RL78/G23

SMS Monitoring Execution of Periodical Processing

Introduction

This application note describes how to monitor execution of periodical processing by using the SNOOZE mode sequencer (SMS) of an RL78/G23 microcomputer.

The SNOOZE mode sequencer operates as a timer function. If the CPU does not clear a counter within a certain period of time, the counter overflows and the SNOOZE mode sequencer generates an interrupt request. This interrupt request allows the CPU to detect that periodical processing was not performed.

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

1.1 Overview of Specification

In this application note, the timer function is achieved by using the SNOOZE mode sequencer of an RL78/G23 microcomputer. The SNOOZE mode sequencer runs a counter, which the CPU clears after performing periodical processing.

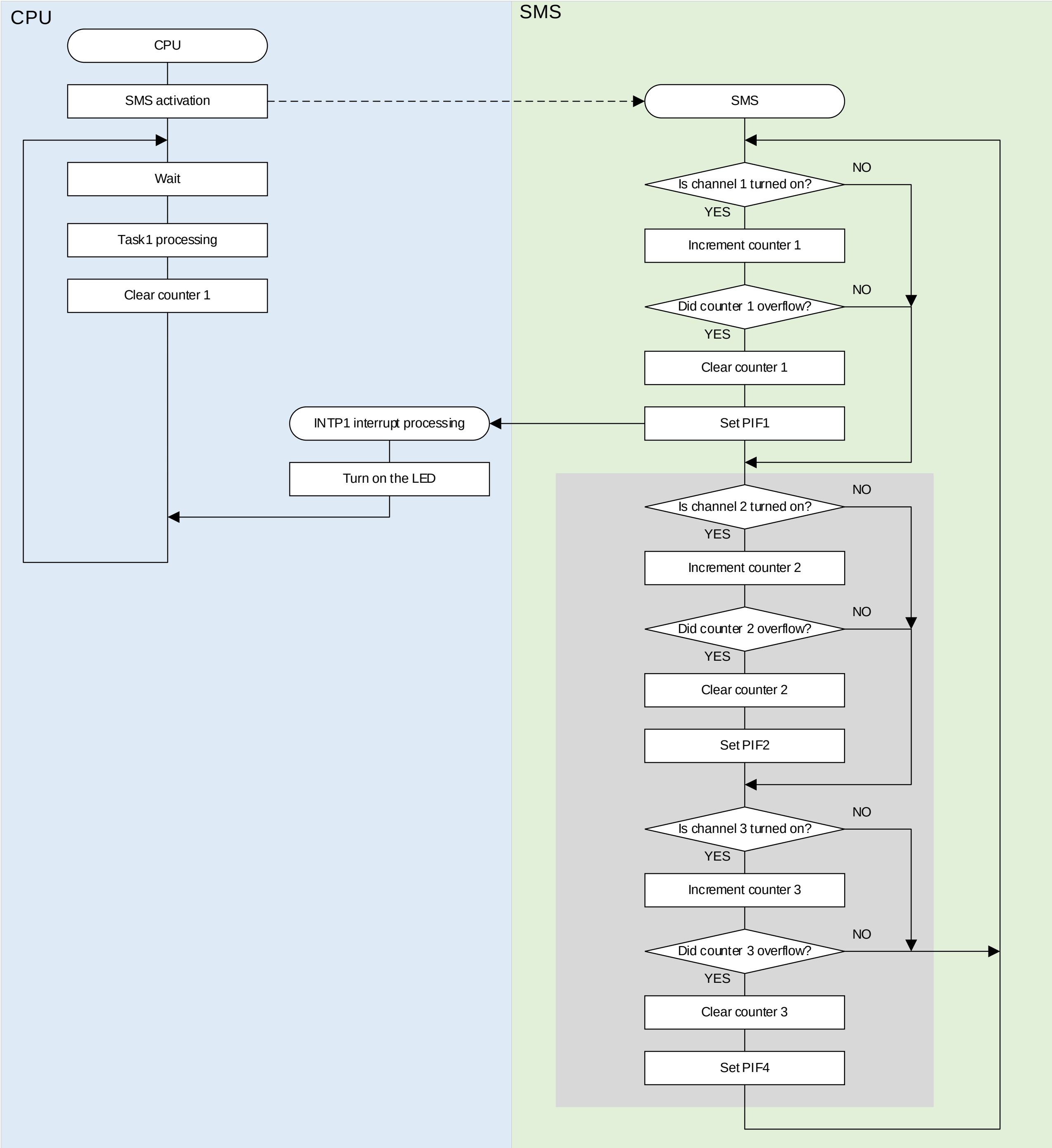
When a switch is pressed, the CPU waits for a certain period of time, causing a delay in execution of the periodical processing. If the counter overflows due to the delay, the SNOOZE mode sequencer generates an interrupt request. This interrupt request allows the CPU to detect that periodical processing was not performed.

Table 1-1 shows the peripheral functions to be used and Figure 1-1 shows an overview of operation.

Table 1-1 Peripheral Function and Use

Peripheral Function	Use
External interrupt (INTP0)	Detects an input signal from the switch.
External interrupt (INTP3)	Triggers starting the SNOOZE mode sequencer.
SNOOZE mode sequencer	Runs a counter as a timer function and generates an interrupt request.

Figure 1-1 Operation overview



Note. In this application note, channels 2 and 3 are set to off. If you turn on channel 2, add "Clear channel 2" and INTP2 interrupt processing in addition to "Clear channel 1" as the CPU processing. Similarly, if you turn on channel 3, add "Clear channel 3" and INTP3 interrupt processing in addition to "Clear channel 1" as the CPU processing.

1.1.1 Timer function specification using the SNOOZE mode sequencer

The timer function using the SNOOZE mode sequencer has three channels. Each channel is turned on or off by storing the set value (SMS_CH_ENABLE for turning on and SMS_CH_DISABLE for turning off) in the following variables.

- Channel 1: p_sms_ch1_enable (The variable is located at the address of the SMSG1 register.)
- Channel 2: p_sms_ch2_enable (The variable is located at the address of the SMSG6 register.)
- Channel 3: p_sms_ch3_enable (The variable is located at the address of the SMSG9 register.)

The calculation formula of the overflow time of the timer function using the SNOOZE mode sequencer is "the value set in p_sms_ch1_compare × 4 ms". Store the set value in the following variables.

- Channel 1: p_sms_ch1_compare (The variable is located at the address of the SMSG3 register.)
- Channel 2: p_sms_ch2_compare (The variable is located at the address of the SMSG8 register.)
- Channel 3: p_sms_ch3_compare (The variable is located at the address of the SMSG11 register.)

The counters of the timer function using the SNOOZE mode sequencer are cleared by storing COUNTER_CLEAR in the following variables.

- Channel 1: p_sms_ch1_ counter (The variable is located at the address of the SMSG2 register.)
- Channel 2: p_sms_ch2_ counter (The variable is located at the address of the SMSG7 register.)
- Channel 3: p_sms_ch3_ counter (The variable is located at the address of the SMSG10 register.)

The following indicates the interrupt request signals used for the timer function using the SNOOZE mode sequencer. Perform processing in the event of an overflow by using the interrupt processing corresponding to the interrupt request signal. An interrupt request signal is generated by setting the target bit of the interrupt request flag register (IF0L) in the SNOOZE mode sequencer.

Note that an INTSMSE interrupt request signal that might be an interrupt source of the SNOOZE mode sequencer is not used. This is because the SNOOZE mode sequencer stops if an INTSMSE interrupt request signal is generated.

- Channel 1: INTP1
- Channel 2: INTP2
- Channel 3: INTP4

1.2 Outline of Operation

In this sample code, a low-level pulse is output from the P30 pin to generate an external interrupt request (INTP3). This external interrupt request triggers activation of the SNOOZE mode sequencer. The SNOOZE mode sequencer increments a counter and judges whether an overflow has occurred. The CPU performs periodical processing and then clears the counter so that the counter does not overflow.

When a switch is pressed, the CPU performs wait processing. This wait processing delays execution of periodical processing, and the counter of the SNOOZE mode sequencer overflows. If an overflow occurs, the SNOOZE mode sequencer generates an INTP1 interrupt request. The CPU detects this INTP1 interrupt request and then turns on an LED.

The following describes the major settings of the peripheral functions.

(1) Initial settings of the external interrupt

- Set the INTP0 pin so that the falling edge is the effective edge.
- Set the INTP3 pin so that the falling edge is the effective edge.
- Set the P30 pin for output (as a trigger to start the SNOOZE mode sequencer).

(2) Initial settings of the SNOOZE mode sequencer

For details about the values to be set, see "4.7 Setting Up the SNOOZE Mode Sequencer".

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

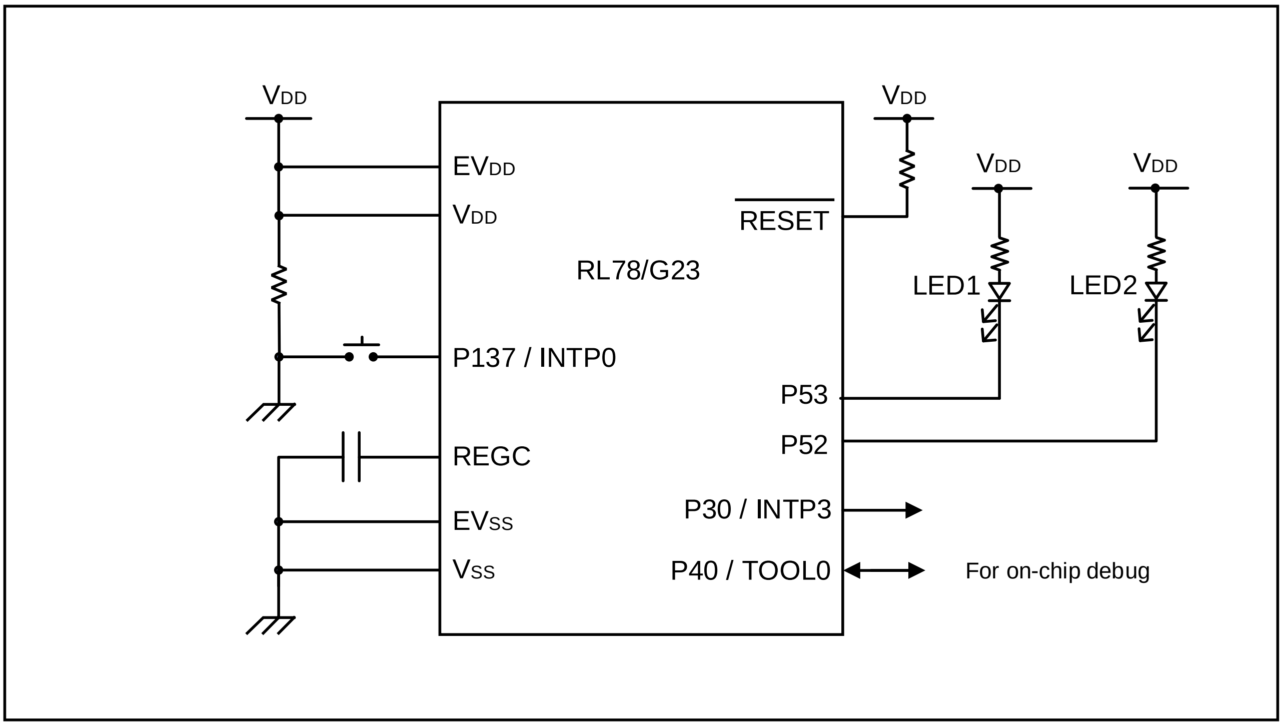
Item	Description
MCU used	RL78/G23 (R7F100GLG)
Board used	RL78/G23 Fast Prototyping Board (RTK7RLG230CLG000BJ)
Operating frequency	● High-speed on-chip oscillator clock (f_{IH}): 32 MHz ● Low-speed on-chip oscillator clock (f_{IL}): 32.768 kHz ● CPU/peripheral hardware clock: 32 MHz
Operating voltage	During V_{DD} operation: 3.3 V 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)
Integrated development environment (CS+)	CS+ V8.09.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.12.00 from Renesas Electronics Corp.
Integrated development environment (e2studio)	e2 studio V2023-04 (23.4.0) from Renesas Electronics Corp.
C compiler (e2studio)	CC-RL V1.12.00 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V4.21.2 from IAR Systems Corp.
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V4.21.2.2420 from IAR Systems Corp.

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 circuits, design them so that they meet electrical characteristics by properly performing pin processing. (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}.

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
P30 / INTP3	Output	SNOOZE mode sequencer activation trigger
P52	Output	LED2 control
P53	Output	LED1 control
P137 / INTP0	Input	Switch input

In this application note, the P30 and INTP3 pins, which are used as external interrupts, are set for output. This is because the high/low level of the output from the P30 pin is controlled by using a CPU instruction to generate an external interrupt request (from the INTP3 pin) that triggers the SNOOZE mode sequencer.

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 ～ 1.95 V) At falling edge TYP. 1.86 V (1.80 V ～ 1.91 V)
000C2H / 040C2H	11101000B	HS mode, High-speed on-chip oscillator clock (f_{IH}): 32 MHz
000C3H / 040C3H	10000100B	Enables on-chip debugging

4.2 List of Constants

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

Table 4-2 Constants

Constant Name	Setting Value	Description
COUNTER_CLEAR	0x0000	counter clear value
SMS_CH_ENABLE	0x0001	Value to turn on each channel
SMS_CH_DISABLE	0x0000	Value to turn off each channel

4.3 List of Variables

Table 4-3 lists global variables.

Table 4-3 Global Variables

Type	Variable Name	Description	Function Used
*(volatile __near unsigned short *)0x3C4	p_sms_ch1_counter	Channel 1 counter (SMSG2 register)	main r_main_user_init
*(volatile __near unsigned short *)0x3CE	p_sms_ch2_counter	Channel 2 counter (SMSG7 register)	main r_main_user_init
*(volatile __near unsigned short *)0x3D4	p_sms_ch3_counter	Channel 3 counter (SMSG10 register)	main r_main_user_init
*(volatile __near unsigned short *)0x3C6	p_sms_ch1_compare	Stores the compare value of channel 1 (SMSG3 register)	main r_main_user_init
*(volatile __near unsigned short *)0x3D0	p_sms_ch2_compare	Stores the compare value of channel 2 (SMSG8 register)	main r_main_user_init
*(volatile __near unsigned short *)0x3D6	p_sms_ch3_compare	Stores the compare value of channel 3 (SMSG11 register)	main r_main_user_init
*(volatile __near unsigned short *)0x3C2	p_sms_ch1_enable	Stores the value to turn on or off channel 1 (SMSG1 register)	main r_main_user_init
*(volatile __near unsigned short *)0x3CC	p_sms_ch2_enable	Stores the value to turn on or off channel 2 (SMSG6 register)	main r_main_user_init
*(volatile __near unsigned short *)0x3D2	p_sms_ch3_enable	Stores the value to turn on or off channel 3 (SMSG9 register)	main r_main_user_init

4.4 List of Functions

Table 4-4 shows a list of functions.

Table 4-4 Functions

Function Name	Outline
main()	Main processing
r_main_user_init()	Main initial settings
r_main_sms_trigger()	SNOOZE mode sequencer activation
r_main_task1()	Task1 processing
r_Config_INTC_intp0_interrupt()	INTP0 interrupt processing
r_Config_INTC_intp1_interrupt()	INTP1 interrupt processing

4.5 Specification of Functions

The function specifications of the sample code are shown below.

main()

Outline	Main processing
Header	r_cg_macrodriver.h、Config_INTC.h、Config_SMS.h、r_cg_userdefine.h
Declaration	void main(void);
Description	This function periodically performs the Task1 processing.
Argument	None
Return Value	None

r_main_user_init()

Outline	Main initial settings
Header	r_cg_macrodriver.h、Config_INTC.h、Config_SMS.h、r_cg_userdefine.h
Declaration	static void r_main_user_init(void);
Description	This function specifies the initial settings for the peripheral functions that are used for the application.
Argument	None
Return Value	None

r_main_sms_trigger()

Outline	SNOOZE mode sequencer activation
Header	r_cg_macrodriver.h、Config_INTC.h、Config_SMS.h、r_cg_userdefine.h
Declaration	static void r_main_sms_trigger(void);
Description	This function generates a trigger to start the SNOOZE mode sequencer.
Argument	None
Return Value	None

r_main_task1()	
Outline	Task1 processing
Header	r_cg_macrodriver.h、Config_INTC.h、Config_SMS.h、r_cg_userdefine.h
Declaration	static void r_main_task1(void);
Description	This function waits for a certain period of time, assuming task processing of the user. LED2 is lit during the wait.
Argument	None
Return Value	None

r_Config_INTC_intp0_interrupt()	
Outline	INTP0 interrupt processing
Header	Config_INTC.h
Declaration	#pragma interrupt r_Config_INTC_intp0_interrupt(vect=INTP0)
Description	This function waits for a certain period of time, assuming interrupt processing of the user.
Argument	None
Return Value	None

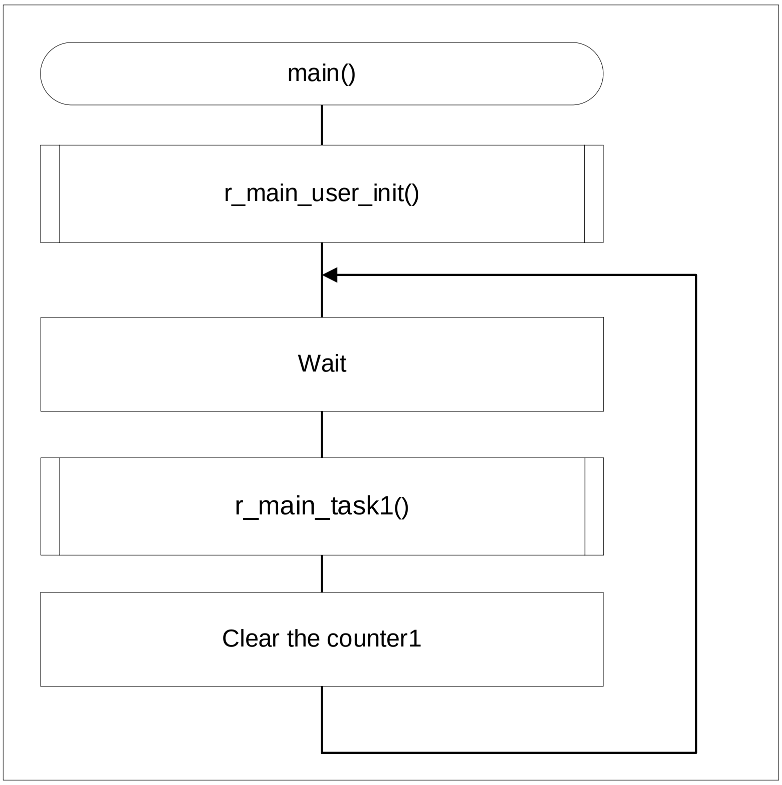
r_Config_INTC_intp1_interrupt()	
Outline	INTP1 interrupt processing
Header	Config_INTC.h
Declaration	#pragma interrupt r_Config_INTC_intp1_interrupt(vect=INTP1)
Description	This function turns on an LED.
Argument	None
Return Value	None

4.6 Flowcharts

4.6.1 Main Processing

Figure 4-1 show flowcharts of the main processing.

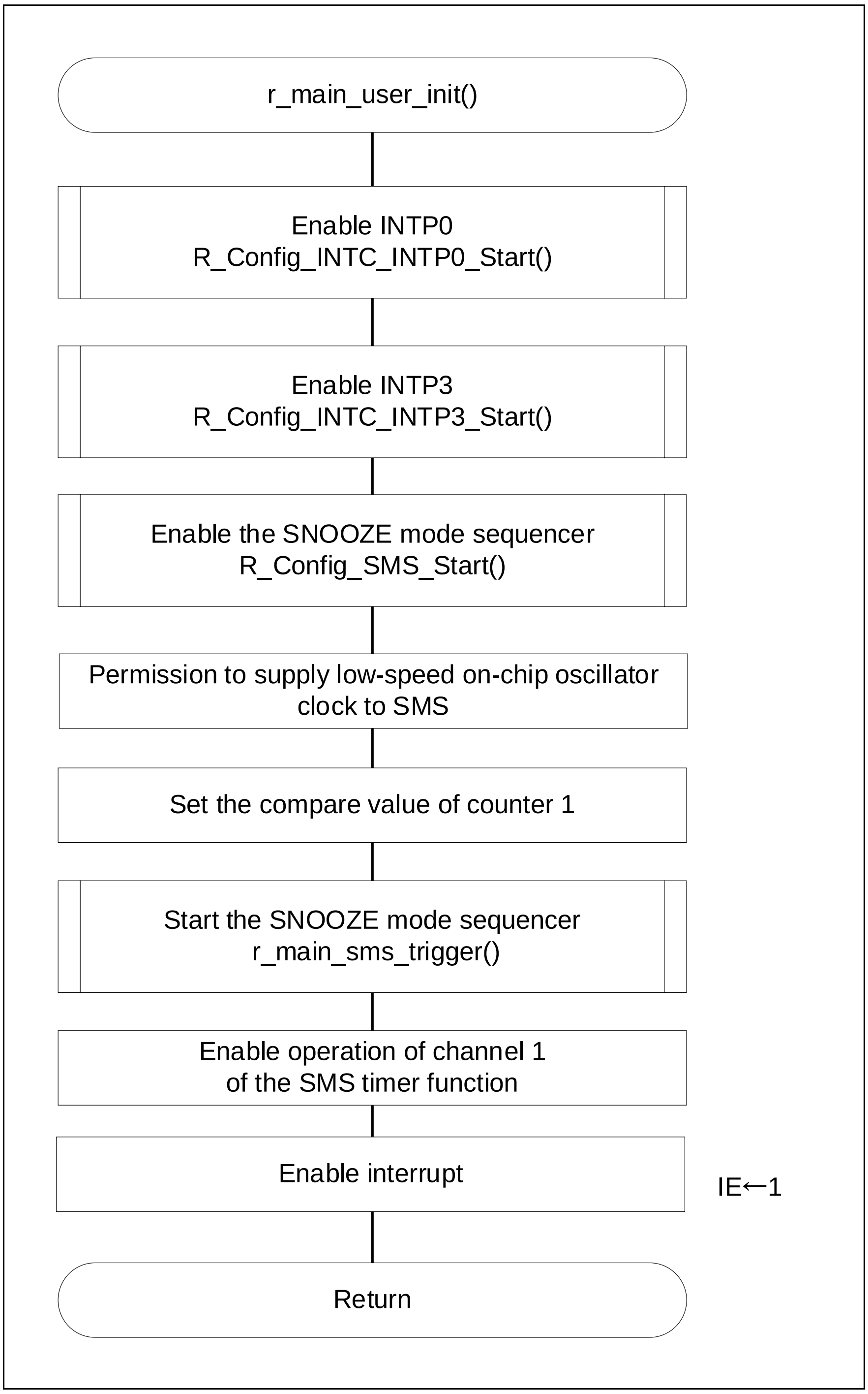
Figure 4-1 Main Processing



4.6.2 Main Initial Settings

Figure 4-2 shows the flowchart of the initial settings for main functions.

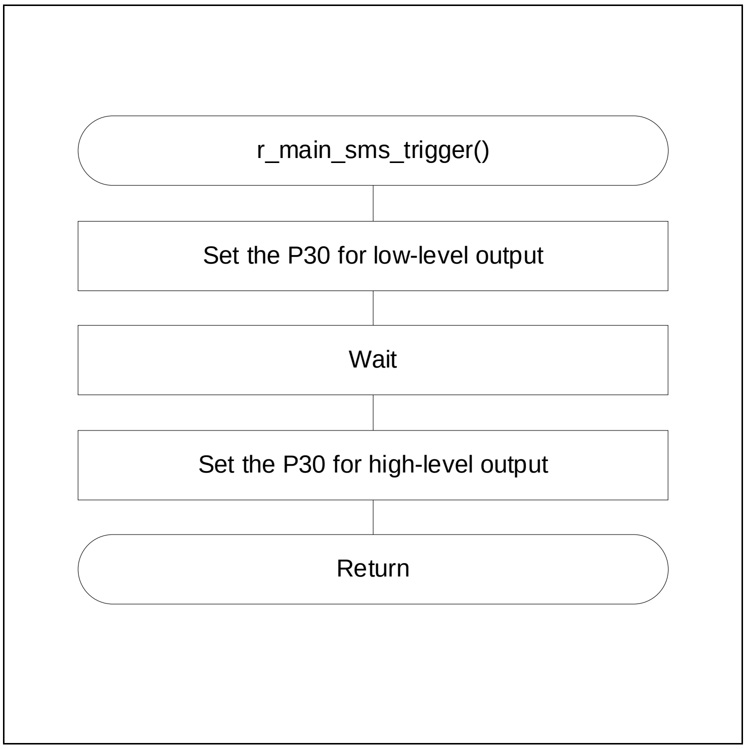
Figure 4-2 Main Initial Settings



4.6.3 SNOOZE Mode Sequencer Activation

Figure 4-3 shows the flowchart of the SNOOZE mode sequencer activation.

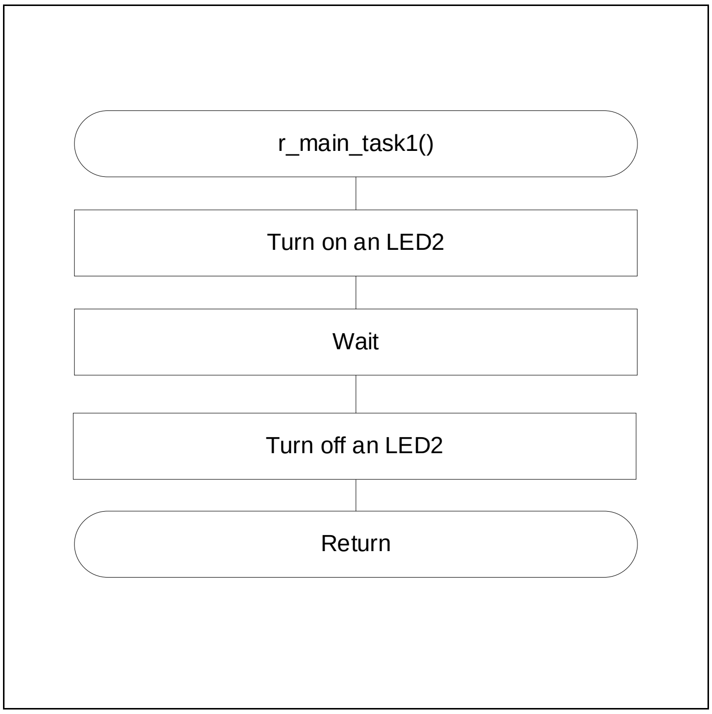
Figure 4-3 SNOOZE Mode Sequencer Activation



4.6.4 Task1 Processing

Figure 4-4 shows the flowchart of the Task1 processing.

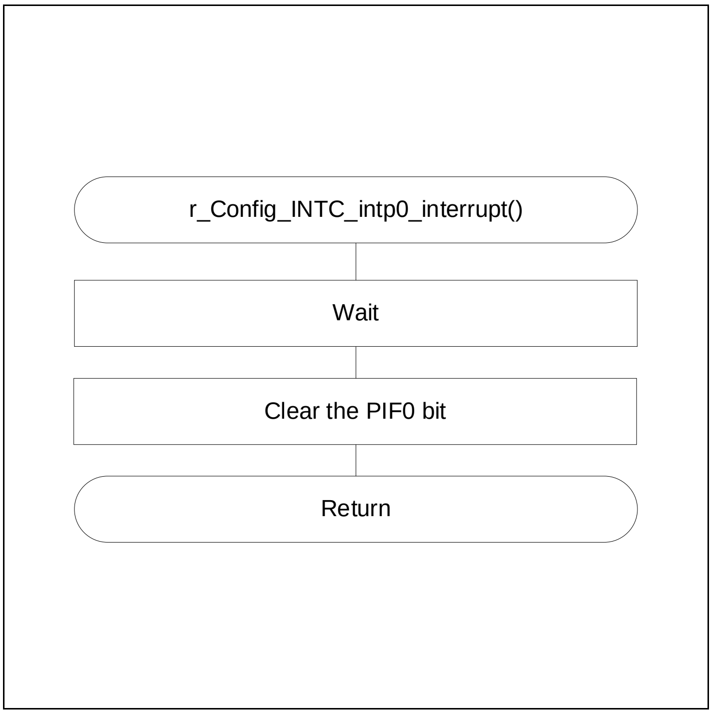
Figure 4-4 Task1 Processing



4.6.5 INTP0 Interrupt Processing

Figure 4-5 shows the flowchart of the INTP0 interrupt processing.

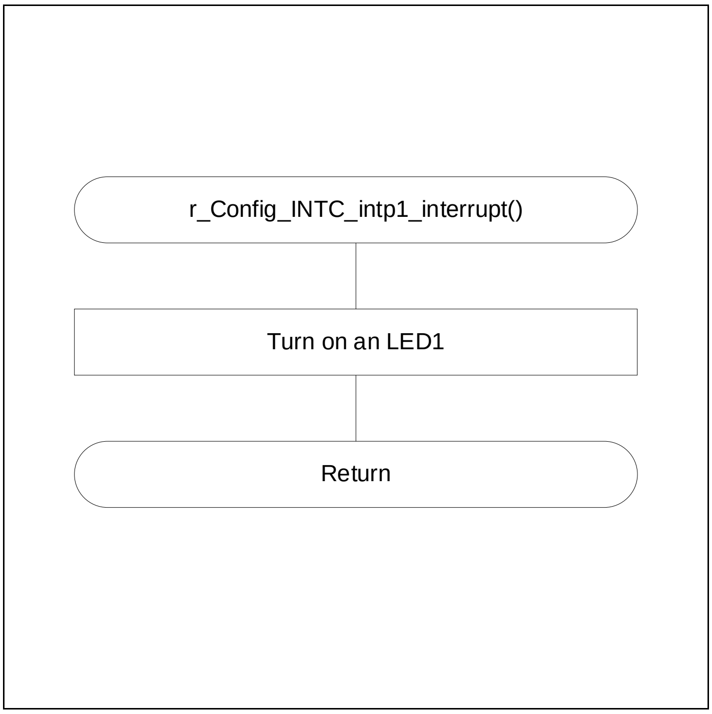
Figure 4-5 INTP0 Interrupt Processing



4.6.6 INTP1 Interrupt Processing

Figure 4-6 shows the flowchart of the INTP1 interrupt processing.

Figure 4-6 INTP1 Interrupt Processing



4.7 Setting Up the SNOOZE Mode Sequencer

When the SNOOZE mode sequencer (SMS) is started by occurrence of a triggering event, it sequentially executes the processing commands that are stored in the sequencer instruction register (SMSI0-31). During execution of these commands, the sequencer general-purpose register (SMSG0-15) is used to store the source address, destination address, arithmetic data, and other data.

The SMSI0-31 and SMSG0-15 registers are set by coding an SMS program (.SMSASM file) in assembly language. You can also use the SNOOZE Mode Sequencer component of Smart Configurator to create an SMS program by combining processing blocks. The created SMS program is converted into C language by the assembler for SMS and then incorporated into the application program.

Figure 4-7 and Figure 4-8 shows a flowchart of the processing of the SNOOZE mode sequencer.

Figure 4-7 Processing of the SNOOZE Mode Sequencer (1/2)

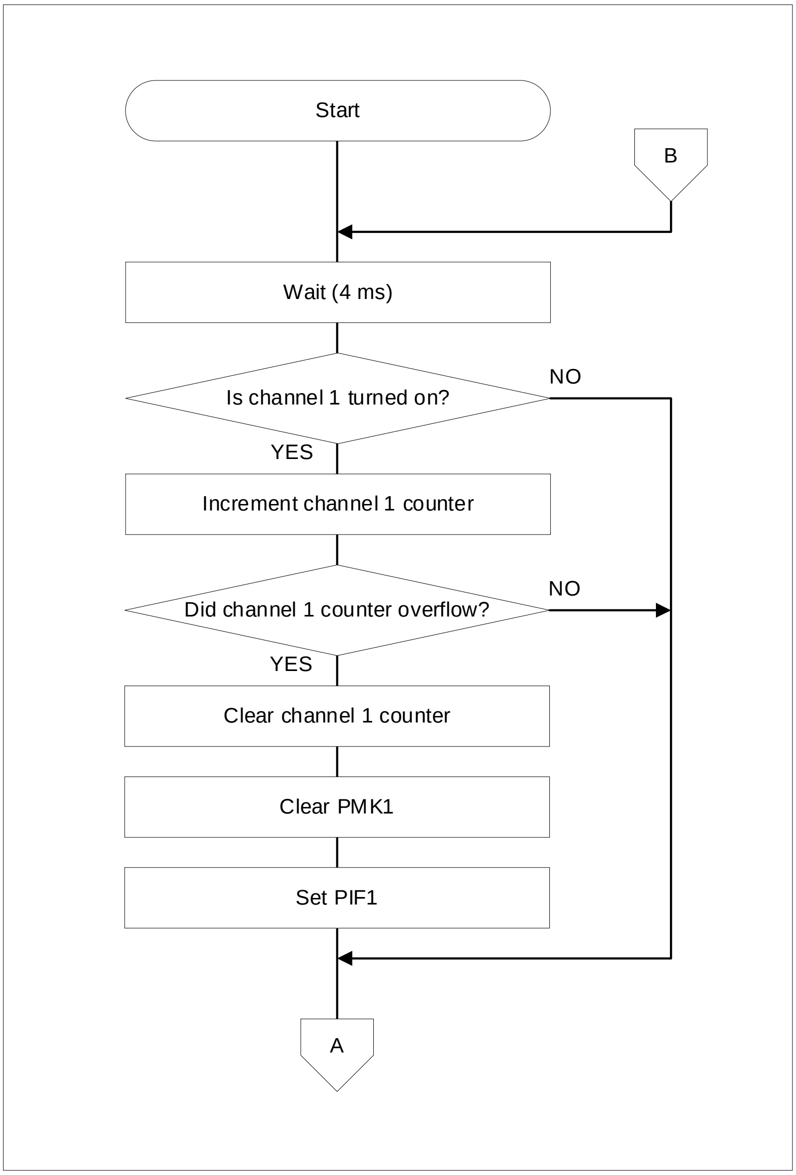


Figure 4-8 Processing of the SNOOZE Mode Sequencer (2/2)

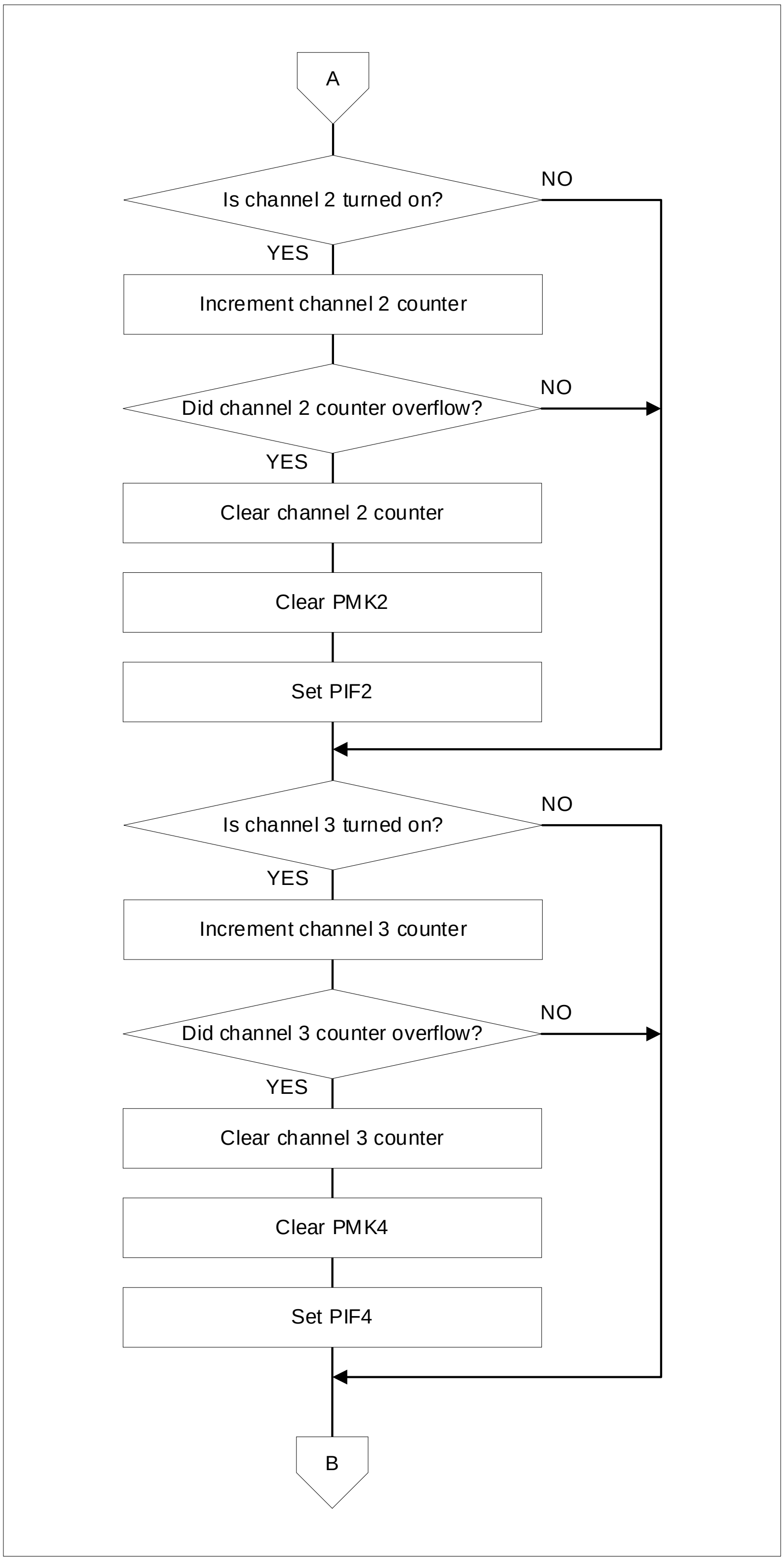


Table 4-5 Sequencer general-purpose registers 0-15

Register Symbol	Setting	Remark
SMSG0	0000H	fixed value: 0000H
SMSG1	0000H	Value to turn on or off channel 1
SMSG2	0000H	Channel 1 counter
SMSG3	0113H	Compare value of channel 1
SMSG4	FFE4H	MK0L register address
SMSG5	FFE0H	IF0L register address
SMSG6	0000H	Value to turn on or off channel 2
SMSG7	0000H	Channel 2 counter
SMSG8	00FFH	Compare value of channel 2
SMSG9	0000H	Value to turn on or off channel 3
SMSG10	0000H	Channel 3 counter
SMSG11	00FFH	Compare value of channel 3
SMSG12	FFFFH	Comparison value
SMSG13	0001H	Increment value or ON setting value
SMSG14	0000H	unused
SMSG15	FFFFH	fixed value: FFFFH

Table 4-6 Sequencer instruction registers 0-31

Register Symbol	Setting	Remark
SMSI0	9C21H	WAIT 194, 1
SMSI1	71D2H	CMPW SMSG1, SMSG13
SMSI2	8073H	BNZ $__9
SMSI3	72D0H	ADDW SMSG2, SMSG13
SMSI4	7232H	CMPW SMSG2, SMSG3
SMSI5	8040H	BC $__9
SMSI6	7221H	SUBW SMSG2, SMSG2
SMSI7	5430H	CLR1 [SMSG4+0].3
SMSI8	4530H	SET1 [SMSG5+0].3
SMSI9	76D2H	CMPW SMSG6, SMSG13
SMSI10	8073H	BNZ $__17
SMSI11	77D0H	ADDW SMSG7, SMSG13
SMSI12	7782H	CMPW SMSG7, SMSG8
SMSI13	8040H	BC $__17
SMSI14	7771H	SUBW SMSG2, SMSG2
SMSI15	5440H	CLR1 [SMSG4+0].4
SMSI16	4540H	SET1 [SMSG5+0].4
SMSI17	79D2H	CMPW SMSG9, SMSG13
SMSI18	8073H	BNZ $__25
SMSI19	7AD0H	ADDW SMSG10, SMSG13
SMSI20	7AB2H	CMPW SMSG10, SMSG11
SMSI21	8040H	BNC $__25
SMSI22	7AA1H	SUBW SMSG10, SMSG10
SMSI23	5460H	CLR1 [SMSG4+0].6
SMSI24	4560H	SET1 [SMSG5+0].6
SMSI25	7C00H	ADDW SMSG12, SMSG0
SMSI26	7C02H	CMPW SMSG12, SMSG0
SMSI27	8E51H	BNC $__1
SMSI28	F000H	FINISH
SMSI29~31	0000H	unused

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.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	2022.11.18	-	First Edition
1.10	2024.1.9	7	Corrected Table 2-1 Operation Confirmation Conditions
		10	Corrected Table 4-3 Global Variables
		21	Corrected Table 4-5 Sequencer general-purpose registers 0-15
		22	Corrected Table 4-6 Sequencer instruction registers 0-31

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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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact information

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