RISC-V

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

RISC-V

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

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 Software Standby mode. When a remote control signal input is detected in Software Standby 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)	Software Standby mode transition decision timer
P008, P403, P110, P100, P402, P104, P304, P305	Output pins to LED1 to LED8

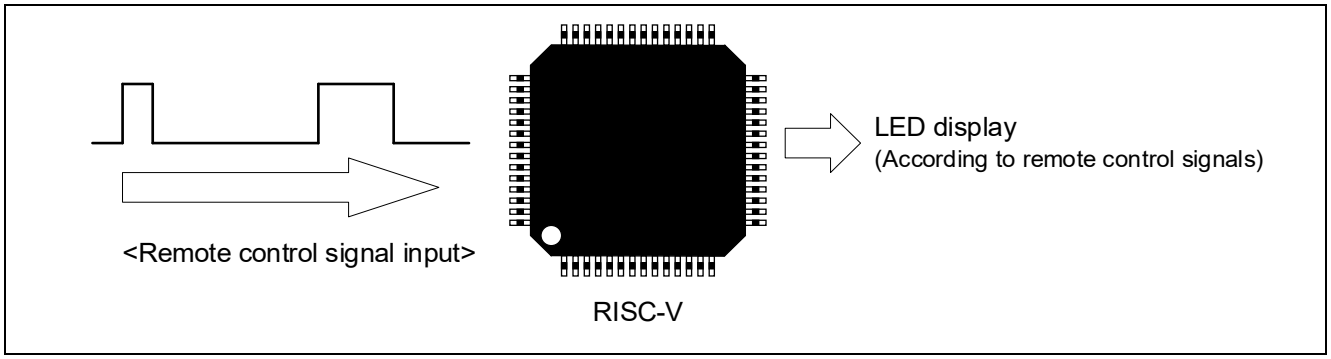

Figure 1.1 Overview of Operation

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.

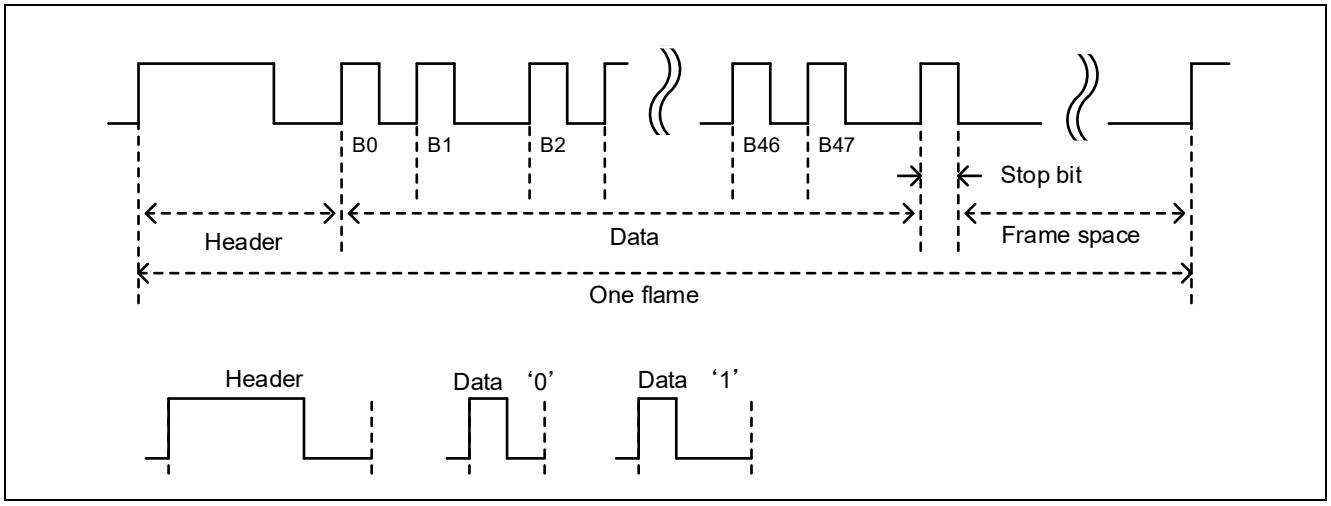

Figure 1.2 Remote Control Signal Reception Timing

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 Software Standby mode. When a remote control signal is detected in Software Standby 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 Software Standby mode) timing. Figure 1.4 shows the state transition diagram.

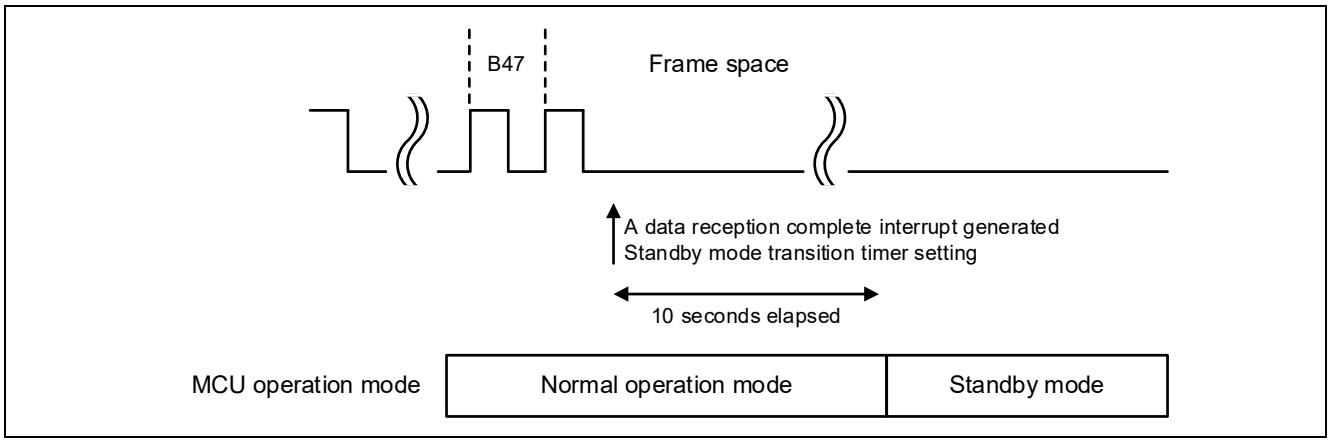

Figure 1.3 Transition (to Software Standby mode) Timing

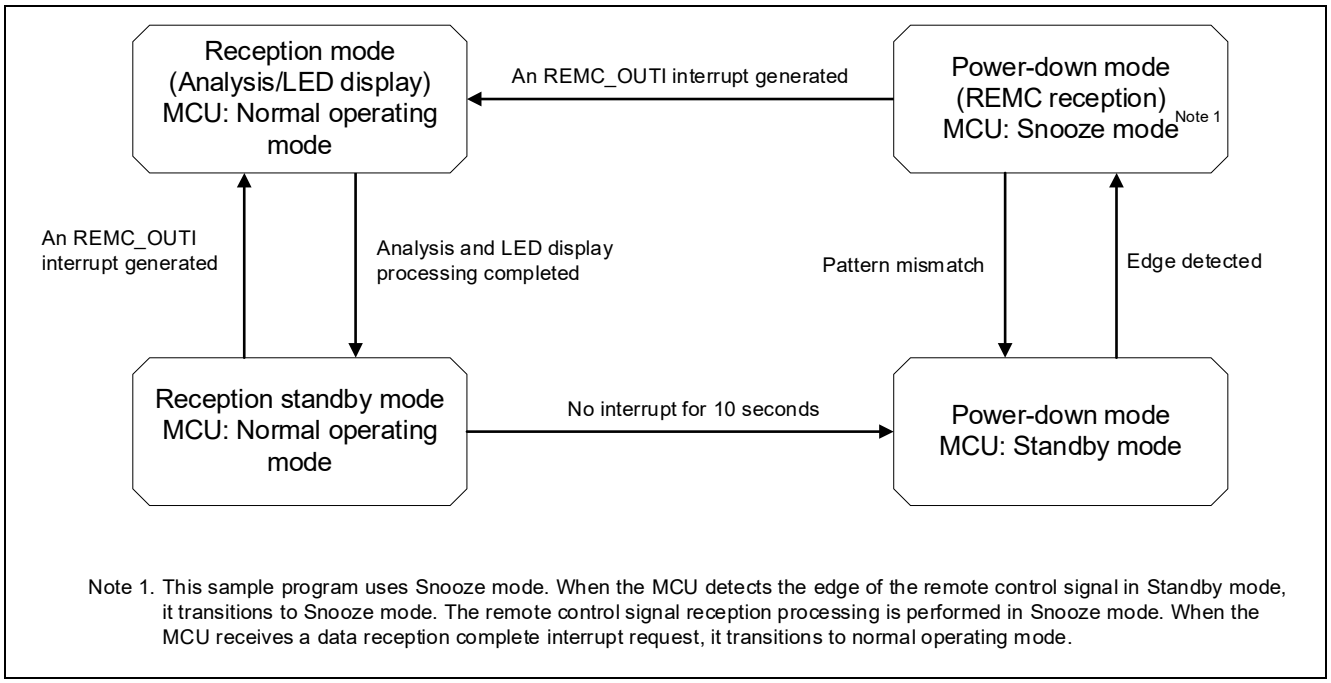

Figure 1.4 Remote Control Signal Reception State Transition Diagram

The following describes the main settings for peripheral functions.

(1) Timer array unit 0 (TAU0) channel 1 (for deciding transition to Software Standby mode)
- Set the timer operation mode to interval timer mode.
- Operating clock: CK00, clock source: PCLKB/2^13
- Interval period: 10,000 ms (10 seconds)
- Disable interrupts at count start.
- Enable TAU0_ENDI1 interrupts (interrupt priority level 15).

(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: PCLKB/2^6
- Interval period: 100 µs
- Disable interrupts at count start.
- Disable TAU0_ENDI6 interrupts.

(3) I/O ports
- P008, P403, P110, P100, P402, P104, P304 and P305 pins: Set as output ports.

(4) Remote control signal receiver (REMC)
- Operating clock: TAU0_ENDI6
- Enable digital filters (three-time match). Digital filter sampling clock: REMCLCLK/REMCSCLK
- Disable transitions from Software Standby 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: 15, compare value: 0x2002.
- Not capture the data after an error pattern is received.
- Enable compare match interrupts and data receiving interrupts.
- Set interrupts mode to normal interrupt mode (interrupt priority level 15)

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	RISC-V (R9A02G021)
Board used	RISC-V-48p Fast Prototyping Board (RTK9FPG021S000W0BJ)
Operating frequency	• High-speed on-chip oscillator clock (HOCO): 48 MHz • Low-speed on-chip oscillator clock (LOCO): 32.768 kHz
Operating voltage	5.0 V (can be operated at 1.6 V to 5.5 V)
Integrated development environment (e^{2}studio)	e^{2}studio V2024-01.1 (24.1.1) from Renesas Electronics Corp.
C compiler (e^{2}studio)	LLVM for RISC-V 17.0.2.202401
Smart configurator (SC)	Smart Configurator for RISC-V V24.1.1.v20240125-1623
Board support package (BSP)	V1.00 from Renesas Electronics Corp.
Remote controller used	AV-R925N supplied by OHM ELECTRIC INC Co., Ltd. (Panasonic TV 0069)

3. Hardware Descriptions

3.1 Example of Hardware Configuration

Figure 3.1 shows an example of the hardware configuration used in the application note.

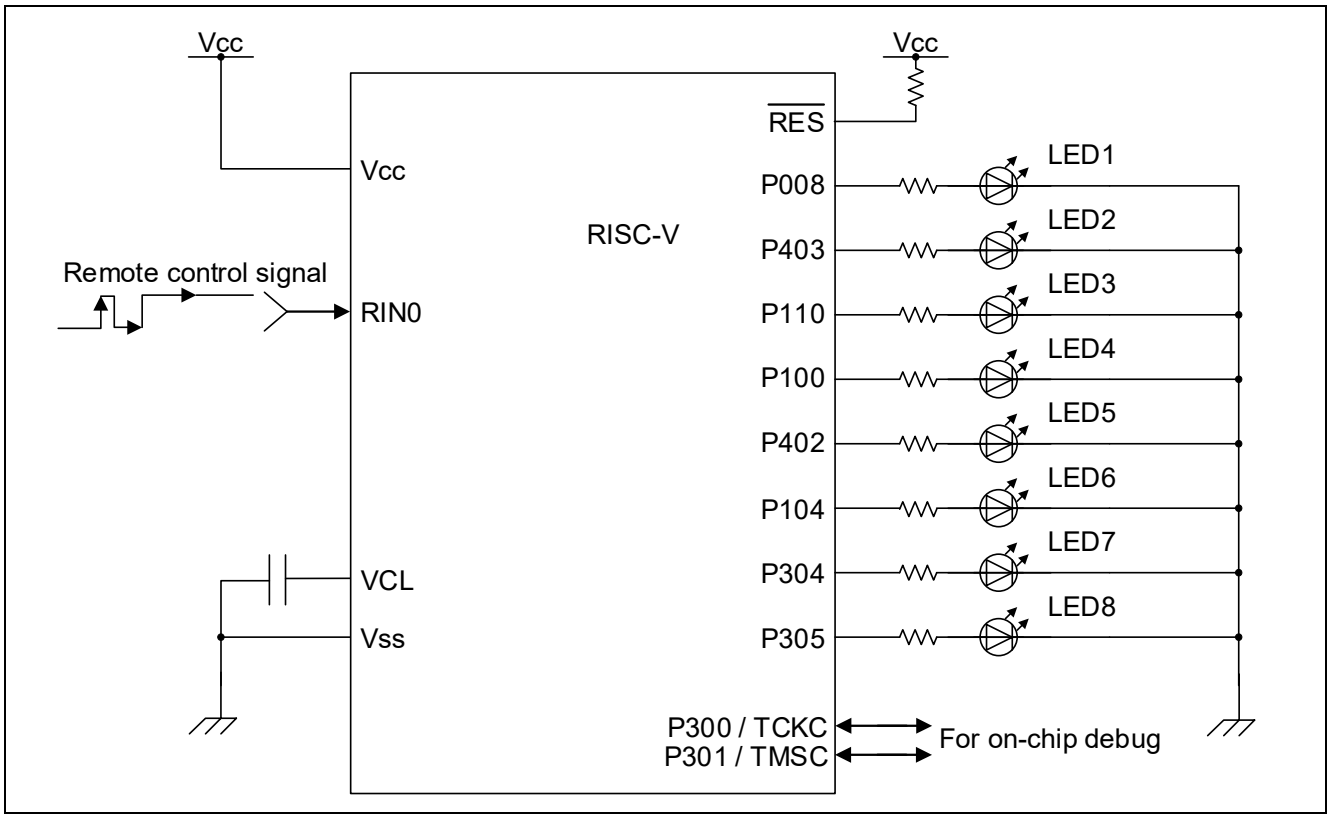

Figure 3.1 Hardware Configuration

Note 1. This simplified circuit diagram was created to show an overview of connections only. When actually designing your circuit, make sure the design includes appropriate pin handling and meets electrical characteristic requirements (connect each input-only port to V_{CC} or V_{SS} through a resistor).

Note 2. V_{CC} must not be lower than the reset release voltage (V_{LVD0}) that is specified for the LVD0.

3.2 List of Pins to be Used

Table 3.1 lists the pins to be used and their functions.

Table 3.1 Pins to be Used and Their Functions

Pin name	I/O	Function
RIN0/P202	Input	Remote control signal input
P008	Output	LED (LED1) control port
P403	Output	LED (LED2) control port
P110	Output	LED (LED3) control port
P100	Output	LED (LED4) control port
P402	Output	LED (LED5) control port
P104	Output	LED (LED6) control port
P304	Output	LED (LED7) control port
P305	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
0000_0400H	FFFF_FFFFH	Disables the watchdog timer. (Counting stopped after reset)
0000_0404H	FFFF_CFFFH	High-speed on-chip oscillator clock : 48 MHz
0101_0008H	FFFF_FFFFH	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	Software Standby 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	Software Standby 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 show the flowchart of the main processing.

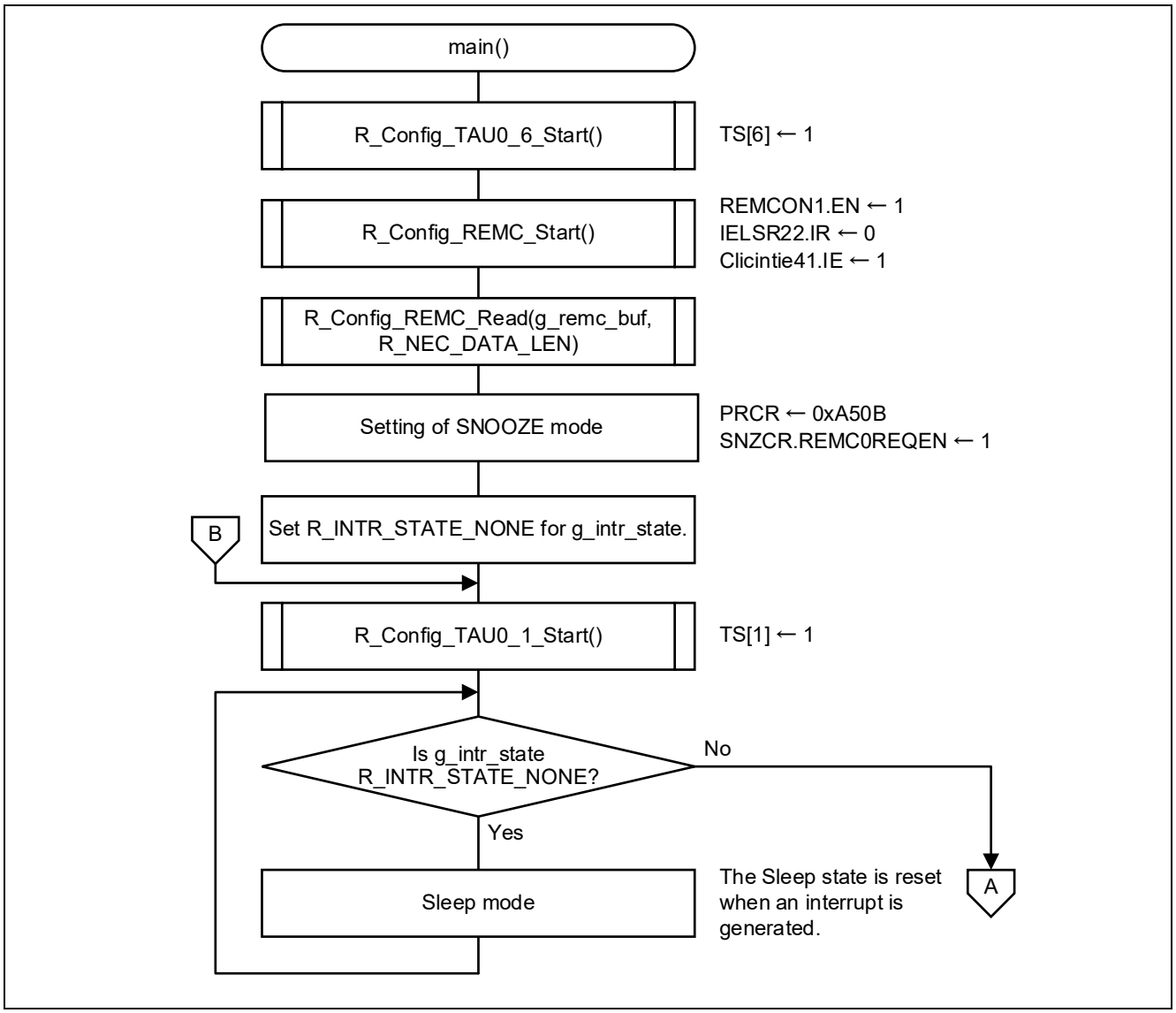

Figure 4.1 Main Processing (1/2)

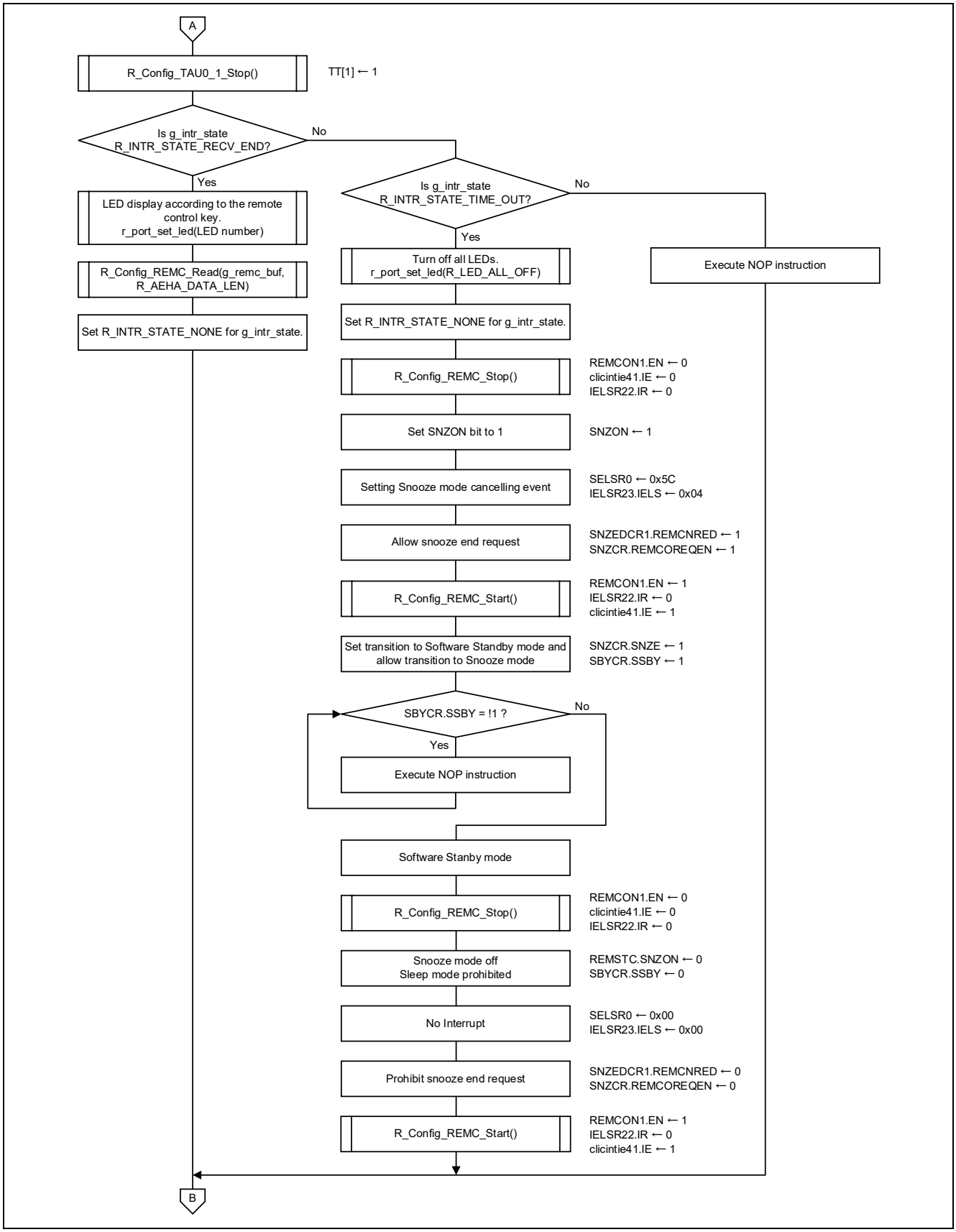

Figure 4.2 Main Processing (2/2)

4.6.2 REMC Reception Complete Interrupts

Figure 4.3 shows the flowchart of the REMC reception complete interrupts.

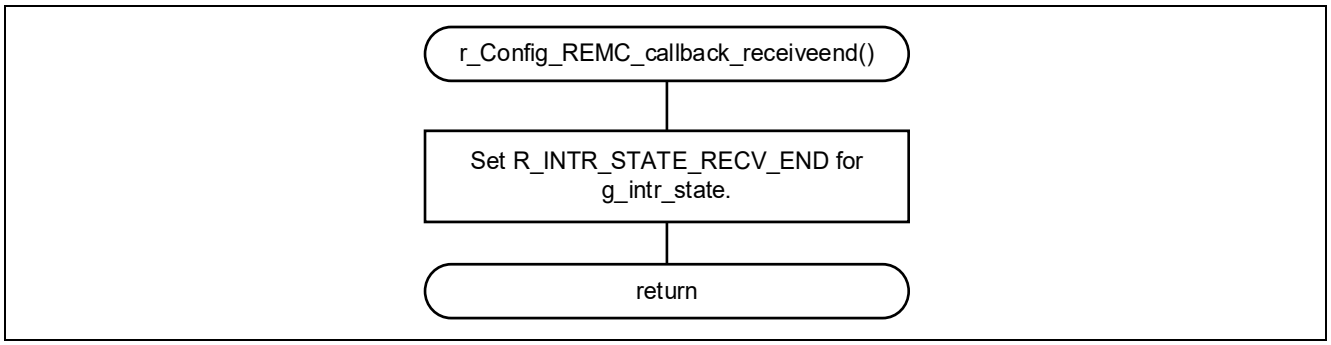

Figure 4.3 REMC Reception Complete Interrupts

4.6.3 LED Lighting Control

Figure 4.4 shows the flowchart for LED lighting control.

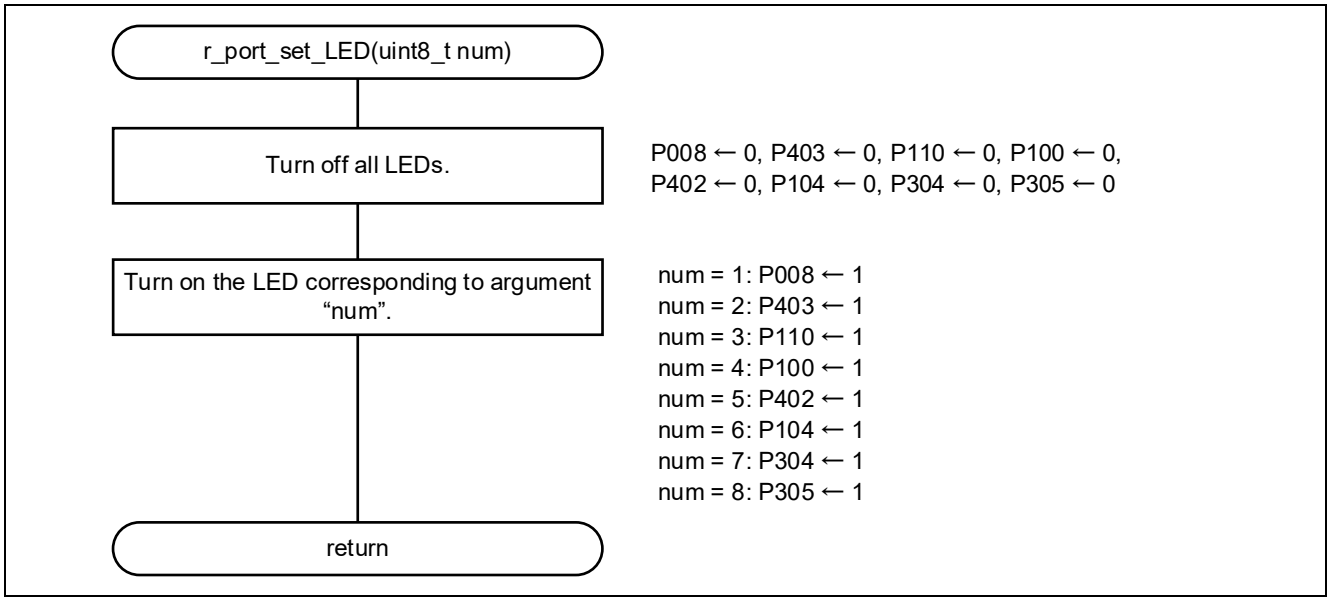

Figure 4.4 LED Lighting Control

4.6.4 Software Standby Mode Transition Timer Interrupts

Figure 4.5 shows the flowchart of the Software Standby mode transition timer interrupts.

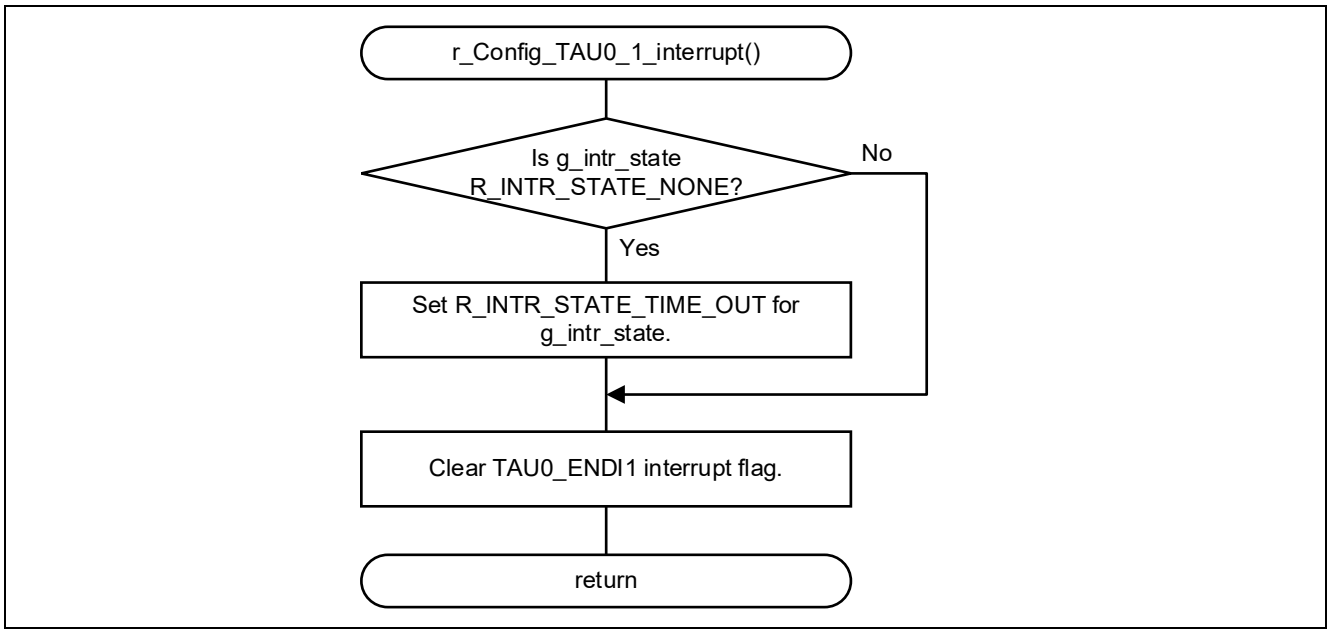

Figure 4.5 Software Standby Mode Transition Timer Interrupts

5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

RISC-V User's Manual: Hardware (R01UH1036EJ)

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

Technical update

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

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar.18.24	—	Initial release

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

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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.).
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