

RL78/G23

Remote Control Signal Reception (AEHA Format, SNOOZE Mode)

Introduction

This application note describes how to receive remote control signals using a remote control signal receiver (REMC) and SNOOZE mode.

The applicable remote control format is AEHA (including header and 48-bit data).

Target Device

RL78/G23

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. Specification	3
1.1 Overview of Specification	3
1.2 Details of Operation	4
2. Operation Confirmation Conditions	8
3. Hardware Descriptions	9
3.1 Example of Hardware Configuration	9
3.2 List of Pins to be Used	10
4. Software Explanation	11
4.1 Setting of Option Byte	11
4.2 List of Constants	11
4.3 List of Variables	12
4.4 List of Functions	12
4.5 Specification of Functions	13
4.6 Flowcharts	14
4.6.1 Main Processing	14
4.6.2 REMC Reception Complete Interrupts	16
4.6.3 LED Lighting Control	16
4.6.4 STOP Mode Transition Timer Interrupts	17
5. Sample Code	18
6. Reference Documents	18
Revision History	19

1. Specification

1.1 Overview of Specification

In this application note, a remote control signal receiver (REMC) is used. LEDs are turned on according to the remote control code received by the remote control signal receiver (REMC). When no remote control signal input is detected for 10 seconds, the MCU shifts to STOP mode. When a remote control signal input is detected in STOP mode, the application transitions to SNOOZE mode and restarts the remote control signal reception processing.

Table 1-1 lists peripheral functions and their use. Figure 1-1 shows an overview of sample code operation. Table 1-2 shows the relation between remote control signal input and LED ON/OFF state.

Table 1-1 Peripheral Function and Use

Peripheral Function	Use
Remote control signal receiver (REMC)	Remote control signal reception
Channels 6 of timer array unit 0 (TAU0)	REMC operating clock
Channels 1 of timer array unit 0 (TAU0)	STOP mode transition decision timer
P03, P02, P43, P42, P77, P41, P31, P76	Output pins to LED1 to LED8

Figure 1-1 Overview of Operation

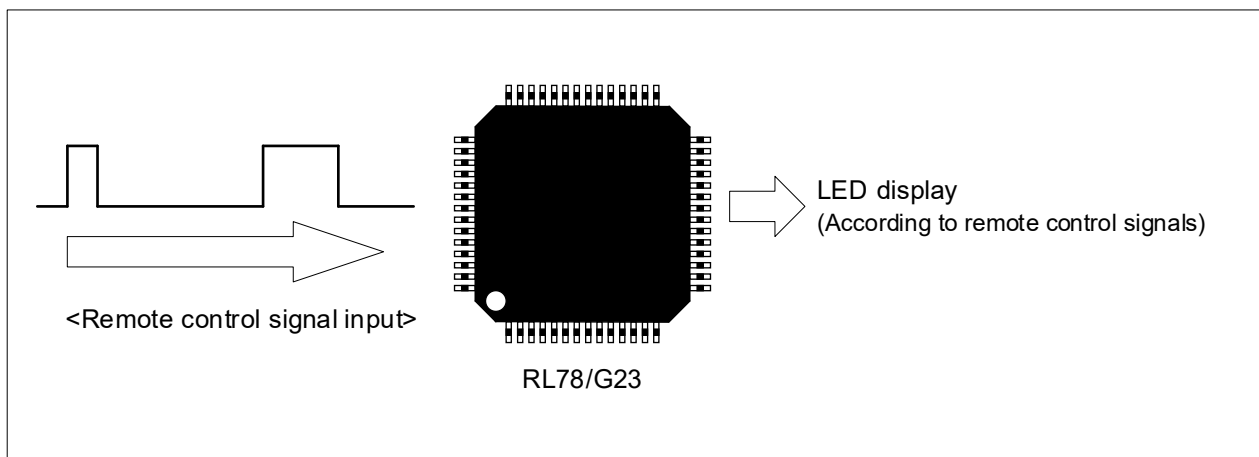


Table 1-2 Relation between Remote Control Signal Input and LED ON/OFF State

Remote Control Signal Input	LED1 to LED8 ON/OFF State
No input	All LEDs OFF
Channel 1 select	LED1 ON
Channel 2 select	LED2 ON
Channel 3 select	LED3 ON
Channel 4 select	LED4 ON
Channel 5 select	LED5 ON
Channel 6 select	LED6 ON
Channel 7 select	LED7 ON
Channel 8 select	LED8 ON
Other signal inputs	All LEDs OFF

1.2 Details of Operation

This application note shows an example of use of the remote control signal receiver (REMC). The REMC receives AEHA-format remote control signals (including header and 48-bit data). When the application recognizes that the relevant channel button was pressed, it turns on the corresponding LED. Figure 1-2 shows the remote control signal (AEHA format including header and 48-bit data) reception timing.

Figure 1-2 Remote Control Signal Reception Timing

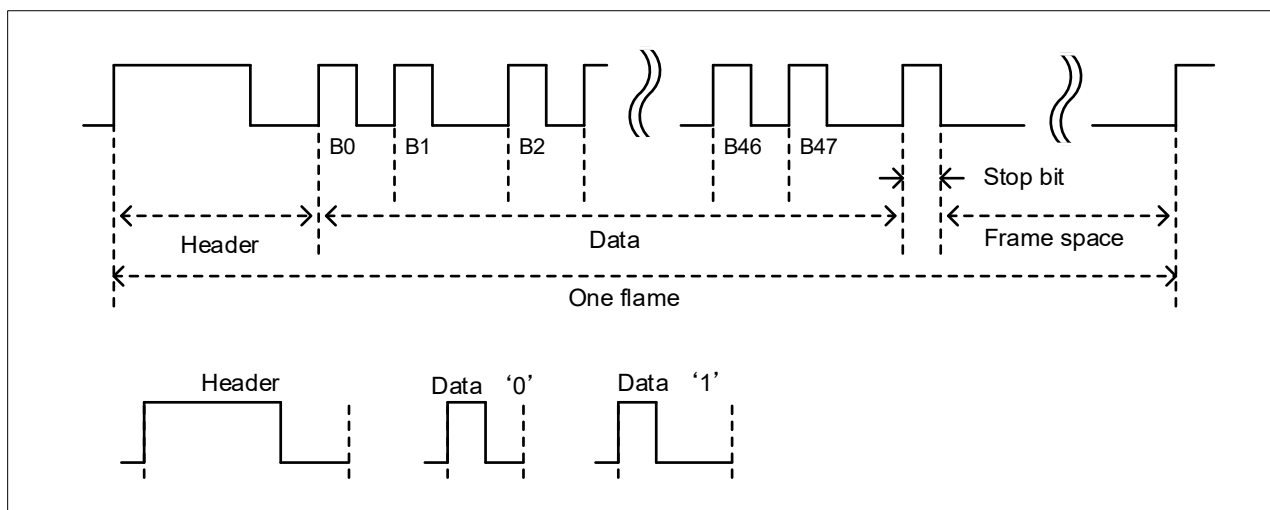


Table 1-3 shows the correspondence between remote control input signals and remote control signal data. When the fifth byte (B32 to B39 in Figure 1-2) of the received remote control signal data matches the signal data in Table 1-3, the application recognizes that the relevant channel button was pressed.

Table 1-3 Correspondence between Remote Control Input Signals and Signal Data

Remote Control Input Signal	Signal Data
Channel 1	0x10
Channel 2	0x11
Channel 3	0x12
Channel 4	0x13
Channel 5	0x14
Channel 6	0x15
Channel 7	0x16
Channel 8	0x17

When no remote control signal input is detected for 10 seconds, the application makes a setting to operate the REMC in SNOOZE mode and shifts to STOP mode. When a remote control signal is detected in STOP mode, the REMC performs remote control signal reception processing in SNOOZE mode. Upon receiving the REMC interrupt request signal, the application transitions from SNOOZE mode to normal operation mode.

Figure 1-3 shows the transition (to STOP mode) timing. Figure 1-4 shows the software state transition diagram.

Figure 1-3 Transition (to STOP Mode) Timing

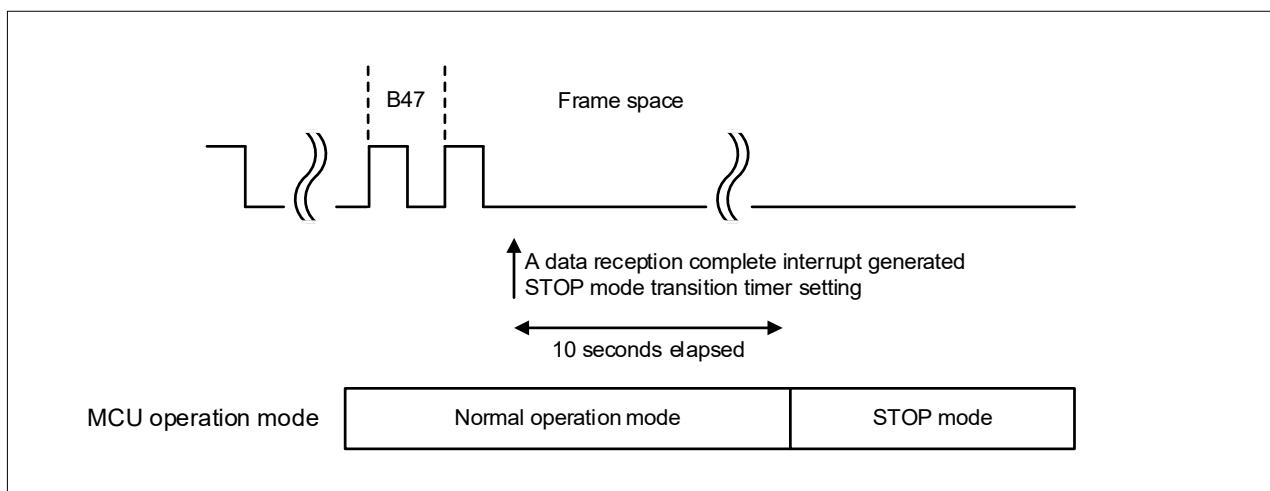
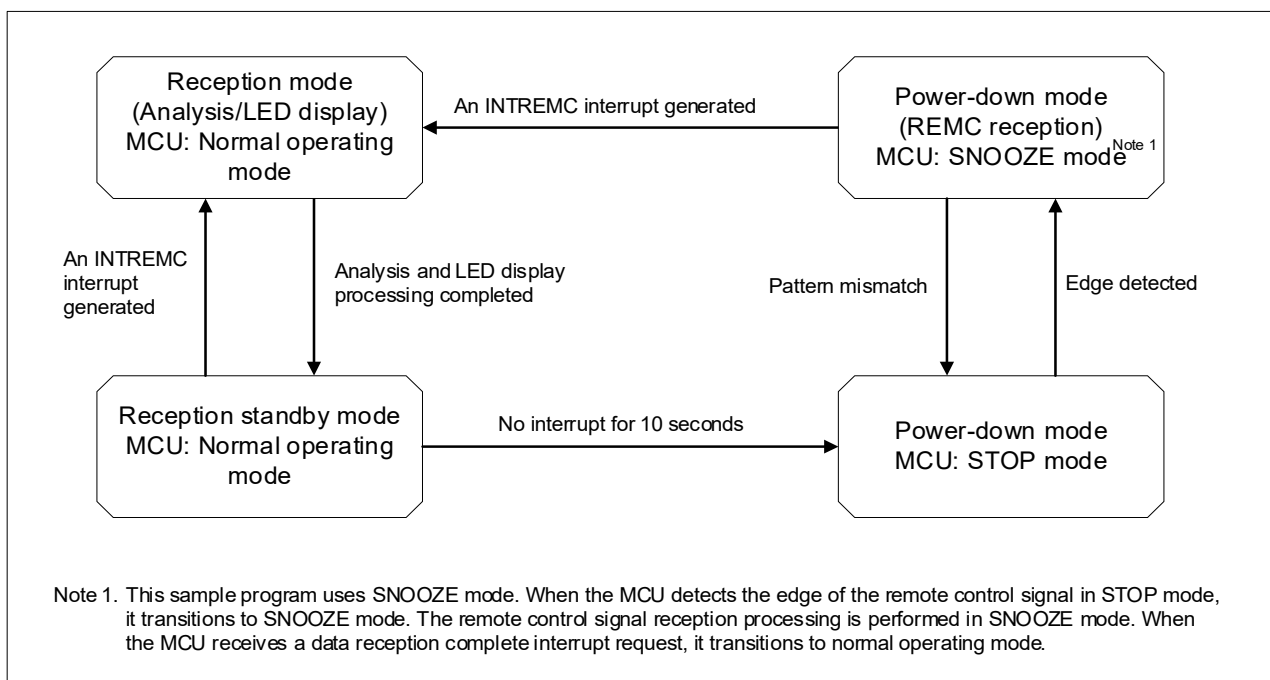


Figure 1-4 Remote Control Signal Reception Software State Transition Diagram



The following describes the main settings for peripheral functions.

(1) Timer array unit 0 (TAU0) channel 1 (for deciding transition to STOP mode)

- Set the timer operation mode to interval timer mode.
- Operating clock: CK00, clock source: fCLK/2¹³
- Interval period: 10,000 ms (10 seconds)
- Disable interrupts at count start.
- Enable INTTM01 interrupts (interrupt priority level 3).

(2) Timer array unit 0 (TAU0) channel 6 (for REMC operating clock)

- Set the timer operation mode to interval timer mode.
- Operating clock: CK01, clock source: fCLK/2⁶
- Interval period: 100 μs
- Disable interrupts at count start.
- Disable INTTM06 interrupts.

(3) I/O ports

- P03, P02, P43, P42, P77, P41, P31 and P76 pins: Set as output ports.

- (4) Remote control signal receiver (REMC)
- Operating clock: INTTM06
 - Enable digital filters (three-time match). Digital filter sampling clock: fSXL
 - Disable transitions from STOP mode to SNOOZE mode.
 - Reception mode: Format A pattern. Enable input/output signal inversion.
 - Pattern settings: Shown below (Special data and patterns are not used.)

Table 1-4 Pattern Settings

Item		Setting Value
Pattern end width		70
Header pattern	Maximum width	60
	Minimum width	42
Data 0 pattern	Maximum width	10
	Minimum width	7
Data 1 pattern	Maximum width	20
	Minimum width	14

- Number of compare bits: 16, compare value: 0x2002
- No data capture at the time of a receive error
- Enable compare match interrupts, data reception complete interrupts, and header pattern match interrupts.
- Set interrupts mode to sequential interrupt mode (interrupt priority level 3)

2. Operation Confirmation Conditions

The operation of the sample code provided with this application note has been tested under the following conditions.

Table 2-1 Operation Confirmation Conditions

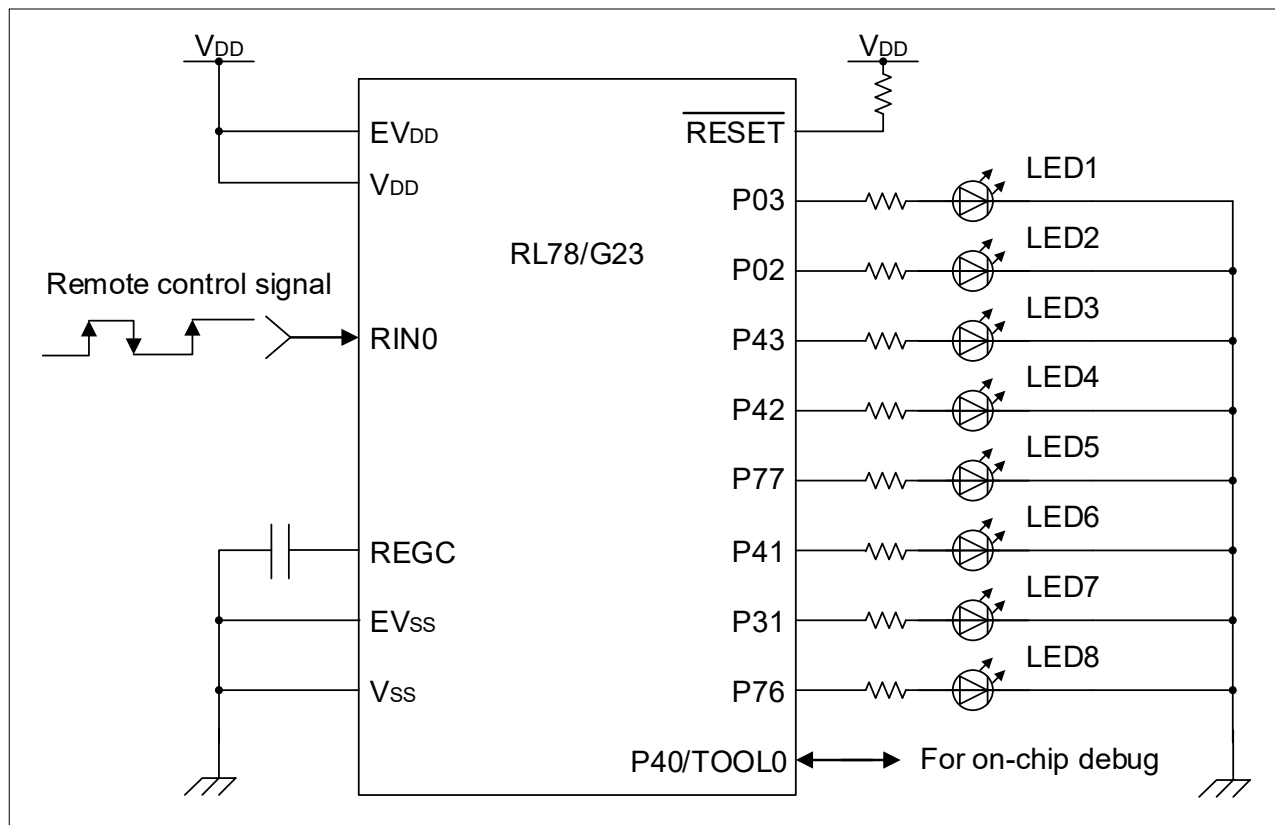
Item	Description
MCU used	RL78/G23 (R7F100GLG)
Board used	RL78/G23-64p Fast Prototyping Board (RTK7RLG230CLG000BJ)
Operating frequency	<ul style="list-style-type: none"> High-speed on-chip oscillator clock (f_{IH}): 32 MHz Low-speed on-chip oscillator clock (f_{IL}): 32.768 kHz
Operating voltage	5.0V (can be operated at 2.0 V to 5.5V) LVD0 operations (V_{LVD0}): Reset mode At rising edge T TYP. 1.90 V (1.84 V to 1.95 V) At falling edge TYP. 1.86V (1.80 V to 1.91 V) V
Integrated development environment (CS+)	CS+ for CC E8.05.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.10.00 from Renesas Electronics Corp.
Integrated development environment (e2studio)	e2studio V2021-04 (21.4.0) from Renesas Electronics Corp.
C compiler (e2studio)	CC-RL V1.10.00 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V4.21.1 from IAR Systems Corp.
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V4.21.1.2260 from IAR Systems Corp.
Smart configurator (SC)	V1.0.1 from Renesas Electronics Corp.
Board support package (BSP)	V1.00 from Renesas Electronics Corp.
Remote controller used	ATV-102 supplied by Asahi Electrochemical Co., Ltd. (Panasonic TV ㊴㊵㊶)

3. Hardware Descriptions

3.1 Example of Hardware Configuration

Figure 3-1 shows an example of the hardware configuration used in the application note.

Figure 3-1 Hardware Configuration



- Note 1. This schematic circuit diagram is simplified to show the outline of connections. When creating actual circuits, design them using appropriate pin processing so that the circuits meet electrical characteristics. (Connect input-only ports to V_{DD} or V_{SS} individually through a resistor.)
- Note 2. Connect pins (with a name beginning with EV_{SS}), if any, to V_{SS} , and connect pins (with a name beginning with EV_{DD}), if any, to V_{DD} .
- Note 3. Set V_{DD} to a voltage not less than the reset release voltage (V_{LVD0}) set by the LVD0.

3.2 List of Pins to be Used

Table 3-1 Pins to be Used and Their Functions lists the pins to be used and their functions.

Table 3-1 Pins to be Used and Their Functions

Pin name	I/O	Functions
RIN0/P70	Input	Remote control signal input
P03	Output	LED (LED1) control port
P02	Output	LED (LED2) control port
P43	Output	LED (LED3) control port
P42	Output	LED (LED4) control port
P77	Output	LED (LED5) control port
P41	Output	LED (LED6) control port
P31	Output	LED (LED7) control port
P76	Output	LED (LED8) control port

Caution In this application note, only the used pins are processed. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements.

4. Software Explanation

4.1 Setting of Option Byte

Table 4-1 shows the option byte settings.

Table 4-1 Option Byte Settings

Address	Setting Value	Contents
000C0H / 040C0H	11101111B	Disables the watchdog timer. (Counting stopped after reset)
000C1H / 040C1H	11111110B	LVD0 detection voltage: reset mode At rising edge TYP. 1.90 V (1.84 V to 1.95 V) At falling edge TYP. 1.86 V (1.80 V to 1.91 V)
000C2H / 040C2H	11101000B	HS mode, High-speed on-chip oscillator clock (f_{IH}): 32 MHz
000C3H / 040C3H	10000101B	Enables on-chip debugging

4.2 List of Constants

Table 4-2 lists the constants that are used in the sample code.

Table 4-2 Constant

Constant Name	Setting Value	Description
R_REMC_BUFF_SIZE	32	REMC receive buffer size
R_AEHA_DATA_LEN	6	Remote control data length (AEHA format)
R_AEHA_DATA_CODE_POS	4	Data storage location (AEHA format)
R_AEHA_DATA_CODE_01	0x10	Channel 1 data (AEHA format)
R_AEHA_DATA_CODE_02	0x11	Channel 2 data (AEHA format)
R_AEHA_DATA_CODE_03	0x12	Channel 3 data (AEHA format)
R_AEHA_DATA_CODE_04	0x13	Channel 4 data (AEHA format)
R_AEHA_DATA_CODE_05	0x14	Channel 5 data (AEHA format)
R_AEHA_DATA_CODE_06	0x15	Channel 6 data (AEHA format)
R_AEHA_DATA_CODE_07	0x16	Channel 7 data (AEHA format)
R_AEHA_DATA_CODE_08	0x17	Channel 8 data (AEHA format)
R_LED_ALL_OFF	0	Data for turning off all LEDs
R_INTR_STATE_NONE	0x00	No interrupt detected
R_INTR_STATE_RECV_END	0x01	REMC reception complete interrupt generated
R_INTR_STATE_TIME_OUT	0x02	Timeout occurred

4.3 List of Variables

Table 4-3 lists global variables.

Table 4-3 Global Variables

Type	Variable Name	Description	Function Used
uint8_t	g_remc_buf[R_REMC_BUF_SIZE]	REMC receive buffer	main
r_intr_state_t	g_intr_state	Interrupt flag	main, r_Config_REMC_callback_receiveend, r_Config_TAU0_1_interrupt

4.4 List of Functions

Table 4-4 shows a list of functions.

Table 4-4 Functions

Function Name	Outline
r_Config_REMC_callback_receiveend	REMC reception complete interrupts
r_port_set_LED	LED lighting control
r_Config_TAU0_1_interrupt	STOP mode transition timer interrupts

4.5 Specification of Functions

The function specifications of the sample code are shown below.

r_Config_REMC_callback_receiveend	
Outline	REMC reception complete interrupts
Header	Config_REMC.h
Declaration	static void r_Config_REMC_callback_receiveend(void)
Description	Sets R_INTR_STATE_RECV_END for the interrupt flag g_intr_state.
Argument	None
Return Value	None

r_port_set_LED	
Outline	LED lighting control
Header	Config_PORT.h
Declaration	void r_port_set_LED(uint8_t num)
Description	Turns on the LED specified by argument "num". When R_LED_ALL_OFF is specified, all LEDs are turned off.
Argument	uint8_t num: Number of LED (1 to 8) to be turned on
Return Value	None

r_Config_TAU0_1_interrupt	
Outline	STOP mode transition timer interrupts
Header	Config_TAU0_1.h
Declaration	static void __near r_Config_TAU0_1_interrupt(void)
Description	Sets R_INTR_STATE_TIME_OUT for the interrupt flag g_intr_state.
Argument	None
Return Value	None

4.6 Flowcharts

4.6.1 Main Processing

Figure 4-1 and Figure 4-2 shows the flowchart of the main processing.

Figure 4-1 Main Processing (1/2)

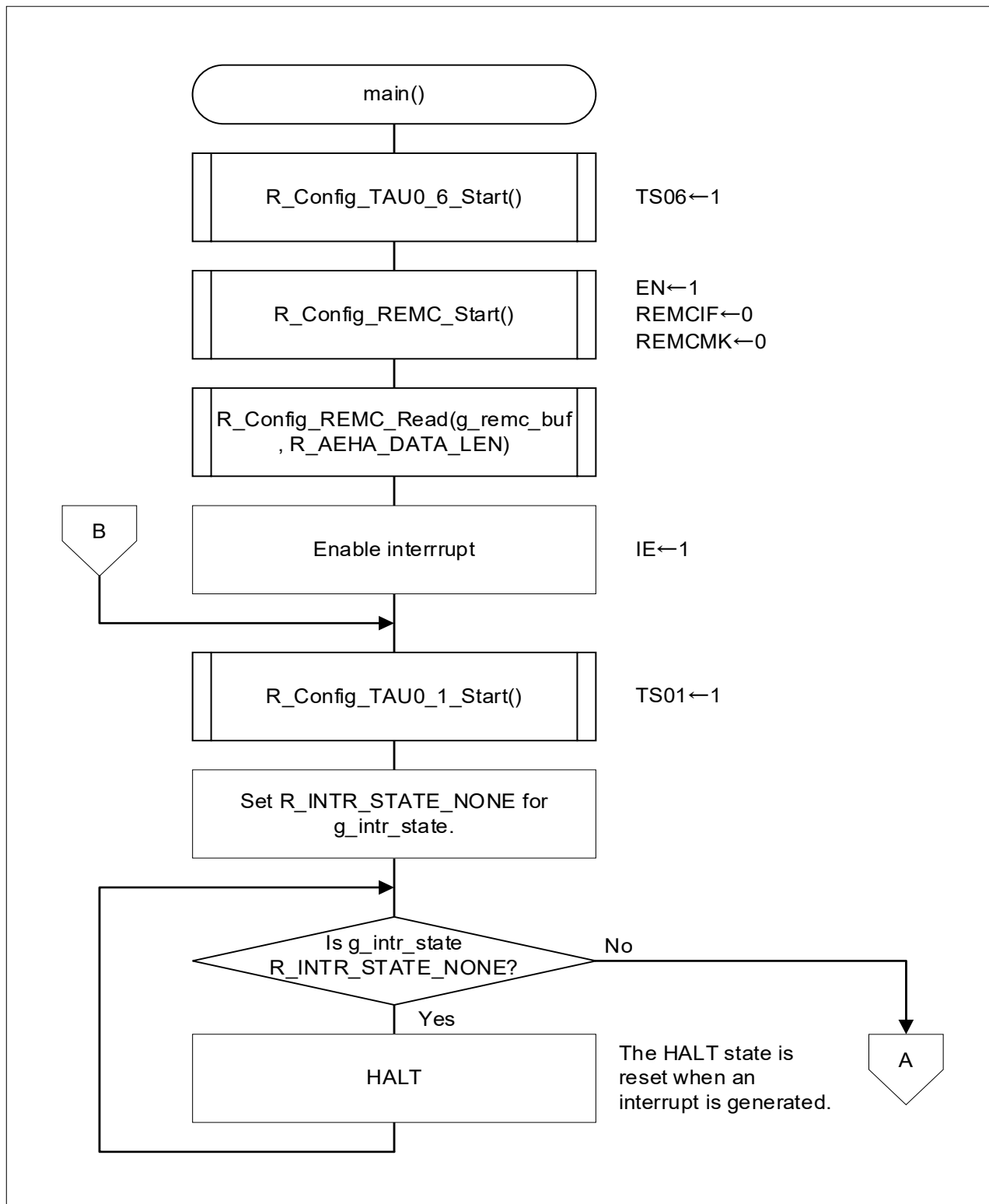
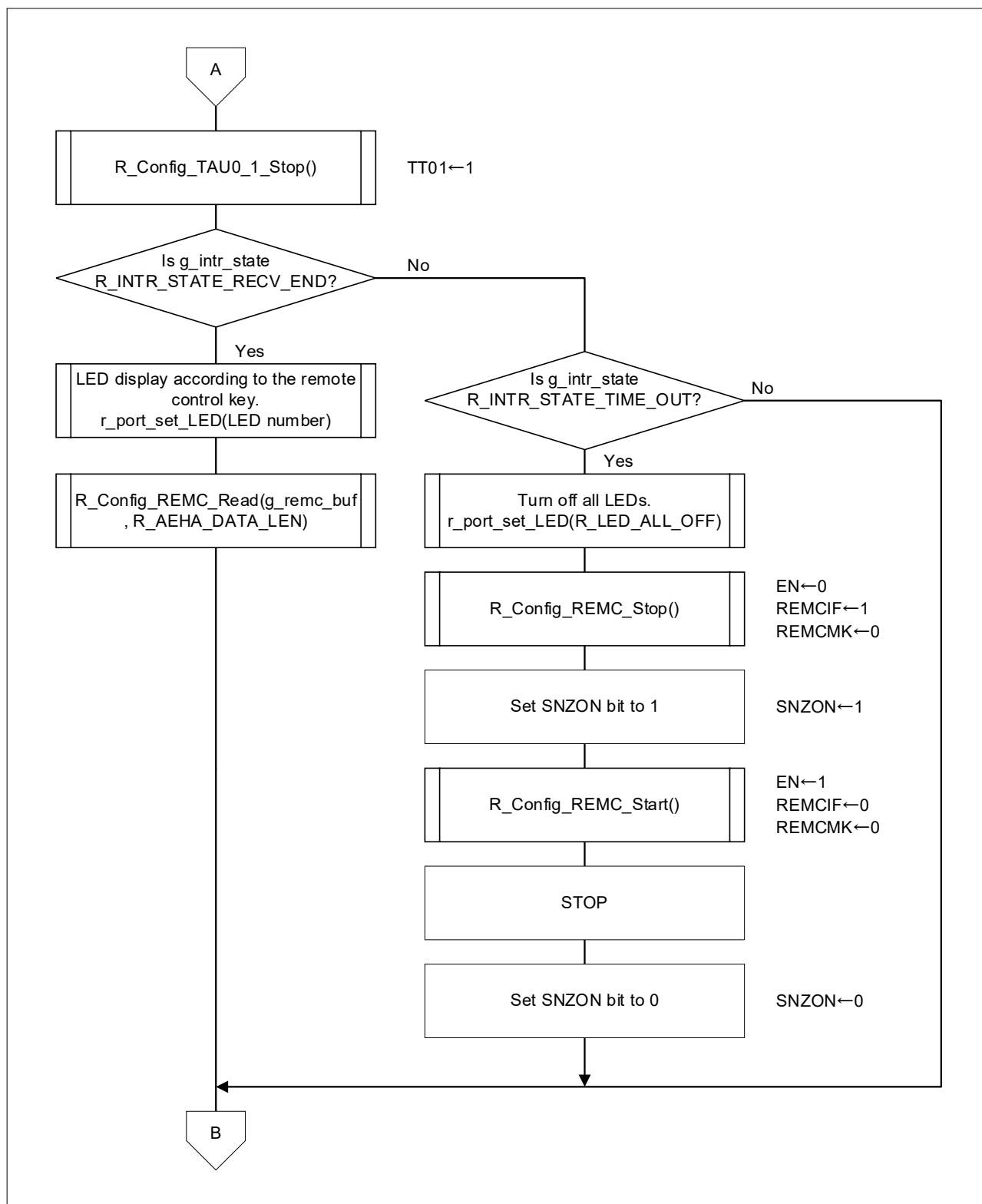


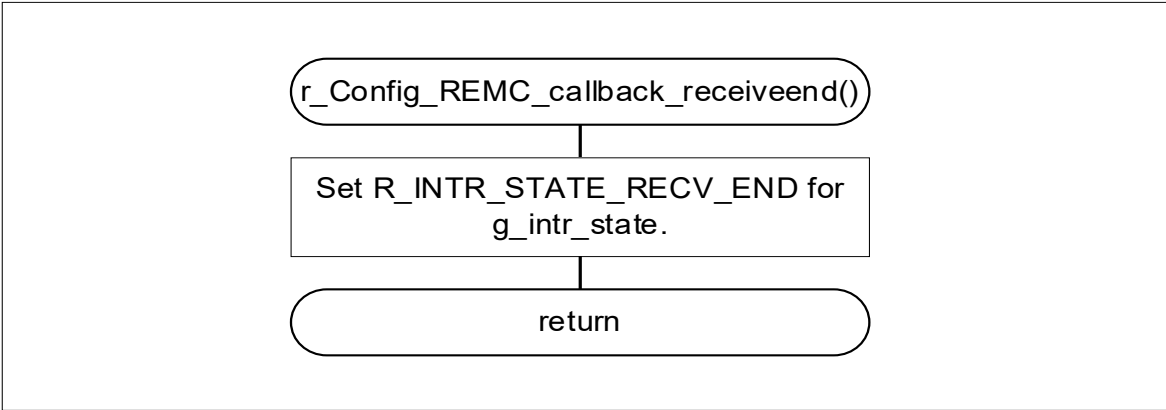
Figure 4-2 Main Processing (2/2)



4.6.2 REMC Reception Complete Interrupts

Figure 4-3 shows the flowchart of the REMC reception complete interrupts.

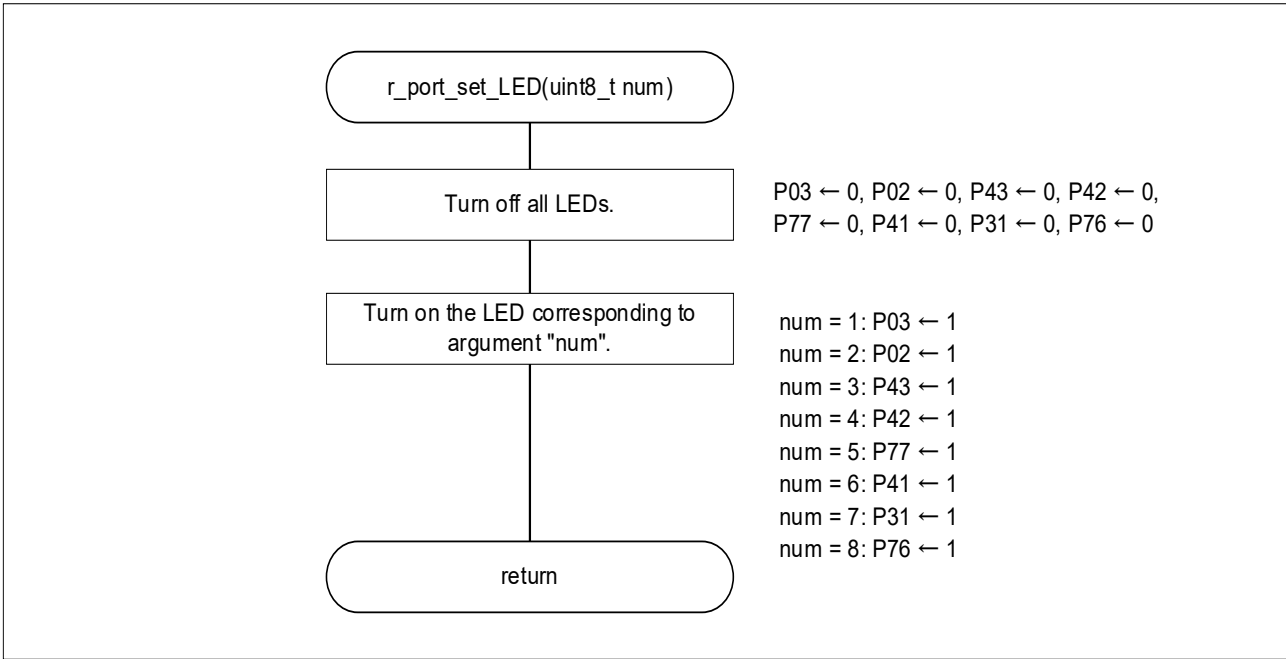
Figure 4-3 REMC Reception Complete Interrupts



4.6.3 LED Lighting Control

Figure 4-4 shows the flowchart for LED lighting control.

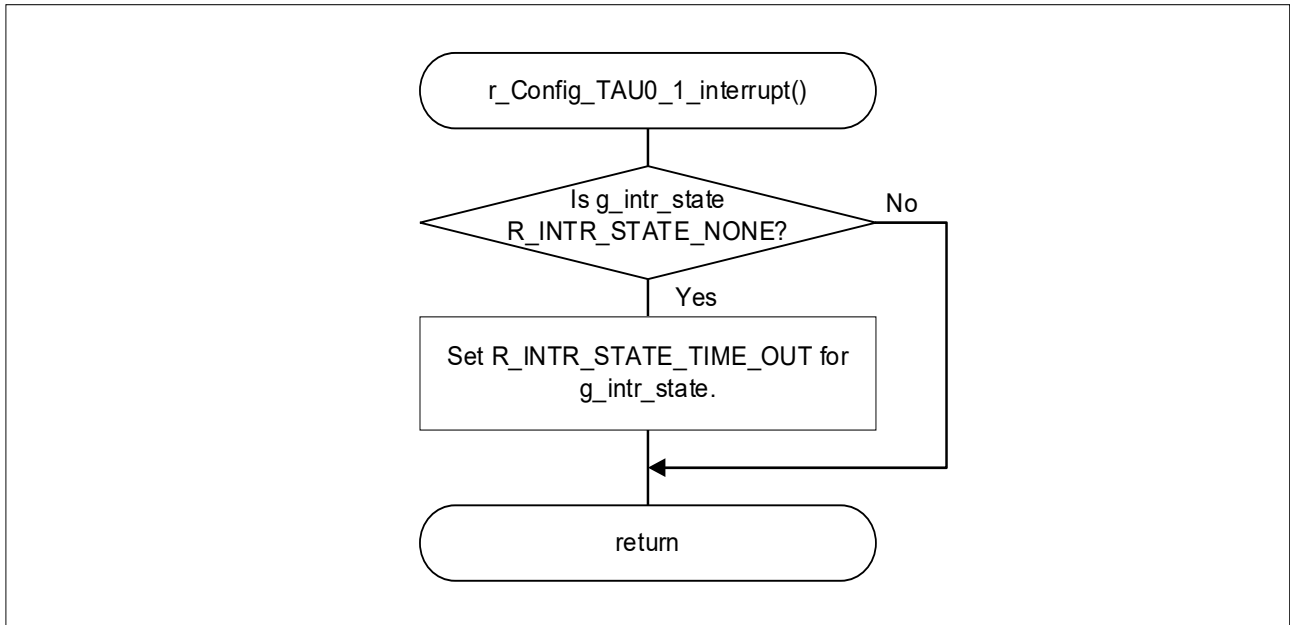
Figure 4-4 LED Lighting Control



4.6.4 STOP Mode Transition Timer Interrupts

Figure 4-5 shows the flowchart of the STOP mode transition timer interrupts.

Figure 4-5 STOP Mode Transition Timer Interrupts



5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

RL78/G23 User's Manual: Hardware (R01UH0896)

RL78 family user's manual software (R01US0015)

The latest versions can be downloaded from the Renesas Electronics website.

Technical update

The latest versions can be downloaded from the Renesas Electronics website.

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

Revision History

Rev.	Date	Description	
		Page	Page
1.00	2021.04.13		First Edition
1.01	2021.07.12	8	Updated the Operation Confirmation Conditions

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.

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 or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving 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, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. 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 shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended 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; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or 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 damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, 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 and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall 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 shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan

www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

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/.