

RL78/G13

R01AN4039EJ0100

Rev.1.00

Measurement of Standby Mode Supply Current CC-RL

Sep. 28, 2018

Introduction

This application note describes the method for measuring the supply current of the RL78/G13 in the STOP mode or the HALT mode.

Target Device

RL78/G13

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. Specifications.....	3
1.1 Standby mode function.....	4
1.2 Supply current of standby mode.....	5
1.3 Example of Circuit Configuration for Measuring Standby Mode Supply Currents	6
1.4 Important Points When Measuring Supply Currents	7
2. Operation Check Conditions.....	8
3. Related Application Notes	9
4. Hardware Explanation	10
4.1 Hardware Configuration Example.....	10
4.2 Used Pin List.....	10
5. Software Explanation.....	11
5.1 Operation Outline.....	11
5.2 Option Byte Settings	12
5.3 Functions	12
5.4 Function Specifications.....	13
5.5 Flowcharts	14
5.5.1 Initialization Function	14
5.5.2 System initial Setting.....	15
5.5.3 CPU Initial Setting.....	16
5.5.4 Input/Output Port Settings	21
5.5.5 Main Processing	22
5.5.6 Main Initializes Settings	23
6. Sample Code	24
7. Reference Documents	24

1. Specifications

In this application note, after a reset is released, a standby mode (STOP mode, or HALT mode during CPU operation using the subsystem clock) is selected through the value of the input voltage at the P137 pin.

The transition to a standby mode can be confirmed from the output states of P10 and P11. In order to correctly measure the supply current in a standby mode, P10 and P11 must be in output mode and must be unconnected (open).

Table 1.1 lists peripheral functions to be used and their uses. Figure 1.1 shows the outline of operation, and Table 1.2 shows operation in each of the operation modes.

Table 1.1 Peripheral Functions and Applications

Peripheral Function	Application
P137	Switch input
P10-P11	Status check

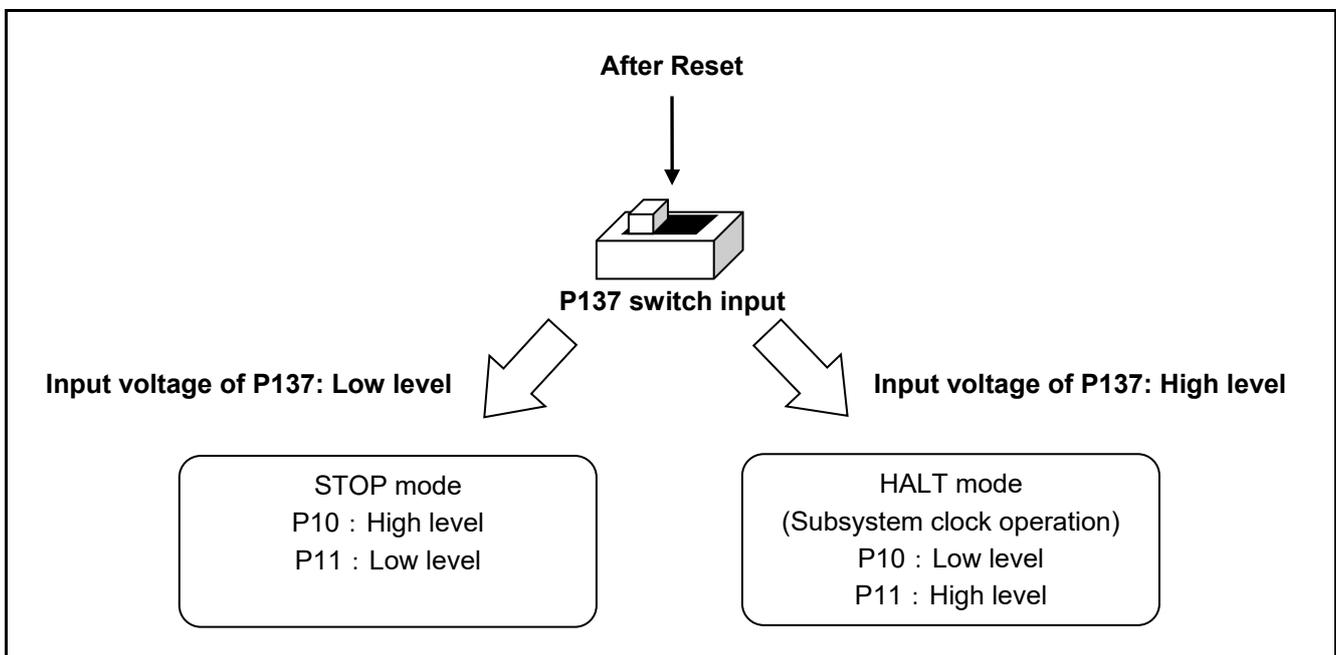


Figure 1.1 Outline of Operation

Table 1.2 Explanation of the standby mode in this application note

Standby mode	CPU/peripheral hardware clock (f_{CLK})	Port output	
		P10	P11
STOP mode	High-speed on-chip oscillator clock (f_{IH})	High level	Low level
HALT mode (Subsystem clock operation)	Subsystem clock (f_{SUB}) ^{Note 1}	Low level	High level

Note 1. The oscillation mode of the XT1 oscillator is set to ultra-low power consumption oscillation (oscillation margin: small).

1.1 Standby mode function

The standby mode functions used in this application note are as follows.

① STOP mode

In the STOP mode, the high-speed system clock oscillator and the high-speed on-chip oscillator are stopped, to stop clocks in the entire system. The CPU operating current can be greatly reduced as a result.

Moreover, the STOP mode can be released by an interrupt request, and so by periodically switching between normal operation and standby operation, the average power supply operating current can be reduced. However, when the STOP mode is released, an oscillation stabilization time must be secured for the high-speed system clock oscillator and the high-speed on-chip oscillator.

The STOP mode is entered by executing the STOP instruction. However, a transition to the STOP mode is not possible in a state in which the subsystem clock is selected for the CPU clock.

② HALT mode (subsystem clock operation)

In the HALT mode, the CPU operation clock is stopped. The real-time clock (RTC) and 12-bit interval timer, operating before the HALT mode is set, can continue operation even during the HALT mode.

This mode is useful when there is a need to promptly execute interrupt processing without waiting the length of the oscillation stabilization time, and when there is a need for frequent intermittent operation.

By executing the HALT command during normal operation using the subsystem clock, the HALT mode is entered during CPU operation using the subsystem clock.

1.2 Supply current of standby mode

The Hardware edition of the RL78/G13 User Manual gives typical and maximum values for the supply current in standby modes. Table 1.3 and Table 1.4 indicate whether the operating currents are included in the typical and maximum values of supply currents for standby modes set in this application note.

Table 1.3 Supply current in STOP mode (TYP. value, MAX. value)

Operating current	TYP. value	MAX. value
Current flowing into VDD, EVDD0	Included	Included
the input leakage current flowing when the level of the input pin is fixed to VDD, EVDD0, or VSS, EVSS0	Included	Included
A/D converter operating current	Not included	Not included
LVD operating current	Not included	Not included
Current flowing through the I/O port	Not included	Not included
Current flowing through on-chip pull-up/pull-down resistors	Not included	Not included
Current flowing when rewriting data flash	Not included	Not included
Real-time clock operating current	Not included	Not included
12-bit interval timer operating current	Not included	Not included
Watchdog dog timer operating current	Not included	Not included
Operating current of other peripheral functions	Not included	Included

Table 1.4 Supply current in HALT mode (subsystem clock operating) (TYP. value, MAX. value)

Operating current	TYP. value	MAX. value
Current flowing into VDD, EVDD0	Included	Included
the input leakage current flowing when the level of the input pin is fixed to VDD, EVDD0, or VSS, EVSS0	Included	Included
A/D converter operating current	Not included	Not included
LVD operating current	Not included	Not included
Current flowing through the I/O port	Not included	Not included
Current flowing through on-chip pull-up/pull-down resistors	Not included	Not included
Current flowing when rewriting data flash	Not included	Not included
Real-time clock operating current	Included	Included
12-bit interval timer operating current	Not included	Not included
Watchdog dog timer operating current	Not included	Not included
Operating current of other peripheral functions	Not included	Included

1.3 Example of Circuit Configuration for Measuring Standby Mode Supply Currents

This application note provides sample code that assumes RL78/G13 peripheral circuitry as shown in Figure 1.2. By using the circuit configuration shown in Figure 1.2, the standby mode supply currents described in the Hardware edition of the RL78/G13 User Manual can be measured.

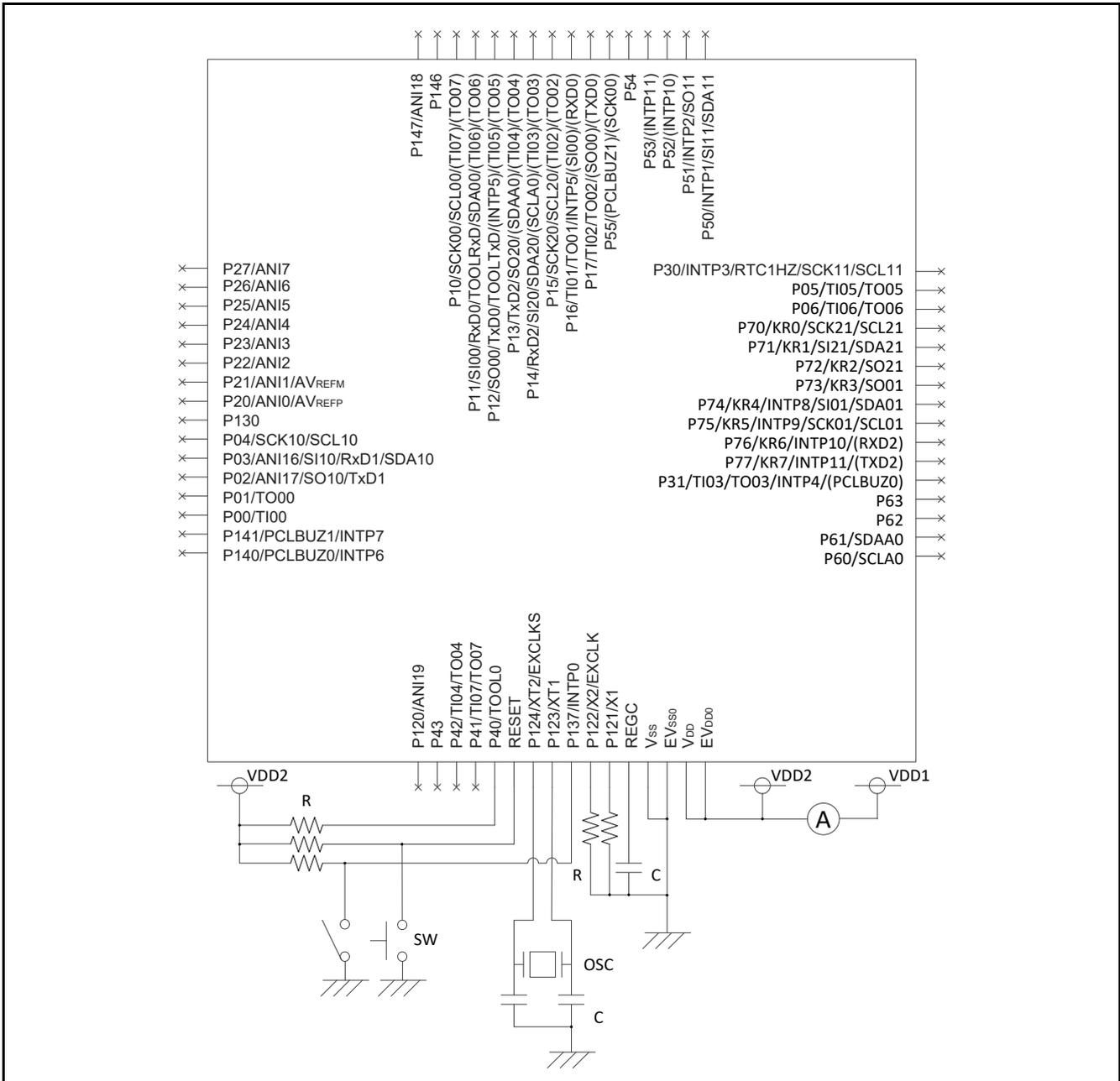


Figure 1.2 schematic

1.4 Important Points When Measuring Supply Currents

The following are important points to be noted when measuring the supply currents described in the Hardware edition of the RL78/G13 User Manual.

① Regarding unused pins

Unused pins should be handled properly without fail. If an unused pin is set as an input port and is unconnected (open), an intermediate potential is applied to the pin and there is the possibility that a through-current may flow. If a through-current flows, standby mode supply currents cannot be accurately measured.

② Regarding currents flowing in ports

When measuring supply currents, confirm that no port currents are flowing.

③ Regarding operating ambient temperature

Check the ambient temperature when measuring the supply currents. The typical values for supply currents given in the Hardware edition of the RL78/G13 User Manual are values for an ambient temperature of 25°C.

④ Regarding supply of a clock to peripheral hardware

The PER0 register should be used to select "Stops input clock supply" for each of the peripheral functions. If "Enables input clock supply" is selected, an operating current flows even in a state in which the peripheral functions have stopped operation.

⑤ Regarding subsystem clock supply

The OSMC register should be used to select "Stops supply of subsystem clock to peripheral functions other than the real-time clock and the 12-bit interval timer" (RTCLPC = 1).

If "Enables supply of subsystem clock to peripheral functions" is selected, then there is the possibility that minute operating currents may flow even in a state in which operation of peripheral functions is stopped.

⑥ Regarding on-chip debugging operations

In a state in which an emulator such as E1 is connected, operating currents cannot be accurately measured. Software should be written into the microcomputer and the operating current of the microcomputer alone should be measured.

2. Operation Check Conditions

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

Table 2.1 Operation Check Conditions

Item	Description
MCU used	RL78/G13 (R5F100LE)
Operating frequencies	<ul style="list-style-type: none"> ● High-speed on-chip oscillator clock: 8MHz ● CPU/peripheral hardware clock: 8MHz
Operating voltage	3.3V (operating range 1.8V to 5.5V) LVD operations (V_{LVD}): LVD off
Integrated development environment (CS+)	CS+ for CC V6.00.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.06.00 from Renesas Electronics Corp.
Integrated development environment (e ² studio)	e ² studio V6.3.0 from Renesas Electronics Corp.
C compiler (e ² studio)	CC-RL V1.06.00 from Renesas Electronics Corp.

3. Related Application Notes

Application notes related to this document are shown below. Please refer to these as needed.

RL78/G13 CPU Clock Changing and Standby Settings (C Language) CC-RL (R01AN3128EJ) Application note

RL78/G13 low-power Consumption Operation CC-RL (R01AN2591EJ) Application note

4. Hardware Explanation

4.1 Hardware Configuration Example

Figure 4.1 shows an example of the hardware configuration used in this application note.

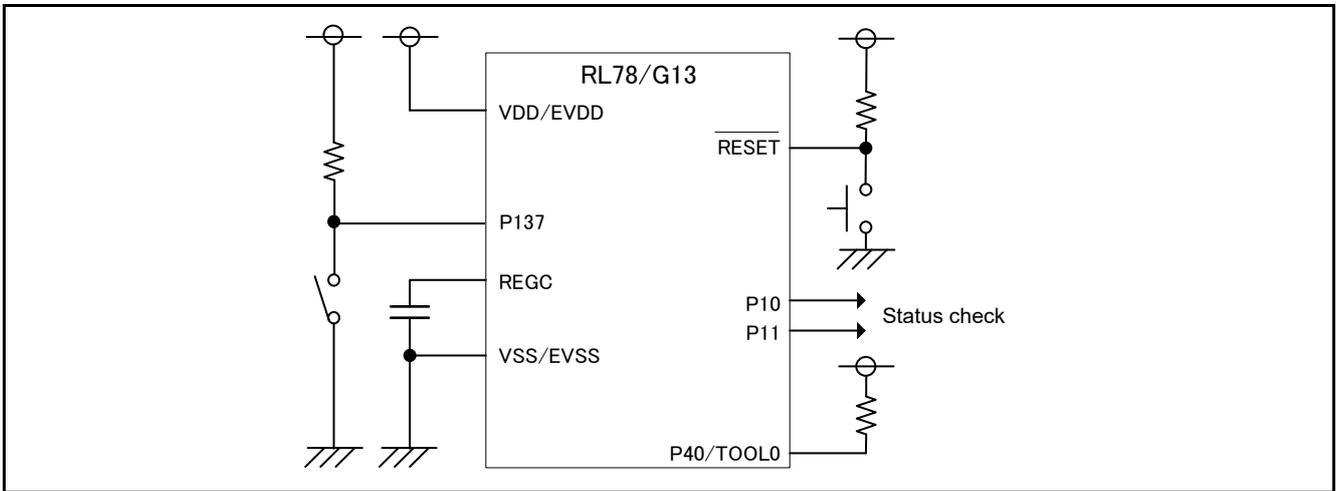


Figure 4.1 Hardware Configuration

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 sufficient pin processing and meets electrical characteristic requirements. (Connect each input-only port to V_{DD} or V_{SS} through a resistor.)

4.2 Used Pin List

Table 4.1 provides List of Pins and Functions.

Table 4.1 List of Pins and Functions

Pin name	Input/Output	Function
P137	Input	Switch input port
P10-P11	Output	Output for status check

5. Software Explanation

5.1 Operation Outline

In this application note, after a reset is released, the input voltage value of the P137 pin is used to select a standby mode (STOP mode, or HALT mode during CPU operation using the subsystem clock). The standby mode state can be determined from the output states of P10 and P11.

Details are explained in ① through ⑤ below.

① Initialize the CPU clock.

<CPU clock setup conditions>

- The 8 MHz high-speed on-chip oscillator clock is set as the CPU/peripheral hardware clock (f_{CLK}).
- The subsystem clock pin operating mode is set to XT1 oscillation mode.

② Initialize the input/output ports.

<Input/output port setup conditions>

- Set P10-P11 to low level.
- Set P10-P11 output mode.

③ Check the P137 input level. Transition to the STOP mode if the P137 input is at low level, and to the HALT mode (subsystem clock operation) if it is at high level. For the STOP mode, execute ④, and for the HALT mode (subsystem clock operation), execute ⑤.

④ After setting P10 to high level output and P11 to low level output, transition to the STOP mode.

⑤ Switch the CPU clock from the high-speed system clock to the subsystem clock. Then, set P10 to low level output and P11 to high level output, and transition to the HALT mode.

5.2 Option Byte Settings

Table 5.1 lists the option byte settings.

Table 5.1 Option Byte Settings

Address	Setting Value	Contents
000C0H/010C0H	1110 1111B	Watchdog timer operation is stopped (count is stopped after reset)
000C1H/010C1H	1111 1111B	LVD off
000C2H/010C2H	1010 1010B	LS mode, High-speed on-chip oscillator clock: 8MHz
000C3H/010C3H	0000 0100B	On-chip debugging disabled

5.3 Functions

Table 5.2 lists the functions.

Table 5.2 Functions

Function name	Outline
main	Main processing
R_MAIN_UserInit	Main initial setting

5.4 Function Specifications

This part describes function specifications of the sample code.

[Function Name]	main
Outline	Main processing
Header	r_cg_macrodriver.h、 r_cg_cgc.h、 r_cg_port.h、 r_cg_intp.h、 r_cg_userdefine.h
Declaration	—
Description	After execution of the main user initialization function, transitions to the STOP mode if the P137 input is at low level, and transitions to the HALT mode (subsystem clock operation) if the P137 input is at high level.
Arguments	None
Remarks	None

[Function Name]	R_MAIN_UserInit
Outline	Main initial setting
Header	r_cg_macrodriver.h、 r_cg_cgc.h、 r_cg_port.h、 r_cg_intp.h、 r_cg_userdefine.h
Declaration	void R_MAIN_UserInit(void);
Description	Disables interrupt processing by the DI instruction.
Arguments	None
Remarks	None

5.5 Flowcharts

Figure 5.1 shows an overall from of the sample code.

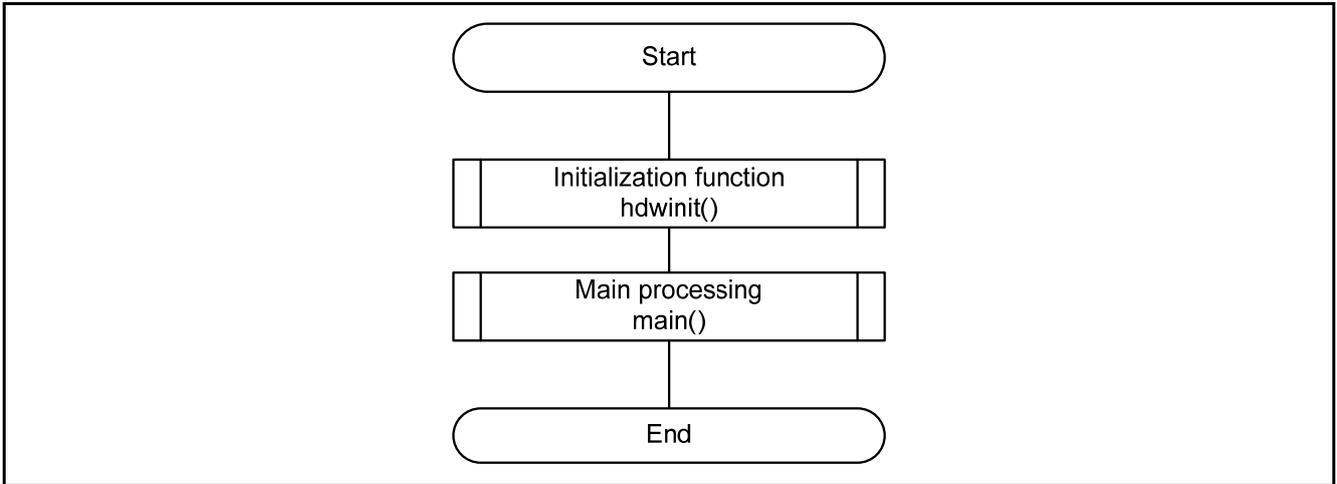


Figure 5.1 Overall Flow

5.5.1 Initialization Function

Figure 5.2 shows the flowchart for the initialization function.

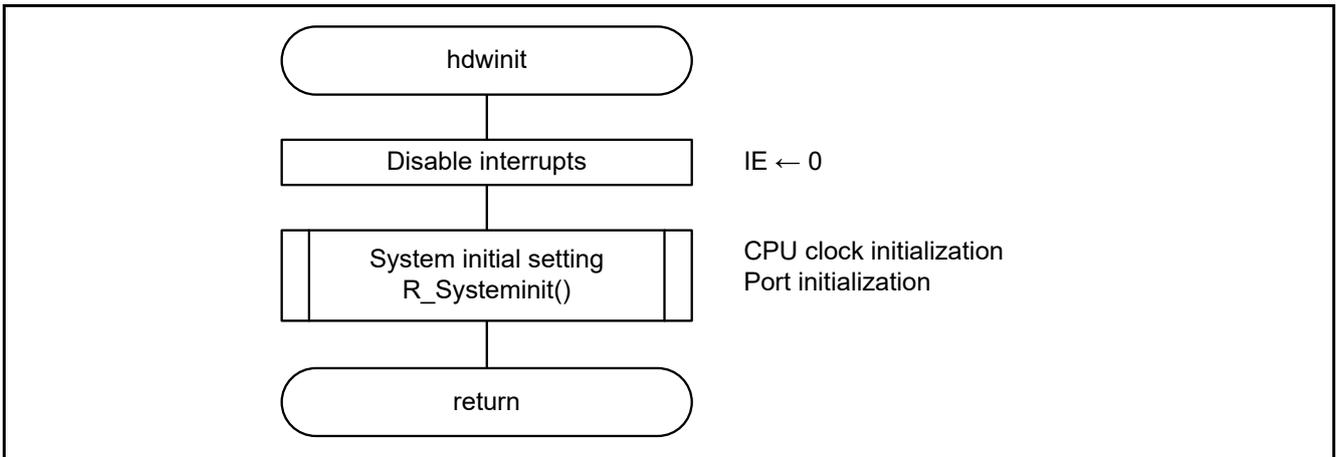


Figure 5.2 Initialization Function

5.5.2 System initial Setting

Figure 5.3 shows the flowchart for the system initial setting.

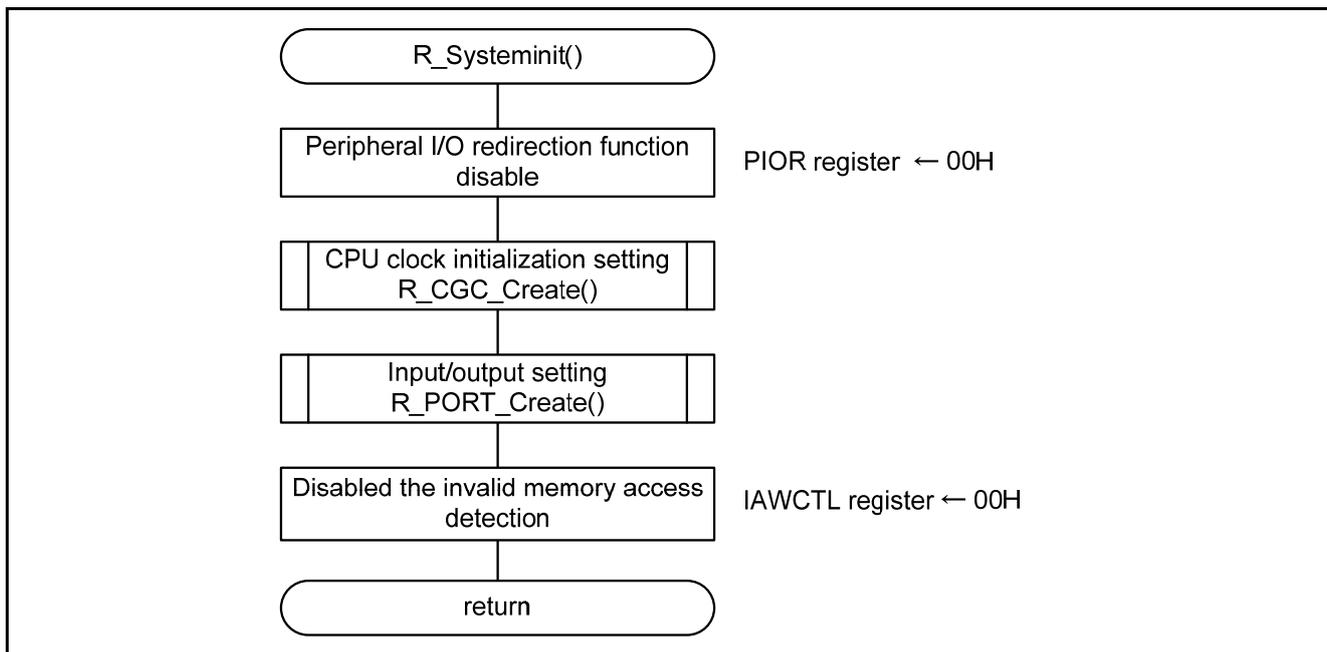


Figure 5.3 System Initial Setting

5.5.3 CPU Initial Setting

Figure 5.4 shows the flowchart for the CPU initial setting.

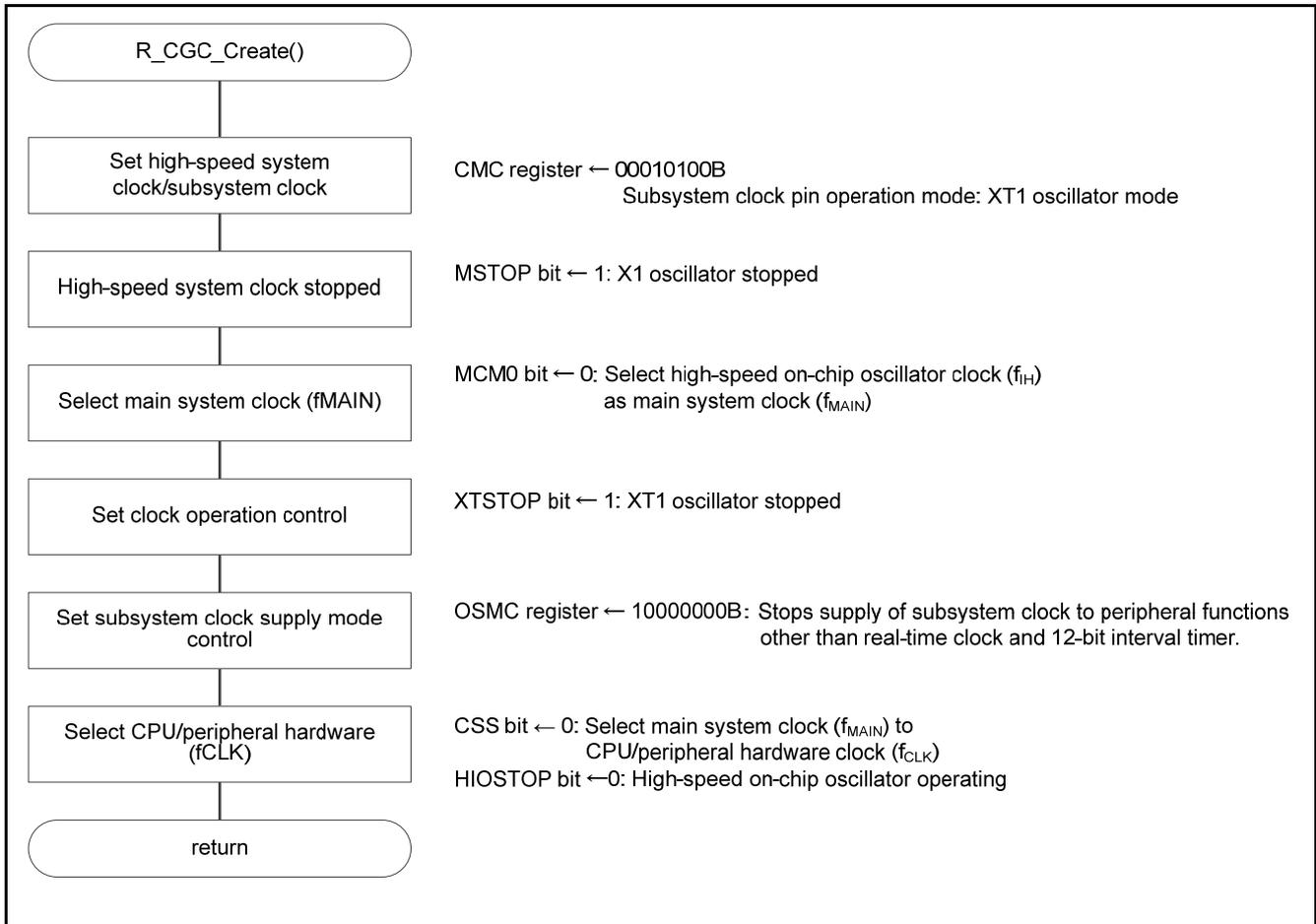


Figure 5.4 CPU Initial Setting

Clock operation mode setting

- Clock operation mode control register (CMC)
 - High-speed system clock pin operation mode: input port mode
 - Subsystem clock pin operation mode: XT1 oscillation mode

Symbol: CMC

7	6	5	4	3	2	1	0
EXCLK	OSCSEL	EXCLKS	OSCSELS	0	AMPHS1	AMPHS0	AMPH
0	0	0	1	0	1	0	0

Bits 7-6

EXCLK	OSCSEL	High-speed oscillation clock pin operation mode	X1/P121 Port	X2/EXCLK/P122 Port
0	0	Input port mode	Input port	
0	1	X1 oscillation mode	Crystal/ceramic resonator connection	
1	0	Input port mode	Input port	
1	1	External clock input mode	Input port	External clock input

Bits 5-4

EXCLKS	OSCSELS	Subsystem clock pin operation mode	XT1/P123 Port	XT2/EXCLKS/P124 Port
0	0	Input port mode	Input port	
0	1	XT1 oscillation mode	Crystal resonator connection	
1	0	Input port mode	Input port	
1	1	External clock input mode	Input port	External clock input

Bits 2-1

AMPHS1	AMPHS0	XT1 oscillator oscillation mode selection
0	0	Low-power consumption oscillation (default)
0	1	Normal oscillation
1	0	Ultra-low power consumption oscillation
1	1	Setting prohibited

Bit 0

AMPH	Control of X1 clock oscillation frequency
0	1MHz ≤ f_x ≤ 10MHz
1	10MHz < f _x ≤ 20MHz

Note: Refer to the RL78/G13 User’s Manual (Hardware version) for details on how to set registers.

Operation control of clocks

- Clock operation status control register (CSC)
- High-speed system clock operation control: X1 oscillator stopped
- Subsystem clock operation control: XT1 oscillator stopped
- HOCO clock operation control: HOCO operating

Symbol: CSC

7	6	5	4	3	2	1	0
MSTOP	XTSTOP	0	0	0	0	0	HIOSTOP
1	1	0	0	0	0	0	0

Bit 7

MSTOP	High-speed system clock operation control		
	X1 oscillation mode	External clock input mode	Input port mode
0	X1 oscillator operating	External clock from EXCLK pin is valid	Input port
1	X1 oscillator stopped	External clock from EXCLK pin is invalid	

Bit 6

XTSTOP	Subsystem clock operation control		
	XT1 oscillation mode	External clock input mode	Input port mode
0	XT1 oscillator operating	External clock from EXCLKS pin is valid	Input port
1	XT1 oscillator stopped	External clock from EXCLKS pin is invalid	

Bit 0

HIOSTOP	High-speed on-chip oscillator clock operation control
0	High-speed on-chip oscillator operating
1	High-speed on-chip oscillator stopped

Note: Refer to the RL78/G13 User’s Manual (Hardware version) for details on how to set registers.

Subsystem clock supply mode control

- Subsystem clock supply mode control register (OSMC)
 Setting in STOP mode or in HALT mode while subsystem clock is selected as CPU clock: disable subsystem clock supply to peripheral functions

Symbol: OSMC

	7	6	5	4	3	2	1	0
RTCLPC	0	0	WUTMM CK0	0	0	0	0	0
1	0	0	0	0	0	0	0	0

Bit 7

RTCLPC	Setting in STOP mode or in HALT mode while subsystem clock is selected as CPU clock
0	Enables supply of subsystem clock to peripheral functions
1	Stops supply of subsystem clock to peripheral functions other than real-time clock and 12-bit interval timer.

Note: Refer to the RL78/G13 User’s Manual (Hardware version) for details on how to set registers.

CPU/peripheral hardware clock (f_{CLK}) setting

- System clock control register (CKC)
 - Status of f_{CLK} : main system clock
 - Selection of f_{CLK} : high-speed on-chip oscillator clock (f_{IH})

Symbol: CKC

7	6	5	4	3	2	1	0
CLS	CSS	MCS	MCM0	0	0	0	0
0	0	0	0	0	0	0	0

Bit 6

CSS	Selection of CPU/peripheral hardware clock (f_{CLK})
0	Main system clock (f_{MAIN})
1	Subsystem clock (f_{SUB})

Bit 4

MCM0	Main system clock (f_{MAIN}) operation control
0	Selects HOCO clock (f_{IH}) as main system clock (f_{MAIN})
1	Selects high-speed system clock (f_{MX}) as main system clock (f_{MAIN}).

Note: Refer to the RL78/G13 User’s Manual (Hardware version) for details on how to set registers.

5.5.4 Input/Output Port Settings

Figure 5.5 shows the flowchart for the input/output port settings.

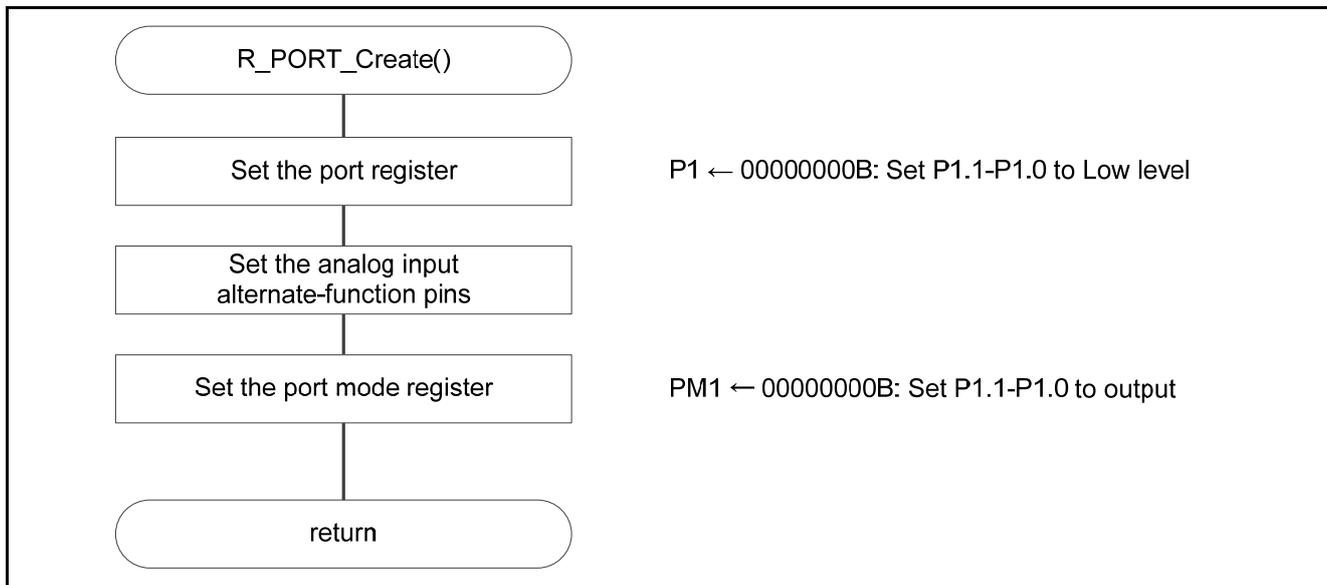


Figure 5.5 Input/Output Port Settings

Note: Refer to the initialization flowchart in the RL78/G13 Initialization (R01AN2575J) Application Note for details on how to set unused ports.

Caution: When designing circuits, always make sure unused ports are properly processed and all electrical characteristics are met. Also make sure each unused input-only port is connected to V_{DD} or V_{SS} through a resistor.

5.5.5 Main Processing

Figure 5.6 shows the flowchart for the main processing.

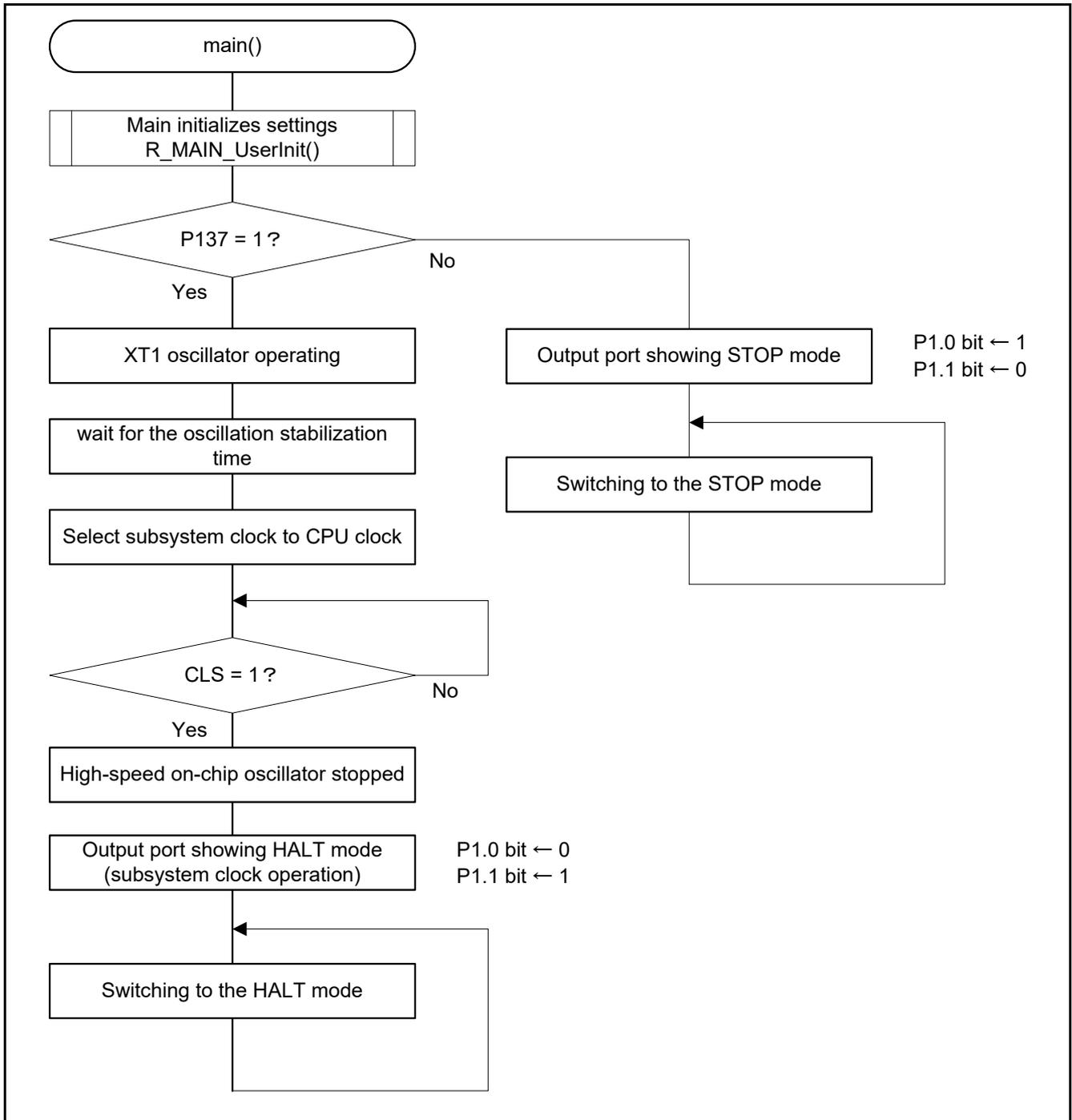


Figure 5.6 Main Processing

5.5.6 Main Initializes Settings

Figure 5.7 shows the flowchart for the main initializes settings.

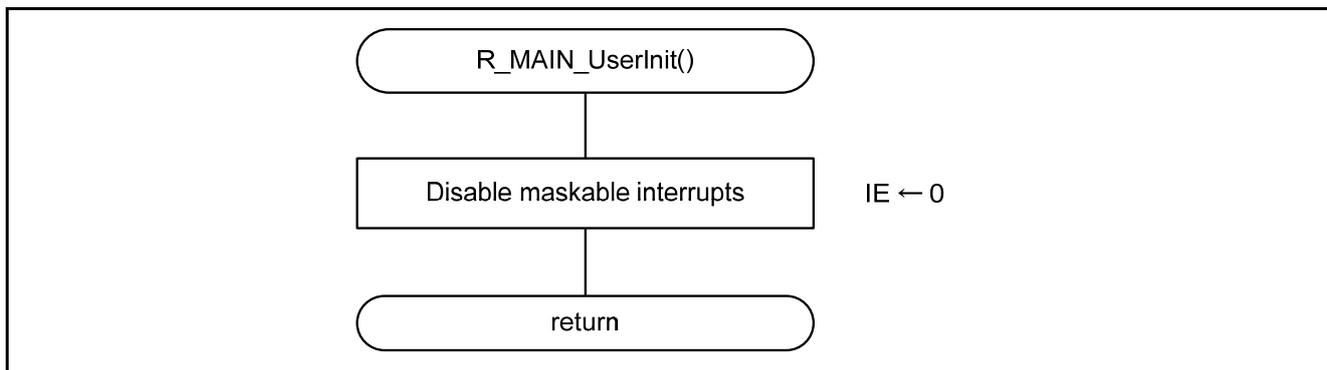


Figure 5.7 Main Initializes Settings

6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference Documents

RL78/G13 User's Manual: Hardware (R01UH0146E)

RL78 Family User's Manual: Software (R01US0015E)

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

Technical Update/Technical News

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

Website and Support

Renesas Electronics website

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sep. 28, 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.

¾ 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.

¾ 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.

¾ 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.

¾ 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.

5. Differences between Products

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.

¾ 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.