RL78/G11

Wireless Doorbell

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Introduction

This document describes a Renesas microcontroller RL78/G11 application for wireless doorbell transmitter and wireless doorbell receiver.

Target Device

RL78/G11

When applying the sample program covered in this application note 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

Wireless door phone or wireless doorbell is also known as wireless remote-control doorbell or remote-control doorbell. The wireless doorbell described in this document is based on civilian wireless technology.

The wireless doorbell kit consists of 1 push button transmitter and 1 plug-in receiver. The push button transmitter triggers the receiver wirelessly without any connecting wires.

The wireless doorbell operates at 1000 ft/300 m in open area, suitable for townhouse, home and office. Users can hear the rings in any room where the receiver is placed when someone rings the bell.

This document provides the wireless doorbell solution based on Renesas low cost microcontroller RL78/G11.

1.2 Specifications and Main Technical Parameters

1.2.1 Transmitter

Technical Parameters

- Power supply: 3 V (CR2032 button battery)
- Low power consumption current (MCU): 106.3 μA (TYP.)
- Wireless method: RL78/G1H sub-GHz wireless communication module Note

Note: The RF module may not be a certificated device for emitting the radio frequency in some regions. You need to do the certifications (like FCC / CE / TELEC) by yourself if it is necessary.

Specifications

- Low power consumption function: After the system is powered on, it operates in low power consumption mode. When an external interrupt (the key is pressed) occurs, the system enters normal operation mode.
- LED indication function: If the key is pressed, the LED will turn on. If the key is released, the LED will turn off.
- Wireless communication: When the key is pressed, the wireless signals are transmitted to the receiver through the RF module.
  Once the key is pressed for 5 seconds, the wireless signals will be transmitted to the receiver again.
- Low power detection: When the MCU detects that the power of the battery is low (< 2.9 V), light indication (the LED blinks for 5 seconds).
- Operating temperature: -10°C ~ 60°C
- Operating humidity: 5 ~ 99% RH (No condensate water)

1.2.2 Receiver

Technical Parameters

- Power supply: External power supply (5 V)
- Indication method: When the receiver received the wireless communication signals, the LED blinks and the speaker sounds.
- Speaker sound: > 80 dB
- Speaker sound lasting time: 5 seconds
  (During this period, if the key located on the receiver is pressed, the LED will stop blinking and the speaker will stop ringing.)
- Wireless method: RL78/G1H sub-GHz wireless communication module

Specifications

- Reset standby function: After the system is powered on, the system starts initialization. After the RF module is initialized, UART0 is ready for receiving.
- Indication function: When the signals are received from the transmitter through the RF module, the LED starts to blink and the speaker starts to sound.
  Audible and visual indication function:
  The LED blinks every 500 millisecond for 5 seconds.
  The speaker plays the indication music for 5 seconds.
  (During this period, if the key located on the receiver is pressed, the LED will stop blinking and the speaker will stop ringing.)
  Other function: the LED goes out to reduce the power consumption.
- Operating temperature: -10°C ~ 60°C
- Operating humidity: 5 ~ 99% RH (No condensate water)

2. RL78/G11 Microcontroller

2.1 RL78/G11 Block Diagram

Figure 2.1 shows the block diagram of the RL78/G11 (20-pin products).

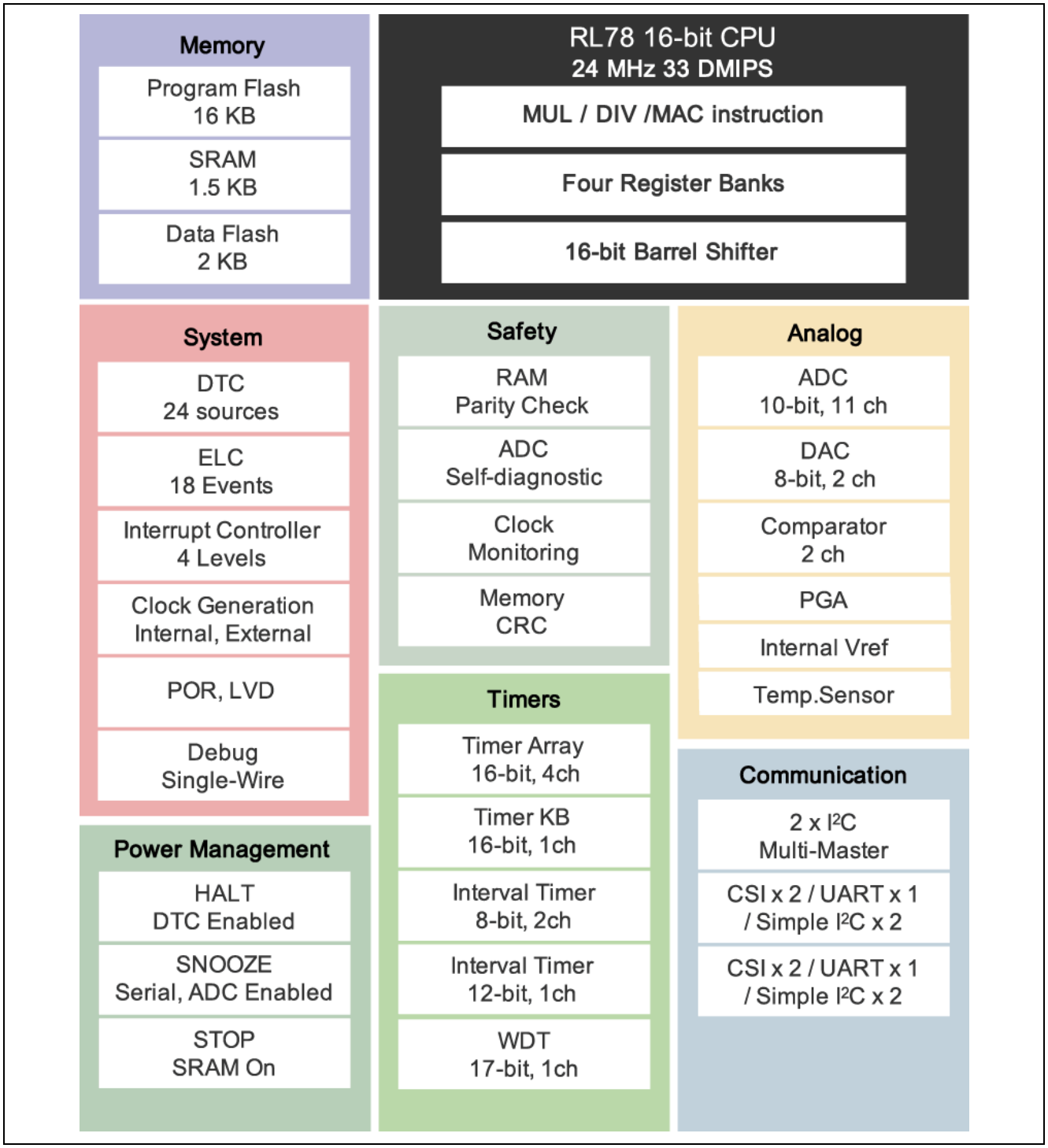


Figure 2.1 RL78/G11 (20-pin products) Block Diagram

2.2 Key Features

- Minimum instruction execution time: Can be changed from high speed (0.04167 µs @ 24 MHz operation with high-speed on-chip oscillator) to low speed (66.6 µs @ 15 kHz operation)
- General-purpose registers: 8-bit register × 8
- ROM: 16 KB, RAM: 1.5 KB, data flash: 2 KB
- Selectable high-speed on-chip oscillator clock: 48/24/16/12/8/6/4/3/2/1 MHz (TYP.)
- Selectable middle-speed on-chip oscillator clock: 4/2/1 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: 6 key interrupt input pins
- On-chip clock output/buzzer output controller
- On-chip BCD (binary-coded decimal) correction circuit
- I/O port: 17 to 21
- Timer
  8/16-bit timer: 4 channels
  12-bit interval timer: 1 channel
  TKB: 1 channel
- Serial interface
  CSI: 4 channels
  UART: 2 channels
  Simplified I^2C communication: 4 channels
  Multi-master I^2C communication: 2 channels
- 8/10-bit resolution A/D converter: 10 channels
- 8/10-bit resolution D/A converter: 2 channels
- Comparator: 2 channels
- PGA: 1 channel
- Data transfer controller (DTC)
- Event link controller (ELC)
- Standby function: HALT or STOP mode
- Power supply voltage: V_{DD} = 1.8 to 5.5 V
- Operating ambient temperature: T_A = -40 to +85 °C

The RL78/G11 is widely used in common technologies for industry, office, home appliance, healthcare, security, city and detectors application.

2.3 Pin Configuration

Figure 2.2 shows the pin configuration of the RL78/G11 (20-pin products).

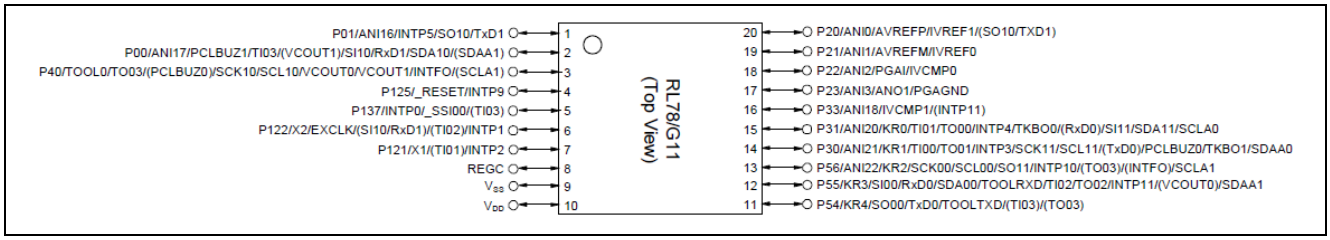


Figure 2.2 RL78/G11 (20-pin Products) Pin Configuration

3. System Outline

3.1 Principle Introduction

Figure 3.1 shows the system block diagram for this document.

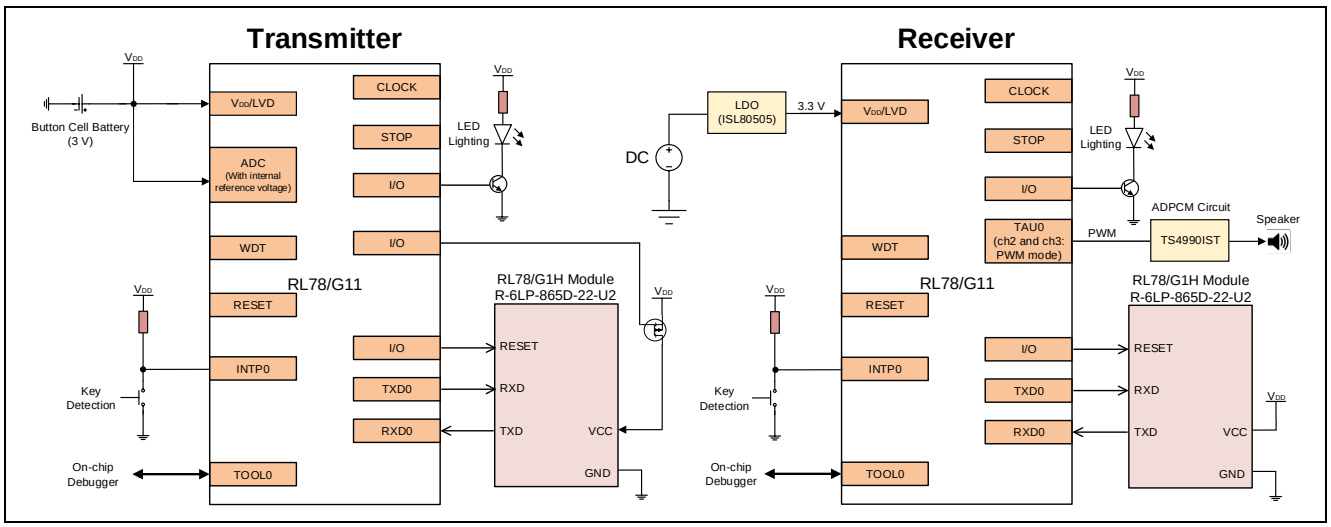


Figure 3.1 System Block Diagram

3.1.1 Transmitter

After the system initialization is completed, the system enters STOP mode. When the key is pressed, the system enters the normal operation mode, and the LED is on. Meanwhile, the RF module is initialized, and the wireless signals are transmitted to the receiver through the RF module. If the key is released, the LED will be off. Additionally, once the key is kept pressed for 5 seconds, the wireless signals will be transmitted to the receiver again.

3.1.2 Receiver

After the system is powered on, the system starts initialization. After the RF module is initialized, UART0 is ready for receiving. When the signals are received from the transmitter through the RF module, the LED starts to blink and the speaker starts to sound. The LED blinks every 500 milliseconds for 5 seconds. The speaker plays the indication music for 5 seconds. During this period, if the key located on the receiver is pressed, the LED will stop blinking and the speaker will stop ringing.

3.2 Peripheral Functions to be Used

3.2.1 Transmitter

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

Table 3.1 Peripheral Functions to be Used (Transmitter)

Peripheral Function	Usage
Channel 0 of TAU0	Operate as a 200 milliseconds counter
Channel 1 of TAU0	Operate as a 500 milliseconds counter
Channel 2 of TAU0	Operate as a 5 seconds counter.
Channel 3 of TAU0	Operate as a 1 milliseconds counter
A/D converter	Detect the battery low power
INTP0	Detect whether the key is pressed
P00	Control the LED
P01	Control the power supply of the RF module
SAU0, P21	Communicate with the RF module

3.2.2 Receiver

Table 3.2 lists the peripheral functions to be used (receiver) and their usages.

Table 3.2 Peripheral Functions to be Used (Receiver)

Peripheral Function	Usage
Channel 1 of TAU0	Operate as a 50 milliseconds counter.
TAU00, TAU02, TAU03	Output PWM for the speaker
P33	Enable /disable the output of the audio power amplifier (TS4990IST)
P00	Control the LED
INTP0	Detect whether the key located on the receiver is pressed.
SAU0, P21	Communicate with the RF module

3.3 Pins to be Used

3.3.1 Transmitter

Table 3.3 lists the pins to be used (transmitter) and their descriptions.

Table 3.3 Pins to be Used (Transmitter)

Pin Name	Description
P00	Drive the LED for indicating the status
P137/INTP0	Detect the status of the key
P01	Control the power supply of the RF module
P54/TXD0, P55/RXD0	Communicate with the RF module
P21	Reset the RF module
P40/TOOL0	On-chip debug
P125/RESET	Hardware reset
V_{SS}	Ground
V_{DD}	Power supply voltage

3.3.2 Receiver

Table 3.4 lists the pins to be used (receiver) and their descriptions.

Table 3.4 Pins to be Used (Receiver)

Pin Name	Description
P00	Drive the LED for indicating the status
P137/INTP0	Detect the status of the key located on the receiver
P56/TO03	Output PWM to drive the speaker
P33	Enable /disable the output of the audio power amplifier (TS4990IST)
P54/TXD0, P55/RXD0	Communicate with the RF module
P21	Reset the RF module
P40/TOOL0	On-chip debug
P125/RESET	Hardware reset
V_{SS}	Ground
V_{DD}	Power supply voltage

3.4 Operating Instructions

3.4.1 Transmitter

(1) After the system is powered on, the MCU is initialized.
(2) After the initialization, the system enters STOP mode.
(3) When the key is pressed, the LED is on, the RF module are initialized, and the wireless signals are transmitted to the receiver.
(4) Once the key is pressed for 5 seconds, the wireless signals are transmitted to the receiver again.
(5) When the key is released, the LED is off.
(6) After transmitting data, the system enters STOP mode, and disable the power supply of the RF module, waiting for the key to be pressed again.
(7) Additionally, when the MCU detects that the power of the battery is low (< 2.9 V), light indication (the LED blinks every 500 milliseconds for 5 seconds).

3.4.2 Receiver

(1) After the system is powered on, the MCU and the RF module are initialized.
(2) Once the signals are received from the transmitter, the LED will blink, and the speaker will sound for 5 seconds.
(3) If the key located on the receiver is pressed, the LED will stop blinking and the speaker will stop ringing.
(4) After the LED stops blinking and the speaker stops ringing, the system waits for the signals from the transmitter.

4. Hardware

On the transmitter board, there is an RF module, a key and an LED circuit. When an external interrupt (the key is pressed) occurs, the LED is on, and the wireless signals are transmitted to the receiver through the RF module. If the key is released, the LED will be off. Additionally, once the key is pressed for 5 seconds, the wireless signals will be transmitted to the receiver again.

Figure 4.1 shows the picture of the transmitter board.

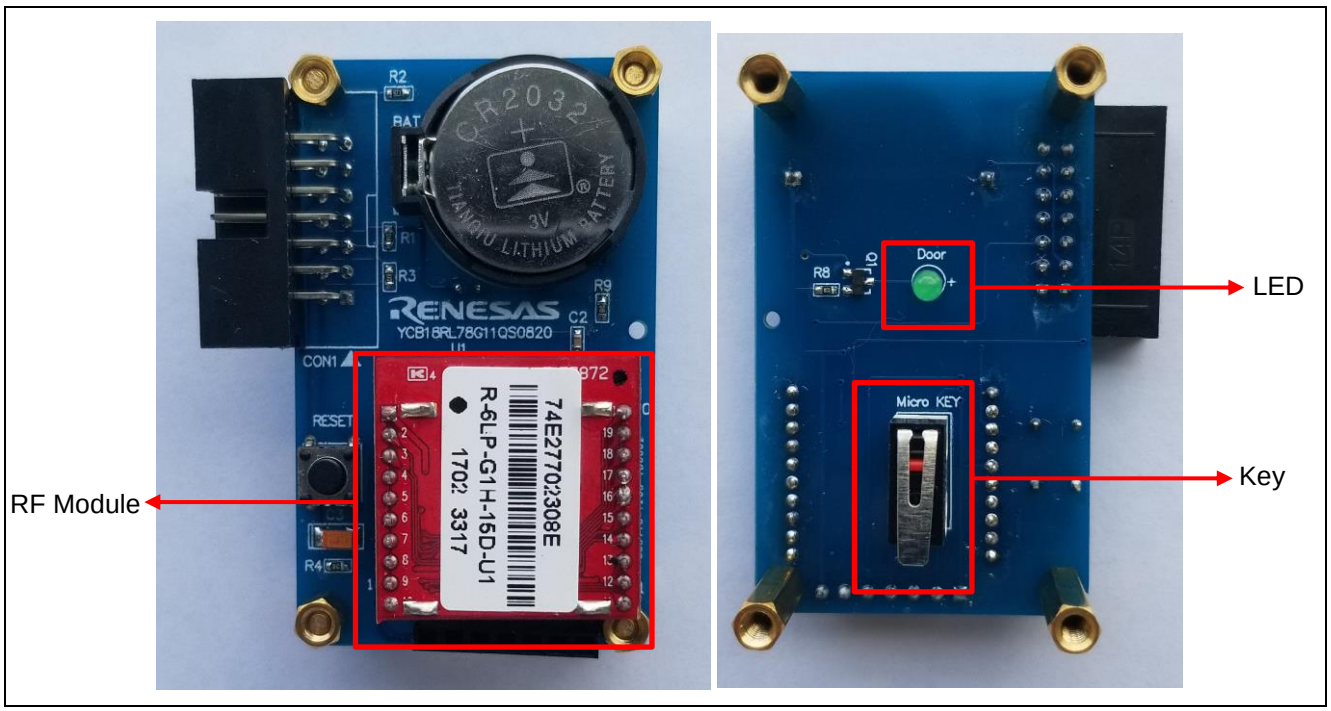


Figure 4.1 Transmitter Board

On the receiver board, there is an RF module, a speaker, a key and an LED circuit.

When the signals are received from the transmitter through the RF module, the LED starts to blink every 500 milliseconds, and the speaker starts to play the indication music. The blinking of the LED and the ringing of the speaker last 5 seconds. During this period, if the key on the receiver board is pressed, the LED will stop blinking and the speaker will stop ringing.

Figure 4.2 shows the picture of the receiver board.

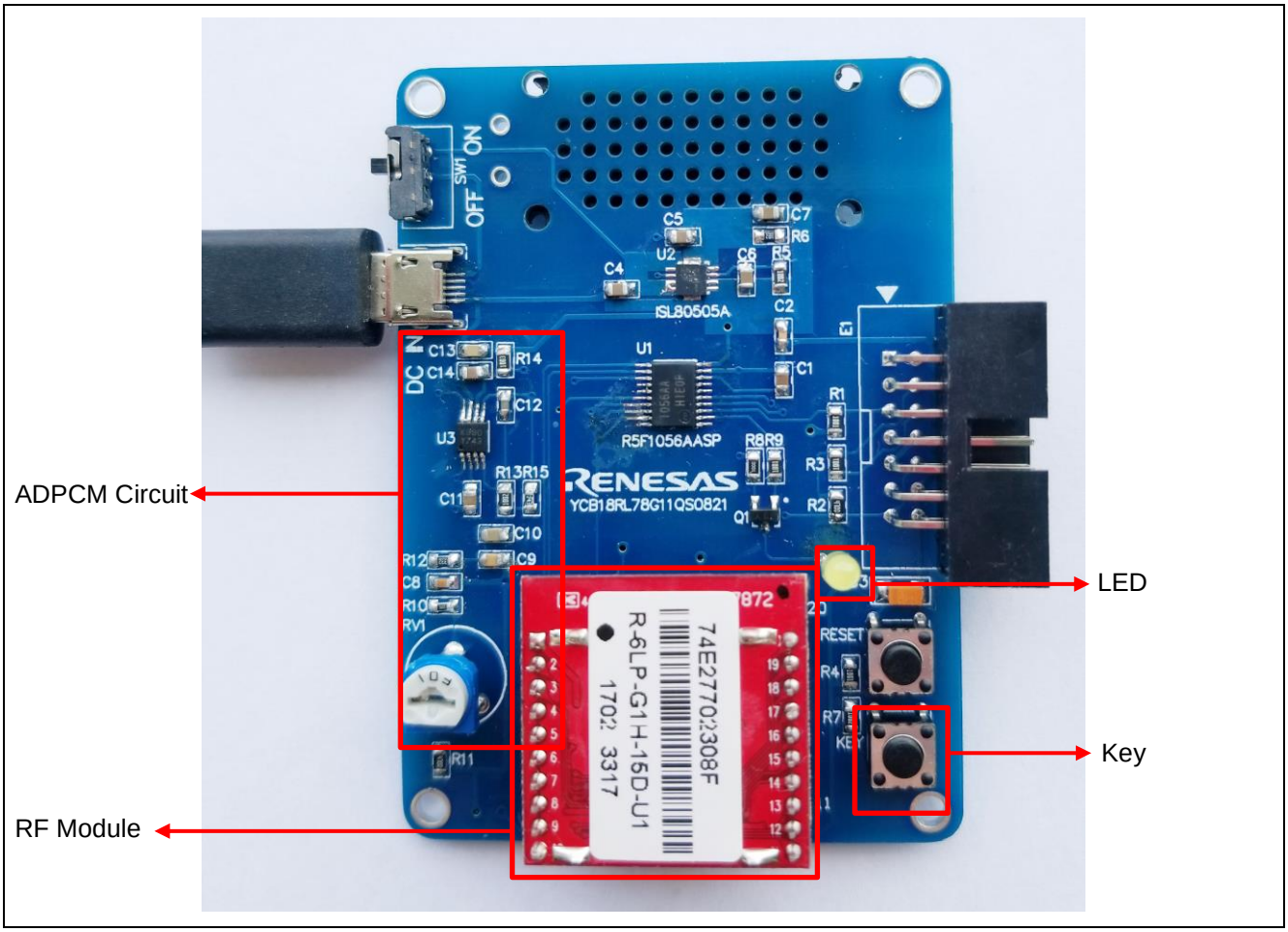


Figure 4.2 Receiver Board

4.1 RF Module

Figure 4.3 shows the RF module (RL78/G1H sub-GHz RF module).

RL78/G1H sub-GHz RF module

R-6LP-865D-15-U2

Figure 4.3 RF Module

RL78/G1H sub-GHz RF module (R-6LP-865D-15-U2):

- Renesas RL78/G1H, 16-bit MCU with integrated sub GHz transceiver
- 2FSK/4FSK with support for data rates 50/100/200 kbps
- Factory calibrated high TX power of up to 15 dBm and RX antenna diversity
- Support standby mode (6 mA at 3.3 V)
- Simple UART interface for easy OEM integration

4.2 Key and LED Circuit (Transmitter)

Figure 4.4 shows the schematic of the key and LED circuit (transmitter).

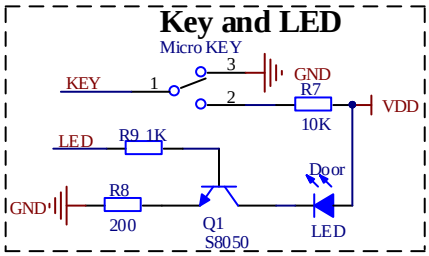


Figure 4.4 Key and LED Circuit (Transmitter)

The indication LED in this system is a green LED of which the drive current is about 5 mA. Because the current driving capability of the MCU is large, the LED can be directly driven by I/O. Low level is used to turn on the LED.

If the key is pressed, the LED will be on. If the key is released, the LED will be off.

When the system detects the battery is low power, the LED blinks every 500 milliseconds for 5 seconds.

4.3 Key and LED Circuit (Receiver)

Figure 4.5 shows the schematic of the key and LED circuit (receiver).

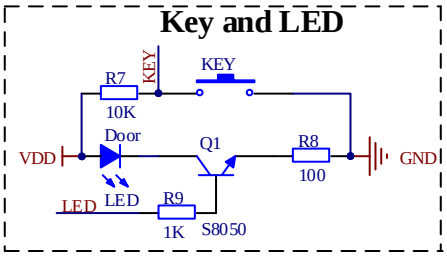


Figure 4.5 Key and LED Circuit (Receiver)

The indication LED in this system is a yellow LED of which the drive current is about 5 mA. Because the current driving capability of the MCU is large, the LED can be directly driven by I/O. Low level is used to turn on the LED.

When received the signals from the transmitter through the RF module, the LED starts to blink every 500 milliseconds for 5 seconds. During this period, if the key on the receiver board is pressed, the LED will stop blinking.

4.4 Power Supply Circuit (Receiver)

Figure 4.6 shows the schematic of the power supply circuit (receiver).

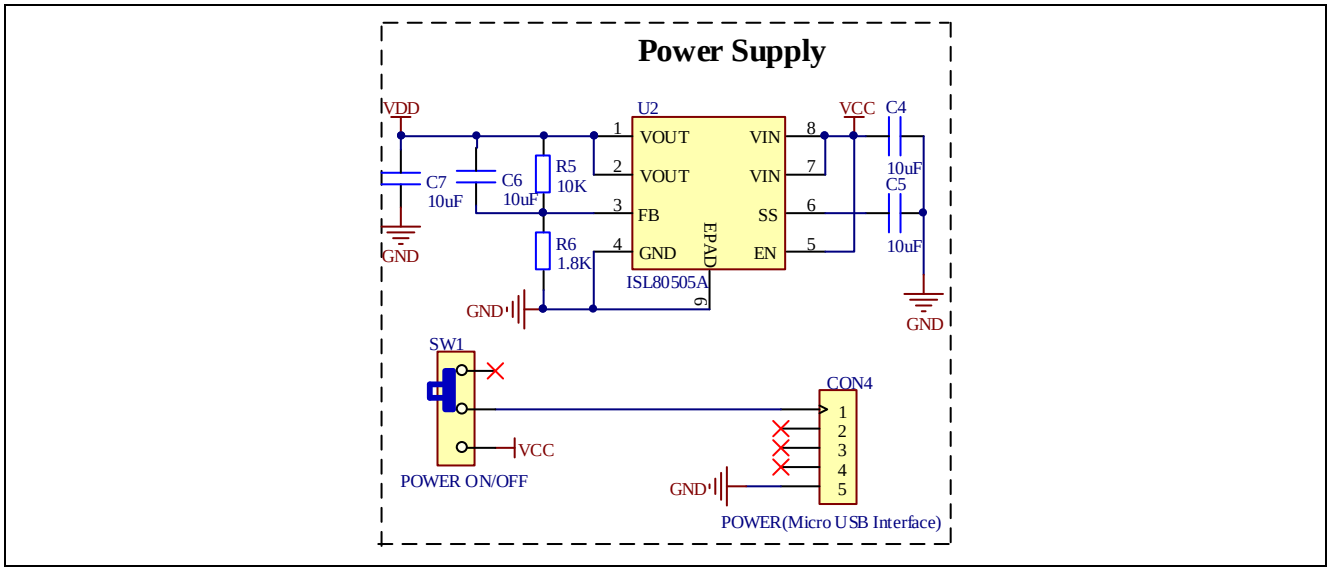


Figure 4.6 Power Supply Circuit (Receiver)

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 voltages of 1.8 V to 6 V. The output voltage of the ISL80505 can be programmed from 0.8 V to 5.5 V. The ISL80505 provides an output accuracy of ±1.8% VOUT accuracy over all load, line and temperature variations (TJ = -40°C to +125°C).

To make the speaker sound better, use the ISL80505 to get a stable voltage supply.

4.5 ADPCM Circuit (Receiver)

Figure 4.7 shows the schematic of the ADPCM circuit (receiver).

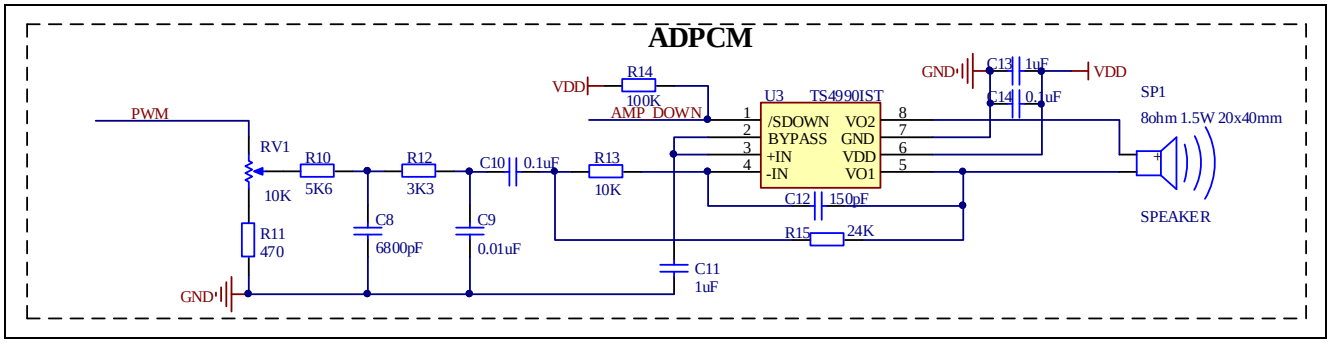


Figure 4.7 ADPCM Circuit (Receiver)

ADPCM (Adaptive Differential Pulse-Code Modulation) is a technique for converting sound or analog information to binary information (a string of 0's and 1's) by taking frequent samples of the sound and expressing the value of the sampled sound modulation in binary terms.

The system uses a speaker for voice indication.

The speaker driver circuit uses the audio power amplifier TS4990 to drive the speaker. The TS4990 is designed for demanding audio applications such as mobile phones to reduce the number of the external components. This audio power amplifier is capable of delivering 1.2 W of continuous RMS output power into an 8 Ω load at 5 V. An externally controlled standby mode reduces the supply current to less than 10 nA. It also includes an internal thermal shutdown protection. The unity-gain stable amplifier can be configured by external gain setting resistors.

When the microcontroller uses PWM for voice output, the PWM frequency is 11.025 kHz (which is the same as the voice signal sampling frequency), and the PWM duty cycle is generated from the decoded PCM data.

In this design, the TS4990 receives the PWM output from the MCU. After internally amplifying, the TS4990 drives the speaker to implement the voice indication function.

5. Software

5.1 Transmitter

5.1.1 Integrated Development Environment (Transmitter)

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

Table 5.1 Operation Check Conditions (Transmitter)

Item	Description
Microcontroller used	RL78/G11 (R5F1056A)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 24 MHz CPU/peripheral hardware clock: 24 MHz
Operating voltage	3.0 V (can run on a voltage range of 2.7 V to 5.5 V.) Low voltage detector operation setting: Reset mode (reset generation level: 1.63 V)
Integrated development environment (CS+)	CS+ V6.00.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.05.00 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio V6.0.0 from Renesas Electronics Corp.
C compiler (e^2 studio)	CC-RL V1.05.00 from Renesas Electronics Corp.

5.1.2 Option Byte (Transmitter)

Table 5.2 summarizes the settings of the option bytes (transmitter).

Table 5.2 Option Byte Settings (Transmitter)

Address	Value	Description
000C0H/010C0H	01101110B	Watchdog timer counter operation disabled (counting stopped after reset) Interval interrupt is not used
000C1H/010C1H	00011111B	Low voltage detector operation setting: Reset mode (reset generation level: 1.63 V)
000C2H/010C2H	11100000B	Operating frequency: 24 MHz (2.7 V ~ 5.5 V) CPU clock f_{CLK}: 24 MHz
000C3H/010C3H	10000100B	Enables on-chip debugging

5.1.3 Operation Outline (Transmitter)

The tasks of the entire system are listed as below: reset/initialization, IDLE mode, transmission mode and low voltage mode.

Figure 5.1 shows the block diagram for the tasks transition.

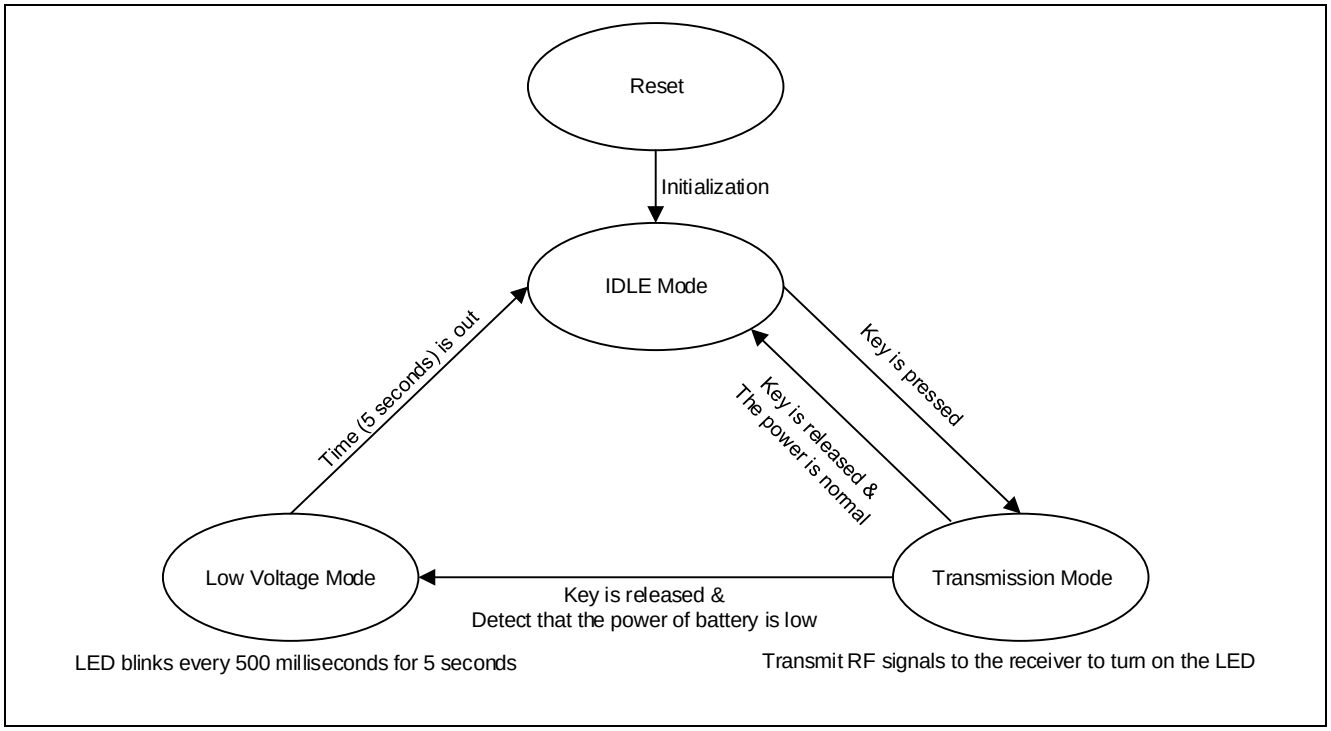


Figure 5.1 Tasks Transition Block Diagram (Transmitter)

(1) Reset / Initialization

After the battery is loaded, the system is powered on and the initialization routine of each module is executed.

(2) IDLE Mode

After initialization, the system enters IDLE mode.

(3) STOP Mode

After the system enters IDLE mode, the system enters low power consumption task by executing the STOP instruction. At this time all peripheral functions stop operating except the interrupt function. And the system doesn't supply the power to the RF module in order to reduce the power consumption.

(4) Transmission Mode

When an external interrupt (the key is pressed) occurs, the system enters transmission mode. When the press of the key is confirmed, the LED is on, the RF module is supplied with power and initialized, and then the wireless signals are transmitted to the receiver through the RF module. If the key is released, the LED will be off. Additionally, once the key is pressed for 5 seconds, the wireless signals will be transmitted to the receiver again.

(5) Low Power Mode

If the key is released, MCU will judge whether the power of the battery is low (< 2.9 V). If the power of the battery is low (< 2.9 V), light will on (the LED blinks for 5 seconds). And then the system enters IDLE mode.

5.1.4 Flow Chart (Transmitter)

5.1.4.1 Main Processing (Transmitter)

Figure 5.2 shows the flowchart for the main processing routine (transmitter).

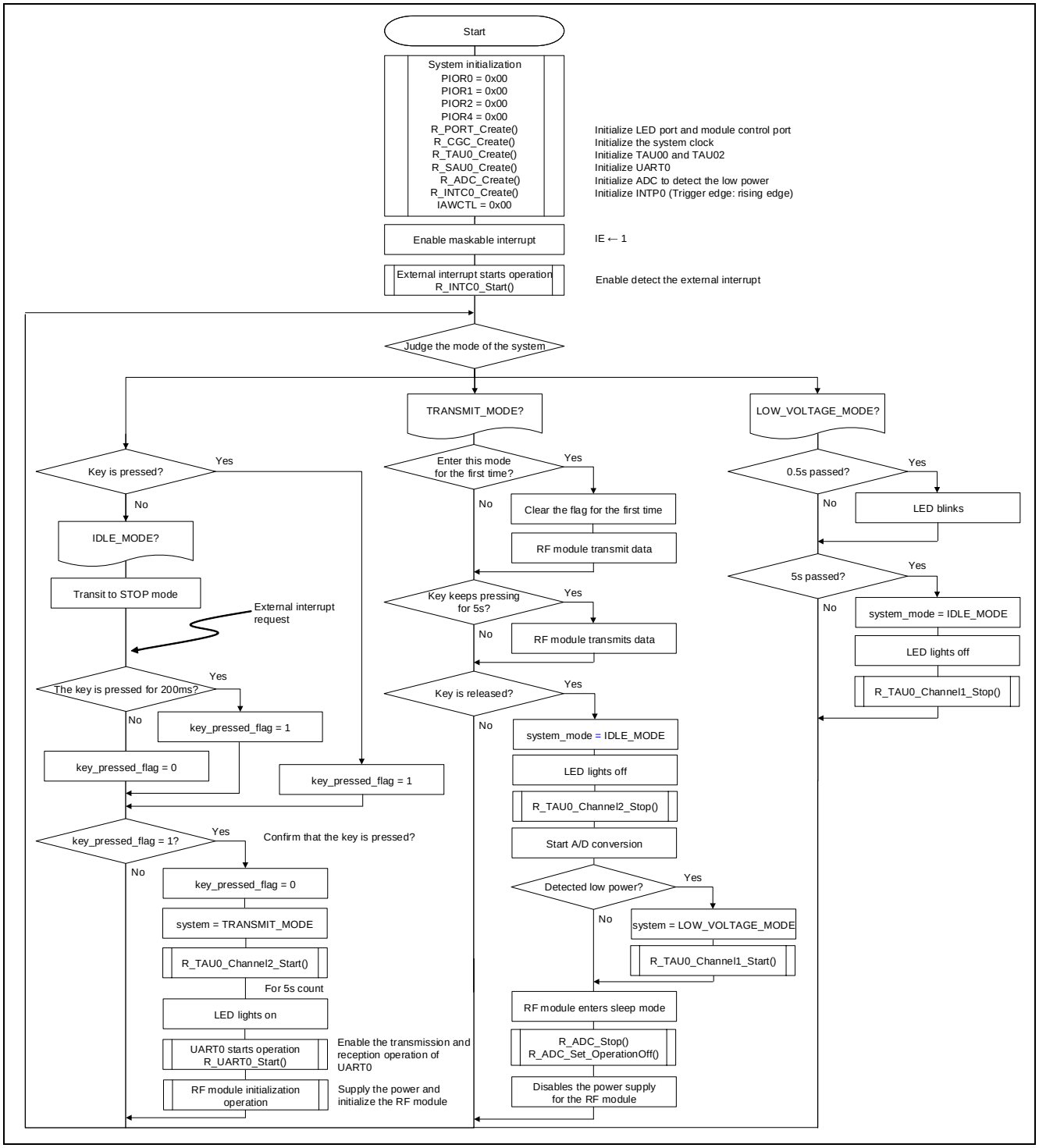


Figure 5.2 Main Processing (Transmitter)

5.1.4.2 Transmission Operation of RL78/G1H sub-GHz RF Module

Figure 5.3 shows the flowchart for the transmission operation of the RL78/G1H sub-GHz RF module.

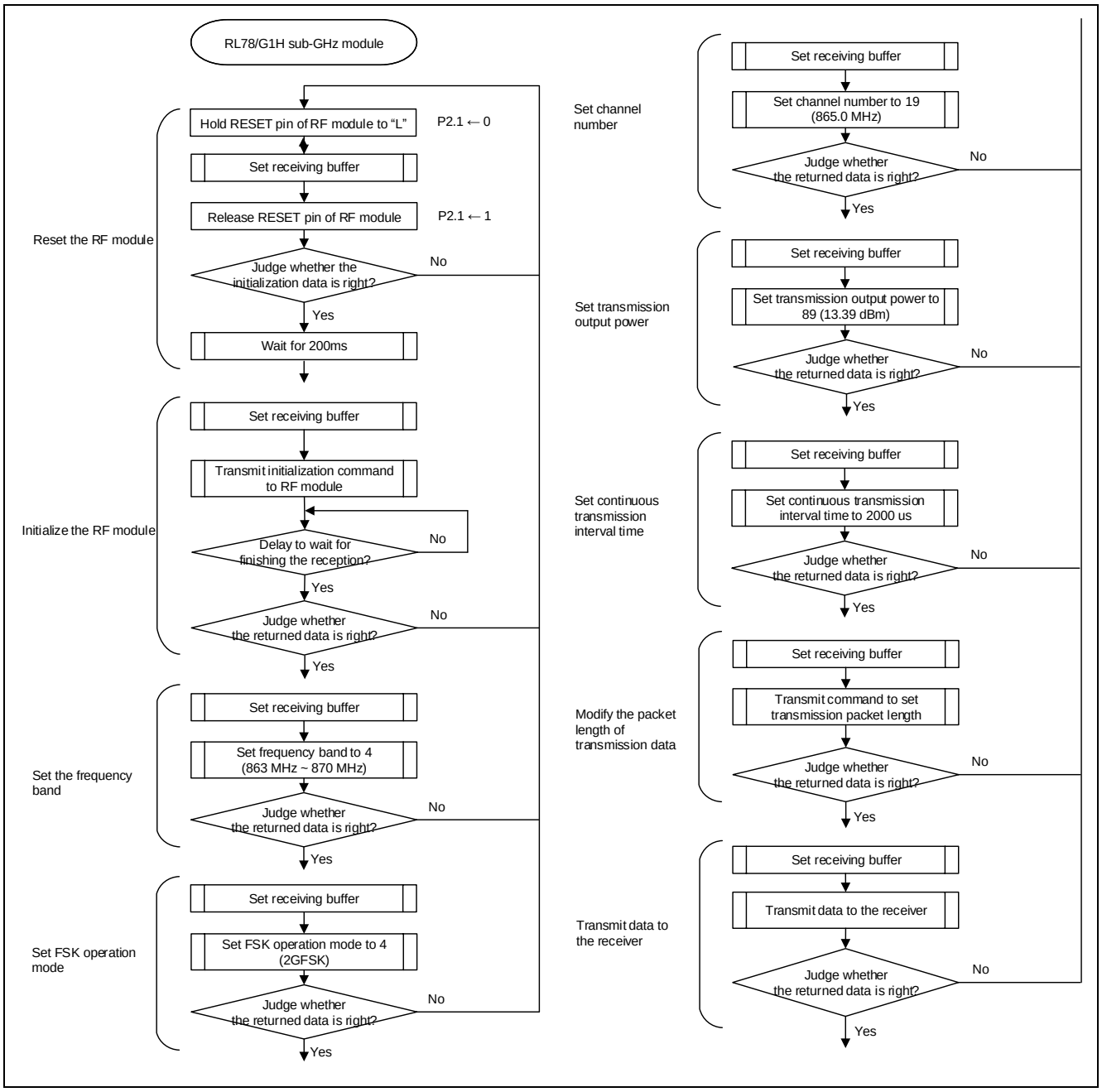


Figure 5.3 Transmission Operation of RL78/G1H sub-GHz RF Module

5.1.4.3 Interrupt Task Processing (Transmitter)

Figure 5.4 shows the flowchart for the interrupt task processing (transmitter).

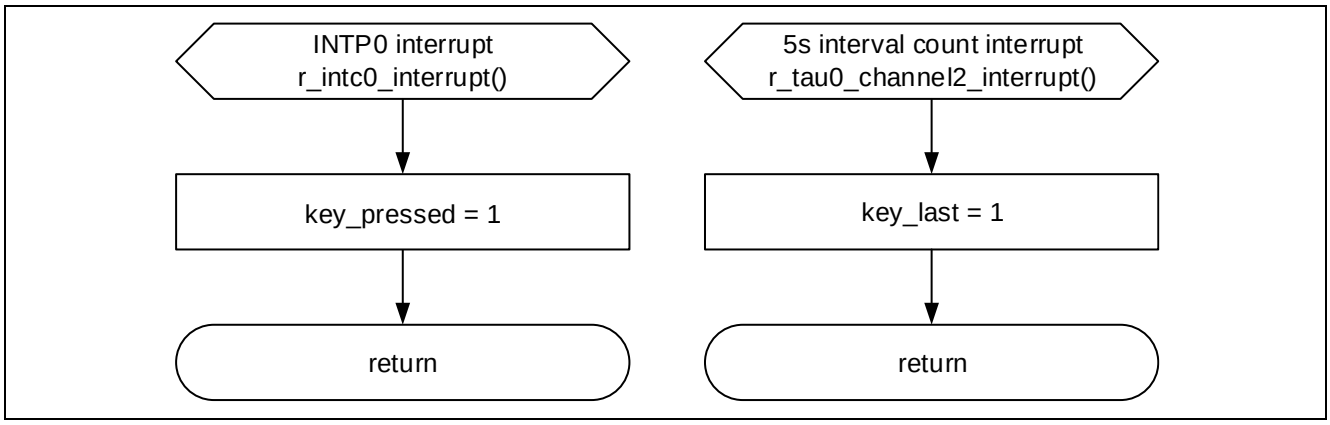


Figure 5.4 Interrupt Task Processing (Transmitter)

5.2 Receiver

5.2.1 Integrated Development Environment (Receiver)

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

Table 5.3 Operation Check Conditions (Receiver)

Item	Description
Microcontroller used	RL78/G11 (R5F1056A)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 16 MHz CPU/peripheral hardware clock: 16 MHz
Operating voltage	5.0 V (can run on a voltage range of 2.7 V to 5.5 V.) Low voltage detector operation setting: Reset mode (reset generation level: 1.63 V)
Integrated development environment (CS+)	CS+ V6.00.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.05.00 from Renesas Electronics Corp.
Integrated development environment (e^2 studio)	e^2 studio V6.0.0 from Renesas Electronics Corp.
C compiler (e^2 studio)	CC-RL V1.05.00 from Renesas Electronics Corp.

5.2.2 Option Byte (Receiver)

Table 5.4 summarizes the settings of the option bytes (Receiver).

Table 5.4 Option Byte Settings (Receiver)

Address	Value	Description
000C0H/010C0H	01101110B	Watchdog timer counter operation disabled (counting stopped after reset) Interval interrupt is not used
000C1H/010C1H	00011111B	Low voltage detector operation setting: Reset mode (reset generation level: 1.63 V)
000C2H/010C2H	11101001B	Operating frequency: 16 MHz (2.7 V ~ 5.5 V) CPU clock f_{CLK}: 16 MHz
000C3H/010C3H	10000100B	Enables on-chip debugging

5.2.3 Operation Outline (Receiver)

The tasks of the entire system are listed as below: reset/initialization, normal mode and receive mode.

Figure 5.5 shows the block diagram for the tasks transition.

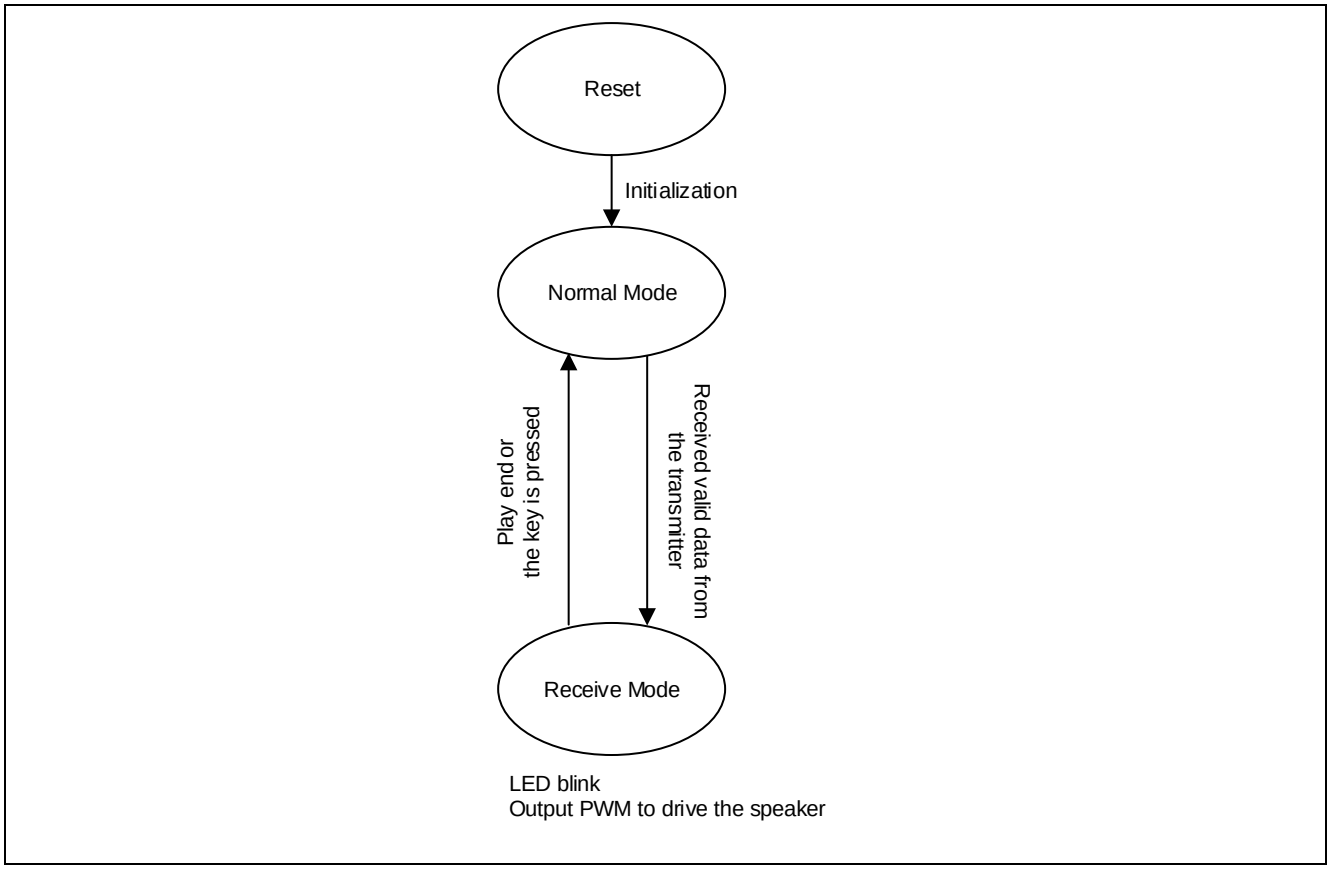


Figure 5.5 Tasks Transition Block Diagram (Receiver)

(1) Reset / Initialization

After the ON-OFF switch is activated, the system is powered on and the initialization routine of each module is executed.

(2) Normal Mode

After initialization, UART0 is ready for receiving data.

(3) Receive Mode

When the signals are received from the transmitter through the RF module, the LED starts to blink and the speaker starts to sound. The LED blinks every 500 milliseconds for 5 seconds. The speaker plays the indication music for 5 seconds. During this period, if the key located on the receiver is pressed, the LED will stop blinking and the speaker will stop ringing.

5.2.4 Flow Chart (Receiver)

5.2.4.1 Main Processing (Receiver)

Figure 5.6 shows the flowchart for the main processing routine (receiver).

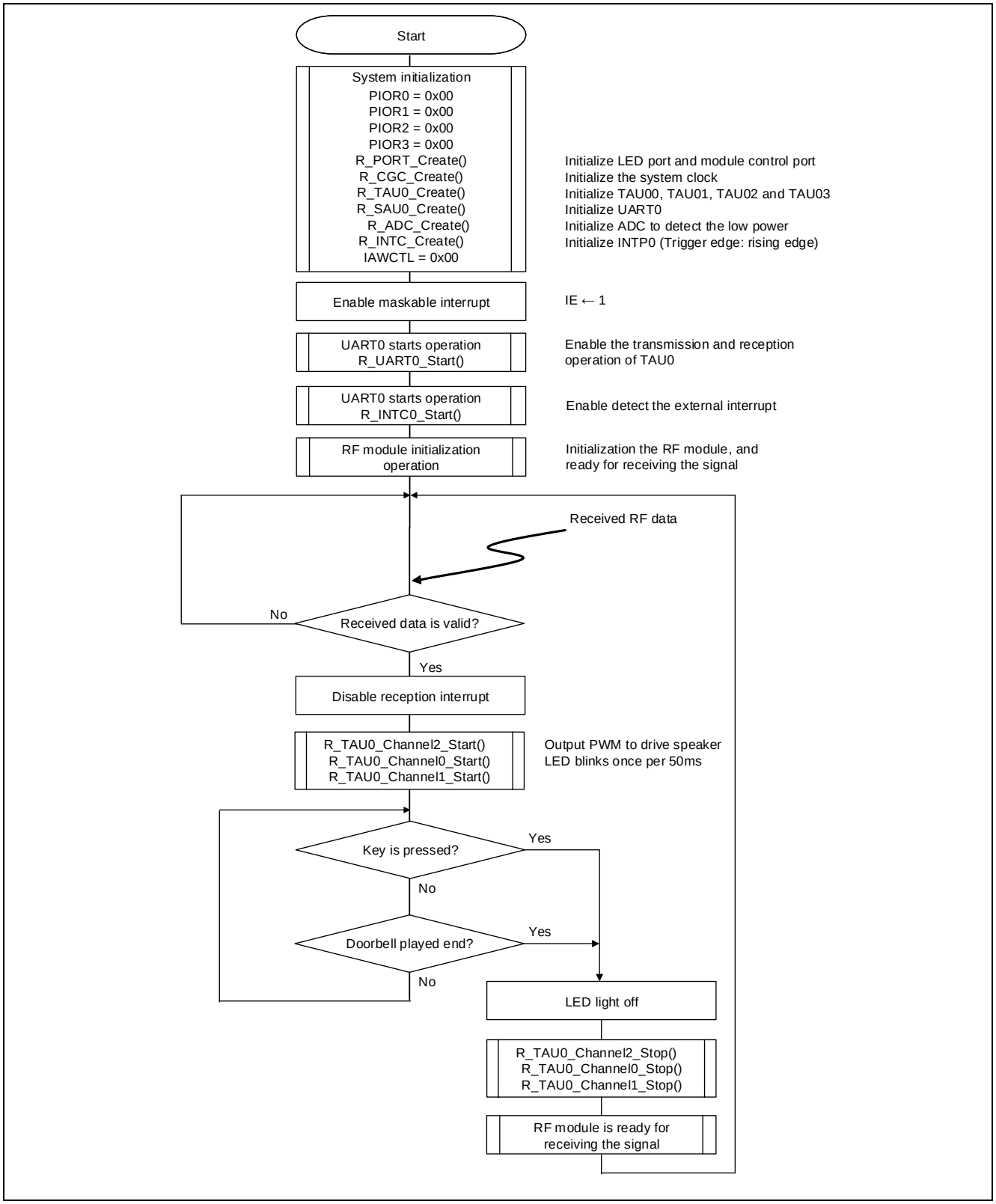


Figure 5.6 Main Processing (Receiver)

5.2.4.2 Reception Operation of RL78/G1H sub-GHz RF Module

Figure 5.7 shows the flowchart for the reception operation of the RL78/G1H sub-GHz RF module.

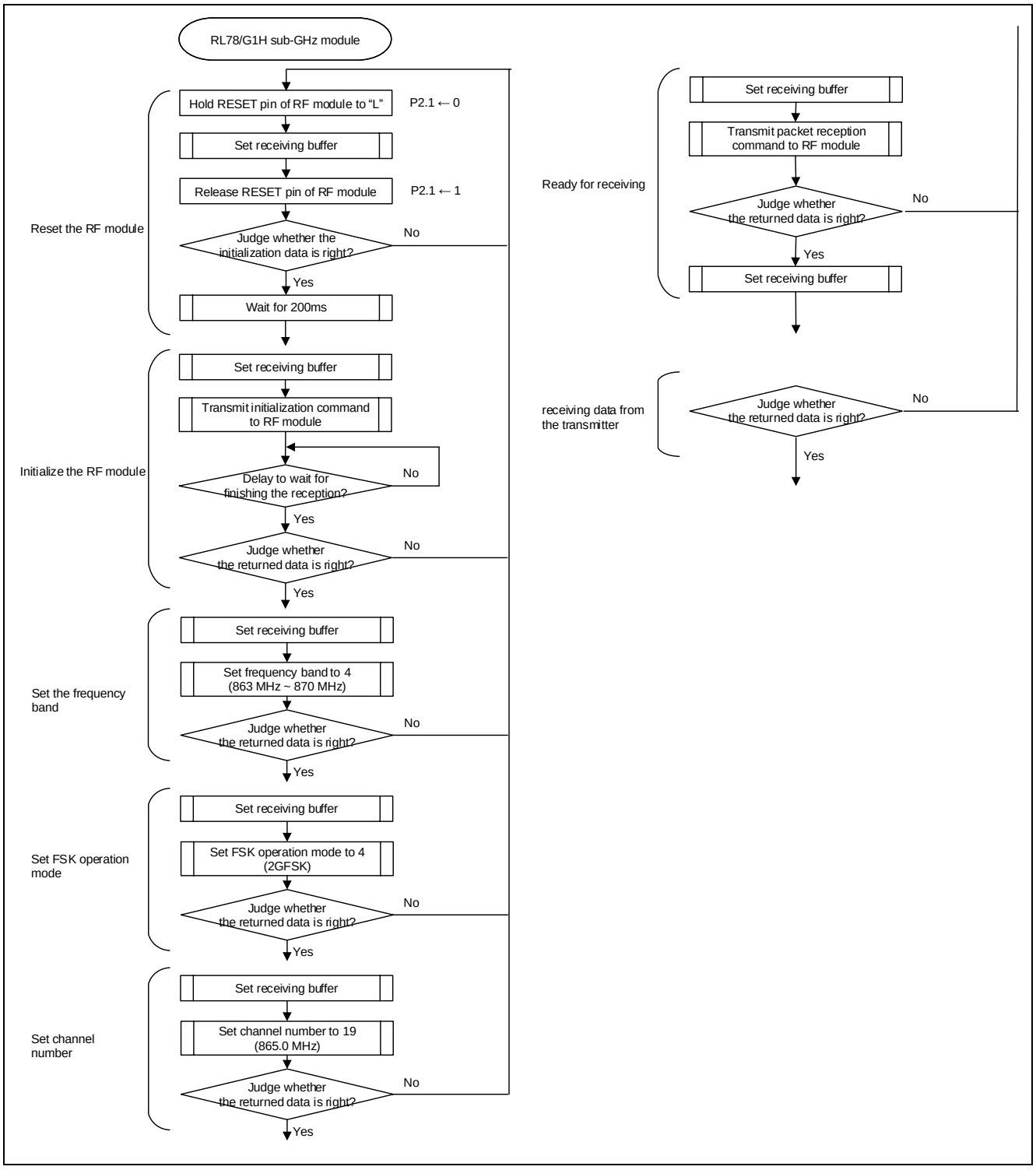


Figure 5.7 Reception Operation of RL78/G1H sub-GHz RF Module

5.2.4.3 Interrupt Task Processing (Receiver)

Figure 5.8 shows the flowchart for the interrupt task processing (receiver).

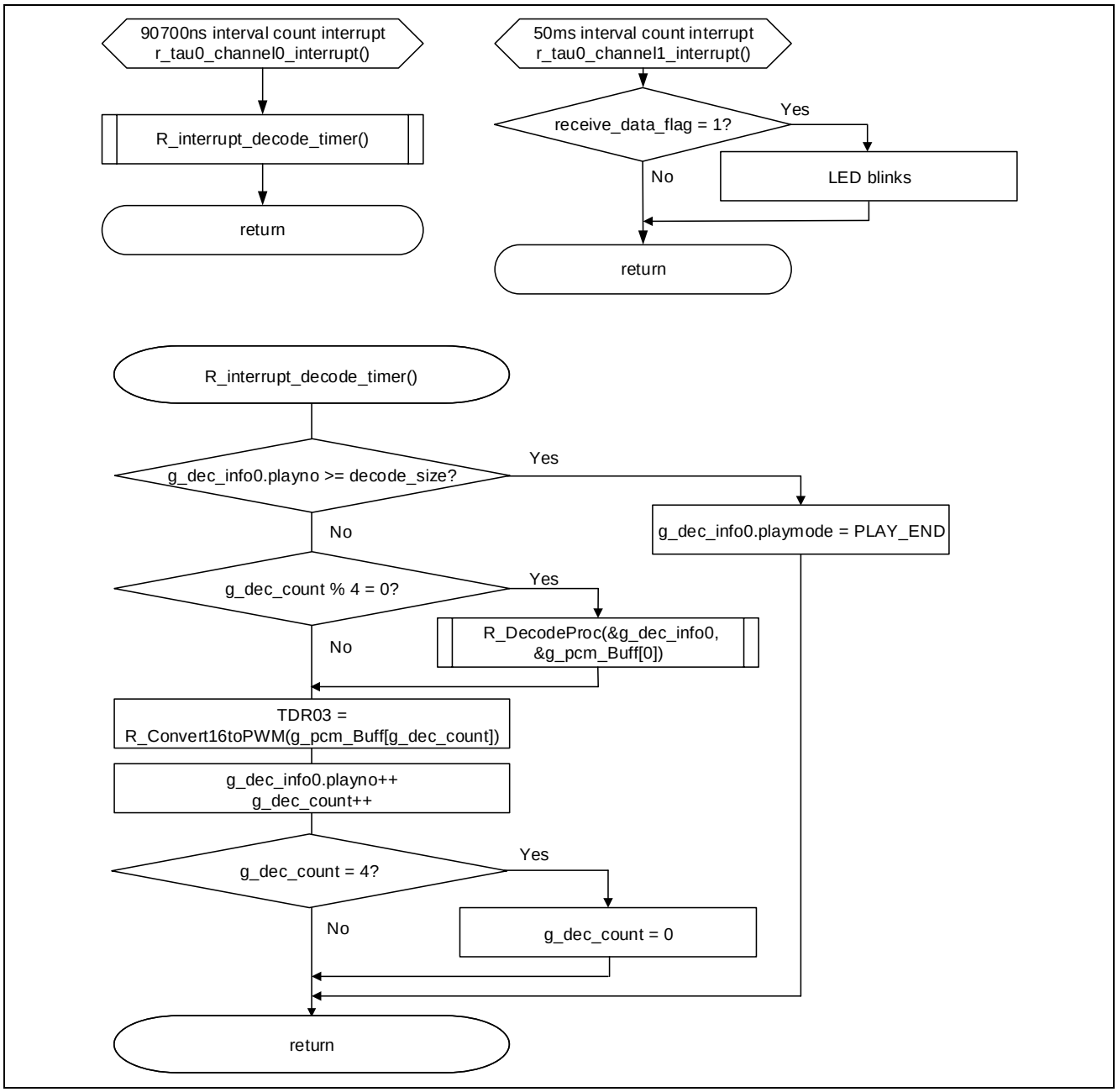
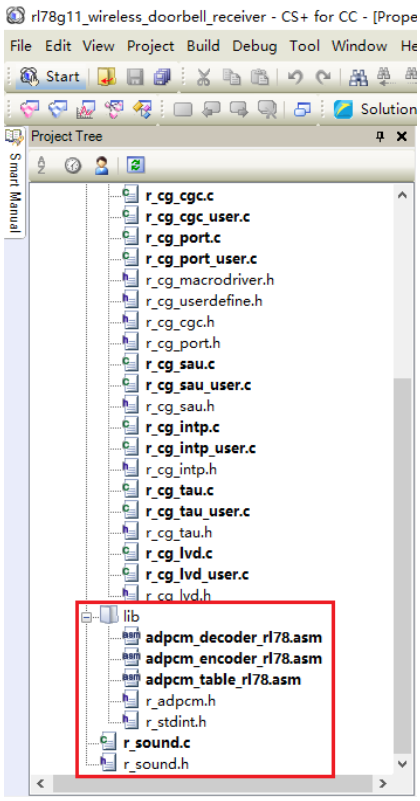


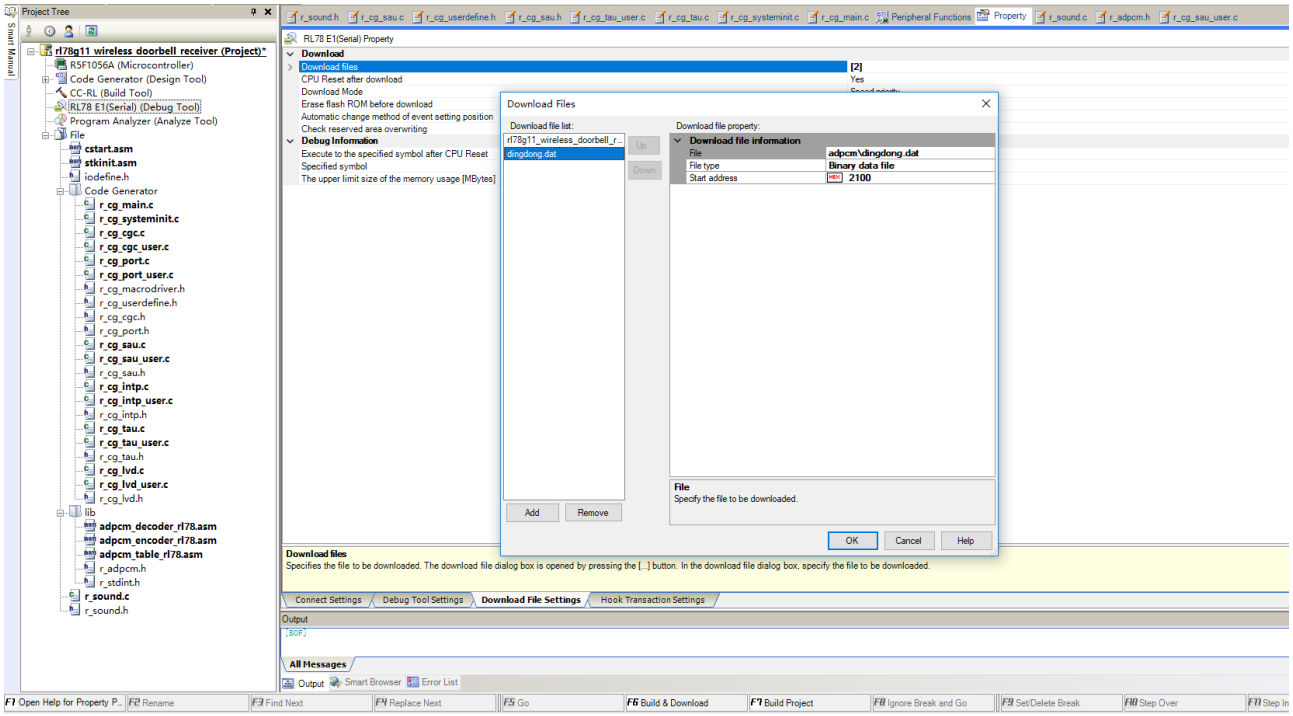
Figure 5.8 Interrupt Task Processing (Receiver)

5.2.4.4 How to Use ADPCM

Step 1: Copy the folders "lib", "sample" and "adpcm" to the folder of user's project. And add these files that related to the ADPCM application to the project in CS+ (CC-RL).



Step 2: Set the sound file in "Download File Settings" of "RL78 E1 (Serial) (Debug Tool)". Download the sound file (".dat" file) with ".mot" file together to the MCU.



Please pay attention to the initial address of the ".dat" file and the size of the ".dat" file.

Step3: In "r_sound.h" file, add the program about the address and the size of the sound file (".dat" file).

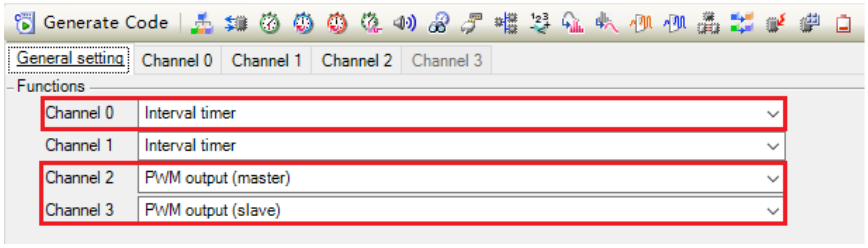
```
/***********************************************************************
Decode Macro Definitions
***********************************************************************/
// Dingdong     2100-30FFH (Size=Datalength*2)
#define DINGDONG_ADDR       0x2100                  /* top address of ADPCM sound data storage */
#define DINGDONG_SIZE       0x2000                  /* size of sound data after decode(compressed data) */

#define PWM_SAMPLING        (0x00000140UL)
```

Step 4: Set TAU00, TAU02 and TAU03.

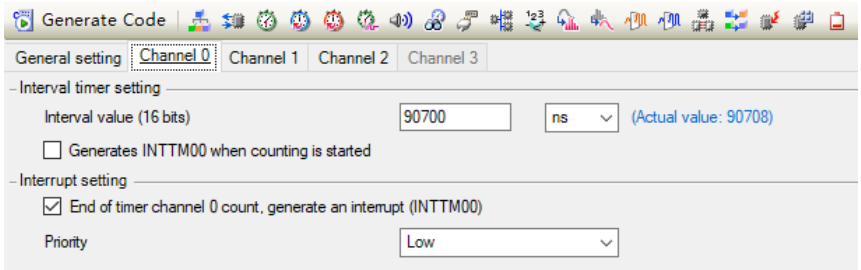
TAU00: Interval timer

TAU02: PWM output (master)

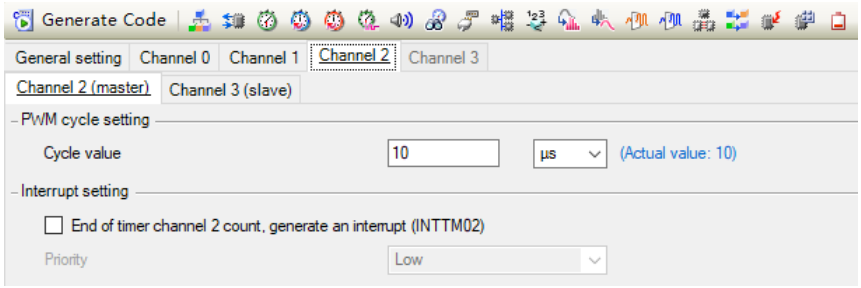
TAU03: PWM output (slave)



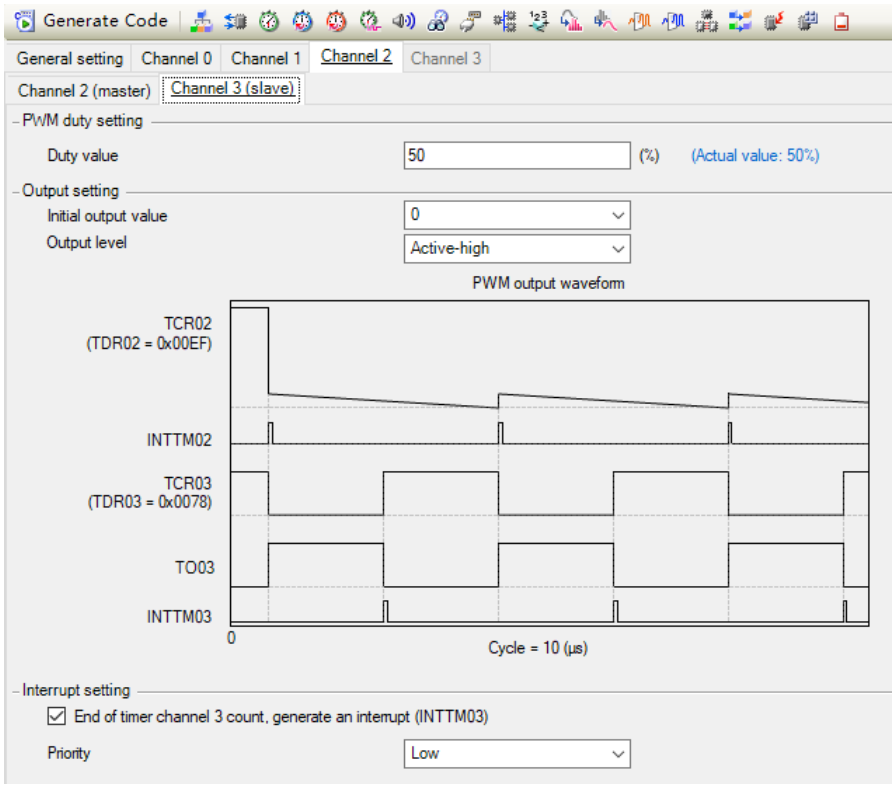
TAU00:



TAU02:



TAU03:



Step 5: In "r_cg_main.c" file, add the corresponding program.

```
/* Start user code for include. Do not edit comment generated here */
#include "r_adpcm.h"
#include "r_sound.h"
/* End user code. Do not edit comment generated here */
```

```
    for(i = 0U; i < 5U; i++ ){
        R_InitDecInfo(&g_dec_info0, &g_st_adpcm0, (const uint8_t  *)DINGDONG_ADDR, DINGDONG_SIZE);
                                        /* Decoded information structure(DECINFO) initialization */
        g_dec_info0.playmode = PLAY_PLAYBACK;

        R_TAU0_Channel2_Start();                        /* start TAU0 CH12 & CH13 with PWM */
        R_TAU0_Channel0_Start();                        /* start TAU0 CH10 with 90700ns interval time */

        while (g_dec_info0.playmode != PLAY_END){       /* wait till play end */
        }
    }
```

Step 6: In "r_cg_tau_user" file, add the corresponding program.

```
/* Start user code for include. Do not edit comment generated here */
#include "r_adpcm.h"
#include "r_sound.h"
/* End user code. Do not edit comment generated here */
```

```
/***********************************************************************************************************************
* Function Name: r_tau0_channel2_interrupt
* Description  : This function INTTM02 interrupt service routine.
* Arguments    : None
* Return Value : None
***********************************************************************************************************************/
static void __near r_tau0_channel2_interrupt(void)
{
    /* Start user code. Do not edit comment generated here */
    R_interrupt_decode_timer();     /* Decode ADPMC data when 97500ns reached */
    /* End user code. Do not edit comment generated here */
}

/***********************************************************************************************************************
* Function Name: r_tau0_channel0_interrupt
* Description  : This function INTTM00 interrupt service routine.
* Arguments    : None
* Return Value : None
***********************************************************************************************************************/
static void __near r_tau0_channel0_interrupt(void)
{
    /* Start user code. Do not edit comment generated here */
    R_interrupt_decode_timer();     /* Decode ADPMC data when 97500ns reached */
    /* End user code. Do not edit comment generated here */
}
```

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Reference Documents

RL78/G11 User's Manual: Hardware (R01UH0384)

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.)

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Dec. 12, 2018	—	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.
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   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.
   — 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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