

---

# RX210, RX21A, and RX220 Groups

R01AN1706EJ0100

Rev. 1.00

Oct. 10, 2014

## HOCO Calibration Using the CAC

---

### Abstract

This document describes the method to adjust frequencies of the high-speed on-chip oscillator (HOCO) using the clock frequency accuracy measurement circuit (CAC) during the RX210, RX21A or RX220 MCU operation.

### Products

- RX210, RX21A, and RX220 Groups

Note: • 48-pin packages of the RX210 and RX220 Groups are not included as the target products.

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

**Contents**

1. Specifications .....	3
2. Operation Confirmation Conditions .....	4
3. Reference Application Notes.....	4
4. Hardware .....	5
4.1 Pin Used.....	5
5. Software .....	5
5.1 Operation Overview .....	5
5.2 File Composition .....	7
5.3 Option-Setting Memory .....	7
5.4 Constants.....	8
5.5 Variables .....	10
5.6 Functions.....	10
5.7 Function Specifications .....	11
5.8 Flowcharts.....	14
5.8.1 Main Processing .....	14
5.8.2 TMR Initialization .....	15
5.8.3 Sub-Clock Oscillation Setting .....	16
5.8.4 RTC Initialization.....	17
5.8.5 RTC Periodic Interrupt Handling.....	18
5.8.6 CMT0 Wait Processing .....	19
5.8.7 CAC Initialization .....	20
5.8.8 CAC Measurement End Interrupt Handling .....	21
6. Applying This Application Note to the RX21A or RX220 Group.....	22
7. Sample Code.....	23
8. Reference Documents.....	23

1. Specifications

HOCO oscillation frequency may differ from the factory-configured frequency due to external factors such as ambient temperature. Calibration needs to be performed to compensate the frequency error. The high-speed on-chip oscillator trimming register (HOCOTRRn (n = 0 to 3)) is used to adjust the HOCO oscillation frequency. Registers HOCOTRR0, HOCOTRR1, HOCOTRR2, and HOCOTRR3 correspond to oscillation frequencies 32 MHz, 36.864 MHz, 40 MHz, and 50 MHz, respectively. When the HOCO clock is 32 MHz, the HOCO frequency error can be compensated by adjusting the value of the HOCOTRR0 register in constant intervals.

In this application note, the HOCO oscillation frequency is measured in 1 second periods using the CAC. Then the value in the HOCOTRR0 register is adjusted with the obtained measurement result. Also a waveform which is equivalent to HOCO divided by 4 is output from the TMO3 pin.

Table 1.1 lists the Peripheral Functions and Their Applications and Figure 1.1 shows the Block Diagram.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
CAC	Measures the HOCO frequency based on the sub-clock.
RTC	Counter for 1 second period
TMR	Outputs a waveform which is equivalent to the HOCO clock divided by 4.

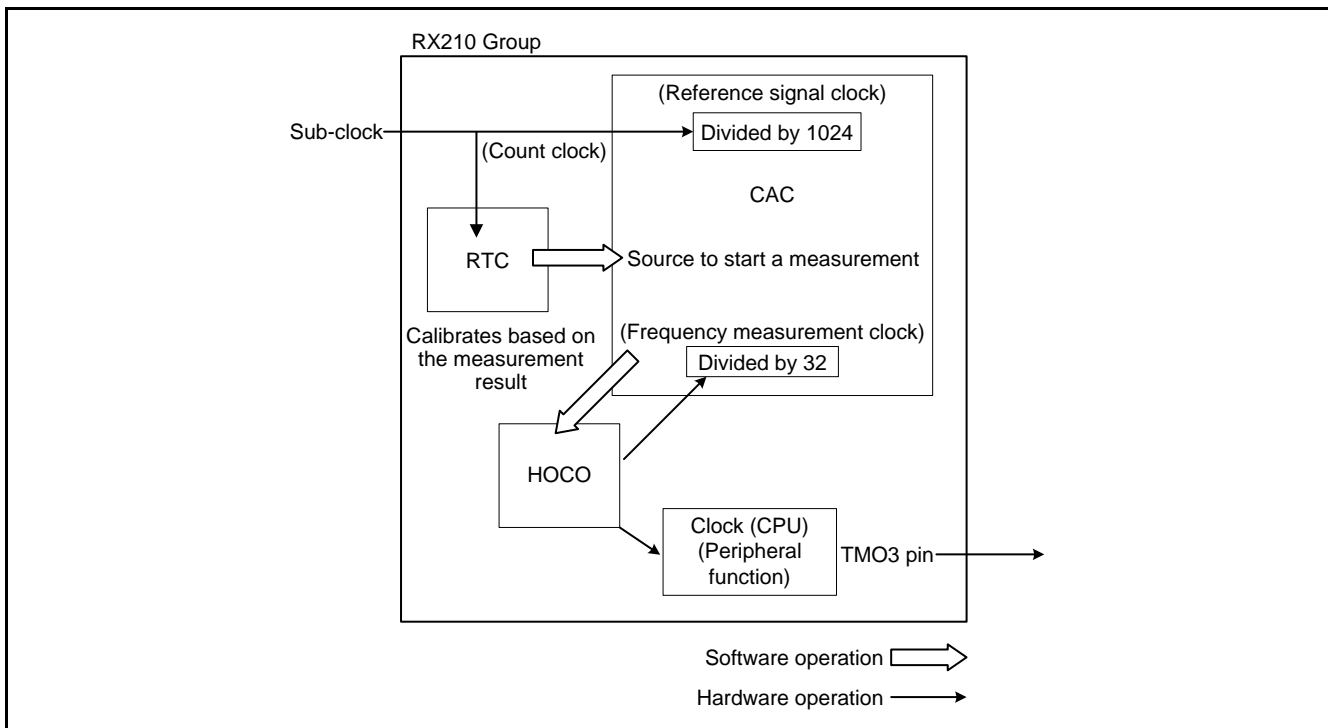


Figure 1.1 Block Diagram

## 2. Operation Confirmation Conditions

The sample code accompanying this application note has been run and confirmed under the conditions below.

**Table 2.1 Operation Confirmation Conditions**

Item	Contents
MCU used	R5F5210BBDFP (RX210 Group)
Operating frequencies	<ul style="list-style-type: none"> <li>• HOCO clock: 32 MHz</li> <li>• Sub-clock: 32.768 kHz</li> <li>• System clock (ICLK): 32 MHz (HOCO clock divided by 1)</li> </ul>
Operating voltage	5.0 V
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Version 4.09.01
C compiler	Renesas Electronics Corporation C/C++ Compiler Package for RX Family V.1.02 Release 01
	Compile options -cpu=rx200 -output=obj="\$(CONFIGDIR)\\$(FILELEAF).obj" -debug -nologo (The default setting is used in the integrated development environment.)
iodefine.h version	Version 1.50
Endian	Little endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.00
Board used	Renesas Starter Kit for RX210 (product part no.: R0K505210S003BE)

## 3. Reference Application Notes

For additional information associated with this document, refer to the following application notes.

- RX210 Group Initial Setting Rev. 2.20 (R01AN1002EJ)
- RX21A Group Initial Setting Rev. 1.10 (R01AN1486EJ)
- RX220 Group Initial Setting Rev. 1.10 (R01AN1494EJ)

The initial setting functions in the reference application notes are used in the sample code accompanying this application note. The revision numbers of the reference application notes are as of when this application note was made. However the latest version is always recommended. Visit the Renesas Electronics Corporation website to check and download the latest version.

## 4. Hardware

### 4.1 Pin Used

Table 4.1 lists the Pin Used and Its Function.

**Table 4.1 Pin Used and Its Function**

Pin Name	I/O	Function
P32/TMO3	Output	Outputs a waveform which is equivalent to the HOCO clock divided by 4.

## 5. Software

### 5.1 Operation Overview

In this application note, the HOCO clock (32 MHz) divided by 32 is used as the frequency measurement clock for the CAC and the sub-clock (32.768 kHz) divided by 1024 is used as the reference signal generation clock. The CAC counts valid edges of the HOCO in the period from a rising edge to the next rising edge of the sub-clock.

The measurement is triggered by the realtime clock (RTC) 1-second periodic interrupt and performed four times continuously.

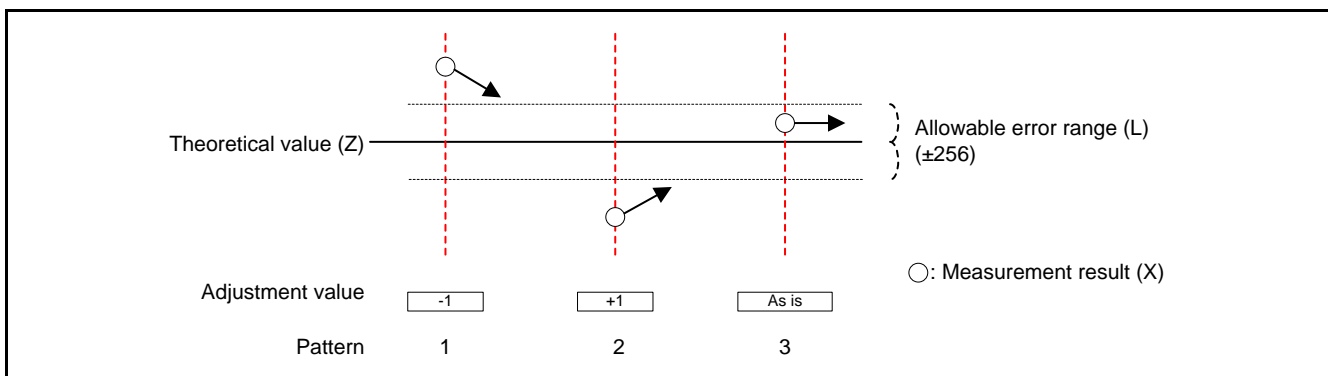
The average of these four measurement results is calculated (measurement result for adjustment). If the difference (A) between the measurement result and the theoretical value is “ $A \leq -256$  counts” or “ $+256$  counts  $\leq A$ ”, addition or subtraction is performed on the HOCOTRR0 register value. If the difference between the measurement result and the theoretical value is “ $-256$  counts  $< A < +256$  counts”, the HOCOTRR0 register value remains as it is.

Table 5.1 lists the Specifications of Register Value Adjustment, Figure 5.1 shows the Specification of Register Value Adjustment, and Figure 5.2 shows the Timing Diagram of Calibration.

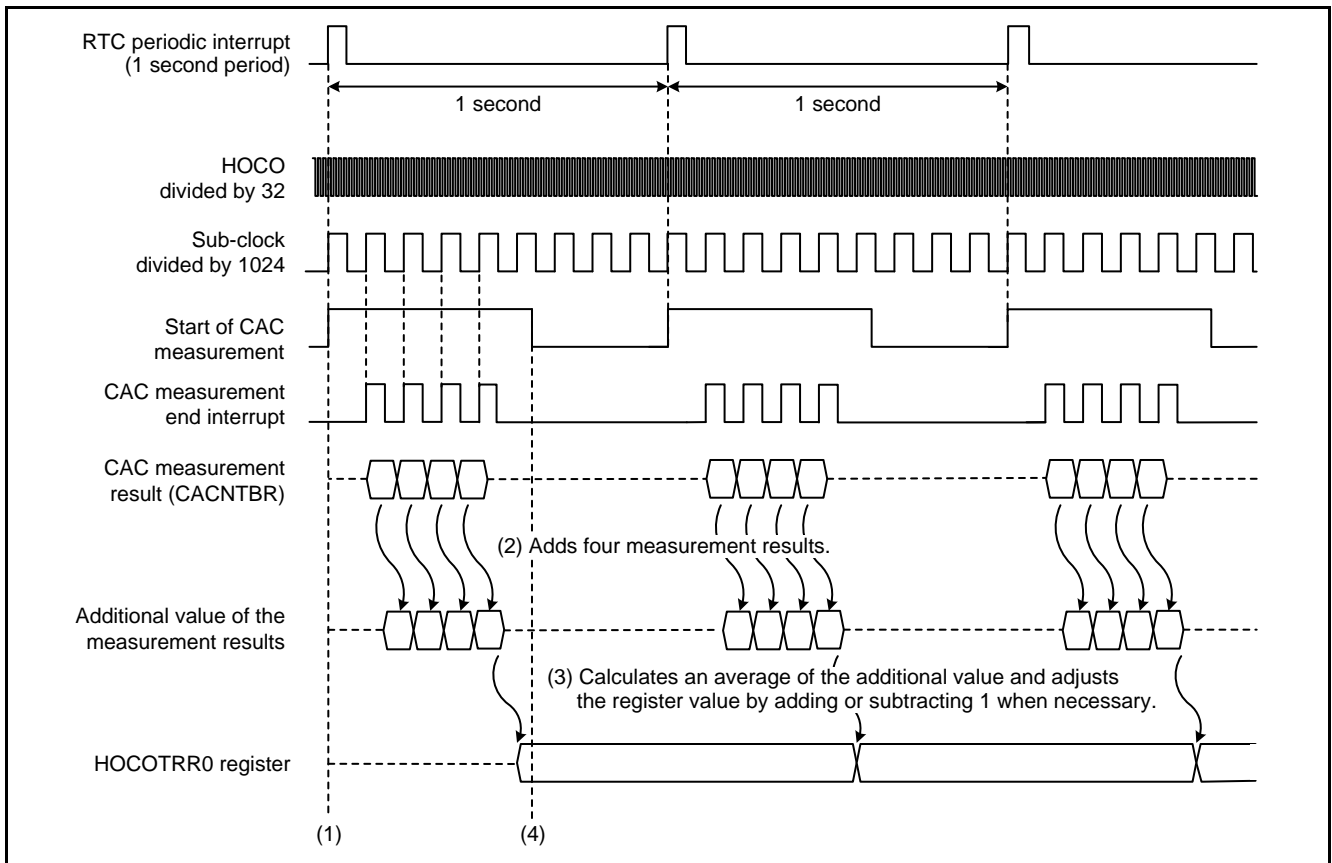
**Table 5.1 Specifications of Register Value Adjustment**

Pattern	Condition	Adjustment Value
1	$X \geq Z (Z + L)$	- 1
2	$X \leq (Z - L)$	+ 1
3	$(Z - L) < X < (Z + L)$	As is

X: Measurement result, Z: Theoretical value, L: Allowable error range



**Figure 5.1 Specification of Register Value Adjustment**



**Figure 5.2 Timing Diagram of Calibration**

- (1) Using the RTC 1-second periodic interrupt as a trigger, the CAC start setting is configured and a measurement is started.
- (2) Valid edges of the HOCO divided by 32 are counted in the period from a rising edge to the next rising edge of the sub-clock divided by 1024. The measurement result is obtained in CAC measurement end interrupt handling. Four measurements are handled as a set of the measurement result.
- (3) A set of the measurement result is averaged and the value in the HOCOTRR0 register is adjusted using the averaged value <sup>(1)</sup>.
- (4) When the adjustment of the HOCO oscillation frequency is completed, the CAC measurement is stopped. A wait for HOCO oscillation stabilization is processed until the next RTC 1-second periodic interrupt occurs while HOCO is being provided to the CPU or the peripheral functions such as ICLK.

**Note:**

1. The following errors are caused by errors between the HOCO and a crystal used for the sub-clock, and the allowable error range ( $\pm 256$  counts) of the theoretical value.
  - When the HOCO is 32 MHz, the maximum error is  $\pm 0.9\%$ .
  - When the HOCO is 36.864 MHz, the maximum error is  $\pm 0.8\%$ .
  - When the HOCO is 40 MHz, the maximum error is  $\pm 0.7\%$ .
  - When the HOCO is 50 MHz, the maximum error is  $\pm 0.6\%$ .

## 5.2 File Composition

Table 5.2 lists the Files Used in the Sample Code. Files generated by the integrated development environment are not included in this table.

**Table 5.2 Files Used in the Sample Code**

File Name	Outline	Remarks
main.c	Main processing	
r_init_stop_module.c	Stop processing for active peripheral functions after a reset	
r_init_stop_module.h	Header file for r_init_stop_module.c	
r_init_non_existent_port.c	Nonexistent port initialization	
r_init_non_existent_port.h	Header file for r_init_non_existent_port.c	
r_init_clock_an1706.c	Clock initialization	
r_init_clock.h	Header file for r_init_clock.c	
rtc_func.c	RTC initialization and 1-second periodic interrupt handling	
rtc_func.h	Header file for rtc_func.c	
cac_func.c	CAC initialization and measurement end interrupt handling	
cac_func.h	Header file for cac_func.c	
tmr_func.c	TMR initialization for PCLK output	

## 5.3 Option-Setting Memory

Table 5.3 lists the Option-Setting Memory Configured in the Sample Code. When necessary, set a value suited to the user system.

**Table 5.3 Option-Setting Memory Configured in the Sample Code**

Symbol	Addresses	Setting Value	Contents
OFS0	FFFF FF8Fh to FFFF FF8Ch	FFFF FFFFh	The IWDT is stopped after a reset. The WDT is stopped after a reset.
OFS1	FFFF FF8Bh to FFFF FF88h	FFFF FFFFh	The voltage monitor 0 reset is disabled after a reset. HOCO oscillation is disabled after a reset.
MDES	FFFF FF83h to FFFF FF80h	FFFF FFFFh	Little endian

## 5.4 Constants

Table 5.4 lists the Constants Used in the Sample Code (Constants from the Initial Setting). Table 5.5 list the Constants Used in the Sample Code.

**Table 5.4 Constants Used in the Sample Code (Constants from the Initial Setting)**

Constants listed in the table are changed their values from those used in the Initial Setting application note.

Constant Name	Setting Value	Contents
SEL_MAIN	B_NOT_USE	Selection of the main clock operation: The main clock is not used (main clock stopped).
SEL_SUB	B_USE	Selection of the sub-clock usage for the system clock: The sub-clock is used <sup>(1)</sup> .
SEL_RTC	B_USE	Selection of the sub-clock usage for the RTC count source: The sub-clock is used.
SEL_PLL	B_NOT_USE	Selection of the PLL clock operation: The PLL clock is not used (PLL clock stopped).
SEL_HOCO	B_USE	Selection of the HOCO clock operation: The HOCO clock is used (HOCO clock oscillating).
SEL_SYSCLK	CLK_HOCO	Clock source selection for the system clock HOCO is selected.

Note:

1. For the clock setting, No. 4 is used in Table 1.3 Examples of Clock Selections in the Initial Setting application note except the SEL\_SUB constant. In this application note, "B\_USE (used)" is set to the SEL\_SUB constant since the sub-clock is used for the CAC.



Table 5.5 Constants Used in the Sample Code

Constant Name	Setting Value	Contents
CHECK_CNT	4	Number of measurements
MEND_FINISH	0	Frequency measurement counter: Measurement stopped
MEND_START	1	Frequency measurement counter: Measurement starts
MEND_CHECK_FINISH	CHECK_CNT	Frequency measurement counter: Measurement completed
ACCEPTABLE_RANGE	256	Allowable error range of the measurement result
MAIN_CLOCK_CYCLE	(1,000,000,000L / MAIN_CLOCK_Hz)	Main clock cycles (ns)
SUB_CLOCK_CYCLE	(1,000,000,000L / SUB_CLOCK_Hz)	Sub-clock cycles (ns)
FOR_CMT0_TIME	232727	Count cycles (ns) for the CMT0 timer to wait for the oscillation stabilization wait time: (1/LOCO) × 32, where LOCO = 137.5 kHz (max.), and 32 = PCLKB divided by 32
REG_HOCOTRR (when HOCO operates at 32 MHz)	SYSTEM.HOCOTRR0	HOCOTRR0 register
TYP_CAC_RESULT (when HOCO operates at 32 MHz)	31250	Measurement theoretical value when HOCO operates at 32 MHz.
REG_HOCOTRR (when HOCO operates at 36.864 MHz)	SYSTEM.HOCOTRR1	HOCOTRR1 register
TYP_CAC_RESULT (when HOCO operates at 36.864 MHz)	36000	Measurement theoretical value when HOCO operates at 36.864 MHz.
REG_HOCOTRR (when HOCO operates at 40 MHz)	SYSTEM.HOCOTRR2	HOCOTRR2 register
TYP_CAC_RESULT (when HOCO operates at 40 MHz)	39062	Measurement theoretical value when HOCO operates at 40 MHz.
REG_HOCOTRR (when HOCO operates at 50 MHz)	SYSTEM.HOCOTRR3	HOCOTRR3 register
TYP_CAC_RESULT (when HOCO operates at 50 MHz)	48828	Measurement theoretical value when HOCO operates at 50 MHz.

## 5.5 Variables

Table 5.6 lists the Global Variables.

**Table 5.6 Global Variables**

Type	Variable Name	Contents	Function Used
static uint8_t	buffer_counter	Frequency measurement counter	INIT_CAC Excep_CAC_MENDF
static uint32_t	result_buffer	Storage buffer for the frequency measurement result	INIT_CAC Excep_CAC_MENDF
static int32_t	result_diff	Storage buffer for the result	INIT_CAC Excep_CAC_MENDF

## 5.6 Functions

Table 5.7 lists the Functions.

**Table 5.7 Functions**

Function Name	Outline
main	Main processing
R_INIT_StopModule	Stop processing for active peripheral functions after a reset
R_INIT_NonExistentPort	Nonexistent port initialization
R_INIT_Clock	Clock initialization
tmr_init	TMR initialization
CGC_oscillation_sub_an1706	Sub-clock oscillation setting
enable_RTC_an1706	RTC initialization
Excep_RTC_PRD	RTC periodic interrupt handling
cmt0_wait_16bit	CMT0 wait processing
INIT_CAC	CAC initialization
Excep_CAC_MENDF	CAC measurement end interrupt handling

## 5.7 Function Specifications

The following tables list the sample code function specifications.

<b>main</b>	
<b>Outline</b>	Main processing
<b>Header</b>	None
<b>Declaration</b>	void main(void)
<b>Description</b>	Calls the following functions: Stop processing for active peripheral functions after a reset, nonexistent port initialization, clock initialization, and TMR initialization.
<b>Arguments</b>	None
<b>Return Value</b>	None
<b>R_INIT_StopModule</b>	
<b>Outline</b>	Stop processing for active peripheral functions after a reset
<b>Header</b>	r_init_stop_module.h
<b>Declaration</b>	void R_INIT_StopModule(void)
<b>Description</b>	Configures the setting to enter the module stop state.
<b>Arguments</b>	None
<b>Return Value</b>	None
<b>Remarks</b>	Transition to the module stop state is not performed in the sample code. For details on this function, refer to the Initial Setting application note for the product used.
<b>R_INIT_NonExistentPort</b>	
<b>Outline</b>	Nonexistent port initialization
<b>Header</b>	r_init_non_existent_port.h
<b>Declaration</b>	void R_INIT_NonExistentPort(void)
<b>Description</b>	Initializes port direction registers for ports that do not exist in products with less than 144 pins.
<b>Arguments</b>	None
<b>Return Value</b>	None
<b>Remarks</b>	The number of pins in the sample code is set for the 100-pin package (PIN_SIZE=100). After this function is called, when writing in byte units to the PDR registers or PODR registers which have nonexistent ports, set the corresponding bits for nonexistent ports as follows: set the I/O select bits in the PDR registers to 1 and set the output data store bits in the PODR registers to 0. For details on this function, refer to the Initial Setting application note for the product used.
<b>R_INIT_Clock</b>	
<b>Outline</b>	Clock initialization
<b>Header</b>	r_init_clock.h
<b>Declaration</b>	void R_INIT_Clock(void)
<b>Description</b>	Initializes the clock.
<b>Arguments</b>	None
<b>Return Value</b>	None
<b>Remarks</b>	The sample code selects processing which uses the HOCO as the system clock and the sub-clock for the RTC and CAC. For details on this function, refer to the Initial Setting application note for the product used.

---

tmr_init	
<b>Outline</b>	TMR initialization
<b>Header</b>	tmr_func.h
<b>Declaration</b>	void tmr_init(void)
<b>Description</b>	Configures channel 3 of the TMR to output PCLK divided by 2.
<b>Arguments</b>	None
<b>Return Value</b>	None

---

CGC_oscillation_sub_an1706	
<b>Outline</b>	Sub-clock oscillation setting
<b>Header</b>	r_init_clock.h
<b>Declaration</b>	void CGC_oscillation_sub_an1706 (void)
<b>Description</b>	Configures settings to use the sub-clock for either of the system clock or the RTC, or both.
<b>Arguments</b>	None
<b>Return Value</b>	None

---

enable_RTC_an1706	
<b>Outline</b>	RTC initialization
<b>Header</b>	rtc_func.h
<b>Declaration</b>	void enable_RTC_an1706 (void)
<b>Description</b>	Initializes the RTC (setting for clock provision and the RTC, and RTC software reset).
<b>Arguments</b>	None
<b>Return Value</b>	None

---

Excep_RTC_PRD	
<b>Outline</b>	RTC periodic interrupt handling
<b>Header</b>	rtc_func.h
<b>Declaration</b>	static void Excep_RTC_PRD(void)
<b>Description</b>	The CAC is initialized in this interrupt handling.
<b>Arguments</b>	None
<b>Return Value</b>	None

---

cmt0_wait_16bit	
<b>Outline</b>	CMT0 wait processing
<b>Header</b>	None
<b>Declaration</b>	static void cmt0_wait_16bit(uint16_t cnt)
<b>Description</b>	This function is used when waiting for RTC clock provision that is six clocks of the sub-clock.
<b>Arguments</b>	uint16_t cnt: Oscillation stabilization wait time $\text{cnt} = \text{oscillation stabilization wait time (ns)}^{(1)} \div \text{FOR\_CMT0\_TIME}^{(2)}$
<b>Return Value</b>	None
<b>Remarks</b>	<ol style="list-style-type: none"><li>1. The oscillation stabilization wait time varies depending on the crystal/ceramic resonator. Set the value based on the calculation method in the Initial Setting application note for the product used.</li><li>2. The value of FOR_CMT0_TIME is calculated where LOCO is 137.5 kHz (max.). The actual wait time may differ depending on the LOCO frequency.</li></ol>

---

---

**INIT\_CAC**

---

**Outline** CAC initialization  
**Header** cac\_func.h  
**Declaration** void INIT\_CAC(void)  
**Description** Initializes the CAC.  
**Arguments** None  
**Return Value** None

---

**Excep\_CAC\_MENDF**

---

**Outline** CAC measurement end interrupt handling  
**Header** cac\_func.h  
**Declaration** static void Excep\_CAC\_MENDF(void)  
**Description** Adjusts HOCO frequencies based on the measurement results.  
**Arguments** None  
**Return Value** None

5.8 Flowcharts

5.8.1 Main Processing

Figure 5.3 shows the Main Processing.

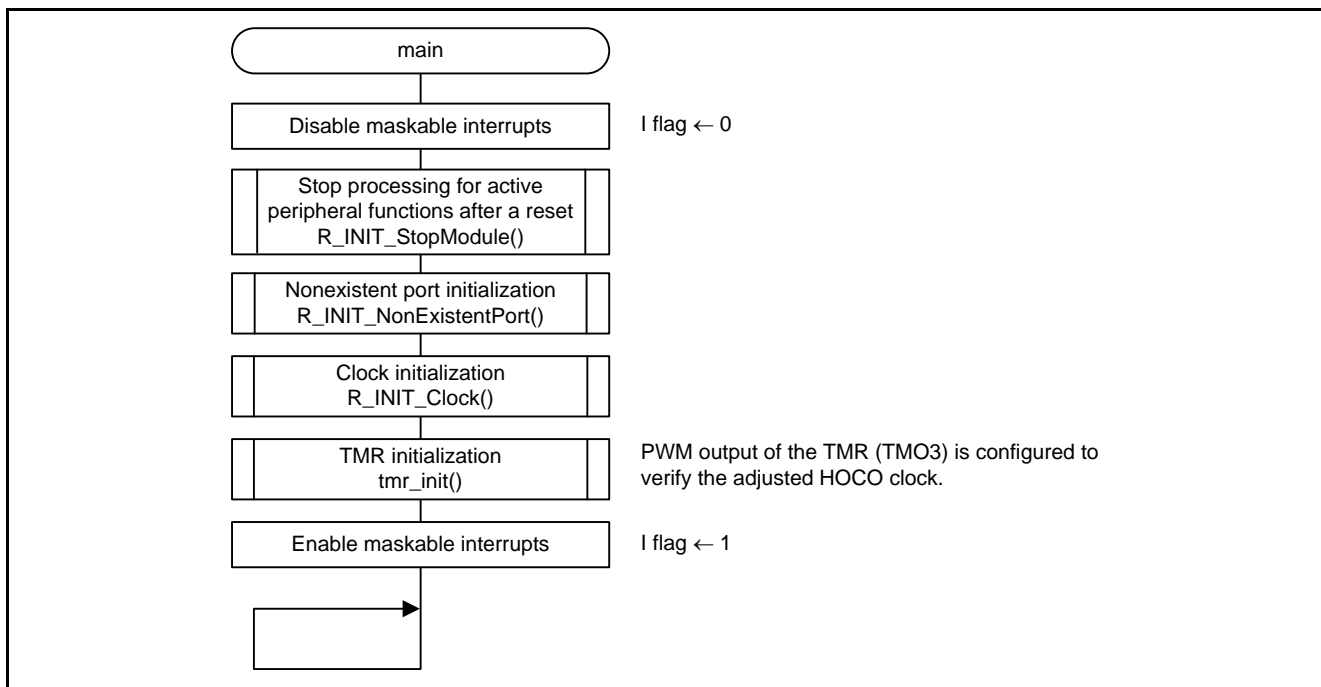


Figure 5.3 Main Processing

5.8.2 TMR Initialization

Figure 5.4 shows the TMR Initialization.

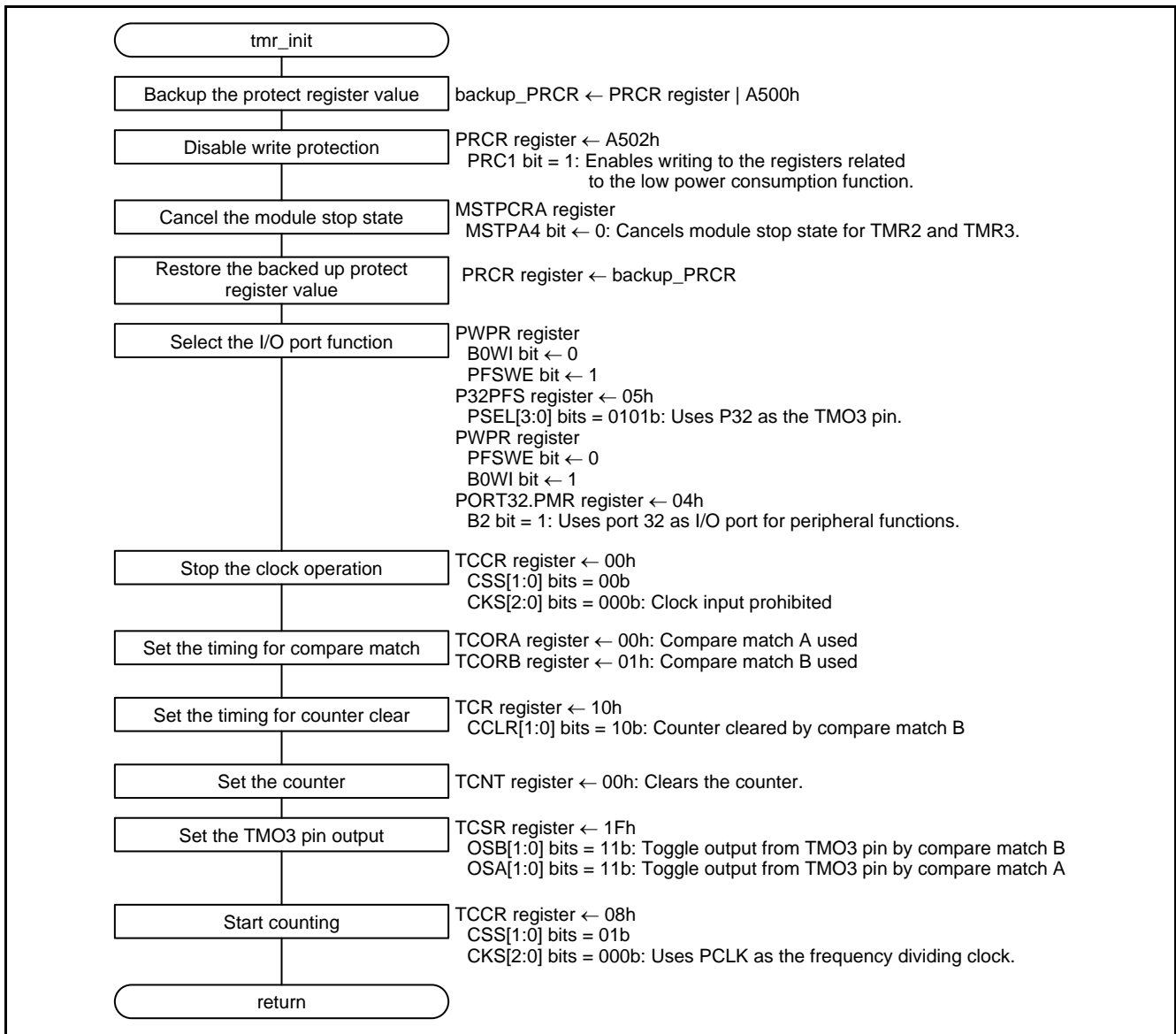


Figure 5.4 TMR Initialization

5.8.3 Sub-Clock Oscillation Setting

Figure 5.5 shows the Sub-Clock Oscillation Setting.

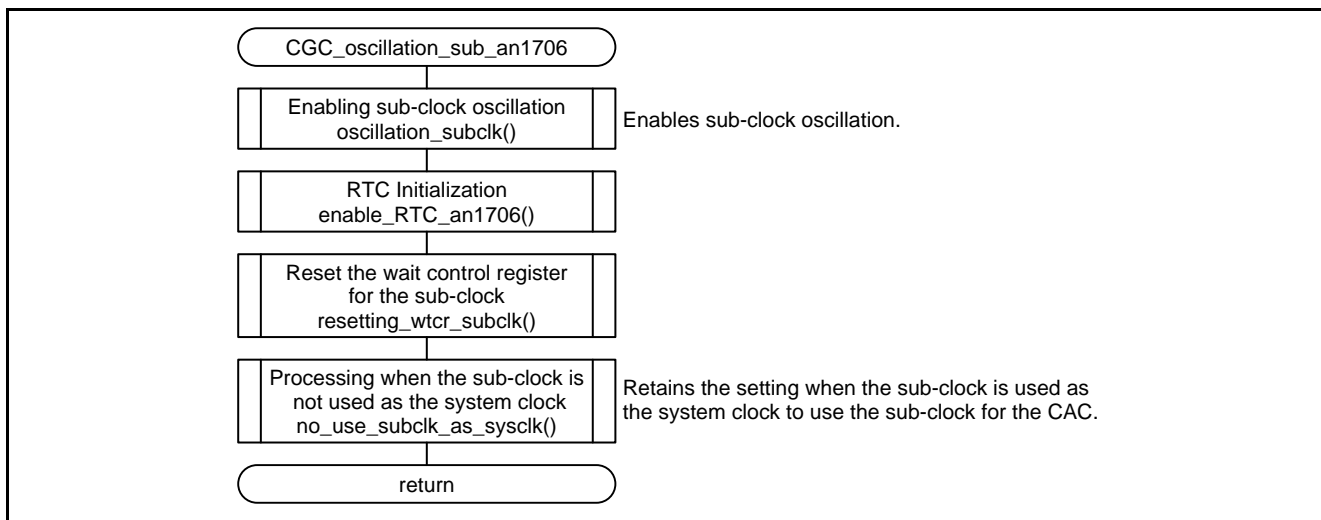


Figure 5.5 Sub-Clock Oscillation Setting



5.8.4 RTC Initialization

Figure 5.6 shows the RTC Initialization.

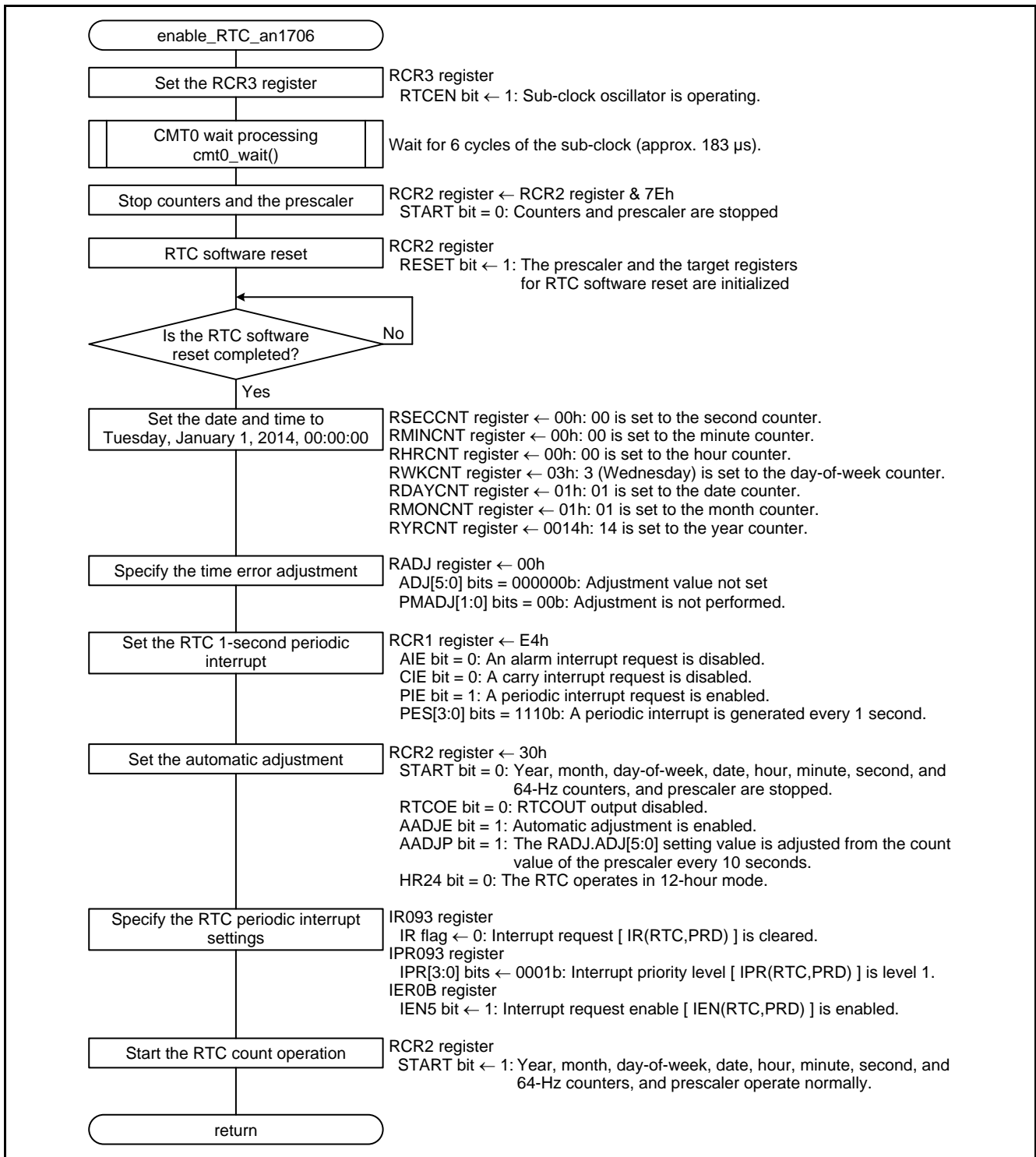


Figure 5.6 RTC Initialization

5.8.5 RTC Periodic Interrupt Handling

Figure 5.7 shows the RTC Periodic Interrupt Handling.

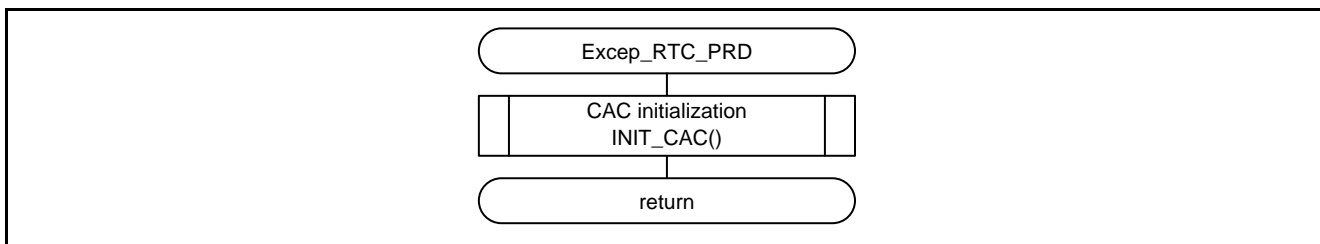


Figure 5.7 RTC Periodic Interrupt Handling

5.8.6 CMT0 Wait Processing

Figure 5.8 shows the CMT0 Wait Processing.

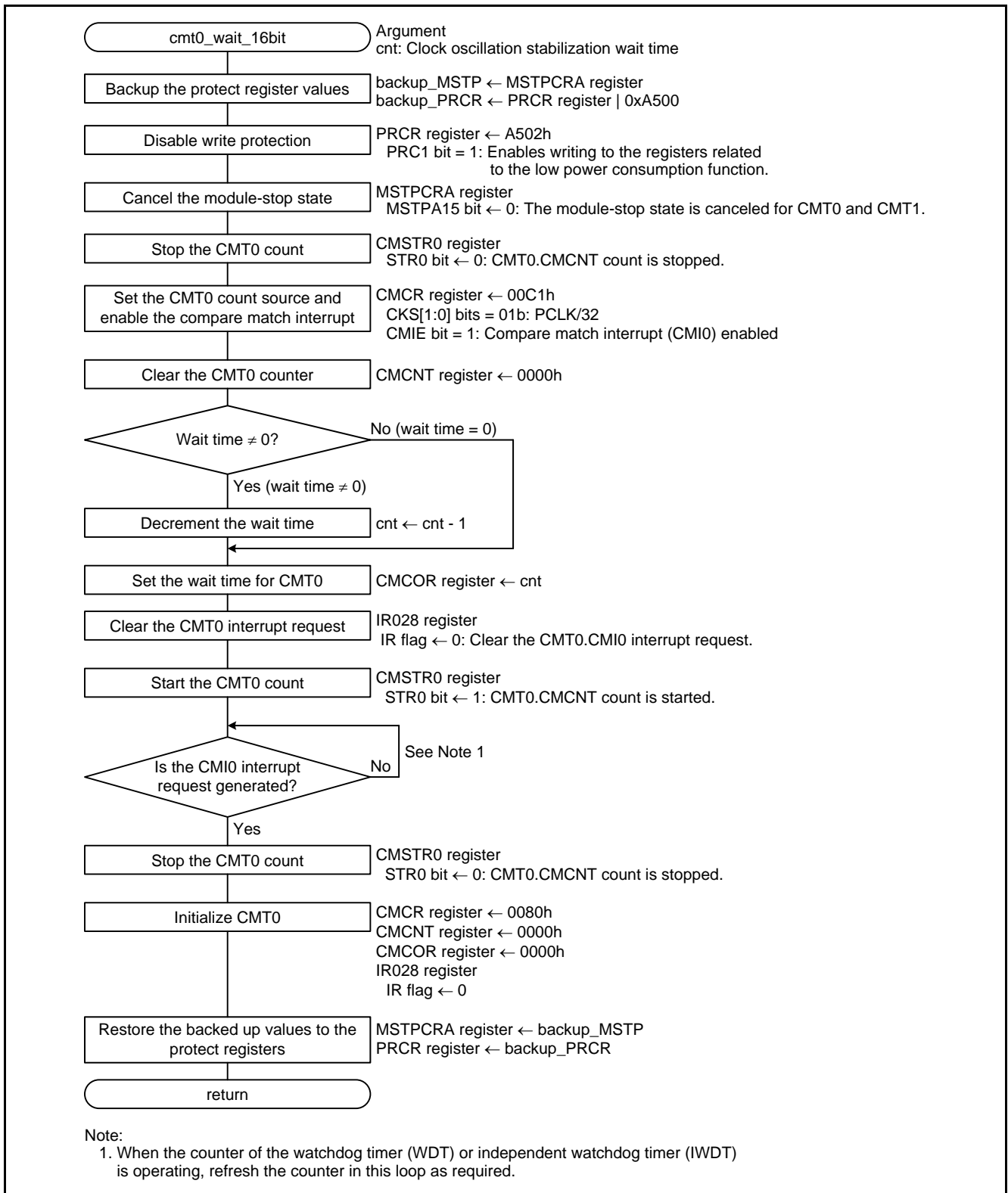


Figure 5.8 CMT0 Wait Processing

5.8.7 CAC Initialization

Figure 5.9 shows the CAC Initialization.

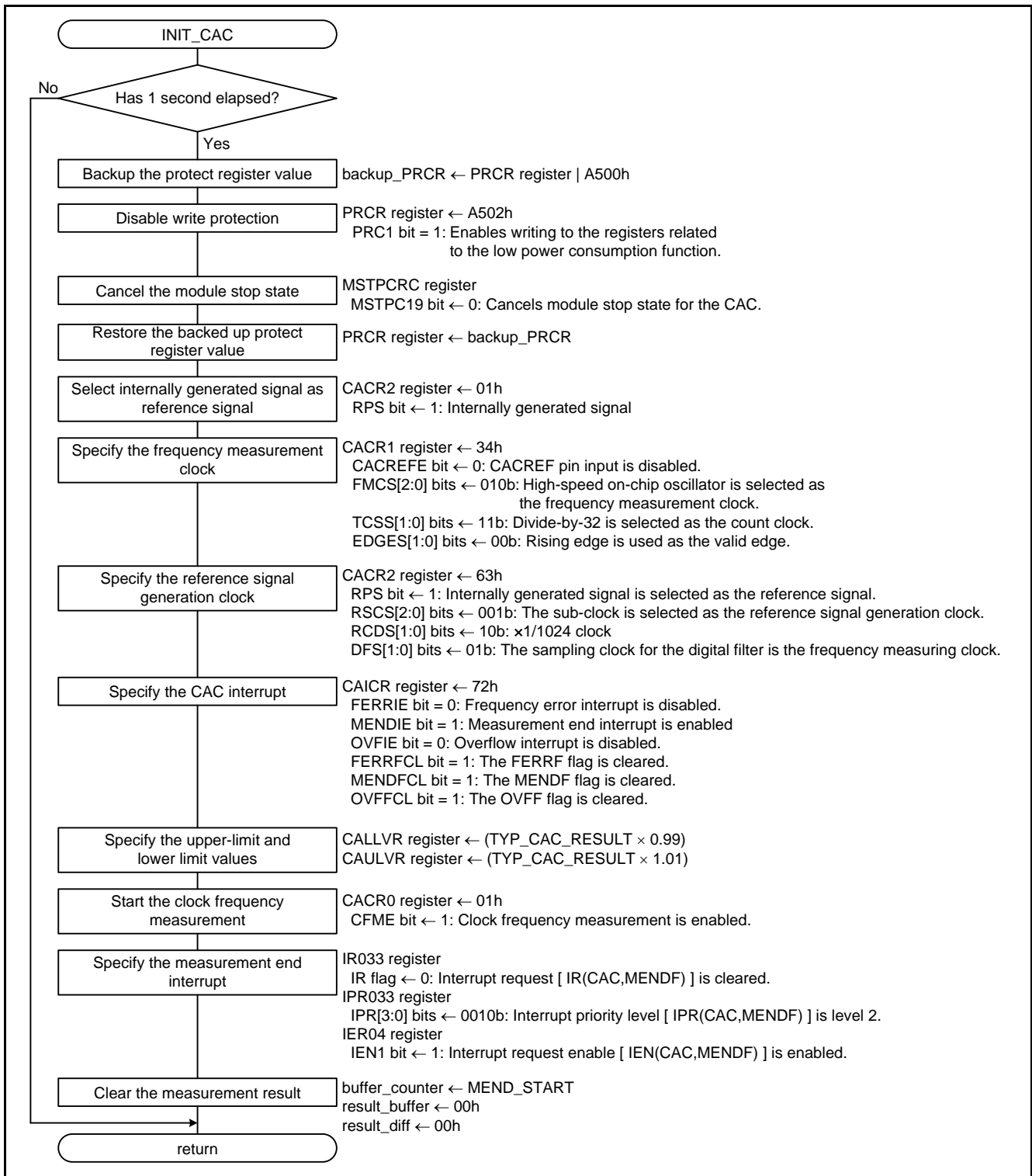


Figure 5.9 CAC Initialization

5.8.8 CAC Measurement End Interrupt Handling

Figure 5.10 shows the CAC Measurement End Interrupt Handling.

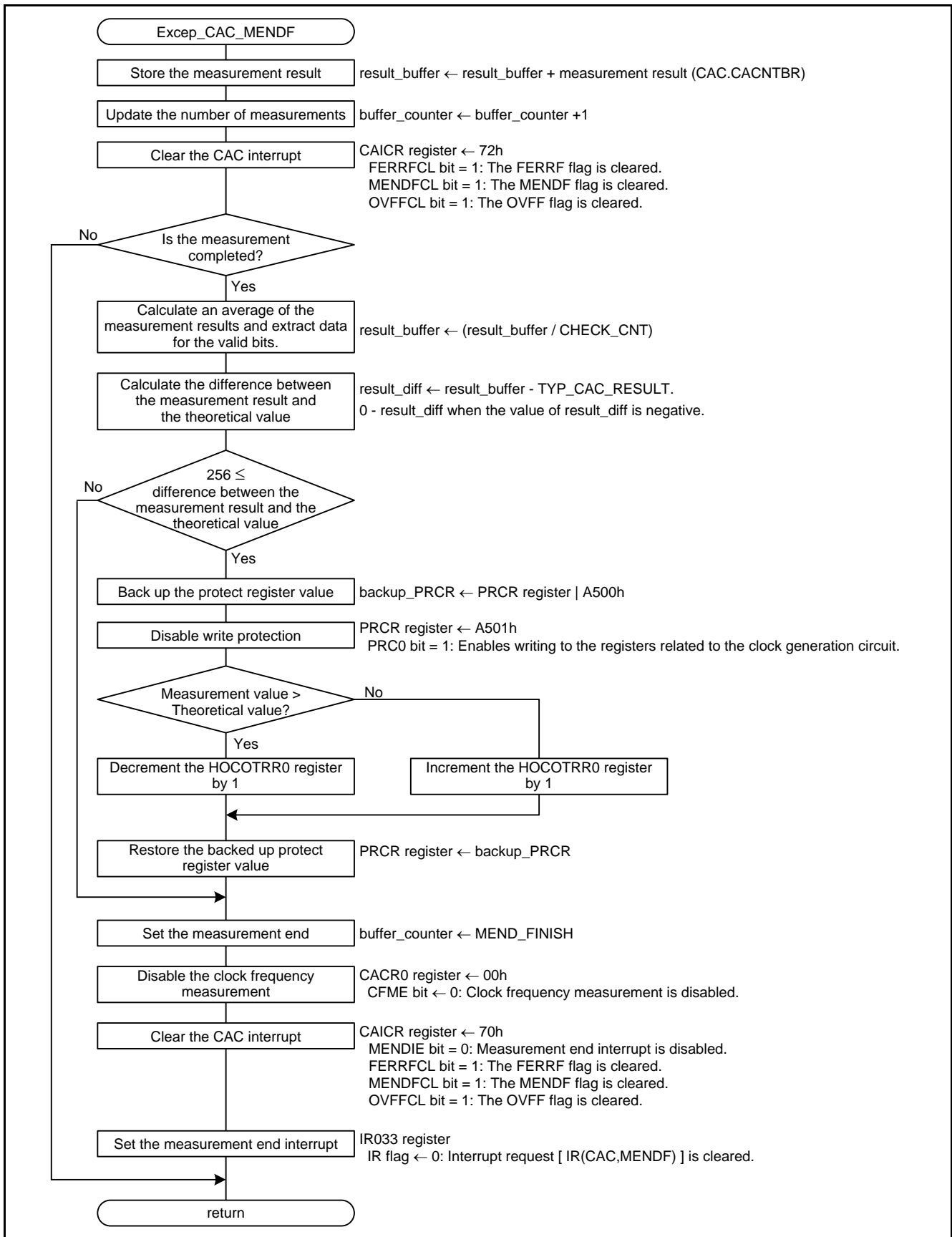


Figure 5.10 CAC Measurement End Interrupt Handling

## 6. Applying This Application Note to the RX21A or RX220 Group

The sample code accompanying this application note has been confirmed to operate with the RX210 Group. To make the sample code operate with the RX21A or RX220 Group, use this application note in conjunction with the Initial Setting application note for each group.

For details on using this application note with the RX21A and RX220 Groups, refer to “5. Applying the RX210 Group Application Note to the RX21A Group” in the RX21A Group Initial Setting application note, and “4. Applying the RX210 Group Application Note to the RX220 Group” in the RX220 Group Initial Setting application note.

Note: • Files `r_init_clock.h` and `r_init_clock.c` will be overwritten when applying the RX21A or RX220 Group Initial Setting. Make the settings in the overwritten files be same as the original settings in files `r_init_clock.h` and `r_init_clock.c` accompanying this application note.

## 7. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

## 8. Reference Documents

User's Manual: Hardware

RX210 Group User's Manual: Hardware Rev.1.50 (R01UH0037EJ)

RX21A Group User's Manual: Hardware Rev.1.00 (R01UH0251EJ)

RX220A Group User's Manual: Hardware Rev.1.10 (R01UH0292EJ)

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.

User's Manual: Development Tools

RX Family C/C++ Compiler Package V.1.01 User's Manual Rev.1.00 (R20UT0570EJ)

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

## Website and Support

Renesas Electronics website

<http://www.renesas.com>

Inquiries

<http://www.renesas.com/contact/>

<b>REVISION HISTORY</b>	RX210, RX21A, and RX220 Groups Application Note HOCO Calibration Using the CAC
-------------------------	---

Rev.	Date	Description	
		Page	Summary
1.00	Oct. 10, 2014	—	First edition issued

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



## General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

### 1. Handling of Unused Pins

Handle unused pins in accordance with the directions given under Handling of Unused Pins in the manual.

- The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

### 2. Processing at Power-on

The state of the product is undefined at the moment when power is supplied.

- The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.  
In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

### 3. Prohibition of Access to Reserved Addresses

Access to reserved addresses is prohibited.

- The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

### 4. Clock Signals

After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

- When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

### 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.

- The characteristics of an MPU or MCU 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.

## 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 of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
  2. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
  3. Renesas Electronics does not assume any liability for infringement of 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. 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 should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from such alteration, modification, copy or otherwise misappropriation of Renesas Electronics product.
  5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The recommended 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; and industrial robots etc.  
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; and safety equipment etc.  
Renesas Electronics products are neither intended nor 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 damages (nuclear reactor control systems, military equipment etc.). You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application for which it is not intended. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for which the product is not intended by Renesas Electronics.
  6. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
  7. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, 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, please evaluate the safety of the final products or systems manufactured by you.
  8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
  9. Renesas Electronics products and technology may 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 should not use Renesas Electronics products or technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. When exporting the Renesas Electronics products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations.
  10. It is the responsibility of the buyer or distributor of Renesas Electronics products, who distributes, disposes of, or otherwise places the product with a third party, to notify such third party in advance of the contents and conditions set forth in this document, Renesas Electronics assumes no responsibility for any losses incurred by you or third parties as a result of unauthorized use of Renesas Electronics products.
  11. This document may not be reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
  12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.
- (Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.
- (Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.



### SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

#### **Renesas Electronics America Inc.**

2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.  
Tel: +1-408-588-6000, Fax: +1-408-588-6130

#### **Renesas Electronics Canada Limited**

1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada  
Tel: +1-905-898-5441, Fax: +1-905-898-3220

#### **Renesas Electronics Europe Limited**

Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K.  
Tel: +44-1628-585-100, Fax: +44-1628-585-900

#### **Renesas Electronics Europe GmbH**

Arcadiastrasse 10, 40472 Düsseldorf, Germany  
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

#### **Renesas Electronics (China) Co., Ltd.**

Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China  
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

#### **Renesas Electronics (Shanghai) Co., Ltd.**

Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333  
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

#### **Renesas Electronics Hong Kong Limited**

Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong  
Tel: +852-2265-6688, Fax: +852 2886-9022/9044

#### **Renesas Electronics Taiwan Co., Ltd.**

13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan  
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

#### **Renesas Electronics Singapore Pte. Ltd.**

80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949  
Tel: +65-6213-0200, Fax: +65-6213-0300

#### **Renesas Electronics Malaysia Sdn.Bhd.**

Unit 906, Block B, Menara Aeoncorp, Aeoncorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia  
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

#### **Renesas Electronics Korea Co., Ltd.**

12F., 234 Teheran-ro, Gangnam-Ku, Seoul, 135-920, Korea  
Tel: +82-2-558-3737, Fax: +82-2-558-5141