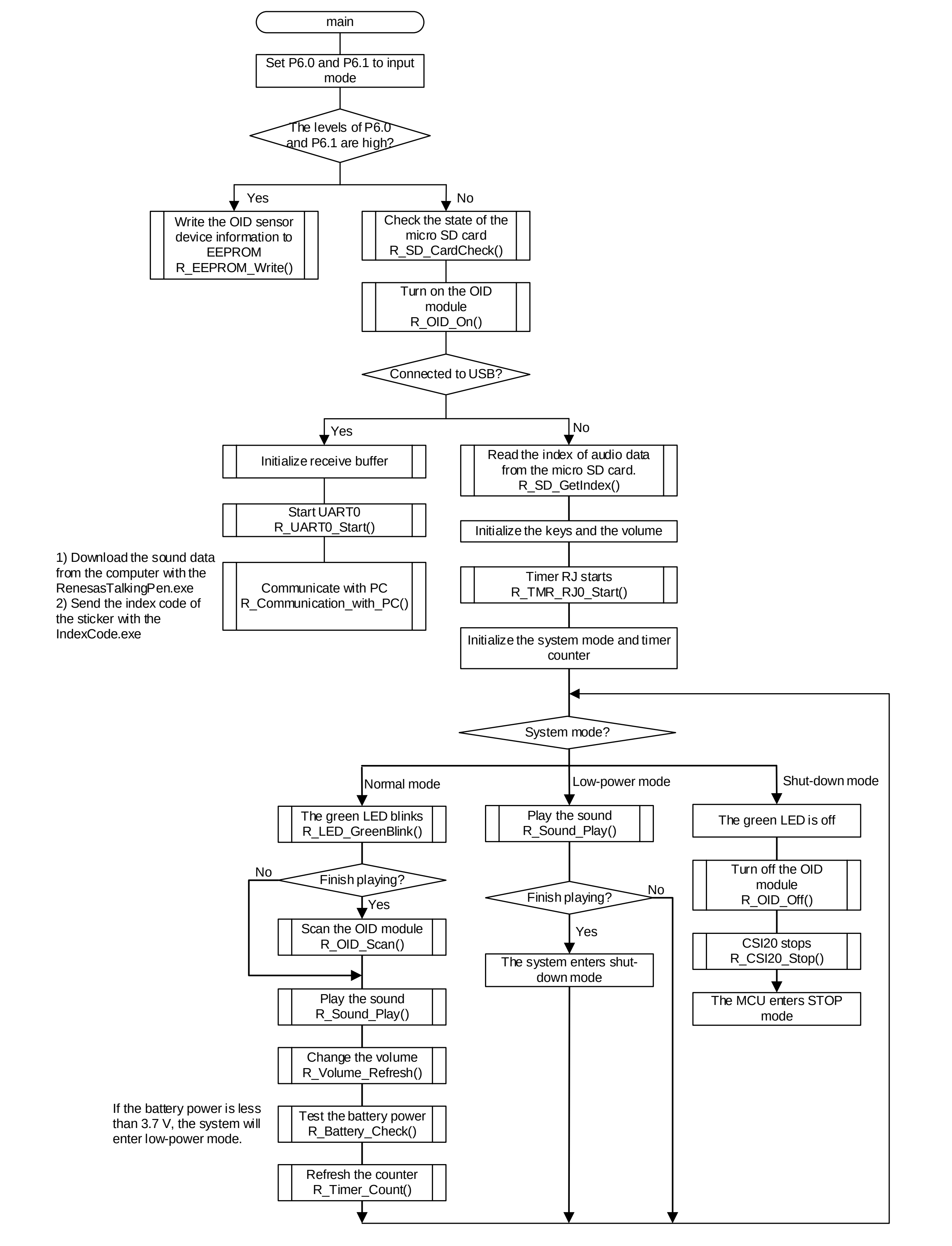


Figure 5.3 Main Processing

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Reference Documents

RL78/G14 User's Manual: Hardware (R01UH0186)

RL78 Family User's Manual: Software (R01US0015)

(The latest versions of the documents are available on the Renesas Electronics Website.)

Technical Updates/Technical News

(The latest information can be downloaded from the Renesas Electronics Website.)

Website and Support

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

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

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar. 31, 2019	—	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. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

   The state of the product is undefined at the time 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 time 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 time 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 time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. 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 the 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.

5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is 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. Additionally, 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.

6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of 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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www.renesas.com

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit: www.renesas.com/contact/.